

RESEARCH

Open Access



# GENESS 2—Generating Standards for In-Situ Simulation project: a systematic mapping review

Kerry Evans<sup>1\*</sup>, Jenny Woodruff<sup>2</sup>, Alison Cowley<sup>3</sup>, Louise Bramley<sup>1</sup>, Giulia Miles<sup>4</sup>, Alastair Ross<sup>5</sup>, Joanne Cooper<sup>1</sup> and Bryn Baxendale<sup>4</sup>

## Abstract

**Background:** In-situ simulation is increasingly employed in healthcare settings to support learning and improve patient, staff and organisational outcomes. It can help participants to problem solve within real, dynamic and familiar clinical settings, develop effective multidisciplinary team working and facilitates learning into practice. There is nevertheless a reported lack of a standardised and cohesive approach across healthcare organisations. The aim of this systematic mapping review was to explore and map the current evidence base for in-situ interventions, identify gaps in the literature and inform future research and evaluation questions.

**Methods:** A systematic mapping review of published in-situ simulation literature was conducted. Searches were conducted on MEDLINE, EMBASE, AMED, PsycINFO, CINAHL, MIDIRS and ProQuest databases to identify all relevant literature from inception to October 2020. Relevant papers were retrieved, reviewed and extracted data were organised into broad themes.

**Results:** Sixty-nine papers were included in the mapping review. In-situ simulation is used 1) as an assessment tool; 2) to assess and promote system readiness and safety cultures; 3) to improve clinical skills and patient outcomes; 4) to improve non-technical skills (NTS), knowledge and confidence. Most studies included were observational and assessed individual, team or departmental performance against clinical standards. There was considerable variation in assessment methods, length of study and the frequency of interventions.

**Conclusions:** This mapping highlights various in-situ simulation approaches designed to address a range of objectives in healthcare settings; most studies report in-situ simulation to be feasible and beneficial in addressing various learning and improvement objectives. There is a lack of consensus for implementing and evaluating in-situ simulation and further studies are required to identify potential benefits and impacts on patient outcomes. In-situ simulation studies need to include detailed demographic and contextual data to consider transferability across care settings and teams and to assess possible confounding factors. Valid and reliable data collection tools should be developed to capture the complexity of team and individual performance in real settings. Research should focus on identifying the optimal frequency and length of in-situ simulations to improve outcomes and maximize participant experience.

**Keywords:** In-situ simulation; simulation-based education, Clinical training, Simulated practice, Health professions

\*Correspondence: Kerry.evans1@nottingham.ac.uk

<sup>1</sup> Nottingham University Hospitals Trust, Institute of Care Excellence, Nottingham, UK

Full list of author information is available at the end of the article

## Background

In-situ simulation (ISS) training enables teams to practice and be assessed in their own, familiar clinical environments [1, 2]. ISS is often focused on training for low



volume, high impact emergencies involving multidisciplinary teams (MDTs) with the aim of reinforcing knowledge and improving the functioning of the clinical team as a whole [3–5]. The main benefit of ISS over other traditional simulation approaches is reported as allowing participants to problem solve within their own dynamic setting which supports the implementation of learning into practice [1, 2].

ISS has been identified as a useful mechanism to explore and learn from adverse events [6–9]. Embedding ISS activities underpinned by Human Factors principles can help to focus on the organisational, procedural and contextual influences on clinical reasoning and actions [10, 11]. ISS has also been developed to test the synergy or dissonance between micro and macro factors: task factors, organisational factors, internal environments and external environments [12]. ISS interventions have been reported as a mechanism to enhance patient flow, improve the design of clinical spaces, and identify latent safety threats (LSTs) within new clinical settings [13–16]. The ability to experiment and see what occurs through interactions, attunement and disturbances enables participants to try out different options and consider possible unintended outcomes [17].

Organisational resilience is focused on understanding how healthcare organisations can deliver standardised, replicable and predictable services while embracing inherent variations, disruptions and unexpected events [18]. During the Covid-19 pandemic, ISS proved useful in helping teams prepare in a rapidly emerging situation. ISS interventions included testing and implementing the use of personal protective equipment (PPE), infection control guidelines and supporting operational readiness of intensive care units and operating rooms [19–23]. ISS interventions are employed to improve the acquisition of NTS, task management, situation awareness, problem-solving, decision-making and enhancing teamwork while testing and probing real-world organisational systems [1, 18, 24–27].

ISS offers a feasible and acceptable approach through which individual and team competency can be assessed through simulated scenarios in controlled and standardised clinical settings [28]. Griswold et al. [29] identify that summative assessment using ISS is suited to clinical procedures with clear chains of action and well-defined processes and standards. Clinical competency measurement and assessment tools are less well-defined for ISS and further complicated when individual performance needs to be isolated from the wider team. Concepts such as ‘effective communication’ are subject to interpretation, and clinical outcomes may be attributed to concepts such as teamwork and coordination in addition to individual clinical skills and knowledge [30].

Although ISS has been identified as a promising approach in healthcare settings, ISS terms and concepts require standardisation and integrated models of learning are required to provide a more comprehensive and cohesive strategic approach [1, 31, 32]. The overall aim of the Generating Standards for In-Situ Simulation project phase 2 (GENESS -2) was to develop evidence-based standards for healthcare professionals, educators and managers interested in developing and implementing ISS interventions in clinical practice. The project was commissioned by Health Education England working across the Midlands and East. A conceptual model of ISS was developed in phase one [33] which proposed four main ISS functions (Fig. 1). The aim of this systematic mapping review was to: explore and map the current evidence base for ISS approaches, identify gaps in the literature and inform future research questions.

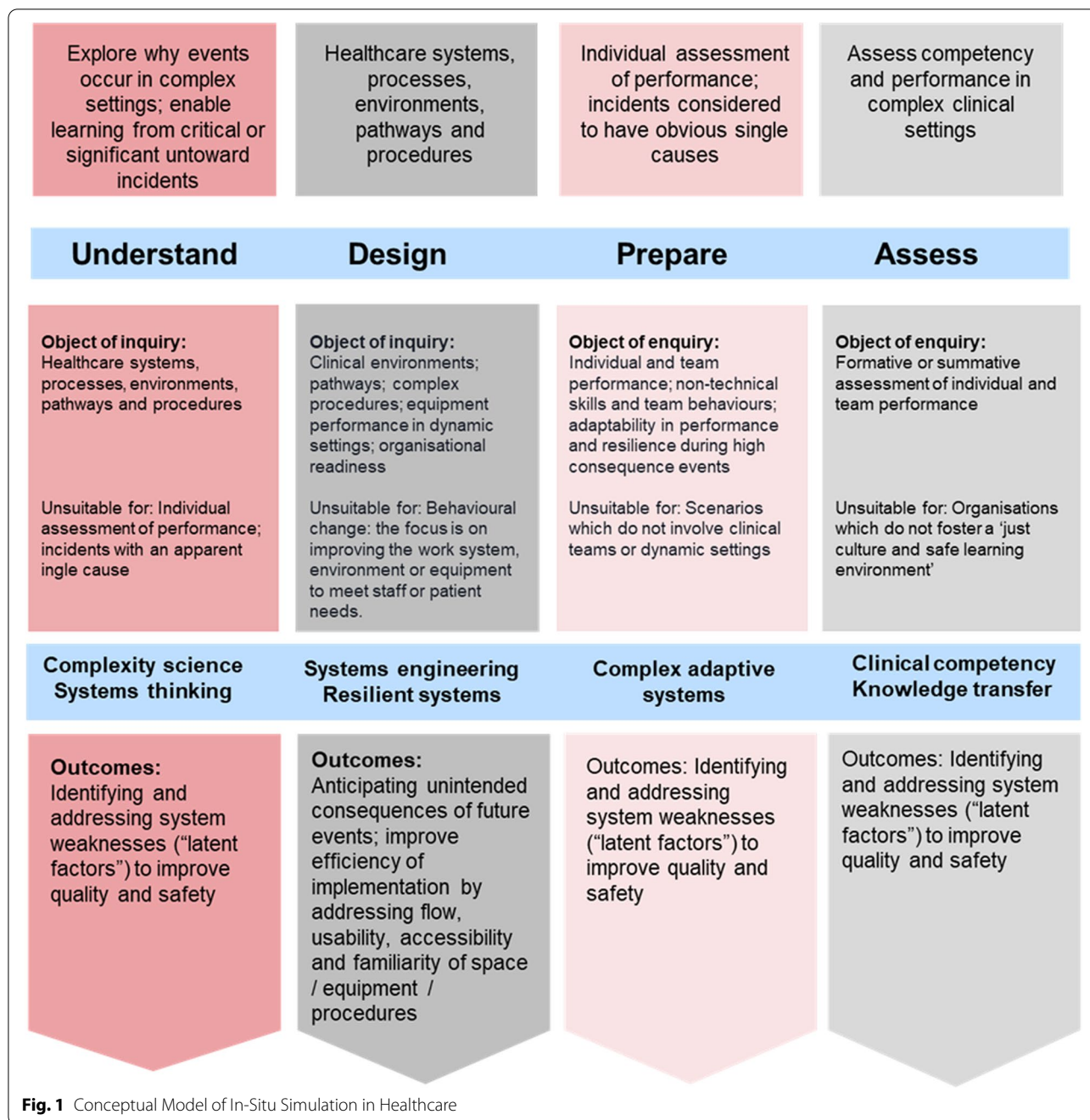
## Methods

We chose to conduct a systematic mapping review to capture the wide evidence base on main uses of ISS in healthcare. Mapping reviews are specifically designed to describe the extent of research in a field, spanning broad topic areas and research objectives to identifying evidence gaps to be addressed by future research [34]. The report follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines [35]. The review protocol was registered on the PROSPERO database (CRD42019128071). Recommendations for systematic mapping reviews [36–38] guided the review conduct.

## Search

The search strategy was developed for MEDLINE, EMBASE, AMED, PsycINFO, CINAHL, MIDIRS and ProQuest databases and completed the literature search in March 2019 and updated in October 2020. A summary of the search terms is included in Table 1 and supplementary file 1 provides details of the full Medline search strategy.

Papers were included in the review if they met the following criteria: (i) published in English, (ii) based in an Organisation for Economic Co-operation and Development (OECD) member country (to enable greater comparability between health systems and socio-economic contexts), (iii) reporting quantitative primary research including randomised controlled trials, quasi-experimental studies, cohort studies, economic evaluation and observational quantitative studies (iv), included healthcare practitioners as participants (individual and teams) (v) reported simulation training or interventions conducted in any patient care settings (vi) reported quantitative measures of safety, governance, quality improvement,



technical and non-technical skills performance, and educational or clinical outcomes. Exclusion criteria were (i) papers reporting simulation activities conducted in educational institutions and centres, simulation laboratories or training suites or non-patient areas (ii) qualitative studies, secondary data analysis and literature reviews. The timeframe for inclusion was from inception to October 2020.

Papers retrieved from the literature databases were imported to an EndNote library, and duplicate records were identified. Two researchers independently screened the titles and abstracts against the review inclusion and exclusion criteria (KE, JW). Full text papers of the remaining citations were then retrieved and independently assessed by two researchers (first stage: KE, JW updated search: KE, AC). A third

**Table 1** Search terms

Simulation training / teaching	and	In-situ	and	Patient safety
Simulation education		In practice		Human factor
Patient simulation		Work based		Adverse event
Simulation		Workplace		Harm / risk / incident
High / Low fidelity simulation		Point of care		Clinical governance
Experiential learning		Real world		Outcome assessment
Drill		Mobile		Patient reported outcomes
Mannequin		Cart		Quality improvement
		Hospital / ward		Medical errors
		Primary care		Clinical competence / skill
		Clinic		Technical skill
		On-site		Non-technical skill
		Patient area		Interpersonal skill
				Situational awareness
				Performance
				Capability / expertise
				Communication
				Knowledge (transition / translation)
				Leadership
				Handover / off
				Organisational (departmental) efficiency / performance
				Pathway / care / flow
				Cost benefit
				Economic / cost
				Orientation

researcher (BB) moderated any discrepancies until the final selection of papers was agreed upon.

### Quality assessment

The quality of studies included in the review was evaluated using a range of established critical appraisal tools selected for the particular study design: Quality Assessment Tool for Before-After (Pre-Post) Studies with No Control Group [39]; The Cochrane Risk of Bias tool for Randomised Controlled Trials [40]; The Joanna Briggs Institute (JBI) Checklist for Quasi-Experimental Studies [41]; CASP tool for cohort studies [42]. Two independent researchers assessed study quality (first stage: KE, JW updated search: KE AC) and banded studies as low, medium and high quality. There was consensus between the two researchers. Although no studies were excluded on the basis of quality, the quality assessment was used to identify the strengths and limitations of the review [43]. JBI levels of evidence [44] for included studies was also reported.

### Data extraction

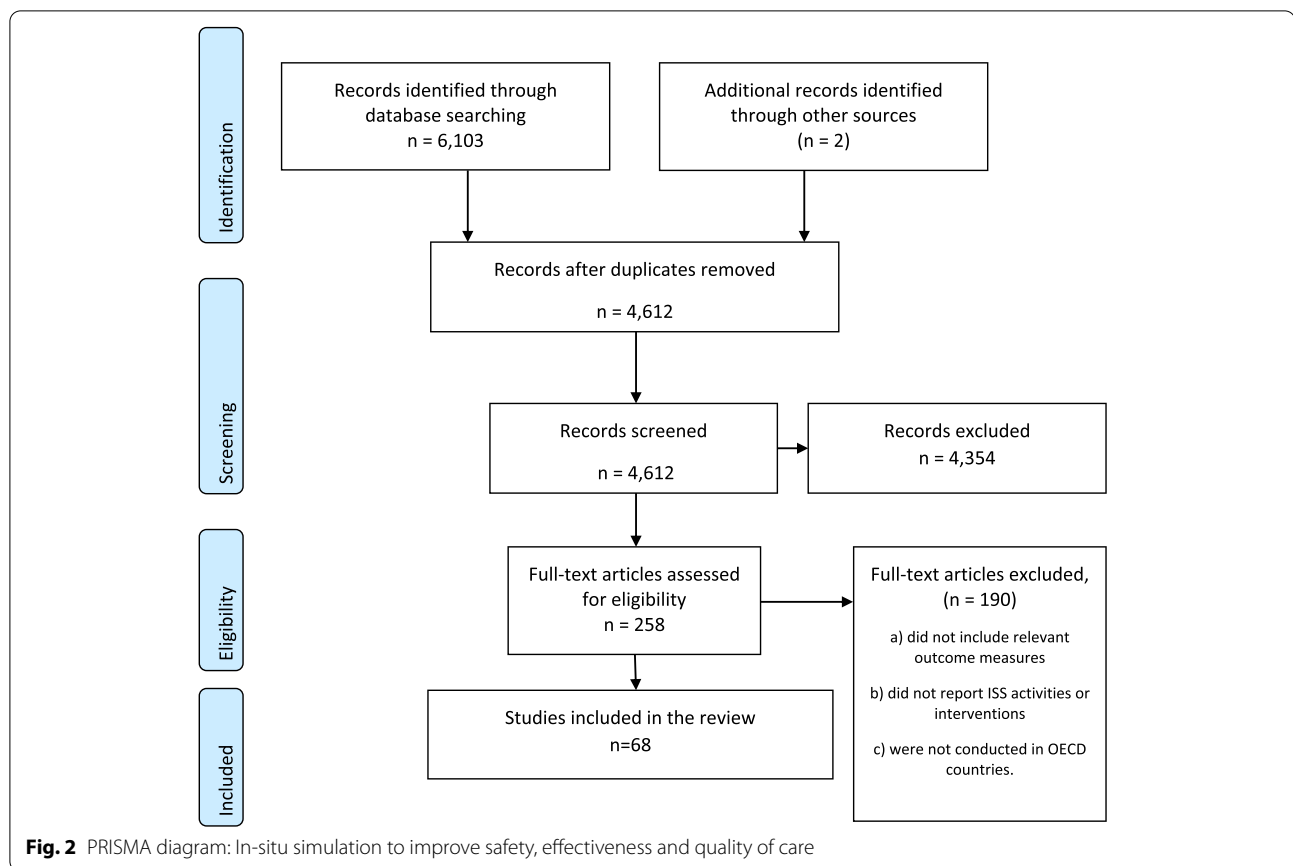
Data extraction forms were designed and piloted before beginning data extraction, completed by two independent researchers. Data extraction tables consisting of numerical and textual data presented the study characteristics, results and quality assessments.

### Data analysis and synthesis

Synthesis of the extracted data were conducted in a descriptive and tabular way [45]. Categories were developed through an iterative process, focusing on the main aims or purposes of ISS interventions, illustrating the range of methods, intervention components, duration, populations, outcome measures and gaps in the research within and between each category. A description of the quantitative data is presented in tables to enhance explanation, understanding and coherence of the findings [37].

### Results

The search identified 6,105 potentially eligible papers. Duplicate papers were removed ( $n=1493$ ). Papers were then screened (4,612) based on the information provided by the title and abstract. Potentially eligible papers ( $n=258$ ) were retrieved for full text assessment by two independent reviewers (KE, JW) and any disagreement resolved by discussion with a third reviewer (BB) until agreement was reached. The level of agreement between the two reviewers produced a kappa value of 0.9 which suggests a very good strength of agreement ( $k=0.9$ ,  $p<0.001$ ). Excluded papers ( $n=189$ ) a) did not include relevant outcome measures, b) did not report ISS activities or interventions c) were not conducted in OECD countries. The literature search and inclusion process are detailed in the PRISMA Flow diagram [46] (Fig. 2). There were 68 papers included in the mapping review which met the inclusion criteria.



Findings were organised into categories to reflect the aims and objectives of the included studies using ISS: 1) as an assessment tool; 2) to assess and promote system readiness and safety cultures; 3) to improve clinical skills and patient outcomes; 4) to improve NTS, knowledge and comfort and confidence. The themes presented are:

#### ISS to assess performance and identify risks

Eighteen studies conducted ISS as a method of assessment (Table 2). Studies were conducted in the US, Canada, Denmark, Sweden, UK, Germany, Switzerland. Most studies were observational ( $n=17$ ), with one study reporting a quasi-experimental design to compare outcomes using different resuscitation equipment [47]. Samples sizes (where reported) ranged from 12 to 277 participants. Five studies reported ISS interventions to assess performance and identify risks: medication errors in emergency departments [48], LSTs in a Children's medical centre [49], paediatric and neonatology departments [50], paediatric tracheostomy care management in Emergency Departments (EDs), Intensive Care Units (ICUs) [51], and blood transfusion policies in the operating room [52]. Four studies reported ISS interventions to assess compliance against clinical guidelines and

standards: cardiac arrest guidelines [53], sepsis guidelines [54], blood transfusion policy and identification [52] and cardiopulmonary resuscitation (CPR) performance [55]. Four studies reported ISS interventions to assess clinical response and task completion time [56–59], with three studies employing a pre / post ISS evaluation to evaluate the effectiveness of training programmes [60–62]. ISS was used to test and assess the safety of new equipment and procedures in two studies: the use electronic health records in the ICU [63] and to assess and compare traditional and automated external defibrillator supplemented responder models [47]. One study [64] conducted ISS to assess performance-relevant effects of task distribution and communication amongst emergency teams.

Auerbach et al. [45] and Kessler et al. [50] employed voluntary participation for ISS assessments, although the authors discussed that selection bias may be introduced as individuals agreeing to participate may be more or less skilled than other staff [53]. In addition scheduling of ISS may have resulted in providers and departments preparing for the day (training effect). Lipman et al. [53] reported that clinical timings may have been underestimated due to participation of highly skilled teams, the close proximity of clinical departments and participants



**Table 2** ISS to assess performance and identify risks

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
<b>Auerbach 2018</b> [45] (US)	Adherence to paediatric cardiac arrest guidelines	ED (50 ED departments), MDT teams	1. Cardiac arrest adherence score (AHA guidelines) 2. Timing and task completion 3. Simulated Team Assessment Tool (STAT)	Prospective observational Quality assessment – good (3e)
<b>Calhoun 2014</b> [46] (US)	Task performance in ICU examining work length on task completion	Paediatric ICU, nurses (n = 28)	1. Task completion via direct observation	Prospective observational Quality assessment: low – moderate (3e)
<b>Campbell 2016</b> [47] (Canada)	Blood administration processes and hazards	Operating room, HCPs (n = 43)	1. Adherence to a process checklist 2. Identification of latent hazards 3. Performance and teamwork ANTS tool and CTS	Prospective observational Quality assessment—good (3e)
<b>Clapper 2018</b> [48] (US)	Assess the impact of the saturation-in-training model of TeamSTEPS implementation	Paediatric in-patient unit (n = 547, ISS with smaller sub-sample)	1. Participant TeamSTEPS knowledge scores 2. TeamSTEPS performance scores	Prospective observational Quality assessment – good (3e)
<b>Hargestam 2015</b> [49] (Sweden)	Time taken to make a decision to go to surgery	ED, trauma teams (n = 96 participants)	1. Clinical management timings 2. Communication 3. Leadership style	Prospective observational Quality assessment: moderate (3e)
<b>Kessler 2016</b> [50] (US)	Adherence to paediatric sepsis guidelines	Paediatric ED, MDT teams (n = 47 teams)	1. Compliance with International sepsis guidelines 2. Experience and attitudes to sepsis care	Prospective observational Quality assessment: good (3e)
<b>Kobayashi 2010</b> [51] (US)	Comparing defibrillators in the ED	Hospital, nurses (n = 50)	1. Resuscitation performance	Quasi-experimental Quality assessment: moderate (2d)
<b>Kozer 2004</b> [52] (Canada)	Characterise the incidence of medication errors	Paediatric ED, 20 physicians, 15 nurses	1. Drug type and drug concentration administered	Prospective observational (3e)
<b>Lipman 2013</b> [53] (US)	Assess performance of response times for emergency caesarean delivery	Maternity unit, MDT (n = 14 teams)	1. Timings to perform emergency caesarean 2. Barriers to optimal team performance	Prospective observational Quality assessment: moderate (3e)
<b>Lipman 2013b</b> [54] (US)	Assess performance of CPR during obstetric crisis in different settings	Maternity unit, MDT (n = 14 teams)	1. Correctly delivered chest compressions 2. CPR skills	Prospective observational Quality assessment: moderate (3e)
<b>Lok 2014</b> [55] (UK)	Identifying latent risks in paediatrics and neonatology	Paediatrics and neonatology MDT (n = 10 hospitals, n = 246)	1. Latent risks (NPSA recommendations)	Prospective observational Quality assessment: moderate (3e)
<b>March 2013</b> [56] (UK)	Establish the role of simulation training to test the efficacy and safety of the electronic health record	ICU Medical staff (n = 38)	1. Identification of action items and clinical trends (patient condition / medical error)	Prospective observational (3e)
<b>Mondrup 2011</b> [57] (Denmark)	CPR performance	Hospital staff (first responders)	1. CPR performance using the Laerdal PC Skill Reporting System based on established ALS guidelines	Prospective observational Quality assessment: moderate (3e)
<b>Author, date (Country)</b>	<b>Research topic</b>	<b>Setting and participants</b>	<b>Outcome methods and measures</b>	<b>Study type (JBI level of evidence)</b>

**Table 2** (continued)

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
<b>Sarfati 2015</b> [58] (France)	Prevent medication errors	Hospital Pharmacy technicians (n = 12)	1. Detection of medication errors pre and post awareness training	Prospective observational Quality assessment: moderate – good (3e)
<b>Shah 2020</b> [59] (US)	Identify LSTs assess care safety	Paediatric and neonatal ICU and ED (n = 65, 21 simulations)	1. Assess the clinical environment and identify LSTs 2. Analyse effects of educational and systems interventions 3. Determine which team factors and interventions were associated with better simulation performance	Prospective observational Quality assessment: moderate – good (3e)
<b>Schmutz 2015</b> [60] (Germany)	Task distribution and communication in emergency teams	Hospital emergency teams paediatric wards (n = 277)	1. Team behaviour 2. Clinical performance using published clinical checklists	Prospective observational Quality assessment: moderate (3e)
<b>Wheeler 2013</b> [61] (US)	Improve quality of care delivered to children with impending respiratory or cardiopulmonary arrest	PICU, CCU, OR, patient care units	1. Identification of latent safety threats 2. Participant evaluation	Prospective observational Quality assessment: moderate (3e)
<b>Zimmermann 2015</b> [62] (Switzerland)	Evaluate resuscitation training	Children's hospital, MDT (n = 95)	1. Team performance 2. LST identification	Prospective observational Quality assessment: good (3e)

ED Emergency Department, ICU Intensive Care Unit, MDT Multi Disciplinary Team, PICU Paediatric Intensive Care Unit, OR Operating Room, CCU Cardiac Intensive Care Unit

to the drill area, absence of patient family members, participant knowledge of the imminent ISS activity and training conducted during daytime hours [55, 58]. Involvement of participants without other clinical duties at a scheduled announced time may limit the generalisability of the findings [53].

ISS performance was assessed by direct observation and by accessing feedback from participants. Two studies used evidence based clinical standards to assess performance, quality and safety metrics [53, 54]. Outcome measures based on established standards were reported to be easily measurable, reproducible, and reflect clinical metrics and benchmarks. However, ISS assessment can be limited by the inability to reliably assess the impact on clinical outcomes due to the low occurrence of critical events [61], and poor sensitivity of outcome measures to assess communication skills in functional teams [57]. Most of the included studies used locally developed checklists, developed through previous pilot testing or amended from checklists developed for other clinical settings. Studies which reported team and system level assessments used established outcome measures including the Simulation Team Assessment Tool [53, 65], Anaesthetists' non-technical skills (ANTS) taxonomy and behaviour rating tool [66, 67], TeamSTEPPS Team Performance Observation Tool [60, 68].

Authors reported positive benefits of conducting ISS to identify risks and hazards in clinical environments and improve the ability to detect errors. ISS was reported to help identify system susceptibilities, evaluate the effectiveness of training programmes and highlight variability in performance across different departments and systems. Overall, authors reported positive benefits of ISS as a method of assessment, providing useful information to inform future improvement initiatives.

#### **ISS to assess and promote system readiness and safety cultures**

Nine studies conducted ISS interventions with the aim of improving system or departmental performance outcomes (Table 3). Studies were conducted in Denmark, the UK and US. All studies were observational, and data were collected via participant questionnaires, and/or direct observation (or a review of audio-visual recordings) by trained assessors or experienced clinicians. Five studies were conducted in EDs [69–73], two in operating theatres [74, 75], one in a neonatal ICU [13] and one in an obstetric unit [76]. Samples sizes (where reported) ranged from 14 to 289 participants. ISS interventions varied from single training sessions to regular training sessions over a period of months. All studies included participants from multi professional healthcare teams. Studies reported ISS was used as a way to assess, prepare

and orient staff to new facilities [70–72, 76, 77] and promote safety cultures across departments or systems [69, 73–75]. All of the studies reported improvements in readiness scores and safety attitudes outcomes.

Data were mainly collected via pre and post participant self-assessment questionnaires, outcomes included identification of LSTs, assessment of departmental readiness scores, safety cultures and attitudes, orientation and team and departmental performance. Identification of LSTs was captured via observation and via participant during ISS debriefing.

Ventre et al. [76] identified that although clinicians participated in a basic orientation to the new space, ISS provided additional opportunity to evaluate whether the electronic and information systems, equipment and devices performed adequately before opening. Kobayashi et al. [72] conducted ISS when a new ED was almost ready to open, yet with enough time remaining for adjustments and corrective actions on identified issues. However, ISS may assist not only in testing the new facility but also in designing the environments [78].

Three studies conducted ISS to improve safety compliance, cultures and attitudes [73–75]. Although safety and teamwork climates were reported as readily measured and amenable to improvement through ISS, it was difficult to demonstrate an association between team and safety training on patient outcomes as improved clinical outcomes are multifactorial [74], evaluating the role of team versus organisational processes can be challenging [73]. Paltved et al. [73] discussed how prolonged engagement with ISS interventions and longer follow-up periods may be required as safety attitudes do not suddenly appear but emerge over time. Jaffrey et al. [75] reported that ISS emphasises the importance of safety measures and empowers participants to make changes and implement them effectively. ISS provides both a learning and a working environment which incorporates the complexity and resources found in the clinical environment and supports knowledge transfer to actual practice [73].

#### **ISS to improve clinical skills, performance and clinical management**

Seventeen studies conducted ISS interventions with the aim of improving clinical skills, performance and clinical management (Table 4). Studies were conducted in Australia, Israel, Italy, the UK and US. Ten studies were Pre / Post observational studies which included ISS interventions, two were prospective cohort studies, two RCTs, one observational study with a control and one multi-component quality improvement project. Studies were conducted in emergency and resuscitation teams and departments [79–86], paediatric and neonatal care settings [87–89], in-patient ward settings [90–92], coronary



**Table 3** ISS to assess and promote system readiness and safety cultures

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
Abulebda 2018 [70] (US)	Assessing paediatric readiness and adherence to guidelines	ED (10 ED departments), MDT teams (n = 41)	1. Paediatric Readiness Score	Prospective observational Quality assessment – moderate (3e)
Bender 2011 [13] (US)	Improve system readiness and staff preparedness in a new NICU	Neonatal ICU (n = 148)	1. System readiness TEST-PILOT 2. Identification of LSTs 3. Staff preparedness	Prospective observational Quality assessment: moderate (3e)
Gardner 2013 [71] (Canada)	ED preparedness: LST detection, orientation, preparedness	ED (n = 55)	1. System readiness 2. Workplace satisfaction	Prospective observational Quality assessment—good (3e)
Hinde 2016 [74] (UK)	Improve safety culture of operating theatres	OR (n = 72)	1. Safety attitude questionnaire 2. Safety Climate scores 3. Teamwork scores	Prospective observational Quality assessment – moderate (3e)
Jaffry 2019 [75] (UK)	Enhance compliance with safety checklists and promote the safety culture	(n = 25)	1. Knowledge and confidence scores 2. Compliance with the WHO Surgical Safety Checklist	Prospective observational Quality assessment: moderate (3e)
Kobayashi 2006 [72] (US)	Evaluate the capacity of a new ED for emergent resuscitative processes and assist facility orientation	ED (n = 14)	1. Staff preparedness 2. Orientation scores	Prospective observational Quality assessment – moderate (3e)
Paltved 2017 [73] (Denmark)	Enhance patient safety attitudes	(n = 39)	1. Safety attitude questionnaires 2. Safety climate scores 3. Teamwork scores	Prospective observational Quality assessment: good (3e)
Patterson 2013 [69] (US)	To decrease the frequency and mitigate the effects of medical error	Paediatric ED (n = 289 / n = 151)	1. Safety climate scores 2. Teamwork climate scores	Prospective observational Quality assessment: good (3e)
Ventre 2014 [76] (US)	Evaluate operational readiness	Children's hospital obstetric unit (n = 133)	1. LST detection rate 2. Equipment checklists	Prospective observational Quality assessment: moderate—good (3e)

ED Emergency Department, ICU Intensive Care Unit, MDT Multi Disciplinary Team, PICU Paediatric Intensive Care Unit, OR Operating Room, CICU Cardiac Intensive Care Unit

care [93], an obstetric unit [94] and a mental healthcare setting [2]. Where reported, ISS interventions frequency varied from single training sessions delivered over one day to repeat ISS training lasting 18 months. The length of ISS was reported to last 30 min to 3 h. Most studies included participants as multi professional healthcare teams, with two studies including doctors and one including only nurses. Sample sizes ranged from 22–303 participants. ISS frequency, outcomes and authors' conclusions are presented in Table 5.

Some studies which involved more complex practices and clinical outcomes implemented regular ISS interventions over longer time periods. Andreatta et al. [87] conducted paediatric mock codes (resuscitation scenarios), on a monthly basis for 48 months and reported hospital survival rates improved significantly over study period. Knight et al. [84] conducted 16 paediatric ISS sessions over 18 months and reported that survival rates had improved when compared to historical controls. Other

studies reporting favourable outcomes for regular ISS training included anaphylaxis management [79], sepsis management [90] response times to hospital emergencies [91], detection of arrhythmias [81], management of medical deterioration [2, 89] and CPR performance [83, 86].

Studies which included more easily defined or isolated tasks, reported one to three ISS sessions as effective in improving: infection control practices [26]; thoracotomy procedures [93]; response times and management of PPH [94]; sedation practices [80]; and resuscitation response times [82].

#### ISS to improve non-technical skills, knowledge and comfort and confidence

Non-technical Skills (NTS) are individual and team social and cognitive skills, that support technical skills when performing complex tasks. NTS can include planning and preparation for complex tasks, situation awareness, perception of risk, decision-making, communication,

**Table 4** ISS to improve clinical skills and outcomes

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type Quality assessment (JBI level of evidence)
<b>Andreatta 2011 [87] (US)</b>	Viability and effectiveness of a simulation-based paediatric mock code program on patient outcomes, as well as residents' confidence in performing resuscitations	Children's hospital (n = 41)	1. Survival rates	Prospective observational Quality assessment – moderate (3e)
<b>Barni 2018 [79] (Italy)</b>	Improve management of anaphylaxis	Paediatric ED (n = 30)	1. Clinical management	Prospective observational Quality assessment—good (3e)
<b>Ben-Ari 2018 [80] (Israel)</b>	Improve safety practice of ED sedation	ED (n = 16)	1. Sedation performance scores	Prospective observational Quality assessment: moderate (3e)
<b>Braddock 2014 [90] (US)</b>	Improve clinical outcomes and safety culture	Inpatient units (n = 303)	1. Incidence of septic shock 2. Incidence of respiratory failure	Prospective observational Quality assessment: good (3e)
<b>Coggins 2019 [86] (Australia)</b>	Improve mechanical CPR performance	(n = 112)	1. CPR performance scores	RCT Risk of bias: moderate (1c)
<b>Generoso 2016 [91] (US)</b>	Improve nurses' responses in the first 5 min of in-hospital emergencies	(n = 147)	1. Clinical management	Prospective observational Quality assessment: moderate (3e)
<b>Gibbs 2018 [88] (US)</b>	Diagnose and correct LST to mitigate a methicillin-resistant Staphylococcus aureus outbreak	NICU (n = 99)	1. Hand hygiene 2. MRSA outbreaks	Prospective observational Quality assessment: good (3e)
<b>Hamilton 2015 [93] (US)</b>	Improving technical and interprofessional skills during an emergent simulated open thoracotomy		1. Time taken to complete procedure	Prospective observational Quality assessment: moderate (3e)
<b>Josey 2018 [85] (US)</b>	Survival rates following in-hospital cardiac arrest for hospitals more and less active in in-situ mock code training	26 Hospital sites	1. Survival rates	Prospective observational Quality assessment: good (3e)
<b>Knight 2014 [84] (UK)</b>	Improving survival to discharge and code team performance after paediatric in-hospital cardiopulmonary arrest	(n = 169 patients. CG = 123 / IG = 46)	1. Survival 2. Neurological morbidity 3. Adherence to standards	Observational with historical controls Quality assessment: moderate (3e)
<b>Kobayashi 2012 [81] (US)</b>	Determine baseline performance of ED telemetry for detecting arrhythmias and improve system performance through human factors engineering (HFE)	ED	1. Detection of ventricular tachycardia and sinus bradycardia	Prospective observational Quality assessment: moderate—good (3e)
<b>Lavelle 2017 [2] (UK)</b>	To improve management of medical deterioration	mental health settings (N = 53)	1. Incident rates	Prospective observational Quality assessment: moderate (3e)
<b>Marshall 2015 [94] (US)</b>	To improve team training for postpartum haemorrhage	Community maternity hospitals (n = 22)	1. Clinical management 2. Response times	Prospective observational Quality assessment: moderate (3e)
<b>Sleeman 2018 [92] (UK)</b>	To improve the identification and treatment of hypoglycaemia	Hospital ward	1. Number of incidents	Prospective observational (Q) Quality assessment: low—moderate (4)
<b>Steinemann 2011 [82] (US)</b>	Evaluate the impact of a team training curriculum on team communication, coordination and clinical efficacy of trauma resuscitation	ED (n = 137)	1. Resuscitation time	Prospective cohort Quality assessment: moderate – good (3e)

**Table 4** (continued)

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type Quality assessment (JBI level of evidence)
<b>Sullivan 2015 [83] (US)</b>	Improve retention of cardiopulmonary resuscitation priorities for in-hospital cardiac arrests	(n = 72)	1. Clinical management 2. Response times	RCT Risk of bias: moderate (1c)
<b>Theilen 2013 [89] (UK)</b>	Evaluate the long-term impact of ongoing regular team training on hospital response to deteriorating ward patients, patient outcome and financial implications	PICU (admissions n = 139)	1. Response times 2. Clinical management 3. Transfer times	Prospective cohort Quality assessment: moderate (3e)

ED Emergency Department, ICU Intensive Care Unit, MDT Multi Disciplinary Team, PICU Paediatric Intensive Care Unit, OR Operating Room, CCU Cardiac Intensive Care Unit

**Table 5** ISS to improve clinical skills and patient outcomes: ISS Frequency and authors conclusions

ISS approach	Author year	ISS focus	Number of ISS (length)	Summary of authors conclusions
<b>Clinical skills</b>	Coggins 2019 [86]	Mechanical CPR	3 sessions with 4 month follow-up in the CG	Providers receiving additional simulation-based training had higher retention levels of M-CPR skills
	Sullivan 2015 [83]	CPR	Every 2, 3 and 6 months	Short ISS training sessions conducted every 3 months are effective in improving timely initiation of chest compressions and defibrillation
	Ben-Ari 2018 [80]	Sedation procedures	1 session	Sedation simulation training improves several tasks related to patient safety during sedation
<b>Clinical management Response times</b>	Hamilton 2015 [93]	Open thoracotomy	3 sessions	ISS appears useful for improving team performance during simulated bedside OT
	Steinmann 2011 [82]	Trauma resuscitation	1 x 3 h (30-min scenario + 150 min debrief)	A relatively brief simulation-based curriculum can improve the teamwork and clinical performance of trauma teams
	Theilan 2013 [89]	Response to deteriorating patients	Weekly (attendance at 10 per year)	Lessons learnt during team training led to sustained improvements in the hospital response to critically deteriorating in-patients, significantly improved patient outcomes and substantial savings
	Barni 2018 [79]	Management of anaphylaxis	4 sessions over 3 months (1 h)	ISS improved the correct management of anaphylaxis and led to a higher number of patients being referred to the allergy unit for evaluation
	Sleeman 2018 [92]	Hypoglycaemia identification and treatment	Not reported	Hypoglycaemia ISS training is a positive addition in the education of healthcare professionals. ISS intervention demonstrated favourable outcomes
	Generoso 2016 [91]	Nurses' response to emergencies	1 session (30 min)	Establishing ISS is feasible and well received. This approach appears effective in increasing confidence, initiating life-saving measures, and empowering nurses to manage emergencies
	Marshall 2015 [94]	Management of Postpartum Haemorrhage	1 ISS repeated at 9–12 months	Simulation and team training significantly improved postpartum haemorrhage response times among clinically experienced community labour and delivery teams

**Table 5** (continued)

ISS approach	Author year	ISS focus	Number of ISS (length)	Summary of authors conclusions
<b>Survival rates, incidents and outcomes</b>				
	Knight 2014 [84]	Responding to paediatric cardiac arrest	16 sessions over 18 months	With implementation of Composite Resuscitation Team Training, survival to discharge after paediatric cardiopulmonary arrest improved, as did code team performance
	Braddock 2014 [90]	Safety culture and outcomes	4 sessions per month	A multifaceted patient safety program suggested an association with improved hospital acquired complications and weighted, risk-adjusted mortality, and improved nurses' perceptions of safety culture on inpatient study units
	Andreatta 2011 [87]	Resuscitation outcomes	Monthly over 48 months	Simulation-based mock code program may significantly benefit paediatric patient outcomes
	Gibbs 2018 [88]	Mitigate a MRSA outbreak	1 session (30 min)	ISS can counter threats to patient safety related to workflow and lapses in infection control practices and improve patient outcomes
	Lavelle 2017 [2]	Manage deteriorating patient	Weekly sessions	ISS for medical deterioration yielded promising outcomes for individuals and teams
	Josey 2018 [85]	Cardiac arrest survival	Not reported	Hospitals with more active ISS participation had higher survival rates than hospitals with less-active ISS participation although the findings should be considered with caution due to the limitations in collecting hospital level data and potential bias from other confounding factors
Use of equipment	Kobayashi [81]	Telemetry for detecting arrhythmias	50 sessions over x 3 2-week periods	Experimental investigations helped reveal and mitigate weaknesses in an ED clinical telemetry system implementation



teamwork and leadership [95]. Twenty-seven studies reported ISS interventions to improve NTS, participant comfort and confidence (Table 6). Studies were conducted in Australia, Canada, Denmark, France, the UK and US. Sixteen studies were observational; there was one prospective cohort study, five RCTs, and five quasi-experimental studies. Studies were conducted in adult and paediatric emergency and resuscitation teams and departments [69, 71, 82, 96–105], paediatric and neonatal care [106–112], obstetric care [24, 113–115], ICU [116, 117], a post anaesthesia care unit [118] and a mental healthcare setting [2]. Where reported, ISS interventions were delivered over periods of one day to 18 months, with training lasting from 30 min to 3 h. Reported sample sizes ranged from 20–750 participants.

Outcome measures included self-reported confidence scores, performance scores, management and leadership scores, communication, and self-reported anxiety and knowledge. Outcome measures, ISS frequency and outcomes scores are presented in Table 7.

- Significant improvements in confidence scores were reported for single session [96, 98, 111, 114], three session [112, 117] or regular departmental training [2].
- Improvements in participants' performance scores were reported in six studies [24, 71, 96, 104, 108, 113], with most studies conducting a single ISS intervention.
- Two studies reported significant improvements in participants management and leadership scores following a single session [111] and three session ISS intervention [112].
- Two studies [71, 118] reported an improvement in communication scores following 1–3 ISS interventions.
- Two studies reported significant improvement in anxiety scores following a single ISS intervention [104, 111].
- Four studies reported a significant improvement in participants knowledge scores following a brief ISS intervention [2, 101, 113, 115].

Rubio-Gurung et al. [24] compared a four-hour ISS intervention to improve neonatal resuscitation across maternity units with control groups ( $n=12$ , 6 units in each group). The median technical score was significantly higher for the ISS groups compared to the control groups. In the ISS groups, the frequency of achieving a heart rate of 90 per minute at 3 min improved significantly and the number of hazardous events decreased significantly. Four studies which compared ISS groups with control or comparison groups

reported no statistical significant difference in outcomes: Gundrosen et al. [28] compared nurses one hour lecture-based training with ISS training on participants situational awareness and team working (ANTS taxonomy); Crofts et al. [115] compared a ISS intervention for obstetric emergency management with training conducted in a simulation centre; Villemure et al. [118] compared ISS in post anaesthetic care units with a control group (no particular interprofessional education); Dowson et al. [112] compared regular ISS training to improve nurses' clinical confidence in the management of paediatric emergencies with a control group (mandatory resuscitation training).

### ISS settings and methods

Studies conducted ISS interventions in in-patient care settings, predominantly in adult and paediatric EDs, obstetric/maternity units, cardiac response teams, adult and paediatric ICUs, and operating rooms. Data collection methods included direct observation, video review and data collected from simulation or clinical equipment. Participants' knowledge, anxiety, comfort and safety attitudes were exclusively measured by self-reported questionnaires. There was a range of methods between and within studies to measure task performance, clinical management, teamwork and communication (including assessment from direct or video observation), alongside participants' self-reported outcomes and /or clinical outcomes data.

Studies used various tools to assess performance during ISS interventions including:

- Teamwork and non-technical skills: Simulation Team Assessment Tool STAT [65], NONTECHS [119], Anaesthetists' non-technical skills (ANTS) taxonomy and behaviour rating tool [67], Team-STEPPS [68], TeamMonitor [120], Clinical Teamwork Scale [121], Team Emergency Assessment Measure (TEAM) [122]
- Readiness scores: TESTPILOT [78], Emergency Medical Services for Children Readiness Survey [123]
- Clinical performance: Clinical performance during Paediatric Advanced Life Support simulation scenarios [124], Self-Efficacy in Clinical Performance scale [125]
- Confidence scale [126]
- Communication and collaboration [127]

The benefits and limitations of conducting ISS reported across all included studies are summarised in Table 8.

**Table 6** ISS to improve non-technical skills, knowledge and comfort and confidence

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
<b>Allan 2010</b> [111] (US)	Improving caregiver comfort and confidence levels regarding future resuscitation events	ICU (n = 182)	1. Function as a team member / leader 2. Confidence 3. Anxiety 4. Preparedness to alert team leader	Prospective observational <i>Quality assessment – moderate – good (3e)</i>
<b>Bayouth 2018</b> [106] (US)	To identify targets for educational intervention and increase provider experience of paediatric trauma simulations		1. Comfort scores 2. Performance scores	Prospective observational <i>Quality assessment – moderate – good (3e)</i>
<b>Boyde 2018</b> [104] (Australia)	To implement and evaluate an innovative simulation experience for registered nurses	(n = 50)	1. Anxiety 2. Clinical performance	Prospective observational <i>Quality assessment: moderate (3e)</i>
<b>Cepeda 2017</b> [97] (US)	Improve provider proficiency and confidence in the performance of neonatal resuscitation with a focus on chest compression effectiveness	(n = 25)	1. Confidence scores 2. Proficiency scores	Quasi-experimental <i>Quality assessment – moderate (2d)</i>
<b>Crofts 2007</b> [115] (UK)	To explore the effect of obstetric emergency training on knowledge. To assess if acquisition of knowledge is influenced by the training setting or teamwork training	Maternity unit (n = 140)	1. Knowledge scores	RCT <i>Risk of bias: moderate (1c)</i>
<b>Davison 2017</b> [98] (Australia)	Orientate staff prior to opening a new paediatric emergency service	ED (n = 89)	1. Confidence scores 2. Orientation scores	Prospective observational <i>Quality assessment – moderate (3e)</i>
<b>Dowson 2013</b> [112] (UK)	Improve the management of paediatric emergencies improves qualified nurses' clinical confidence	(n = 20)	1. Technical scores 2. Non-technical scores 3. Management scores 4. Confidence scores	Quasi-experimental <i>Quality assessment – good (2d)</i>
<b>Freund 2019</b> [105] (Denmark)	Perception of learning and stress comparing announced and unannounced ISS	ED / Trauma (n = 130)	1. Learning scores 2. Stress scores 3. Unpleasantness scores 4. Anxiety scores	Quasi-experimental <i>Quality assessment – moderate – good (2d)</i>
<b>Author, date (Country)</b>	<b>Research topic</b>	<b>Setting and participants</b>	<b>Outcome methods and measures</b>	
<b>Gardner 2013</b> [71] (US)	To identify if ISS can impact important employee perceptions and attitudes in a new facility	ED (n = 55)	1. Communication scores 2. Self-efficacy 3. Performance beliefs	Prospective observational <i>Quality assessment – good (3e)</i>
<b>Gundrosen 2014</b> [116] (Norway)	To assess the feasibility of ISS and assessing non-technical skills	ICU (n = 72)	1. Knowledge and confidence scores 2. Compliance with the WHO Surgical Safety Checklist	Feasibility RCT <i>Risk of bias: moderate (1c)</i>
<b>Katznelson 2014</b> [99] (US)	ISS to increase provider comfort with seriously ill children	ED (n = 69)	1. Comfort scores	Prospective observational <i>Quality assessment – moderate (3e)</i>
<b>Katznelson 2018</b> [100] (US)	In-situ paediatric simulation in on care team performance during resuscitation scenarios	Hospital (hospital n = 5)	1. Performance scores	Prospective observational <i>Quality assessment – good (3e)</i>

**Table 6** (continued)

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
<b>Kurosawa 2014</b> [108] (US)	Feasibility and effectiveness of ISS Paediatric Advanced Life Support training for recertification	Paediatric (n = 40)	1. Clinical performance scores 2. Behavioural scores	RCT Risk of bias: moderate (1c)
<b>Lavelle 2017</b> [2] (UK)	To improve management of medical deterioration in mental health settings	Mental Health Settings (n = 53)	1. Knowledge 2. Confidence 3. Attitudes	Prospective observational Quality assessment: moderate (3e)
<b>Nickerson 2019</b> [113] (US)	Improve knowledge, confidence, and clinical skills in performing manoeuvres to reduce a shoulder dystocia and neonatal resuscitation	ED (n = 52)	1. Knowledge 2. Confidence 3. Clinical skills	Prospective observational Quality assessment: moderate (3e)
<b>Nunnink 2009</b> [117] (Australia)	Evaluate the impact on knowledge and confidence of team-based chest reopen training using a patient simulator	ICU (n = 49)	1. Knowledge scores 2. Confidence scores	Quasi-experimental Quality assessment: good (2a)
<b>Patterson 2013</b> [69] (US)	To decrease the frequency and mitigate the effects of medical error	Paediatric ED (n = 289 / n = 151)	1. Knowledge scores	Prospective observational Quality assessment: good (3e)
<b>Patterson 2013b</b> [101] (US)	Promote identification of LSTs and systems issues at a higher rate than seen in the simulation lab setting	ED (n = 218)	1. Perceived value 2. perceived impact 3. Non-technical skills	Prospective observational Quality assessment: moderate—good (3e)
<b>Rubio-Gurung 2014</b> [24] (France)	Improve neonatal resuscitation performed by the staff at maternities	Maternity unit (n = 49)	1. Technical scores 2. Performance scores	RCT Risk of bias: moderate (1c)
<b>Author, date (Country)</b>	<b>Research topic</b>	<b>Setting and participants</b>	<b>Outcome methods and measures</b>	
<b>Sage-Rockoff 2019</b> [96] (US)	Improve nurse's competence and self-efficacy in paediatric resuscitation scenarios using a low-fidelity simulation	(n = 43)	1. Confidence scores 2. Performance scores	Prospective observational Quality assessment: good (3e)
<b>Siegel 2015</b> [102] (US)	Investigation of Emergency Department Procedural Sedation (EDPS) testing an informatics system	ED (n = 24)	1. Situational awareness scores	RCT Risk of bias: low—moderate (1c)
<b>Steinemann 2011</b> [82] (US)	Evaluate the impact of a team training curriculum on team communication, coordination and clinical efficacy of trauma resuscitation	ED (n = 137)	1. NONTECHS (non-technical skills) scores	Prospective cohort Quality assessment: moderate—good (3e)
<b>Stocker 2012</b> [109] (UK)	To evaluate the impact of ISS on perceived performance	PICU (n = 219)	1. Perceived impact 2. Non-technical skills scores 3. Technical skills 4. Confidence	Prospective observational Quality assessment: moderate—good (3e)
<b>Surcouf 2013</b> [114] (US)	Improve residents' self-confidence and observed performance of adopted best practices in neonatal resuscitation	(n = 27)	1. Self-confidence scores 2. Performance scores	Prospective cohort Quality assessment: moderate—good (3e)
<b>Van Schaik 2011</b> [103] (US)	Interprofessional team training in Paediatric resuscitation to enhance self-efficacy among participants	Paediatric	1. Confidence scores	Prospective observational Quality assessment: moderate—good (3e)

**Table 6** (continued)

Author, date (Country)	Research topic	Setting and participants	Outcome methods and measures	Study type (JBI level of evidence)
Villemure 2019 [118] (Canada)	ISS training on interprofessional collaboration during crisis event management in post-anaesthesia care	Post anaesthesia care unit	1. Collaboration scores 2. Communication scores	Quasi-experimental Quality assessment: good (2a)
Von Arx 2010 [110] (US)	Improving participant comfort and subjective knowledge of paediatric codes	(n = 27)	1. Comfort scores 2. Knowledge scores	Prospective observational Quality assessment: moderate (3e)

ED Emergency Department, ICU Intensive Care Unit, MDT Multi Disciplinary Team, PICU Paediatric Intensive Care Unit, OR Operating Room, CICU Cardiac Intensive Care Unit

**Table 7** Confidence, performance, management, communication, anxiety and knowledge scores reported in the included studies

Confidence scores			
	Pre Mean Scores (SD)	Post Mean Scores (SD)	Significance
<b>Davison 2017</b> [98] 1 × ISS (n = 89) <i>Study specific questionnaire</i>	28.8 (6.3)	30.8 (4.6)	< 0.001
<b>Allan 2010</b> [111] 1 × ISS (n = 182) <i>Study specific questionnaire</i>	Pre v Post		< 0.001
<b>Lavelle 2017</b> [2] Regular weekly ISS (n = 53) <i>Study specific questionnaire</i>	3.6 (0.9)	4.1 (0.9)	< 0.001
<b>Nickerson 2019</b> [113] 1 × 15 min ISS (n = 23) <i>Study specific questionnaire</i>	1.4	2.8	NR
<b>Saqe-Rockoff 2019</b> [96] 1 × ISS (n = 43) <i>C-Scale (Grundy 1993)</i>	2.5 (0.8)	3.9 (0.6)	< 0.001
<b>Surcouf 2013</b> [114] 1 × ISS (n = 27) <i>Study specific questionnaire</i>	2.53 (0.46)	2.92 (0.56)	< 0.001
<b>Van Schaik 2011</b> [103] Regular interprofessional team training (monthly – quarterly) <i>Study specific questionnaire</i>	Basic PGY 1/2/3	Basic PGY 1/2/3	0.301
	3.59 (0.56)	3.73 (0.6)	0.110
	4.08 (0.44)	3.97 (0.44)	0.156
	4.12 (0.5)	4.36 (0.37)	0.011
	Advanced PGY1/2/3	Advanced PGY1/2/3	
	2.35 (0.6)	2.52 (0.67)	
	2.81 (0.6)	2.68 (0.6)	
	2.71 (0.52)	3.17 (0.51)	
	Expert PGY1/2/3	Expert PGY1/2/3	
	1.5 (0.76)	1.75 (0.71)	
	1.73 (0.82)	1.54 (0.8)	
	1.44 (0.57)	1.95 (0.84)	
	Leadership PGY1/2/3	Leadership PGY1/2/3	
	1.88 (0.79)	2.32 (0.88)	
2.77 (0.62)	2.84 (0.61)		
3.06 (0.91)	3.57 (0.62)		
<b>Dowson 2013</b> [112] IG 3 × ISS (n = 20) <i>Clinical Confidence Rating Scale</i> [108]	Month 1	Month 3	NS
	CG 57.8 (10.7)	CG 60 (10)	< 0.001
	Month 1	Month 3	
	IG 47.3 (6.68)	IG 56.6 (7)	
<b>Nunnink 2009</b> [117] 3 × ISS and 2 × video training (n = 49) <i>Study specific questionnaire</i>	ISS 9 (4.3)	ISS 12.9 (3.6)	0.001
	Video 11.2 (3.8)	Video 12.4 (4.1)	0.03
<b>Performance scores</b>			
<b>Gardner 2013</b> [71] 1 × ISS <i>Study specific questionnaire</i>	3.72 (0.53)	3.52 (0.7)	< 0.001
<b>Nickerson 2019</b> [113] 1 × ISS 15 min (n = 23) <i>Study specific questionnaire</i>	67%	86%	Not reported
	62%	89%	
<b>Saqe-Rockoff 2019</b> [96] 1 × ISS (n = 43) <i>Clinical Performance Tool (Donoghue et al. 2010)</i>	5.3 (0.9)	9.2 (0.6)	0.004
<b>Boyd 2018</b> [104] 1 × ISS (n = 50) <i>Self-Efficacy in Clinical Performance scale (Munroe et al., 2015)</i>	165.15 (28.1)	214.12 (26)	< 0.001
<b>Rubio-Gurung 2014</b> [24] IG 1 × 4-h ISS training session (n = 120) <i>Team Emergency Assessment Measure (TEAM) (Cooper et al. 2010)</i>	CG post	IG post	0.001
	Median 6.7 (3.4–8.3)	Median 19.9 (13.3–25)	
<b>Kurosawa 2014</b> [108] 6 × ISS (n = 40) <i>Validated Clinical Performance Tool</i>	CG post 14.9 (4.4)	IG post 22.4 (3.9)	0.001
<b>Management and leadership scores</b>			
<b>Allan 2010</b> [111] 1 × ISS (one component of improvement project) (n = 182) <i>Study specific questionnaire</i>	NR	NR	< 0.001
<b>Dowson 2013</b> [112] IG 3 × ISS training (n = 20) <i>Clinical Confidence Rating Scale</i>	Month 1	Month 3	NS
	CG 2.9 (0.57)	CG 2 (0.7)	< 0.05
	Month 1	Month 3	
	IG 2.2 (0.42)	IG 2.8 (0.4)	
<b>Communication scores</b>			
<b>Gardner 2013</b> [71] at least 1 × ISS <i>Questionnaire developed by O'Neill et al. (1994)</i>	3.64 (0.64)	3.82 (0.6)	< 0.05
<b>Villemure 2019</b> [118] IG 6 h training: including 3 × ISS scenarios 30 min each <i>Work Collaborative Questionnaire (Chiocchio et al. 2012)</i>		CG 5.27 (0.95)	NS
		IG 4.9 (0.91)	
<b>Anxiety scores</b>			
<b>Allan 2010</b> [111] 1 × ISS as one component of improvement project (n = 182) <i>Study specific questionnaire</i>	Pre / Post		< 0.001
<b>Boyd 2018</b> [104] 1 × ISS (n = 50) <i>State-Trait Anxiety Inventory (STAI) Anxiety State (Spielberger et al. 1983)</i>	38.56 (9.87)	33.54 (9)	< 0.001



**Table 7** (continued)

<b>Knowledge scores</b>			
<b>Crofts 2007</b> [115] Single ISS (comparing in situ <i>n</i> = 64, with simulation centre training <i>n</i> = 69, without and without teamwork training) <i>Study specific questionnaire</i>	In situ pre 81.5 (21.3) Simulation centre pre 79.4 (22.1)	In situ post 101.5 (21.5) Simulation centre post 100.5 (21.1)	NS difference between ISS and sim centre
<b>Lavelle 2017</b> [2] Regular weekly ISS ( <i>n</i> = 53) <i>Study specific questionnaire</i>	38.6 (19.3)	53 (16)	< 0.001
<b>Nickerson 2019</b> [113] 1 × 15 min ISS <i>Study specific questionnaire</i>	57%	72%	Not reported
<b>Patterson 2013b</b> [101] 2 day education intervention with ISS ( <i>n</i> = 289), re-evaluation at 10 months ( <i>n</i> -151) <i>Study specific questionnaire</i>	86% (SD 9.8%)	96% (SD 5.8%) Re-evaluation 93% (SD 7.3%)	< 0.001

NR Not Reported, NS Not Significant, IG Intervention Group, CG Control Group, SD Standard Deviation

**Table 8** Benefits and limitations of ISS reported in the included studies

<b>Benefits</b>	<b>Limitations</b>
Realism: Real setting enabling teams to perform with actual equipment and resources Locate and test equipment Facilitates safe transitions to new facilities	Possibility of selection bias / lack of randomisation of participants Releasing participants from other clinical duties while undertaking ISS may limit generalisability to the clinical setting Possibility of training effect for pre-announced ISS: enabling participants to prepare (as opposed to unannounced ISS) Observers and video reviewers are unblinded to the type of participant and setting Lack of usual clinical distractions and lack of assessment over the full 24-h period may limit generalisability High cancellation rate in high acuity areas Fidelity issues in key components of task completion (lack of adequate visual cues regarding patient output, monitor function and appearance)
Scenarios can be rated independently by numerous assessors	Small sample sizes and inadequately powered studies prevents formal statistical analysis Problems with recruitment Use of non-validated assessment tools
Some tasks are capable of high fidelity and reproducibility	Confounding factors: unable to capture all of the complex all factors which contribute to outcomes in a changing climate of practice Inadequate collection of participant demographic data which may impact the findings (e.g., number of shifts worked or days off before the data collection, participation in more than one scenario, prior simulation training)
Assessment of tasks with clearly defined and established standards	Potential 'refresher effect' if participants repeatedly engage in ISS simulations Efforts to standardise ISS activities may limit including variation between scenarios and tasks Evaluation of ISS assessment in one setting reduces generalisability to the wider context
Identified opportunities for improvement in the clinical setting	Lack of formal measures to translate the findings into practice and inform action plans
Enables more team members to participate compared to off-site training	Variation in teams when evaluating pre / post assessments over longer follow-up periods Measuring communication in an established team maybe difficult as the need for communication decreases Lack of availability of experienced non-technical skills assessors Maintaining participant anonymity in smaller sites / studies Performance anxiety, reluctance to participate

**Discussion**

This systematic mapping review found that ISS is reported to be feasible and beneficial in a variety of

inpatient clinical settings. It is used to assess a number of different domains of practice including adherence to clinical guidelines and standards, task completion times,

team performance, non-technical skills, detection of errors and latent safety threats.

Lamé and Dixon-Woods [128] make an important distinction between research which is conducted about simulation and research conducted through simulation. The findings from this review include both of these approaches, which at times overlap, studied through various experimental designs. Research conducted about ISS (where ISS was an active intervention) included studies exploring acceptability and usefulness of ISS to clinicians and educators and evaluating the ability of ISS to identify LSTs and improve individual, team and system-level outcomes. Research conducted through ISS often included ISS as part of a multicomponent approach to improve clinical skills, performance and outcomes.

ISS outcomes were used to highlight where additional or new methods of training might be required to improve the quality of care, to identify LSTs and explore the accuracy and efficiency of task completion over the period of a working shift. Exploring the factors that can affect variations in adherence to clinical procedures, outcomes and performance may help to uncover where and why errors occur. ISS has the potential to reveal the constraining and facilitating mechanisms which impact performance and to identify modifiable factors at the individual, departmental, institutional level or system level [52–54].

Some multicentre studies were conducted to assess clinical performance used validated tools to assess adherence to guidelines and departmental readiness scores. The ability to standardise simulation across participating sites can help isolate independent variables and to reduce the risk of bias introduced by variations in local contexts [129]. Differences in performance can be explored between sites and be used to generate theory about why differences may occur. For example, Auerbach et al. [53] used ISS to explore hospital characteristics to adherence to paediatric cardiac arrest guidelines across four paediatric EDs. ISS outcomes based on clinical standards can serve as a proxy for real performance, enhancing the external validity of the study findings [54].

There were considerable variations in the frequency of ISS sessions, length of ISS sessions and use of announced and unannounced ISS. However the length and frequency of ISS were not always reported. Studies which are focused on relatively straightforward, easily defined or isolated tasks, see improved outcomes after one to three ISS sessions [80, 82, 88, 93, 94]. Studies involving more complex practices or outcomes seem to require interventions over longer time periods [2, 79, 84, 87]. This may indicate a potential benefit of ISS to support complex skills acquisition through behavioural learning strategies, where skills are developed through repetition and behaviour change occurs through feedback from the

simulation activity, interaction between the task, environment, and the team.

Most of the studies included in the review used locally developed checklists, developed through previous pilot testing or amended from checklists developed for other clinical settings. In general, there was a paucity of reporting of the validity and reliability of assessment measures and tools. Studies which reported team and system level assessments adopted more established outcome measures [65, 67, 68, 120, 121, 123]. Measurement methods for assessing individual competencies involved in complex care processes are less well-defined, and further complicated when individual performance needs to be isolated from the wider team. Concepts such as ‘effective communication’ are subject to interpretation and clinical outcomes may be attributed to concepts such as teamwork, communication and leadership in addition to clinical skills and knowledge [30]. Griswold et al. [29] identify that for clinical procedures with clear chains of action and well-defined processes and standards, summative ISS assessment is much simpler than in more “dynamic, multifactorial practices in which cognitive, procedural, and communication skills are simultaneously applied in a team environment” (Griswold et al. 2017, page 170). Criterion standards and benchmarks of quality performance need to be further developed to reliably and accurately capture the individual performance which is linked to relevant clinical competencies.

Goldstein et al. [130] stated that literature reporting ISS interventions on patient outcomes is scarce. Surrogate endpoints, such as response times are frequently adopted but this does not truly represent the complex factors that lead to improved patient outcomes [130]. In this review, ISS was often incorporated within larger, multi-component educational improvement projects. Most studies were observational with only thirteen adopting experimental designs. Small, observational studies are often limited by the potential for introducing selection bias, observer bias and confounding. Lamé & Dixon-Woods [128] state that ISS which can reproduce situations identically before and after the intervention increases confidence that the intervention can explain the variation in outcomes. Time-series designs which collect data at multiple times before and after the intervention or controlled studies are required to provide greater confidence in the findings of ISS interventions [128].

Unannounced ISS (or mock drills) were mainly conducted where studies sought to carry out a system audit or to assess clinical performance against a benchmark. Whereas announced ISS, which gave participants varying levels of notice and access to supportive resources, were mainly conducted as part of improvement projects or as part of clinical training. Posner et al. [32] highlight

that both announced and unannounced ISS approaches can be conducted to detect LSTs, although assessment of factors such as response times and leadership assignment are more suited to unannounced ISS [55, 58]. Freund et al. [105] compared unannounced to announced (one hour prior to ISS) team training and reported no significant differences on self-perceived learning and self-reported stress outcomes. It is reported that ISS can pose numerous threats to an individual's psychological safety which can have a negative effect on learning. Participants may feel under increased scrutiny from colleagues or burdened by their other clinical work. Psychological safety can be supported by including a pre-simulation brief to discuss training objectives, expectations and develop trust between educators and learners [32, 131, 132].

Cheng et al. [129] recommend an extension to the CONSORT guidelines for reporting simulation-based research to include demographics and clinical characteristics of participants and the setting. This should include participants' previous experience with simulation, skill mix, staffing, capacity pressures and other relevant features to facilitate an assessment of the external validity of the findings [53]. A review by Goldshtein et al. [130] reported that it was difficult to assess who was participating in ISS and their prior experience of ISS participation. Lipman et al. [53] reported that clinical timings evaluated in their study may have been underestimated due to participation of highly skilled teams, the close proximity of clinical departments and participants to the drill area, absence of patient family members, participant knowledge of the imminent ISS activity and the daytime hours [55]. In future studies, detailed information on other potential sources of bias and other confounding, contextual and system level factors should be presented to assist researchers, educators and clinicians to assess the relevance of the findings to other settings and participant groups [129].

ISS to assist teams train, rehearse and practice for low frequency, high impact events were frequently reported simulation activities in the review. The theoretical base for ISS as a training intervention was not reported in many studies, however ISS as a training intervention maps to the concepts within cognitive learning approaches where participants' preconceptions are explored, and new or unexpected events are presented via the simulation activity to challenge precognitions [133]. ISS is also underpinned by situativity theory, in which knowledge transfer is considered optimal when the learning environment matches the environment in which it will be applied [28, 131, 134]. During the Covid-19 pandemic, ISS has been used to help staff prepare for emerging challenges. ISS interventions have helped to identify LSTs, highlight inadequacies in guidelines and

protocols policies, improve the correct use of PPE, and orientate staff to newly established Covid-19 intensive care unit and wards [135, 136].

### Study strengths and limitations

This review should be viewed in light of several limitations. This review did not include grey literature, conference abstracts and academic theses. It is likely that grey literature may include ISS practice-based improvement and educational projects which further illustrate the current uses of ISS in healthcare settings. However, this review highlights the lack of rigorous intervention ISS research and the urgent need to increase research output and methodological quality. The mapping review aimed to provide an overview of the broad ISS published literature and did not conduct in-depth analysis of study outcomes to enable meaningful comparisons. The review has highlighted different categories and approaches to ISS, identifying common outcomes measures and measurement tools. Mapping reviews are distinguished by the presentation of the data in a digestible format and assessment of whether the total population of studies is similar enough to undertake a coherent synthesis of the current data [36]. Therefore, this review may provide a useful starting point for other researchers seeking to develop and define parameters for future ISS systematic reviews.

### Conclusion

This review presents an overview of the literature on ISS interventions by mapping the study objectives, methods, outcomes, barriers, and facilitators at work across different settings. The mapping review provides a useful summary for healthcare educators and researchers seeking to develop ISS strategies in healthcare settings. Additionally, it highlights important evidence gaps, including the need to (1) identify appropriate tasks capable of standardisation and reproducibility in ISS assessment scenarios (2) capture adequate demographic data from participants to assess the impact on outcomes (e.g. work-patterns, skill-mix, experience, ISS experience and exposure, willingness to participate) (3) explore different methodologies in an attempt to reduce bias and confounding factors (4) develop and validate sensitive data collection methods and tools to capture the complexity of team and individual performance in real settings (5) identify optimal frequency and length of time to complete ISS, considering feasibility and acceptability in the clinical setting. This systematic mapping review has provided a useful framework to navigate the expansive and diverse research literature on a relatively new and underdefined approach to ISS as a function to assess individual, team and departmental performance. There is currently a

lack of consensus for the rationale for conducting ISS interventions and well-developed studies are required to identify the potential benefits of ISS and the impacts on patient outcomes. Overall, studies reported ISS to be feasible and beneficial to address various learning and improvement objectives. The components and mechanisms employed across the included studies which have been designed to address a range of objectives can inform future design of ISS interventions to meet specific objectives.

#### Abbreviations

ISS: In-situ simulation; MDT: Multidisciplinary team; LST: Latent safety threat; PPE: Personal protective equipment; ED: Emergency Departments; ICU: Intensive Care Unit; CPR: Cardiopulmonary resuscitation.

#### Acknowledgements

Not applicable

#### Authors' contributions

Conception and design of the study (BB, KE, LB, GM, JC), data collection and analysis (KE, JW, AC, LB), initial drafting of the manuscript (BB, AR, KE, AC, JW, LB, JC), critical review of the manuscript (BB, AR, KE, AC, LB, AR, JC) and all authors provided final approval of the submitted manuscript.

#### Funding

The project was commissioned by Health Education England, Midlands and East.

#### Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

#### Declarations

##### Ethics approval and consent to participate

Not applicable.

##### Consent for publication

Not applicable as all images within the manuscript were created by the research team.

##### Competing interests

The authors declare that they have no competing interests.

#### Author details

<sup>1</sup>Nottingham University Hospitals Trust, Institute of Care Excellence, Nottingham, UK. <sup>2</sup>Birmingham Children's Hospital, Birmingham, UK. <sup>3</sup>Nottingham University Hospitals Trust, Research & Innovation, Nottingham, UK. <sup>4</sup>Trent Simulation & Clinical Skills Centre, Nottingham University Hospitals NHS Trust, Nottingham, Notts, UK. <sup>5</sup>Glasgow Dental School, University of Glasgow, Glasgow, UK.

Received: 18 December 2021 Accepted: 8 April 2022

Published online: 11 July 2022

#### References

- Kelsey NC, Claus S. Embedded, in situ simulation improves ability to rescue. *Clin Simul Nurs*. 2016;12(11):522–7.
- Lavelle M, Attoe C, Tritschler C, Cross S. Managing medical emergencies in mental health settings using an interprofessional in-situ simulation training programme: a mixed methods evaluation study. *Nurse Educ Today*. 2017;59:103–9.
- Kurup V, Matei V, Ray J. Role of in-situ simulation for training in healthcare: opportunities and challenges. *Curr Opin Anaesthesiol*. 2017;30(6):755–60.
- Guise J-M, Madenovic J. In situ simulation: identification of systems issues. *Semin Perinatol*. 2013;37(3):161–5.
- Pucher PH, Tamblyn R, Boorman D, Dixon-Woods M, Donaldson L, Draycott T, Forster A, Nadkarni V, Power C, Sevdalis N, et al. Simulation research to enhance patient safety and outcomes: recommendations of the Simnovate Patient Safety Domain Group. *BMJ Simul Technol Enhanc Learn*. 2017;3(Suppl 1):S3–7.
- Commission on Education and Training for Patient Safety: Improving Safety Through Education and Training. In: Health Education England; 2016.
- Simms ER, Slakey DP, Garstka ME, Tersigni SA, Korndorffer JR. Can simulation improve the traditional method of root cause analysis: a preliminary investigation. *Surgery*. 2012;152(3):489–97.
- Slakey DP, Simms ER, Rennie KV, Garstka ME, Korndorffer JR Jr. Using simulation to improve root cause analysis of adverse surgical outcomes. *Int J Qual Health Care*. 2014;26(2):144–50.
- Yajamanyam PK, Sohi D. In situ simulation as a quality improvement initiative. *Arch Dis Child Educ Pract Ed*. 2015;100(3):162.
- Patterson MD, Blike GT, VM N. In Situ Simulation: Challenges and Results. In: *Advances in Patient Safety: New Directions and Alternative Approaches*. Volume 3, edn. Edited by Henriksen K, Battles JB, Keyes MA, et al. Rockville, US: Agency for Healthcare Research and Quality; 2008.
- Uttley E, Suggitt D, Baxter D, Jafar W. Multiprofessional in situ simulation is an effective method of identifying latent patient safety threats on the gastroenterology ward. *Frontline Gastroenterol*. 2020;11(5):351.
- Holden RJ, Carayon P, Gurses AP, Hoonakker P, Hundt AS, Ozok AA, Rivera-Rodriguez AJ. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics*. 2013;56(11):1669–86.
- Bender GJ. In situ simulation for systems testing in newly constructed perinatal facilities. *Semin Perinatol*. 2011;35(2):80–3.
- Medwid K, Smith S, Gang M. Use of in-situ simulation to investigate latent safety threats prior to opening a new emergency department. *Safety Sci*. 2015;77:19–24.
- Chen PP, Tsui NT, Fung AS, Chiu AH, Wong WC, Leong HT, Lee PS, Lau JY. In-situ medical simulation for pre-implementation testing of clinical service in a regional hospital in Hong Kong. *Hong Kong Med J*. 2017;23(4):404–10.
- Combes J: 0121 Sequence simulation 'the hyper acute stroke thrombolysis pathway. *BMJ Simul Technol Enhanc Learn* 2015;1.
- Lefroy J, Yardley S. Embracing complexity theory can clarify best practice frameworks for simulation education. *Med Educ*. 2015;49(4):344–6.
- Macrae C, Draycott T. Delivering high reliability in maternity care: in situ simulation as a source of organisational resilience. *Safety Sci*. 2016;117:490–500.
- Choi GYS, Wan WTP, Chan AKM, Tong SK, Poon ST, Joynt GM. Preparedness for COVID-19: in situ simulation to enhance infection control systems in the intensive care unit. *Br J Anaesth*. 2020;125(2):e236–9.
- Fregene TE, Nadarajah P, Buckley JF, Bigham S, Nangalia V. Use of in situ simulation to evaluate the operational readiness of a high-consequence infectious disease intensive care unit. *Anaesthesia*. 2020;75(6):733–8.
- Dharamsi A, Hayman K, Yi S, Chow R, Yee C, Gaylord E, Tawadrous D, Chartier LB, Landes M. Enhancing departmental preparedness for COVID-19 using rapid-cycle in-situ simulation. *J Hosp Infect*. 2020;105(4):604–7.
- Lie SA, Wong LT, Chee M, Chong SY. Process-oriented In Situ simulation is a valuable tool to rapidly ensure operating room preparedness for COVID-19 outbreak. *Simul Healthc*. 2020;15(4):225.
- Muret-Wagstaff SL, Collins JS, Mashman DL, Patel SG, Pettorini K, Rosen SA, Shaffer VO, Sumler ML, Sweeney JF, Sharma J. In Situ simulation enables operating room agility in the COVID-19 pandemic. *Ann Surg*. 2020;272(2):e148–50.
- Rubio-Gurung S, Putet G, Touzet S, Gauthier-Moulinier H, Jordan I, Beissel A, Labaune JM, Blanc S, Amamma N, Balandras C, et al. In situ simulation training for neonatal resuscitation: an RCT. *Pediatrics*. 2014;134(3):e790-797.

25. Boet S, Bould MD, Fung L, Qosa H, Perrier L, Tavares W, Reeves S, Tricco AC. Transfer of learning and patient outcome in simulated crisis resource management: a systematic review. *Can J Anaesth*. 2014;61(6):571–82.
26. Gibbs K. A Novel In Situ Simulation intervention used to mitigate an outbreak of Methicillin-Resistant Staphylococcus aureus in a Neonatal Intensive Care Unit. 2018.
27. Murphy M, Curtis K, McCloughen A. What is the impact of multidisciplinary team simulation training on team performance and efficiency of patient care? An integrative review. *Australas Emerg Nurs J*. 2016;19(1):44–53.
28. Gundrosen S, Solligard E, Aadahl P. Team competence among nurses in an intensive care unit: the feasibility of in situ simulation and assessing non-technical skills. *Intensive Crit Care Nurs*. 2014;30(6):312–7.
29. Griswold S, Fralliccardi A, Boulet J, Moadel T, Franzen D, Auerbach M, Hart D, Goswami V, Hui J, Gordon JA. Simulation-based education to ensure provider competency within the health care system. *Acad Emerg Med*. 2018;25(2):168–76.
30. Brunette V, Thibodeau-Jarry N. Simulation as a tool to ensure competency and quality of care in the cardiac critical care unit. *Can J Cardiol*. 2017;33(1):119–27.
31. Pucher P, Tamblyn R, Boorman D, Dixon-Woods M, Donaldson L, Draycott T, Forster A, Nadkarni V, Power C, Sevdalis N, et al. Simulation research to enhance patient safety and outcomes: recommendations of the Simnovate Patient Safety Domain Group. *BMJ Simul Technol Enhanc Learn*. 2017;3:53–7.
32. Posner GD, Clark ML, Grant VJ. Simulation in the clinical setting: towards a standard lexicon. *Adv Simul*. 2017;2(1):15.
33. Baxendale B, Evans K, Cowley A, Bramley L, Miles G, Ross A, Dring E, Cooper J. GENESISS 1 - Generating Standards for In-Situ Simulation project: a scoping review and conceptual model. in submission 2021.
34. Sutton A, Clowes M, Preston L, Booth A. Meeting the review family: exploring review types and associated information retrieval requirements. *Health Info Libr J*. 2019;36(3):202–22.
35. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535.
36. Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J*. 2009;26(2):91–108.
37. Miake-Lye IM, Hempel S, Shanman R, Shekelle PG. What is an evidence map? A systematic review of published evidence maps and their definitions, methods, and products. *Syst Rev*. 2016;5(1):28.
38. Wolffe TAM, Whaley P, Halsall C, Rooney AA, Walker VR. Systematic evidence maps as a novel tool to support evidence-based decision-making in chemicals policy and risk management. *Environ Int*. 2019;130:104871.
39. NIH. Study Quality Assessment Tools. In: National Heart, Lung and Blood Institute. 2014.
40. Cochrane Handbook for Systematic Reviews of Interventions version 6.1 <http://www.training.cochrane.org/handbook>.
41. Critical Appraisal Tools <https://joannabriggs.org/critical-appraisal-tools>
42. CASP Checklists <https://casp-uk.net/casp-tools-checklists/>
43. Joanna Briggs Institute Reviewer's Manual <https://reviewersmanual.joannabriggs.org/>
44. Joanna Briggs Institute Levels of Evidence and Grades of Recommendation Working Party: JBI Levels of Evidence. In. University of Adelaide, Australia: Joanna Briggs Institute; 2013.
45. Auerbach M, Brown L, Whitfill T, Baird J, Abulebda K, Bhatnagar A, Lutfi R, Gawel M, Walsh B, Tay K-Y, et al. Adherence to pediatric cardiac arrest guidelines across a spectrum of fifty emergency departments: a prospective, In Situ Simulation-based Study. *Acad Emerg Med*. 2018;25(12):1396–408.
46. Calhoun AW, Boone MC, Dauer AK, Campbell DR, Montgomery VL. Using simulation to investigate the impact of hours worked on task performance in an intensive care unit. *Am J Crit Care*. 2014;23:387–95.
47. Campbell DM, Poost-Foroosh L, Pavenski K, Contreras M, Alam F, Lee J, Houston P. Simulation as a toolkit—understanding the perils of blood transfusion in a complex health care environment. *Adv Simul (Lond)*. 2016;1:32.
48. Clapper TC, Ching K, Mauer E, Gerber LM, Lee JG, Sobin B, Ciralo K, Osorio SN, DiPace JL. A Saturated Approach to the Four-Phase, Brain-Based Simulation Framework for TeamSTEPPS® in a Pediatric Medicine Unit. *Pediatr Qual Saf*. 2018;3(4):e086.
49. Härgestam M. Trauma teams and time to early management during in situ trauma team training. 2016.
50. Kessler DO, Walsh B, Whitfill T, Dudas RA, Gangadharan S, Gawel M, Brown L, Auerbach M. Disparities in Adherence to pediatric sepsis guidelines across a Spectrum of Emergency Departments: a multi-center, cross-sectional observational In Situ Simulation Study. *J Emerg Med*. 2016;50(3):403–415.e401–403.
51. Kobayashi L, Dunbar-Viveiros JA, Sheahan BA, Rezendes MH, Devine J, Cooper MR, Martin PB, Jay GD. In situ simulation comparing in-hospital first responder sudden cardiac arrest resuscitation using semiautomated defibrillators and automated external defibrillators. *Simul Healthc*. 2010;5(2):82–90.
52. Kozar E, Seto W, Verjee Z, Parshuram C, Khattak S, Koren G, Jarvis DA. Prospective observational study on the incidence of medication errors during simulated resuscitation in a paediatric emergency department. *BMJ*. 2004;329(7478):1321.
53. Lipman SS, Carvalho B, Cohen SE, Druzin ML, Daniels K. Response times for emergency cesarean delivery: use of simulation drills to assess and improve obstetric team performance. *J Perinatol*. 2013;33(4):259–63.
54. Lipman SS, Wong JY, Arafeh J, Cohen SE, Carvalho B. Transport decreases the quality of cardiopulmonary resuscitation during simulated maternal cardiac arrest. *Anesth Analg*. 2013;116(1):162–7.
55. Lok A, Peirce E, Shore H. Identifying latent risks through in situ simulation training to improve patient safety. *Arch Dis Child*. 2014;99.
56. March CA, Steiger D, Scholl G, Mohan V, Hersh WR, Gold JA. Use of simulation to assess electronic health record safety in the intensive care unit: a pilot study. *BMJ Open*. 2013;3(4):e002549.
57. Mondrup F. In-hospital resuscitation evaluated by in situ simulation: a prospective simulation study. 2011.
58. Sarfati L, Ranchon F, Vantard N, Schwiertz V, Gauthier N, He S, Kiouris E, Gourc-Berthod C, Guédat MG, Alloux C, et al. SIMMEON-Prep study: Simulation of Medication Errors in Oncology: prevention of antineoplastic preparation errors. *J Clin Pharm Ther*. 2015;40(1):55–62.
59. Shah SJ, Cusumano C, Ahmed S, Ma A, Jafri FN, Yang CJ. In Situ Simulation to assess pediatric tracheostomy care safety: a novel multi-center quality improvement program. *Otolaryngol Head Neck Surg*. 2020;163(2):250–8.
60. Schmutz J, Hoffmann F, Heimberg E, Manser T. Effective coordination in medical emergency teams: the moderating role of task type. *Eur J Work Organ Psy*. 2015;24(5):761–76.
61. Wheeler DS, Geis G, Mack EH, LeMaster T, Patterson MD. High-reliability emergency response teams in the hospital: improving quality and safety using in situ simulation training. *BMJ Qual Saf*. 2013;22(6):507–14.
62. Zimmermann K, Holzinger IB, Ganassi L, Esslinger P, Pilgrim S, Allen M, Burmester M, Stocker M. Inter-professional in-situ simulated team and resuscitation training for patient safety: description and impact of a programmatic approach. *BMC Med Educ*. 2015;15:189–189.
63. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *JBI Evidence Implementation* 2015;13(3).
64. Moher D, Liberati A, Tetzlaff J, Altman D, Group TP. Preferred reporting items for systematic reviews and metaanalyses: the PRISMA Statement. *PLoS Med*. 2009;6(7):e1000097.
65. Reid J, Stone K, Brown J, Caglar D, Kobayashi A, Lewis-Newby M, Partridge R, Seidel K, Quan L. The Simulation Team Assessment Tool (STAT): development, reliability and validation. *Resuscitation*. 2012;83(7):879–86.
66. Campbell DM, Poost-Foroosh L, Pavenski K, Contreras M, Alam F, Lee J, Houston P. Simulation as a toolkit—understanding the perils of blood transfusion in a complex health care environment. *Adv Simul*. 2016;1(1):32.
67. Flin R, Patey R, Glavin R, Maran N. Anaesthetists' non-technical skills. *Br J Anaesth*. 2010;105(1):38–44.
68. Internet Citation: Team Performance Observation Tool. <https://www.ahrq.gov/teamstepps/longtermcare/sitetools/tmpot.html>
69. Patterson MD, Geis GL, Falcone RA, LeMaster T, Wears RL. In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. *BMJ Qual Saf*. 2013;22(6):468.



70. Abulebda K, Lutfi R, Whitfill T, Abu-Sultaneh S, Leeper KJ, Weinstein E, Auerbach MA. A collaborative In Situ Simulation-based pediatric readiness improvement program for community emergency departments. *Acad Emerg Med*. 2018;25(2):177–85.
71. Gardner AK, Ahmed RA, George RL, Frey JA. In Situ Simulation to assess workplace attitudes and effectiveness in a new facility. *Simul Healthc*. 2013;8(6):351.
72. Kobayashi L, Shapiro MJ, Sucov A, Woolard R, Boss Iii RM, Dunbar J, Sciamacco R, Karpik K, Jay G. Portable advanced medical simulation for new emergency department testing and orientation. *Acad Emerg Med*. 2006;13(6):691–5.
73. Paltved C, Bjerregaard AT, Krogh K, Pedersen JJ, Musaeus P. Designing in situ simulation in the emergency department: evaluating safety attitudes amongst physicians and nurses. *Adv Simul (Lond)*. 2017;2:4.
74. Hinde T, Gale T, Anderson I, Roberts M, Sice P. A study to assess the influence of interprofessional point of care simulation training on safety culture in the operating theatre environment of a university teaching hospital. *J Interprof Care*. 2016;30(2):251–3.
75. Jaffry Z, Jaze P, Laws-Chapman C, Zhao J, Pontin L. Safer surgery through simulation: increasing compliance with the 5 Steps to Safer Surgery through an in-situ simulation based training programme at Guy's and St Thomas' NHS Foundation Trust. *BMJ Simul Technol Enhanc Learn*. 2019;5(4):196–7.
76. Ventre KM, Barry JS, Davis D, Baiamonte VL, Wentworth AC, Pietras M, Coughlin L, Barley G. Using in situ simulation to evaluate operational readiness of a children's hospital-based obstetrics unit. *Simul Healthc*. 2014;9(2):102–11.
77. Bender GJ, Maryman JA. Clinical macrosystem simulation translates between organizations. *Simul Healthc*. 2018;13(2):96–106.
78. Bender J, Shields R, Kennally K. Transportable enhanced simulation technologies for pre-implementation limited operations testing: neonatal intensive care unit. *Simul Healthc*. 2011;6(4):204–12.
79. Barni S, Mori F, Giovannini M, de Luca M, Novembre E. In situ simulation in the management of anaphylaxis in a pediatric emergency department. *Intern Emerg Med*. 2019;14(1):127–32.
80. Ben-Ari M, Chayen G, Steiner IP, Schinasi DA, Feldman O, Shavit I. The effect of in situ simulation training on the performance of tasks related to patient safety during sedation. *J Anesth*. 2018;32(2):300–4.
81. Kobayashi A. Use of in situ simulation and human factors engineering to assess and improve emergency department clinical systems for timely telemetry-based detection of life-threatening arrhythmias. 2012.
82. Steinemann S, Berg B, Skinner A, DiTulio A, Anzelon K, Terada K, Oliver C, Ho HC, Speck C. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. *J Surg Educ*. 2011;68(6):472–7.
83. Sullivan NJ, Duval-Arnould J, Twilley M, Smith SP, Aksamit D, Boone-Guercio P, Jeffries PR, Hunt EA. Simulation exercise to improve retention of cardiopulmonary resuscitation priorities for in-hospital cardiac arrests: a randomized controlled trial. *Resuscitation*. 2015;86:6–13.
84. Knight LJ, Gabhart JM, Earnest KS, Leong KM, Anglemeyer A, Franzon D. Improving code team performance and survival outcomes: implementation of pediatric resuscitation team training. *Crit Care Med*. 2014;42(2):243–51.
85. Josey K, Smith ML, Kayani AS, Young G, Kasperski MD, Farrer P, Gerkin R, Theodorou A, Raschke RA. Hospitals with more-active participation in conducting standardized in-situ mock codes have improved survival after in-hospital cardiopulmonary arrest. *Resuscitation*. 2018;133:47–52.
86. Coggins AR, Nottingham C, Byth K, Ho KR, Aulia F, Murphy M, Shetty AL, Todd A, Moore N. Randomised controlled trial of simulation-based education for mechanical cardiopulmonary resuscitation training. *Emerg Med J*. 2019;36(5):266–72.
87. Andreatta P, Saxton E, Thompson M, Annich G. Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates. *Pediatr Crit Care Med*. 2011;12(1):33–8.
88. Gibbs K, DeMaria S, McKinsey S, Fede A, Harrington A, Hutchison D, Torchen C, Levine A, Goldberg A. A novel In Situ simulation intervention used to mitigate an outbreak of methicillin-resistant *Staphylococcus aureus* in a Neonatal Intensive Care Unit. *J Pediatr*. 2018;194:22–27.e25.
89. Theilen U, Leonard P, Jones P, Ardill R, Weitz J, Agrawal D, Simpson D. Regular in situ simulation training of paediatric Medical Emergency Team improves hospital response to deteriorating patients. *Resuscitation*. 2013;84(2):218–22.
90. Braddock CH 3rd, Szaflarski N, Forsey L, Abel L, Hernandez-Boussard T, Morton J. The TRANSFORM Patient Safety Project: a microsystem approach to improving outcomes on inpatient units. *J Gen Intern Med*. 2015;30(4):425–33.
91. Generoso JR Jr, Latoures RE, Acar Y, Miller DS, Ciano M, Sandrei R, Vieira M, Luong S, Hirsch J, Fidler RL. Simulation Training in Early Emergency Response (STEER). *J Contin Educ Nurs*. 2016;47(6):255–63.
92. Sleeman K, Davis A, Veall A. Point-of-care simulation training to address serious untoward incidence of hypoglycaemia. *J Diabetes Nurs*. 2018;22(1):5–10.
93. Hamilton AJ, Prescher H, Biffar DE, Poston RS. Simulation trainer for practicing emergent open thoracotomy procedures. *J Surg Res*. 2015;197(1):78–84.
94. Marshall NE, Vanderhoeven J, Eden KB, Segel SY, Guise JM. Impact of simulation and team training on postpartum hemorrhage management in non-academic centers. *J Matern Fetal Neonatal Med*. 2015;28(5):495–9.
95. Prineas S, Mosier K, Mirko C, Guicciardi S. Non-technical skills in health-care. In: Donaldson L, Ricciardi W, Sheridan S, Tartaglia R, editors. *Textbook of patient safety and clinical risk management*. Cham: Springer International Publishing; 2021. p. 413–34.
96. Saqe-Rockoff A, Ciardiello AV, Schubert FD. Low-fidelity, in-situ pediatric resuscitation simulation improves RN competence and self-efficacy. *J Emerg Nurs*. 2019;45(5):538–544.e531.
97. Cepeda Brito JR, Hughes PG, Firestone KS, Ortiz Figueroa F, Johnson K, Ruthenburg T, McKinney R, Gothard MD, Ahmed R. Neonatal resuscitation program rolling refresher: maintaining chest compression proficiency through the use of simulation-based education. *Adv Neonatal Care*. 2017;17(5):354–61.
98. Davison M, Kinnear FB, Fulbrook P. Evaluation of a multiple-encounter in situ simulation for orientation of staff to a new paediatric emergency service: a single-group pretest/post-test study. *BMJ Simul Technol Enhanc Learn*. 2017;3(4):149.
99. Katznelson JH, Mills WA, Forsythe CS, Shaikh S, Tolleson-Rinehart S. Project CAPE: a high-fidelity, in situ simulation program to increase Critical Access Hospital Emergency Department provider comfort with seriously ill pediatric patients. *Pediatr Emerg Care*. 2014;30(6):397–402.
100. Katznelson JH, Wang J, Stevens MW, Mills WA. Improving pediatric preparedness in Critical Access Hospital Emergency departments: impact of a longitudinal in situ simulation program. *Pediatr Emerg Care*. 2018;34(1):17–20.
101. Patterson MD, Geis GL, LeMaster T, Wears RL. Impact of multidisciplinary simulation-based training on patient safety in a paediatric emergency department. *BMJ Qual Saf*. 2013;22(5):383.
102. Siegel NA, Kobayashi L, Dunbar-Viveiros JA, Devine J, Al-Rasheed RS, Gardiner FG, Olsson K, Lai S, Jones MS, Dannecker M, et al. In situ medical simulation investigation of emergency department procedural sedation with randomized trial of experimental bedside clinical process guidance intervention. *Simul Healthc*. 2015;10(3):146–53.
103. van Schaik SM, Plant J, Diane S, Tsang L, O'Sullivan P. Interprofessional team training in pediatric resuscitation: a low-cost, in situ simulation program that enhances self-efficacy among participants. *Clin Pediatr (Phila)*. 2011;50(9):807–15.
104. Boyde M, Cooper E, Putland H, Stanton R, Harding C, Learmont B, Thomas C, Porter J, Thompson A, Nicholls L. Simulation for emergency nurses (SIREN): a quasi-experimental study. *Nurse Educ Today*. 2018;68:100–4.
105. Freund D, Andersen PO, Svane C, Meyhoff CS, Sørensen JL. Unannounced vs announced in situ simulation of emergency teams: Feasibility and staff perception of stress and learning. *Acta Anaesthesiol Scand*. 2019;63(5):684–92.
106. Bayouth L, Ashley S, Brady J, Lake B, Keeter M, Schiller D, Robey WC 3rd, Charles S, Beasley KM, Toschlog EA, et al. An in-situ simulation-based educational outreach project for pediatric trauma care in a rural trauma system. *J Pediatr Surg*. 2018;53(2):367–71.
107. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, Abdelalim A, et al. Global burden of 369 diseases and injuries in 204 countries and territories,

- 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1204–22.
108. Kurosawa H, Ikeyama T, Achuff P, Perkel M, Watson C, Monachino A, Remy D, Deutsch E, Buchanan N, Anderson J, et al. A randomized, controlled trial of in situ pediatric advanced life support recertification ("pediatric advanced life support reconstructed") compared with standard pediatric advanced life support recertification for ICU frontline providers\*. *Crit Care Med*. 2014;42(3):610–8.
  109. Stocker M, Allen M, Pool N, De Costa K, Combes J, West N, Burmester M. Impact of an embedded simulation team training programme in a paediatric intensive care unit: a prospective, single-centre, longitudinal study. *Intensive Care Med*. 2012;38(1):99–104.
  110. von Arx D, Pretzlaff R. Improved nurse readiness through pediatric mock code training. *J Pediatric Nurs*. 2010;25(5):438–40.
  111. Allan CK, Thiagarajan RR, Beke D, Imprescia A, Kappus LJ, Garden A, Hayes G, Laussen PC, Bacha E, Weinstock PH. Simulation-based training delivered directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary resuscitation teams. *J Thorac Cardiovasc Surg*. 2010;140(3):646–52.
  112. Dowson A, Russ S, Sevdalis N, Cooper M, De Munter C. How in situ simulation affects paediatric nurses' clinical confidence. *Br J Nurs*. 2013;22(11):610–612-610617.
  113. Nickerson JE, Webb T, Boehm L, Neher H, Wong L, LaMonica J, Bentley S. Difficult delivery and neonatal resuscitation: a novel simulation for emergency medicine residents. *West J Emerg Med*. 2019;21(1):102–7.
  114. Surcouf JW, Chauvin SW, Ferry J, Yang T, Barkemeyer B. Enhancing residents' neonatal resuscitation competency through unannounced simulation-based training. *Med Educ Online*. 2013;18:1–7.
  115. Crofts JF, Ellis D, Draycott TJ, Winter C, Hunt LP, Akande VA. Change in knowledge of midwives and obstetricians following obstetric emergency training: a randomised controlled trial of local hospital, simulation centre and teamwork training. *BJOG*. 2007;114(12):1534–41.
  116. Gundrosen S, Solligård E, Aadahl P. Team competence among nurses in an intensive care unit: the feasibility of in situ simulation and assessing non-technical skills. *Intensive Crit Care Nurs*. 2014;30(6):312–7.
  117. Nunnink L, Welsh AM, Abbey M, Buschel C. In Situ Simulation-based team training for post-cardiac surgical emergency chest reopen in the intensive care unit. *Anaesth Intensive Care*. 2009;37(1):74–8.
  118. Villemure C, Georgescu LM, Tanoubi I, Dube J-N, Chiochio F, Houle J. Examining perceptions from in situ simulation-based training on interprofessional collaboration during crisis event management in post-anesthesia care. *J Interprof Care*. 2019;33(2):182–9.
  119. Mishra A, Catchpole K, McCulloch P. The Oxford NOTECHS System: reliability and validity of a tool for measuring teamwork behaviour in the operating theatre. *Qual Saf Health Care*. 2009;18(2):104–8.
  120. Stocker M, Menadue L, Kakat S, De Costa K, Combes J, Banya W, Lane M, Desai A, Burmester M. Reliability of team-based self-monitoring in critical events: a pilot study. *BMC Emerg Med*. 2013;13:22–22.
  121. Guise JM, Deering SH, Kanki BG, Osterweil P, Li H, Mori M, Lowe NK. Validation of a tool to measure and promote clinical teamwork. *Simul Healthc*. 2008;3(4):217–23.
  122. Cooper S, Cant R, Porter J, Sellick K, Somers G, Kinsman L, Nestel D. Rating medical emergency teamwork performance: development of the Team Emergency Assessment Measure (TEAM). *Resuscitation*. 2010;81(4):446–52.
  123. Remick K, Gausche-Hill M, Joseph M. American Academy of Pediatrics Committee on pediatric emergency medicine and section on surgery, American College of Emergency Physicians Pediatric Emergency Medicine Committee, Emergency Nurses Association Pediatric Committee. Pediatric Readiness in the Emergency Department. *Pediatrics*. 2018;142(5):e20182459.
  124. Donoghue A, Nishisaki A, Sutton R, Hales R, Boulet J. Reliability and validity of a scoring instrument for clinical performance during Pediatric Advanced Life Support simulation scenarios. *Resuscitation*. 2010;81(3):331–6.
  125. Munroe B, Buckley T, Curtis K, Murphy M, Strachan L, Hardy J, Fethney J. The impact of HIRAID on emergency nurses' self-efficacy, anxiety and perceived control: a simulated study. *Int Emerg Nurs*. 2016;25:53–8.
  126. Grundy SE. The confidence scale: development and psychometric characteristics. *Nurse Educ*. 1993;18(1):6–9.
  127. Chiochio F, Grenier S, O'Neill T, Savaria K, Willms J. The effects of collaboration on performance: a multilevel validation in project teams. *Int J Proj Organ Manag*. 2012;4:1–37.
  128. Lamé G, Dixon-Woods M. Using clinical simulation to study how to improve quality and safety in healthcare. *BMJ Simul Technol Enhanc Learn*. 2018;6:87–94.
  129. Cheng A, Kessler D, Mackinnon R, Chang TP, Nadkarni VM, Hunt EA, Duval-Arnould J, Lin Y, Cook DA, Pusic M, et al. Reporting guidelines for health care simulation research: extensions to the CONSORT and STROBE statements. *Adv Simul*. 2016;1(1):25.
  130. Goldshtein D, Krensky C, Doshi S, Perelman VS. In situ simulation and its effects on patient outcomes: a systematic review. *BMJ Simul Technol Enhanc Learn*. 2020;6(1):3–9.
  131. Bonfield A, Cusack J. Effective training in neonatal medicine. In: Boyle E, Cusack J, editors. *Emerging topics and controversies in neonatology*. Switzerland: Springer; 2020.
  132. Rudolph JW, Raemer DB, Simon R. Establishing a safe container for learning in simulation: the role of the presimulation briefing. *Simul Healthc*. 2014;9(6):339–49.
  133. Fenwick T, Dahlgren MA. Towards socio-material approaches in simulation-based education: lessons from complexity theory. *Med Educ*. 2015;49(4):359–67.
  134. Durning SJ, Artino AR. Situativity theory: a perspective on how participants and the environment can interact. *AMEE Guide no. 52. Med Teach*. 2011;33(3):188–99.
  135. Sharara-Chami R, Sabouneh R, Zeineddine R, Banat R, Fayad J, Lakissian Z. In Situ Simulation: an essential tool for safe preparedness for the COVID-19 pandemic. *Simul Healthc*. 2020;15(5):303.
  136. Lakissian Z, Sabouneh R, Zeineddine R, Fayad J, Banat R, Sharara-Chami R. In-situ simulations for COVID-19: a safety II approach towards resilient performance. *Adv Simul*. 2020;5(1):15.
  137. Josey K. Hospitals with more-active participation in conducting standardized in-situ mock codes have improved survival after in-hospital cardiopulmonary arrest. 2018.
  138. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8(1):19–32.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Ready to submit your research? Choose BMC and benefit from:**

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

**At BMC, research is always in progress.**

Learn more [biomedcentral.com/submissions](https://biomedcentral.com/submissions)

