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Review Article

Patient Safety Elements Taught to Preregistration Nurses Using Simulation Designs: An Integrative Review

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KEYWORDS
Nursing;
Patient safety;
Preregistration;
Simulation;
Standards;
Students

Abstract This integrative literature review aimed to examine preregistration nursing simulation-based education aligned to patient safety. Understanding quality standards and simulation best practices used to guide the simulation activities also featured.

Eight data bases were searched using a standardized search strategy. A total of 33 studies met the inclusion criteria. Six patient safety standards featured in over 38 simulation scenarios, particularly the management of deteriorating patients. Students' patient safety knowledge and simulated performances consistently returned significant gains following the interventions. Manikin-based, face to face delivery was the most commonly described simulation modality, followed by virtual simulation and virtual reality programmes. The evidence supports simulation as a beneficial technique for teaching patient safety in nursing education. In future, well planned controlled experimental studies are needed to deliver more evidence. Simulation design best practices aligned to international guidelines could be reported in more depth.

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Introduction

The World Health Organization (WHO, 2023) reports the cost of adverse healthcare events is as much as 15% of total health care expenditure. Hence, it is imperative that healthcare graduates are prepared to provide safe and high-quality health care. Simulation-based education (SBE) focusing on published safety standards and patient safety competency elements can be an effective strategy for improving pre-registration nursing students' safe clinical knowledge, skills, and practice (Seaton et al., 2019).

Research confirms that many nursing SBE studies report on elements of patient safety (Ambrosio Mawhirter & Ford Garfolol, 2016; Mariani et al., 2015; Seaton et al., 2019). Yet, studies of the effectiveness of SBE to improve nursing students' patient safety knowledge and skills continue to attract much attention. Positive learning outcomes have been reported. Fisher and King (2013) reviewed 18 studies preparing students through simulation to respond to deteriorating patients, reporting that students' confidence, knowledge and competence generally increased. Cooper, Cant, Bogossian, Kinsman, and Bucknall (2015a) reported on a primary study of nursing students, using FIRST2ACT™ patient deterioration scenarios, that both face-to-face and computer e-simulation approaches were effective in improving students' performances. Cant et al. (2023) reviewed the overall effectiveness of computer-based simulation across 18 literature review studies, reporting that virtual simulations can be effective in developing nursing students' knowledge, psychomotor and psychosocial skills, for example for medication administration and communication.

Key Points

- Preregistration nurses' patient safety knowledge and performances improved post simulations, although it is unknown if this is retained in the clinical setting.
- Recognition of patient deterioration was the most common patient safety standard taught, with less focus on communicating for safety, medication safety, infection prevention and control, blood management and comprehensive care standards.
- Reporting of simulation design standards was not always apparent, raising concerns about the quality of simulation-based education for teaching patient safety, despite there being scant evidence of impact on learner knowledge and performance gains.

Liu, Aungsuroch, Sha, Gunawan, and Zeng (2021) and Shin, Rim, Kim, Park, and Shon (2019) argue that what is lacking in nursing SBE *is research* that reports the use of safety frameworks to teach nursing students safer patient care. Further, Bogossian et al. (2019) identified that nursing simulation in Australia and New Zealand lacked best practice informing simulation design and evaluation, potentially impacting the quality of nursing SBE.

There are published national and international safety standards informing healthcare safety education and defining essential healthcare practitioner safety skills. Eight Australian National Safety and Quality Health Service standards (NSQHS) guide services and practitioners in providing safe and high-quality health care (NSQHS, 2023). The Quality and Safety Education for Nurses (QSEN), an affiliation of American nurses developed six key patient safety competencies for nursing curricula (Cronenwett et al., 2007).

Best practice standards informing the quality of simulation-based learning are also available. The International Nursing Association for Clinical Simulation and Learning (INACSL) Healthcare Simulation Standards of Best Practice™ prescribe eleven standards to address quality in nursing education programs (INACSL, 2023). One standard, 'Simulation Design' outlines 11-steps for quality in scenario design and administration of SBE (INACSL, 2021).

The earlier developed Jeffries Simulation Design Scale (Jeffries & Rizzolo, 2023) can be used in designing, implementing and evaluating simulation–based teaching in nursing education. It includes simulation design characteristics and outcomes. TeamSTEPPS™ is an evidenced-based framework,suited to SBE, designed to teach healthcare professionals effective teamwork and communicating for patient safety (AHRQ, 2023). Regarding safer healthcare communication there is ISBAR (Introduction, Situation, Background, Assessment, Recommendation) a clinical handover framework endorsed by the World Health Organization for use in healthcare and other contexts (Burgess, van Diggele, Roberts, & Mellis, 2020).

This review aims to report contemporary evidence on the teaching of patient safety in preregistration nursing education using SBE and to identify and report on the safety elements taught and the simulation design standards used to frame patient safety simulations.

Review Aim

Review questions to be addressed are:

(I) Is patient safety taught to nursing students via simulation-based education?
(II) What simulation design standards are used to inform nursing simulations?
(III) What safety and quality elements are taught and what are the learning outcomes?

Methods

Integrative review results are intended to guide practice (Whittemore & Knafl, 2005). This review methodology was chosen because it enables researchers to synthesise evidence from a range of study methodologies, including both experimental and non-experimental designs, and from diverse sources that authors consider important for capturing the available evidence (Souza, Silva, & Carvalho, 2010). Lubbe, Ham-Baloyi, and Smit (2020) contemporary five-step integrative literature review method, based on previous methods by Whittemore and Knafl (2005) and Souza et al. (2010) guided the review. The recommended steps include (a) defining review aims and questions, (b) searching and selecting evidence based on inclusion criteria and search strings, (c) critically appraising included articles, (d) extracting and synthesising data, and (e) presenting and discussing findings (Lubbe et al., 2020).

Search Strategy

Searches were conducted in March and April 2023. MeSH terms were included, noting that the MeSH term for simulation is "computer simulation," the keyword "simulation" was included. The MeSH term "guideline" was chosen to include the keywords "standard" and "framework." This search string was designed in the OVID platform and adapted to meet the individual databases searched.

> (nursing students OR students, nursing OR undergraduate student nurses OR pre- licensure nurse OR preregistration nurse) AND computer simulation OR simulation AND patient safety AND quality AND (teaching methods OR teaching approaches OR teaching strategies or instruction) AND guideline.

The databases CINAHL Ultimate, Ovid Johanna Briggs Institute, Ovid Emcare, Ovid Medline, ProQuest One Academic, ProQuest Central and PubMed were searched. A second phase search was conducted in the key journal Clinical Simulation in Nursing. A hand search of the reference lists of included articles completed the searches.

Inclusion and Exclusion Criteria

Inclusion criteria were English language research publications of any design, published between 2010 and 2023. Studies that reported on SBE to teach elements of patient safety were selected. Patient safety was referred to as nursing care based on skills and knowledge including the elements; communication, medication administration, evidence-based practice and recognition of patient deterioration.

Studies were excluded if they reported samples that did not include undergraduate nurses or where nursing students were in the minority. Studies that measured participants' self-reported satisfaction, self-efficacy, confidence with SBE or evaluation of simulation tools, prototypes and programmes (without reporting nursing student outcomes) were excluded. A flow chart showing search outcomes is seen in Figure 1 (Page et al., 2021).

Critical Appraisal

In keeping with the published recommendations (Lubbe et al., 2020), articles were assessed for methodological quality and rigour, based on dual ratings. Articles were rated 1= low and 2 = high to assess the clarity of study aims, methodology, rigour and reported results (maximum score of 8). Lower scores indicate the appraised elements were either not clear, or in some designs were not reported. No studies were excluded following the critical appraisal.

Data Extraction

Tables of characteristics of studies were designed to capture; author, year, country of research origin, study design and aim, number of participants, simulation scenario content and modality, simulation design standard, safety standard, study results and relevant author recommendations (Lubbe et al., 2020).

Synthesis

The primary source details that were extracted and tabulated were examined for repeated patterns of results and to detect use of simulation design and safety standards. As this review informs a larger Australian-led multicentre study the safety elements taught were mapped to the Australian safety standards (NSQHS, 2023). Three authors (CR, CK, RC) collaborated to develop the results narrative.

Results

Thirty-three studies reported the use of simulation-based education to teach elements of patient safety to nursing students. The majority of studies were primary studies of nursing students' simulation-based education with use of various research designs. Six studies were randomised controlled trials (Jarvill, Jenkins, Jacobs, Astroth, & Pohl, 2018; Liaw, Rethans, Scherpbier, & Piyanee, 2011; Merriman, Stayt, & Ricketts, 2014; Padilha, Machado, Ribeiro, Ramos, & Costa, 2019; Saastamoinen, Härkänen, Vehviläinen-Julkunen, & Näslindh-Ylispangar, 2022; Sarvan & Efe, 2022).

Many studies (n = 12) were single group quasi-experimental designs, 10 of which included pre–post-tests (Choi, Lee, & Gwon, 2021; Coskun & Sendir, 2022; Costa et al., 2019; Goldsworthy et al., 2022; Hart et al., 2014; Kim & Chun, 2022; Prentice & O'Rourke, 2013;

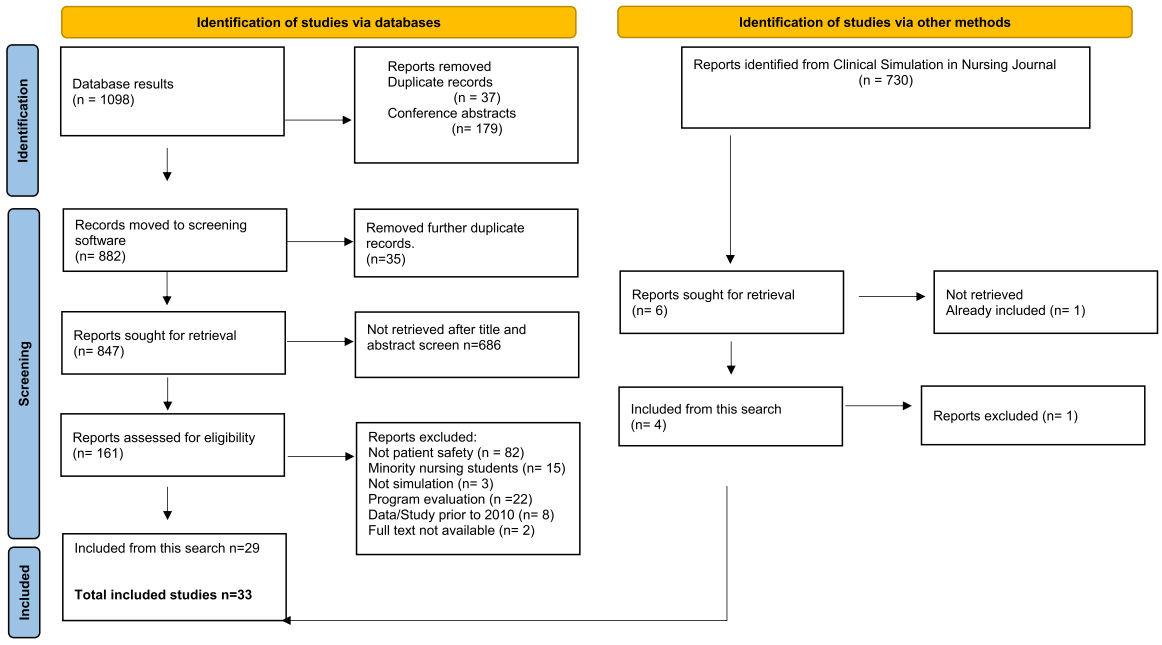

Figure 1 Search results.

Prince, Winmill, Wing, & Kahoush, 2016; Sparkes, Chan, Cooper, Pang, & Tiwari, 2016; Wilson, Klein, & Hagler, 2014). Two conducted post-test measurements only (Redmond et al., 2020; Sharpnack & Madigan, 2012).

Six studies used a two-group quasi-experimental design (Ballard, Piper, & Stokes, 2012; Borg Sapiano, Sammut, & Trapani, 2018; Cooper et al., 2015a; McCormick, de Slavy, & Fuller, 2013; Soledad & Ramirez, 2018; Stuart, Aul, Bumbach, Stephen, & Lok, 2021) or multigroup design (Cooper et al., 2017). There was a mix of other research designs; one study was a re-analysis of original web-based performance data (Cooper, Cant, Bogossian, Bucknall, & Hopmans, 2015b). Four were descriptive observational designs (Ambrosio Mawhirter & Ford Garfolol, 2016; Cantrell, Mariani, & Meakim, 2016; Fusco, Alfes, Weaver, & Zimmermann, 2021; Unsworth, McKeever, & Kelleher, 2012), one a longtitudinal cohort study (Schneidereith, 2021) and one a case study (Kelly, Berragan, Husebo, & Orr, 2016). The final included study was an integrative review of studies using the TeamSTEPPS model for teaching communication for team care via simulation (Foster, Gilbert, Hanson, Whitcomb, & Graham, 2019). The included studies generally represented designs that were at the lower end of the research evidence scale (The Joanna Briggs Institute, 2023), except for the random control trials (RCT) which were experimental trials.

The years of publication of studies ranged from 2011 to 2022. There was good representation of international research as studies originated in 15 countries. Eleven studies originated in the USA, six in Australia, two in Canada, in South Korea and in Turkey, Single studies originated in Brazil, Chile, England, Finland, Hong Kong, Ireland, Malta, Portugal, Singapore and the UK. Two of the Australian studies were international collaborations; Australia and Norway (Kelly et al., 2016) and Australia, Canada, England and Scotland (Goldsworthy et al., 2022). In total, the studies included over 4,100 participants, ranging in individual studies from 14 to 1,742 participants.

Studies commonly comprised two, three, or more medical conditions offering students serial practice in a single simulation programme. The combined dataset included more than 38 conditions portrayed in simulations, requiring students to perform beginning level skills (handwashing) to the more advanced skills of critical thinking when managing the deteriorating patient. The frequency of simulation modalities used in teaching nursing students safe practice is charted in Figure 2. Fifteen studies involved face-to-face (FTF) interaction with a manikin or a standardised patient (an actor). Computer-based virtual simulation with a videoed patient actor was common, with virtual reality (computer-based avatar figures to represent patient and/or staff) also used. This result shows that a number of simulation modalities and skills covered in the scenarios have potential for use by educators in their patient safety simulation curriculum.

Thus, we confirm in relation to review question 1, that patient safety remains a focus of nursing student education, taught via simulation-based education.

This review also aimed to explore the question of: What simulation design standards are used to inform nursing

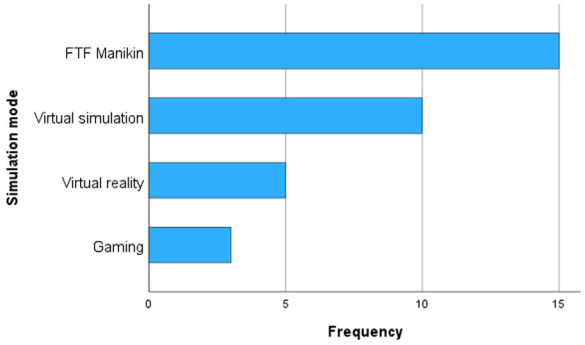

Figure 2 Simulation modalities applied in teaching patient safety (n = 33 studies). *Note.* This figure reports the variety of simulation modalities across the 33 included studies.

simulations for teaching patient safety? (RQ2). Fewer than half of the included studies (n = 14; 42% %) reported use of a simulation design standard (see Table 1). The most common simulation design reported was Jeffries Simulation Design Scale (Jeffries & Rizzolo, 2023). The remaining 19 studies not reporting a formal design standard are shown in Table 2 .

To answer the third review question we mapped the results to the Australian national patient safety standards (NSQHS, 2023). Table 3 shows that six of the relevant safety standards, used to teaching safe nursing practice, were taught to nursing students via simulation strategies.

Simulation Safety Education Outcomes: "Patient deterioration"

Almost half the included studies (n = 15; 45%) reported SBE regarding Recognising and responding to patient deterioration. Various research methodologies were used, with all studies reporting positive learning outcomes. Several studies addressed the "rescue" or resuscitation of a rapidly deteriorating patient, while others involved a more general focus, such as an exacerbation of a medical condition. Most student samples were senior and final year level students, indicating the safety scenarios were aligned to students expected skills proficiency, that is, the advanced level of nursing knowledge and critical thinking required to effectively manage deteriorating patients.

As seen in Table 1, eight studies in this category used a formal simulation design framework: FIRST2ACT^{TM} (n = 5), the Jeffries Simulation Design Scale (n = 2), or the INACSL Healthcare Simulation Standards of Best Practice (n = 1).

Four studies of patient deterioration conducted a randomised controlled trial. Liaw et al. (2011) conducted laboratory-based simulations with 31 nursing students in groups of five, using high fidelity manikins. They reported significant gains in knowledge of patient deterioration in the intervention group at post-test (t = 4.24; $p < .01$) and also when compared with a control group at post-test (F = 8.98; $p < .01$). A trial by Sarvan and Efe (2022) tested the impact of a serious game simulation on nursing students' neonatal resuscitation skills, reporting performance outcomes. A significant positive difference was identified in the ventilation and chest compression skills of the intervention group ($p = .011$) compared with the control group ($p = .020$). Trials conducted by #bib likewise reported positive student gains.

Of three primary studies that utilised the Web-based FIRST2ACT^{TM} programme which included three patient deterioration scenarios (first2act.com), each study reported significant gains in students' knowledge of patient deterioration ($p< .001$). A further related study of international nursing students using FIRST2ACT^{TM} employed a secondary analysis (participant data extracted online) to report significant gains in the performance of clinical interventions after virtual simulation experiences.

Five other studies of patient deterioration comprised quasi-experimental research designs. Measurements were derived from pretests and post-tests (four studies), while one used a post-test evaluation alone. Two further studies in this patient deterioration category were a case study and a mixed methods study. The majority of patient deterioration studies measured immediate knowledge gains alone, although three individual designs tested students' clinical skill performance. One, described above, by Sarvan and Efe (2022) used a game-based approach to teach neonatal resuscitation. Alternatively, the FIRST2ACT^{TM} interactive web-based program collected performance data based on students' mouse 'clicks' (representing appropriate actions). A qualitative study by Unsworth et al. (2012) used a high fidelity manikin to explore final year students' recognition and management of physical deterioration in mental health patients, with skill performances measured by an observer using a checklist. Positive outcomes across the range of studies in this category confirm the application of simulation-based patient deterioration education as valid and relevant in nurse education.

Simulation Education Outcomes: "Comprehensive Care"

Table 3 shows a total of six quality and safety standards taught to nursing students using SBE. The second most common standard taught was 'Comprehensive care' (n = 6 studies). This generally involved a simulated patient who presented with an exacerbation of their medical condition and required participants to conduct a nursing assessment, develop a conceptual plan of care and limit harm to the patient. A number of conditions were presented in this way: sepsis, diabetic ketoacidosis, postoperative partial gastrectomy, Parkinson's disease and chronic obstructive pulmonary disease. Measurement of learning outcomes was conducted by self-administered student knowledge test or satisfaction survey.

Table 1 – Characteristics of Studies (n = 14) Teaching Patient Safety Using SBE With a Formal Simulation Design

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Borg Sapiano et al., 2018 Malta	Quasi-experimental, two group, pre-posttests. To investigate the effectiveness of virtual simulation in improving student nurses' knowledge and performance during rapid patient deterioration.	n = 166 84 diploma students 82 various year levels degree students	**DESIGN: First[†]Act Web™ simulation*** MEASURES: **First2Act Web™ validated knowledge test, performance data collected by website.**	STANDARD: NSQHS Deterioration - managing and responding to MODALITY: Web-based interactive program with actors SCENARIOS: Cardiac Shock Respiratory	Returned significant improvement in the students' post-scenario knowledge ($z = -6.506$, $p < .001$). There were reported differences in performance indicating First2Act may **improve performance as well as knowledge.**
Cooper et al., 2015a **Australia**	Quasi-experimental two group comparison study with observational and digital measurements. To examine simulation- based strategies that may be used to teach nursing students to recognize and manage patient deterioration.	**N = 427 97 final year in face to face 330 mixed level web-based**	**DESIGN: First[2]Act Web™ simulations in 2 versions: face-to-face and Web-based** MEASURES: V**alidated knowledge test, observed OSCE or performance data collected by website**	STANDARD: NSQHS Deterioration - managing and responding to MODALITY: Face to face with simulated patient (actor) or Web-based interactive program with feedback. SCENARIOS: Cardiac Shock Respiratory	Both groups had moderate performance scores (mean: F2F 49%, simulation 69%. Gain in skills showed a higher effect in the F2F group than in the simulation group. The F2F group were more satisfied, with more positive appraisals.
Cooper et al., 2015b **Australia**	Observational study; secondary analysis of collected Web-based program performance data. To assess nursing students' performance identifying treatment priorities and clinical actions using First two Act simulation.	**n = 427: 97 second year 330 various year levels**	**DESIGN: First[†]Act Web™ simulations** MEASURES: Course of Action Simulation Analysis	STANDARD: NSQHS Deterioration - managing and responding to MODALITY: Web-based interactive program with feedback SCENARIOS: Cardiac Shock Respiratory	Significant improvement in knowledge and skills ($p < .001$). Course of Action Simulation Analysis modeling identified three groupings; 18% took the "best course of action" (the right actions and timing), with most (70%) completing the right actions but in the wrong order. 12% produced incomplete assessments and actions in an incorrect sequence.

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Table 1 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Cooper et al., 2017 **Australia**	Quasi-experimental, multi group, pre-post-tests. To determine if e-simulation is a feasible education solution to the management of deteriorating patients.	**n = 1,742 final year nursing students from 20 countries**	**DESIGN: FIRST2ACT Web™ simulation** MEASURES: V**alidated knowledge test, performance data collected by website**	STANDARD: NSQHS Deterioration - managing and responding to MODALITY: Web-based interactive program with feedback SCENARIOS: Cardiac Shock Respiratory	**Knowledge improved significantly, pre-post-test (M = 7.75, M = 8.48 ($p < .001$).**
Foster et al., 2019 USA	Integrative literature review. To synthesize the literature on how simulation is used to teach teamwork skills to prelicensure nursing students.	**n = 21 articles**	**DESIGN: Every included study used TeamSTEPPS**[†] **MEASURES: TeamSTEPPS frameworks**	STANDARD: QSEN Communicating for safety Teamwork and Collaboration MODALITY: TeamSTEPPS SCENARIOS: Various involving nursing and medical students	**Communication was the most common safety element addressed in TeamSTEPPS. Communicating to escalate and confidence communicating in a team featured, without fear of retribution and to solve problems.**
Fusco et al., 2021 USA	Quasi-experimental, two group, descriptive comparative design. To examine junior and senior baccalaureate nursing students using the Medication Administration Safety Assessment Tool during simulation.	n = 188 98 juniors 90 seniors	DESIGN: INACSL[‡] Healthcare Simulation Standards of Best Practice Jeffries Simulation Design Scale[§] MEASURES: **validated medication administration safety assessment tool MASAT**	STANDARDS: NSQHS Medication safety MODALITY: Low fidelity simulation SCENARIOS: medication administration	Independent samples t-tests comparing medication safety competency revealed 29.6% of juniors and 14.4% of seniors demonstrated competence on all eight MASAT items. Overall, seniors did not demonstrate greater medication safety competence than juniors.

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Table 1 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Goldsworthy et al. 2022 Canada, England, Scotland, Australia	Quasi-experimental, single group, descriptive and pre-post design. To explore the impact of a virtual simulation on undergraduate nursing student ability to recognise and respond to a rapidly deteriorating patient.	n = 88 final year	DESIGN: INACSL Healthcare Simulation Design Best Practice standards VSim®‖ MEASURES: **Clinical self-efficacy 10-item survey Cronbach α = 0.91 A purposively designed 20-item multichoice test on evidence based practice related to care of deteriorating patients**	STANDARDS: NSQHS Deterioration - managing and responding to Blood Management MODALITY: Virtual reality scenarios SCENARIOS: Cardiac Anaphylaxis Respiratory Blood transfusion	**Both groups returned positive mean changes for five items relating to managing deteriorating patients. Mean for the intervention group was much higher Pretest (M 40.67-83.06) and post-test (M 58.8-91.71) (nonsignificant). Haemorrhage and adjunct airway support scored lowest. Knowledge test items were significantly different p = .001.**
Jarvill et al., 2018 USA	Randomized controlled trial with pretest–post-test To compare simulation experience vs traditional practice on nursing student medication administration competence.	n = 85 first-year control group (n = 42) administered medication to a staff member in a classroom; intervention group (n = 43) practiced on a manikin until skill mastery was achieved.	**DESIGN: Jeffries Simulation Design Scale MEASURES: Validated medication administration safety assessment tool MASAT**	STANDARD: NSQHS Medication safety MODALITY: high fidelity manikin simulation SCENARIOS: medication administration	Medication administration practice significantly improved in the intervention group (M = 7.52,) compared to the control group (M = 6.37,),p = <.01). Cohen's effect size (d = 0.53) showed a medium effect.

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Table 1 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Kelly et al., 2016 **Australia, Norway**	Case study To report four (4) simulation cases designed to improve patient safety, identifying issues that prevent safe practice in care of mental health and, postoperative patients.	**N = not reported**	**DESIGN: Jeffries Simulation Design Scale Quality indicators in simulation (QIS) design[¶] MEASURES: qualitative analyses**	STANDARD: NSQHS Deterioration - managing and responding to **Communicating for safety QSEN Teamwork and Collaboration** MODALITY: Manikins and simulated patient actors SCENARIOS: Surgical patients Trauma Mental health	**All four cases had a positive impact on students' learning to promote patient safety through prioritization and the time critical nature of recognising and responding to deteriorating patients. Pedagogical frameworks are key to successful learning.**
Liaw et al., 2011 **Singapore**	Randomized controlled trial with pretest-post-test To develop, implement and evaluate **RAPIDS, an evidence-based simulation program,** on undergraduate nurses' competency in assessing, managing and reporting of patient deterioration.	**n = 31 final year n = 15 control group n = 16 intervention** Both groups completed manikin simulation Intervention only completed RAPIDS program	**DESIGN: Jeffries Simulation Design Scale MEASURES: validated RAPIDS knowledge test**	STANDARD: NSQHS Deterioration-managing and responding to MODALITY: manikin Computer simulation (RAPIDS) SCENARIOS: Respiratory Endocrine (hypoglycaemia) Sepsis Circulatory (haemorrhage)	Management of deteriorating patient was significant in the intervention group pretest to post-test ($t = 9.26$; $p < .0001$) and compared to the control group post-test mean scores ($F = 77.28$; $p < .0001$). Intervention group reporting of deterioration was significantly higher post-test ($t = 4.24$; $p < .01$) and compared to the control group post-test ($F = 8.98$; $p < .01$).
Redmond et al., 2020 **Ireland**	Quasi-experimental, single group with post-test only To design and evaluate a "virtual patient" simulation for nursing students to safely manage wound care by assessing the patient and the wound.	**n = 148** Second year	**DESIGN: Jeffries Simulation Design Scale MEASURES: Author designed wound care competency outcome questionnaire Cronbach $\alpha = 0.70$**	STANDARDS: NSQHS Comprehensive care QSEN Patient-centred Care MODALITY: Virtual simulation SCENARIOS: Wound assessment	**89.6%-96.5% strongly agreed/agreed in four items that simulation supported them to correctly categorising the wound. 86.1% strongly agreed/ agreed that the simulation allowed them to choose the correct wound dressing. 86% s agreed that feedback enhanced their ability to prioritise care and confirm their provisional diagnosis.**

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Table 1 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Schneidereith, 2020 **USA**	Single group observational longitudinal cohort study To report the differences in nursing student safe medication administration over four semesters of study.	**n = 78 same cohort began as junior students and completed as senior students**	**DESIGN: INACSL** Healthcare Simulation Standards of Best Practice **Jeffries Simulation Design Scale MEASURES: Purposefully designed checklist for observational assessment (yes/no) of students performing safe medication administration using five rights.**	**STANDARDS: QSEN Medication administration MODALITY: High fidelity manikin SCENARIOS: medication administration**	**Students use of the five rights (drug, patient, dose, time and route) was observed between 70-100% of the time. The exception was right dose that was not observed in first semester but achieved 70% in the third semester and dropped back to 30% in the final semester.**
Sharpnack & Madigan, 2012 **USA**	**Quasi-experimental, single group, post-test only with descriptive items. To assess** computer-assisted instruction as a supplement to a low-fidelity simulation to prepare students as safe practitioners.	**n = not reported Second year**	**DESIGN: Jeffries Simulation Design Scale MEASURES: Educational Practice Scale for Simulation (EPSS)**	**STANDARDS: QSEN Patient-centred care Teamwork and Collaboration Informatics** MODALITY Low fidelity manikin scenario SCENARIOS: Endocrine (diverticulitis) Integumentary (pressure ulcer)	**High means were returned on a five point Likert scale EPSS (M = 4.30-4.60) and SDS (M = 4.00-5.00). Verbatim data confirmed positive evaluations. Te**am-building was rated highly.

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Table 1 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Simulation Design Reported Measures	Safety Standard (NSQHS) or as a Competence Standard (QSEN) Simulation Topic/Modality/Scenario Description	Results /Main Recommendations
Sparkes et al., 2016 **Hong Kong**	Quasi-experimental, single group, pre-post-test. To evaluate FIRST[2] ACTWeb, in a Chinese student population.	**n = 62 final year**	**DESIGN: First[†] Act Web™ simulation** MEASURES: Early version of **First[†] Act Web™ validated knowledge test. Authors verified for use with this** population.	STANDARDS: NSQHS Deterioration- managing and responding to MODALITY: Web-based interactive program with feedback SCENARIOS: Cardiac Shock Respiratory	Significant improvements ($p = < .001$) in assessing heart rate ($p = .04$), breathing ($p = .001$), conscious state ($p = <.04$) and use of oxygen therapy ($p = .001$). Two items returned significant knowledge decreases: cardiac output (pretest M = 0.61, post-test M = 0.53,$p = .21$) and needle size (pre-test M = 0.42,post-test M = 0.38, $p = .53$). Participants' performance significantly improved between the first cardiac scenario and the final respiratory scenario (M = 18.44, M = 21.08, $p = <.001$).

Notes: i) where participant numbers are not reported studies reported a majority of undergraduate nursing students
ii)only results relevant to this review are reported for example, student satisfaction, self-efficacy are not included.
iii) Modality descriptions align with the Healthcare Simulation Healthcare (second ed.). https://www.ssih.org/dictionary
Description of the reported simulation design and program

* **First2Actweb - an Australian i**nteractive video simulation software that allows students and professionals to practice medical emergency scenario**s to identify and manage patient deterioration. Developed in 2011 and informed by learning theory and empirical literature to design a five -step educational cycle including developing core knowledge, assessment, simulation, reflective self-review and performance feedback** https://first2act.com/

† TeamSTEPPS - a framework to design simulations that educate and assess on **five safety principles (a) team structure, (b) communication, (c) leadership, (d) situation monitoring, and (e) mutual respect** https://www.ahrq.gov/teamstepps/about-teamstepps/index.html

‡ INACSL Healthcare simulation standards of best practice–International Nursing Association for Clinical Simulation and Learning includes 12 best practice simulation design standards

§ Jeffries SDS–Jeffries Simulation Design Scale a 20-item instrument evaluating five design features (a) objectives/information; (b) support; (c) problem solving; (d) feedback; (e) fidelity. Two subscales are (a) presence of design features, Cronbach $\alpha = 0.92$, and (b) importance of the design features Cronbach $\alpha = 0.96$. Jeffries, P. & Rizzolo, M. (2005). Simulation design scale. National League for Nursing https://www.nln.org/education/teaching-resources/tools-and-instruments

‖ VSim®-commercial nursing simulation program https://laerdal.com/au/products/courses-learning/virtual-simulation/vsim-for-nursing

¶ QIS- Quality indicators for the design and implementation of simulation experiences this article reports on the pedagogical principles and teaching strategies that are indicative of quality in simulation-based learning activities. Arthur, C., Levett-Jones,T.,& Kable, A.(2013).Quality indicators for the design and implementation of simulation experiences: a Delphi study.Nurse EducationToday,33(11), 1357-1361.https://doi.org/10.1016/j.nedt.2012.07.012

Table 2 – Characteristics of Studies (n = 19) Teaching Patient Safety Using SBE Without Reporting Simulation Design

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Ambrosio-Mawhirter & Ford Garfolol, 2016 **USA**	Descriptive study with self-reported questionnaires. To reduce fear about clinical placement through realistic simulation games that mimic acuity and uncertainty of clinical environment.	**n = 18 seven first year 11 senior**	STANDARD: NSQHS Deterioration- managing and responding to QSEN Patient centred care Teamwork and Collaboration MEASURES: QSEN (2009) 60-second situational assessment learner evaluation tool	**MODALITY: serious games SCENARIOS: three scenarios designed by faculty to meet QSEN safety and quality elements in care of deteriorating patients**	Simulation games designed with QSEN principles offered faculty deeper insight into student management of deteriorating patients.
Ballard et al., 2012 **England**	Quasi experimental, two group, post-test only. To identify whether additional teaching and simulated learning of one-hour duration could improve the blood pressure measurement skills of nursing students.	**n = 14 first year group numbers not reported.** Both groups received a lecture and practiced on a simulated arm. Experimental group also listened to recorded systolic sounds and watched procedural videos	STANDARD: **NSQHS Blood management** QSEN **Patient-centred care Safety MEASURES: Author designed assessment tool using procedural guidelines for assessing blood pressure**	MODALITY: Manikin arm (part task trainer) SCENARIO: Assessment -perform blood pressure	**Control group were significantly less able to determine correct systolic readings compared to the experimental group (M = 11.00, M = 1.86, p = .017).**
Cantrell et al., 2016 USA	Qualitative interventional evaluation To enhance students' knowledge of safety principles.	n = 175 final year	STANDARD: QSEN Teamwork and Collaboration Safety MEASURES: A simulated environment checklist (not described inarticle)	MODALITY: Computer simulation (videos) SCENARIOS: Nurses violating safety principles Nurses consistently demonstrating safety principles	Students self-reported improved understanding of delegation, the importance of acknowledging mistakes, reporting errors and teamwork. Students were observed explaining patient safety principles topatients. Using errors helped students to problem solve safer patient care during the simulations.

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Table 2 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Choi et al., 2021 **South Korea**	Quasi-experimental, single group pre-post-test with descriptive items. To design, implement and evaluate communication simulation (ComEd) and test effectiveness on nursing students' communication knowledge.	**n = 30** **mixed junior and senior**	STANDARD: NSQHS **Communicating for safety** Used ADDIE design framework (Analysis, Design, Development, Implementation, and Evaluation) **MEASURES: Validated author designed 22-item communication efficacy scale Cronbach α = 0.94**	MODALITY: Computer simulation with virtual patient actors and avatars (ComEd) SCENARIOS: Communication	**ComEd simulation program positively impacted nursing students' communication knowledge** **Pretest M = 10.73 post test M= 13.83** **Repetitive learning through the ComEd program could improve nursing students' communication skills for clinical practice.**
Coskun & Sendir, 2022 **Turkey**	Quasi-experimental, single group, pre-post-test. To compare the effectiveness of two simulation modalities in teaching ventrogluteal intramuscular injections.	**n = 81** **first year**	STANDARD: NSQHS **Medication safety** **Preventing and controlling infection** **MEASURES:** Purposively designed 25 item knowledge test with content validity 0.988 and Kuder Richardson-20 reliability score 0.762	MODALITY: computer simulation with simulated patient actor SCENARIOS: medication administration (ventrogluteal injection)	**There were no statistically significant differences between the groups' pre-post test results (p = .837; p > .05). Safer ventrogluteal administration was significantly higher in the computer simulation than the simulated patient scenario (p =.001; p .01).**
Costa et al., 2019 **Brazil**	Quasi-experimental single group, pre–post-test To evaluate the performance of nursing undergraduates on administration of vaccines in the vastus lateralis thigh muscle in paediatric clients	**n = 39** **mixed second and third year**	STANDARD: NSQHS **Medication safety** **MEASURES: Author developed 21-item knowledge test with Kappa Fleiss test = 0.73**	MODALITY: Virtual simulations–computer based SCENARIOS: Medication preparation (vaccine) Medication administration (pediatric vastus lateralis) Hand Hygiene	**Significant knowledge gain pre-test M = 12.5 post-test 17.4 (p = 0.0001).** **Of 39 participants, 94.9% had a higher score in the post-test.**

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Table 2 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Hart et al., 2014 USA	Quasi-experimental, single group, repeated-measures design. To evaluate the effectiveness of simulation training in improving students' performance in managing cardiac deterioration.	n = 48 39 juniors 9 seniors	STANDARDS: NSQHS Deterioration - managing and responding to QSEN Teamwork and collaboration. **Used Laerdal Medical Simulation[3]** **MEASURES:** Validated Emergency Response Performance tool (ERPT) A patient outcome tool	MODALITY: high-fidelity manikin simulations SCENARIOS: Laerdal's cardiac scenarios–3 scenarios depicting various stages of cardiac arrest	Performance scores for chest compressions, bag-valve-mask ventilation with high-flow oxygen and electrical intervention increased significantly from a mean of 51.0 at preintervention to M=89.3; p= 0.035) at mid-intervention. Performance scores were significantly improved from preintervention to postintervention (p = .01). NB not clear if electrical intervention is defibrillation or cardioversion
Kim & Chun, 2022 **South Korea**	Quasi-experimental, single group pre-post-test To evaluate a virtual reality blended learning program developed for nursing students.	**n = 82** **second year**	STANDARD: NSQHS Communicating for Safety **Preventing and controlling infection** **MEASURES: Patient Safety Management scale for hospital employees**	MODALITY: Virtual reality and wearable simulated devices SCENARIOS: Intravenous cannulation, mobilizing with intravenous fluids, urinary catheterization breast exposure for procedure	**Patient safety scores (pretest M = 44.5, post M = 45.0, post-test M = 46.5, (p = .005).** **Communication scores between the three timed intervals were not significant.**
McCormick et al., 2013 **USA**	Quasi experimental, two-group with comparative pre–post-test To determine the effect of simulations on students' knowledge regarding care of patients with Parkinson's disease.	**n = 84** **final year** **group numbers not reported** **Both groups completed readings and were provided tools to assess patients with Parkinson's** **Control group received a lecture intervention** **group experienced the simulation**	STANDARD: NSQHS Deterioration- managing and responding **Comprehensive care** **MEASUREMENTS:** **purposively developed 10 item tool measuring changes in knowledge (no psychometric properties reported)**	MODALITY: Manikins- low and high fidelity SCENARIOS: Neurology (Parkinson's disease)	**The traditional teaching group and the low-fidelity case study group had significant increases in knowledge in post-test scores (p = .40), The low fidelity case study group had significantly higher (p = .31) post-test scores compared with the traditional teaching group.**

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Table 2 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Merriman et al., 2014 **UK**	Randomised controlled trial with single-blinded pre–post-observational performance assessments. To evaluate the effectiveness of clinical simulation compared with classroom teaching in teaching the assessment of the deteriorating patient.	n = 34 first year n =15 intervention group received simulation n = 19 control group normal lecture	STANDARD: NSQHS Deterioration- managing and responding to MEASUREMENT Observational OSCE performance assessments	MODALITY: high fidelity manikin SCENARIO ABCD assessment of 'patient' and facilitator feedback	Participants in both groups significantly improved performance post OSCE ($p < .05$).
Padilha et al., 2019 Portugal	Randomized controlled trial with pre-post-post-tests To evaluate the effectiveness of virtual simulation on nursing students' knowledge retention, clinical reasoning, self-efficacy, and satisfaction with the learning experience.	n = 42 Second year n = 21 control group manikin n = 21 intervention group virtual simulator	STANDARDS: NSQHS Deterioration - managing and responding to **Used** BodyInteract™ simulation **MEASURES: knowledge test, not well described**	MODALITY: Virtual reality simulator Low fidelity manikin SCENARIOS: Respiratory	All students gained significant knowledge at post-test (t40 = −3.656; $p = .001$) and at two months post-post-test (t40 = −2.439; $p = .02$). Changes were more significant in intervention group and maintained a 20.4% improvement after two months.
Prentice and O'Rourke 2013 **Canada**	Quasi-experimental, single group, pre-post-test. To increase student nurses' knowledge and skills in caring for clients receiving blood transfusions.	**n = 19 second year**	STANDARD: NSQHS **Blood management** **MEASURES: Purposively developed nine-item tool measuring preparation for simulation, anxiety during simulation, blood transfusion reaction knowledge and satisfaction with learning (no psychometric properties reported).**	MODALITY: High fidelity manikin SCENARIOS: Blood transfusion–three di**fferent transfusion reactions**	**Pretest scored 4.3 of 10. Post-test average was 7.3 of 10.** **Manikin simulation may improve students safe care of patients experiencing blood transfusion.**
Prince et al., 2016 **USA**	Quasi-experimental, single group, pre-post-test with descriptive items. To determine baccalaureate nursing students' perceptions of a multiple-patient simulation experience.	**n = 52 final year**	STANDARD: QSEN Patient centred care **MEASURES:** **Faculty developed pre-post-test 12 item quiz measures** **safe patient care (deterioration, planning /adapting care) Cronbach α = 0.754-0.871**	MODALITY: Manikin SCENARIOS: Endocrine (diabetes) Surgical (postoperative partial gastrectomy) Respiratory (chronic obstructive pulmonary disease.	**Recognising symptoms, planning appropriate care and modifying care returned positive mean changes M = 3.52-4.18; pretest and M =3.98-4.42, post-test. Student perceptions confirmed the simulations enabled them to prioritise patient care.**

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Table 2 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Soledad & Ramirez, 2018 **Chile**	Quasi-experimental, two group pre-post-test with descriptive items. To compare simulation and self-instruction on nursing students' understanding of standard infection precautions and disease transmission.	**n = 98 second year** Both groups received the simulation n = 49 intervention group completed self-instruction using provided and self-accessed library resources. n = 49 control group, traditional lectures.	STANDARD: NSQHS **Preventing and controlling infection MEASURES: purpose built tool validated by three content experts to assess student knowledge of infection control and disease transmission.**	MODALITY: low fidelity manikin SCENARIOS: infected surgical site	**Intervention group returned significant improvement in the knowledge post-test ($p = .002$) and for the qualitative items ($p = .043$) compared to the control group. Simulation scenarios combined with self-instruction may be useful for learning components of infection control**
Saastamoinen et al., 2022 **Finland**	Randomised control trial with pre-post-test. To determine the use- fulness of 3D simulation games in learning medication administration.	**n = 123 mixed year levels n = 71 intervention group, simulation n = 52 control group read material online**	**STANDARD: NSQHS Medication Safety MEASURES: Author designed 56 item knowledge test on medication administration**	MODALITY: Serious game SCENARIOS: Medication administration	**Theoretical knowledge increased significantly post-test in intervention group M = 67 and control group M = 50 ($p = < .001$). Most increases were in patient identification and medication allergies knowledge. Using the serious game alone was reported as not the right modality for teaching safe medication administration.**
Sarvan & Efe, 2022 **Turkey**	Randomized control trial with pre-post-tests. To determine the impact of serious game simulation (SGS) on neonatal resuscitation skills.	**n = 90 final year nursing students** n = 45 Intervention group simulation n = 45 control group lectures/skills videos.	STANDARD: NSQHS Deterioration- managing and responding to QSEN evidence based practice **Faculty designed skills and knowledge tool based on European National Resuscitation Standards**	MODALITY: Serious game SCENARIOS: neonatal resuscitation	**Intervention group returned significant positive differences in ventilation and chest compression skills ($p = .011$) compared to the control group ($p = .020$).**

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Table 2 (continued)

Author/Year/ Country of Origin	Study Design/Aim	Nursing Student Sample	Safety Standard/ NSQHS/QSEN or Other Measures	Simulation Topic/Modality/Scenario Description	Results /Recommendations
Stuart et al., 2021 **USA**	Quasi-experimental, two-group study, pre-post tests To evaluate a simulation on students learning handover and triaging.	**n = 69 senior nursing students group number not reported** **One group received knowledge prompts and one group received questions.**	**STANDARD: NSQHS Communication for Safety QSEN Teamwork and Collaboration** **Author designed tool assessing SBAR and triage knowledge.**	MODALITY Computer based simulation SCENARIO Trauma-two (triage and handover)	Triage group Pretest M = 51.6, post-test M = 49.3. No change in Prompting group Pre and Post M = 53. SBAR test score returned M = 75.5 question group and M = 74.6 prompt group. No post-test was reported.
Unsworth et al., 2012 **United Kingdom**	Qualitative study To understand participant perceptions of manikin simulation to recognize and appropriately manage physical deterioration in mental health patients	**n = not reported (final year nursing students)**	**STANDARD:** NSQHS Deterioration- managing and responding to **A lecturer designed Objective Structured Clinical Examination (OSCE) rubric assessed students' problem identification, physical assessment and ability to determine a differential diagnosis.**	MODALITY Sim Man manikin SCENARIO alcohol intoxication drug induced psychosis chest infection in a patient with Alzheimer's dementia	**Participants valued the experience for recognising and managing deteriorating patients. Students reported scenario realism and lecturer support is key to student engagement and successful learning**
Wilson et al., 2014 **USA**	**Quasi-experimental, single group, crossover design.** **To determine the difference in clinical reasoning and communication skills learning with computer-based simulation scenario compared with a manikin.**	n = 54 final year nursing students	STANDARD: NSQHS Comprehensive care Faculty designed rubric informed by SBAR (situation, background, assessment, recommendations).	MODALITY Lab-based with manikin and VS (computer simulation) SCENARIO: Acute care-3 Sepsis (was the only named scenario)	Manikin simulation was significantly more effective than computer simulation for developing students SBAR assessment and clinical reasoning skills [$t(47) = 2.08$; $p < .05$] and recommendation [$t(47) = 4.79$; $p < .001$].

Simulation Education Outcomes: Other Safety Standards

In addition to the patient safety elements described above, studies described teaching students "Communicating for patient safety," "Medication safety," "Blood management" and "Preventing/controlling infections." A total of 13 simulation studies were identified in these categories, some of which taught across more than one safety category (see Table 1 and 2). Foster et al. (2019) conducted an integrative review of literature on team communication based on the TeamSTEPPS communication model. Costa et al. (2019) taught medication safety through computer-based virtual simulations of intramuscular injections of vaccines for children, plus hand hygiene, with positive gains in knowledge and in Objective Structured Clinical Exam (OSCE) rated performances ($p < .0001$). Coskun and Sendir (2022) compared two methods of teaching intramuscular injection via simulation in the category "Blood Management"; the only study that reported no change in knowledge at post-test. Prentice and O'Rourke (2013) taught blood management through a high-fidelity manikin experiencing three separate blood transfusion reactions. The students' knowledge scores increased from an average 4.3 of 10 to 7.0. Patient safety scores reported by Kim and Chun (2022) increased significantly at post-test ($p = .005$) when teaching infection control via a blended learning programme with virtual reality simulations; intravenous cannulation, managing mobilising with intravenous fluids, and urinary catheterisation.

The results for SBE teaching various elements of patient safety consistently show positive gains in students' knowledge and/or skills after the interactive patient care activities.

Discussion

This review intended to produce evidence on the use of SBE to teach nursing students patient safety elements and understand the safety elements taught and what simulation design standards or frameworks were used.

Impact on Nursing Students Safety Knowledge and Performances of Safe Patient Care

Studies suggested participants' patient safety knowledge and performances improved post SBE. Of 33 included studies, almost all identified significant gains. The experimental randomised studies, in particular, reported significant knowledge gains at post-test, compared with a control group. A second key finding was that students' performances of safe patient care could also be improved. Our findings confirm many studies reporting SBE is favoured for positive knowledge change and increased skills proficiency in healthcare students (Cant & Cooper, 2017; Cant et al., 2023). A recent review extends the positive impacts of SBE, to include behaviour changes in students learning from virtual reality and computer-based simulations (Phillips, Harper, & DeVon, 2023).

One-third of studies (n= 10) coupled knowledge tests with measuring students' performance. Among these, three utilised an observer-based OSCE to evaluate clinical skills (Cooper et al., 2015a; Merriman et al., 2014; Unsworth et al., 2012). Four virtual simulation studies extracted web-based performance data (Borg Sapiano et al., 2018; Cooper et al., 2015b; Cooper et al., 2017; Sparkes et al., 2016). Another study by Padilha et al. (2019) used BodyInteract (2023) a commercial virtual reality nurse education program with virtual patients which also reported performance feedback. The only longitudinal study, observed a lapse in performance part way through, however overall there were positive changes in students' safe medication administration (Schneidereith, 2021). As teaching of patient safety elements aims to help develop students' skills, performance data is a key component that should be considered for inclusion in future research designs. What requires more attention now is studies that investigate this performance and whether improved safety knowledge was retained when students' were on clinical placements.

The patient safety standards and competencies used in included patient safety simulations

This review confirms nursing students are taught to perform and understand safe patient care practices, across six common safety standards (medication safety, communication, deteriorating patient, infection control, comprehensive care and blood transfusion management). The topic remains of global interest to nursing education (Mariani et al., 2015), with studies originating in 15 countries. More than 38 different scenarios were identified including skills ranging from handwashing to the more complex skills required to care for patients experiencing cardiac, respiratory and post-operative deterioration (see tables 1 and 2). Patient deterioration was the most common, featuring in nearly half of the 33 reviewed studies. There was less of an emphasis on communicating for patient safety. This is concerning, given communication errors commonly place healthcare consumers at great risk (AHRQ, 2023). Another obvious oversight was the lack of teaching sepsis, an international patient safety concern, often caused by poor healthcare worker infection control practices (World Health Organization, 2023). Only two early studies featured the condition (Liaw et al., 2011; Wilson et al., 2014). Most study participants were senior level students. The most common modality used was face to face manikins. Whilst virtual simulations and virtual reality featured (combined, representing 15 of 33

Table 3 – Australian Safety and Quality of Healthcare Standards Cross-Tabulated With Frequency of Studies Reporting Patient Safety Elements Taught to Nursing Students Using Simulation-Based Education

The NSQHS standards related to nursing practice [1]					
Recognising and Responding to Acute dDeterioration	**Blood Management**	**Communicating for Safety**	**Medication Safety**	**Preventing and Controlling Infections**	**Comprehensive Care** (*Nursing Assessment, Care Planning, Minimising Harm*)**.**
√√√√√ √√√√√ √√√√√	√√√	√√√√	√√√√√√	√√	√√√√√√

Note. Table aligns the 33 reviewed studies to the Australian National Safety and Quality Health Service [NSQHS] Standards (2023). Each symbol represents one study, even though many studies included multiple serial simulations (e.g., see patient deterioration studies). Four studies taught across more than one category. Of the eight Australian National Safety and Quality Health Service standards, 'Clinical governance' and 'Partnering with consumers' were omitted, as they are directed at leaders of health service organisations and considered not relevant to this review.

studies), the use of artificial intelligence (Robert, 2019), telemedicine and telehealth (Bouamra et al., 2021), also compatible with SBE, did not feature.

Most studies originated from USA (11) and Australia (6), two countries with large published bodies of work on patient safety standards (NSQHS, 2023) and nursing patient safety competencies (QSEN, 2023). Both of these works provide broad definitions of patient safety, with the lack of detail potentially impacting teaching of patient safety. One body of work not identified is the Patient Safety Competency Framework (PSCF) for nursing students. PSCF was designed to guide nursing education to embed patient safety standards that are more appropriate for student nurses, Levett-Jones et al. (2023). The nine included standards are evidence based and similar to the QSEN and NSQHS (Guinea et al., 2019).

We suggest the review evidence could inform scaffolding of SBE across the three year nursing curriculum, aligned to year level skills proficiency. First improving use of the patient safety guidelines developed for nursing education could be considered.

The simulation design standards used in included patient safety simulations.

Less than half (14 of 33) of the included articles cited using formal design standards; extending a recent scoping review that use of evidence-based standards in virtual simulations are not closely followed and rarely, if ever, reported (Violato, MacPherson, Edwards, MacPherson, & Renaud, 2023). However our results indicate no negative impact on learner knowledge and performance gains; nearly all included studies reported significant positive changes. Only two quasi- experimental studies did not (Coskun & Sendir, 2022; Stuart et al., 2021). While it is acknowledged that simulation developers most likely use some form of evidence base to design the simulations, this cannot be assumed. Omitting to report use of evidence-based design standards means researchers and educators may struggle to understand how scenarios were administered, including student preparation, feedback, and debriefing. Further, not following best practice poses risks to learners. One emerging area of risk is learner psychological safety, negatively impacted by participant lack of preparation for and expert debriefing following, SBE (Kolbe et al., 2020; Roh, Jang, & Issenberg, 2021).

Prebriefing, feedback, debriefing and other simulation best practices are described and have been available for nearly two decades (Arthur et al., 2013; Jeffries & Rizzolo, 2023). In fact, 2023 marks 20 years since INACSL first formed and began developing earlier versions of the Healthcare Standards for Simulation Best Practice (INACSL, 2023). For all the reasons listed, the apparent under reporting of formal simulation design evidence-based practices requires immediate investigation. We do recommend that rigourous study designs including RCT, longitudinal studies and measuring students' performance and knowledge gains on clinical placement settings are the first next steps.

Limitations

The exclusive use of English language articles may have limited the perspectives included. Simulation based education is rapidly evolving and despite choosing a broadly inclusive review method studies may have been missed. Conducting a systematic review could be a next logical step. The research evidence available was limited, with mostly single-group and uncontrolled studies. Identified studies were not evenly distributed across all published safety elements, potentially indicating a bias towards patient deterioration.

Conclusion

Simulation-based learning is useful for teaching preregistration nurses patient safety knowledge and practice. Almost all (31 from 33) included studies showed students gained knowledge and/or skills performance across

six published safety standards, via more than 38 SBE scenarios, taught using five simulation modalities. Yet there is an identified need for well-designed, experimental studies with a control group, to determine the impact of patient safety SBE on nursing students' authentic clinical practice.

Reported SBE tended to favour teaching safe patient care through scenarios designed for students to manage and respond to deteriorating patients. Safety elements of communication and infection control were not as apparent, while others such as nursing informatics rarely featured. Additionally, most studies lacked reporting use of evidence-based simulation design standards, although the apparent oversight has not greatly impacted gained safety knowledge and demonstration of safer patient care, post intervention.

Enhancing the quality and effectiveness of preregistration patient safety SBE through aligning scenarios to patient safety standards and simulation design best practice is key. Without reporting use of evidence-based practices, in simulation design and implementation, there is risk SBE may fail both learners and healthcare consumers.

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