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The Impact of High-Fidelity Simulation on Undergraduate Nursing students Performing Safe Medication Administration: A Systematised Review

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Abstract

High-fidelity simulation (HFS) stands out as a pivotal asset in nursing education, particularly for honing medication administration skills. This review, aligned with PRISMA guidelines, analyzed 148 studies spanning 2012 to 2023, with only seven meeting inclusion criteria. Despite methodological limitations in the selected studies, a consistent trend suggests that HFS significantly enhances knowledge, competence, and confidence in safe medication administration among undergraduate nursing students. Importantly, the selection of HFS or other approaches should be contingent upon specific goals and intended learning outcomes. Notably, intervention groups consistently outperformed control groups, underscoring HFS's efficacy in elevating students' capabilities. However, the overall quality of the included studies was moderate, highlighting the need for more robust methodologies in future research. This study underscores HFS as a valuable approach in nursing education, providing essential insights for effective teaching practices. It emphasizes the imperative to consider alternative approaches based on educational goals and learning outcomes while advocating for further research on cost-effectiveness, measurement tools, and optimal simulation session duration.

Keywords: High-Fidelity Simulation, nursing education, PRISMA.

CHAPTER 1: INTRODUCTION

Medication administration is an essential part of nursing practice. As future nurses, undergraduate students require comprehensive knowledge and practical competence in drug administration to ensure patient safety. However, the acquisition of drug administration skills might pose a significant challenge among nurses from varied practice areas and nursing students from various types of nursing schools owing to the intricate nature of this task and the potential for errors (Andrew *et al.*, 2009). One of the significant risks of poor medication administration is medication errors, which are considered one of the serious causes of morbidity and mortality in hospital settings (Thomas *et al.*, 2019). Consequently, nursing programs worldwide endeavour to provide students with diverse educational methods, such as simulation- based learning, to develop their practical skills and improve patient outcomes (Rajaguru & Park, 2021) .

1.1 BACKGROUND

Medication administration errors (MAEs) are a significant threat to patient safety, causing increased healthcare costs and legal consequences. These errors, occurring at any stage of the medication process, were responsible for over half of patient mortality among 780 Medicare patients, highlighting their impact on morbidity and mortality (Levinson, 2010). The Institute of Medicine reported 1.5 million avoidable hazardous drug errors annually in 2006, emphasizing the prevalence of MAEs. Nursing students and new nurses are particularly prone to these errors due to insufficient information, skills, supervision, and role models during clinical rotations (Musharyanti *et al.*, 2019). Effective educational strategies are crucial to enhance their proficiency in medication administration before they enter challenging hospital context.

Simulations, a transformative training approach for healthcare professionals and medical students, involve fidelity components influencing overall effectiveness. High-fidelity healthcare simulations

(HFSs) replicate real patient scenarios realistically, using advanced simulators, interactive scenarios, and authentic equipment (Hanshaw & Dickerson, 2020). For instance, in medication administration, HFSs use lifelike mannequins and interactive elements to enhance clinical judgment and critical thinking (Massoth *et al.*, 2019).

Conversely, low-fidelity simulations lack realism, often involving basic paper-based exercises without physical interaction. These simulations may include tasks like reading medication orders and performing calculations. The choice between low and high fidelity depends on goals, resources, and the desired realism-affordability balance. The effectiveness of simulation varies with fidelity levels, making studies using different levels not directly comparable (Kim *et al*., 2016). Recognizing these distinctions is crucial for a comprehensive understanding of the impact of simulation fidelity on training outcomes.

Limited research has explored simulation-based learning in nursing education, encompassing various procedures, including medication administration (Curl *et al*., 2016). Building on this, (Menon *et al*., 2021) emphasized the positive impact of high-technology simulation on pre-clerkship medical students, particularly in enhancing teamwork and communication skills. Expanding on these teamwork skills, (Sessions *et al*., 2020) Sessions *et al*.,'s, study highlighted the efficacy of simulation-based learning in boosting healthcare professionals' confidence in managing high-alert medications. In a related context, (Avraham *et al*., 2018) Avraham *et al*., suggested that medication administration simulation training adeptly translates acquired skills into real-world practice. However, (Santana *et al*., 2020) the integrative review, while underscoring the value of simulation strategies for medication administration, noted fidelity level variations across studies.

Despite the exploration of simulation-based learning in nursing education, a specific examination of High-Fidelity Simulation's (HFS) impact on the medication administration skills of undergraduate nursing students remains limited. Bridging this gap is crucial. Previous reviews focused on medical students and healthcare professionals or included studies using different types of simulation, leaving a gap in understanding the precise influence on undergraduate nursing students. Therefore, a systematic review is imperative for a comprehensive synthesis of existing evidence and a clearer understanding of HFS's impact on this specific student population.

1.2. Aim

The aim of this review was to explore the impact of HFS on undergraduate nursing students' knowledge, confidence, and competence in performing safe drug administration. The information gained from this review will have clinical relevance, as it can be used to inform future nursing education curricula.

CHAPTER 2: LITERATURE REVIEW

2.1. Review Question

To formulate a focused review question, the PICO framework was used to enable participants, interventions, comparators, and outcomes to be clearly identified (Table 2.1) (Templier & Paré, 2015). The review question is as follows: What is the impact of HFS on undergraduate nursing students' knowledge, confidence, and competence in safe medication administration compared to traditional teaching methods? See **Table 1.**

Table 1

PICO Element	Description
Population	Undergraduate nursing students who are currently enrolled in a nursing programme and have not yet graduated or obtained their nursing license.
Intervention	High-fidelity simulation for safe medication administration.
Comparison	Traditional teaching methods, which may include didactic lectures, assigned textbook readings, case studies, and other non-high-fidelity simulation-based activities in a laboratory setting.
Outcome	Knowledge, confidence, and competence in safe medication.

2.2. Review Design

This paper utilised a systematised literature review approach, which is similar to a systematic review but lacks some key features, such as a quantitative evaluation of the internal validity of the literature of each study and dual reviewers (Grant & Booth, 2009).

To ensure a systematised review, this study's development was structured into six stages as recommended by (Templier & Paré, 2015): (1) defining the research question and aim by a scoping search, (2) finding relevant literature, (3) screening and selecting articles, (4) evaluating the articles' quality, (5) extracting data, and (6) analysing the data.

2.3. Search Method

2.3.1. Inclusion and Exclusion Criteria

The criteria for inclusion in the review were established based on the PICO framework and the specific objectives of the study, as follows:

- Study Design: Randomised controlled trials (RCTs) were considered for inclusion due to their ability to minimise bias and establish cause–effect relationships (Creswell, 2009). Quasi- experimental and pre-post studies were also included to address the limited availability of research on the topic.
- Population: Undergraduate nursing students currently enrolled in a nursing programme and

without a nursing licence were targeted for inclusion. This approach aimed to reduce variability in education level and experience that could influence the results, considering global differences in nursing education, accreditation, and qualification (Baker *et al*., 2021).

- Intervention: HFS was the focus of interest in the review. Studies using low-fidelity simulation were excluded to ensure the integrity and realism of the results, as the level of fidelity can impact a simulation's effectiveness.
- Publication Criteria: Original peer-reviewed articles published in English within the last 10 years were included. This selection was based on the need for high-quality, reliable, and valid research, as recommended in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins *et al.*, 2011). Limiting the review to the last 10 years and publications in English ensured the inclusion of current and relevant information that the author could effectively analyse.
- Exclusion Criteria: Articles that did not undergo peer review, were published in languages other than English, employed low-fidelity simulation, did not address at least one of the outcomes, and/or included postgraduate or diploma students; conference abstracts; and case reports were excluded.

2.3.2. Information Sources

Four electronic databases were searched: CINAHL, Medline, Scopus, and the Education Resources Information Center (ERIC). To minimise the risk of missing relevant studies, hand searching of reference lists was also performed. This approach was expected to ensure that all available research was considered in the review process (Tricco *et al*., 2018).

2.3.3. Keywords and Search String

The article search used MeSH subheadings and keywords such as "simulation," "nursing students," and "medication systems." Boolean operators "AND" and "OR" refined and broadened the search. Synonyms were included. The search string: (("simulation training" OR "realistic simulation" OR "simulated training" OR "simulated learning" OR "simulation-based education" OR "virtual simulation" OR "computer simulation" OR "High Fidelity Simulation Training") AND ("undergraduate nurs*" OR "student nurs*" OR "pupil nurs*" OR "novice nurs*" OR "beginning nurs*" OR "pre licensure nurs*" OR "basic nurs*" OR "Baccalaureate Nursing Education") AND ("medic* admin*" OR "medic* system" OR "medic* delivery" OR "medic* dispens*" OR "medic* calculation" OR "drug admin*" OR "medication safety" OR "clinical pharmacology")). See detailed search strategy in (See SDE content1 Appendix 1 for more details).

2.3.4. Study Selection

The study selection adhered to PRISMA 2020 guidelines, conducted by a single reviewer (Page, Moher, *et al*., 2021). A protocol, encompassing the research question, criteria, search strategy, and data analysis methods, was developed. A comprehensive search, using specified keywords, covered electronic databases from December 15, 2022, to April 15, 2023 (Medline, CINAHL, Scoups, and ERIC). Results were managed in EndNote, facilitating the identification and removal of duplicates. After screening titles, relevant abstracts were assessed, and eligible studies underwent full-text review. Transparency was ensured by documenting the process using a PRISMA flow chart.

2.4. Data Collection Process

The researcher conducted the data extraction process individually, utilising a template that was adapted from (Lei *et al.*, 2022). The author further modified the template to ensure its alignment with the critical elements necessary to address the research question effectively. It encompassed key components, such as the author and publication year, study design, participant characteristics, sample size, intervention group, control group(s), and outcome measures.

2.5. Quality Assessment and Risk of Bias

The quality assessment of eligible papers was conducted using the Joanna Briggs Institution's Critical Assessment Tool (JBI) (Page, McKenzie, *et al*., 2021). Two specific JBI appraisal checklists were employed: the Checklist for Quasi-Experimental Studies and Pre-Post Designs for RCT research, and the Checklist for RCTs for studies with an RCT design.

2.6. Data Synthesis

In data synthesis, the quality of each study was considered. The quality assessment was followed by a review of the statistical results from each study, including the means, standard deviations, and p-values. Additionally, the consistency of the results across studies, including the direction and magnitude of the effects reported, was evaluated. Any discrepancies in the results were noted and explored, with a focus on uncovering the potential reasons for these variations. A narrative approach was adopted for evidence synthesis, offering a descriptive presentation of outcomes to convey a coherent and comprehensive research story (Popay *et al*., 2007), facilitating effective communication of findings and their implications.

CHAPTER 3: RESULTS

3.1 Search Results

In total, 148 studies were found, and 49 remained after removal of duplicates. Titles were screened against the inclusion and exclusion criteria, leaving 16 studies for full-text screening, of which seven met the eligibility criteria. These seven quantitative studies involved a range of study designs, including

RCTs, quasi-experimental studies, and pre-post studies (Figure 1).

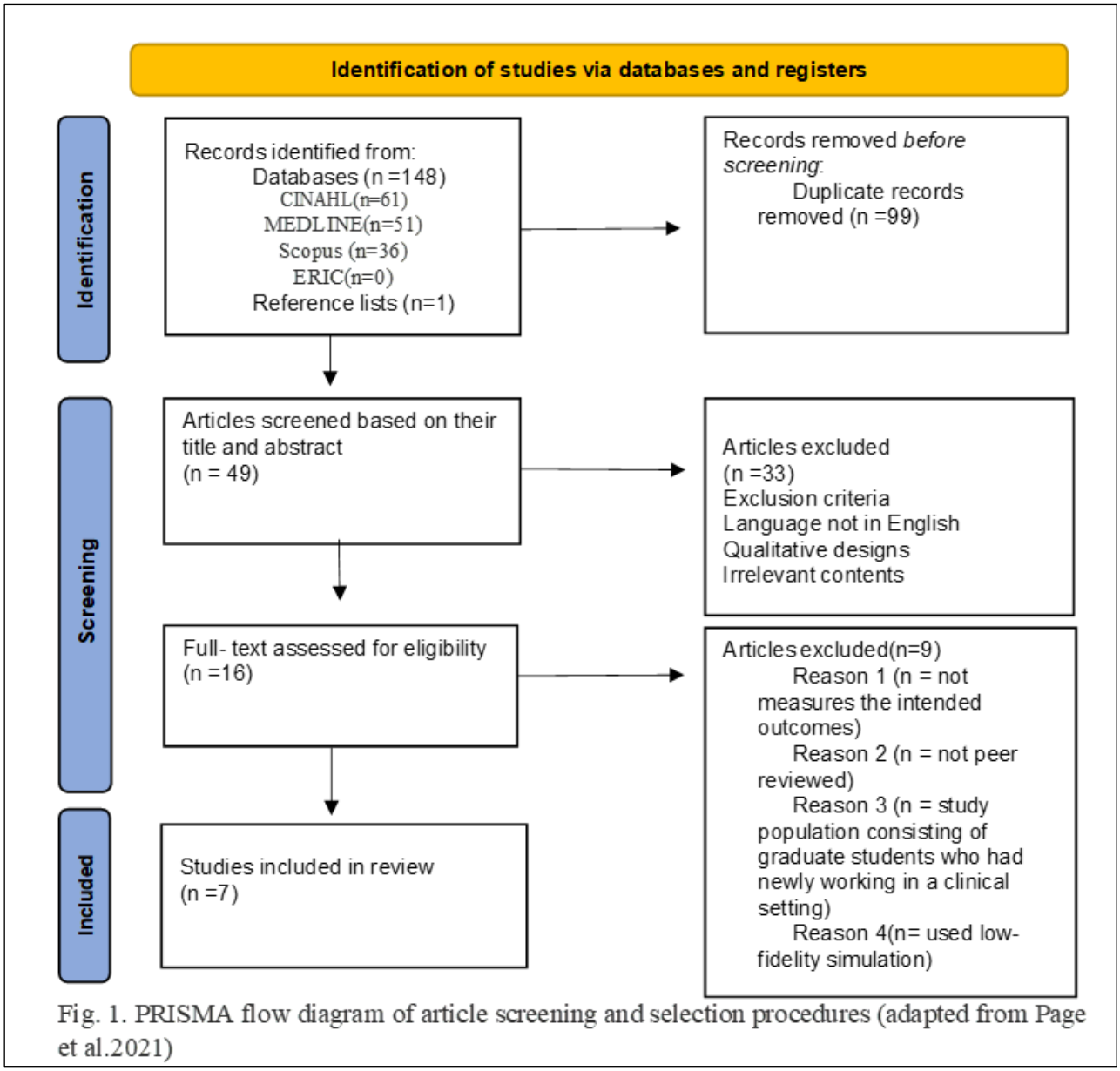

Fig. 1. PRISMA flow diagram of article screening and selection procedures (adapted from Page et al.2021)

This flowchart outlines the step-by-step process of the systematic review conducted according to PRISMA guidelines. Rectangles represent stages of the review, ovals indicate decisions or actions, and diamonds denote endpoints. Each step corresponds to a specific task such as literature search, screening, eligibility assessment, and inclusion in the final analysis. Refer to the legend for symbols and annotations used in the flowchart.

Supplementary Digital Content (SDC) legend:

SDC 1: Details of Search Strings on Databases

This file (Appendix 1) includes additional details about the search strings used in the study. Refer to this supplementary material for a comprehensive understanding of the search methodology employed in the literature review.

SDC 2: Risk of Bias Assessment for Included Studies

This file (Appendix 2) contains the detailed risk of bias assessment for each included study in the research. Consult this supplementary material for a thorough examination of the methodological quality and potential biases in the included studies.

3.2. Study Characteristics

Studies arose from only two countries, with most originating from the USA (n = 7) and one from Spain. The settings in all cases were educational institutions. The research designs employed encompassed quasi-experimental designs (n = 3),

pretest-post-designs (n = 3), and RCTs (n = 1). Convenience sampling was predominantly utilised to select participants, with some studies also employing purposive sampling (Harris *et al*., 2014). The sample sizes ranged from 51 to 237 participants.

A range of high-fidelity modalities were employed. Some studies utilised mannequins (Mariani *et al*., 2017; Sanko & Mckay, 2017), whereas others utilised technology-based simulation,such as automated medication-dispensing systems (Craig *et al*., 2021; Jarvill *et al*., 2018). Role-play simulations with realistic scenarios (Pol-Castañeda *et al.*, 2022), simulations involving real equipment (Harris *et al*., 2014), and computer-based human simulators (Konieczny, 2016) were also utilised. However, despite the variations across the studies in the use of different types of HFSs, there appeared to be no significant differences in the effectiveness of these simulations when compared to each other. **See Table 2 for more details.**

Table 2

Author & years	**Design & Sample**	**Population & Country**	**Experimental group**	**Control group**	**Measurement tool**	**Simulation Duration**	**Outcome & findings**	**Quality Score**
(Sanko& Mckay. 2017)	Quasi- experimental longitudinal design Final & target=120 students Convenience	USA Students enrolled in pharmacology courses.	Manikin based simulation	Teaching as usual	Competence Confidence Adverse drug reactions Medication delivery techniques Self-report and observation MCCS	2 hours	Competence: Time 1: Intervention Group: Mean = 55.52, P =.221 (not significant) Control Group: Mean = 70.45, P = .221 (not significant) Time 2: Intervention Group: Mean = 68.00, P = .034 (significant) Control Group: Mean = 72.12, P = .034 (significant) Confidence: Time 1: Intervention Group: Mean = 55.65, P = .718 (not significant) Control Group: Mean = 54.68, P = .718 (not significant) Time 2: Intervention Group: Mean = 67.18, P = .096 (not significant) Control Group: Mean = 52.58, P = .096 (not significant) Simulation increases competence, confidence, and actions, and lowers frequency of adverse drug events (ADEs).	7/9(Level 2.d)
(Craig *et al*., 2021)	Quasi- experimental Target=83 Final= 80 Convenience	USA, Third years student enrolled medical-surgical nursing course	Technology based simulation	Standard skills training	Knowledge, Competence, Confidence, MSCEC, MSKA	15-min	HFS enhance the students' knowledge, confidence and competence in safe medication administration Competence: Intervention Group: Mean = 14.69, SD = 2.92 Control Group: Mean = 11.98, SD = 3.12 (p = .663) knowledge: Intervention Group: Baseline (Week 1) Mean =16.94, Week 4 Mean = 18.45 Control Group: Baseline (Week 1) Mean = 17.18, Week 4 Mean = 17.82 p= .07 Confidence: Intervention Group: Mean = 4.03, SD = 0.51 Control Group: Mean = 3.71, SD = 0.87 p = .045).	8/9 (Level 2.d)

(Harris *et al*., 2014)	(Konieczny 2016)	(Jarvill *et al.*, 2018)	(Pol-Castañeda *et al*., 2022)	(Mariani *et al.*, 2017)
Quasi- experimental pilot study Final & target=237, Purposive	RCT Final = 126, Target =132, Random	Experimental pre-post-test control group design Final & target = 85, Convenience	Mixed method pretest- posttest, Final=179 Convenience	Pre-post-test control group experimental study design Final target= 86 Convenience
USA Junior-level nursing students	USA Students enrolled in pharmacological and medical surgical course	USA Nursing students enrolled in their first semester	Spain Second year enrolled in pharmacology course	USA Medical- surgical students
Realistic scenarios with real equipment	human patient simulator	Manikin-based simulation and automated medication dispensing system	Role play simulation and realistic scenario	Manikin based simulation
Teaching as usual	Low- fidelity simulation	Traditional practice session	None	low- fidelity simulation
Knowledge and skills in drug calculation, MAE	Knowledge The10- item assessment Researcher-developed	Competence MASAT	Competence Pre- simulation questionnaire and MASAT	Knowledge Competence perception, and comfort level regarding patient safety. MSKA AND MSCEC
Not specified	12 -min	10-min	15-min	20-min
Simulation improves medication administration exam scores in the intervention group. The MAE scores for the intervention group (M = 95, SD = 6.8) were significantly higher than the MAE scores for the control group (M = 90, SD = 12.9) at the p = .004 level (t = 2.92, df = 118)	HFS increases nursing student' s knowledge Low-fidelitygroup: Pretest mean score = 5.00, Posttest mean score = 7.02 High- fidelity group: Pretestmean score = 5.00, Posttest mean score = 8.15	Individual simulation improves nursing students'ability to administer medications safely. ISE group (M = 7.52 SD = 0.67) outperformed the traditional practice group (M = 6.37, SD = 1.00) on the posttest, controlling for pretest scores, F(1, 82) = 35.46, p = .00, with a medium effect (d = 0.53).	Simulation improves nursing students competence to administer medications safely. Competence in: Identifying the patient: Improved from 64.4% to 83.3% Selecting the correct medication: Improved from 87.7% to 95.8% Calculating the dose: 60.3% Stating the correct route of administration: 54.8% Assessing the right time for drug administration: Improved from 24.7% to 70.8% Performing the right documentation: 54.8%	Simulation improves knowledge and competence for medication administration Competence: Intervention Group: Mean = 70.4%, SD = 19.49 Control Group: Mean = 56.1%, SD = 23.38(p = .028) Knowledge: Intervention group: 57% passed with cut score >21 Control group: 28% passed (p = .02).
7/9 (Level 2.d)	5/12 (Level 1.c)	6/9 (Level2.d)	4/9 (Level 3.e)	8/9 (Level 2.d)

3.3 Robustness of the outcome measures: See Table 3 for more Details

Table 3

Tool Name	MASAT Medication Administration Safety Assessment Tool	MSCEC The Medication Safety Critical Element Checklist	MSKA Medication Safety Knowledge Assessment	MACCS Self-reported medication administration competency and confidence scale
Purpose	Measure competence in medication administration	Measure competence in the skill of safe medication administration	Measure students' knowledge about medication administration	Measure confidence and competence in pharmacology tasks or knowledge
No. Domains	1 (competence)	1 (competence)	N/S	2 (confidence, competence)
No. Items	8	11	25	16
Examples of Items	Rights: " Student asked patient to state name and DOB."	" Patient identification included checking the name band and verbally confirming identification using two unique identifiers."	" Using critical thinking, analyse the medication error."	Confidence Domain: " How confident do you feel in your ability to administer IV continuous infusion?" Competence Domain: " How competent do you feel in your ability to administer other routes of medication?"
Scoring Information	Checklist-based: " Correct criteria met = Yes, criteria not met = No."	Credit given if all steps of a critical element are completed	Criterion- referenced test that determines passing (21 and above) and failing (below 21) scores	0-10 scale (0 = not at all confident/competent, 10 = fully confident/competent)
Reliability	Cronbach's alpha of 0.84; interrater agreement index (RAI) of 0.83 for student samples	Cronbach's alpha: 0.69-0.72	Pretest Cronbach's alpha: < 0.73 Posttest Cronbach's alpha: < 0.96	Reliability: $\alpha = 0.90$; All item-total correlations > 0.30
Validity	Strong validity index (CVI = 0.93) Interrater reliability (0.83 to 0.90)	Strong validity index (CVI = 0.92) Inter-rater reliability (IRR = 0.96)	Strong validity index (CVI = 0.94)	N/S
Knowledge assessment	Measure students' knowledge of medication administration	N/S	10	" A nurse is preparing to administer furosemide (Lasix) 80 mg by mouth. In addition to checking the blood pressure, which other nursing intervention does the nurse perform?
Each item scored 1 point	Mean correlation coefficient = 0.50	N/S		

				A. Monitor heart rate.			
				B. Check the serum potassium level.*			
				C. Insert an indwelling urinary catheter.			
				D. Administer with apple or cranberry juice."			
Pre-simulation questionnaire	Measure the students' knowledge about the six rights of medication administration	6 (rights)	8	" How would you identify the patient (open question)?"	N/S	N/S	N/S
MAE Medication Administration Examination	Measure the knowledge	N/S	10 basic conversion items and 9 medication orders	N/S	N/S	N/S	N/S

3.4. Risk of Bias Within Studies (Check SDE content 1Appendix 2 for more details)

The selected studies share common limitations introducing potential bias. The lack of prior power calculation, as observed across studies, increases the risk of underpowered research and random variation, diminishing statistical power and compromising the reliability of conclusions (Nayak, 2010). For instance, (Harris *et al*., 2014)noted small sample sizes, reducing internal validity and reliability (Creswell, 2009).

Another prevalent limitation is the use of single-site and convenience sampling in studies like those by (Craig *et al*., 2021; Mariani *et al*., 2017; Sanko & Mckay, 2017) (Pol-Castañeda et al., 2022) (Jarvill *et al*., 2018). This approach may limit the generalizability of findings due to selection bias, compromising the internal validity of the studies (Creswell, 2009).

Concerns arise from the lack of explicit information on blinding in(Konieczny, 2016), randomized controlled trial, introducing potential performance bias that could undermine credibility (Polit & Beck, 2020). Implementing double-blinding in simulation-based interventions is challenging, but assessor blinding is recommended to minimize bias (Boutron *et al*., 2007).

Konieczny (Konieczny, 2016), did not mention the validity of the outcome measures used for the researcher- developed questionnaires. Similarly, (Harris *et al*., 2014) Harris did not discuss the reliability or validity of the medication administration exams employed. The absence of information regarding the reliability of these measures raises concerns about the consistency and accuracy of the results obtained. As highlighted, this limitation affects the overall validity and reliability of the findings (Creswell, 2009).

3.5. Effectiveness of HFS for Nursing Students

3.5.1. Knowledge Enhancement

In the analysis of the seven studies included in this systematised review, four studies consistently demonstrated the potential effectiveness of HFS in enhancing undergraduate students' knowledge. For instance, Konieczny(Konieczny, 2016) observed a substantial increase in posttest scores among nursing students exposed to HFS, demonstrating a notable improvement from 5 to 8.15 out of 10. This implies that the immersive and realistic nature of HFS positively impacts students' understanding and retention of medication-related concepts. Similarly, Harris *et al*., (Harris *et al*., 2014)reported higher scores on MAE assessments for the intervention group that underwent HFS (mean = 95, SD = 6.8) compared to the control group (mean = 90, SD = 12.9), further supporting the effectiveness of HFS in enhancing knowledge in this area. However, the lack of transparency in scoring criteria and potential subjectivity may introduce bias or inconsistency in the assessment process, which can limit

the generalizability of the findings. To strengthen the evidence on HFS effectiveness, standardised scoring methods should be adopted to ensure the validity and reliability of the results across different studies.

Craig *et al*., (Craig *et al*., 2021) observed an overall increase in mean scores for both the intervention and control groups over the study period, indicating some progress in knowledge enhancement. However, the lack of statistical significance (p = 0.075) raises questions about the reliability of the observed improvement. The indications of a difference suggest that the intervention group experienced greater improvement than the control group, but the variability in timing and delivery of simulated content between the first and second HFSs may have introduced discrepancies in the results. These differences in preparation and exposure to the clinical practice setting might have influenced the outcomes, compromising the study's internal validity. As a result, the study's findings should be interpreted cautiously, and future research should address these timing and delivery concerns to ensure more robust and reliable results.

Mariani *et al*., (Mariani *et al*., 2017) identified a significant disparity between the intervention and control groups in the post-MSKA assessment results, with a higher proportion of participants in the HFS intervention group successfully passing (57% passed) compared to the control group (28% passed). The notable difference suggests that HFS played a pivotal role in augmenting knowledge acquisition and practical application among undergraduate students. One potential explanation for this result lies in the use of low-fidelity simulation in the control group. The limited realism and interactivity of low-fidelity simulations might have restricted the depth of understanding and critical thinking development among the control group students (Ka Ling *et al*., 2021). Conversely, the immersive and lifelike learning experience provided by HFS in the intervention group likely facilitated active participation, critical decision-making, and iterative practice, resulting in a deeper understanding of medication- related concepts and improved competence in medication administration (Kim *et al.*, 2016). The emphasis on experiential learning and problem-solving in HFS simulations further reinforced students' knowledge retention and transfer to real clinical settings, ultimately contributing to the observed positive outcomes.

3.5.2. Improving Competence Level

Regarding nursing students' competence in safe medication administration, the reviewed studies consistently demonstrated a positive influence of HFS. In Sanko and McKay's (Sanko & Mckay, 2017) study, both the intervention and control groups showed improvements in competence over time. At Time 2, the control group had significantly higher competence scores compared to the intervention group. The intervention group showed statistically significant differences in certain medication administration actions, such as infusing medications over the correct time and adhering to proper hand hygiene practices.One possible explanation for this result could be the presence of confounding variables. The control group might have had more prior experience or exposure to medication administration practices, leading to a higher baseline level of competence.

Craig *et al*., (Craig *et al*., 2021) found that in Week 4, the intervention group achieved significantly higher scores than the control group on the MSCEC. The mean score for the intervention group was 14.69 (SD = 2.92), whereas the control group had a mean score of 11.98 (SD = 3.12). However, the change in MSCEC scores from Week 2 to Week 4 for the intervention group was not statistically significant. This lack of significant change raises questions about the duration of the administration simulation. It is possible that the relatively short period between Week 2 and Week 4 may have limited the demonstration of greater intervention effects. Alternatively, it could indicate a plateau effect, suggesting that the effectiveness of the intervention may have reached its maximum potential and did not further improve over time. This raises questions about the long-term sustainability and efficacy of the intervention in improving medication administration competence.

Mariani *et al*., (Mariani *et al*., 2017) observed that the intervention group scored significantly higher than the control group on the MSCEC, indicating a higher level of competence in safe medication administration. The specific statistical values were not provided in the given information. Similarly, Jarvill *et al*., (Jarvill *et al*., 2018) found that nursing students in the HFS intervention group scored significantly higher on the posttest compared to students in the traditional practice session group. The mean scores were 7.52 (SD = 0.67) for the HFS group and 6.37 (SD = 1.00) for the traditional practice group. Additionally, in the HFS group, 59.5% of students achieved a perfect score in the medication administration process, whereas only 9.3% of students in the traditional practice group achieved a perfect score.

Pol-Castañeda *et al.*, (Pol-Castañeda *et al*., 2022) reported improvements in competency in safe medication administration. During the simulation activity, 83.3% of the students appropriately identified the patient, and correct medication identification improved to 95.8% of the cases. All groups correctly calculated the dose, and there was a significant improvement in assessing the right time principle, from 24.7% in the pre- simulation questionnaire to 70.8% during the SBA.

3.5.3. Enhancing Confidence in Medication Administration

Among the studies included in the review, only two specifically investigated the influence of HFS on confidence levels. The first (Sanko & Mckay, 2017)

revealed a significant improvement in confidence over time for the intervention group, whereas the control group experienced a decrease in confidence. This difference was statistically significant ($p < .001$), indicating a positive effect of HFS on confidence levels. The second study (Craig *et al.*, 2021) focused on a more detailed analysis of specific areas of medication administration. At Time Point 1, no significant differences in confidence were found between the intervention and control groups for any items. However, at Time Point 2, the intervention group displayed higher confidence levels compared to the control group in most areas, although not all differences reached statistical significance. For instance, regarding pharmacological knowledge, the intervention group had slightly higher confidence scores than the control group, but the difference was not statistically significant ($p = 0.073$). Similarly, no statistically significant differences in confidence were observed between the two groups for continuous IV infusion, IV push, IV piggyback, subcutaneous administration, per os/oral administration, other routes of administration, and calculations. However, it is noteworthy that when participants self-reported their confidence levels, the intervention group consistently reported greater confidence than the control group for all eight items. One item, "How confident are you in administering medications safely?", showed a statistically significant difference ($p = .045$), whereas two other items exhibited some evidence of a difference ($p = .082$ and $p = .098$, respectively).

CHAPTER 4: DISCUSSION

4.1. DISCUSSION

This systematised review indicates a positive impact of High-Fidelity Simulation (HFS) on nursing students' knowledge, competence, and confidence in medication administration. The evidence quality varied, with most studies providing moderate-quality evidence supporting HFS effectiveness, except for one study (Pol-Castañeda *et al.*, 2022), with lower-quality evidence. Factors like absence of power calculation, convenience sampling, and lack of blinding raised concerns. Notably, (Konieczny, 2016) study had a low score, indicating methodological limitations.

In terms of knowledge, four studies consistently demonstrated significant improvement after HFS exposure, highlighting its immersive and realistic nature (Craig *et al.*, 2021; Harris *et al.*, 2014; Konieczny, 2016; Mariani *et al.*, 2017). Regarding competence, all studies consistently showed a positive influence on safe medication administration competence, with intervention groups exhibiting higher scores (Craig *et al.*, 2021; Mariani *et al.*, 2017; Sanko & Mckay, 2017) (Jarvill *et al.*, 2018; Mariani *et al.*, 2017; Pol-Castañeda *et al.*, 2022). Specific actions, like infusing medications correctly, showed significant improvements with HFS. Two studies specifically investigating confidence levels reported a positive effect of HFS, with intervention groups consistently exhibiting higher confidence compared to control groups across various medication administration areas (Craig *et al.*, 2021; Sanko & Mckay, 2017).

These findings robustly support the effectiveness of High-Fidelity Simulation (HFS) in nursing education. HFS is extensively employed to enhance students' technical and non-technical skills (Cortegiani *et al.*, 2015; Ka Ling *et al.*, 2021; Lewis *et al.*, 2012) (Ka Ling *et al.*, 2021). Lei *et al.*,'s (Lei *et al.*, 2022), systematic review reinforces this, underscoring its substantial impact on knowledge acquisition, skill refinement, and the development of critical clinical practice abilities, including critical thinking and communication.

Furthermore, HFS excels in guiding nursing students through intricate scenarios, providing a realistic simulation environment for hands-on practice in various procedures such as medication administration, wound care, or IV catheter insertion. This iterative practice not only sharpens technical skills but also creates a safe space for students to learn from mistakes (Hanshaw & Dickerson, 2020).

An essential aspect of HFS is its provision of timely feedback through post-simulation debriefing sessions. This empowers students to apply enhanced competence in real-life situations, allowing them to identify performance gaps, discuss areas for improvement, and receive reinforcement of knowledge and skills (Neill & Wotton, 2011). Additionally, the realistic simulation effectively bridges theory-practice gaps, facilitating the transfer of skills to real-world patient care settings. Through repeated practice, students develop competence and confidence in critical areas such as medication administration, enhancing both knowledge retention and application (Hanshaw & Dickerson, 2020).

However, Despite the positives outcomes associated with High-Realism Simulations, Recent literature has affirmed the effectiveness of various educational approaches within nursing education, as highlighted by Massoth *et al.*, (Massoth *et al.*, 2019). This encompasses traditional methodologies and low-fidelity simulations, with methods like didactic lectures, hands-on clinical training, case studies, and mentorship programs proving notably effective in specific contexts.

While High-Realism Simulations offer a sophisticated and immersive learning experience, it is crucial to consider the associated costs. High-fidelity simulations often demand substantial financial investments in technology, infrastructure, and ongoing maintenance. This financial commitment prompts a critical examination of whether comparable educational goals can be achieved through more economical means.

In contrast, traditional methodologies and low-fidelity simulations, such as didactic lectures, hands-on

clinical training, case studies, and mentorship programs, have proven to be effective in various contexts. These approaches not only come with potentially lower financial burdens but also offer a pragmatic alternative for achieving similar educational objectives.

The choice between high or low-realism simulations and traditional approaches should be guided by a careful consideration of educational goals and cost-effectiveness. While high-fidelity simulations may provide a cutting-edge and immersive experience, the potential to achieve comparable learning outcomes through traditional methods highlights the need for a balanced and economically sustainable approach to nursing education. This nuanced perspective encourages educators to explore diverse methods that align with specific learning objectives while being mindful of resource allocation and overall cost efficiency.

This review stands out for its specific effort to fill a noticeable gap in existing scholarly literature. Prior studies often showed variation in the types of simulation methods used or were primarily focused on professional healthcare aspects rather than outcomes centered around students. By conducting a systematized review explicitly concentrating on studies that utilized High-Fidelity Simulation in nursing education, this investigation provides a clear and comprehensive understanding of how it impacts student learning outcomes.

4.2. Implications

The reviewed studies lack clarity on the optimal duration of High-Fidelity Simulation (HFS) in nursing programs and follow-up procedures. Simulation durations varied from 12 minutes to 2 hours, emphasizing the need for longitudinal research with extended follow-up to assess the sustained impact on knowledge and skills. Despite the absence of cost data, implementing HFS is acknowledged to be resource-intensive (Wright *et al.*, 2006). To optimize resource allocation and cost-effectiveness, thorough cost-effectiveness analyses comparing HFS to alternative approaches are essential. These analyses can inform efficient resource allocation and decision-making. Moreover, the effectiveness of simulation is influenced by facilitator expertise, but the use of varied assessment tools in the studies hinders result comparison. Future research should adopt standardized outcome measures for better comparability and generalizability within the field.

4.3. Limitations of the Review

This systematised review has several limitations. First, the variability in study designs and the diverse measurement methods used to assess the impact of HFS make it unsuitable to conduct a meta-analysis. Second, the small number of eligible primary studies limits the generalisability of the findings. Lastly, the inclusion criteria of English-language publications and the reliance on only four major electronic databases may have introduced a language and publication bias. It is important to consider these limitations when interpreting the results of this review.

CHAPTER 5: CONCLUSION

HFS has the potential to be a valuable approach for enhancing the knowledge, competence, and confidence of nursing students in medication administration, despite the methodological limitations reported within the included studies. The findings from these studies provide important guidance for effective teaching practices and shaping nursing curricula. Further research is needed to improve the quality of evidence by using more robust methodologies. Additionally, future studies should investigate the cost-effectiveness of HFS, develop reliable measurement tools, and determine the optimal duration of a simulation session.

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