REVIEW

Effectiveness of Digital Simulation on Student Nurses' Knowledge and Confidence: An Integrative Literature Review

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Abstract: Digital simulation is an emerging innovation with the potential to address the limitations to traditional clinical simulation. The pandemic has accelerated teaching on digital platforms, which is now embedded in pedagogic practice. This integrative review will evaluate the effectiveness of digital simulation on nursing students' knowledge and/or confidence. The electronic database search carried out between October 3 and 7, 2021. We included primary research articles published in English language between January 2012 and October 2021. From 14,369 citations, 10 full-text documents were included in our final analysis and synthesis. Results suggest that digital simulation with realistic, immersive and interactive characters had a positive impact on students' learning outcome in terms of knowledge acquisition and self-confidence. Therefore, combining digital simulation with face-to-face simulation will enhance learning.

Keywords: digital simulation, confidence, knowledge, nursing

Introduction

Simulation bridges the theory–practice gap in nurse education.[1] Specially, in-person laboratory-based simulation purports to address the gap between theoretically acquired knowledge and skills performance. It builds knowledge and skills in a safe environment allowing participants to repeatedly practice complex skills and rare, but clinically significant scenarios.

In a pre-COVID era, health care students would have been prepared to care for the medically compromised population in a face-to-face simulated environment: an educational approach known to have a favourable effect on patient outcomes. During lockdown, this was impossible and contingency arrangements were rapidly implemented and a shift from in-person to online learning occurred globally.[2]

This dramatic rise in e-learning, and rapid development and implementation of digital simulation reaped benefits. Digital simulation is an emerging innovation with the potential to address the limitations to traditional clinical simulation.[3] For example, students' digital competence has positively and significantly correlated with their digital informal learning and academic engagement since the COVID pandemic.[4] Likewise, digital simulation is an improving learner engagement allowing participants to adopt a flexible approach and revisit simulation at a time, place and pace suitable to them. Its overall impact on the learning outcomes of student nurses is believed to be novel and provides a consistent approach to clinical decision-making. Yet, its impact on nurse students' confidence and knowledge requires further evaluation to establish a robust evidence base to embed digital simulation-based education in the health care curricula. A systematic review of 80 studies concluded that several studies found no significant differences in students' self-confidence when comparing virtual simulation to traditional methods.[5,6]

Moreover, the aim of the review was to explore the impact of digital simulation on learning outcomes rather than specifically investigating the impact of simulation on knowledge acquisition and confidence. Therefore, this review aims

to evaluate and synthesize the up-to-date evidence based on the effectiveness of digital simulation and its effect on student nurses´ knowledge and confidence. This review is of global interest because not only will it ratify the growth of digital simulation but it will also support low- and middle-income countries, where resources are limited for in-person simulation activities, to implement digital learning experience into their curriculum. Furthermore, digital simulation opportunities could be valuable supplements to clinical simulation, offering exposure to rare but clinical significant clinical events in a safe environment.[7]

Materials and Methods
Design
We adopted an integrative review approach as it allows inclusion of findings from diverse methodologies and evidence-based clinical practice initiatives.[8]

Search Strategy
The electronic database search carried out between October 3 and 7, 2021. We searched articles in PubMed, Google Scholar, Edinburgh Napier University databases, HINARI and other World Health Organization (WHO) database portals for low- and middle-income countries that includes the Web of Science, SCOPUS, African Index Medicus (AIM), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCOhost), WHO's Institutional Repository for Information Sharing (IRIS) and African Journals Online databases. In addition, articles were included through a review of the grey literature available in institutional repositories and a review of the reference lists of already identified articles.

The following main terms were used during electronic database search: ("Simulation" AND Nurs* AND "Student*" AND ("knowledge" OR "Confidence")). Please see (Appendix A) for a detail article searching strategies, terms used in each database and search results.

Eligibility Criteria
Inclusion Criteria
All English-language studies that reported the effectiveness of digital simulation on nursing students' knowledge and/or confidence were eligible for the review. Both qualitative and quantitative studies are included in the review. To reach an up-to-date conclusion, our searching strategy was limited to articles published between January 2012 and October 2021.

Exclusion Criteria
Non-primary sources such as editorials, opinion pieces, letters and review papers are excluded. Articles dealing with multidisciplinary professionals were not eligible for review unless they show a subgroup analysis that meets the objective of our review. Also, we excluded articles that were inaccessible following three e-mail contacts with the principal investigator. More importantly, the decision whether to include an article was based on the consensus of all the authors.

Selection of Studies
All database search results were exported to the Mendeley reference manager software version 1.19.4. With the help of this software, duplicate search results were removed. Subsequently, a two-step article selection process was carried out. In step 1, two independent reviewers scanned the titles and abstracts of all articles reporting on the effectiveness of digital simulation on nursing students' knowledge and/or confidence. And in step 2, full-text articles were screened by the reviewers to determine their eligibility. Finally, fully eligible articles were selected for further analysis (Figure 1).

Data Extraction, Analysis, and Synthesis
The framework of integrative review by Whittemore and Knafl directed the data extraction, analyses and synthesis.[8] Initially, we read the articles at least three times to grasp a comprehensive understating of the methodology and findings. Based on this, we identified the common observations and patterns in each article. Next, we abstracted variables that were considered as important measure of the effectiveness of digital simulation on nursing students' knowledge and/or confidence. Consequently, we recorded the author, year of publication, study setting, design, purpose and main findings

of each article. With regard to analysis, all articles that meet the eligibility criteria are categorized based on the study design, objective, sample size and primary outcome measurements. Finally, the result was synthesized based on the study characteristics and the main outcomes of our research question. Basically, our synthesis focused on the effectiveness of digital simulation on student nurses' self-confidence, anxiety and knowledge acquisition in comparison to face-to face or traditional simulation.

Quality Assessment

The methodological quality of the papers evaluated using the JBI quality assessment checklists for quasi-experimental, randomized controlled trial and qualitative research.[9–11]

Results

Study Selection and Characteristics

A PRISMA flowchart was used to demonstrate the process of article selection and inclusion for the review. Accordingly, we found 14,369 records in databases searching. After duplicates removal, we screened 9753 records, from which we reviewed 69 full-text documents, and finally included 10 papers (Figure 1).[12–21] Later, we searched documents that cited any of the initially included articles as well as the references of the initially included articles. However, no more studies,
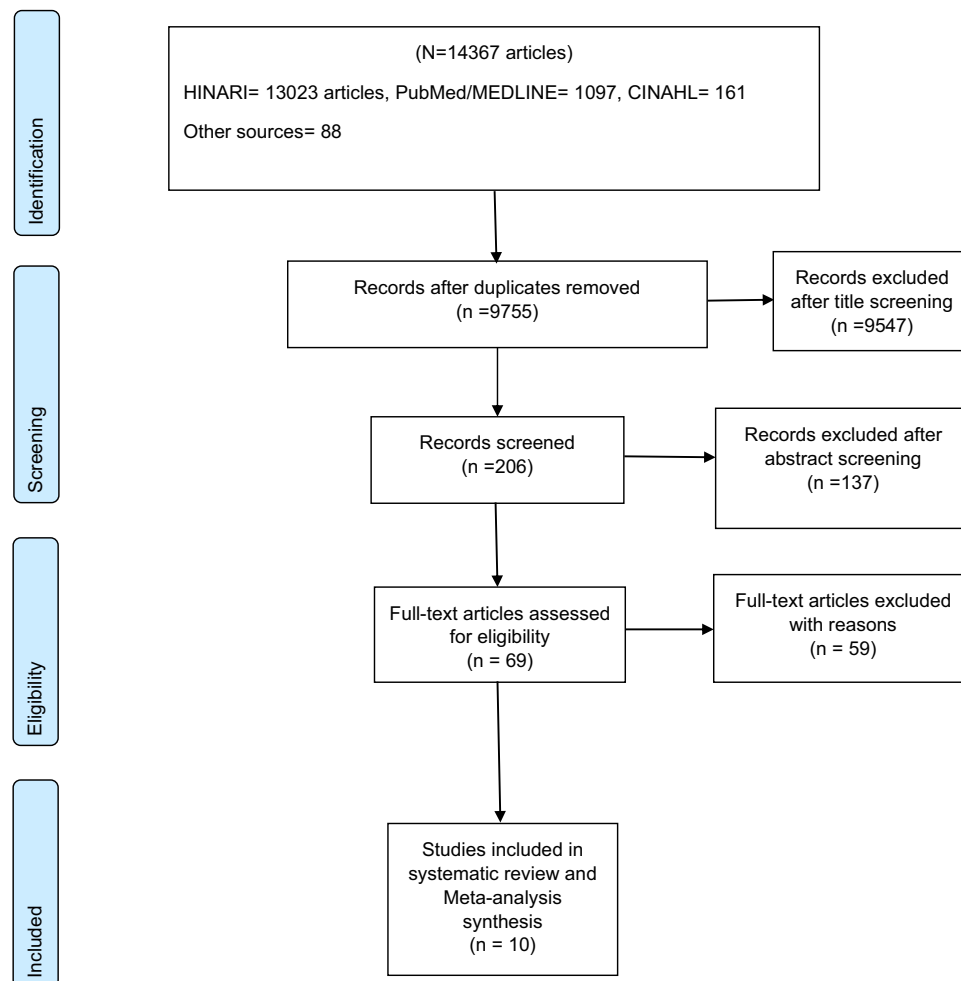
Figure 1 A PRISMA flow chart that shows the process of article selection.
Notes: PRISMA figure adapted from Moher D, Liberati A, Altman D, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Journal of clinical epidemiology. 2009;62(10). Creative Commons.[22]

that fulfilled eligibility criteria, were found in these searches. The studies we found were conducted in North America, Europe and Asia. In particular, two articles were from Turkey,[13,17] three from the USA[12,14,21] and the remaining were each from Taiwan,[18] Malta,[19] the UK,[16] Sweden[20] and Canada.[15] Of all, seven studies[12–15,17,18,21] used experimental study design while the other three employed qualitative,[20] mixed[16] and pre-post designs.[19] The sources of study population were student nurses of different levels of study with sample size across the studies ranging from 14 to 166, with a total of 795 student nurses participating (Table 1).

Quality Appraisal

The JBI quality assessment tools were adopted to evaluate the methodological quality of the articles, depending on the consensus of the all the authors (evaluators). The purpose of this appraisal is to assess the methodological quality of articles and to see the extent to which an article has addressed the possibility of bias in its analysis, conduct and design. Subsequently, we adopted three appraisal tools based on the appropriateness of the methodology being employed during the study in each article. Accordingly, we used checklist appraisal tools for quasi-experimental, randomized controlled trial and qualitative research.[9–11] Studies with clear eligibility criteria for inclusion within the study, randomization process, detailed description of the context, reliable and valid measure of exposure, and adequate statistical analysis were included in the review. All authors agreed that articles with >50% score of the checklist elements to be categorized as high-quality papers. As a result, 10 studies were of high methodological quality because all of these papers received a "Yes" rating for most relevant elements of the JBI Quality Assessment Tools.[12–21] No articles were excluded for low methodological quality.

Effectiveness of Digital Simulation on Nurse Students' Knowledge Acquisition and Self-Confidence

Ten articles demonstrated the effect of digital simulation on student nurses' knowledge acquisition.[12–21] Three studies revealed that there was a significant knowledge difference between student nurses who used mobile simulation and those who did not. More importantly, students who participated in a mobile simulation demonstrated higher knowledge score than students who did not.[13,17,18] In one study, majority of nurse students who had participated in a sepsis digital simulation reported a positive impact on knowledge acquisition.[16] Similarly, a significant improvement in the student nurses' post-scenario knowledge was recorded following their participation in a computer-based virtual simulation program, FIRST2ACTWeb™.[19] In the context of medicine administration, digital simulation was superior to face-to-face simulation in terms of knowledge acquisition.[12] Likewise, virtual reality simulation has shown a positive impact on nurse students' knowledge retention.[20,21] Conversely, one study revealed that there were no statistical differences in student knowledge between face-to-face and virtual clinical simulations.[15]

Five studies focused on the effectiveness of digital simulation on student nurses' self-confidence.[12,14–17] Three studies proved that a significant increase in perceived self-confidence score of student nurses' pre- and post-electronic simulation.[12,16,17] Also, nursing students' self-confidence in simulated patient scenario delivered via video was higher than prior high-fidelity simulation experiences in the laboratory.[14] One study did not show significant difference between the student's self-confidence in the face-to-face group and virtual clinical simulation group.[15]

With regards to anxiety, only two articles are found that link digital simulation and anxiety level among student nurses.[15,16] According to these articles, digital simulation was found to be effective in decreasing nurse students' anxiety.

Discussion

Currently in the literature, there appears to be a wide variety of digital technologies utilized in nurse education. We set out to summarize the effectiveness of digital simulation on student nurses' knowledge and confidence in comparison to face-to-face simulation. We found 10 articles that demonstrated the effect of digital simulation on nursing students learning that is appropriate to the topic of discussion. There were a greater number of quantitative studies which revealed high-quality evidence that digital simulation was an effective tool for users to gain knowledge, boost confidence and decrease anxiety level in nursing education. The qualitative parts in these selected articles highlighted students' perception and engagement were high and encouraged the users to undertake during their study.

Table 1 Characteristics of Studies Included in the Review

Authors (Year)	Country	Aim	Study Design	Sample Size	Population	Sampling Technique	Intervention	Comparison	Outcome Variables	Findings
Smith et al[21] (2016)	USA	To evaluate the effect of virtual reality simulation on learning outcomes and retention	Qausi-experiemental	108	BSc student nurses	SRS	Decontamination training	VRS versus printed directions about decontamination	Knowledge and performance	VRS is at least as good as traditional methods for retention of knowledge and performance of skills.
Forsberg et al[20] (2016)	Sweden	To explore if virtual simulation had an impact on postgraduate pediatric nursing students' clinical reasoning	Descriptive qualitative	14	Pediatric nursing students	Convenience	Formative VP-based assessments	N/A	Clinical reasoning	The students were more certain of knowing how to solve the VP cases and improve their self-efficacy.
Mager and Campbell[12] (2013)	USA	To test a home care simulation model of education and examine students' confidence and knowledge in managing medications and prefilling patient medication boxes in a home care setting	Qausi-experiemental	60	BSc student nurses	SRS	Medication administration	Classroom versus electronic MAR	Self-confidence and knowledge	Students' knowledge and skill levels in cardiac auscultation were found to be improved using high-fidelity simulators and standard training techniques. The high-fidelity simulator method, on the other hand, was found to be more effective than traditional teaching methods in

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Table 1 (Continued).

Authors (Year)	Country	Aim	Study Design	Sample Size	Population	Sampling Technique	Intervention	Comparison	Outcome Variables	Findings
Adhikari et al[16] (2021)	UK	To investigate the impact of immersed virtual reality (IVR) sepsis game on pre-registration nurses' self-efficacy and explore their perceptions of the acceptability and applicability of IVR sepsis game as an adjunct to nursing simulation education	Mixed	19	Pre-registration student nurses	Convenience	Sepsis	Pre-post sepsis game	Knowledge, self-confidence and anxiety	A significant increase was evidenced in perceived self-confidence score from pre to post simulation. Moreover, student nurses suggest that the IVR sepsis simulation was realistic, immersive and interactive.
Cobbett and Snelgrove-Clarke[15] (2016)	Canada	To compare the effectiveness of two maternal newborn clinical simulation scenarios; virtual clinical simulation and face-to-face high-fidelity manikin simulation	RCT	66	BSc student nurses	SRS	Preeclampsia and group B strep	Face-to-face versus Virtual clinical simulation	Knowledge, self-confidence and anxiety	Between face-to-face and virtual clinical simulations, there were no statistically significant changes in student knowledge and self-confidence. Anxiety scores were higher for nurse students in the virtual clinical simulation than for those within the face-to-face simulation.

Powers[14] (2020)	USA	To evaluate nursing students' satisfaction and self-confidence with high-fidelity simulation laboratory and explore their perceptions in comparison to simulated patient scenario delivered via video in the classroom	Qausi-experiemental	54	BSc student nurses	Convenience	Gastrointestinal bleeding scenario	Pre-post unfolding video scenario	Self-confidence and satisfaction	Participants had a better level of satisfaction and self-confidence following the classroom video intervention than for prior high-fidelity simulations within the laboratory. Nurse students perceived that the simulation design was preferable for the classroom intervention than for
Borg Sapiano et al[19] (2018)	Malta	To investigate the effectiveness of virtual simulation in improving student nurses' knowledge and performance during rapid patient deterioration	Pre-post design	166	Diploma and BSc student nurses	NA	Cardiac-shock-respiratory	Pre-post virtual simulation	Knowledge and skill	IVR sepsis simulation was realistic, immersive and interactive. Also, the majority students perceived that IVR had a positive impact on knowledge acquisition.
Kurt and Öztürk[17] (2021)	Turkey	To evaluate the effect of Mobile Augmented Reality (MAR) educational materials on the knowledge and skill levels of nursing students on injection practices	RCT	122	BSc student nurses	NA	Injection	Mobile Augmented Reality (MAR) versus projection tool	Knowledge, self-confidence and skill	Between face-to-face and virtual clinical simulations, there were no statistically significant changes in student knowledge and self-confidence. Anxiety scores were higher for nurse students in the virtual clinical simulation than for those within the face-to-face simulation.

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Table 1 (Continued).

Authors (Year)	Country	Aim	Study Design	Sample Size	Population	Sampling Technique	Intervention	Comparison	Outcome Variables	Findings
Bayram and Caliskan[13] (2019)	Turkey	This study aims at determining the effect of a game-based virtual reality phone application on tracheostomy care education for nursing students	RCT	86	BSc student nurses	SRS	Tracheostomy care	Mobile virtual game versus clinical	Knowledge and skill	Participants had a better level of satisfaction and self-confidence following the classroom video intervention than for prior high-fidelity simulations within the laboratory. Nurse students perceived that the simulation design was preferable for the classroom intervention than for
Chang et al[18] (2021)	Taiwan	The study's aim was to test the hypothesis that nursing students who used a mobile learning app would have significantly higher levels of knowledge about medication administration and nasotracheal suctioning	RCT	100	BSc student nurses	SRS	Nasotracheal suctioning and medication administration	Mobile app versus traditional teaching simulation	Knowledge, skill, and satisfaction	A significant improvement in the students' knowledge was observed after carrying out the web-based simulation intervention

In this review, majority of the articles confirmed that digital simulation has a positive effect on student nurses' knowledge and confidence. Eight articles indicated that the digital simulation was found to be effective in improving the nursing students' knowledge.[12,13,16–21] Whereas the study by S. Cobbett et al argues that virtual clinical simulations do not make differences on the students' knowledge acquisition in comparison to face-to-face simulation. Also, a pooled analysis of studies comparing the effect of virtual patients to traditional education showed similar results for knowledge between virtual and traditional education in health professions education.[23] Hence, the inconsistency between studies might be originated from the trials comparing digital simulation with different forms of traditional education packages and design variants. A related review concluded that e-based programs can supplement traditional teaching methods in the teaching of nursing assessment.[24] This is because e-based learning facilitates grants students a sense of control, encouraging them to reflect and self-correct their actions. However, the effectiveness of e-learning-based programs requires the education providers' extra effort in planning the program and conducting training for staff and students. With these considerations, e-based learning offers an excellent tool to complement face-to-face teaching in enhancing learners' clinical skills and knowledge, although further targeted research on the modes and weighting of blended learning is necessary.[24]

With regard to self-confidence, three out of five articles suggested that digital simulation has a positive impact in boosting self-confidence of student nurses.[12,16,17] Also, a complementary finding reported higher perceived levels of confidence among pathology students who undertook virtual simulation.[25] Conversely, one study in our review reported no significant difference in student's self-confidence when face-to-face and virtual clinical simulation were compared.[15] This conflicting evidence might be resulted from the possible differences in case scenario, involved technology, and other environmental factors. The online e-learning exemplars increase assessment expectations through repetitive preparation of students on their self-confidence, knowledge, and capacity. In addition, digital simulations provide a flexible, innovative, and clear example of the assessment process. This improves self-rated student confidence and understanding of expected performances.[26,27]

In the present review, two studies showed that the digital simulation tends to be effective in decreasing anxiety level of nursing students in comparison to face-to-face clinical simulation.[15,19] In fact, mild anxiety is inevitable during first exposure to clinical simulation and practice. In a previous study, anxiety was reported frequently among nursing students undertaking computer-based simulation. Students noted feelings of being overwhelmed by the amount of information to know and did not feel the lab simulation was a learning process.[28] One advantage of digital simulation is that it can be undertaken at any environment where students feel free of anxiety triggers and hassles. Thus, digital simulation may have a greater effect on reducing of students' anxiety and consequently increase their learning performance. In all aspects, face-to-face simulation learners perform under the scrutiny of educators and peers and this may have a negative effect on learning. Digital simulation may mitigate the negative aspects of stress during simulations and clinical trainings as well as improve teaching–learning performances.[26]

Conclusion

Overall, available literature encourages integration of digital simulation with the existing face-to-face on campus simulation in the nursing education system. Our findings suggest that the utilization of digital simulation can improve the student nurses' knowledge acquisition, increase self-confidence and decrease anxiety level. During clinical placements, exposure to clinically significant events is unpredictable and digital simulation provides a novel approach to preparing students to manage critical and emergency situations in a timely manner.[29,30] More importantly, the integration of self-paced learning with facilitated synchronous debriefing improves the experience of students by allowing the opportunity for in-depth dialogue and reflective practical discussions.[31] Therefore, students can keep practicing their simulation session using any electronic device from a safer environment at a time, place and pace of their choosing. Furthermore, with the progressing worldwide internet coverage, digital simulation could be a collaborative and cost-effective component to simulation in low- and middle-income countries.

With regards to the limitations of this study, primarily, the included articles were limited to English-language publications despite the fact that related articles would have been also published in other languages. Second, we found limited number of studies evaluating the relative effectiveness of digital simulation in terms of knowledge acquisition and confidence among nursing students. Furthermore, majority of the articles included in this review were conducted with small sample sizes resulting in insufficient power, and lacks comparison of a variety of simulation types. In addition, none of these articles evaluated if digital simulation is a cost-effective approach as per the students' knowledge and

confidence score improvements. Therefore, before digital simulation can be verified as a robust pedagogic approach, high-quality studies, addressing these limitations are recommended.

Disclosure

The authors report no conflicts of interest in this work.

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