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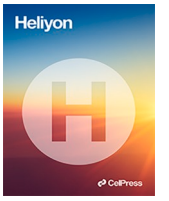

Research article

Simulation-based learning in nursing curriculum- time to prepare quality nurses: A systematic review and meta-analysis

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ABSTRACT

Background: Simulation-based learning (SBL) emerged as an imperative pedagogical approach adaptable to situations involving widely varying clinical content without exposing patients to the risks inherent in trainee learning. The purpose of the present review was to assess the outcome of SBL on the domains of learning i.e cognitive, affective, and psychomotor.

Methods: We searched PubMed, Embase, Cochrane library, Clinical Trial database, and other sources to evaluate the effectiveness of SBL versus traditional teaching methods among nursing students till March 2021. Two authors individually extracted the data and identified the risk of bias and analyzed the data.

Results: The selected studies with a total of 364 nursing students were included for analysis. Overall, it was found that learning via simulation has beneficial effects. In combined subgroup analysis, use of simulation showed significant effects on students' understanding (SMD = 1.31, 95% CI [0.80, 1.82], P < 0.00001), Self-confidence (SMD = 1.93, 95% CI [1.01,2.84], P < 0.0001), (SMD = 1.83, 95% CI [0.91,2.74], P < 0.0001), Learning satisfaction [E:17.94, C-17.60] and Skill (SMD = 1.62, 95% CI [0.62,2.62], P = 0.002) and psychological care (SMD = 1.60, 95% CI [0.61,2.58], P = 0.001). Heterogeneity ranging from I2 = 54%–86% was found during the analysis.

Conclusion: The findings of the present study considered simulation as an effective teaching method to enhance cognitive, affective, and psychomotor skills.

1. Introduction

Simulation-based learning (SBL) is pedagogical access that permits learners to experience real patient situations without putting patients to the risks inherent in learner learning and is adaptable to cases involving a wide variety of clinical content [1]. SBL is a technique, not a technology that uses innovative ways to teach and make students learn by providing hands-on experiences in a variety of ways [2]. The present decade has illustrated the necessity of SBL within the nursing profession too. It's attentively the best strategy for bridging the gap between theory and practice [3]. Nursing education strives to improve knowledge in recognition and management of patient deterioration among nursing students [4]. To create these skills including the ability to work as a team, self-assessment, and using critical thinking while dealing with actual real patients among nursing students many institutions have used SBL in the nursing curriculum [5]. Changing trends regarding patient safety, placement of students in clinical practice, and ethical concerns have peaked the utilization of simulation. SBL might be an important constituent for the suitable learning of student nurses for shifting into a

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dynamic health care atmosphere [6]. Simulation is a sequence that begins from low-fidelity stimulation (LFS) to high-fidelity simulation (HFS) [7]. Moreover, the simulation also uses trained persons or standardized patients, role-playing, and realistic virtual environments, not just handling mannequins.

Several nursing research articles have evidenced the effectiveness of simulation-based education [7]. However, the results varied with the interventions and their outcome measures. Thus, the current study was carried out to assess the effectiveness of learning via SBL in acquiring knowledge, skill, confidence, and learning satisfaction among student nurses based on available evidence.

To evaluate the effectiveness of SBL, a meta-analysis of available Randomized Controlled Trials (RCTs) was evaluated. It is challenging to assess the research studies in this field as limited RCTs are available regarding SBL in the nursing curriculum. However, the prime aim of the review was to assess the effect of simulation-based education via a variety of simulators ranging from low to high versus traditional methods of teaching on knowledge, skill, confidence, and learning satisfaction among nursing students. Hence, this provides the answer to the question, of whether simulation-based education should be a part of the new nursing curriculum.

2. Methods

Meta-analysis is a quantitative study design used to systematically derive conclusions based on previous research studies.

The present study used PRISMA [8] guidelines (Preferred Reporting Items for Systematic Review and Meta-analyses). [Fig. 1]. The research question was framed as per PICOT (Populations, Intervention, Comparison, Outcomes, Time). Here, Population refers to nursing students, Intervention here is simulation-based learning, Comparison is with traditional learning methods, Outcomes are cognitive domain, affective domain and psychomotor domain and Time refers to studies published from 2010 to 2021.

2.1. Search strategy

The electronic searches were performed from Pub Med, Embase, Cochrane Library, and another database. The studies which were published in the English language from the year 2010–2021 were included. The MeSH terms for the search were "simulation-based learning"; "traditional teaching method"; "Nursing"; "Students"; "Randomized Controlled Trials"; "Affective"; "Psychomotor"; "Knowledge"; "Self-confidence"; "Satisfaction"; "Skill". (Appendix 1).

The clinical trials which are ongoing and available at ClinicalTrials.gov and the International Clinical Trial Registry Platform were also evaluated. In addition, for the missing studies, the reference of the present study and systematic reviews were explored.

2.2. Inclusion criteria and study selection

All Studies considering the effectiveness of simulation and fulfilling the following criteria were selected and included: 1) pre-licensure nursing students utilizing simulation as a teaching-learning method. 2) Full texted RCTs articles available in the English language before 2021 3) All randomized controlled trials till the date of search 4) Interventions included simulation-based learning involving all types of simulators, i.e., standardized patients (SPs), partial-task trainers, full-body task trainers, low-fidelity simulators,

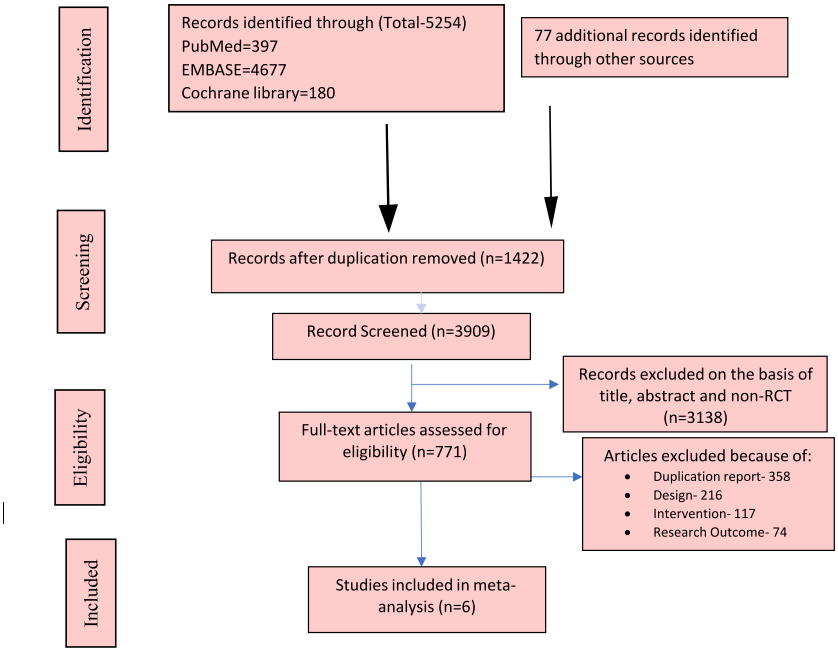

Fig. 1. PRISMA flow diagram.

and high-fidelity simulator 4) Comparator included traditional teaching method, i.e., Lecture, Discussion, PowerPoint presentation, Video, and demonstration outcomes showing the positive, negative or no change after the introduction of simulation training.

2.3. Exclusion criteria

We excluded studies without a focused research question, individual case reports, case series associated with literature reviews, conference abstracts, and letters to the editor.

2.4. Data collection

All the articles as per the search strategy were imported into the Mendeley reference management system and duplicates were removed. Two independent reviewers performed the Initial screening of research for the idea of title, abstracts, full-text, inclusion, and exclusion criteria. For the non-availability of full text or any ambiguity, the authors communicated via electronic mail and social media networks like Google Scholar and Research Gate. The dissents for the review were resolved by discussion. However, a third reviewer RM was consulted for consensus. The studies which were excluded were documented with reasons.

2.5. Assessment of risk bias

The risk of bias for the selected studies was calculated using the Cochrane Collaboration risk of bias Tool version 2 [9] and for quality Joanna Briggs Institute (JBI) Critical Appraisal tool. Two independent reviewers did the risk of bias assessment [10]. Disagreements among the two primary reviewers were resolved by the third reviewer before summarizing and grading the risk of bias.

2.6. Quality assessment

The risk of bias and the methodological quality of six RCTs is depicted in Figs. 2 and 3. One study showed a high risk [11], Two studies [12,13] were at low risk, and three studies [14–16] were at unclear risk of bias for participant blinding, allocation concealment, and missing data [Figs. 2 and 3]. Additionally, among the six studies, one study was of high quality [12]; Four studies [13–16] were categorized as moderate quality, whereas one study [11], was found to be of low quality (Table 1).

2.7. Data analysis

Analysis of data was done using Cochrane's Review Manager (RevMan version 5.4), and the results of meta-analysis (MA) were shown using the standardized mean difference by using a random-effects model with a 95% confidence interval (CI). To assess heterogeneity, I2 statistics were used. However, further subgroup analysis was not done due to the insufficient number of studies.

3. Results

3.1. Study selection and characteristics

A total of 5331 studies were identified in the following databases: PubMed (397), Embase (4677), Cochrane Library (180), and other sources (77). After removing duplicate articles, a total of 3909 articles were left. Following this, the articles were scrutinized based on inclusion criteria. Among these, only six met the inclusion criteria hence, included in the present systematic review.

In Table 1, among the six included studies, two were from Turkey [12,14], one was from Japan, Brazil, Jordon, and Iran, respectively [11,13,15,16]. A total of 364 nursing students were enrolledin the included studies; of these, 186 underwent simulation, and 172 underwent the Traditional Teaching method at Undergraduate Nursing Schools. The ages of the sample included in the study ranged from 18 to 23 years. Students' grades were Third-year [13,15,16], third, fourth year [11], First-year [14], and Second year [12] respectively. These included studies were published in years ranging from 2010 to 2021. Two studies took Standardized Patients (SPs) as a simulator [12,13], and the rest four studies took High Fidelity Simulator and Static Manikin for training nursing students [11,

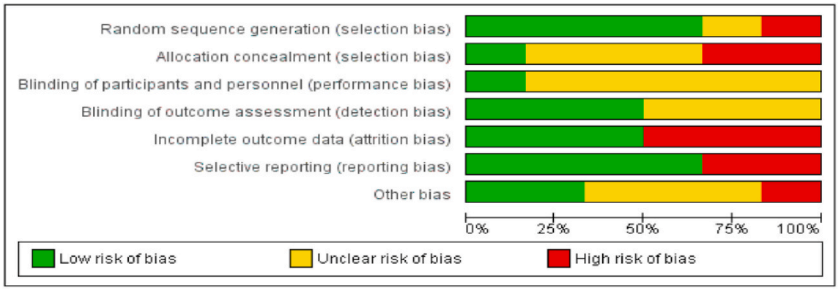

Fig. 2. Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies.

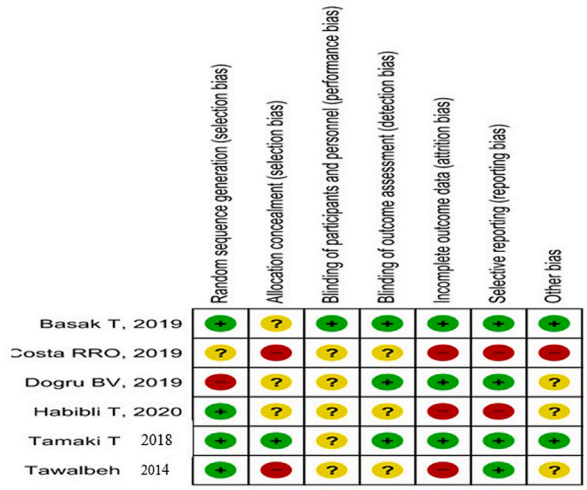

Fig. 3. Risk of bias summary: review authors' judgments about each risk of bias item for each included study.

14–16]. The subject varied frommedical-surgical nursing [11–13,15,16], fundamental nursing [14] for training students via simulation. Simulation-based learning was given for 5 min and 30 min. All RCTs included a control group with a traditional method of teaching. All studies primarily evaluated the Knowledge and secondary evaluated the skill, Self-confidence, and Learning Satisfaction at different follow-up duration. The follow-up duration of the studies ranged from 4 h to 3 months. The follow-up duration of two studies [15,16] was reported as 3 months, one week [13], and two weeks [14], respectively. However, one study scheduled a follow-up immediately after the intervention [12]. Four studies used a knowledge questionnaire [13–16], Two confidence scales [11,15], Two performance checklists [14,16]], One OSCE [13], and One Learning Satisfaction scale [11] toevaluate the effectiveness of the intervention. Four studies used a pre-post design [13–16], and Two studies compared only post-test [11,12].

3.1.1. Effects of the intervention

3.1.1.1. Cognitive domain. Three study findings [13,15,16] with 169 subjects randomized to simulation-based learning (n = 88) and traditional methods (n = 81) assessed the knowledge component. The results reported that the standardized mean difference in pre-and post-interventional knowledge scores was 1.52, 1.63, and 0.80 [13,15,16]. Additionally, the results showed a significant effect on knowledge acquisition (SMD = 1.31, 95% CI [0.80, 1.82], P < 0.00001), indicating a varied heterogeneity between study estimates (I2 = 54%). The significant intervention effect size is in favor of Simulation-based learning [Fig. 4].

3.1.1.2. Affective domain. Three studies [12,13,15] with 191 subjects, randomized into simulation-based learning groups (n = 95) and traditional methods (n = 96), assessed the effects of the intervention on the affective domain, i.e., self-confidence with one study having physical assessment as an affective domain component. The findings revealed that the standardized mean difference in pre-and post-interventional Self-confidence scores was 1.23, 1.89, and 2.69, respectively [12,13,15]. The pooled results of the meta-analysis showed a significant effect on self-confidence (SMD = 1.93, 95% CI [1.01,2.84], P < 0.0001). Furthermore, the heterogeneity between the studies is high, with I2 -85%. [Fig. 5]. Similarly, pooled analysis of self-confidence when compared with one study having psychological care as an effective domain component revealed a significant effect size (SMD = 1.83, 95% CI [0.91,2.74], P < 0.0001). [Fig. 6].

The difference in standardized mean confidence scores in pre-and post-interventional was 1.23, 1.56, and 2.69, respectively [12,13, 15]. The heterogeneity between the studies is high with I2 -85% [Fig. 8]. Overall, the pooled effect size for the studies [12,13,15] shows a significant effect in favor of Simulation-based learning compared to the traditional method [Fig. 6]. However, due to missing data, MA was not done for one study [11]. However, the findings showed improvement in Learning Self-confidence [E: 19.44, C-14.41] and Learning Satisfaction [E:17.94, C-17.60] among the simulation group.

3.1.1.3. Psychomotor domain. Findings of the three studies [12,13,16] with 158 subjects, randomized into simulation-based learning group (n = 83) and traditional methods (n = 75), measured the intervention effects on the psychomotor domain, i.e., skills with one study having physical assessment as a psychomotor domain component. The findings revealed that the standardizedmean difference in pre-and post-interventional Skills was 2.20, 0.69, and 2.01 [12,13,16]. The pooled result of the meta-analysis depicted the significant learning outcome in the psychomotor domain i.e., skill (SMD = 1.62, 95% CI [0.62,2.62], P = 0.002). Furthermore, the heterogeneity between the studies is high, with I2 -86%. [Fig. 7]. Similarly, pooled analysis of the psychological domain compared with one study having psychological care as an effective domain component revealed significance (SMD = 1.60, 95% CI [0.61,2.58], P = 0.001). The standardized mean difference in pre-and post-interventional Skills was 2.20, 0.69, and 1.94, respectively [12,13,16]. The

Table 1
Characteristics of Included study.

Study	Participant characteristics		Intervention (Simulation)	Comparison (Traditional)	Outcome						Quality (JBI tool)
					Primary (Knowledge)		Secondary (skill)		Secondary (Self-confidence)		
	Age (Mean ± SD)	Year of Bachelor's Degree in Nursing			I	II	I	II	I	II	
[13]; **Japan**	21.0 ± 0.62	Third Year	End of Life Care by Standardized Patients (SPs)	Nursing curriculum (one class on palliative care and four classes involving case study discussions of patients at the EOL stage	E:6.15 ± 1.23 C: 6.00 ± 1.33	E: 8.45 ± 1.36 C: 6.17 ± 1.38	***Physical assessment*** E: 2.10 (1.45); C: 2.94 (1.51) ***Psychological care*** E: 3.30 (2.15); C: 5.78 (3.54)	***Physical assessment*** E: 5.55 (1.67); C: 2.39 (1.38) ***Psychological care*** E: 11.75 (2.38); C: 6.00 (3.40)	***Physical assessment*** E:1.50 (0.69); C:1.39 (0.70) ***Psychological care*** E:1.30 (0.47); C:1.67 (0.77)	***Physical assessment*** E: 2.80 (0.89); C: 1.33 (0.59) ***Psychological care*** E:2.25 (0.10); C:1.56 (0.62)	Moderate 8/13
[12]; **T, Turkey**	19.5 ± 0.57	Second Year	Simulation with SPs	Regular curriculum lessons and clinical practice training programs at the chest diseases clinic	–	–	–	E: 39.08 (±5.49) C: 26.73 (±5.63)	–	E: 8.48 (±0.88) C: 7.07 (±1.33)	High 12/13
[11]; **Brazil**	18–23	Third year + internship	Lecture & dialogical classes, skills training Simulation	Lecture & dialogical classes, skills training	–	–	–	–	–	**Learning Self Confidence** E: 19.44; C: 14.41 **Satisfaction:**E: 17.94 C: 17.60	Low 5/13
[14]; **Turkey**	19.95 ± 1.77	First-year	Cardiac auscultation training by using a high- fidelity simulator	Training received with the traditional teaching method.	Median score E: 64 (8.00 ± 100.00) C: 69 (28.00 ± 92.00)	E: 92 (62.00 ± 100.00) C: 83 (36.00 ± 100.00)	E: 14 ± 18.00); C: 13.50 ± 32.00) (0.00 ± 5.00	E: 25 ± 27.00) (22.00 ± 9.00) C: 17 ± 24.00)	–	–	Moderate 8/13
[15] Jordan	20.2 ± 1.00	–	ACLS simulation scenario, a 4-h PowerPoint presentation, and a demonstration of a static manikin	PowerPoint presentation and a demonstration only	E: 5.01 ± 1.78 C: 4.59 ± 1.86	E: 12.92 ± 3.02 C: 7.88 ± 3.50	–	–	E:11.01 ± 5.86 C:10.50 ± 4.96	E: 74.38 ± 11.55 C: 32.85 ± 18.16	Moderate 7/13
[16]; **Iran**	22.7 ± 3.03	Third year	BLS education with conventional method + Clinical skill using CPR mannequins	BLS education With the conventional method	E:10.18 ± 2.61 C: 10.05 ± 2.78	E:16.78 ± 1.97 C: 14.14 ± 2.43	***Performance*** E:5.43 ± 3.01 C: 6.19 ± 2.13	***Performance*** E: 17.78 ± 1.91 C: 14.95 ± 2.92	–	–	Moderate 8/13

Footnotes: E-Experimental; C-Control; BLS-Basic Life support; ACLS-Advanced cardiac life support.

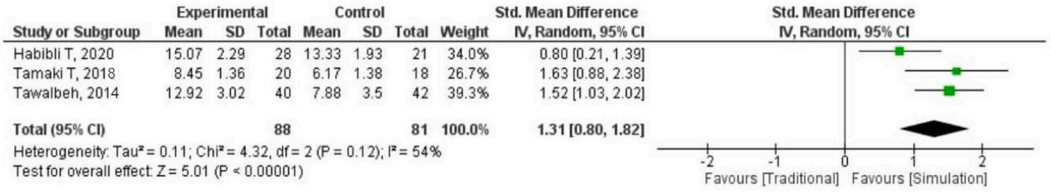

Fig. 4. Forest plot of Effect size and 95% CI by Simulation-based learning versus the traditional method of Knowledge.

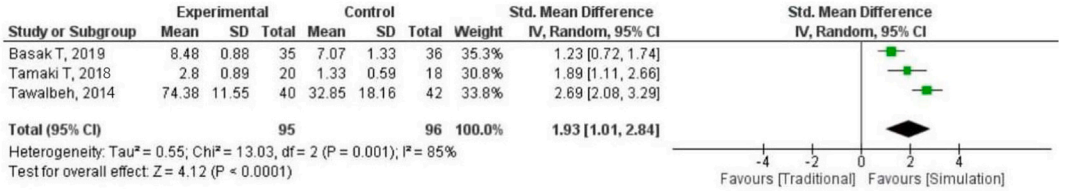

Fig. 5. Forest plot of Effect size and 95% CI by Simulation-based learning versus traditional method on Self-confidence (Physical assessment).

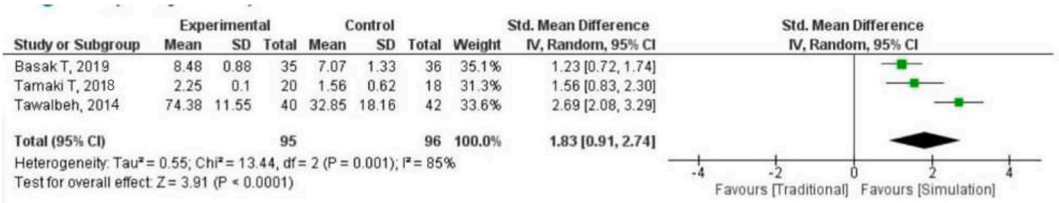

Fig. 6. Forest plot of Effect size and 95% CI by Simulation-based learning versus traditional method on Self -confidence (Psychological Care).

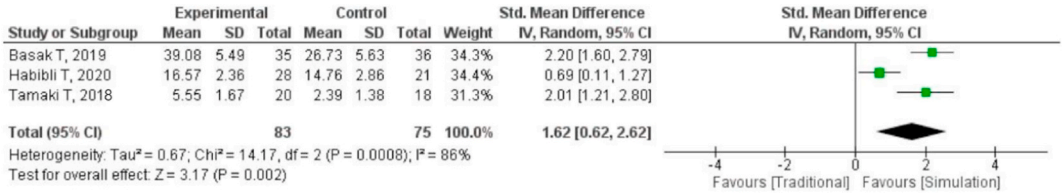

Fig. 7. Forest plot of Effect size and 95% CI by Simulation-based learning versus traditional method on Skill (Physical assessment).

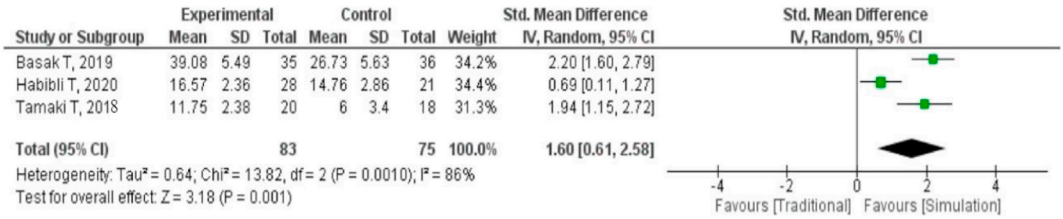

Fig. 8. Forest plot of Effect size and 95% CI by Simulation-based learning versus traditional method on Skill (Psychological Care).

heterogeneity among the studies is high with I2 -86% [Fig. 8]. Overall, the pooled effect size for the studies [12,13,16] shows a significant effect in favoring Simulation-Based learning in comparison to the traditional methods.

4. Discussion

Healthcare is constantly evolving, which means modes for training future healthcare professionals are ever-changing. SBL is the tool to develop knowledge and skills for a clinical procedure that can be done in a real environment [17]. SBL is a structured learning experience for the students. SBL is a widespread pedagogical method that provides an opportunity to learners to improve their skills and decision-making knowledge through experience of real-life situations [7]. Although, the simulation process creates continuity in skill from low-fidelity to high-fidelity simulation, aiming to fill the gap between theory and practice through innovative teaching

strategies compared with traditional teaching methods [7]. Many researchers have proven the efficacy of SBL. However, very few meta-analyses and systematic reviews were reported in the field of nursing. Hence, the purpose of the current study was to assess the effect of simulation on learning outcomes. It will further help to answer whether SBL should be an integral part of the nursing curriculum.

The findings from present meta-analysis showed that SBL has beneficial effects on knowledge as compared to traditional method (SMD = 1.31, 95% CI [0.80, 1.82], P < 0.00001). In addition, Simulation-based education evaluates students critical thinking and decision-making skills. Once students receive feedback during debriefing sessions from the respective instructor, the scenarios can be repeated for the augmentation of skills and the ability to retain and apply knowledge [18]. The pooled result of all three studies [13,15,16] revealed a significant statistical difference between the interventional and control group, thereby favoring SBL in knowledge acquisition. Similar findings are reported by other studies favoring SBL [5,7,19]. In addition, a meta-analysis [20] evaluated a significant effect in favor of simulation with less statistical heterogeneity (I2 = 23%). Although, this analysis was considered as low-quality of evidence.

In Contrast, the present study findings have high heterogeneity (I2 = 54%), but the pooled results showed significant findings. The reason for heterogeneity can be due to the limited number of RCTs eligible for analysis. The analysis results of the study conducted among nurses revealed that knowledge retention among the intervention group was higher than in the control group (SMD = 1.89, 95% CI = 0.76–2.87, P = 0.0008) [21].

Simulation-based training is an effective way to improve nurses' skills, thereby improving healthcare quality and reducing errors [2]. Present study findings showed significant improvement in skill after simulation as compared to other traditional methods of teaching (SMD = 1.62, 95% CI [0.62,2.62], P = 0.002) and (SMD = 1.83, 95% CI [0.91,2.74], P < 0.0001) respectively with heterogeneity ranging from I2 = 95%–96%. However, there was a noteworthy statistically significant difference between the interventional and control groups that indicate the efficacy of simulation-based learning in improving skills. Various Clinical trials reported similar findings [7,22–24] and supported simulation in undergraduate nursing education. The findings of various research also revealed the efficiency of Simulation on learning [25,26].

Self-confidence is an important factor that hinders the student's knowledge and clinical skill application. Self-confidence can reduce students' fear of applying the knowledge that they have gained [27]. The current results suggest that SBL can improve self-confidence among learners. The findings were in favor of SBL in increasing self-confidence (SMD = 1.93, 95% CI [1.01,2.84], P < 0.0001) and (SMD = 1.83, 95% CI [0.91,2.74], P < 0.0001) respectively. Similarly, the random-effect model findings showed that the self-confidence among the interventional group is higher than the control group (SMD = 1.19, 95% CI = 0.48–1.90, P = 0.001) [21].

Student satisfaction is an essential factor for evaluating the efficiency and learning interest regarding the teaching method. Few studies depict that the learning environment and teaching-learning methods directly influence the interest and learning satisfaction of students. Evidence shows high learner satisfaction among students using simulators [24,27,28]. The Present study reported learning satisfaction among students with simulation-based learning (17.94) as compared to traditional teaching. (17.60) reported similar findings with a mean difference of 1.57, signifying learning satisfaction among students [22]. In addition, an integrated review found that students were satisfied with the simulation [29]. Learning satisfaction among the intervention group is higher than the control group as shown by the radon-effect model (SMD = 0.86, 95% CI = 0.13–1.60, P = 0.02) [21].

Overall, findings of present meta-analysis recommend the use of SBL in improving the critical thinking skills among student nurses' thereby preventing patients from any harm related to direct practice. Further it is recommended that every hospitals and teaching institute must have SBL facilities to prepare student nurses to deal with real clinical scenarios efficiently.

4.1. Limitations

The review included various limitations. The literature search was only for published research and English studies thereby limiting the inclusion of fewer studies for analysis. The data collection tools to evaluate outcomes were varying, and evidence for identifying the best tool was uneven in the reviewed studies. The selected studies lack methodological quality since there is no clarity regarding allocation concealment and blinding. Research had a non-equivalent control group post-test-only design and thus, was at risk for bias. Small sample sizes were another limitation to generalize the outcomes.

5. Conclusion

The knowledge and clinical skills of nursing students were improved with Simulation-based education also it has been observed to increase self-confidence and learning satisfaction. The outcomes of this review analyzed the effectiveness of simulation-based learning on students learning. The combined results of the studies showed that the nursing students secured good marks after simulated-based learning than those who underwent traditional teaching methods. Hence, it can be concluded that simulation must be a part of the nursing curriculum, and every institution should implement the use of simulation to produce efficient future nurses.

Author contribution statement

Rakhi Mishra; Hemlata; Divya Trivedi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of competing interest

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.

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