Simulation-based learning in nursing education and effects on nursing students: A systematic review

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Abstract

Simulation-based learning is a method that encourages students to participate in the learning process in real situations. The purpose of this systematic review is to review the types and effects of simulation-based learning in nursing education. The Medline, CINAHL, Cochrane Library, ScienceDirect, Clinical Key, Scopus, ThaiJO, ThaiLIS, Google Scholar, and Research Gateway Common Service databases were searched for eligible research published in English and Thai from 2011 to 2020. The researchers searched the quasi-experimental, experimental, and randomized control trials research study only. The research must examine the effects of simulation on nursing students. All researchers independently assessed the articles to find PICOS-qualifying research. The Cochrane Collaboration tool was used to assess risk of bias. A total of 17 articles were included in this review. There were several types of simulations with a wide range of scenarios: standardized patients, partial-task trainer, low-fidelity simulation, high-fidelity simulation, game-based virtual simulation, and mannequin-based simulation. The articles used a variety of instruments and assessment methods with different scenarios. The results of the review show that simulation-based learning affects nursing students' performance, knowledge, confidence, satisfaction, stress, anxiety, critical thinking, and attitude. The effects of simulation-based learning on student performance were the most commonly studied because researchers assumed that simulation-based learning would improve nursing students' clinical practice skills. However, the literature review revealed a contradiction between the results, as the study results were not statistically significant in several articles. The articles are contradictory regarding the effects of simulation-based learning because each article used very different simulation types and assessment tools. Therefore, further studies are needed to find reliable evidence on the type and effects of simulation-based learning and standardized assessment tools.

Keywords: nursing education, nursing student, simulation-based learning, systematic review

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การเรียนรู้โดยใช้สถานการณ์จำลองทางการพยาบาลและผลกระทบต่อนักศึกษาพยาบาล : การทบทวนวรรณกรรมอย่างเป็นระบบ

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บทคัดย่อ

การเรียนรู้โดยใช้สถานการณ์จำลองเป็นวิธีการที่กระตุ้นให้นักศึกษามีส่วนร่วมในกระบวนการเรียนรู้ในสถานการณ์จริง วัตถุประสงค์การทบทวนวรรณกรรมอย่างเป็นระบบครั้งนี้เพื่อศึกษาประเภทและผลกระทบของการเรียนรู้โดยใช้สถานการณ์จำลองในการศึกษาทางการพยาบาลจากฐานข้อมูล Medline, CINAHL, Cochrane Library, ScienceDirect, Clinical Key, Scopus, ThaiJO, ThaiLIS, Google Scholar, and Research Gateway Common Service ทั้งภาษาอังกฤษและภาษาไทย ระหว่างปี 2554-2563 ซึ่งเป็นงานวิจัยกึ่งทดลอง, การวิจัยเชิงทดลองและการทดลองแบบสุ่มและมีกลุ่มควบคุม พบงานวิจัยที่ผ่านการประเมินตามเกณฑ์ของ Cochrane Collaboration's tool จำนวน 17 เรื่อง ผลการศึกษาพบว่าการเรียนรู้โดยใช้สถานการณ์จำลองมีหลายวิธีด้วยสถานการณ์จำลองที่หลากหลาย ได้แก่ ผู้ป่วยมาตรฐาน ชุดฝึกสอนเฉพาะส่วน หุ่นจำลองผู้ป่วยเสมือนจริงสมรรถนะต่ำ หุ่นจำลองผู้ป่วยเสมือนจริงสมรรถนะสูงและเกมส์คอมพิวเตอร์ การเรียนรู้ด้วยสถานการณ์จำลองส่งผลต่อทักษะการปฏิบัติงาน ความรู้ ความมั่นใจ ความพึงพอใจ ความเครียด ความวิตกกังวล การคิดเชิงวิพากษ์ และทัศนคติของนักศึกษาพยาบาล อย่างไรก็ตาม การทบทวนวรรณกรรมพบว่าผลลัพธ์มีความขัดแย้งกันเนื่องจากผลการศึกษาไม่มีนัยสำคัญทางสถิติในหลายบทความ บทความมีข้อขัดแย้งเกี่ยวกับผลกระทบของการเรียนรู้โดยใช้การจำลองเนื่องจากแต่ละบทความใช้แบบจำลองและเครื่องมือประเมินผลที่แตกต่างกันอย่างมาก ดังนั้น จำเป็นต้องมีการศึกษาเพิ่มเติมเพื่อค้นหาหลักฐานที่เชื่อถือได้เกี่ยวกับประเภทและผลกระทบของการเรียนรู้โดยใช้การจำลองและเครื่องมือประเมินผลที่ได้มาตรฐาน

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Introduction

Simulation-based learning is designed by applying new techniques and methods through devices or computer programs to develop the situation as realistic as possible. Simulation-based learning helps to train nursing students' nursing skills to increase patient safety[1]. Nursing students participate in the self-learning process as if they were in real situations. Summarizing learning outcomes by reflecting on experiences from simulation scenarios allows nursing students to learn their strengths and weaknesses in order to develop their nursing practice skills[2]. Nursing students also can practice situations many times to gain confidence[3].

Simulation-based learning not only affects the satisfaction and attitudes of nursing students but also reduces anxiety and increases the confidence of nursing students[4]. Nursing students who learned through simulations had higher knowledge, satisfaction, and self-confidence than those who learned through traditional methods because simulation-based learning helped establish a link between nursing theory and clinical practice[5]. In addition, nursing students can exchange ideas in various situations and develop their abilities with their classmates, making nursing students feel confident and have positive experiences[6]. These learning outcomes also enhance nursing practice skills, critical thinking, clinical reasoning, and clinical judgment, including teamwork and communication skills[7].

Simulation-based learning has many types, such as Low-Fidelity Simulation (LFS), High-Fidelity Simulation (HFS), Standardized Patient (SP), and Virtual Simulation (vSim). LFS is a mannequin that cannot respond, such as an IV arm[8]. HFS includes a humanoid model that can respond through computerized commands. HFS can react to learners' actions in a controlled and safe setting[8]. SP is an individual who has been trained to act the role of either a patient, family member, or others in a consistent, standardized manner for the educational benefit of healthcare learners[9]. Nursing students can also practice simulations through computer programs (Vsim), which have become increasingly popular in recent years. Moreover, there are many forms of simulation-based learning in nursing education, resulting in diverse research findings. The diversity of simulation-based learning types and their effects on nursing students has led to the confusion in choosing which would be the best simulation-based learning type. Therefore, the researchers conducted a systematic review to gather and analyze information to find the appropriate approach for using simulation-based learning in nursing education.

Objective

To collect and synthesize the types and effects of simulation-based learning in nursing education.

Methods

Search strategy

This study was based on research literature from databases, including Medline, CINAHL, Cochrane Library, ScienceDirect, Clinical Key, Scopus, Thai Journal Online (ThaiJO), Thai Library Integrated System (ThaiLIS), Google Scholar, and Research Gateway Common Service. The researchers used the following keywords in the search: simulation, virtual patient, nursing education, and nursing student. The search was limited to the following study designs: quasi-experimental, experimental, and randomized control trial.

Inclusion criteria

The researchers defined the PICOS framework to be used as inclusion criteria as follows:

P (Population): Nursing students

I (Intervention): Simulation-based learning

C (Comparison): Simulation-based learning, traditional teaching, other methods of teaching

O (Outcome): Different types and various effects of simulation-based learning

S (Study design): Quasi-experimental, experimental, and randomized control trial

Additionally, inclusion criteria were (a) the research was published in full-text articles, (b) the research was published in Thai and/or English languages between 2011-2020, and (c) the research included a combination of simulation-based learning and other teaching methods.

Assessment of methodological quality

All researchers evaluated using the Cochrane Collaboration's tool for assessing risk of bias[10]. This assessment considered the quality of research in 7 dimensions: 1) Random sequence generation, 2) Allocation concealment, 3) Blinding of participants and personnel, 4) Blinding of outcome assessment, 5) Incomplete outcome data, 6). Selective reporting, and 7). Other sources of bias. For each dimension, there were three levels of assessment criteria: 'Yes', 'Unclear', or 'No'. These levels could be interpreted as three levels of risk of bias: Low risk of bias, unclear risk of bias, and high risk of bias[10]. High-quality research must have a score greater than or equal to 4 points. In this process, each researcher works independently of the other. However, if some researchers disagree, all researchers meet to find the final decision.

Study selection process

A total of 1,299 articles were retrieved. After screening for duplication, 192 articles were excluded. Next, the researchers evaluated the abstracts for the remaining 1,107 articles. Then, the remaining 598 articles were evaluated to see if each article fit the criteria which we outlined using the PICOS framework. After that, the remaining 117 articles were evaluated using the Cochrane Collaboration's tool. Finally, seventeen articles were included in this systematic review (Figure 1).

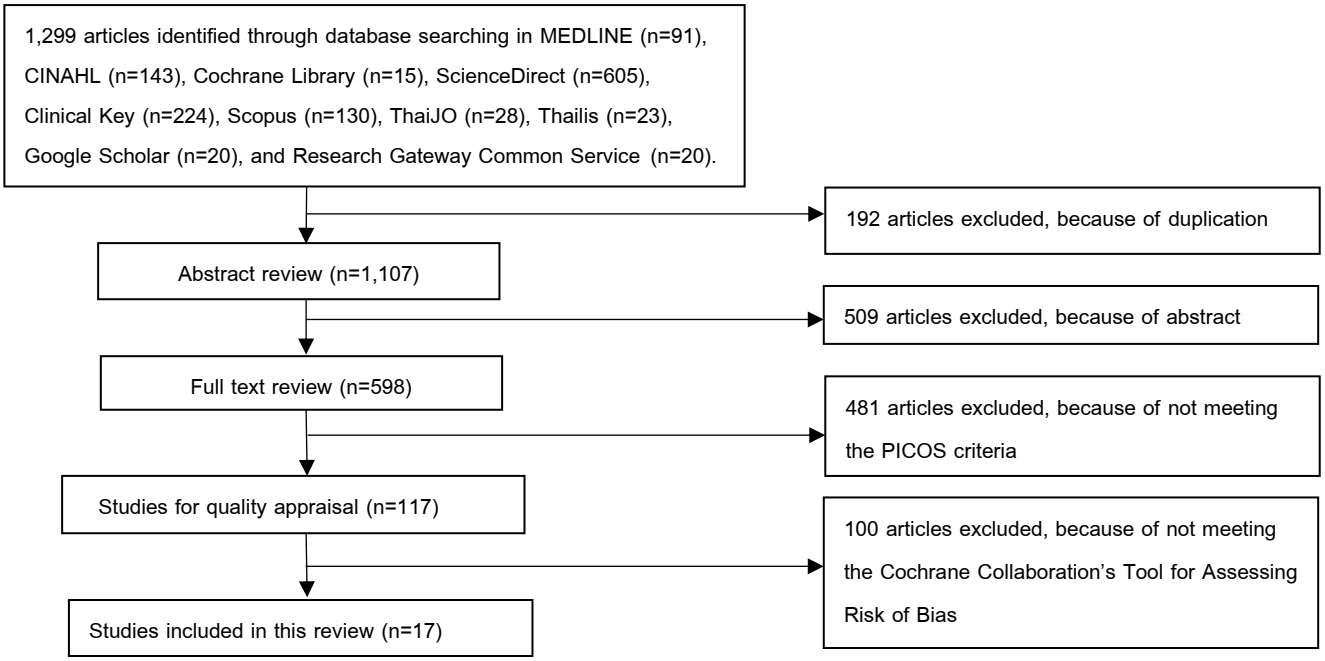

Figure 1. Flowchart of the screening and the selection process[28].

Table 1. Review summary of simulation-based learning among nursing students

Author (Year)	Design	Intervention and comparison	Sample	Instruments	Research Findings	Quality of Research
Bayram & Caliskan (2019)[11]	RCT	Exg[a]: Mannequin and game-based Cg[b]:Mannequin	Exg[a]: 43 Cg[b]: 43	● Care test ● Skill checklists	The experimental group had statistically significant higher final test scores compared to the control group (p=.017 and p=.003, respectively).	5
Çalım, et al. (2020)[12]	Quasi-experimental study	Group 1: LFS Group 2: HFS	Group 1: 37 Group 2: 38	● Skill checklists ● Satisfaction and self-confidence scale	The two groups had no significant differences in skills scores, satisfaction, and confidence.	4
Chen, et al. (2015)[13]	Quasi-experimental study	Exg[a]1: HFS Exg[a]2: LFS Cg[b]: Traditional learning	Exg[a]1: 21 Exg[a]2: 23 Cg[b]: 16	● Low-fidelity outcome test ● High-fidelity outcome test	Both intervention groups had superior performance compared to the control group. However, there was no significant difference in performance between the HFS and LFS groups.	6
Cura, et al. (2020)[14]	RCT	Group 1: SPs Group 2: HFS Group 3: Partial task trainer	Group 1: 48 Group 2: 45 Group 3: 46	● Knowledge test ● Skill checklist ● Virtual Analog Scale (VAS)	● VAS stress levels of the students in the SPs group were higher than those of others. ● The SPs group had higher satisfaction scores compared to the HFS and Partial task trainer groups.	4

Author (Year)	Design	Intervention and comparison	Sample	Instruments	Research Findings	Quality of Research
				● Satisfaction and self-confidence scale	● Self-confidence scores of the partial task trainer group were significantly lower than those of the other groups (p=0.001).	
Dogru & Aydın (2020)[15]	RCT	Exg[a]: HFS Cg[b]: Traditional teaching method	Exg[a]: 36 Cg[b]: 36	● Knowledge assessment form ● Skill evaluation form ● State anxiety inventory	● HFS can increase students' knowledge and skill statistically significantly compared to traditional teaching (p=0.001 and p<0.001), respectively. ● The students' anxiety scores in the simulation group were significantly lower than those in the traditional teaching group (p<0.001).	4
Jaberi & Momennasab (2019)[16]	RCT	Exg[a]: Lectures, video presentation and SPs Cg[b]: Lectures and video presentations	Exg[a]: 45 Cg[b]: 42	OSCE	No significant difference in overall OSCE score was observed between the groups. However, there was a significant difference between the mean pre-test and post-test scores for each group (P<0.05).	6
Jang, et al. (2019)[17]	experimental study	Exg[a]: Lecture and SPs Cg[b]: Lecture and case-based learning	Exg[a]: 25 Cg[b]: 29	● Knowledge questionnaires ● Performance ability checklist ● Satisfaction evaluation tool	● Knowledge of oncology nursing increased in both the experimental and control groups. ● The experimental group showed significantly higher nursing performance ability and satisfaction than the control group.	6
Jung, et al. (2012)[18]	RCT	Group A: IV arm Group B: IV sim Group C: IV arm and IV sim	Group A: 41 Group B: 40 Group C: 38	● VAS ● Effectiveness and satisfaction questionnaires	● The three groups had no statistically significant differences in anxiety. ● The performance score of Group C was higher than Groups A and B; however, there were no significant differences. ● Group C had statistically significantly higher satisfaction than Groups A and B (p=0.014). In addition, Groups A and C had significantly higher satisfaction than group B (p=0.005).	6

Author (Year)	Design	Intervention and comparison	Sample	Instruments	Research Findings	Quality of Research
Kahraman, et al. (2019)[19]	Quasi-experimental study	Exg[a]: Simulation-based training Cg[b]: Standard child mannequin training	Exg[a]: 36 Cg[b]: 36	● Knowledge test ● Knowledge and attitude scale ● Management skills checklist	● There was had no statistically significant difference in knowledge scores between intervention and control group (p=0.829). ● The intervention group showed a statistically significant improvement in attitudes after training (p=0.008). ● Both groups' self-confidence significantly increased after the training (p=0.000).	4
Kang, et al. (2020)[20]	Quasi-experimental study	Group 1: vSim Group 2: HFS Group 3: vSim with HFS	Group 1: 60 Group 2: 76 Group 3: 75	● Knowledge scale ● Confidence tool ● Performance tool	● There were statistically significant differences in knowledge and confidence among the three groups (p=0.026 and p<0.001), respectively. The mean differences in Group 1 and 3 were higher than Group 2. ● The three groups had statistically significant differences in performance (p<0.001). Both Group 2 and 3 showed higher mean scores than Group 1.	6
Liaw, et al. (2014)[21]	RCT	Exg[a]: vSim Cg[b]: Mannequin-based simulation	Exg[a]: 31 Cg[b]: 30	Learning experiences questionnaires	The post-test scores for the experimental group (p<0.05) and control group (p<0.01) were significantly higher than the pretest scores. However, there was no significant difference in students' performance scores between the experimental and control groups.	6
Norouzi, et al. (2019)[22]	Quasi-experimental study	Exg[a]: SPs Cg[b]: Team-based learning.	Exg[a]: 38 Cg[b]: 37	Skill performance checklist	The experimental group had significantly higher skills than the control group (p=0.039).	6
Reinhardt, et al. (2011)[23]	experimental design	Group 1: Latex arm. Group 2: HFS and then latex arm Group 3 latex arm and then HFS	94 baccalaureate nursing students	● Skills evaluation tool ● Confidence tool ● Clinical follow-up form	● The skill scores found no statistically significant differences in return demonstration skill among different simulation instruction methods used (p=0.70). ● No significant difference was seen in the student confidence score versus the simulation method.	5

Author (Year)	Design	Intervention and comparison	Sample	Instruments	Research Findings	Quality of Research
Sarmasogl, et al. (2016)[24]	Quasi-experimental design	Exg[a]: SPs Cg[b]: Partial task trainer	Exg[a]: 44 Cg[b]: 43	● Performance observation form ● SPs assessment form	The experimental group's performance was significantly higher than the control group (p<0.001).	5
Tamaki, et al. (2019)[25]	RCT	Exg[a]: SPs Cg[b]: Usual nursing curriculum	Exg[a]: 20 Cg[b]: 18	● Knowledge questionnaires ● OSCE ● Self-reported questionnaires	● Knowledge, physical assessment, psychological care, and self-confidence scores significantly increased among the simulation group (p=0.000).	5
Tan, et al. (2017)[26]	RCT	Exg[a]: Serious game before posttest Cg[b]: Serious game after posttest	Exg[a]: 57 Cg[b]: 46	● Knowledge questionnaires ● Confidence scale ● Performance tool	● The experimental group demonstrated significantly higher post-test knowledge and confidence scores than the control group (p<0.001). ● The experimental group did not demonstrate a significantly higher performance score than the control group (p=0.105).	6
Yelapa, et al. (2017)[27]	Quasi-experimental design	Exg[a]: HFS Cg[b]: Traditional method	Exg[a]: 35 Cg[b]: 35	Critical thinking assessment	The mean scores of the critical thinking were higher and significantly different in both groups. However, critical thinking scores between experimental and control groups were not different.	6

[a] Experimental group

[b] Control group

Type of simulations

The 17 studies contained various different types of simulations. The SPs was used in seven studies[14,16-17,19,22,24-25]. The partial task trainer was used in two studies[14,24]. LFS was used in three studies[12-13,18]. HFS was used eight studies[12-15,19-20,23,27]. Game-based was used in two studies[11,26]. Virtual simulation was used in three studies[18,20-21]. Mannequin-based simulation was used in one study[21].

Effects of simulation-based learning

Skill performance

Cura et al. found that the skill scores of the HFS and partial task trainer groups were significantly higher than the SPs[14]. Dogru and Aydın found that the HFS method was more effective in enhancing the skills of nursing students than the traditional teaching method[15]. Kang et al. found that both the HFS group and vSim with HFS group showed higher

performance mean scores than vSim group[20]. Moreover, et al. showed that the SPs group had significantly higher performance ability than case-based learning group[17]. Norouzi et al. illustrated that the SPs group had significantly higher skills than the team-based learning group[22]. Tamaki et al. found that the SPs group's mean physical assessment and psychological care score had significantly increased[25].

On the other hand, Jung et al. showed that IV arm and IV sim (Group C) did not have statistically higher scores for the performance of the procedure compared to IV arm (Groups A) and IV sim (group B)[18]. Jaberi and Momennasab revealed that there were no significant differences in the OSCE overall scores between the control and experimental groups[16]. Reinhardt et al. showed that there were no statistically significant differences in return demonstration skill among all groups[23]. Similarly, Calim et al. found that no significant differences scores for the second and third stages of labor skills between the two groups[12]. Sarmasogl et al. found that there was no significant difference between the control and experimental groups[24]. Tan et al. found that the difference in the performance scores between the two groups was not statistically significant[26]. Moreover, Chen et al. showed that no statistically significant differences were found in the high-fidelity outcome measures between the HFS and LFS groups. However, all intervention groups had higher performance than the control group[13]. Liaw et al. also found that there were statistically significant increases in the first posttest performance scores compared to the pretest scores for the experimental and control groups. Similarly, the second posttest performance scores for the experimental and control groups were significantly higher than the pretest scores[21].

Knowledge

Bayram and Caliskan illustrated that the experimental group had statistically significant final test scores higher than the control group[11]. Cura et al. displayed that the pretest and posttest results of knowledge levels among the three groups were similar[14]. Similarly, Dogru and Aydın found that the HFS was more effective in increasing students' knowledge scores than the traditional method[15]. Kang et al. found that the vSim group and vSim with HFS group had higher knowledge scores than the HFS group[20]. Tamaki et al. also found that the knowledge score of the simulation group had significantly increased after the simulation[25]. In the same way, Tan et al. found that the experimental group had significantly higher mean post-test scores compared to the control group[26].

On the other hand, Jang et al. found that the post-experimental knowledge score of the experimental group and the control group increased, but no interaction was found between group[17]. Similarly, Kahraman et al. found that the knowledge scores of both groups significantly increased after training, but

the difference between the groups was not statistically significant[19].

Confidence

Cura et al. revealed that the self-confidence scores of the partial task trainer group were significantly lower than other groups[14]. Kang et al. found statistically significant mean differences in confidence among vSim, HFS, and vSim with HFS groups[20]. Tamaki et al. showed that the simulation group had a statistically significant increase in self-confidence after testing and psychological care[25]. Likewise, Tan et al. demonstrated significantly higher post-test confidence scores in the experimental group compared to the control group[26]. In contrast, Calim et al. illustrated that the high-fidelity computer-based mannequin group did not have statistically significantly higher self-confidence scores than the low-fidelity pelvic model group[12]. Similarly, Reinhardt et al. showed that no statistically significant differences in the confidence scores of the latex arm, HFS and then latex arm, and latex arm and then HFS[23].

Satisfaction

Jung et al. showed that both the IV arm and IV sim group had higher satisfaction than the Group IV arm and IV sim. In addition, Group IV arm and Group IV arm and IV sim group had significantly higher satisfaction than IV sim group[18]. Cura et al. also found that the SPs group had higher satisfaction scores compared to the HFS and Partial task trainer groups[14]. Jang et al. found that the experimental group had significantly higher satisfaction than the control group[17]. On the contrary, Calim et al. found that the HFS group did not have higher satisfaction scores compared to the LF group[12].

Stress and anxiety

Cura et al. found that the students in the SPs group had statistically significantly higher stress scores compared to other groups[14]. Dogru and Aydın showed that the anxiety scores of students in the simulation group were significantly lower than those for students in the control group[15]. However, Jung et al. found no significant differences in anxiety after venipuncture training between the three groups[18].

Critical thinking

Yelapa et al. showed that the critical thinking abilities before and after simulation-based learning were statistically significantly different. However, critical thinking scores between experimental and control groups were not different[27].

Attitude

Kahraman et al. revealed that the experimental group had a significant increase in attitude scores after simulation-based training[19].

Summary

This review found that there are several types of simulation, including SPs,

partial task trainer, LFS, HFS, game-based, virtual simulation, mannequin-based simulation. Simulation-based learning affects nursing education, including students' skill performance, knowledge, confidence, satisfaction, stress, anxiety, critical thinking, and attitude. However, study results are conflicted because each research used different simulation types, scenarios, and evaluation tools. Therefore, the effect of simulation-based learning on nursing students is questionable. Although this systematic review cannot formulate the appropriate type of simulation-based learning, the instructors should play the role of facilitator to encourage the nursing students' skills such as critical thinking, clinical reasoning, clinical judgment, nursing practice, teamwork, and communication to increase the confidence of nursing students. Importantly, a study in Thailand showed that simulation-based learning increases nursing students' critical thinking, an essential skill for effective nursing care. Hence, instructors should develop simulation-based learning methods to stimulate critical thinking.

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