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REVIEW

Influence of simulation design on stress, anxiety and self-confidence of nursing students: Systematic review with meta-analysis

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Abstract

Aim: To evaluate the simulation design characteristics that may influence the stress, anxiety and self-confidence of undergraduate nursing students during learning.

Design: Systematic review with meta-analysis.

Data Sources: Searchers were conducted in October 2020 and updated in August 2022 in the databases CENTRAL, CINAHL, Embase®, ERIC, LILACS, MEDLINE, PsycINFO®, Scopus and Web of Science, PQDT Open (ProQuest), BDTD, Google Scholar and specific journals on simulation.

Review Methods: This review was conducted according to the recommendations of Cochrane Handbook for Systematic Reviews and reported according to the PRISMA Statement. Experimental and quasi-experimental studies that compared the effect of simulation on stress, anxiety and self-confidence of nursing students were included. The selection of studies and data extraction was performed independently by two reviewers. Simulation information was collected as prebriefing, scenario, debriefing, duration, modality, fidelity and simulator. Data summarization was performed by qualitative synthesis and meta-analytical methods.

Results: Eighty studies were included in the review, and most reported in detail the structure of the simulation, contemplating prebriefing, scenario, debriefing and the duration of each step. In subgroup meta-analysis, the presence of prebriefing, duration of more than 60 min and high-fidelity simulations helped reduce anxiety, while the presence of prebriefing and debriefing, duration, immersive clinical simulation modalities and procedure simulation, high-fidelity simulations and use of mannequins, standardised patients and virtual simulators, contributed to greater students' self-confidence.

Conclusions: Different modulations of simulation design components imply reduction of anxiety and increased self-confidence in nursing students, especially highlighting the quality of the methodological report of simulation interventions.

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Relevance to Clinical Practice: These findings help to support the need of more rigorous methodology in simulation designs and research methods. Consequently, impact on the education of qualified professionals prepared to work in clinical practice. No Patient or Public Contribution.

KEYWORDS
anxiety, nursing, nursing education, self-confidence, simulation

1 | INTRODUCTION

Simulation as a pedagogical strategy allows students to experience varying clinical challenges safely through scenarios representing reality with simulated patients (INACSL Standards Committee, 2021c). The World Health Organization (2013) and Pan American Health Organization (2022) recommend simulation-based learning (SBL) due to its educational advantages for the training of nurses and general health professionals (de Góes et al., 2017; Eyikara & Baykara, 2017; Ha, 2018; Nye et al., 2019; Oh et al., 2015).

Rigorous standards of best practice for simulation have been identified in the literature as necessary to achieve the learning outcomes and reach the educational potential with SBL, especially when adopting recommendations for design and facilitation of the simulation, enabling scientific research on the subject (INACSL Standards Committee, 2021a, 2021c).

Thus, the success of simulation as a teaching strategy begins with the planning of the activity, including the following characteristics: 1. That the scenario is compatible with reality—motivating the participant to engage in problem solving (Gamble, 2017); 2. That the resolution of the challenge is based on scientific results and up-to-date information on the subject, strengthening evidence-based practice (Alexander et al., 2015); 3. That the organisation of the simulated experience and facilitator mediation are compatible with learning objectives and promote student's psychological safety (INACSL Standards Committee, 2021b).

In this sense, developing positive SBL experiences requires the use of instructional design, and access to resources (e.g. didactic materials like lectures, readings, videos) used to guide the creation of learning situations focused on the development of knowledge, skills and attitudes (Chiniara et al., 2013; de Melo et al., 2017; Fransen et al., 2018; Sagalowsky et al., 2018). The pedagogical planning of the educator/facilitator includes developing the learning experience and determining the method and strategies to achieve the learning objectives (INACSL Standards Committee, 2021b). The planning of SBL considers the standards of best practice, protocols and guides, and is referred to as simulation design (INACSL Standards Committee, 2021c; O'Donnell et al., 2014).

Researchers have addressed different classifications, concepts and characteristics of simulation design that can be used in health and nursing education. Extensive references exist to support educators in the development and structuring of SBL appropriate to the desired learning and objectives (Arthur et al., 2013; Chiniara et al., 2013; INACSL Standards Committee, 2021c; Issenberg et al., 2005; O'Donnell et al., 2014; Paige & Morin, 2015).

What does this paper contribute to the wider global community?

- Simulation is an effective pedagogical strategy to reduce anxiety and increase self-confidence related to the different designs adopted.
- When developing simulations from the point of view of instructional design, greater impacts can be achieved on learning outcomes.
- Simulations developed to achieve greater learning outcomes impact better qualified professionals.

Considering the different SBL designs, it is theorised that the strategy chosen can have a different impact on the emotions experienced by students during the activity. This may happen, as researchers have shown that emotions have an important impact on the success of the activity, as neuroscience brings together positive emotions of learning (Vogel & Schwabe, 2016). This is exemplified in the variation of stress and anxiety levels that can lead to a warning (e.g. pay closer attention) or harm (e.g. to the processing of information) in students' reaction (Al-Ghareeb et al., 2017, 2019).

Thus, in simulation activities, stress and anxiety are not always negative, as they contribute to good performance (Al-Ghareeb et al., 2019). However, high levels of stress (the body's physiological response to an event) or anxiety (self-perceived psychological response resulting from the physiological response; Ghazali et al., 2016) can negatively impact the performance of simulation participants (Al-Ghareeb et al., 2017).

In addition, considering that self-confidence is the conviction that a person has of being able to do or accomplish something (Bandura, 1986; Lundberg, 2008) and is directly related to learning and clinical decision-making (Fry & MacGregor, 2014; Groom et al., 2014; Oliveira Silva, Fonseca, et al., 2022; Oliveira Silva, Oliveira, et al.,2022), understanding aspects of simulation design that best impact this competence can help in the elaboration of SBL for the best achievement of learning outcomes, consequently, impacting on the training of better qualified nurses. In this study, we adopted the recommendation of O'Donnell et al. (2014) to treat self-confidence and self-efficacy as synonymous; thus, to both concepts we used the term self-confidence.

Additionally, we theorise that different simulation designs can influence the student's emotional self-regulation, consequently influencing the learning outcomes. It is mostly based on the psychological fidelity and pedagogical approach used by facilitators, which will be discussed further in this text. Therefore, this study is based on the concept framework of instructional design, which is a systematic procedure for designing the learning experience, carried out by the professor and influenced by the student's motivation for the teaching-learning process (Seel et al., 2017).

Based on this framework, a scoping review identified three major groups of simulation design components (structural, methodological and theoretical-pedagogical) (Oliveira Silva, Fonseca, et al., 2022; Oliveira Silva, Oliveira, et al.,2022), so the focus of this systematic review is to identify the influence of structural components, such as the presence of prebriefing and debriefing, duration, modality, fidelity and type of simulator on stress, anxiety and self-confidence outcomes.

In preliminary searches on PROSPERO (International Prospective Register of Systematic Reviews), Cochrane Database of Systematic Reviews, CINAHL (Cumulative Index to Nursing and Allied Health Literature), JBI Database of Systematic Reviews and Implementation Reports and MEDLINE via PubMed (Medical Literature) Analysis and Retrieval System Online, we found no other systematic reviews or registered protocols that evaluated the effect of simulation design on the stress, anxiety and self-confidence of nursing students. Also, the available reviews only emphasise the use of high-fidelity simulators (La Cerra et al., 2019; Labrague et al., 2019), lacking investigation of other simulation design characteristics. Considering that the simulation design can influence the learning results, the present review can point out important results in the elaboration of SBL.

2 | AIM

The aim of this study was to evaluate the characteristics of simulation design that could influence the stress, anxiety and self-confidence of undergraduate nursing students during learning.

3 | METHODS

3.1 | Design

This systematic review was conducted according to the recommendations of Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2022) and reported according to the Preferred Reporting Items for Systematic Reviews and Metanalyses (PRISMA) Statement (Page et al., 2021; see Appendix S1). This study answers the second question of the systematic review protocol registered in the Prospective Register of Ongoing Systematic Reviews (PROSPERO) (registration number PROSPERO 2020 CRD42020206077).

3.2 | Research question and eligibility criteria

The acronym PICOS (Patient/Population, Intervention, Comparison, Outcomes, Study Type) (Hastings & Fisher, 2014) was used to elaborate the research question, where:

P: undergraduate nursing students in any period of the program or discipline;
I: SBL of any kind;
C: educational interventions or without intervention in the comparator;
O: stress, anxiety and self-confidence;
S: experimental and quasi-experimental studies.

Based on the acronym, the following research question was elaborated: *What is the impact of the characteristics of simulation design on stress, anxiety and self-confidence of undergraduate nursing students compared to another or no educational intervention?*

As inclusion criteria we considered experimental and quasi-experimental studies with comparison group, no limitation of time, published in English, Portuguese and Spanish, and that presented stress, anxiety and/or self-confidence/self-efficacy as outcomes. Were excluded those studies with qualitative assessment of outcomes; through unvalidated instruments or unique questions with Likert-type scales, as well as systematic, integrative, or narrative reviews, conference proceedings, opinion studies, books and editorials.

For those inaccessible studies and clinical trial records, we contacted the authors to obtain the manuscript, so that when contact was unsuccessful, the study was excluded related to inaccessibility or unavailability. All clinical trial records were screened to identify previously published results. Those studies still in progress and without published results were excluded.

3.3 | Search methods

Central Database (The Cochrane Central Register of Controlled Trials - The Cochrane Library), CINAHL (Cumulative Index to Nursing and Allied Health Literature), ERIC (Education Resources Information Center), LILACS (Scientific Literature and Latin America and Caribbean technique), MEDLINE (Medical Literature Analysis and Retrievals System Online), PsycINFO®, Scopus (Elsevier) and Web of Science were included as databases to identification of the studies. Additional searches were performed on Google Scholar, considering the first 200 references by order of relevance (Bramer et al., 2017), PQDT Open (ProQuest), Brazilian Digital Library of Theses and Dissertations (BDTD), references of the included studies and journals about simulation.

For each item of the acronym PICOS, standardised and non-standard descriptors were established. MeSH (Medical Subject Headings), DeCS (Health Descriptors) and Emtree (Embase subject headings) terms were included as standardised descriptors. Non-standardised descriptors were found in titles, abstracts

and keywords of articles on the subject, identified in preliminary searches. To bring more specificity to the search, tags were incorporated into the search syntax to signal the descriptors (e.g. '[MeSH Terms]' on PubMed; 'MH' on CINAHL; 'mh:' on LILACS).

The searches were carried out in October 2020, and the review was updated in August 2022. In both stages, the searches were carried out independently by two researchers. Search strategies were established for each database (see Appendix S2).

3.4 | Study selection and data extraction

From the records identified in the search, a database was prepared in the software for reference management EndNote version 20. Then, the database was imported to the Covidence systematic review management software (Veritas Health Innovation, 2022) to allow for identification of duplicate records and the beginning of the studies selection process.

The first step of the study selection was the assessment of titles and abstracts (screening), and the second was the full-text evaluation (confirmation). The articles and dissertations/thesis included in this review were selected by peer evaluation. Disagreements were resolved by a third reviewer. Good agreement was obtained between the reviewers both in the screening step (kappa = 0.75) and confirmation step (kappa = 0.75).

For data extraction, an instrument based on INACSL standards (INACSL Standards Committee, 2021c) and Chiniara et al. (2013) simulation framework was elaborated to identify the description of simulation design components in each study. The data extraction form was prepared in Covidence containing items related to the prebriefing, debriefing, duration, modality, fidelity, scenario and simulator. In the present study, we defined these items as structural simulation design components, understood by the authors as the fundamental characteristics necessary for the elaboration of SBL.

For each outcome, sufficient data were collected to carry out the meta-analyses, such as sample size, means and standard deviations. In studies with missing data, minimal information necessary to obtain measurements was extracted by other methods, such as p-value.

3.5 | Quality appraisal

The Revised Cochrane Risk of Bias Assessment for Randomized Trials (RoB 2) was used to assess the methodological quality of experimental studies (Sterne et al., 2019). The tool is based on five criteria: bias due to deviations from predefined interventions, bias due to deviations from intended interventions, bias in the assessment of lack of outcome interventions, bias in selection of the randomization process and bias in selection of outcome error. The final assessment is classified as high risk of bias, some concerns or low risk of bias.

To assess the methodological quality of quasi-experimental studies, the Risk of Bias in Non-randomised Studies—of Interventions tool (ROBINS-I tool) was used (Sterne et al., 2016). The tool is based on seven criteria: bias due to confounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes and bias in selection of the reported result. The final assessment is classified as low risk of bias, moderate risk of bias, severe risk of bias, critical risk of bias and no information. The risk of bias plots were generated from the *robvis* package of the R software (McGuinness & Higgins, 2020).

The assessment of the risk of bias in the included studies was realised by two independent researchers. Disagreements were solved by a third researcher.

3.6 | Synthesis and analysis of data

The summarization of the findings was performed by qualitative and quantitative synthesis. In qualitative synthesis, a table was made with the descriptive summary of the results and the simulation design components reported in each study. In quantitative synthesis, global and subgroup meta-analysis was used to evaluate the effect of interventions on outcomes based on the simulation design components.

The software R (version 4.3.1) and RevMan (version 5.4.1) were used to conduct study analysis. For meta-analysis, models of inverse of the variance were adopted to determine the weight of each study. A random-effects model was used due the heterogeneity of the population (Harrer et al., 2021). For those studies that did not present any measure of interest, such as mean and standard deviation, methods were used to obtain missing data. Thus, mean and standard deviation obtained from the median and *p*-value and standard deviation obtained from the *p*-value. To evaluate the magnitude in the differences between the groups, Cohen classification was adopted for the standardised mean difference (Borenstein et al., 2009a). Also, the standardised mean difference for estimates was adopted, and I^2 was used to calculate heterogeneity (Borenstein et al., 2009b). The estimates reported in the present study were carried out after exclusion of identified outliers from the sensitivity analysis (Baujat et al., 2002).

As a criterion for the inclusion of studies in the meta-analyses for each outcome, we established a minimum of 10 studies, considering this the amount necessary to perform analyses by subgroup (Schwarzer et al., 2015), which for this study were essential for the investigation of the effects of the simulation design components. For each component, scores of 1 point when reported and 0 when not reported were assigned (minimum 0 and maximum 7 points). Thus, the global meta-analyses were ordered according to the number of components reported in the studies. Subgroup analyses were conducted according to the structural components of the simulation identified in the included studies. Publication bias was assessed though the funnel plots (Rothstein et al., 2006).

Considering that combining studies in simulation may not present homogeneity in the results due to the different educational

contexts, simulation designs and the decision-making of the student in the strategy, we decided to carry out the meta-analyses even with the high heterogeneity and explore their sources through subgroup and meta-regression analyses (Harrer et al., 2021). A bilateral alpha of 0.05 was defined for statistically significant results.

4 | RESULTS

The total number of records identified via databases, registers and additional searches was 1805. After removing 701 duplicates records, 1104 studies were evaluated in the screening stage, with 378 eligible for reading the full texts. At the elegibility stage, 284 records were excluded and 80 studies were included in the final review sample, with 68 studies eligible for meta-analysis (Figure 1).

4.1 | Methodological quality

Methodological quality assessment was performed separately for experimental and quasi-experimental studies. Among the experimental studies, 11 (33.3%) had a high risk of bias, while 9 (27.2%) had some concerns and 13 (39.4%) had a low risk of bias. The biggest sources of bias were related to the selection of reported results, missing data and the randomization process. Among the quasi-experimental studies, 9 (19.1%) had a critical risk of bias, 10 (21.2%) had a serious risk of bias, and 27 (57.4%) had moderate risk. The biggest sources of bias were related to confounding, especially the lack of homogeneity in the groups, the selection of participants and the measurement of outcomes. The detailed risk of bias for each study is presented in Appendix S3.

4.2 | Characterisation of the included studies

This review included a global sample of 5972 nursing students, with studies conducted in the regions of Americas (42.5%; $n = 34$), Asia (28.5%; $n = 23$), Middle East (21.2%; $n = 17$), Europe (5%; $n = 4$), Africa (1.2%; $n = 1$) and a multicentre study conducted in America, Europe and Australia (1.2%; $n = 1$). Thirty-four studies (42.5%) had the experimental design, and 46 (57.5%) had quasi-experimental design.

Regarding the simulation structure (prebriefing, simulated scenario and debriefing), 46 studies (57.5%) highlighted the phases and time spent in each, 23 studies (28.7%) reported only the phases, without detail, and 11 studies (13.7%) did not specify the structure used in the strategy. In just 30 studies (37.5%), prebriefing or briefing was reported in the description of simulations, highlighting

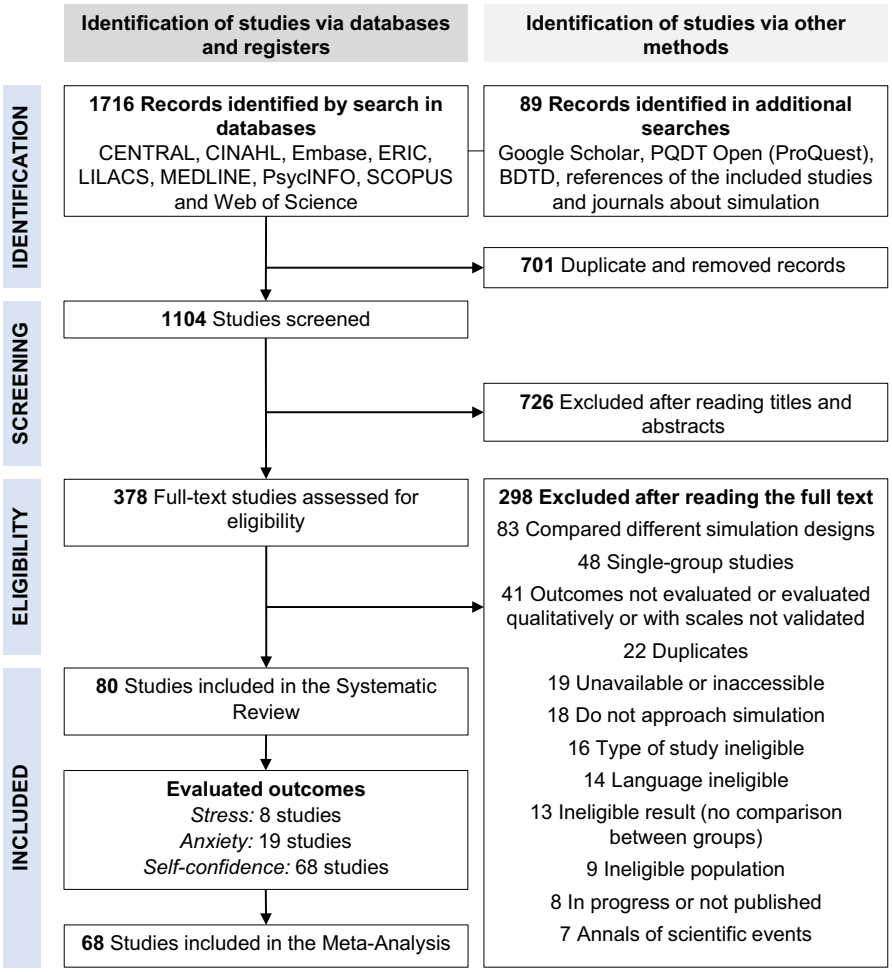

FIGURE 1 PRISMA flowchart for the selection of studies.

the scenario presentation stage to students, and supplying the first clues to assist decision-making in the simulated scenario. However, debriefing was described by most studies, totalling 59 (73.7%).

Regarding simulation characteristics, 57 studies (71.2%) used the immersive clinical simulation modality, 11 studies (13.7%) computer-based simulation, seven studies (8.7%) procedure simulation, three studies (3.7%) immersive clinical simulation associated with computer-based simulation and two studies (2.5%) did not specify the modality.

Regarding the fidelity, 42 studies (52.5%) used high-fidelity simulation, 10 studies (1.2%) mid-fidelity, five studies low-fidelity (6.2%) and 23 studies (28.7%) did not specify. As for simulators, in 43 studies (53.7%) human patient simulators were used, and of these 28 (35%) did not describe the simulator model used. In 11 studies (13.7%), standardised patients were used, and 12 studies (15%) adopted virtual simulators. The absence of this information is highlighted in 14 studies (17.5%).

The scenarios used in the simulations included various topics that were grouped in the areas: drug administration (5%; $n = 4$), emergencies (36.2%; $n = 29$), physical examination and vital signs evaluation (18.7%; $n = 15$), nursing procedures (26.2%; $n = 14$), various clinical scenarios (7.5%; $n = 6$), biosecurity measures (2.5%; $n = 2$), others (2.5%; $n = 2$) and not specified (2.5%; $n = 2$). The summarization of the characteristics of each study and the structural components of the simulation design is presented in Table 1.

4.3 | Effect of interventions

Global meta-analysis was performed for anxiety and self-confidence classifying estimates according to the number of simulation design components reported in the studies. Considering the small number of studies that evaluated stress ($n = 8$), it was not possible to evaluate the effect of simulation design in this outcome. In all studies included in the meta-analysis, anxiety and self-confidence were assessed using validated instruments immediately after the simulation. The sensitivity analysis showed the studies by Younghee (2015) and Tawalbeh (2017) as outliers for anxiety and self-confidence, respectively. Therefore, these studies were excluded from the meta-analyses.

The meta-analysis showed that studies with greater detail of the simulation design (≥6 components), the effect size was medium and significant suggesting that in these studies the anxiety was lower in groups that participated in the simulation ($d = -0.52$, 95% CI = −1.00 to −0.04, $p = .05$, $I^2 = 77\%$; Figure 2). For self-confidence, there were no differences related to the simulation design components, although effect sizes were higher the greater the detail of the simulation design (≥6 components: $d = 0.74$, 95% CI = 0.42–1.07, $p < .001$, $I^2 = 90\%$; between 4–5 components: $d = 0.59$, 95% CI = 0.26–0.91, $p < .001$, $I^2 = 89\%$; ≤3 components: $d = 0.43$, 95% CI = 0.19–0.67, $p < .001$, $I^2 = 0\%$; Figure 3).

The publication bias analysis through the funnel plots showed asymmetry for anxiety (Figure 4) and self-confidence (Figure 5) based on the simulation design components. These results suggest publication bias for the two outcomes.

4.4 | Subgroup analysis

Meta-analyses were performed based on the subgroups of the structural components of the simulation design, such as prebriefing and debriefing presence, activity duration, modality, fidelity and simulator type (Table 2). The highlights brought by the analysis of subgroups by structural components of simulation design suggest that there are changes in effect size as different ways of design simulation activities are adopted. As much as such changes do not imply changes between groups, they highlight positive effects of the different designs on anxiety and self-confidence within the group (intragroup).

However, it suggests that better results come from better described development and mediation path of simulation in the methodological step of the studies (highlighting the pedagogical rigour of the strategy). In this context, the presence of prebriefing, simulation activities lasting longer than 60 minutes and high-fidelity simulations obtained greater effect sizes, suggesting that these components contributed to students having less anxiety in simulation than in conventional teaching strategies.

Simulations with the presence of prebriefing and debriefing, regardless of duration, the immersive clinical simulation, procedure simulation, and computer-based simulation modalities, high-fidelity simulations and use of mannequins and virtual simulators, contributed to greater students' self-confidence in comparison with conventional teaching strategies.

In the subgroup analyses, a reduction in anxiety heterogeneity was evidenced in studies that used prebriefing ($I^2 = 53.3\%$) and low-fidelity simulations ($I^2 = 0.0\%$), while the use of standardised patient helped to reduce the heterogeneity of self-confidence ($I^2 = 64.5\%$). These findings are possibly associated with the greater similarity between these studies.

4.5 | Meta-regression

Meta-regressions were performed to identify possible sources of heterogeneity for anxiety and self-confidence and predictors of the effect size. For anxiety, were heterogeneity sources the simulation duration, explaining 21.3% [$F(\text{df} = 2) = 5.241$, $p = .072$, $R^2 = 21.33\%$], and the simulation fidelity [$F(\text{df} = 3) = 5.620$; $p = .131$; $R^2 = 18.07\%$], explaining 18% of the between-study heterogeneity, although they did not predict the effect size ($p > .05$). For self-confidence, the prediction of the effect sizes and the between-study heterogeneity was associated with the country of the study, explaining 40.9% of the heterogeneity [$F(\text{df1} = 14, \text{df2} = 47) = 3.955$; $p < .001$; $R^2 = 40.9\%$] and the simulation duration, explaining 8% [$F(\text{df1} = 2, \text{df2} = 59) = 3.666$; $p = .031$; $R^2 = 8.1\%$], with emphasis on the studies that did not describe the duration that most contributed to this

TABLE 1 Summary of the structural components of the simulation found in the studies included in the systematic review.

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Abu Sharour (2019)	Jordan	70	Immersive clinical simulation	High	Management of septic shock and chemotherapy infusion reaction	Patient simulator not specified	2 simulated scenarios (20 min) + debriefing (30 min)	Self-confidence; Self-efficacy
Ahn and Kim (2015)	South Korea	69	Procedure simulation	High	Medication administration and aspiration	METI® 3G	2 simulated scenarios (30 min) + debriefing (70 min)	Self-confidence
Akalin and Sahin (2020)	Turkey	107	Immersive clinical simulation	High	Essential nursing interventions for a pregnant woman with preeclampsia	Patient simulator not specified	Simulated scenario (15 min) + debriefing (30 min)	Self-confidence
Akhu-Zaheya et al. (2013)	Jordan	121	Immersive clinical simulation	High	Basic adult life support and automatic external defibrillator (AED) use	METI® version 6	Simulated scenario (15 min) + debriefing (10 min)	Self-confidence
Alamrani et al. (2018)	Saudi Arabia	30	Immersive clinical simulation	High	Interpretation of arrhythmia on the electrocardiogram	Patient simulator not specified	6 simulated scenarios (60 min) + debriefing (20 min)	Self-confidence
Alfes (2011)	United States	63	Immersive clinical simulation	High	Comfort interventions and pain management	Laerdal SimMan®	Video briefing (5 min) + simulated scenario (15 min) + debriefing (10 min)	Self-confidence
Arslan et al. (2018)	Turkey	247	Immersive clinical simulation	Not specified	Paediatric assessment, anthropometric measurement, vital signs, medication administration, and paediatric patient care practice	Patient simulator not specified	5 simulated scenarios (25–50 min)	Anxiety; Self-efficacy
Basak et al. (2019)	Turkey	71	Immersive clinical simulation	High	Teaching patients about the use of inhaled drugs	Standardised patient	Prebriefing + simulated scenario (20 min) + debriefing (40 min)	Self-confidence
Blum et al. (2010)	United States	53	Immersive clinical simulation	Medium	Health assessment skills development (unspecified)	Laerdal SimMan®	13 simulated scenarios + debriefing	Self-confidence
Boostel et al. (2018)	Brazil	52	Immersive clinical simulation	High	Change in vital signs and heart rhythm with evolution to atrial fibrillation	METIman®	Briefing (5 min) + simulated scenario (15 min) + debriefing (5 min)	Anxiety

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Bowling and Underwood (2016)	United States	73	Immersive clinical simulation	Medium	Paediatric assessment and care of a paediatric patient with respiratory distress	Patient simulator not specified	Briefing + simulated scenario (30 min) + debriefing (20 min)	Self-confidence
Brannan et al. (2008)	United States	107	Immersive clinical simulation	High	Care of the patient with acute myocardial infarction with diagnostic evaluation, pathogenesis and prevention, nursing care in the acute phase, nursing care during recovery	Patient simulator not specified	5 simulated scenarios (20 min) + debriefing (10 min)	Self-confidence
Brauneis et al. (2021)	United States	44	Immersive clinical simulation	Low	Safe medication administration	Patient simulator not specified	Prebriefing +3 simulated scenarios (60 min) + debriefing (15 to 20 min)	Self-confidence
Chang et al. (2021)	Taiwan	107	Computer-based simulation + Immersive clinical simulation	Not specified	Nursing process; nursing care to the patient with constipation; death	Simulation-based nursing process educational program (animation + standardised patient)	Animation (8 min) + simulated scenario (20 min) + debriefing	Self-confidence
Chang et al. (2022)	Taiwan	101	Computer-based simulation	Not specified	Scenarios based on complementary and alternative medicine (CAM)	Virtual simulator (CAM program app)	13 simulated scenarios (15–20 min)	Self-efficacy
Choi et al. (2020)	South Korea	131	Computer-based simulation	Medium	Interaction with patients in hallucinations, depressive symptoms, or suicidal ideation	ComEd program	Video briefing +5 simulated scenarios + video debriefing	Self-efficacy
Costa, de Medeiros, et al. (2020)	Brazil	94	Procedure simulation	High	Adult immunisation in the context of Primary Health Care	Standardised patient	Prebriefing (5 min) + simulated scenario (15 min) + debriefing (30 min)	Self-confidence
Costa, Medeiros, et al. (2020)	Brazil	34	Immersive clinical simulation	High	Vaccination nursing consultation in the context of community nursing	Standardised patient + low-fidelity simulator Not specified + Real patient trained for simulation	2 simulated scenarios (15 min) + debriefing (30 min)	Self-confidence

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Curtis (2015)	United States	60	Immersive clinical simulation	High	Congestive heart failure and asthma	Patient simulator not specified	2 simulated scenarios	Self-confidence
DiGiacomo (2018)	United States	68	Immersive clinical simulation	High	Management of postpartum haemorrhage	Noelle, Gaumard Scientific Company	Simulated scenario + debriefing	Self-confidence
Doğru and Aydın (2020)	Turkey	72	Immersive clinical simulation	High	Cardiac auscultation	Patient simulator not specified	Prebriefing + simulated scenario	Anxiety
D'Souza et al. (2020)	Oman	140	Immersive clinical simulation	High	Complications of diabetes (ketoacidosis)	Laerdal SimMan®	Prebriefing (1 h) + simulated scenario (30 min) + debriefing (1 h)	Self-confidence
Furr (2014)	United States	15	Immersive clinical simulation	Not specified	Care of patients with symptoms of schizophrenia, bipolar disorder, borderline personality disorder, and substance abuse	Patient simulator not specified	Not specified	Anxiety
Goldsworthy et al. (2019)	Canada	63	Immersive clinical simulation + Computer-based simulation	Medium	Recognition and response to the rapidly deteriorating adult and paediatric patient	Patient simulator not specified + Simulator Laerdal VSim®	Prebriefing (15 min) + 6 simulated scenarios (20 min) + debriefing (25 min)	Self-efficacy
Goldsworthy et al. (2022)	Canada, England, Scotland and Australia	88	Computer-based simulation	Not specified	Angina/cardiac arrest; anaphylaxis; acute exacerbation of asthma; COPD/pneumothorax, pulmonary embolism; and blood transfusion reaction	VSim® medical surgical suite (Wolters Kluwer Publishers and Laerdal Medical)	Briefing +4 simulated scenarios + debriefing	Self-efficacy
Gore et al. (2011)	United States	70	Immersive clinical simulation	Low	Nursing interventions focusing on personal hygiene, wound care, and medication administration	Patient simulator not specified	Pre-conference (30 min) + case discussion and care planning (30 min) + simulated scenario (120 min) + debriefing and guided reflection (60 min)	Anxiety
Haddeland et al. (2021)	Norway	158	Immersive clinical simulation	High	Clinical deterioration	Laerdal SimMan® 3G	Simulated scenario + debriefing	Self-confidence
Halloran (2018)	United States	137	Computer-based simulation	Low	Gastroenteritis and dehydration and in-hospital treatment of cystic fibrosis	ATI Real Life modules (ATI Testing, n.d.)	Introductory video (4 min) + 2 simulated scenarios (~45 min)	Anxiety

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Hensley (1996)	United States	15	Immersive clinical simulation	High	Vaginal bleeding during pregnancy, preterm labour, hypertension in pregnancy, postpartum haemorrhage	Standardised patient	Briefing +4 simulated scenarios (20–30 min) + debriefing	Anxiety; Self-confidence
Hudder et al. (2021)	Canada	36	Computer-based simulation	Not specified	Assessment of the newborn's vital signs	Virtual simulator not specified	Simulated scenario + debriefing	Self-confidence
Huse (2010)	United States	47	Immersive clinical simulation	Low	Medication calculation and administration	Patient simulator not specified	Not specified	Self-confidence
Jang and Moon (2021)	South Korea	77	Immersive clinical simulation	Not specified	Patient care with increased intracranial pressure	Standardised patient	2 simulation sessions (2 h)	Self-confidence
Jang and Park (2016)	South Korea	80	Immersive clinical simulation	High	Clinical judgement in the care of patients with upper gastrointestinal bleeding	Patient simulator not specified	Pre-simulation team activity (60 min) + simulated scenario (20 min) + poststimulation (20 min)	Self-confidence
Jang et al. (2021)	South Korea	91	Immersive clinical simulation	High	Continuous bleeding in the mouth after brushing teeth	Patient simulator not specified	Simulated scenario (39 min) + Debriefing (30 min)	Self-confidence
Jarzemsky and McGrath (2008)	United States	85	Procedure simulation	Low	Assessment of vital signs, urinary catheterization, administration of intravenous medication, nasogastric tube	Not specified	5 simulated scenarios	Stress; Self-confidence
Jeong et al. (2022)	South Korea	65	Computer-based simulation	Not specified	Wearing Personal Protective Equipment in the context of COVID-19	Oculus Quest 2 (®Oculus) headset.	Orientation (5 min) + VR simulation (15 min) + debriefing (20 min)	Self-efficacy
Karahan OkuroĞLu et al. (2021)	South Korea	94	Immersive clinical simulation	High	Communication; sanitization of hands; assessment of vital signs	Patient simulator not specified	Prebriefing (10 min) + 1 simulated scenario (15 min) + debriefing (35 min)	Self-confidence
Kim and Kim (2015)	Turkey	98	Immersive clinical simulation	High	Evaluation of the patient with intestinal bleeding (Group A) and evaluation of the patient with compartment syndrome (Group B)	Laerdal SimMan®	2 simulated scenarios (15 min) + debriefing	Stress
Kim et al. (2020)	South Korea	60	Immersive clinical simulation	High	Advanced life support (ACLS)	Patient simulator not specified	Briefing (10 min) + simulated scenario (20 min) + debriefing (30 min)	Self-efficacy

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Lee et al. (2016)	South Korea	23	Immersive clinical simulation	Medium	Delivery and birth	Gaumard Scientific Noelle S575	Briefing + simulated scenario (15 min) + debriefing (20 min)	Stress; Self-confidence
Li et al. (2019)	China	132	Immersive clinical simulation	Not specified	Interpersonal communication	Not specified	16 simulated scenarios (30 min)	Self-efficacy
Liaw et al. (2012)	Singapore	31	Immersive clinical simulation	Not specified	Pneumonia, shock, hypoglycaemia, and septic shock	Patient simulator not specified	Briefing +4 simulated scenarios (60 min) + debriefing	Self-confidence
Lim et al. (2021)	South Korea	67	Computer-based simulation	Not specified	Developing entrepreneurship skills	Start-Up Nurses program	E-learning phase (180 min) + 2 simulated scenarios (40 min) + e-executive phase (30 min)	Self-efficacy
Luebbert and Popkess (2015)	United States	34	Immersive clinical simulation	High	Assessment of a patient with moderate depression and suicide risk	Standardised patient	Simulated scenario (10 min) + debriefing (20 min)	Self-confidence
Mager and Campbell (2013)	United States	60	Immersive clinical simulation	Not specified	Home care with medication calculation and administration	Not specified	Simulated scenario + debriefing	Self-efficacy
Merriman et al. (2014)	United Kingdom	34	Immersive clinical simulation	High	Evaluation of a polytraumatized patient (ABCDE)	Patient simulator not specified	Not specified	Self-efficacy
Ok et al. (2019)	Turkey	85	Immersive clinical simulation	High	Care of the psychiatric patient with schizophrenia	Standardised patient	Simulated scenario (10–12 min) + debriefing (30–35 min)	Anxiety
Olaussen et al. (2022)	Norway	103	Immersive clinical simulation	Not specified	1. Nursing home patient with chronic pulmonary disease deterioration; 2. Nursing home patient dementia, developing delirium caused by urinary retention; 3. Administration of medications to nursing home patient with left ventricular heart failure	Patient simulator not specified	Preparation before the simulation training (1 h) + briefing (30–45 min) + 3 simulated scenarios (30–40 min) + debriefing (90 min) + time to write individual reflection notes (1 h)	Self-efficacy
Ozcelik and Ayhan (2021)	Turkey	53	Immersive clinical simulation	High	Perioperative care	Standardised patient	Briefing (8 min) + simulated scenario (15 min) + debriefing (30 min)	Stress; Anxiety; Self-confidence

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Ozkara San (2020)	United States	57	Immersive clinical simulation	High	Support for transgender women with cancer	Standardised patient	Prebriefing + simulated scenario + observation + debriefing + reflection	Self-efficacy
Rashwan et al. (2021)	Egypt	60	Immersive clinical simulation	Medium	Holistic care for the preterm neonate	Not specified	Briefing + simulated scenario (15 min) + debriefing (10 min)	Anxiety
Ravert (2004)	United States	25	Immersive clinical simulation	High	Medical-surgical patient who suffered an accident with a motor vehicle; woman in postpartum haemorrhage; woman with pregnancy-induced hypertension; man feeling chest pain; man with disseminated intravascular coagulation	Patient simulator not specified	Prebriefing +5 simulated scenarios (90 min) + debriefing	Self-efficacy
Rivers (2012)	United States	72	Immersive clinical simulation	High	Assessment of the newborn's vital signs	Laerdal SimB®	Briefing + simulated scenario + debriefing	Self-confidence
Ross et al. (2022)	United States	60	Immersive clinical simulation	Not specified	Adult medical-surgical, obstetrics, and paediatrics	Not specified	6 simulated scenarios (30 min) + debriefing (30 min)	Anxiety; Self-confidence
Sanko and McKay (2017)	United States	120	Procedure simulation	Not specified	Medication administration, safety, calculating dosages, hand hygiene, proper use of personal protective equipment, researching medication information, and properly checking laboratory values and vital signs before administering medication	Patient simulator not specified	4 simulated scenarios + debriefing	Self-confidence
Sari et al. (2018)	Turkey	57	Immersive clinical simulation	Medium	Care for children with respiratory problems	Patient simulator not specified	Simulated scenario (15–20 min) + debriefing	Stress; Anxiety
Şentürk Erenel et al. (2021)	Turkey	122	Immersive clinical simulation	Not specified	Gestation; birth; Gestational diabetes; sexual violence; infertility; endometrial cancer	Unspecified birth simulators, newborns, and breasts	6 simulated scenarios (1 to 1.5 h)	Stress; Self-confidence
Seo and Eom (2021)	South Korea	45	Immersive clinical simulation	Not specified	Bleeding from the gastrointestinal tract; acute myocardial infarction	Not specified	2 simulated scenarios (10 to 15 min) + debriefing (1 h)	Self-efficacy

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Shinnick and Woo (2014)	United States	161	Immersive clinical simulation	High	Care of patients with acute congestive failure	Laerdal SimMan®	Prebriefing +1 simulated scenario (12 min) + debriefing (~20 min)	Self-efficacy
Smith (2014)	United States	101	Not specified	High	Not specified	Patient simulator not specified	Not specified	Anxiety
Soccio (2017)	United States	48	Immersive clinical simulation	Not specified	Care for patients with post-traumatic stress disorder; psychosis; and psychiatric emergency with pulse cutting and depression	Not specified	3 simulated scenarios	Self-confidence
Sokolowski (2015)	United States	34	Immersive clinical simulation	High	Communication and assessment of vital, cardiac, respiratory, and abdominal signs	Standardised patients	Briefing (10 min) + Simulated scenario (20 min) + debriefing (20 min)	Stress; Anxiety
Soucy (2011)	United States	49	Immersive clinical simulation	High	Stabilisation of a newborn with respiratory distress	Not specified	Not specified	Self-confidence
Stayt et al. (2015)	United Kingdom	98	Immersive clinical simulation	Medium	Evaluation of a polytraumatized patient (ABCDE)	Laerdal ALS	Simulated scenario + feedback	Self-efficacy
Tan et al. (2017)	Singapore	103	Immersive clinical simulation	Medium	Blood transfusion	Serious game	Simulated scenario + feedback	Self-confidence
Tawalbeh (2017)	Jordan	69	Immersive clinical simulation	High	Cardiopulmonary physical exam	METI® version 6	Simulated scenario (20 min) + debriefing	Self-confidence
Tawalbeh (2020)	Jordan	76	Immersive clinical simulation	High	Cardiac, respiratory, and neurological health problems	METI® version 6	9 simulated scenarios (2 h each) + debriefing (20 min)	Self-confidence
Tawalbeh and Tubaishat (2014)	Jordan	82	Immersive clinical simulation	High	Advanced life support (ACLS)	METI® version 6	Simulated scenario (30 min) + debriefing (10 min)	Self-confidence
Terzi et al. (2019)	Turkey	59	Procedure simulation	High	Training of the first blood pressure assessment	SUSIE S1001	Not specified	Anxiety; Self-confidence; Self-efficacy
Thomas and Mackey (2012)	United States	24	Immersive clinical simulation	High	Assessment of heart rate, calculation of intravenous medication, interpretation of arterial blood gases	Not specified	Simulated scenario + debriefing	Self-confidence
Topbaş et al. (2019)	Turkey	28	Procedure simulation	Not specified	Performing peritoneal dialysis	Body part simulator not specified	Simulated scenario + debriefing	Self-efficacy

Author (year)	Country	Sample size	Structural simulation design components					Evaluated outcome
			Modality	Fidelity	Scenario	Simulator	Structure	
Tuttle (2009)	United States	103	Not specified	High	Not specified	Patient simulator not specified	Simulated scenario + debriefing	Self-efficacy
Uslu et al. (2020)	United States	41	Procedure simulation	Not specified	Measurement of vital signs	Patient simulator not specified	Simulated scenario (10 min) + debriefing (45 min)	Stress; Anxiety
Valizadeh et al. (2013)	Iran	45	Procedure simulation	High	Peripheral venous catheterization in a paediatric patient	CRISIS mannequin	Simulated scenario (20 min) + feedback (25 min)	Self-confidence
Warren (2015)	United States	58	Immersive clinical simulation	Medium	Nursing process, complete physical examination, wound care	Patient simulator not specified	Prebriefing (15 min) + 3 simulated scenarios + debriefing	Anxiety; Self-confidence
Widiasih et al. (2022)	Indonesia	139	Computer-based simulation	Not specified	Intravenous catheterization in a patient with dengue hemorrhagic fever	VNursLab 3D simulator	Virtual simulated scenario	Self-confidence
Yang and Oh (2022)	South Korea	77	Computer-based simulation (VR group); Immersive clinical simulation (Simulation group)	High	Neonatal resuscitation	The immersive VR neonatal resuscitation gamification program (VR group); Laerdal® Premature Anne (Simulation group)	VR group: VR gamification program (50 min); Simulation group: Prebriefing (10 min) + simulated scenario (20 min) + debriefing (20 min)	Anxiety; Self-confidence
Younghee (2015)	South Korea	44	Immersive clinical simulation	High	Admission care, communication with the patient, taking vital signs, immediate recognition and response on patient change, and communication with a physician to inform the status of patients	Patient simulator not specified	Not specified	Anxiety; Self-efficacy
Yu and Yang (2022)	South Korea	50	Computer-based simulation	Not specified	Use of Personal Protective Equipment and paediatric respiratory care	VR infection control simulation program	Prebriefing (50 min) + VR simulation session (110 min) + debriefing (20 min)	Self-efficacy
Yu et al. (2021)	South Korea	50	Computer-based simulation	Not specified	Basic care, feeding management and skin care and environmental management	High-Risk Neonatal Infection Control VR simulation program	Prebriefing (30 min) + 3 simulated scenarios (40 min) + debriefing (20 min)	Self-efficacy

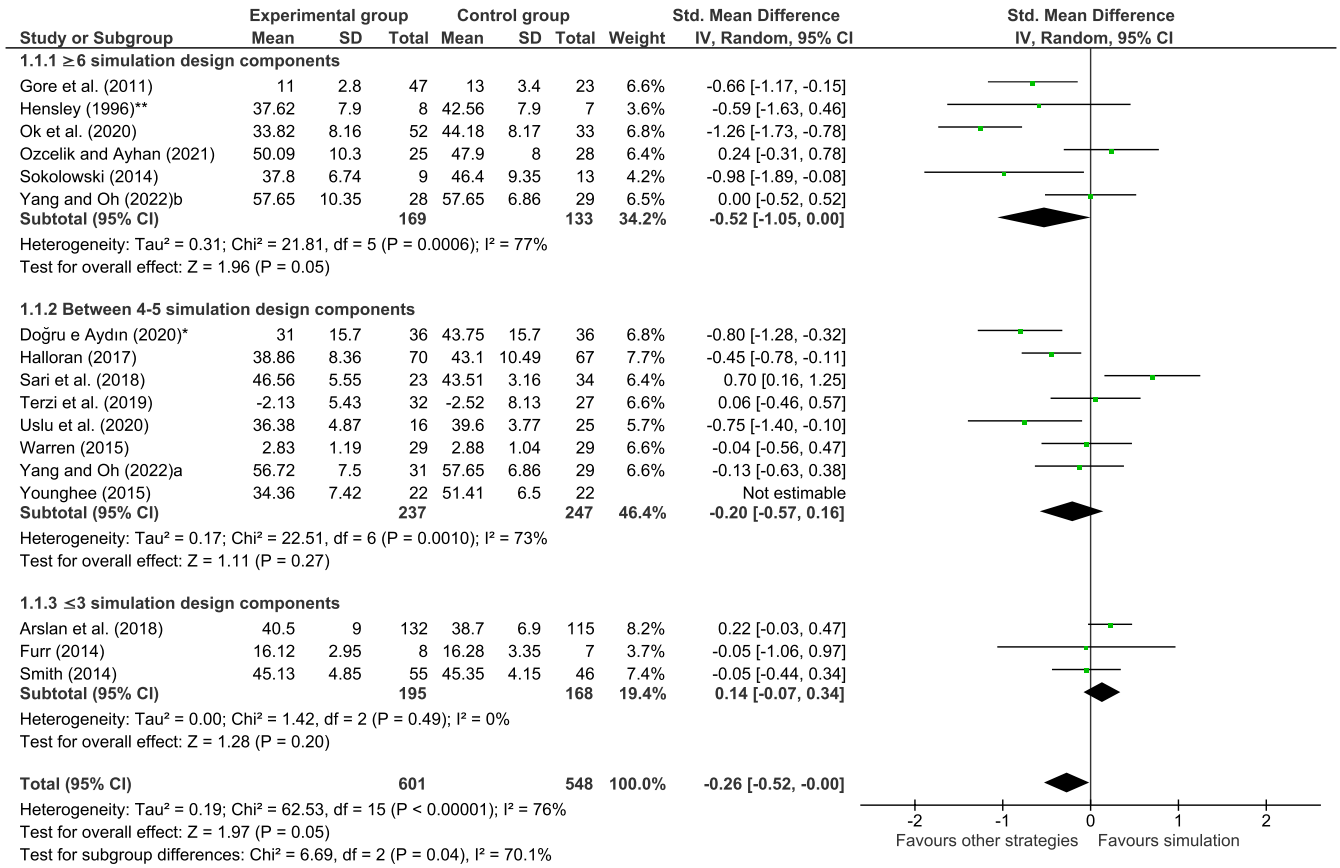

FIGURE 2 Meta-analysis according to the quantity of components of the simulation design for anxiety. *Mean and standard deviation obtained from the median and *p*-value. **Standard deviation obtained from the *p*-value.

finding. Study characteristics such as sample size, risk of bias, instrument used to evaluate the outcome and program period were not statistically significant.

5 | DISCUSSION

The results of this study provide evidence that there is an effect of the simulation design on the anxiety and self-confidence of nursing students, suggesting impact in the simulation depending on the adopted format. From the perspective of instructional design, it is possible to reflect that the simulation design process (Chiniara et al., 2013; Seel et al., 2017) produces positive results in reducing anxiety and developing self-confidence in nursing students.

It is necessary to reinforce the importance of rigorous planning, especially in simulation, as it is an activity in which the student is expected to perform actions based on evidence-based practice (INACSL Standards Committee, 2021c).

In this context, to ensure that a given activity is called simulation, it is necessary that it follows the Healthcare Simulation Standards of Best Practice™ (HSSOBP™) (INACSL Standards Committee, 2021c, 2021d; McDermott et al., 2021). However, paramount attention to three core areas in the planning and facilitation of scenarios is key to its success: prebriefing, scenario design facilitation and debriefing. The scenario mimics reality, providing the student with an experience in a safe and autonomous context that allows them to practice clinical decision-making for problem-solving, in which errors can occur that do not result in patient harm (Roussin et al., 2018), and without pre-determined script, which allows the learner to apply previous knowledge and promote interventions in the scenario.

Most of the studies (57.5%) included in this review presented a detailed description of the simulation structure containing prebriefing, scenario and debriefing, as well as the duration of each step, however, the rest of the sample presented weaknesses in the simulation description, reinforcing the importance of minimum simulation structure to achieve the learning objectives (INACSL Standards Committee, 2021c; McDermott et al., 2017; O'Donnell et al., 2014). Cheng et al. (2016) addresses key elements for the description of SBL in research, contemplating the participant's orientation, the type of simulator, the simulation environment, instructional design and debriefing.

There were no differences in the impact of prebriefing in the comparison between groups for anxiety and self-confidence. In the intragroup analysis, both an increase in self-confidence and a reduction in anxiety were verified in the studies in which the prebriefing was applied and described. From the results of this study, specifically

Study or Subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.2.1 ≥6 simulation design components								
Ahn e Kim (2015)a	4.05	0.48	35	3.86	0.53	34	1.7%	0.37 [-0.10, 0.85]
Ahn e Kim (2015)b	3.56	0.34	34	3.37	0.41	35	1.7%	0.50 [0.02, 0.98]
Akhu-Zaheya et al. (2013)*	9.1	0.77	52	8.6	0.77	58	1.7%	0.64 [0.26, 1.03]
Alfes (2011)	32.48	3.83	29	30.74	3.1	34	1.6%	0.50 [-0.01, 1.00]
Basak et al. (2019)	8.48	0.88	35	7.07	1.33	36	1.6%	1.23 [0.72, 1.74]
Bowling and Underwood (2016)	32.05	3.68	37	33.86	3.27	36	1.7%	-0.51 [-0.98, -0.05]
Brauneis et al. (2021)	43.66	16.95	21	33.3	16.32	23	1.6%	0.61 [0.01, 1.22]
Choi et al. (2020)	54.91	6.2	66	54.28	7.46	65	1.8%	0.09 [-0.25, 0.43]
D'Souza et al. (2020)	35.8	2.45	70	26.7	5.61	70	1.7%	2.09 [1.68, 2.50]
Jang and Park (2021)	23.49	3.99	41	22.41	5.04	39	1.7%	0.24 [-0.20, 0.68]
Jang et al. (2021)	28.27	4.58	45	27.41	9.6	46	1.7%	0.11 [-0.30, 0.52]
Kim and Kim (2015)	37.56	6.03	48	38.5	5.09	46	1.7%	-0.17 [-0.57, 0.24]
Kim et al. (2020)	4.01	0.45	30	3.67	0.72	30	1.6%	0.56 [0.04, 1.08]
Lee et al. (2016)	6.17	6	12	0.73	5.31	11	1.3%	0.92 [0.05, 1.79]
Luebbert and Popkess (2015)	4.1	0.46	18	3.7	0.47	16	1.5%	0.84 [0.13, 1.55]
Olaussen et al. (2022)	28.9	3.9	52	30.3	3.5	51	1.7%	-0.37 [-0.76, 0.01]
Ozkara San (2020)	1.35	0.709	16	0.85	0.809	41	1.6%	0.63 [0.04, 1.22]
Ravert (2004)*	22.3	9.07	12	14.8	9.07	13	1.4%	0.80 [-0.02, 1.62]
Rivers (2012)*	4.67	1.07	31	4.15	1.07	37	1.7%	0.48 [-0.00, 0.96]
Shinnick and Woo (2014)	2.47	0.86	72	2.08	0.97	89	1.8%	0.42 [0.11, 0.73]
Tawalbeh (2017)	24	1.89	35	8.02	1.43	34		Not estimable
Tawalbeh (2020)	35.76	5.45	38	23	3.33	38	1.5%	2.80 [2.16, 3.44]
Tawalbeh and Tubaishat (2014)	74.38	11.55	40	32.85	18.16	42	1.6%	2.69 [2.08, 3.29]
Yang and Oh (2022)b	56.57	9.21	28	47	12.13	29	1.6%	0.87 [0.33, 1.42]
Yu and Yang (2022)	6.64	0.52	25	5.72	0.79	25	1.5%	1.35 [0.73, 1.97]
Yu et al. (2021)	8.57	0.98	25	7.72	1.37	25	1.6%	0.70 [0.13, 1.28]
Subtotal (95% CI)			**912**			**969**	**40.6%**	**0.72 [0.41, 1.02]**
Heterogeneity: Tau² = 0.53; Chi² = 233.42, df = 24 (P < 0.00001); I² = 90%								
Test for overall effect: Z = 4.62 (P < 0.00001)								
1.2.2 Between 4-5 simulation design components								
Abu Sharour (2019)a	61.95	12.1	35	38.5	6.2	35	1.5%	2.41 [1.79, 3.04]
Abu Sharour (2019)b	35.5	6.2	35	24.25	2.85	35	1.6%	2.31 [1.69, 2.92]
Akalin e Sahin (2020)	42.72	6.62	53	40.16	10.33	54	1.7%	0.29 [-0.09, 0.67]
AlAmrani et al. (2017)	3.89	0.63	15	3.8	0.73	15	1.5%	0.13 [-0.59, 0.84]
Blum et al. (2010)	12.48	1.3	37	13.03	1.38	16	1.6%	-0.41 [-1.00, 0.18]
Brannan et al. (2008)	113.51	17.87	54	106.29	19.71	53	1.7%	0.38 [-0.00, 0.76]
Chang et al. (2021)	43.71	6.87	58	44.02	7.19	49	1.7%	-0.04 [-0.42, 0.34]
Chang et al. (2022)	54.3	5.72	53	50.1	7.05	48	1.7%	0.65 [0.25, 1.05]
Curtis (2014)	59.03	6.25	30	60.23	5.28	30	1.6%	-0.20 [-0.71, 0.30]
DiGiacomo (2017)	39.29	2.91	31	38.55	3.65	37	1.7%	0.22 [-0.26, 0.70]
Goldsworthy et al. (2022)	80.12	12.019	38	70.73	13.76	28	1.6%	0.73 [0.22, 1.23]
Hudder et al. (2021)	49.08	5.42	25	56.23	6.35	11	1.4%	-1.22 [-1.99, -0.45]
Jang and Moon (2021)	22.13	7.4	38	20.64	4.61	39	1.7%	0.24 [-0.21, 0.69]
Jeong et al. (2021)	3.6	0.55	32	3.54	0.59	33	1.7%	0.10 [-0.38, 0.59]
Liaw et al. (2012)	24.53	6.56	15	20.63	6.05	16	1.5%	0.60 [-0.12, 1.33]
Lim et al. (2021)	3.37	0.67	34	2.74	0.59	33	1.6%	0.99 [0.48, 1.49]
Merriman et al. (2014)	148	14.8	15	149	10.76	19	1.5%	-0.08 [-0.75, 0.60]
Sanko and Mckay (2017)a	55.65	6.95	60	54.68	6.83	60	1.8%	0.14 [-0.22, 0.50]
Sanko and Mckay (2017)b	67.18	8.39	60	52.58	6.57	60	1.7%	1.93 [1.49, 2.36]
ŞENTÜRK ERENEL et al. (2021)	127.09	14.36	58	128.83	17.11	64	1.8%	-0.11 [-0.46, 0.25]
Seo and Eom (2021)	137.4	22.24	25	112.45	27.15	20	1.5%	1.00 [0.37, 1.63]
Stayt et al. (2015)	141	15	50	137	15	48	1.7%	0.26 [-0.13, 0.66]
Tan et al. (2017)	16.46	1.86	57	11.76	2.26	46	1.6%	2.28 [1.78, 2.78]
Terzi et al. (2019)a	2.63	9.3	32	-1.26	7.4	27	1.6%	0.45 [-0.07, 0.97]
Terzi et al. (2019)b	0.91	3.5	32	-1.26	3.39	27	1.6%	0.62 [0.10, 1.15]
Thomas and Mackey (2012)	4.14	1.7	14	0.7	2.5	10	1.2%	1.61 [0.66, 2.56]
Valizadeh et al. (2013)a	0.92	0.9	16	0.58	0.94	14	1.5%	0.36 [-0.36, 1.08]
Valizadeh et al. (2013)b	0.92	0.9	16	0.17	0.67	15	1.4%	0.92 [0.17, 1.66]
Warren (2015)	0.58	1.17	29	1.14	1.25	29	1.6%	-0.46 [-0.98, 0.07]
Yang and Oh (2022)a	62.48	8.48	31	47	12.13	29	1.6%	1.47 [0.89, 2.04]
Younghee (2015)	70.32	7.85	22	54.82	8.16	22	1.5%	1.90 [1.18, 2.62]
Subtotal (95% CI)			**1100**			**1022**	**49.5%**	**0.62 [0.34, 0.90]**
Heterogeneity: Tau² = 0.56; Chi² = 281.54, df = 30 (P < 0.00001); I² = 89%								
Test for overall effect: Z = 4.30 (P < 0.0001)								
1.2.3 ≤3 simulation design components								
Huse (2010)	4.46	0.33	22	4.26	0.58	25	1.6%	0.41 [-0.17, 0.99]
Li et al. (2019)	41.23	5.01	66	37.91	5.32	66	1.8%	0.64 [0.29, 0.99]
Mager and Campbell (2013)*	8.6	1.31	30	7.7	1.31	30	1.6%	0.68 [0.16, 1.20]
Topbas et al. (2018)	31.79	5.39	14	32.57	9.94	14	1.4%	-0.09 [-0.84, 0.65]
Tuttle (2009)	156.35	24.06	54	147.39	27.68	49	1.7%	0.34 [-0.05, 0.73]
Widiasih et al. (2022)	36.25	3.48	69	34.96	3.39	70	1.8%	0.37 [0.04, 0.71]
Subtotal (95% CI)			**255**			**254**	**9.9%**	**0.45 [0.27, 0.62]**
Heterogeneity: Tau² = 0.00; Chi² = 4.43, df = 5 (P = 0.49); I² = 0%								
Test for overall effect: Z = 4.96 (P < 0.00001)								
Total (95% CI)			**2267**			**2245**	**100.0%**	**0.64 [0.45, 0.82]**
Heterogeneity: Tau² = 0.46; Chi² = 521.02, df = 61 (P < 0.00001); I² = 88%								
Test for overall effect: Z = 6.80 (P < 0.00001)								
Test for subgroup differences: Chi² = 2.67, df = 2 (P = 0.26), I² = 25.1%								

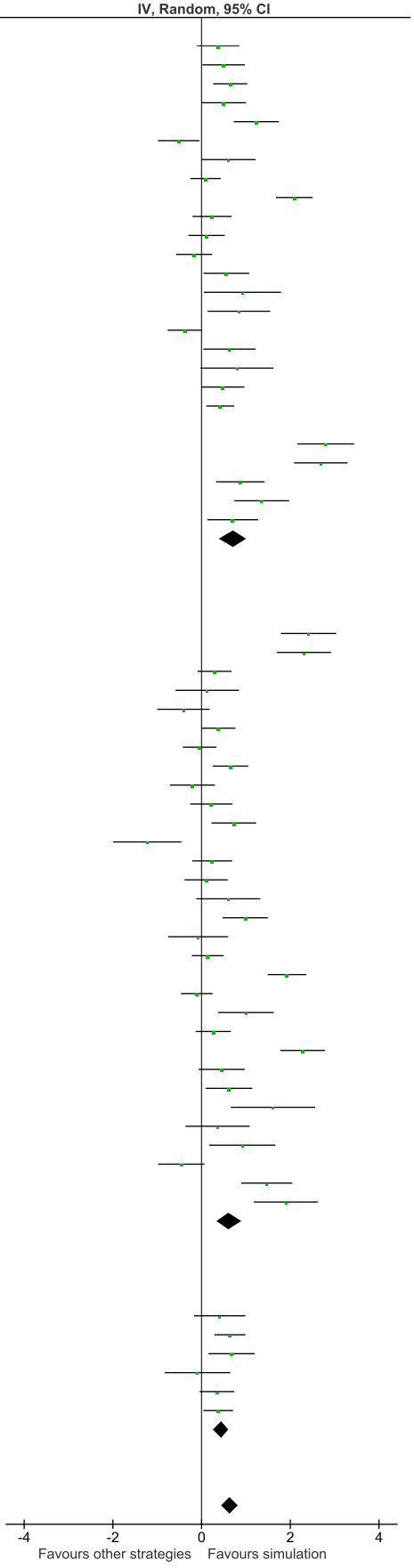

FIGURE 3 Meta-analysis according to the quantity of components of the simulation design for self-confidence. *Standard deviation obtained from the *p*-value.

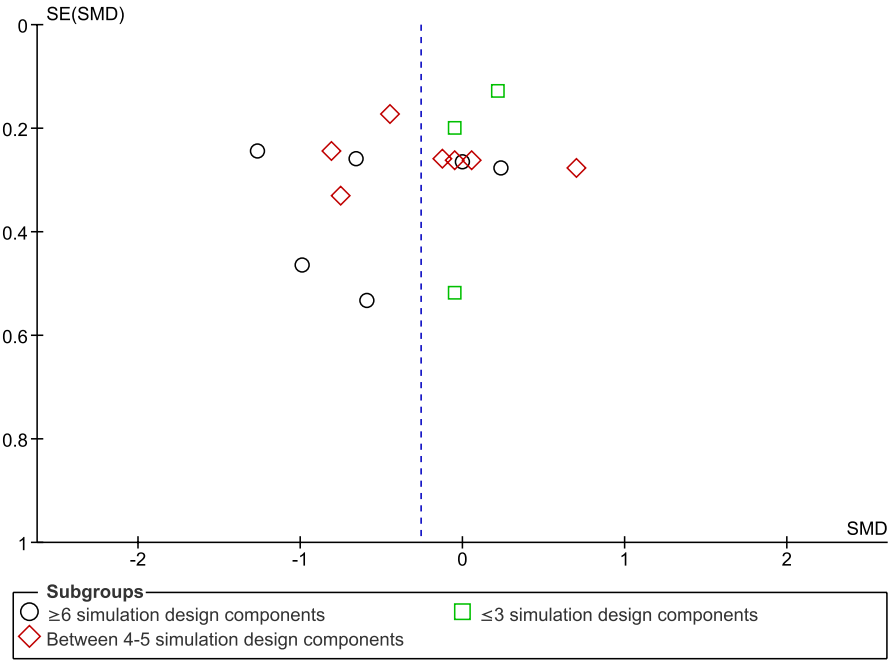

FIGURE 4 Funnel plot of anxiety according to the quantity of components of the simulation design. SE, Standard Error. SMD, Standardised Mean Difference.

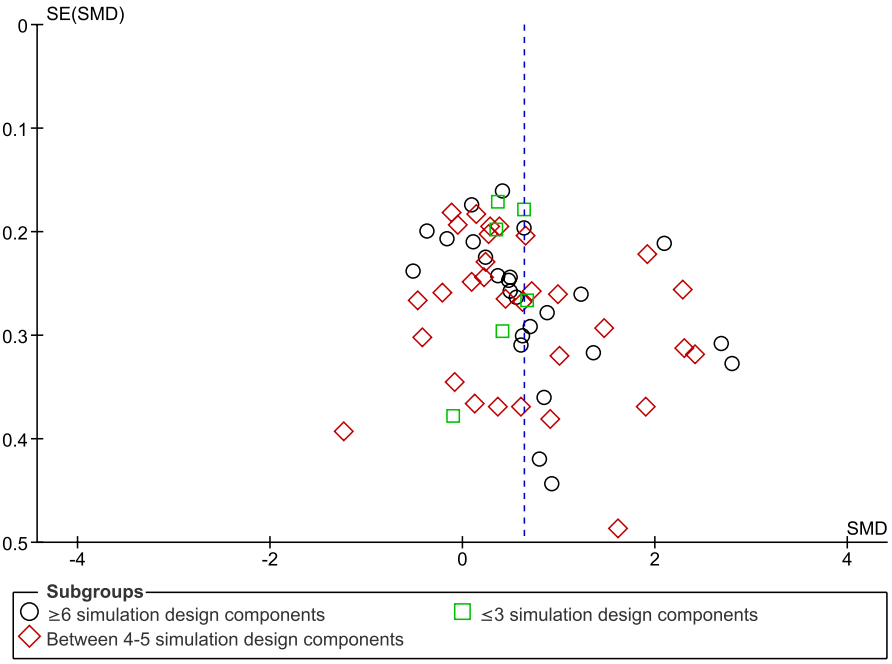

FIGURE 5 Funnel plot of self-confidence according to the quantity of components of the simulation design. SE, Standard Error; SMD, Standardised Mean Difference.

for anxiety, it is possible to indicate that when present, prebriefing reduces students' anxiety, allowing greater use of the activity.

Whereas prebriefing is the initial stage of the simulation that is intended to prepare the student to meet the learning objectives, establish a safe learning environment and provide general information about the simulation process (McDermott, 2016; McDermott et al., 2021; Page-Cutrara, 2015), the results of the present study reinforce the role of this stage in the student's emotional control and in providing security for the performance of actions in the scenario. Additionally, the results highlight the role of prebriefing in preparing students for the educational experience provided and in transmitting the basic rules of SBL (McDermott et al., 2021).

The debriefing did not show differences between groups for anxiety and self-confidence, but in the intragroup analysis, the presence of this stage indicated greater self-confidence of students in simulation activities. Considering that the debriefing is a bidirectional step with the participation of the educator/facilitator and the student to discuss the reactions experienced, analyse the content presented, identify gaps in learning; in addition, it has a summary of the SBL, recapitulating the main topics of the simulation and discussion of how competencies can be transferred to practice (INACSL Standards Committee, 2021d). Such results reinforce the role of this stage in the consolidation of learning and, consequently, of self-confidence (Oliveira Silva, Oliveira, et al., 2022).

TABLE 2 Meta-analysis of anxiety and self-confidence according to simulation design components.

Simulation design components	Anxiety					Self-confidence				
	Studies	I^2 (%)	SMD	CI95%	*p*	Studies	I^2 (%)	SMD	CI95%	*p*
Prebriefing					.636					.788
Yes	8	53.3	−0.32	−0.64; −0.01**		21	86.2	0.60	0.30; 0.89**	
No	8	84.6	−0.19	−0.62; 0.23		41	89.4	0.65	0.37; 0.93**	
Debriefing					.812					.844
Yes	11	76.5	−0.28	−0.63; 0.07		48	89.0	0.64	0.40; 0.88**	
No	5	78.5	−0.22	−0.58; 0.14		14	86.1	0.60	0.19; 1.01**	
Simulation duration					.042*					.029*
<60 min	5	67.3	0.03	−0.43; 0.48		17	91.7	0.96	0.48; 1.43**	
≥60 min	8	83.1	−0.55	−0.90; −0.19**		31	88.4	0.64	0.36; 0.90**	
Not specified	3	0.0	−0.01	−0.28; 0.24		14	70.4	0.25	−0.10; 0.60	
Modality					.738					.612
Immersive clinical simulation	11	82.1	−0.27	−0.64; 0.09		41	89.3	0.64	0.37; 0.91**	
Procedure simulation	2	72.4	−0.32	−1.07; 0.44		9	83.3	0.59	0.13; 1.04**	
Computer-based simulation	2	4.3	−0.33	−0.67; 0.01		11	89.5	0.69	0.09; 1.28**	
Not specified	1	–	−0.04	−0.44; 0.34		1	–	0.34	−0.04; 0.73	
Fidelity					.004*					.017*
High	9	74.7	−0.43	−0.79; −0.06**		34	88.2	0.82	0.54; 1.11**	
Medium	2	73.8	0.32	−0.38; 1.02		5	72.2	−0.08	−0.80; 0.64	
Low	2	0.0	−0.51	−0.81; −0.21**		2	0.0	0.50	−0.78; 1.79	
Not specified	3	0.0	0.11	−0.15; 0.39		21	88.8	0.51	0.16; 0.86**	
Simulator					.345					.247
Patient simulator (mannequin)	10	71.2	−0.12	−0.42; 0.17		41	89.8	0.62	0.35; 0.88**	
Standardised patient	4	82.4	−0.64	−0.67; 0.01		4	64.5	0.71	0.02; 1.41**	
Virtual simulator	2	4.3	−0.33	−0.67; 0.01		11	89.5	0.69	0.09; 1.28**	
Virtual simulator + Standardised simulator	–	–	–	–		1	–	−0.04	−0.42; 0.33	
Body part simulator	–	–	–	–		1	–	−0.09	−0.83; 0.64	
Not specified	–	–	–	–		4	27.8	0.86	0.26; 1.47**	

Abbreviations: 95%CI, 95% confidence interval; SMD, Standardised Mean Difference.

*Statistical difference in effect size between subgroups with $p < .05$.; **Statistical difference in effect size within subgroups with $p < .05$.

It should be noted that the results referring to prebriefing and debriefing in this review are limited to the presence or absence of these steps, since the studies do not report in detail the prebriefing or debriefing modalities used. It is understood that these steps are inherent to the simulation and are directly related to the student's preparation to perform the actions foreseen in the simulated scenario (prebriefing) and consolidation of learning from the discussion between peers and facilitators (debriefing) (INACSL Standards Committee, 2021d; McDermott et al., 2021; Page-Cutrara, 2015; Sawyer et al., 2016). When reported in studies, they allow an accurate assessment of their effect on the learning outcomes achieved by participants (INACSL Standards Committee, 2021b; McDermott, 2016; Sawyer et al., 2016).

Statistically significant differences were found between the subgroups regarding the duration of the simulation, so that SBL lasting more than 60 minutes between prebriefing, scenario and debriefing, in one or more scenarios, resulted in lower students' anxiety. Labrague et al. (2019) identified variability similar to this

study regarding the duration of SBL, highlighting the need to investigate the relationship of duration with student learning outcomes. Thus, based on the results of the present study, it is theorised that the greater the student's experience in SBL, the less anxious they will feel, as they will be able to process the emotion and favour the consolidation of learning (Vogel & Schwabe, 2016; Yockey & Henry, 2019). For self-confidence, when reported, the simulation favoured student self-confidence regardless of the duration.

Researchers examined theoretical references on simulation design addressing different modalities that can be used depending on the goals established by the educator (Chiniara et al., 2013; INACSL Standards Committee, 2021b). For this review, only the immersive clinical simulation, procedure simulation and computer-based simulation modalities were considered, and no differences were found between the effect size, supporting the use of different simulation modalities with positive impacts on students' self-confidence.

It is noteworthy that the researchers did not explicitly report the modality adopted. Thus, in the data extraction stage, the classification was performed according to the proximity between the study report and the concepts brought by INACSL (INACSL Standards Committee, 2021c) and by Chiniara et al. (2013).

Like the modality, fidelity is an element of the simulation design and determines the proximity of SBL to real clinical practice (Arthur et al., 2013; O'Donnell et al., 2014). Although commonly attributed to the characteristics of simulators regarding the level of technological resources and functions that imitate the human being, adding realism, fidelity involves other aspects and follows a categorization in levels (Dieckmann et al., 2007).

The classification of fidelity varies among high, medium or low, and it is applied to assess a. physical and b. environmental aspects, regarding available resources such as laboratory and simulator; c. conceptual, related to the execution of the educational strategy and its pedagogical approach; and d. psychological, regarding the level of immersion as an outcome of the synergy among the three aspects cited before (INACSL Standards Committee, 2021c).

However, the fidelity described in the analysed studies was limited to the simulator fidelity and showed statistical difference in the meta-analysis by subgroups. These results suggest that high-fidelity simulations evoke lower levels of anxiety and higher levels of self-confidence compared to other strategies, while the low-fidelity ones helped to reduce anxiety, but with no effect on self-confidence—which indicates the student's perception of their own preparation for clinical practice after SBL. In this context, it is essential to point out that most studies used high-fidelity simulators, obtaining favourable results for the simulation, similar to the findings of La Cerra et al. (2019).

It is understood that the choice of the best simulator or strategy that mimics a human interaction in the health context depends both on the defined learning objectives and on the available resources (Al-Ghareeb & Cooper, 2016; INACSL Standards Committee, 2021b; Lapkin & Levett-Jones, 2011). However, in the present study, the type of simulator used did not result in differences in the effect sizes for self-confidence, supporting the use of different types of simulators and confirming that the choices made by the educators in planning the activities described in the articles were meeting the established learning objectives.

Differences observed between the subgroups implied a greater effect size in SBL for self-confidence with the use of human patient simulators (HPS) and standardised patients, in which the interaction was made between the student and the simulator can represent the patient in a clinical situation (Labrague et al., 2019). Furthermore, the use of standardised patients helps in the realism of the simulation and favours the development of skills related to communication, in addition to allowing the student to be able to observe nuances such as gestures and facial expressions that can be decisive in the clinical evaluation, and may not be replicated in mannequins, especially medium and low fidelity (Ignacio et al., 2015).

It should be noted that the effect was also positive on self-confidence among the studies that used virtual simulators, like virtual reality (VR) technologies, reinforcing that computer-based simulation is a promising strategy to promote learning (Kononowicz et al., 2019; Shorey & Ng, 2021). Although the use of technologies such as VR in simulations is recent, the results are promising and show positive impacts on students' self-confidence (Yu et al., 2021; Yu & Yang, 2022).

The scenario in general, to favour the development of critical thinking, clinical reasoning and decision-making (aspects constantly required in clinical practice) (Chiniara et al., 2013; INACSL Standards Committee, 2021c), should seek to promote an authentic experience of an active role in the participants and be reproducible and reliable with outcomes consistent with reality.

In this context, scenario validation, an aspect reinforced as important to ensure realism and evidence-based practice (INACSL Standards Committee, 2021c), was not explored in the studies included in this review, and progress in this aspect is needed in the articles published in the area. It should be added that with the dynamics of updating procedures in the health area, the periodic review is a condition to guarantee the quality of the scenario over time and the engagement and learning of the participants.

Although the results show high heterogeneity between studies, the results are valid because this variation is associated with the inclusion of studies in different contexts of nursing education. In addition, it is possible to understand that the simulation duration was important predictors of self-confidence, suggesting that the more hours of simulation, the greater the student's self-confidence.

5.1 | Recommendations for future research

Future studies can address certain components of simulation design not addressed on the studies included in this review, such as types of prebriefing and debriefing; other simulation modalities such as in situ simulation and hybrid simulation, which were not addressed in this review due to the lack of primary studies evaluating them; different levels of fidelity, in addition to the impact of different types of fidelity (environmental, conceptual and psychological); types of

simulators, in particular virtual simulators; and the importance of scenario validation.

It is also suggested that new systematic reviews with meta-analysis evaluate the effect of simulation design on learning domains (cognitive, procedural and attitudinal) and other learning outcomes obtained through simulation activities, such as critical thinking, clinical reasoning, clinical judgement and therapeutic communication.

6 | LIMITATIONS

The lack of studies addressing the effect of simulation on stress compared to conventional teaching strategies limited the assessment of the effect of simulation design on this outcome. Another important limitation was the lack of reporting of the simulation design components in the methodological stage of the studies, which made classification difficult for comparison by subgroups. However, this limitation is conditioned to the classification proposal of the present study, so that future studies can use the results of this review as a model for better reporting of their interventions. Despite being provided for in the review protocol, the assessment of the quality of the evidence produced was not performed because the GRADEpro GDT tool does not include analyses in which experimental and quasi-experimental studies were included.

7 | CONCLUSION

The results of this study allowed us to identify the effect of the simulation design on the anxiety and self-confidence of nursing students, highlighting the impact of intentional SBL design on the development of emotional competences. Thus, this study was a pioneer in evaluating the relationship between simulation design and outcomes, identifying that different modulations of its components, imply differences in effect sizes, highlighting, in particular, the quality of the methodological report of interventions with simulation.

Despite this, differences between subgroups were found only regarding the duration and the fidelity of simulation, the intragroup estimates raise hypotheses about which characteristics have the most impact on outcomes. Thus, the results of this review allow us to infer that when developing SBL from the perspective of simulation design, it is possible to obtain intentional outcomes in reducing anxiety and developing self-confidence in nursing students, with the consequent development of emotional control, decision-making and learning.

8 | RELEVANCE TO CLINICAL PRACTICE

By providing information on the impact of simulation design, the results of this review allow for the development of more intentional strategic designs to strengthen pedagogical and strategic planning in health courses. In addition, they highlight those studies with a solid description of the simulation in its methodological stage, tend to obtain statistically significant results. In association with the findings of Mariani et al. (2020), the finding of the present study helps to support the need of more rigorous methodology in ours simulation designs and research methods.

Consequently, the results support SBL implementation in undergraduate nursing curricula, encouraging the education of qualified professionals prepared to work in clinical practice. Furthermore, the qualified education of nurses is in line with the global goal of the Pan American Health Organization of offering health to all by 2030, and this same body explicitly recommends the use of clinical simulation as a strategy for the improvement of health teams (Pan American Health Organization, 2022, Pan American Health Organization, 2019).

PROSPERO REGISTRATION

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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