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Review

Effect of simulation training on the development of nurses and nursing students' critical thinking: A systematic literature review

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ABSTRACT

Objective: To gain insight into the existing scientific evidence on the effect of simulation on critical thinking in nursing education.
Design: A systematic literature review of original research publications.
Data Sources: In this systematic review, the papers published in English and Farsi databases of PubMed, Science Direct, ProQuest, ERIC, Google Scholar and Ovid, MagIran and SID, from 1975 to 2015 were reviewed by two independent researchers.
Review Methods: Original research publications were eligible for review when they described simulation program directed on nursing student and nurses; used a control group or a pretest post-test design; and gave information about the effects of simulation on critical thinking. Two reviewers independently assessed the studies for inclusion. Methodological quality of the included studies was also independently assessed by the reviewers, using a checklist developed by Greenhalgh et al. and the checklist of Cochrane Center. Data related to the original publications were extracted by one reviewer and checked by a second reviewer. No statistical pooling of outcomes was performed, due to the large heterogeneity of outcomes.
Results: After screening the titles and abstracts of 787 papers, 16 ones were included in the review according to the inclusion criteria. These used experimental or quasi-experimental designs. The studies used a variety of instruments and a wide range of simulation methods with differences in duration and numbers of exposures to simulation. Eight of the studies reported that simulation training positively affected the critical thinking skills. However, eight studies reported ineffectiveness of simulation on critical thinking.
Conclusion: Studies are conflicting about the effect of simulation on nurses and nursing students' critical thinking. Also, a large heterogeneity exists between the studies in terms of the instruments and the methods used. Thus, more studies with careful designs are needed to produce more credible evidence on the effectiveness of simulation on critical thinking.

1. Introduction

Global changes in health care require nurses with critical thinking skills that can effectively be accountable in complex clinical situations (IOM, 2011). Guidelines of nursing education in the United States (U.S.) have a strong emphasis on the need for critical thinking, so that the American Association of Colleges of Nursing considers critical thinking as an essential outcome of nursing education (AACN, 2008.

Critical thinking is defined as a purposeful and self-regulatory judgment which results in interpretation, analysis, evaluation and inference (Shin, Ma, Park, Sun Ji, & Kim, 2015). Critical thinking in the profession of nursing has been defined as "the process of reflective and reasonable thinking about nursing problems without a single solution and is focused on deciding what to believe and do" (Yildrim & Ozkahraman, 2011, p.257). Nurses and nursing students as health care providers should be creative, self-directed and critical thinkers to be able to make appropriate decisions and solve clinical problems they are encountered (Azizi, Hajibagheri, & Adib, 2015). Given the importance of critical thinking in nursing, nurse educators should use teaching methods that can foster this ability in nursing students (Shin et al., 2015). It is believed that using experiential learning methods such as scenarios and simulation programs can simultaneously provide the students opportunities for training and promoting their critical thinking skills (Ravert, 2008). Simulation, in its many forms, has been a part of nursing education and practice and has appeared in the past 40 years (Nehring & Lashley, 2009). As a method of active learning, human patient simulation provides opportunities for the students to implement

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the content of theoretical courses in clinical settings (Cant & Cooper, 2010).

In the current health education system, the demand for clinical placements is increased while the availability of practice supervisors is limited. On the other hand, there are some ethical issues related to patient care and safety such as the need for higher quality healthcare services with lower costs and shorter length of hospital stay. In this condition the students have low chance for active involvement with patient care and opportunities to deal with practice situations have also reduced. Hence, there has been a need to reproduce that experience by some other means (Alinier, Hunt, Gordon, & Colin, 2006; Azizi et al., 2015). Simulation methods enable learners to learn experientially in a safe environment (Cioffi, 2001), and give them the opportunity to discover and follow the patients' problems through practicing clinical reasoning and judgment skills (Shinnick, Woo, Horwich, & Steadman, 2011).

A wide range of low to high-fidelity simulation methods are available in nursing education (Cant & Cooper, 2010) that their effectiveness is confirmed by the National Council of State Boards of Nursing (2005), nurse educators (Hammond, 2004; Henneman & Cunningham, 2005) and nursing students (Reilly & Spratt, 2007; Lasater, 2007, 12). In a recent study, Maneval et al. (2012) reported that simulation using human-like mannequins is a good strategy to promote the critical thinking and clinical decision-making skills of new graduate nurses.

In another study, Nehring and Lashley (2004) reported that human patient simulators could improve the nursing students' critical thinking skills and helped them to implement theory in clinical practice. Although a number of researchers reported that using simulation methods in education and particularly the human patient simulation (HPS) are associated with gains in knowledge (Shinnick et al., 2011), gains in self-efficacy (Brown & Chronister, 2009), skill attainment (Alinier et al., 2006) and gains in problem solving skills (Steadman et al., 2006). However, inconsistencies exist not only about the effects of clinical simulators on learning, but also about their effects on nursing students' critical thinking skills. Nonetheless, proponents of simulation strongly believe that this approach has positive effects on nurses' critical thinking and clinical skills (Shinnick & Woo, 2013). In spite of this, some of the studies have produced conflicting results regarding the effects of simulation programs on the students' critical thinking skills (Maneval et al., 2012; Shinnick & Woo, 2013). Thus, the question still comes to mind whether using simulation is more effective on the development of nursing students' critical thinking skills than traditional methods? To answer this question, an effort was made to systematically review and summarize the results of published studies on the effectiveness of simulation on nursing students' and nurses' critical thinking skills. The main objective of our literature review is to provide a systematic and contemporary review of researches on the effects of simulation training on nurses' and nursing students' critical thinking. In this review we appraised the methodological quality of the studies reviewed, without imposing restrictions regarding countries, health care settings or time periods. The main question is whether in nursing students and nurses, dose simulation-based training is better than usual teaching methods in development of critical thinking skills? To respond this question, we reviewed the characteristics of simulation methods (i.e. the type of simulation methods, its duration and number of sessions) in relevant studies, the quality of studies, and the effectiveness of these methods on nursing students' and nurses' critical thinking skills.

2. Method

2.1. Inclusion Criteria

The following inclusion criteria were used for the selection of studies for this review:

1. The study has to relate to simulation methods only directed on nurses and nursing student.
2. The study has to concern empirical research with a comparative design in which simulation is compared with the routine teaching methods or another interventions. Randomized or non-randomized control group designs and one-group pre-test post-test designs are considered.
3. The study has to give information about the effects of simulation on nurses` or nursing students` critical thinking.
4. The full text of study has to be available in English or Farsi languages.
5. Excluded were non-original publications such as letters to the editor, abstracts only, and editorials.

2.2. Searching in Databases

The papers published in English international databases, Science Direct, ProQuest, ERIC, Google Scholar and Ovid and Farsi databases of MagIran and SID from January 1975 to June 2015 were extracted by two independent researchers. The titles and abstracts of papers stored in international databases were searched using different combination of keywords including simulation, human patient simulation, simulated patient, simulation training, critical thinking, nurse or nursing education, that were combined with search operators (AND, OR). Since Iranian databases are not sensitive to search operators (AND, OR), they were searched the Farsi equivalent of the main keyword.

2.3. Selection

Initially, 787 studies were retrieved. After screening of titles and abstracts, 767 studies were excluded as they were not appropriate according to the inclusion criteria. The full texts of the 20 remaining studies were then examined and four studies that were not in English language were discarded. Finally 16 research studies remained in the review (Fig. 1). The characteristics of the 16 included studies are presented in Table 2.

2.4. Assessment of Methodological Quality

The quality of all the reviewed studies was independently evaluated by the two authors. Experimental studies were evaluated using the Cochrane checklist whereas quasi-experimental studies were evaluated using the checklist developed by Greenhalgh, Robert, and Bate (2004). Accordingly, the scores 2 or 1 were respectively given to a study if a criterion was fully or partially covered. However, the score zero was given if the concerned criteria were not covered or did not mention in a study (Table 1).

2.5. Data Extraction and Synthesis

Next, one reviewer extracted and descriptively analyzed the characteristics of the simulation method of the included studies, as well as the research methods and outcomes (Table 2). Then, the second reviewer checked the data extraction process through critical reading of the studies. No statistical pooling of outcomes was performed, because there was considerable heterogeneity between the 16 studies.

3. Results

The main focus of this systematic literature review is on the effects of simulation on nurses' and nursing students' critical thinking (research question). However, to optimize the interpretation of these effects, we will first clarify the methodological quality and characteristics of the studies, as well as the characteristics of the simulation methods under review.

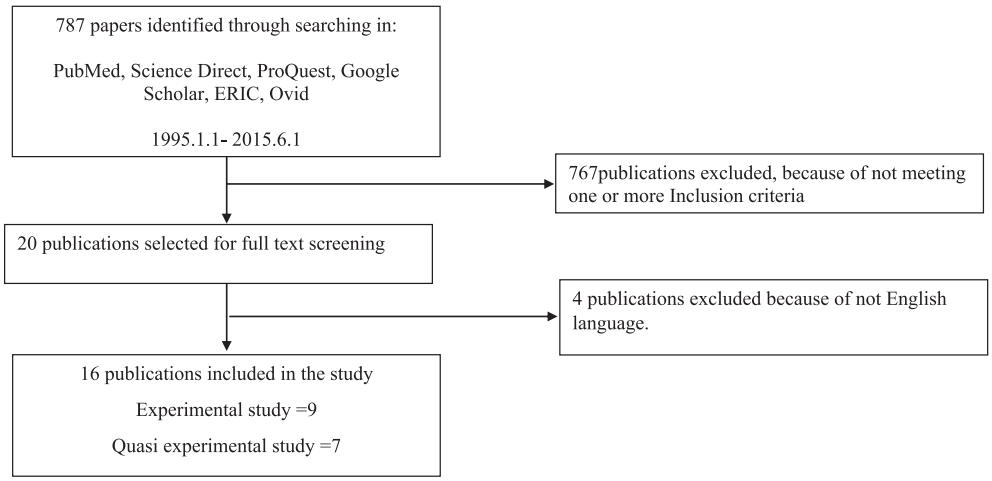

Fig. 1. Flow diagram of the searches and the selection process.

4. Characteristics of the Simulation Programs

4.1. Origin of the Studies

From a total of 16 studies, 10 studies were conducted in the U.S. (Weatherspoon et al., 2015; Ndiwane et al., 2014; Sharpnack et al., 2013; Goodstone et al., 2013; Maneval et al., 2012; Schubert, 2012; Wood & Toronto, 2012; Sullivan-Mann et al., 2009; Brown & Chronister, 2009; Ravert, 2008), four in Korea (Shin et al., 2015; Ahn & Kim, 2015; Shin & Kim, 2014; Eun & Young, 2014) and two in Hong Kong (Shinnick & Woo, 2013; Chiang & Chan, 2013).

4.2. Type of Simulation

A wide range of simulation methods were used in the 16 studies. High fidelity simulation (HFS) such as sophisticated mannequins were used in 11 studies (Shin et al., 2015; Ahn & Kim, 2015; Shin & Kim, 2014; Shinnick & Woo, 2013; Chiang & Chan, 2013; Goodstone et al., 2013; Maneval et al., 2012; Schubert, 2012; Wood & Toronto, 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009). In three studies, standardized patients (SP) were used (Ndiwane et al., 2014; Eun & Young, 2014; Ravert, 2008). In addition, two studies examined the effects of video simulation (Sharpnack et al., 2013) and electronic interactive simulation (Weatherspoon et al., 2015) on nursing students.

4.3. Topics

The scenarios used in simulation methods were different in terms of their objectives and contents. Two studies used scenarios on pediatric nursing (Shin et al., 2015; Shin & Kim, 2014). Other scenarios were related to adults' medical-surgical nursing care (Ahn & Kim, 2015; Chiang & Chan, 2013; Ravert, 2008) education of cardiac diseases and electrocardiogram (Shinnick & Woo, 2013; Brown & Chronister, 2009), failure of cardiopulmonary resuscitation (Schubert, 2012) health assessment skills (Goodstone et al., 2013; Wood & Toronto, 2012), and acute and emergency care (Weatherspoon et al., 2015; Eun & Young, 2014; Sharpnack et al., 2013). In Maneval et al. (2012), scenarios were designed based on the situations nurses frequently encounter in patient care. Scenarios were designed by a team of cardiovascular nurse experts and the manager of the hospital's simulation center. In another study, scenarios were designed by the research team with an emphasis on cultural issues in the patient care, to teach cultural diversity to graduate nursing students in Northeast United State (Ndiwane et al., 2014). A study also used the METI simulator software to design the needed scenarios (Sullivan-Mann et al., 2009).

4.4. Period and Duration

The duration of the studies and the number and time of training sessions were different among the studies (Table 2). In some of the studies, simulation method was conducted over a several-hour session (Ahn & Kim, 2015; Eun & Young, 2014; Shinnick & Woo, 2013; Schubert, 2012; Wood & Toronto, 2012). In other studies, the simulation methods were held on a weekly basis for three (Shin et al., 2015; Shin & Kim, 2014), five (Brown & Chronister, 2009; Ravert, 2008), or 14 sessions (Goodstone et al., 2013), or 5 sessions in a semester (Sullivan-Mann et al., 2009). However, the duration of the sessions were not mentioned in the papers. In some of the studies, the simulation methods ran for a certain period, such as two weeks (Weatherspoon et al., 2015), 10 weeks (Maneval et al., 2012), six months (Chiang & Chan, 2013), nine months (Ndiwane et al., 2014), or 12 months (Sharpnack et al., 2013), however, the number and the duration of the sessions were not mentioned.

4.5. Methodological Quality Assessment

All of the 16 studies had several methodological problems. Only one study (Maneval et al., 2012) was performed with higher quality. Lack of protection against information contamination between the study groups, lack of adequate blinding, especially by outcome evaluators, lack of covert allocation into the study groups, and short-term follow-up were the most common shortcomings in experimental studies. In the case of quasi-experimental studies, small sample size, lack of control over the contaminating factors or extraneous variables, and short-term follow-up were the most prevalent shortcomings. Nonetheless, experimental studies were scored higher than that of pretest-posttest quasi-experimental studies (Table 1).

5. Methods Used in the Studies

5.1. Design

Among the reviewed studies, nine studies had experimental designs (Weatherspoon et al., 2015; Ahn & Kim, 2015; Eun & Young, 2014; Goodstone et al., 2013; Maneval et al., 2012; Wood & Toronto, 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009; Ravert, 2008), seven studies were quasi-experimental with pretest-posttest designs (Shin et al., 2015; Shin & Kim, 2014; Ndiwane et al., 2014; Chiang & Chan, 2013; Sharpnack et al., 2013; Shinnick & Woo, 2013; Schubert, 2012) and two studies had three group designs (Shin et al., 2015; Ravert, 2008). A quasi-experimental pretest-posttest study used an

Table 1
Criteria list for the methodological quality assessment.

Quasi-experimental study	Shin et al., 2015	Ndiwane et al., 2014	Shin & Kim, 2014	Shinnick & Woo, 2013	Chiang & Chan, 2013	Sharpnack et al., 2013	Schubert, 2012	Experimental study	Ravert, 2008	Brown & Chronister, 2009	Sullivan-Mann et al., 2009	Wood & Toronto, 2012	Maneval et al., 2012	Goodstone et al., 2013	Eun & Young, 2014	Ahn & Kim, 2015	Weatherspoon et al., 2015
Research question/design clear and appropriate	2	2	2	2	2	2	2	Concealment of allocation	1	1	1	1	2	0	0	1	1
Intervention independent of other changes over time Sufficient data points	1	1	1	1	1	1	1	Follow-up of all patients/professionals care randomized	1	1	1	1	1	1	1	1	1
Sufficient data points	2	1	1	1	2	2	1	Blinded assessment of primary outcome(s)	1	1	1	1	1	1	0	1	1
Statistical tests appropriate	2	1	2	2	2	2	2	Baseline comparability of groups	1	2	2	2	2	2	1	2	2
Outcome measures valid and reliable	2	1	2	2	2	1	1	Reliable primary outcome measure(s)	1	1	2	2	2	1	2	1	2
Data collection same before and after	2	2	2	2	2	2	2	Protection against contamination	1	1	1	1	1	1	1	1	1
Completeness of data set (does the data set cover all or most of the episodes of care)	2	1	2	2	2	2	2										
Long enough follow-up to show impact	1	2	1	1	2	2	2										
Summary	14	11	13	13	15	14	13		8	7	8	8	9	6	5	7	8

asynchronous control group (Eun & Young, 2014). In another study, Chiang and Chan (2013) used a mixed-method design. The quantitative phase included a one group, pretest-posttest design, whereas interviews were conducted with participants in the qualitative phase (Chiang & Chan, 2013).

5.2. Samples

The sample sizes were also very different among the studies and ranged from 26 (Maneval et al., 2012) to 237 (Shin et al., 2015) (Table 2).

5.3. Instruments

A variety of instruments (ten instruments) have been used to measure the critical thinking skills in the reviewed studies (Table 2). Some of the studies used general scales for measurement of critical thinking such as the California Critical Thinking Disposition Inventory (CCTDI) (Weatherspoon et al., 2015; Chiang & Chan, 2013; Wood & Toronto, 2012; Ravert, 2008) and California Critical Thinking Skills Test (CCTST) (Ravert, 2008). All of the four Korean studies used some general critical thinking scales that were standardized to Korean populations (Shin et al., 2015; Ahn & Kim, 2015; Shin & Kim, 2014; Eun & Young, 2014) such as Yoon's Critical Thinking Disposition tool (YCTDT). Some of the studies also used the Health Science Reasoning Test (HSRT) which is specifically designed for measuring the critical thinking skills in health care professionals (Shinnick & Woo, 2013; Goodstone et al., 2013; Maneval et al., 2012; Sullivan-Mann et al., 2009). A number of studies also used some uncommon instruments such as Students' Satisfaction Scale (SSS) (Ndiwane et al., 2014), Holistic Critical Thinking Scoring Rubic (HCTSR) (Chiang & Chan, 2013), Creightone Stimulation Evaluation Instrument (C-SEI) (Sharpnack et al., 2013), and Learning Transfer Tool (LTT) (Schubert, 2012) to measure the critical thinking skills. In a study, a computerized electrocardiogram software, named 'ECG SimTest' was used to examine the effect of simulation learning on critical thinking (Brown & Chronister, 2009). The validity and reliability of the instruments used were reported in 14 studies (and all were valid and reliable), but was not in two studies (Ndiwane et al., 2014; Chiang & Chan, 2013).

5.4. Effects

In addition to critical thinking, reviewed studies have examined a number of outcome variables, however, according to the research question, the present review focused only on critical thinking.

Eight studies reported the positive effect of simulation training on critical thinking, whereas other studies reported conflicting findings.

5.5. Positive Effect of Simulation Training on Critical Thinking

Among the 16 studies, eight studies reported that simulation training positively affected the critical thinking skills in nurses and nursing students (Weatherspoon et al., 2015; Ahn & Kim, 2015; Ndiwane et al., 2014; Shin & Kim, 2014; Chiang & Chan, 2013; Goodstone et al., 2013; Sharpnack et al., 2013; Schubert, 2012). In Weatherspoon et al. (2015), the effect of an electronic interactive simulation program on senior baccalaureate nursing students' critical thinking was compared to traditional case study. At the end of the study, students who participated in the electronic interactive simulation program gained higher critical thinking scores than the comparison group ($P = 0.012$). Ahn and Kim (2015) also compared the effect of high-fidelity simulation scenarios and traditional teaching methods (i.e. lecture and case studies) on critical thinking of Korean nursing students. The researchers implemented two simulation scenarios and reported no significant difference between the experimental and control groups after the first scenario ($P = 0.971$). However, the experimental group demonstrated

Table 2
Methodological characteristics and effects measured[a].

Source/country	Objective	Design	Sample	Instrument	Type of simulation	Number of sessions	Duration of sessions	Result
Shin et al. (2015)/South Korea	Examining the effect of an integrated pediatric nursing simulation on students' CT[b] abilities	Pre-post test	237 undergraduate senior nursing students in 3 universities	YCTDT[c]	HFPS	School A = 1 session, school B = 2 sessions, school C = 3 sessions	Not specified	Single exposure to the simulation courseware resulted in no gain in CT; three exposure showed significant gains in CT; two exposures showed gains in CT, but it was not statistically significant
Weatherspoon, Phillips, and Wyatt (2015)/USA	To compare the effects of EIS[d] and TPCSS[e] on CT in senior nursing students	RCT	117 senior nursing students Exp[f] = 60 Con[g] = 57	CCTDI[h]	Electronic interactive	Not specified	Not specified	Between-subject and within-subject comparisons, and interaction effects indicated a significant increase in overall CT disposition ($P < 0.012$) and in three dimensions of CT disposition (i.e. truth seeking, open mindedness and confidence in reasoning)
Ahn and Kim (2015)/Korea	Using learning outcomes (including CT skills) to evaluate the students' simulation experience	Two groups post-test design	72 third year nursing students, Group1 = 35 Group2 = 34	KNSCTT[i]	HFPS	1 session	Each scenario 2 h	No statistically significant difference was found between the experimental and control groups in CT skills neither scenario 1 nor in scenario 2.
Ndiwane, Omanand Koul, and Theroux (2014)/USA	Assessing the effect of simulated patient on the students outcomes (i.e. CT, student satisfaction, self-confidence, and cultural competence)	Pre-post test	29 first-year graduate nursing students	SSS[j]	Standardized patients	Not specified	Not specified	The mean CT scores increased.
Shin and Kim (2014), South Korea	Examining the effect of integrated pediatric nursing simulation courseware on students' CT	Pre-post test	95 senior undergraduate nursing students	YCTDT	HFPS	3 sessions	Not specified	The CT score significantly increased by 6.27 points ($P = 0.001$). Five of the seven categories of CT significantly increased
Eun and Young (2014)/Korea	To identify the effects of multi-mode simulation learning on CT disposition	Pre-posttest nonequivalent control group	The treatment group consisted of 33 juniors in 2010 and the control group 32 juniors in 2011	YCTDT	Standardized patient/LFPS	1 session	4 h	No significant difference was observed between the two groups.
Shinnick and Woo (2013)/Hong Kong	To determine the effect of HPS on CT in prelicensure nursing students	Pre-post test	154 prelicensure nursing students	HSRT[k]	HFPS	1 session	Not specified	No statistically significant gains on CT.
Chiang and Chan (2013), Hong Kong	To evaluate the development of CT disposition and skills of nursing students	Mixed-method	132 undergraduate pre registration nursing students	CCTDI/HCTSR	HFPS	Not specified	Not specified	There was a significant increase in overall CCTDI scores acrossT1 and T3 ($P = 0.000$)
Sharpnack, Goliat, Baker, Rogers, and Shockey (2013)/USA	To examine the effectiveness of using video-taped scenario simulations on the CT scores	Pre-post test	54 nursing students enrolled in a senior-level leadership course	C-SEI	Video scenario	Not specified	Not specified	Significant increase in all C-SEI competencies between pre-post test
Goodstone et al. (2013)/ USA	To compare the effects of HFPS and instructor- written case studies on the development of CT skills	Two groups pre-post test	Associate degree nursing student; HFPS group = 20 Case study group (LFPS) = 22	HSRT	HFPS	14 sessions	3 h	Both groups showed an increase in CT skills' however no significant difference was found between the two groups.
Maneval et al. (2012)/USA	To determine the effect of high-fidelity patient simulation on CT	Pre-post test	New graduate nurses, Exp = 13 Con = 13	HSRT	HFPS	Not specified	Not specified	No statistically significant difference was found between the two groups.
Schubert (2012)/USA	To determine whether the simulation improved nurses' knowledge of failure to rescue events and CT	Pre-post test	58 staff nurses from four medical-surgical units	Learning transfer tool	HFPS	1 session	Not specified	A significant change in CT between pretest and posttest ($P = 0.001$).
Wood and Toronto (2012)/USA	Assessing the influence of human patient simulator on CT dispositions	Pre-post test	85 novice baccalaureate nursing students, Exp = 42 Con = 43	CCTDI	HFPS	1 session	2 h	No significant difference was found between the posttest scores of the two groups.

(continued on next page)

Table 2 (*continued*)

Source/country	Objective	Design	Sample	Instrument	Type of simulation	Number of sessions	Duration of sessions	Result
Sullivan-Mann, Perron, and Fellner (2009)/USA	To investigate the effect of simulation teaching on the critical-thinking abilities	RCT	53 associate degree students, Exp = 27 Con = 26	HSRT	HFPS	Exp = 5 sessions Con = 2 sessions	Not specified	On the posttest, the experimental group answered significantly more questions than they did at pretest but although the control group improved, its change was not significant. Also, the difference of the two groups was not significant.
Brown and Chronister (2009)/USA	To assess the effect of simulation activities on CT and self-confidence in an electrocardiogram nursing course	Comparative, correlative	140 senior baccalaureate nursing students	ECG sim test	HFPS	5 sessions	100 min	No significant differences were observed in the overall ECG SimTest score or the subcategories
Ravert (2008)/USA	To determine whether measures of critical thinking show differences between three groups (simulator, non-simulator, control) of baccalaureate nursing students.	Pre-post test	40 undergraduate students in three groups: Exp 1 (non-HPS) = 13 Exp 2 (HPS simulation) = 12 Con = 15	CCTS[l]/CCTDI	HFPS	5 sessions	Not specified	The HPS group and the non-HPS group both experienced a moderate effect in CCTDI scores while the control group experienced a large effect. However, the experimental groups experienced a larger effect size than the control group in CCTST scores.

[a] Only methods and effects meeting our review questions are reported.
[b] Critical thinking.
[c] Yoon's Critical Thinking Disposition tool.
[d] Electronic interactive simulation.
[e] Traditional paper case study simulation.
[f] Experimental group.
[g] Control group.
[h] California critical thinking dispositions inventory.
[i] Korean nursing students' critical thinking tendency.
[j] Student satisfaction survey.
[k] Health science reasoning test.
[l] Californian critical thinking skill.

significantly higher critical thinking skills after the second simulation scenario (P = 0.047) (Ahn & Kim, 2015).

Ndiwane et al. (2014) also investigated the effects of a simulation method on first-year graduate nursing students' critical thinking. The simulation method was implemented for nine months and the results indicated that not only the students were satisfied with the program, but also the method could promote their critical thinking scores so that the students received a mean of 4.45 on a scale of 1 to 5. Furthermore, one study reported positive effects of an integrated pediatric nursing simulation courseware on critical thinking of Korean nursing students who enrolled in a pediatric nursing practicum (Shin & Kim, 2014). Chiang and Chan (2013) also implemented a simulation training method designed based on the results of qualitative interviews and reported that the intervention could significantly increase the participants critical thinking scores (P = 0.000). In another study conducted at a Midwestern college in the U.S., Sharpnack et al. (2013) investigated the effectiveness of using video simulation scenarios on the critical thinking scores of baccalaureate nursing students in both the traditional and second-degree accelerated nursing pathways. The study showed that the intervention could significantly improve the students' critical thinking skills (P = 0.0001). Goodstone et al. (2013) also showed the positive effect of both HFS and Low Fidelity Simulation (LFS) programs on nursing students' critical thinking. In addition, finding of Schubert (2012), confirmed the effectiveness of a simulation training method on promotion of nurses' knowledge and critical thinking about failure to rescue events.

5.6. Ineffectiveness of Simulation Training on Critical Thinking

Eight studies reported ineffectiveness of simulation methods on critical thinking (Shin et al., 2015; Eun & Young, 2014; Shinnick & Woo, 2013; Maneval et al., 2012; Wood & Toronto, 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009; Ravert, 2008). In Shin et al. (2015) study, a simulation program was conducted on undergraduate senior nursing students in three nursing schools. Students at schools A, B and C respectively completed one, two, and three simulation scenarios during a similar practicum on pediatric nursing. Results showed that the effect of the program on the students' critical thinking scores increased with the numbers of exposures to the simulation program. So that in within group comparison, only the students with three exposure showed a significant increase in critical thinking score (P = 0.002). However, in between group comparison no statistically significant difference was found between the posttest critical thinking mean scores of the students in the three schools (P = 0.642). In another study, Eun and Young (2014) examined the effect of a multi-mode simulation program on critical thinking of junior nursing students enrolled in a 4-year curriculum. Finally, the critical thinking score of the experimental and the control groups increased by 0.11 and 0.14 points respectively. However, the difference between the two groups was not statistically significant (P = 0.692) (Eun & Young, 2014). In another study, Shinnick and Woo (2013) reported that simulation training could not significantly affect the nursing students' critical thinking scores (P = 0.76).

Maneval et al. (2012) investigated the effect of simulation training on nurses' critical thinking and reported that although the intervention increased the overall critical thinking score, no significant differences were found in critical thinking mean scores neither in between-group (t = −0.38, P = 0.70) nor in within-group comparisons (P = 0.30 and 0.40, for the experimental and control groups respectively). Similarly, Wood and Toronto (2012) reported that although using human patient simulators could increase the critical thinking score of novice nursing students in the intervention group, however, no significant difference was observed between the mean critical thinking scores of the

experimental and the control group (Wood & Toronto, 2012). In a pre-test-posttest two group study, Sullivan-Mann et al. (2009) implemented a human patient simulation method in 56 nursing students who were allocated in the intervention and control groups. The intervention group received more simulation scenarios than the control group. Although the posttest scores were significantly increased in the intervention group, however, no significant difference was found in posttest critical thinking mean scores in between-group comparisons ($P > 0.05$). Brown and Chronister (2009) examined the effect of a simulation learning program that was incorporated into an electrocardiogram nursing course in senior-level baccalaureate nursing students. The researchers could not find a significant difference between the critical thinking scores of the intervention and the control groups ($P = 0.791$). In Ravert (2008), although the implemented simulation training could increase the critical thinking scores, however, the participants' disposition to critical thinking did not significantly affected ($P = 0.94$).

6. Discussion

Several studies have been conducted to investigate the effect of simulation training on nursing students' and nurses' critical thinking. Although the majority of the studies demonstrated that simulation had a positive impact on critical thinking, the observed effect was not statistically significant in half of the studies, especially when the resultant effects have been compared with the control groups (Shin et al., 2015; Eun & Young, 2014; Shinnick & Woo, 2013; Maneval et al., 2012; Wood & Toronto, 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009; Ravert, 2008). One study even indicated a decrease in post test scores of critical thinking (Chiang & Chan, 2013).

Although critical thinking was the main outcome variable in all of the reviewed studies, a wide range of instruments have been used to measure the critical thinking. So, the inconsistent results may be attributed to the use of different measurement instruments. A number of the studies used a broad-spectrum scale for measuring critical thinking such as the California Critical Thinking Disposition Inventory or California Critical Thinking Skills Test, whereas, others used specific and culturally adopted instrument appropriate to the educational content (Sharpnack et al., 2013; Brown & Chronister, 2009). The question now is whether a general measurement scale of critical thinking is appropriate for evaluating the effect of training specialized nursing topics in nurses and nursing students. On the other hand, disposition toward critical thinking depends largely on people's character and their rearing process, and might not be easily manipulated in a short-term course. Thus, measuring the effect of such short-term courses on critical thinking disposition would be questionable.

The wide variation in the simulation methods used might be another reason for the inconsistent results between the studies. Moreover, in a number of studies a single method was used, whereas some others used a combination of simulation methods. For instance, Ahn and Kim (2015) used two different simulation scenarios and the second scenario was more effective than the first one. Goodstone et al. (2013) also compared two types of HFS and LFS, and both methods were associated with increases in critical thinking scores. Moreover, some of the studies with positive results have reported that longer duration of the intervention and more frequent exposures to simulation can increase or reinforce the effect of simulation on critical thinking (Weatherspoon et al., 2015; Ndiwane et al., 2014; Shin & Kim, 2014; Chiang & Chan, 2013; Goodstone et al., 2013; Sharpnack et al., 2013). However, a number of studies with several exposures could not confirm this hypothesis (Maneval et al., 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009; Ravert, 2008). Thus, the question still comes to mind that how many exposures to simulation training might be required to promote the students' critical thinking? This question has not been responded yet and further studies are needed in this regard.

It also should be noted that a number of the studies with positive results suffer from some methodological weaknesses as they were one group pretest–posttest design studies (Ndiwane et al., 2014; Shin & Kim, 2014; Chiang & Chan, 2013; Goodstone et al., 2013; Sharpnack et al., 2013; Schubert, 2012). Thus, it is impossible to distinguish the effects of simulation from those of experience, increased knowledge or other external factors such as self-study or use of books, media or other educational materials. Moreover, in some of the experimental studies that did not confirm the effect of simulation on critical thinking (Eun & Young, 2014; Maneval et al., 2012; Brown & Chronister, 2009; Sullivan-Mann et al., 2009; Ravert, 2008), the control groups were simultaneously under a routine education that might developed their critical thinking scores. Such changes might have obscured the effects of simulation. Thus, further studies with more rigorous designs are needed yet to clarify the effect of simulation on nursing students' and nurses' critical thinking skills.

It seems that simulation-based learning results in improvements in nursing students' clinical judgment, self-efficacy, clinical abilities, and self-confidence (Ahn & Kim, 2015). However, the existing evidence on the positive effects of simulation on critical thinking is insufficient. Thus, the results of the present review raise some questions:

Is critical thinking an appropriate construct by which to judge the effect of simulation training? And do nurse instructors should use simulation training with greater efforts to enhance the students' critical thinking as a consequence of academic educations? Also, given the high costs of production and maintenance of simulators, there is the question that should these facilities only be kept for training certain skills or they can be used for the most parts of nursing educations?

The answers to these questions could lay a foundation for further researches to direct nurse educators effectively to optimize the use of simulation in nursing education to promote critical thinking.

7. Conclusion

It is important to use effective methods to promote the nurses and nursing students' critical thinking. However, the reviewed studies were inconsistent in their results. The effect of simulation-based education on nursing students' and nurses' critical thinking is still questionable because of a lack of rigorous published studies and substantial evidence, which play a major role in determining the reliability of the results and the validity of estimates of effects. This systematic review showed a vast heterogeneity among the studies that evaluated the effects of simulation-based learning on critical thinking in nurses and nursing students. A possible explanation for the findings may be that critical thinking is not a construct by which to judge the effect of simulation. On the other hand, the inconsistent results of the reviewed studies may to some extent be attributed to the vast range of the instruments and the scenarios used. Thus, efforts should be made to design specific instruments and scenarios for measuring the critical thinking in nurses and nursing students. Furthermore, this review might lay a foundation for further researches with more rigorous designs.

7.1. Study Limitations

In the present study, we only reviewed the English studies that their full texts were available. As limited high quality experimental studies were available on the issue, we entered the quasi-experimental pretest-posttest studies in our review. Furthermore, we did not use 'clinical reasoning' as a keyword because although it is an outcome of critical thinking, but it is not an interchangeable phrase for critical thinking.

Conflict of Interest

All authors disclose no conflict of interest.

Ethical Approval

The authors declare that no ethical approval was required for this systematic literature study.

Contributions

Mohsen Adib-Hajbaghery and Najmeh Sharifi were the principal investigators and were responsible for study concept and design, analysis, interpretation of data and preparation of the manuscript.

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