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Systematic Review Of Impact Of Physical And Asynchronous Lectures On Information Retention In Nurses-Patients Safety: Evidence To Guide Practice

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ABSTRACT

Background: Patient safety is fundamental to healthcare, and nursing students must be trained to minimize risks and protect patients. Traditional physical lectures and asynchronous formats are widely used, yet evidence on their effectiveness in supporting knowledge retention is mixed.

Purpose: This systematic review aimed to evaluate the effectiveness of physical and asynchronous lectures on knowledge retention in nurse patient safety education.

Methods: A comprehensive search of PubMed, MEDLINE, ProQuest, and Scopus identified peer-reviewed studies published between 2016 and 2025. Eligible studies involved nursing students or adult learners (≥18 years) and used randomized controlled trials, quasi-experimental, pre-post, or interventional designs. Study quality was assessed using Cochrane ROB 2.0 for randomized trials and ROBINS-I for non-randomized studies.

Results: Eleven studies with 851 participants were included. Both physical and asynchronous lecture methods showed positive effects on knowledge retention, competency, and self-efficacy in patient safety education. The most consistent improvements were reported in blended and interactive formats, including flipped classrooms, simulation-based training, and technology-enhanced approaches. However, the certainty of evidence was limited. None of the studies achieved an overall low risk of bias; most were rated moderate, and three critical, mainly due to confounding and outcome measurement issues.

Conclusion: Physical and asynchronous teaching methods can both enhance knowledge retention in patient safety education, but blended and interactive approaches appear most effective. Future rigorously designed randomized trials with standardized outcome measures are needed to strengthen the evidence base, particularly in resource-constrained educational settings

Keywords: *Patient safety; Information retention; Nursing education; Physical lecture; Asynchronous lecture; Blended learning*

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1. INTRODUCTION

Patient safety (PS) refers to the prevention of avoidable harm to patients during the delivery of healthcare services (Li et al., 2023). Globally, about 10% of patients experience harm during hospital care, underscoring the urgent need to prioritize PS measures to reduce risks and errors in healthcare systems (Kar & Metal, 2020) Improving PS requires that healthcare professionals and students actively learn from mistakes and apply patient safety principles during their training, which necessitates effective educational models (Chavez-Maisterra et al., 2024).

Nursing education plays a vital role in promoting patient safety, which requires comprehensive PS education from the beginning of their training (Dimitriadou et al., 2021). In response, the World Health Organization (WHO) introduced

patient safety curriculum guidelines in 2011 to embed core PS competencies into health professional education (Huang et al., 2020). However, the adoption of these guidelines has been inconsistent worldwide, and it has been recommended that nursing curricula be updated to incorporate new teaching strategies (Farokhzadian et al., 2024).

Educational strategies to sustain PS knowledge have evolved in recognition of the need for continuous learning across classroom and clinical settings (Ji et al., 2021; Wu, 2019). Physical (synchronous) lectures (sometime refer to face-to-face lecture) foster real-time interaction and communication, whereas asynchronous approaches offer flexibility and self-paced learning (Lee et al., 2022). Evidence suggests that students often prefer synchronous formats due to the perceived value of teacher presence, although both approaches offer distinct benefits and limitations (Azar & Tan, 2023; Le, 2022; Phuong et al., 2020). Therefore, aligning instructional methods with student learning preferences is crucial for maximizing outcomes, as satisfaction and engagement greatly influence knowledge retention (Solomon, 2020). Despite the growing use of both physical and asynchronous methods, evidence regarding their effectiveness in improving knowledge retention in patient safety education remains limited. Addressing this gap is crucial to guide the development of effective teaching strategies that ensure nursing students acquire and retain the skills necessary to maintain patient safety in practice.

Cognitive Load Theory (CLT) provides a useful framework to explain how different instructional strategies influence learning. According to CLT, learners' working memory has limited capacity, and instructional design should minimize extraneous load while enhancing germane load for deeper processing (Sweller,2019). Blended and flipped approaches that combine physical and asynchronous learning may therefore optimize cognitive resources and support knowledge retention in patient safety education. Therefore, this systematic review aimed to evaluate the effectiveness of physical and asynchronous lectures on knowledge retention in nurse patient safety education.

2. METHODS

Research design

This study employed a systematic review design to evaluate the impact of physical and asynchronous lectures on knowledge retention in nurse-patient safety education among nursing students. A review protocol was developed before the study. No major deviations from the protocol occurred; however, the research team proposed and agreed to add a second reviewer to strengthen the screening and selection process. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

Search method

The PICO framework (Population, Intervention, Comparison, Outcome) was applied to guide the formulation of the search strategy and the inclusion/exclusion criteria for this review. A comprehensive search was conducted across four databases: PubMed, MEDLINE, ProQuest, and Scopus. The initial keywords used for searching in the title and abstract were undergraduate students, nursing students, learners, patient safety, nursing safety, pre-recorded lectures, asynchronous lectures, online lectures, physical lectures, synchronous lectures, face-to-face lectures, knowledge retention, student performance, and academic performance. Search filters applied included English language only, Boolean operators, phrases, and related searches of the title and abstracts. The keyword and search protocol details using the PICO framework are presented in Table 1 (a) and (b).

Table 1(a): PICO Framework

Review question:		1. What is the common method of teaching delivery of nursing safety protocol? 2. What is the effect of knowledge retention on patients-nurses safety protocol comparing each method of teaching delivery?
P	**Population of interest**	Undergraduate student from health sciences course
I	**Intervention**	Nurse safety related education delivered via physical (synchronous)
C	**Comparison**	Nurse safety related education delivered via pre-recorded (asynchronous)
O	**Outcome**	Knowledge retention

Inclusion criteria:	1. Peer-reviewed literature 2019-2025 2. Published studies (English language, Full article) 3. Quasi-experimental, interventional study, randomized controlled experiment, pre and post study.
Exclusion criteria:	1. Primary and secondary school students 2. The studies that used mixed population such as teacher, educator and mixed settings were excluded, unless a clear separation between these populations was reported.
Databases:	1. PubMed 2. MEDLINE 3. ProQuest 4. Scopus

Table 1(b) : PICO Search Grid

		Key Term		Alternate Term		Alternate Term
P – population	AND	"Undergraduate students *" AND "Patients safety*"	OR	"Nursing students*" "Nursing safety"	OR	"Learner"
I – intervention	AND	"Patients safety*" AND "pre-recorded lecture*"	OR	"Asynchronous lecture"	OR	"Online lecture"
C – comparison		"Physical lecture"		"Synchronous lecture"		"Face to face lecture"
O – outcomes	AND	"Information retention"	OR	"Student performance"	OR	"Academic performance"

Inclusion and exclusion criteria

The inclusion criteria were based on the PICO framework. We excluded studies involving primary and secondary school students, as well as those with mixed populations, such as teachers and educators, or those in mixed settings, unless a clear

separation between these groups was reported. The PRISMA flow diagram shown in Figure 1 was used to illustrate the progression of information through the four review phases. It details the number of records identified, screened, eligible, and included in the review, and highlights the processes of article selection and exclusion.

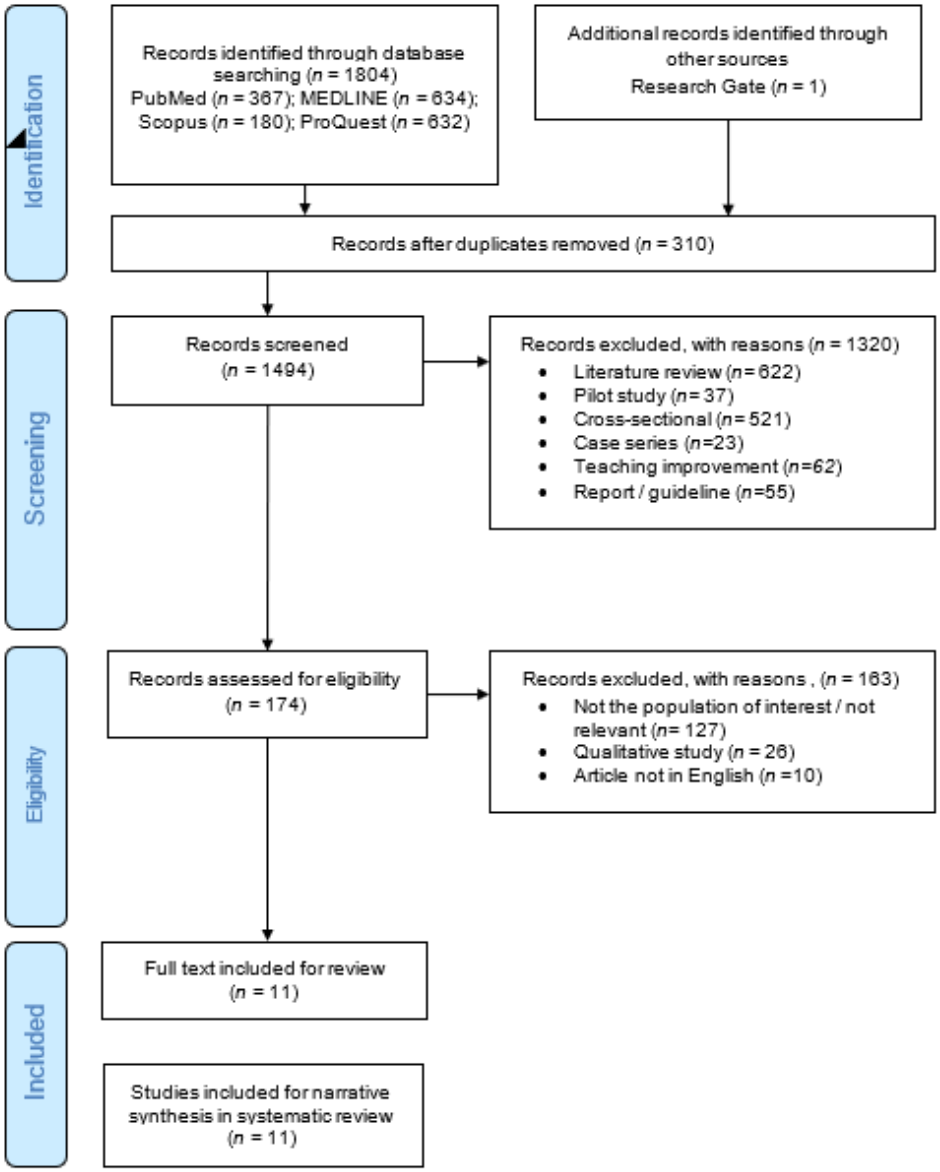

Figure 1: PRISMA flowchart

Screening of Article and Data Extraction

Full-text articles that met the inclusion criteria were collected. Before detailed evaluation, all papers were assessed for methodological validity by two independent reviewers (RN and DCT). If RN and DCT disagreed, a third reviewer (JDM) was consulted. JDM resolved disagreements to ensure both reviewers accurately completed the screening process. Reconciliation plays a vital role in confirming that abstract screeners make correct decisions at each stage (Seniwati et al., 2023). Two independent researchers used the JBI data extraction tool to extract data from the full-text review article. Details such as the nation, population, research design, sample size, interventions, control groups, first author (s), and relevant outcome measures were among the information retrieved.

Quality assessment of the selected article

The methodological quality of non-randomized trials was assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist for quasi-experimental studies (Sterne et al., 2021). Two reviewers (RN and DCT) independently conducted the critical appraisal. Any disagreements were resolved through discussion, with a third reviewer (JDM) consulted as

necessary, in accordance with JBI guidelines. To ensure consensus on study eligibility, the reviewers convened to reconcile differences and reach a common agreement. Additionally, all reference lists from the included studies were carefully reviewed to identify relevant articles that may have been missed initially. This approach improved the thoroughness of the review and reduced the chances of missing eligible studies.

Risk of bias

The quality of the included studies was evaluated, and potential sources of bias were assessed using standardized tools. For quasi-experimental and interventional studies, the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) tool was applied, as described by (Sterne et al., 2021). The ROBINS-I assessment categorized studies into three levels: low risk of bias, moderate risk of bias, or insufficient information. The randomized controlled trial (RCT) study was evaluated using the Cochrane Risk of Bias (ROB 2.0) tool (J. P. Higgins et al., 2019). This tool evaluates bias across five domains: (1) bias arising from the randomization process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in outcome measurement, and (5) bias in selection of the reported results. The overall risk of bias was summarized into four categories: low risk, moderate risk, high risk, or insufficient information. The outcomes of the risk of bias assessments for the eleven studies are presented in Figure 2 (a) and 2 (b).

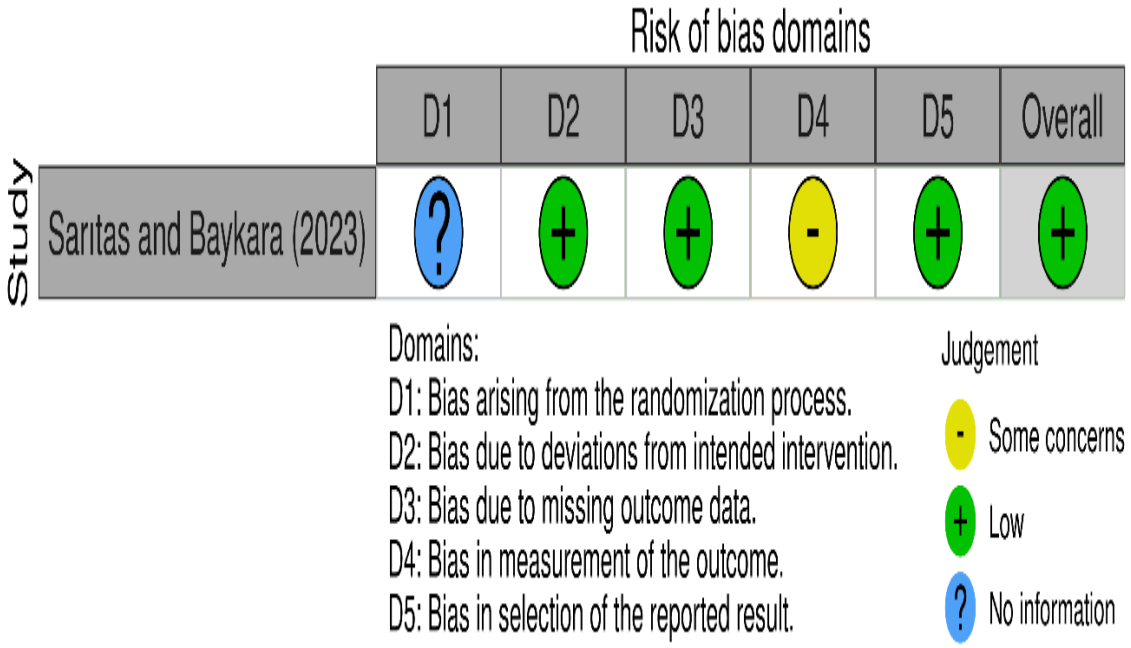

Figure 2 (a): Result of the risk of bias assessment: Traffic plot for randomized control trial

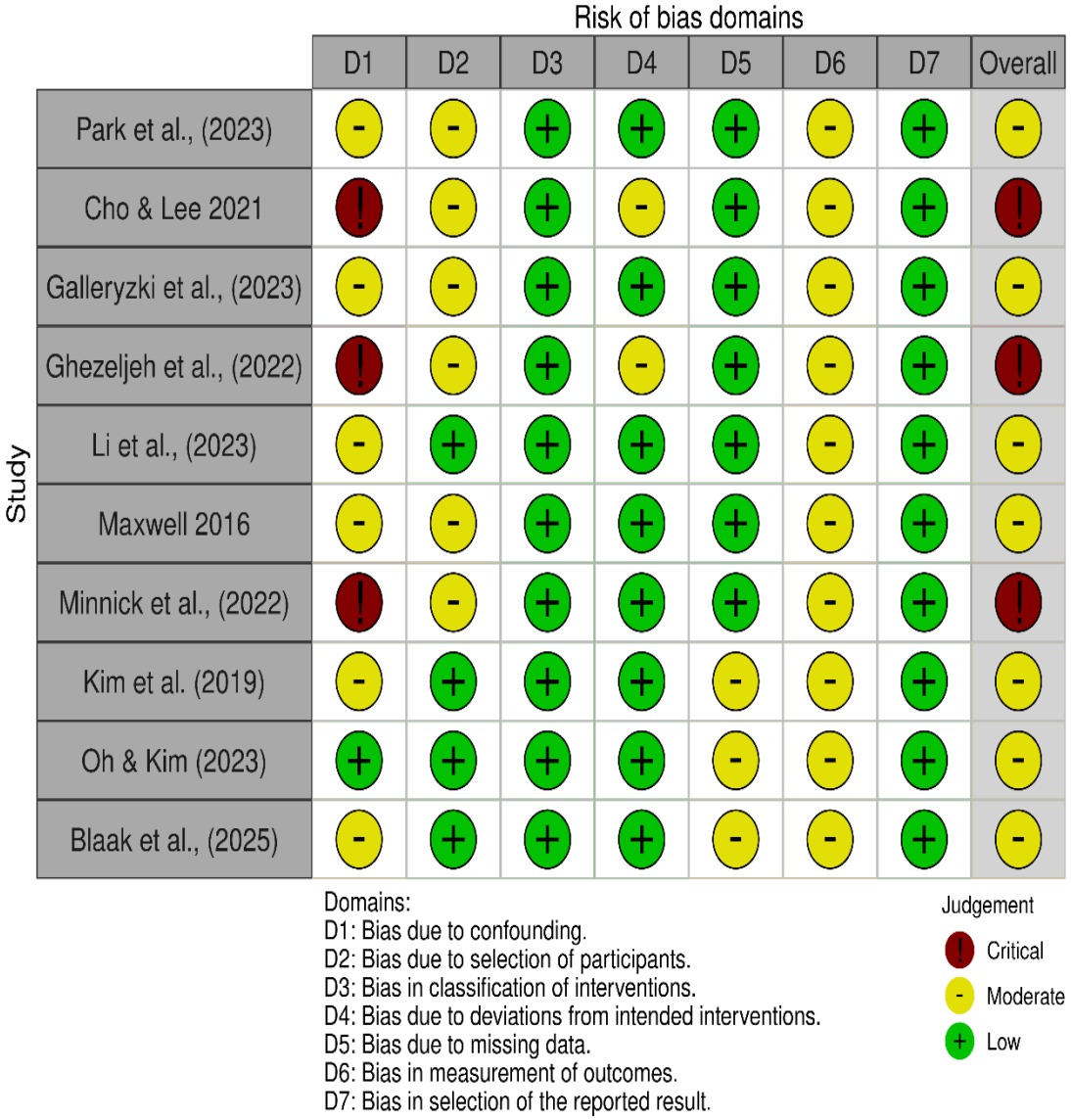

Figure 2 (b): Result of the risk of bias assessment: Traffic plot for non- randomized control trial (quasi-experimental and pre and post-test)

Data analysis

Statistical pooling of quantitative data was not possible due to the variability in study designs and outcomes. Instead, each study was analyzed based on its research design, population, sample size, teaching method, and main findings. The results are therefore summarized and presented in a narrative format, as shown in Table 2.

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Table 2 Characteristics of the Studies Included in the Review: Randomized Controlled Trial, Quasi-experimental and Pre-post Study (N = 11).

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
1. Blaak et al., (2025) • Morocco • Quasi-experimental • N=120 • 3 Month	• Nursing students • N= 60	• Lecture based course and Simulation • The researcher • 3 Month • Education content ❖ Patient safety ❖ Adverse events ❖ Risk management ❖ Evidence-based nursing ❖ Effective communication ❖ Teamwork ❖ Clinical practice ❖ Patient-centred care • Teaching delivery ❖ Lecture ❖ Simulation debriefing	• Nursing students • N= 60	• Lecture based course • The researcher • 3 Month • Education content ❖ Patient safety ❖ Adverse events ❖ Risk management ❖ Evidence-based nursing ❖ Effective communication ❖ Teamwork ❖ Clinical practice ❖ Patient-centred care • Teaching delivery ❖ Simulation-based training	• The intervention group achieved significantly higher scores in knowledge acquisition (14.92 vs. 13.32), self-efficacy (33.02 vs. 31.05), and three-month knowledge retention (12.4 vs. 10.6) compared to the control group ($p < 0.001$). Large effect sizes ($d \approx 1.0$) indicate strong and sustained educational benefits.	Level II

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
2. (Sarıtaş & Baykara, 2023) • Turkey • Randomised controlled trial study. • N=89	• Nursing student • *N* = 45	• Flipped learning. (face-to-face and online platform) • The researchers • 4week • Teaching delivery ❖ Out-of-class - Teaching, - Watching video with interactive ❖ In-class stages Visualization, case study, group discussion, concept map • Educational content ❖ Risk patient safety ❖ Appropriate nursing interventions to eliminate existing risks.	Nursing student • *N*=44	• Tradition education • The researchers • 4weeks • Teaching Delivery ❖ In-class - ZOOM, - Visualization and discussion, ❖ Out-of-class - Teaching, reading, writing, watching video	• Compared with the control group, the intervention group demonstrated significantly higher outcomes in **knowledge acquisition** (14.92 vs. 13.32), **self-efficacy** (33.02 vs. 31.05), and **three-month knowledge retention** (12.4 vs. 10.6; $p < 0.001$). The large effect sizes ($d \approx 1.0$) suggest substantial and lasting educational advantages.	Level II

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
3. (Galleryzki et al., 2023) • Indonesia • Quasi-experimental • *N*= 46 • 3 months	Nursing Student *N*= 46	• Patient Safety Course (Nurse-PSC) application • Nursing practitioners • 8 weeks • Education Contents ❖ Fundamental concepts of patient safety ❖ Nurses' role in patient safety ❖ Communication in support of patient safety ❖ Work in teams for patient safety ❖ Safety culture ❖ Infection prevention and control ❖ Patient safety incidents and safety incident reporting • Teaching Delivery ❖ e-learning methods	No Control Group		• Results showed a significant increase in patient safety competence after the intervention ($\rho < 0.001$), with improvements in knowledge, skills, and attitude ($p < 0.001$).	Level IV

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
4. Park et al., (2023) • Korea • Quasi-experimental • N= 45 • 3 Month	• Nursing students • N= 22	• Simulation-based patients safety education program (Individual lecture education and individual practice education) • The researcher • 2 times for 2 weeks (40 minute per session) • Education content v Patient Safety and Infection Control v Patient safety and operating room management • Teaching delivery v Simulation based education	• Nursing students • N= 23	• Patients' safety education program (Group lecture education) • The researcher • 2 times for 2 weeks (60 minute per session) • Education content v Patient Safety and Infection Control v Patient safety and operating room management Teaching delivery v Group lecture	• The experimental group was significantly higher in terms of compliance with patient safety ($p = 0.021$), the perception of patient safety culture ($p = 0.039$), and education satisfaction ($p < 0.001$) than the control group.	Level II

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
5. Li et al., (2023) • China • Quasi-experimental • N= 219 • 6 Months	•	• Small private online course(SPOC) and Simulation based training • The researcher • 6 Months • Education content v Patient safety v Adverse events v Risk management v Evidence-based nursing v Effective communication v Teamwork v Clinical practice v Patient-centred care • Teaching delivery v Simulation-based training	• Nursing students • N= 102	Small private online course only • The researcher • 6 Month • Education content v Patient safety v Adverse events v Risk management v Evidence-based nursing v Effective communication v Teamwork v Clinical practice v Patient-centred care • Teaching delivery v Online course	• Both groups showed significant improvements in Patient Safety Competency Scale for Nursing Students (PSCSE) scores after training ($P < 0.01$). Post-test scores were higher in the intervention group receiving SPOC combined with simulation-based training than in the control group (176.24 ± 13.73 vs. 160.87 ± 14.88, $P < 0.01$).	Level II

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
6. (Oh & Kim, 2023) • Korea • Pre-test-post study • N=44 • 2 month	Nursing students *N= 22*	• Mobile web-based training programme (VR-based smartphone application) on patients • Health-care professionals' safety • 2 month • Education Contents ❖ Patient safety management knowledge ❖ Patient safety management attitude ❖ Confidence in performing patient safety management. • Teaching delivery ❖ Educational materials (VR-based smartphone application) ❖ Games	Nursing students *N*= 22	• Training booklet on patient safety • Health-care professionals • 2 month • Education Contents ❖ Patient safety management knowledge ❖ Patient safety management attitude ❖ Confidence in performing patient safety management. • Teaching delivery • Training booklet	• In the experimental group, patient safety competency improved significantly compared with the control group, with notable gains in **knowledge** (11.68 - 18.55; $p < 0.001$), **attitude** (3.38 - 4.01; $p < 0.005$), and **performance confidence** (3.93 - 4.52; $p < 0.001$).	Level III

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		

7. Minnick et al., (2022)
• USA
• Pre-test-post study
• N=19
• 3 Month
	Student N=9	• Active learning
		• Researcher
		• Education content
		  ○ Hazard Communication Standard (HCS)
		• Teaching delivery
		  ○ Lecture via power point
		  ○ Case study
		  ○ Collaboration
		  ○ CDS & labelling
			Student N=10	• Traditional learning
				• Researcher
				• Education content
				  ○ Hazard Communication Standard (HCS),
				• Teaching Delivery
				  ○ Lecture via power point
					• Students in traditional training scored higher immediately, but after one month, active learning students outperformed, suggesting better retention despite greater score variability in the active learning group.	Level III

8. Ghezeljeh et al. (2022) • Iran • Single group Quasi-experimental pre & post • N=50 • 3 Month	• Nurses • N=50	• Online patient safety education • The researcher • 3 Month • Education content ❖ Patient safety and its different aspect ❖ Patients safety culture ❖ The effect of human factor ❖ Important of communication ❖ Root cause analysis ❖ Activity analysis ❖ Risk management • Teaching delivery ❖ Video and ,image ,audio ,text	No control group	• The mean scores for PS knowledge (21.75 ±3.28), attitude (61.52 ±4.19), and skill (84.66 ±53.7) were significantly higher than pretest scores (P<0.001). The overall competency score averaged 167.93 ±11.61 and increased significantly. The program boosted nurses' competence by 17.86 %.	Level IV
9. (Cho & Lee, 2021) • Korea • Pre & Post Study • *N*=94 • 4 month	• Inpatients • *N* = 94	• Self-education smartphone application (patients safety education) • The researcher • 3 days • Education content ❖ Introduction and Importance of patient	No control Group	• The mean score of safety behavior score rose from 2.00 ± 0.67 to 2.62 ± 0.76, with significant	Level IV

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
		involvement in patient safety ❖ Improve patient safety. ❖ Major adverse events in healthcare settings ❖ Reports on medical errors • Teaching delivery ❖ Video clips ❖ Animations ❖ Quiz			improvements in all subscales after self-education via the smartphone app ($t = -8.62$, $p < 0.001$).	

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
10. (Kim et al., 2019) • South Korea • Quasi-experimental • N=75 • 16 weeks	• Undergraduate nursing students • *N* = 32	• Flipped classroom • Faculty member with a PhD degree in nursing and specialized in nursing management and patient safety. • 14 weeks (28 hours) • Education Contents ❖ Introduction of patient safety ❖ Important applying human factors in patient safety ❖ Understanding systems and the effect of complexity on patient care. ❖ Effective team player and learning from errors to prevent harm ❖ Understanding, and managing clinical risk. ❖ Method of quality-improvement ❖ Engaging with patients and carers. • Teaching delivery ❖ Online learning ❖ Face to Face ❖ Case studies ❖ Discussions (face to face in classroom) ❖ Group projects	• Undergraduate nursing students • N= 43	• **No intervention was provided**. • Control group post-test survey only (same as experimental groups)	• The experimental group demonstrated significant improvements across all patient safety domains. Attitude scores increased (4.00 - 4.19; p = 0.001), while both skills (2.89 - 4.31) and knowledge (2.32 - 4.31) improved markedly (p < 0.001), confirming the course's effectiveness.	Level II

First author (year) Country Research design Total sample Study duration	Intervention group (IG)		Control group (CG)		Results	Level of Evidence
	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery	▪ Population ▪ Sample size (*N*)	▪ Intervention ▪ Interventionist ▪ Duration ▪ Student Education Contents ▪ Teaching delivery		
11. (Maxwell & Wright, 2016) • United States. • Pre & Post Study (control group) • *N*=64	Nursing student *N*= 31	• Online modules & flipped classroom. • Doctoral student. • Educational content ❖ Root cause analysis ❖ Human factors and safety ❖ Culture of safety ❖ teamwork and communication. • Teaching delivery ❖ Discussion seminar ❖ Visual aids ❖ Video clip ❖ Case studies • Games to engage their classmates.	Nursing student N=33	• Online modules • Doctoral student. • Educational content ❖ Root cause analysis ❖ Human factors and safety ❖ Culture of safety ❖ teamwork and communication. • Teaching delivery ❖ Discussion seminar ❖ Visual aids ❖ Video clip ❖ Case studies • Games to engage their classmates	• No statistically significant differences were found between groups in overall patient safety outcomes (p = .59, power = .18). While the experimental group showed slightly higher knowledge scores, skill and attitude scores were largely comparable to the control group.	Level III

Quality evaluation of the studies

The risk of bias was evaluated using the Cochrane ROB 2.0 tool for randomized controlled trials (RCTs) and the ROBINS-I tool for quasi-experimental and pre–post studies. Among the included studies, one RCT (Sarıtaş & Baykara, 2023) showed an overall low risk of bias, with all domains properly addressed. For the ten non-randomized studies, the ROBINS-I assessment indicated that most (n = 7) had a moderate risk of bias, while three studies (Cho & Lee, 2021; Minnick et al., 2022; Najafi Ghezeljeh et al., 2022) were judged to be at critical risk bias. None of the studies achieved an overall low risk of bias rating.

Domain-specific analysis showed consistent strengths and recurring limitations. All studies were rated at low risk for classification of interventions (D3) and deviations from intended interventions (D4), indicating clear intervention delivery and adherence to study protocols. However, confounding factors (D1) and outcome measurement (D6) posed the biggest challenges, with most studies rated at moderate risk, highlighting insufficient control of external variables and possible issues with outcome assessment methods. Participant selection (D2) was also a concern in some studies, especially those using convenience samples or lacking clear recruitment procedures. Conversely, missing data (D5) and selective reporting

(D7) were generally well managed, with most studies rated as low risk. Overall, the methodological quality of the included studies shows that while interventions were implemented consistently and with few protocol deviations, the overall confidence in the evidence remains limited due to issues related to confounding and outcome measurement. These findings warrant cautious interpretation when drawing conclusions about the effectiveness of physical and asynchronous teaching methods in enhancing patient safety knowledge retention among nursing students.

Knowledge retention

All eleven studies reported on outcomes related to knowledge retention. Both physical and asynchronous teaching methods demonstrated positive effects, though results varied by design and instructional approach. Studies employing blended or interactive learning approaches showed the most robust outcomes. Sarıtaş & Baykara. (2023) reported significantly higher achievement scores and self-efficacy among students in the flipped learning group compared to traditional lectures. Similarly, (Li et al., 2023) found that combining a small private online course (SPOC) with simulation training improved Patient Safety Competency Scale scores more than online learning alone, while Blaak et al.(2025) demonstrated sustained knowledge retention at three months in students receiving simulation-enhanced teaching.

Technology-based asynchronous interventions also yielded improvements. Oh and Kim (2023) reported significant gains in knowledge, attitude, and performance confidence using a mobile VR application, while Cho and Lee (2021) observed increased self-efficacy and safety behaviors among inpatients following smartphone-based education. Najafi Ghezeljeh et al.(2022) Likewise, we found that online patient safety modules improved nurses' overall competency scores. By contrast, outcomes from single-mode or shorter interventions were less consistent. Maxwell and Wright (2016) found no significant differences between flipped classroom and online modules, while Minnick et al.(2022) reported greater variability in learning outcomes with active learning, though retention benefits were apparent at follow-up. Taken together, these findings suggest that both physical and asynchronous lectures can enhance knowledge retention in patient safety education. However, blended approaches that combine simulation, interactive learning, and digital tools appear to offer the most sustained and meaningful improvements.

3. DISCUSSION

Sample characteristics

A total of eleven studies published between 2016 and 2025 met the inclusion criteria, involving 851 participants across diverse educational and clinical contexts. One study was a randomized controlled trial Sarıtaş & Baykara.(2023), six adopted quasi-experimental designs (Blaak et al., 2025; Galleryzki et al., 2023; Kim et al., 2019; Najafi Ghezeljeh et al., 2022; Park et al., 2023), and four were pre–post studies (Cho & Lee, 2021; Maxwell & Wright, 2016; Minnick et al., 2022; Najafi Ghezeljeh et al., 2022; Oh & Kim, 2023). Most studies were conducted among undergraduate nursing students (n = 9), with two focusing on practicing nurses (Najafi Ghezeljeh et al., 2022) and inpatients (Cho & Lee, 2021). Study populations varied from small groups of fewer than 20 students (Minnick et al., 2022) to larger cohorts exceeding 200 participants (Li et al., 2023). Geographically, the studies were undertaken in Asia (Korea, China, Indonesia, Iran, Turkey), Africa (Morocco), and North America (United States), reflecting the global emphasis on integrating patient safety into healthcare education.

Interventions included a range of delivery methods: lecture-based teaching, flipped classrooms, simulation and debriefing, online or mobile applications, and blended learning approaches. Educational content consistently focused on key domains of patient safety, such as risk management, communication, teamwork, clinical practice, and patient-centred care. Teaching strategies ranged from traditional didactic approaches to interactive, technology-enhanced formats.

Impact of physical and asynchronous on knowledge retention.

The primary aim of this review was to examine the impact of physical and asynchronous lectures on knowledge retention in patient safety education. Across the 11 included studies, both delivery methods were shown to improve students' knowledge, skills, and attitudes, although the degree and durability of improvement varied. Notably, studies employing blended or interactive learning strategies reported the strongest outcomes. For example Sarıtaş & Baykara (2023), demonstrated that flipped learning, which integrated online and physical activities, significantly improved achievement and self-efficacy compared to traditional lectures. Similarly, Li et al. (2023) and Blaak et al.(2025) reported that combining online courses with simulation-based training enhanced both knowledge retention and self-efficacy, with effects sustained at follow-up assessments. Cognitive Load Theory (CLT) helps explain these results by emphasizing the importance of managing intrinsic, extraneous, and germane load during learning. Physical lectures, while fostering real-time interaction, may sometimes increase extraneous cognitive load if content is delivered too rapidly. Conversely, asynchronous methods allow learners to control pacing, which can reduce extraneous load and support deeper processing. Blended strategies, such as flipped classrooms or simulation-based training, optimize germane cognitive load by engaging learners in active, problem-based activities that promote schema construction. This theoretical perspective reinforces the observed benefits of interactive and multimodal approaches in enhancing sustained learning outcomes.

These findings are consistent with prior evidence that multimodal, learner-centered approaches enhance cognitive

engagement and long-term knowledge retention (Anugrahsari et al., 2022; Moon & Chang, 2024).

By contrast, studies adopting single-mode approaches yielded mixed results. Maxwell & Wright (2016) found no significant differences between flipped classroom and online modules, while Minnick et al.(2022) noted variability in retention outcomes, with active learning showing promise for long-term gains but inconsistent short-term results. Technology-enhanced asynchronous learning platforms, such as VR-based mobile applications (Oh & Kim, 2023) and smartphone self-education tools (Cho & Lee, 2021), were associated with significant improvements in self-efficacy and safety behaviors, suggesting that well-designed asynchronous interventions can support applied learning. These variations highlight that intervention design, instructional quality, and learner engagement are critical determinants of effectiveness.

Flipped classroom approaches and knowledge retention

Evidence from Sarıtaş & Baykara (2023) showed that flipped learning significantly improved achievement and self-efficacy compared to traditional lectures, while Kim et al. (2019) also reported positive effects of flipped teaching on patient safety competence. The flipped classroom model requires students to engage with core content asynchronously before class and then apply knowledge through interactive, face-to-face activities. This structure is consistent with Cognitive Load Theory (CLT), as pre-class self-directed learning reduces extraneous load by allowing learners to process foundational information at their own pace, while in-class active engagement increases germane load by promoting problem-solving, reflection, and peer discussion (Sweller,1990). These outcomes suggest that the flipped classroom not only supports immediate knowledge acquisition but also strengthens retention through repeated cognitive engagement across multiple modalities. By scaffolding learning in this way, flipped approaches align well with CLT principles and offer a promising framework for designing patient safety education that is both effective and sustainable.

Methodological considerations

The methodological appraisal underscores important limitations in the current evidence base. None of the studies included achieved an overall low risk of bias. The most frequent sources of bias were confounding and outcome measurements, both of which undermine confidence in reported findings. Many studies relied on convenience sampling, lacked randomization, or used self-reported questionnaires without blinding, which raised concerns about the overestimation of effects. Furthermore, variability in intervention duration and outcome measurement tools makes cross-study comparison challenging. Despite these limitations, consistent low-risk ratings in the domains of intervention classification and adherence to protocols indicate that interventions were well-defined and delivered with fidelity. Future research should prioritize rigorously designed RCTs, larger and more representative samples, and standardized outcome measures to strengthen the evidence on how physical and asynchronous teaching methods impact knowledge retention in patient safety education.

4.4 Implications and limitations

This review highlights that both physical and asynchronous lectures can enhance knowledge retention in patient safety education, with the strongest evidence supporting blended and interactive approaches such as flipped classrooms, simulation-based learning, and technology-enhanced platforms. These methods consistently demonstrated greater improvements in knowledge, self-efficacy, and long-term retention compared with single-mode interventions, providing valuable guidance for nursing curricula seeking to strengthen patient safety competencies. However, the overall certainty of the evidence remains limited, as none of the included studies achieved a low risk of bias, and most were rated at moderate or critical risk due to confounding factors, reliance on self-reported measures, and variability in intervention design and outcome assessment. Additionally, small sample sizes, single-institution settings, and the exclusion of non-English studies restrict the generalizability of findings. The need for more studies employing standardized tools is also evident, as variation in outcome measures across studies made direct comparisons challenging. Despite these limitations, the results highlight the potential of integrating diverse teaching modalities into undergraduate and continuing nursing education. Future research should prioritize rigorously designed randomised trials, standardised outcome measures, and larger, more representative cohorts to provide stronger evidence on the comparative effectiveness of physical and asynchronous teaching in patient safety education.

4. CONCLUSION

The results of this systematic review indicate that combining physical and asynchronous lectures can positively influence knowledge retention in undergraduate nursing students studying the nurses ' patient safety education. The data indicated that both physical and asynchronous methods may effectively support learning outcomes in this context. Despite these promising results, there remain areas of uncertainty, especially in resource-limited settings, where access to diverse educational methods may be constrained. To build on these insights, further research is required to enhance our understanding of how physical and asynchronous lectures specifically impact knowledge retention and learning satisfaction with the nurses-patients safety education. Further studies could help to clarify the adaptability and effectiveness of these instructional approaches across different educational environments, providing more robust guidance for institutions with varying resources.

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Author contribution

DCT and RN were responsible for screening full-text articles, data extraction, and critical evaluation of methodological quality. JDM acted as the third reviewer to reconcile disagreements and ensure the accuracy of the screening and appraisal process. RN led the manuscript preparation, writing, and revisions, while DCT contributed to editing and reviewing the final draft. All authors approved the final version of the manuscript.

Conflict of interest

The author(s) declared no actual or potential conflict of interest in relation to this article.

Clinical trial number

Not Applicable

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Data Availability

All the generated data during this review is available upon request.

Declarations

Ethics approval and consent to participate

Not applicable. This study is a systematic review of previously published literature

and did not involve direct contact with human or animal subjects.

Consent for publication

Not applicable.

Competing interests

The authors have no competing interests to declare that are relevant to the content of this article

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