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Learning practical nursing skills in simulation centers – A narrative review

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ABSTRACT

Background: Practical skills are complex procedures integrating communication and caring, as well as technical and manual aspects. Simulation at a simulation/skills center offers a wide range of learning activities and aims to imitate patient situations.
Objectives: To investigate the international research literature on practical skills learning in simulation/skills centers in nursing education. Research questions: 1. What are the range and type of practical skills studied? 2. What learning activities are focused on in the studies included in the review? 3. What are the learning outcomes and how are they assessed?
Design: Narrative review.
Methods: We searched electronically and included studies from Medline Ovid, CINAHL, Eric, Embase, Academic Search Premiere, and Cochrane. Unique indexing terms and search strategies were developed for each database. The criteria for inclusion were bachelor nursing students as the study population and practical nursing skills learning in simulation/skills centers. We used Rayyan QCRIt for the initial screening and the Mixed Method Appraisal Tool for quality assessment. We used a narrative approach to synthesize the diverse range of studies.
Findings: One hundred and twenty-one studies from 26 countries published between January 2013 and March 2022 were included. The amount of quantitative research was overwhelming (n = 108). A total of 50 different practical skills were represented. The studies focused on which learning modalities resulted in the best learning outcomes. Only 8.5% (n = 7) of the included studies concerned students' learning processes. Skill performance (n = 101), knowledge (n = 57), confidence (n = 34), and satisfaction (n = 32) were the main learning outcomes measured.
Discussion: The quality assessment indicated that 10 of the studies achieved 100% on the mixed method appraisal tool criteria. In many of the studies with quasi-experimental and randomized controlled trial designs, the intervention group received some form of educational treatment while the control group received no treatment. The choice of no treatment for the control group in pedagogical research seems to disregard the inherent purpose and effect of teaching and learning.
Conclusion: Heterogeneity in the use of learning modalities and measuring instruments precludes the possibility of building on other research. Technical skills were the preferred choice of skill, while skills that involved a fair measure of communication and collaboration were only sparingly studied. Students' learning processes were barely touched on in the included studies. More focus should be placed on this area in further research, since the choice of learning modalities may affect the students' learning processes in significant ways.

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What is already known

- Newly registered nurses often lack the required competence in basic practical skills, although these are a mainstay of nursing practice.
- Despite simulation-based learning in a skills center being the norm for practical skills learning in nursing education, the characteristic of such learning is rarely explored.

What this paper adds

- There is a lack of accumulated knowledge about practical skills learning in nursing education due to the heterogeneity of learning modalities and measuring instruments.
- There is a gap in knowledge about nursing students' learning processes in skills centers.
- We question the appropriateness of traditional experimental research design in pedagogical investigation.

1. Introduction

Every day, nurses perform practical skills that constitute a mainstay of clinical nursing practice (Ewertsson et al., 2015). Practical skills learning is therefore an important part of nursing education. Despite this, newly registered nurses often lack the required competence in basic practical skills (Ravik et al., 2017a; Zamanzadeh et al., 2015). Students learn practical skills in two arenas: simulation/skills centers and clinical placements. Learning opportunities in clinical placements are defined by the learning situations available at the precise time when students are present. Learning in skills centers has increased in importance due to a changing health care system in which it is difficult to find sufficient relevant clinical placements for nursing students (de Lima Lopes et al., 2019; Traynor et al., 2010; Yuan et al., 2012). However, there is little systematic knowledge about the best way to support such learning. In the present review, we adopt an overarching perspective to explore some characteristics of practical skills learning in simulation/skills centers.

Practical skills are complex procedures integrating communicative and caring aspects, as well as technical and manual aspects, as shown in the Model of Practical Skill Performance (Bjørk, 1999; Bjørk et al., 2013). Practical skills in nursing can be grouped according to the challenges they present to a nurse (Bjørk, 1999): 1) skills characterized by gross motor movements and considerable collaboration between patient and nurse (for example, postoperative ambulation or bed bathing), and 2) skills characterized by fine motor movement, precision, and logic in the use of equipment and patient passivity (for example, blood pressure measurement or peripheral vein cannulation). The latter group can also be labelled technical skills. All learning in a skills center involves some form of simulation. The Healthcare Simulation Dictionary (2020, p. 21) defines simulation as "a technique that creates a situation or environment to allow persons to experience a real event for the purpose of practice, learning, evaluation, testing or to gain understanding of systems or human actions". Simulation-based learning provides a safe environment for students to practice their skill performance (de Lima Lopes et al., 2019). The focus is on the student and not the patient, which gives students an opportunity to practice without fearing for the safety of the patient (Eyikara and Baykara, 2018; Reid-Searl et al., 2012). Hereafter in this article, we use the terms simulation-based learning and practical skills learning.

Practical skills learning in skills centers in nursing education is intended to introduce a variety of nursing skills (Wighus and Bjørk, 2018), ranging from technical skills such as monitoring vital signs and performing injections, to more interactional skills, such as body care and ambulation. Such learning is seldom mastery learning that purports to deliver proficiency in performance when students enter the clinical setting (Cook et al., 2013). Simulation in a skills center offers a wide range of learning activities and is expected to imitate patient situations. When practicing on each other or a standardized patient, students can integrate patient interaction and communication skills in their performance. This makes the procedure more complex and lifelike. Equipment such as task trainers and more technologically advanced virtual reality devices give students opportunities to develop dexterity and accuracy because they can repeatedly practice the same skill without harming the patient (de Lima Lopes et al., 2019). Students need enough time to facilitate the development of skills and confidence, experience feedback that fosters reflection, and critically think to develop a knowledge base that can support safe practice with future patients.

Fidelity is a commonly used term to describe the realism of a simulation and is categorized as high, medium, or low. However, there seems to be no clear consensus on how to interpret fidelity as a term in simulation research. According to the Healthcare Simulation Dictionary (2020), fidelity is related to learning modalities used in simulations. Modalities refer to the type of simulation used as part of the simulation activity, including the simulation equipment, concept, or technique that constitutes a method of simulation use (Healthcare Simulation Dictionary 2020), p. 31). In recent years, technology and digitization have resulted in a wider range of different simulation modalities for use in education. The number of studies on the use of virtual reality in simulations reflects this trend (Shorey and Ng, 2021).

Scenario simulation is well-documented. A simulation scenario is an imitated representation of a real event designed to assess, educate, and help learners to achieve educational goals through experimental learning (Harrington and Simon, 2021). The equipment used in studies on scenario simulation often consists of advanced patient simulators that can be labeled high fidelity. Learning outcomes are often related to cooperation and communication rather than to practical skills. There is an increasing number of reviews that synthesize knowledge about scenario simulation. There are also several pedagogical recommendations concerning scenario simulation

in nursing education; e.g., the NLN Jeffries simulation theory (Jeffries, 2021), First2Act (Buykx et al., 2011), Essentials of Debriefing in Simulation Learning (Dreifuerst, 2009), and the International Nursing Association of Clinical Simulation Learning (INACSL Standards Committee, 2016). However, few reviews exist that focus on practical skills learning in skills centers, and, to our knowledge, no similar pedagogical recommendations exist regarding practical skills learning for nursing students. In this review, we therefore aimed to fill a knowledge gap by investigating the international research literature on practical skills learning in skills centers in nursing education. We used Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 (Moher et al., 2015) in this review.

We explored the following research questions:

1 What are the range and type of practical skills studied?
2 What learning activities are focused on in the included studies?
3 What are the learning outcomes and how are they assessed?

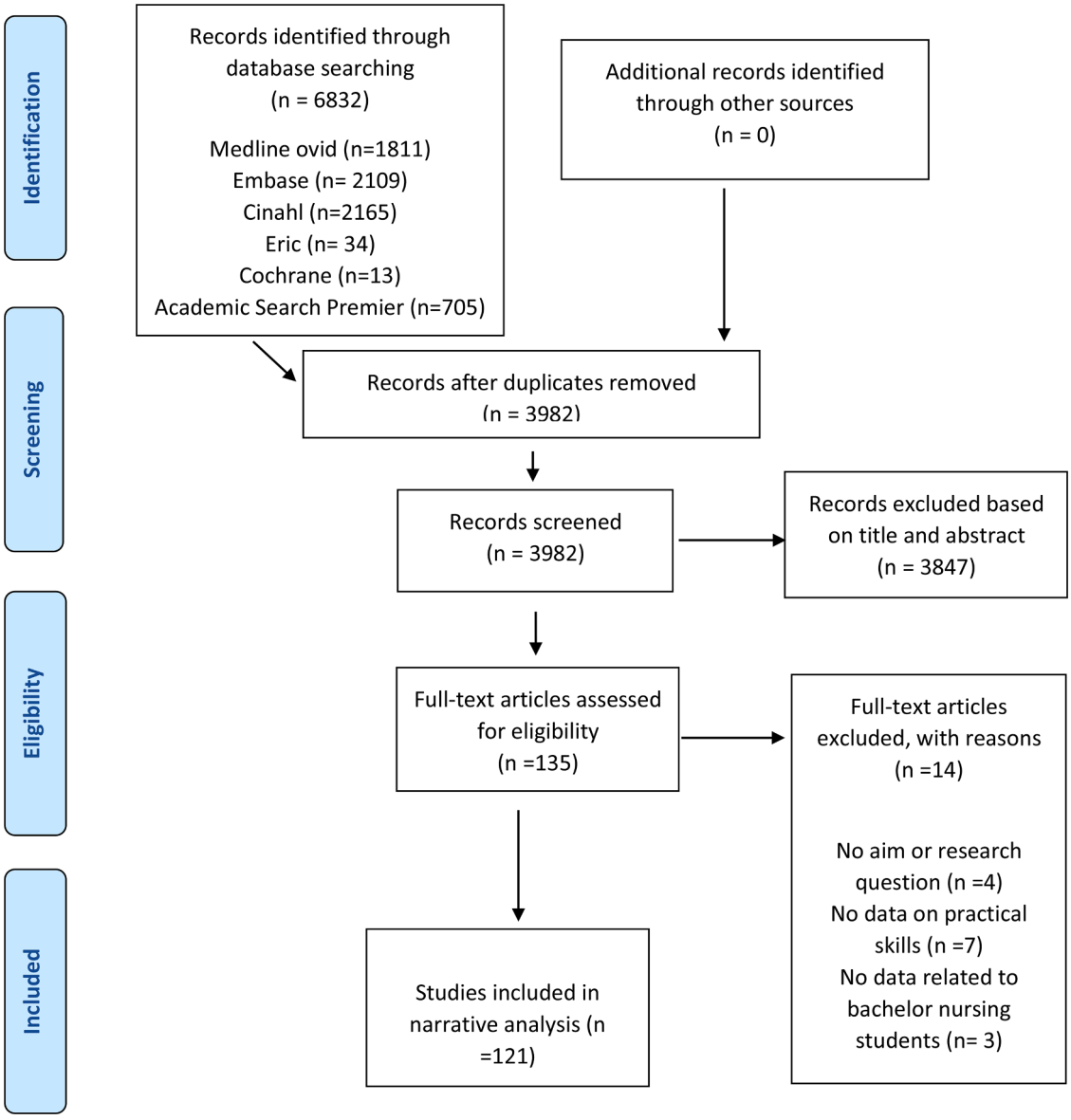

Fig. 1. The screening process.

2. Methods

2.1. Data sources and searches

The primary search was conducted by a librarian at the The university is Oslo Metropolitan University library in June 2017 and supplemented in July 2019 and March 2022. We searched electronically and included studies from Medline Ovid, CINAHL, Eric, Embase, Academic Search Premiere, and Cochrane. Unique indexing terms and search strategies were developed for each database by the librarian in cooperation with the researchers. The search strategy was built around three elements. The first element identified articles about simulation, including terms related to simulation; e.g., skills laboratory, role play, and manikins. The second element identified studies related to bachelor level nursing students; e.g., education, nursing baccalaureate, and undergrad*. The third element identified skills. The different terms used to refer to practical skills in studies; e.g., skill, aptitude, ability, and competence, were included in this element. Both the first and third elements were widely searched for due to the lack of consistent use of the terms. The search resulted in a large number of studies for assessment, making the screening process more comprehensive.

2.2. Search outcomes

A total of 3982 unique publications was retrieved from the database searches and added to Rayyan QCRIt, a web and mobile app for systematic reviews (Ouzzani et al., 2016). Two pairs of researchers (IHSH & ITB and IHSH & BC), independent and blinded to each other's assessments, screened and assessed the title and abstract of each publication against the inclusion criteria. All the researchers met and discussed the publications if there was a conflict between them. The same pairs of researchers screened and assessed a total of 135 publications in full text.

2.3. Inclusion criteria

The inclusion criteria, both eligibility criteria and report characteristics, were pre-defined. Studies were required to meet the following criteria to be eligible for inclusion: bachelor-level nursing students as a study population and the learning of practical nursing skills in skills centers. Original articles with full-text versions available, published in English and/or a Scandinavian language between 2013 and 2022, were included. Letters, editorials, and comments were excluded. The screening process was conducted using Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Moher et al., 2015). The screening process is shown in Fig. 1.

2.4. Assessment of the methodological quality of the included studies

We used the Mixed Method Appraisal Tool (Hong et al., 2018) to appraise the quality of the included studies. This tool is designed for systematic reviews that include qualitative, quantitative, and mixed-method studies and can be used to assess the quality of the most common types of studies. The Mixed Method Appraisal tool has been cited in more than 100 systematic reviews. It includes five screening questions for all designs, including qualitative, quantitative randomized controlled trials, quantitative non-randomized, quantitative descriptive, and mixed methods (Hong et al., 2018). Most of the included studies lacked clear research questions, which led to us agreeing to include studies with a clear aim. Four studies with neither a research question nor a clear aim were excluded. After responding to the two overall screening questions, all the researchers rated the methodological quality of each included study together. We categorized and appraised the included studies based on the authors' own definitions of design. Some definitions of design were incorrect, which meant that some studies were misplaced. Other studies did not have an explicit design, and a discretionary assessment was made to categorize them by design. Due to these deficiencies, quality appraisal was somewhat challenging for some of the studies.

In general, the quality of the included studies was unsatisfactory. Only 10 studies achieved 100% on the Mixed Method Appraisal Tool. Major deficiencies were found in all designs except qualitative design, where the four included studies fulfilled all the five quality criteria. In only 36 of the 121 included studies were research questions formulated. In 14 of the 29 quantitative randomized controlled trials, the trial groups were homogenous, and nine studies fulfilled both criteria relating to randomization of participants and blinding of assessors. Most of the quantitative non-randomized and descriptive studies lacked information about how representative the sample was in relation to the target population. This was probably related to the use of convenience samples. In addition, information on non-response bias was generally lacking in the descriptive studies, while authors did not address possible confounders in the design and analysis in the quantitative non-randomized studies. Of the nine mixed-method studies included, information was lacking in seven studies on quality criteria related to integration of the components of the study, integration of the output of each component, and on divergences and inconsistencies in the qualitative and quantitative results.

2.5. Data extraction and synthesis

The following data relevant to the research questions were extracted and included: author, year, nationality, aim/purpose, research questions, practical skills, study participants (student year of study and number of participants), learning modalities, learning outcomes, study design, assessment forms with reliability and validity, and results. We used a narrative approach to synthesize the diverse range of studies in a structured manner. A narrative systematic organization and presentation of data can help to identify themes across studies (Petticrew et al., 2013).

Table 1
Summary of the included studies ($N = 121$).

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
Aebersold et al., 2018 **USA**	To determine the impact of an anatomy-augmented procedure training video with interactive virtual simulation exercises (VR) on nasogastric tube (NG) placement skill and assessing qualitative metrics.	Mixed method IG / CG Post	69 Second and third year	NG tube placement VR on iPad / Trad. training	Skill perf. Perception of training	The ability to correctly place the tube through all the checklist items was statistically significant in the VR group compared with the CG.
Aggar et al., 2018 **Australia**	To examine the effectiveness of a time management and prioritization intervention on nursing students' perceived preparedness for medication administration (MA) in a clinical setting.	QE IG / CG Pre / post	221/180 Second year	MA Time management intervention / Clinical simulated laboratory	Perception of preparedness	IG showed significant improvement inthree items, and CG showed significant improvement inone item. No significant difference between groups.
Aqel and Ahmad 2014 **Jordan**	Effect of using high-fidelity (HF) simulators on knowledge and skills acquisition and retention in cardiopulmonary resuscitation (CPR).	RCT IG / CG Pre / post / retention	90/90/90 Unknown	CPR HF manikin / Low Fidelity (LF) manikin	Skill perf. Knowledge	Reduction in both knowledge and skills after three months, IG had significantly better results on knowledge and skills, post and retention.
Arabpur et al., 2021 **Iran**	To compare the effectiveness of demonstration using hybrid simulation versus task trainer for training nursing students in using pulse-oximeter and suction following cardiac arrest.	RCT IG (2 groups) / CG Pre / post	45 Second year	Pulse-oximeter, suction with standardized patient (SP) and task trainer in ambulance / Manikin in simulation laboratory / No treatment	Skill perf. Knowledge	No significant difference between the two IG in knowledge or skill scores. Both IGs had significantly higher scores than CG in knowledge and skill
Arrogante et al., 2021 **Spain**	To analyze the effects of deliberate practice using a feedback device (FD) on the CPR performance of nursing students prior to, immediately after, and three months after training, considering their physical characteristics.	RCT IG / CG Pre / post / post	60/59 Second year	CPR Little Anne / No treatment	Skill perf.	IG had significantly higher scores on all measures at both post measuring points.
Avraham et al., 2018 **Israel**	To evaluate the impact of MA simulation-based learning on students' preparedness and performance in the clinical setting, among students who practice simulation individually or in a group of students.	QE IG / IG Pre / post / transfer	77 Third year	MA Individual simulation with manikin / Group simulation with manikin	Skill perf. Preparedness for MA Satisfaction	Simulation experience in the individual sample impacted their satisfaction, preparedness, and clinical MA evaluation, whereas the simulation experience in the group sample impacted their satisfaction and preparedness, but

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
						not their clinical MA evaluation.
Basak et al., 2019 **Turkey**	To compare the effect of SP and the use of low-fidelity mannequins in teaching hygiene care.	RCT IG / CG Post	64 First and second year	Hygiene care SP / LF manikin	Skill perf. Confidence Satisfaction	SPs gave better learning opportunities overall.
(Bautista and Zakari, 2014) **Saudi Arabia**	To compare two different teaching strategies among nursing students by applying Bloom's Taxonomy of learning domains.	QE IG / CG Post	21/21 Second year	SC Practice with pricking of needle / Practice without pricking of needle	Skill perf.	Significant difference in eight of 17 items in skill performance in favor of IG.
Bayram and Caliskan, 2019 **Turkey**	To determine the effect of the game-based VR phone application on tracheostomy care education for nursing students.	RCT IG / CG Pre / post / post	93/90/86 First year	Tracheostomy care VR-App / No treatment	Skill perf. Knowledge	No significant difference in knowledge. Significant difference in some measuring points on skills. VR increased learning of skill.
Boada et al., 2015 **Spain**	To compare educational efficacy of the serious game Life Support Simulation Activities (LISSA) with that obtained from traditional teaching.	RCT IG / CG Post	109 Second year	CPR LISSA with two scenarios / No treatment	Skill perf.	Significant higher scores on skill performance in LISSA group.
Boucheix et al., 2018 **France**	To investigate the effect of mixed camera viewpoints on learning a complex medical hand procedure from a video.	QE IG (3 groups) / CG Pre / post	43 Second year	Urinary catheter insertion Face-to-face view / Over-the- shoulder view / Both views / No treatment	Skill perf. Confidence	IGs overall better than CG, significant in performance. No significant difference between groups in time used.
Brannagan et al., 2013 **USA**	To examine the impact of peer teaching learning experiences on nursing students in roles of tutee and tutor.	Mixed method IG / CG Pre / post	179/51 First and third year	Surgical dressing Unknown modality	Knowledge Satisfaction Self-efficacy	No significant difference between groups in knowledge and self-efficacy. IG statistically more anxious about performing with peer tutors.
Burbach et al., 2019 **USA**	To examine the relationship among anxiety, self-efficacy, and nursing knowledge and students' performance during low stakes simulation	Mixed method Pre / post	104	Insulin administration SimMan	Skill perf. Knowledge Self-efficacy Anxiety	Significant relationships were identified between knowledge of nursing care and simulation performance. Student qualitative reports of heightened anxiety and lack of self-efficacy and uncertainty contrasted from quantitative measures.
Calim et al., 2020 **Turkey**	To determine the effects of simulation training on student midwives' management of normal childbirth	QE IG / CG Post	75 Third year	Childbirth skills HF manikin / Task trainer	Skill perf. Confidence Satisfaction	No significant difference in skill, satisfaction or self-confidence between groups.

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	(second and third stages of labor) and their learning satisfaction.					
Chang et al., 2021 **Taiwan**	The study's aim was to test the hypothesis that nursing students who used a mobile learning app would have significantly (1) higher levels of knowledge about medication administration and nasotracheal suctioning, (2) better development of skill performances on MA and nasotracheal suctioning, (3) higher satisfaction, and (4) lower cognitive load than a control group.	RCT IG / CG Pre / post	100 Unknown	MA Nasotracheal suction VR mobile app / Trad. paper materials	Skill perf. Knowledge Satisfaction Cognitive load	IG significant better scores than CG on all measures.
Charlier et al., 2020 **Belgium**	To identify which basic life support (BLS) skills of student nurses deteriorate in a period of four months and investigate the link between a specific cognitive skill and its corresponding motor skill in BLS.	One group Post / retention	114 First year	BLS Ambu Airway Man W	Skill perf. Knowledge	Students' knowledge was sufficient for most BLS components, but they failed in actual performance.
Chen et al., 2015 **Canada**	To explore the effectiveness of HF and lLF simulation for learning of cardiac and respiratory auscultation and physical assessment skills.	QE IG (2 groups) / CG Post	60/54 Fourth year	Cardiac and respiratory auscultation HF manikin / LF Personal Computer(PC) / No treatment	Skill perf.	LF group had significantly better scores on LF auscultation test than HF and CGs. No significant differences on HFS and auscultation tests.
Chen et al., 2018 **China**	To develop and evaluate a standardized high-tech simulation-based emergency and intensive care nursing curriculum on nursing students' response time in a resuscitation simulation.	QE IG / CG Pre / post	39 Third year	CPR Simulation-based curriculum / Trad. curriculum	Skill perf. Perception of training	Students in IG used significantly less time to call for assistance, initiate compression, and perform successful defibrillation than CG. Significant higher scores in IG on perception of training.
Costa et al., 2019 **Brazil**	To evaluate the performance of nursing undergraduates on administration of vaccines using simulated scenario, skill training and VR	Quantitative descriptive Pre / post	39 7th, 8th, or 9th period	IM VR + Static dummy	Skill perf. Knowledge	Overall significant increase in knowledge and performance.
Costa et al., 2019 **Brazil**	To identify and compare satisfaction and self-confidence in the learning of nursing	RCT IG / CG Post	34 Third, fourth, and fifth year	Immunization Clinical scenarios, lecture classes, skills training, and	Confidence Satisfaction	No significant difference in scores between IG and CG

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	students from the use of simulation and traditional teaching in adult immunization scenarios in the context of primary health care			simulated scenarios / Trad. teaching		
Costa et al., 2020 **Brazil**	To evaluate the effectiveness of clinical simulation on the cognitive performance of nursing students in adult immunization scenarios in the context of primary health care	RCT IG / CG Pre / post / post /post	34 Third, fourth and fifth year	Immunization Clinical scenarios, lecture classes, skills training, and simulated scenarios / Trad. teaching	Knowledge	IG had higher scores than CG on all tests. Significance reached on post 1 and 2 tests.
Craig et al., 2021 **USA**	To examine the effects of an educational strategy using a medication safety enhancement simulation program with integrated technology on the MA knowledge, competency, and confidence levels of undergraduate nursing students	QE IG / CG Pre / post	80/77 Third year	MA Three simulations / Standard MA education and one simulation	Skill perf. Knowledge Confidence	IG significant higher scores than CG on skill performance. No significant difference in knowledge scores. Score onone of eight items on confidence instrument significantly higher in IG.
Dal and Sarpkaya, 2013 **North Cyprus**	To determine the CPR knowledge and skill levels of nursing students .	QE Pre / post / retention	83/83/62 Third year	CPR Resusci-Anne	Skill perf. Knowledge	Knowledge increased significantly post. Knowledge and skill decreased significantly at retention test after six months.
David et al., 2020 **India**	To assess lecture cum demonstration versus video-based teaching regarding active management of the third stage of labor in terms of knowledge and skills of General Nursing Midwifery students	QE IG / CG Pre / post	100 Third year	Childbirth skills Video-based teaching / Lecture and demonstration	Skill perf. Knowledge	No significant difference in scores on knowledge or skill between IG and CG.
de Lima Lopes et al., 2019 **Brazil**	To test the efficacy of a video-assisted bed bath simulation on improving the performance of psychomotor skills of undergraduate nursing students.	RCT IG / CG Pre / post	56 Second year	Bed bath Video-and-tutor assisted simulation / Tutor assisted simulation	Skill perf.	IG had significantly higher scores than CG.
Demirtas et al., 2021 **Turkey**	To assess the effectiveness of simulation-based CPR training programs on the knowledge, skills, satisfaction, and self-confidence of nursing students.	Mixed Method Pre / Post	89 Fourth year	CPR Theoretical CPR Training Medium-fidelity CPR model	Skill perf. Knowledge Confidence satisfaction	Improvement in the CPR knowledge and skills scores of the students following theoretical and simulation-based CPR training. In focus group interviews, students expressed their worries before the

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
						simulation and their satisfaction after the simulation.
Demirtas et al., 2022 **Turkey**	The purpose of this study was to evaluate game-based CPR training for first-year nursing students in terms of students' knowledge levels, performance, satisfaction, and confidence.	QE IG / IG Pre / post / post	104 First year	CPR Serious Game & Integrated Real-Time Audiovisual Feedback Simulator / Real-time audiovisual feedback simulator	Skill perf. Knowledge Confidence Satisfaction	No significant difference in any scores between the groups. Both groups had reduced score on second post-test.
Devenney et al., 2018 **USA**	To demonstrate the effectiveness of the Avstick in nursing education to increase nurse-patient communication and trainee self-efficacy.	Quantitative descriptive Pre / post / post	25 Third and fourth year	Peripheral Venous Catheter(PVC) Avstick + SP and Static manikin	Self-efficacy Communication skills	The Avstick and the standard manikin similarly provided self-efficacy. The Avstick increased interpersonal skills to nursing students learning PVC insertion
Dick-Smith et al., 2020 **Australia**	To investigate whether CPR feedback devices improve performance for nursing students.	QE IG (3 groups) Post 64	64 Third year	CPR All groups CPR without feedback, then CPR with feedback from Simpad, TrueCPR, or Brayden	Skill perf.	All devices with feedback increased skill compared to training of CPR with no feedback. Variation in best results across parameters related to type of feedback device.
Vural Dogru and Zengin Aydin, 2020 **Turkey**	To compare the effectiveness of high-fidelity simulator and traditional teaching method on nursing students' knowledge and skill development in terms of cardiac auscultation and their anxiety levels	RCT IG / CG Pre / post (Transfer)	72 First year	Cardiac auscultation HFS scenario / Trad. teaching with manikin	Skill perf. Knowledge Anxiety	IG had significantly higher scores on knowledge and skill than CG and significantly lower scores on anxiety. Within-group scores on skill performance were significantly higher on skill performance after clinical placement.
Du et al., 2021 **China**	To evaluate the effectiveness of a clinical scenario simulation method among nursing students for assessing the risk of patients developing pressure ulcers compared with the traditional didactic method	QE IG / CG Pre / post 47	47 Second year	Pressure ulcer assessment Clinical simulation teaching / Trad. teaching	Skill perf. Knowledge	IG had significant higher scores on OSCE compared to CG
Eghbalibabadi and Ashouri, 2014 **Iran**	To compare two methods of blood pressure measurement training on nursing students' performance.	QE IG / CG Pre / post	36/36 First year	BP Simulator / Peers	Skill perf. Knowledge	No significant difference in knowledge gain or skill between groups.
Eyikara and Baykara, 2018 **Turkey**	To identify the effect of simulation on the ability of first year students to learn how to measure vital signs.	QE IG (2 groups) / CG Pre / post / transfer	90/90/90 First year	Vital signs SimMan / Laboratory practice + SimMan / Laboratory practice	Skill perf. Knowledge	Knowledge and skill significant higher at post-test in both IGs. No difference between IG1 and

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
						IG2. BP scores significantly higher in IG2 than IG1 performing on healthy adults.
Fard et al., 2020 **Iran**	To compare and investigate the effect of a peer education method, a mentor-led education method versus a traditional faculty-led method for instruction regarding surgical wound care skills among nursing students.	QE IG (2 groups) / CG Pre / post	120/102 First and second year	Surgical wound care Peer-led learning / Mentorship-led learning / Faculty-led learning	Skill perf.	Mentorship-led group had significantly higher scores than peer-led group. No significant difference between mentorship-led or peer-led and the faculty-led group.
Ferguson et al., 2014 **USA**	Evaluate the perceptions of first semester nursing students following the implementation of a medication dispensing system in the skills laboratory.	Quantitative descriptive Pre / post	51 First year	MA DemoDose MediDispense	Skill perf. Knowledge Confidence	Benefits were increased student confidence, prevention of medication errors and enhanced knowledge. Challenges were expense and need of maintenance. Students need more time in skill center.
Findik et al., 2019 **Turkey**	To determine the effect of education with a stoma model on knowledge and skill levels of student nurses.	QE IG / CG Post	133 Unknown	Stoma care Stoma model training / No treatment	Skill perf. Knowledge	No significant difference in knowledge scores IG had significant higher scores on skill than CG. Weak correlation between knowledge and skill
Flood and Higbie, 2016 **USA**	To measure cognitive knowledge in nursing students who receive a related didactic lecture compared with students who did not receive the lecture.	QE IG / CG Pre / post	86/86 Unknown	Blood transfusion Didactic lecture / No treatment	Knowledge	Students in IG had significantly higher post-test knowledge scores than students in CG.
Fusco et al., 2021 **USA**	To measure the medication safety competence of undergraduate junior and senior nursing students and determine if there was a difference in retention between the two groups.	Descriptive comparative study Post	98 / 90 Junior / senior	MA Mannequin	Skill perf.	More juniors than seniors demonstrated competence in all items on the checklist. Juniors correctly documented all medications significantly more than seniors.
(Garcia-Exposito et al., 2021) **Spain**	1) To assess nursing students' evidence-based knowledge on the use of PVCs, and 2) to examine the perception of learning and teaching strategies aimed at this skill.	Mixed Methods	675 Second, third and fourth year	PVC Unknown modality	Knowledge Learning and teaching strategies	The students assessed their knowledge as basic but improving year by year. They identified a need to apply more active and experiential methodologies that would allow for reflection.

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
Germain et al., 2018 **USA**	To evaluate the effect of simulation on confidence levels of a group of diverse nursing students.	Quantitative descriptive Pre / post / transfer	61 Third year	Obstetric skills LF Manikin + Task trainer	Confidence	Overall confidence level increased significantly from pre to post and pre to follow-up after clinical practice
Gniadek et al., 2021 **Poland**	To assess the performance and the efficiency of a hand-rubbing disinfection technique among nursing students	Observational study Post	190 First year	Hand disinfection	Skill perf.	Problems in performing the procedure were observed, mostly connected with thumbs and back of both hands. Regular training and assessment should take place after completing each cycle of nursing education.
Goldsworthy et al., 2021 **Canada**	To explore a specific virtual auscultation learning strategy among undergraduate nursing students and the impact on competency in auscultation of heart and lung sounds versus traditional methods of auscultation education	RCT IG / CG Pre / post	127 Second year	Heart and lung auscultation Virtual auscultation / No treatment	Knowledge	Only significant increase in score in IG in identification of a murmur on cardiac auscultation
Gonzalez and Sole, 2014 **USA**	To assess student competency on skill attainment in urinary catheter insertion to identify the most common breaches in aseptic technique.	Quantitative descriptive	13 Unknown	Urinary catheter insertion Female manikin	Skill perf. Confidence	77% breached aseptic technique in at least one category, some in several categories. Ongoing practice was important to ensure competence.
Gu et al., 2022 **China**	To determine the effect of a game-based mobile application on the skill levels of nursing students in respect of flushing and locking of venous catheters with pre-filled saline syringes.	RCT IG / CG Pre / post	154 Unknown	Flush and lock PVC Game-based mobile app / No treatment	Skill perf.	Significant higher scores on skill in IG. Practice 11 times in IG necessary to master the skill.
Gu and Sok, 2020 **South Korea**	To examine the effects of the simulation practicum using flipped learning on nursing competency, core basic nursing skill (SC) performance, self-efficacy, and learning satisfaction .	QE IG (2 groups) / CG Pre / post / post	101 Second year	SC Video + simulation / Simulation / Trad. teaching	Skill perf. Satisfaction Self-efficacy Nursing competency	IG with video and simulation had significantly higher scores for all measures than IG with only simulation and CG. IG with only simulation had significantly higher scores on all measures than CG.
(Gutierrez-Puertas et al., 2021) **Spain**	To explore the experiences and perceptions of nursing students after applying advanced life support techniques on a hospitalized patient in	Qualitative descriptive Focus- group interviews	54 Unknown	CPR Theoretical CPR Scenario, manikin	Experiences and perceptions	Practicing for an emergency situation allowed them to acquire skills necessary for emergency situations and improve their

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	cardiac arrest in a simulated setting					clinical performance in advanced life support
Ha and Lim, 2018 **South Korea**	To evaluate nursing students' knowledge and confidence in preoperative nursing skills and satisfaction with debriefing and multimode simulation using peer-led written debriefing (PLWD) and instructor-led oral debriefing (ILOD).	QE IG / CG Pre / post	122 Third year	Preoperative skills PLWD / ILOD	Knowledge Confidence Satisfaction	Confidence was significantly higher in ILOD than in PLWD group. No other differences.
Habibli et al., 2020 **Iran**	To investigate the effect of simulation-based education on the knowledge and performance of nursing students of adult essential life support cardiopulmonary resuscitation (BLS-CPR).	QE IG / CG Pre / post / post	52 / 49 Third year	CPR HFS / No treatment	Skill perf. Knowledge	IG had significantly higher scores on knowledge and skill performance than CG that received no treatment, both immediately and three months after intervention
Hernández-Padilla et al., 2016 **UK**	To evaluate whether a short simulation-based workshop in radial artery puncture would improve nursing student competence to a level which they could practice the procedure on a live patient without compromising his safety	Quantitative descriptive Pre / post	86/86 Third year	Arterial puncture Arterial puncture wrist + SP	Skill perf. Knowledge Self-efficacy	The proportion of students who achieved the safety benchmarks at post-test was significantly higher than at pre-test for all study variables. Simulation-based training in arterial puncture does not necessarily need to be resource-intensive as long as it is well-planned and evidence-based.
Hester et al., 2021 **USA**	To show the utility of the Clinical Vitals app as a pedagogical tool in comparison to in-person nursing educational instruction	Crossover design Pre / post	41 First year	Vital signs Clinical vitals app / Trad. in-person instruction	Skill perf. Preparedness Helpfulness	No significant difference in skills. Participants rated the app as helpful and helped them somewhat to prepare.
Hudder et al., 2021 **Canada**	To study the efficacy of a virtual simulation compared to traditional lab-based learning to support students' knowledge, skill, and self-confidence in newborn care.	QE IG / CG Pre / post	36 Second year	Newborn assessment Virtual simulation / Trad. teaching	Knowledge Satisfaction Self-efficacy	IG had significantly higher scores on knowledge, while CG had significantly higher scores on satisfaction and self-efficacy.
Inkaya et al., 2020 **Turkey**	To evaluate the knowledge and skills of students studying in the nursing department and to investigate the effect of use high-fidelity simulator and standard patient on	QE IG / IG Pre / post	42 Fourth year	Diabetic foot assessment HFS / SP	Skill perf. Knowledge	No significant differences in scores between the groups in either knowledge or skill.

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	their diabetic foot examination.					
Ismailoglu et al., 2020 **Turkey**	To compare the effect of the virtual simulator and video assisted teaching on the level of intravenous catheterization skills and self-confidence of nursing students.	QE IG / IG Pre / post	60 Second year	PVC VIS Video film	Skill perf. Confidence Knowledge	No significant difference in knowledge and self-confidence between groups. Virtual group had significant higher skill scores than Video group.
Ismailoglu and Zaybak, 2018 **Turkey**	To compare the effects of using a VISwith a plastic arm model for teaching PVC insertion skills to nursing students and to determine which teaching method is more effective and enables students to work without an instructor.	QE IG / CG Pre / post / transfer	66/65 Second year	PVC VIS / Plastic arm	Skill perf. Knowledge Confidence Satisfaction Anxiety	No significant difference in scores on knowledge, confidence and skill on actual patient. Significant higher scores in IG on skill in skills laboratory and satisfaction. Significant higher scores on three of 17 items concerning anxiety in CG.
Jaberi and Momennasab, 2019 **Iran**	To evaluate the effect of using SP on the performance of nursing students in the physical examination of the abdomen.	RCT IG / CG Pre / post / post	91 / 87 Third year	Physical examination of the abdomen Practice on SP / No treatment	Skill perf.	No significant difference in scores between IG and CG.
Jarvill et al., 2018 **USA**	To examine the effect of an individual simulation experience (ISE) on nursing students' medication administration competence.	QE IG / CG Pre / post	85 First year	MA ISE / Trad. training	Skill perf.	Simulation improved nursing students' MA competence.
Jarvill et al., 2018 **USA**	To determine if the use of an expert role modeling video during pre-briefing improved skill performance in simulation.	RCT IG / CG Post	68 Unknown	Central line dressing Expert role modeling video / No treatment	Skill perf.	Scores on skill test were significantly higher in IG.
Jarvill, 2021 **USA**	To compare first- and final-semester nursing students' MA performance, describe graduating nursing student performance, assess the long-term effect of an Individual Simulation-Based Experience (ISBE), and determine if nursing assistant experience impacted performance.	QE IG / CG Pre / post / post	68 Unknown	MA ISBE / Trad. teaching	Skill perf.	No significant difference between scores at any time in IG and CG.
Johannesson et al., 2013 **Sweden**	The aim was to investigate students' perceptions of how they learn manual clinical skills, i.e., to discover what students are experiencing and what they think about their learning in	Qualitative	10 Third year	Urinary catheter insertion UrecathVision VR task trainer	Skill perf. Confidence Satisfaction Learning process	The students learned by practicing techniques in a hands-on fashion and reflecting in and on action. The simulator provided opportunities for students to see

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	simulated skills training.					anatomical structures, to feel resistance, and to become aware of their own performance ability
Johnson et al., 2020 **USA**	To explore the effect of deliberate practice (DP) combined with skill practice during HFS scenarios on urinary catheter insertion skill competency and retention in prelicensure nursing students.	Mixed methods Pre / post / retention	8/10/10 Senior-level students	Urinary catheter insertion Combinations of: Peer coaching (DP) IL training HFS Training in skills laboratory No treatment	Skill perf.	The group participating in skill practice before and during HFS scenarios demonstrated a reduction in errors when performing the skill and an improvement in retention of skill competency.
Jones et al., 2014 **USA**	To determine if using the rubber mannequin PVC arm was equivalent to using a student model to teach PVC-insertion and to determine if the use of this simulation decreased fear and anxiety and increased students' preparedness.	RCT IG / CG Post / retention	260 /259 /208 Unknown	PVC Task trainer / Each-other's arm	Skill perf. Confidence Satisfaction Perception of training Anxiety	No significant difference in skill performance, anxiety and preparedness between the two groups. Practicing on each other made the students significantly more confident and prepared for real-life situations.
Karaman et al., 2019 **Turkey**	To identify the effects of lab-assisted training on surgical hand scrubbing skill.	QE IG / CG Post	142/142 Second year	Surgical handwashing Training in skills laboratory / No treatment	Skill perf. Knowledge	Skill and knowledge scores were significantly higher in students who practiced in the skills laboratory. There was a weak correlation between students' knowledge and skill.
Kardong-Edgren et al., 2020 **USA**	To report the effectiveness of the Resuscitation Quality Improvement (RQI) system for reestablishing and/or improving CPR skills after one practice session and objectively document the CPR skill loss expected for these novice learners based on findings from prior studies.	Quantitative descriptive Pre / post	467 First and second year	CPR Resusci Anne	Skill perf.	Significant improvements in both compressions and ventilations after one training session with the RQI training system.
Karkada et al., 2019 **Oman**	To examine the efficacy of simulation versus case scenario as a teaching method for novice nursing students in the skill of NGT feeding.	QE IG / CG Pre / post	69 Unknown	NGT feeding Simulation / Case scenario	Skill perf. Confidence Knowledge Satisfaction	No significant difference in scores on knowledge, satisfaction, or self-confidence; skills scores were significantly higher in IG.
Kim et al., 2020 **South Korea**	To identify the effects of simulation-based advanced life support education on nursing students' knowledge,	QE IG / CG Post	60 Fourth year	CPR Simulation / Lecture-based teaching	Skill perf. Knowledge Self-efficacy Teamwork	Significant higher scores on knowledge, skill, and self-efficacy in IG. No significant difference

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	performance, self-efficacy, and teamwork.					between groups on teamwork.
Kim et al., 2021 **South Korea**	To develop non-contact CPR training using smart technology for nursing students and to examine its effects, focusing on the accuracy of their performance.	RCT IG / CG Pre / post / post	68/64 Third year	CPR Training with smart technology & Rescusi Anne simulator / Trad. training & Rescusi Anne simulator	Skill perf.	IG had significantly higher scores on skill performance than CG immediately and four weeks after intervention.
Kim and De Gagne, 2018 **South Korea**	To compare the effects of two debriefing methods (peer-led [PL] and instructor-led [IL]) on nursing skills, knowledge, self-confidence and quality of debriefing among undergraduate nursing students .	QE IG / CG Pre / post	57/57 Third year	Preoperative nursing skills PL / IL	Skill perf. Knowledge Confidence Satisfaction	Nursing skills and satisfaction were significantly higher in IL group compared to PL group. No significant difference in knowledge and confidence.
Kim and Lee, 2021 **South Korea**	To develop a maternal nursing competency reinforcement program for nursing students and assess the program's effectiveness .	Mixed Methods IG / CG Pre / post / post	28/33 Third year	Maternal nursing performance IG: LF simulator Standardized patients CG: usual care program	Skill perf. Problem-solving ability Emotional intelligence Self-directed learning ability	The training program (IG) had significant effect in increasing maternal nursing performance, problem-solving ability, and emotional intelligence over time. There were significant differences between groups in self-directed learning ability, but not over time.
Kol et al., 2021 **Turkey**	To determine the effect of using SPs in a simulated hospital environment (SHE) on first-year nursing students' psychomotor skills.	Semi-experimental Pre / post	128 First year	BP Mobilizing the patient Hot/cold application SHE with SPs and non-simulated clinical skill laboratory with peers or mannequins	Skill perf. Satisfaction	Significant better perf. in BP and hot/cold application when practicing in SHE with SPs, particularly in the stages of meeting the patient, performing the procedure and ending the procedure.
Liaqat et al., 2021 **Pakistan**	To determine the educational efficacy of diverse strategies on knowledge and skill of nursing students regarding neonatal resuscitation	QE / One group Pre / post	65 First and second year	CPR (neonatal) Simulation and practice for all	Skill perf. Knowledge	Significant higher scores on knowledge and skill after simulation and practice.
(Luctkar-Flude et al., 2018) **Canada**	To evaluate feasibility and learner outcomes of a novel epidural analgesia workshop that included interactions with professional SPs	Quantitative descriptive Pre / post	43 Third year	Epidural dressing SP	Skill perf. Knowledge Confidence Satisfaction Perception of training	The workshop proved to be feasible and satisfactory and suggested learning outcomes were achieved.
	To determine perceived benefits of	Quantitative descriptive	57 Third year	Obstetric skills LF and medium	Skill perf. Knowledge	Significant correlation between

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
Madhavanprabhakaran et al., 2015 **Oman**	pre-clinical simulation-based training (PSBT) among the nursing students and to identify their overall level of satisfaction with PSBT	Post		fidelity manikins	Satisfaction Confidence Comfort	learning outcomes, indicate students perceived benefits of PSBT. It provided Arab male nursing students a way to achieve clinical maternity skills, which they have limited opportunities to practice due to cultural barriers.
Mariani et al., 2017 **USA**	To pilot test a new medication safety simulation-based learning experience and investigate the effect of the program on nursing students' knowledge, skill and comfort on medication safety and patient safety.	QE IG / CG Pre / post	86/71 Third year	MA Simulation + debriefing / No treatment	Skill perf. Knowledge Perception and comfort	IG had significantly higher scores on knowledge and skill. No significant difference in perception and comfort.
McWilliams et al., 2021 **USA**	To examine the impact of cooperative learner simulation order on performance on a haptic intravenous simulator.	QE IG (3 groups) Post	81 First year	PVC Variation in who was 1st, 2nd, or 3rd to perform in group	Skill perf. Number of attempts to be successful	First learners have significantly lower initial performance scores than 2nd and 3rd learners No significant difference between 2nd and 3rd learners. No significant difference in learner position in no. of attempts to be successful.
(Mehdipour-Rabori et al., 2021) **Iran**	To assess the effect of simulation-based mastery learning on the clinical skills of undergraduate nursing students from 2017 to 2019	QE IG / CG Pre / post	105 Fourth year	Cluster of skills Simulation-based mastery learning / Trad. teaching	Skill perf.	Significant higher scores on skill in IG.
Mert Karadas and Terzioglu, 2019 **Turkey**	To compare the efficiency of different simulation methods used for training nursing students in the management of postpartum hemorrhage.	RCT IG (7 groups) / CG Pre / post	84/83 Third year	Obstetric skills Combinations of: HF manikin SP Trad. laboratory No treatment	Knowledge Satisfaction Anxiety Communication skills	IG group that practiced all three modalities had significantly higher knowledge and communication scores. No significant difference in anxiety scores.
Musharyanti et al., 2021 **Indonesia**	To compare the knowledge and skills in medication safety of nursing students after the medication-safety training using four components of instructional design known as 4C/ID.	QE IG / CG Post	95 Second year	MA 18 h instruction and practice / one lecture and video playback	Skill perf. Knowledge	Significant higher scores on knowledge and skill in IG with more education
Mutlu et al., 2019 **Turkey**	To determine the effects of high- and LF simulators on student nurses' learning of heart and lung sounds.	RCT IG / CG Pre / post	71 Third and fourth year	Heart and lung auscultation HFS (Nasco Smartscope Simulator) /	Listening skill	IG had significantly higher total mean scores than CG

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
				Computer-based program		
Nasr-Esfahani et al., 2019 **Iran**	To determine the effect of role-playing method education compared to traditional method education on the performance of nursing students in advanced CPR	QE IG /CG Pre / post	70 Second year	Advanced CPR (with drugs) Roleplay / Trad. teaching Rescusi Anne	Skill perf.	Significant higher scores on performance in IG.
Oermann et al., 2020 **USA**	To compare nursing students' CPR skills (compressions and ventilations) with four differently- spaced training intervals: daily, weekly, monthly, and quarterly, each for four times in a row	QE IG (four groups) Pre /post	475/396 Unknown	CPR Intervals of training: daily weekly, monthly quarterly Rescusi Anne	Skill perf.	CPR performance improved in all four training intervals, although shorter intervals resulted in a faster overall rate of improvement for overall compression and ventilation skills.
Onder and Sari 2021 **Turkey**	To examine the effect of simulation-based learning in development of peripheral intravenous catheter insertion skill of nursing students.	RCT IG / CG Pre / post 72	72 Second year	PVC Simulation / No treatment	Skill perf. Knowledge Only IG: Simulation design Satisfaction and self-confidence	No significant difference in knowledge between IG and CG either pre or post. Significant higher scores on skill in IG post.
Onturk et al., 2019 **Turkey**	To evaluate the effects of simulation techniques on learning outcomes in the teaching of safe drug applications to first year nursing students	Quantitative descriptive Pre / post	58 First year	MA / cluster of skills Task trainer, SP, case scenarios, VR	Skill perf. Knowledge Confidence Satisfaction	Knowledge levels and performance were related. A high level of knowledge and successful performance increased satisfaction with simulation.
Ostovar et al., 2019 **Iran**	To compare the effects of oral and video-assisted debriefing on development of learning outcomes in nursing students.	QE IG / CG Pre / post	50/48 First year	I.V. fluid Video-assisted debriefing / Oral debriefing	Skill perf. Confidence Satisfaction	No significant difference between groups. Both groups improved skills performance, self-confidence, and satisfaction.
Park, 2018 **South Korea**	To identify the effect of an intensive clinical skills course for senior nursing students on their self-confidence and clinical competence'.	QE IG / CG Post	162 Fourth year	Cluster of skills Intensive clinical skills course / No treatment	Skill perf. Confidence	The IG had significant higher scores on confidence and skills.
Parmar et al., 2020 **India**	To assess peer learning versus conventional teaching regarding antenatal assessment in terms of knowledge, skills, and satisfaction among nursing students	QE IG / CG Pre / post	51 Third year	Antenatal assessment Peer learning / Trad. teaching	Skill perf. Knowledge Satisfaction	No significant difference in knowledge scores between groups, IG had significant higher scores than CG in skill both before and after intervention. CG was more satisfied with teaching modality than IG.
Pedersoli et al., 2016 **Brasil**	To teach airway management with laryngeal mask to	RCT IG / CG Pre / post	17 Fourth year	Laryngeal mask LF manikin / Trad. training	Skill perf. Knowledge	No significant difference between groups in either

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Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	nursing students through dialogic lectures along with laboratory activities or exclusively through simulation class.					knowledge or skill performance.
Pujalte-Jesus et al., 2021 **Spain**	To analyze the differences in the quality of the basic CPR between the algorithms of compressions with rescue ventilation (30:2) and chest compressions only (CPR C/O).	QE, cross-sectional study	114 Third year	CPR Resusci Anne	Skill perf.	30:2 provides less quality than C/O, due to ineffective mouth-to-mouth ventilations. C/O minimizes interruptions in compressions, but fatigue in performers is a problem.
Raman et al., 2019 **Oman**	To compare the effects of a combination of traditional clinical training with HFSactivities vs clinical training alone on the clinical competency and knowledge among students enrolled in a maternity nursing course.	QE IG / CG Pre / post	80/74 Fourth year	Obstetric skills 25% HFS as part of clinical training / Clinical training	Skill perf. Knowledge	No significant difference between groups.
(Ravik et al., 2017a) **Norway**	To explore, describe and compare learning actions that nursing students used during peripheral vein cannulation training on a latex arm or each other's arms in a clinical skills center.	Qualitative	9 Second year	PVC Latex arm / Each other	Learning actions	Students' learning actions depended on the simulation modality; more student-centered learning actions in the latex-arm-group. More teacher centered learning actions in each-other's-arm-group Teachers were important for students' engagement and involvement.
Requena-Mullor et al., 2021 **Spain**	To analyze the learning outcomes of university nursing students who took a BLS clinical simulation course	One group intervention study Pre / post	479 First year	CPR Mannequin	Skill perf. Knowledge	Students with prior knowledge had higher average scores in both the pre- and post-test. Significant increase in knowledge for all students. No significant differences in performance between students who had or did not have previous knowledge. Training can improve the learning outcomes.
Roel and Bjørk, 2020 **Norway**	To compare nursing students' knowledge and skill in CPR before and after a	QE IG / CG Post	142 Third year	CPR Third year curriculum including more tests, simulated	Skill perf. Knowledge	Significant higher knowledge scores in IG. Both groups fulfilled guidelines

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	pedagogical intervention.			practice and knowledge input / Third year trad. curriculum Little Anne		on compression depth, not on other parameters.
Roh and Issenberg, 2013 **South Korea**	To assess the quality of CPR psychomotor skills and to evaluate whether an association exists between the quality of CPR psychomotor skills and knowledge and self-efficacy in nursing students who complete a CPR skills training session	Quantitative descriptive Post	124 Second year	CPR Static manikin / Resusci Anne	Skill perf. Knowledge Self-efficacy	Higher self-reported self-efficacy with correct performance. No compression or ventilation skills were correlated with knowledge of compression or ventilation. Total self-efficacy significantly correlated with total CPR knowledge.
Roh et al., 2016 **South Korea**	To investigate the effect of peer-led (PL) debriefing compared with instructor-led (IL) debriefing among nursing students performing CPR.	QE IG / CG Pre / post	65/65 Third year	CPR PL / IL	Skill perf. Satisfaction	Students in the IL-group had significantly lower penalty scores on two skill items and on total penalty score, and they were significantly more satisfied with the simulation experience than the PL-group.
Roh and Lim, 2013 **South Korea**	The purpose of the study was to identify factors influencing quality of chest compression depth in nursing students	Quantitative descriptive	102 Second year	CPR Resusci Anne	Skill perf.	Students with correct compression had higher bodyweight and BMI. Height did not affect compression rate.
Roh et al., 2018 **South Korea**	To identify the effects of pre-briefing on team psychological safety, academic safety, satisfaction with debriefing and performance in nursing students.	QE IG / CG Post	50 Fourth year	CPR Concept mapping and fiction contract / No treatment	Skill perf. Satisfaction Anxiety Safety (Psychological and academic)	IG had significantly higher scores on psychological safety and CPR performance skills.
Ross, 2015 **USA**	To determine the effect of simulation training on nursing students' competency on IM administration and the effect of simulation training on students' transfer of IM skills from the learning laboratory to an actual patient care setting.	QE IG / CG Pre / post / transfer	37/37 Second and third year	IM SP / Guided skill training by students using task trainers	Skill perf.	No significant difference between groups at any time.
Ross, 2019 **USA**	To determine the effect of repetitive practice with peer mentoring on baccalaureate nursing students' competence in and retention of vital signs assessment and auscultation of	Quantitative descriptive Pre / post / retention	69 Second and third year	Vital signs and auscultation of heart/lung Peers	Skill perf.	Significant difference in vital signs competence between pre and post, but not between post and retention. No significant difference between pre, post, or

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	breath and heart sounds.					retention on auscultation.
Rushton et al., 2020 **UK**	To explore the use of immersive VR technologies in an unfamiliar environment for the students (TheOctave), compared to the familiar environments of the immersive video technology and no immersive clinical skills room.	Mixed method 3 groups.	55/73/80 Second year	CPR HF manikin in three different environments, of which one unfamiliar with the use of VR	Skill perf Confidence	Overall, participants were more competent in the immersive suite. The Octave offered the higher level of simulation utilizing VR technology. Students felt less comfortable and less confident in the Octave.
Samosorn et al., 2020 **USA**	To examine whether an educational intervention with a pilot contemporary immersive virtual reality simulation builds knowledge and is feasible to implement among nursing students and faculty	Combined survey and QE one group Pre / post	21 Unknown	Airway insertion VR	Knowledge Realism VR reality sickness	The students' knowledge increased significantly. Participants were well-immersed in the virtual experiment and experienced little to no cybersickness.
Sarmasoglu et al., 2016 **Turkey**	Examine the impact of (SPs on the development of skills among nursing students and highlight the evaluations of SPs regarding students' interactions, and if students are comfortable during performing skills on real patients.	QE IG / CG Post	86 First year	BP / SC SP + debriefing + oral feedback from SP / Task trainer	Skill perf. Comfort Communication (in SP-group only)	Skill scores significantly higher in IG for measurement of BP but not on SC . Similar feelings of comfort in both groups.
Sarvan and Efe, 2022 **Turkey**	To determine the impact of integrating serious game simulation) into neonatal resuscitation training on the neonatal resuscitation related knowledge, skills, satisfaction with training, and self confidence in learning of nursing students.	RCT IG / CG Pre / post	90 Third year	CPR (Neonatal) Video-based neonatal resuscitation theoretical training + training with serious game app / Video-based neonatal resuscitation theoretical training + nothing	Skill perf. Confidence Knowledge Satisfaction	No difference in knowledge or satisfaction and self-confidence between groups either pre or post. Three of 12 items of skill performance instrument significant higher scores in IG.
Schneidereith, 2021 **USA**	To measure use of the five rights of MA during simulation experiences in a single cohort and identify performance differences over four consecutive semesters.	Non-experimental longitudinal study	78 First, second and fourth year	MA	Skill perf.	None of the students in first semester verified all five rights. 80% of students did not verify all five rights at graduation.
Sendir et al., 2022 **Turkey**	To determine the effectiveness of using haptic technology in teaching urinary catheter application skill on levels of success and	RCT IG / CG Post	79 Unknown	Urinary catheterization 3D Systems Touch Haptic Simulator / LF task trainer	Skill per. Satisfaction	IG had statistically higher scores than CG on both skill and performance and satisfaction.

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Author (year) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	satisfaction about this skill.					
Seol and Lee, 2020 **South Korea**	To identify the effects of CPR training among Registered Nurse-Bachelor of Science in Nursing students .	One group quasi-experimental Pre / post / retest	32 /23	CPR Little Anne	Self-efficacy Attitude	Significant increase in both attitude and self-efficacy immediately after intervention. Decline in both attitude and self-efficacy after 20 weeks, significant in attitude.
Sezgunsay and Basak, 2020 **Turkey**	To investigate the effectiveness of moulage in the improvement of pressure injury assessment skills of nursing students	QE IG / IG Pre / post (transfer)	73/42 Fourth year	Assessment of pressure injury Moulage and simulation / Wound visuals and simulation	Skill perf. Knowledge Confidence Satisfaction Simulation design satisfaction	No significant difference in knowledge scores. Significant higher scores on skill in laboratory and clinic and in satisfaction with the simulation design in the moulage group.
Smereka et al., 2019, **Poland**	To assess the role of the TrueCPR device in the process of teaching cardiopulmonary resuscitation in nursing students	RCT IG / CG Pre / post	94 First year	CPR CPR practice with TrueCPR (Physio-Control, Redmond, WA, USA) / CPR practice	Skill perf. Confidence	IG had significantly higher scores than CG on all parameters except correct hand placement at post testing. IG had significantly higher scores on self-confidence measurement.
Sowan and Idhail, 2014 **USA**	To describe the design and students' response to an interactive web-based course tailored to students' need and the course objectives of the fundamentals of nursing skills clinical course.	Mixed method Post	102 First year	MA Virtual course with streaming	Skill perf. Satisfaction Self-efficacy	Students were satisfied with the online course. Significant correlations between achievement and satisfaction. Significant correlation between satisfaction and self-efficacy in five of seven administration skills.
Stoodley et al., 2020 **Australia**	To evaluate the impact that simulated learning activity had on midwifery students' knowledge, confidence and skills post-simulation and on completion of a clinical placement.	Descriptive explorative Pre / post / transfer	60 Third year	Neonatal nasogastric tube insertion and management Demonstration and simulation	Skill perf. Knowledge Confidence	Significant increase in perception of own level of knowledge, confidence and skill from pre to post, and from post to transfer after clinical placement
Struksnes and Engelien, 2016 **Norway**	To compare nursing students' experiences with a skills training situation immediately after the training and after their ten weeks clinical placement in nursing homes.	Quantitative descriptive Post / transfer	187/153 First year	Sponge bath Peers	Confidence Satisfaction	Students reported that the exercise was a useful preparation for clinical practice, but students' satisfaction and confidence declined significantly after clinical placement.
Surabenjawong et al., 2020 **USA**	To evaluate whether peer-to peer teaching is not inferior to standard teaching in basic airway management for	RCT IG / IG Crossover trial Pre / post	48 Unknown	Oropharyngeal/ nasopharyngeal airway insertion Bag-mask ventilation Peer-to peer learning / Expert instructor	Skill perf. Knowledge Confidence	No significant difference in scores in knowledge or confidence. Peer group had significant higher skill scores

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Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	undergraduate nursing students.					than expert instructor group.
Tan et al., 2017 **Singapore**	To describe the development and evaluation of a serious game to improve nursing students' knowledge, confidence and performance in blood transfusion.	RCT IG / CG Pre / post	103 Second year	Blood transfusion Serious game on PC / No treatment	Skill perf. Knowledge Confidence Perceptions of training	No significant higher performance score after gaming. Significantly weak to moderate positive correlation between knowledge and confidence, confidence and performance, and knowledge and performance.
Tawalbeh, 2017 **Jordan**	To test the effect of simulation on the confidence of university nursing students in applying heart and lung physical examination skills.	RCT IG / CG Pre / post / retention	84/69 Unknown	Heart and lung examination HF simulator / No treatment	Confidence	Simulation significantly improved confidence in IG.
Tawalbeh and Tubaishat, 2014 **Jordan**	To examine the effect of simulation on nursing students' knowledge in providing advanced cardiac life support (ACLS), knowledge retention, and confidence in applying ACLS activities.	RCT IG / CG Pre / post / retention	100/82/82 Unknown	CPR HF manikin / No treatment	Knowledge Confidence	Simulation positively affects students in applying ACLS. Use of HFSimproved knowledge of and confidence in ACLS skills.
Terry et al., 2016 **Australia**	To implement the online intravenous pump emulator (IVPE) and evaluate student learning outcome and perceptions of device use compared to a physical piece of medical equipment on-campus.	QE IG (3 groups) Post	179 First year	IV-pump IVPE online / Task trainer / IVPE online + task trainer	Skill perf. Satisfaction	IG3 significantly better skill score than IG2. IG3 significantly faster completion than the other groups. Correlation between faster completion and better performance.
Terry et al., 2018 **Australia**	To compare retention of competence in using an IV infusion pump among nursing students trained in its use using three different protocols.	QE IG (3 groups) Post / post	179/102 First year	IV pump IVPE online / Task trainer / IVPE online + task trainer	Skill perf.	Use of IVPE to augment traditional face-to-face training benefitted retention of competence.
Topbas et al., 2019, **Turkey**	To investigate the effects of different education methods in peritoneal dialysis application training on the psychomotor skills and self-efficacy of nursing students	RCT IG / IG Pre / post	28 Third year	Peritoneal dialysis Peritoneal dialysis simulator / Video	Skill perf. Self-efficacy	IG significantly higher scores on skill performance. No significant difference in self-efficacy either pre or post.
Uys and Treadwell, 2014 **South Africa**	To determine whether students who trained in IM on SP with a strap-on injectable device displayed more patient-centeredness when performing the skill in real practice	QE IG / CG Post	36 Second year	IM SP / Injection model	Skill perf.	The use of SP in training significantly enhanced patient centeredness in skill performance compared to training on an injection

(*continued on next page*)

Table 1 (*continued*)

Author Year (published) Country	Aim/purpose	Design of study	Participants & educational year	Skill & learning modalities	Outcome variables	Key findings
	than students who used an injection model					model in clinical practice.
Uysal, 2016 **Turkey**	To determine nursing students' common mistakes in nursing skill laboratory examination and evaluate the effect of scenario-based nursing skill laboratory practices on reducing students' mistakes in exams and the nursing skills laboratory achievement scores.	Quantitative descriptive Retrospective study of checklist	605 Second year	IM/SC/PVC LF-simulator	Skill perf.	Not following the principles of asepsis was the most common mistake in all three skills. Reduction of errors after inclusion of simulation case training not always statistically significant
Uzen Cura et al., 2020 **Turkey**	To compare the effect of different simulation modalities on knowledge, skill, stress, satisfaction, and self-confidence levels of students receiving undergraduate education in three nursing schools	RCT IG (3 groups) Pre / post	139 Second year	Assessment of respiratory sounds SP / High-fidelity manikin / Task trainer	Skill perf. Knowledge Confidence Satisfaction Stress	No significant difference in knowledge pre or post. Stress scores and satisfaction scores were significantly higher and skill scores significantly lower in SP group. Self –confidence scores significantly lower in task trainer group.
Webber et al., 2021 **USA**	a. Explore through qualitative investigation the impact of a lactation simulation experience on the breastfeeding self-efficacy of undergraduate nursing students. b. Identify qualitative differences between the use of LF or HF breastfeeding simulation model.	Qualitative questionnaires at two-time points.	76 Unknown	Breastfeeding Management Skills Two groups HF / LF breast models, students worked in pairs	Skill perf. Self-efficacy (in breastfeeding)	Students in both groups reported increased breastfeeding skills (breastfeeding self-efficacy)
Yilmazer et al., 2020 **Turkey**	To explore the effects of education on the performances and knowledge of undergraduate nursing students using SP simulation practice in the prevention of pressure ulcers.	QE intervention group Pre / post	38 Second year	Pressure ulcer assessment SP	Skill perf. Knowledge	The level of knowledge and performance was retained by students in the evaluations used after comprehensive training using SPs.

ACLS = Advanced Cardiac Life Support, BLS = Basic Life Support, BP = Blood Pressure Measurement, Cath. = Catheter, CG = Control Group, C/O = Chest compressions Only, CPR = Cardio-Pulmonary Resuscitation, DP = Deliberate Practice, FD = Feedback Device, HF = High Fidelity, HFS = High Fidelity Simulator, IG = Intervention Group, IL = Instructor-Led, ILOD = Instructor-Led Written Debriefing, IM = Intra-Muscular Injection, ISBE = Individual Simulation-Based Experience, ISE = Individual Simulation Experience, IVPE = Intravenous Pump Emulator, LF = Low Fidelity, LISSA = Life Support Simulation Activities, MA = Medication Administration, NGT = Nasogastric Tube, OSCE = Objective Structural Clinical Examination, PL = Peer-Led, PLWD = Peer-Led Written Debriefing, PSBT = Pre-clinical Simulation-Based Training, PVC = Peripheral Venous Catheter,PC = Personal Computer, QE = Quasi-Experimental, RCT = Randomized Controlled Trial, RQI = Resuscitation Quality Improvement, SC = Subcutaneous Injection, SHE = Simulated Hospital Environment, Skill perf. = Skill Performance, SP = Standardized Patient, Trad. = Traditional, VIS = Virtual Intravenous Simulator, VR = Virtual Reality

3. Findings

One hundred and twenty-one studies were included in this review (Table 1). The studies were published between January 2013 and March 2022. The studies were from 26 different countries: United States of America (USA) ($n = 27$), Turkey ($n = 25$), South Korea ($n = 12$), Iran ($n = 8$), and Spain ($n = 6$). Other countries contributed between 1 and 5 studies (Table 2). All the studies were published in English, except one that was in Danish. The number of participants included in the individual studies ranged from nine to 675 and numbered 11,775 in total.

Thirty studies were quantitative randomized controlled trials, 52 were quantitative non-randomized studies, 26 were quantitative descriptive studies, nine studies had a mixed-method design, and four were qualitative studies.

Both quantitative and qualitative designs were used when skills learning in clinical skills centers was investigated. However, the amount of quantitative research was overwhelming ($n = 108$). In line with traditional medical randomized controlled trials, 14 studies were designed to give the intervention group a pedagogical treatment, while the control group received no treatment. This was also the case in nine studies with a quasi-experimental design.

3.1. Range and type of practical skills

Fifty different practical skills were represented in the included studies (Table 3). Student training in cardio-pulmonary resuscitation was investigated in 35% ($n = 29$) of the included papers, while medication administration ($n = 13$), peripheral venous catheter cannulation ($n = 9$), and urinary catheterization ($n = 7$) were covered in a further 35% of the papers. In 11 studies, the designed interventions included more than one skill, and three studies included a cluster of skills. Onturk et al. (2019) investigated a cluster of skills related to medication administration. The students followed a four-step program where they practiced different skills in each step, including subcutaneous and intramuscular injections, peripheral venous catheter cannulation, and preparing and calculating medications.

Most of the practical skills included in our review are ones that Bjørk (1999) labels as technical skills. Practicing the technical aspects of these skills does not necessarily require the student to interact with the patient, such as learning cardio-pulmonary resuscitation, peripheral venous catheter cannulation, and urinary catheterization. Cardio-pulmonary resuscitation, for example, is investigated in 29 of the included papers, with skill performance as the main learning outcome in 25 of them. The cardio-pulmonary resuscitation-algorithm is an international guideline on how to perform cardio-pulmonary resuscitation, including the assessment of airways, how/when to alert, and performance of compression and ventilation. Several checklists and questionnaires have been developed to test students' performance and knowledge of cardio-pulmonary resuscitation. Although the studies on cardio-pulmonary resuscitation describe the algorithm, the focus is on correct performance of compression and ventilation. In three studies, the authors took a different approach from the other 29; Roh and Lim (2013) and Arrogante et al. (2021) investigated which physical factors in students influenced the depth of compression, and Roh and Issenberg (2013) investigated whether there was any association between skill performance and knowledge or self-efficacy.

3.2. The learning activities reported on in the included studies

In this article, we define learning activities as comprising everything that happens in a skills center, including the use of various learning modalities, pre-briefings, and debriefings.

The learning modalities that were used in the studies comprised low-, mid-, and high-fidelity simulation, simulators with or without voice-over options, traditional teaching methods (lectures, demonstrations, and laboratory training with task trainers), virtual reality and other self-learning programs, and use of standardized patients, case scenarios, and peers. Some simulators and task trainers were specified with brand names, and manikins and task trainers from Lærdal were the most common. However, most studies included no details about the equipment used. Based on the date of publication, we found there was a development in technology relating to learning modalities in the past few years. For example, the use of virtual reality as a learning modality was found more often in studies

Table 2
Country of origin.

No. of studies	Country
27	USA
25	Turkey
12	South Korea
8	Iran
6	Spain
5	Australia, Brazil
4	Canada
3	China, Jordan, Norway, Oman
2	India, Poland, UK
1	Belgium, France, Indonesia, Singapore, North Cyprus, Pakistan, Saudi Arabia Israel, South Africa, Sweden, Taiwan

Table 3
Type of skill investigated.

No. of studies	Skill
29	Cardiopulmonary resuscitation
13	Medication administration
11	Various physical assessments
9	Peripheral vein cannulation
8	Obstetric/maternal skills
7	Urinary catheterization
5	Subcutaneous injection, Auscultation skills
4	Intramuscular injection
3	Blood pressure measurement, Vital signs, Hygiene care, Airway management
2	Intravenous pump use, Blood transfusion, Immunization, Nasogastric tube placement, Hand disinfection/washing, Preoperative skills, Surgical wound care, Suctioning.
1	Stoma care, Spirometry measurement, Arterial puncture, Central line dressing, Epidural dressing, Laryngeal mask use, Mobilization, Peritoneal dialysis, Hot-cold application, Flush and lock PVC, Nasogastric feeding, Pulse-oximeter

conducted after 2018.

The aim of all studies designed as randomized controlled trials or quasi experiments was to find the learning modality that had the best effect on nursing students' learning outcomes. However, the variation in skills, interventions, and measuring instruments meant that there were few possibilities to draw detailed conclusions about this effect. A few general statements are nonetheless possible. Students' skills were the most commonly studied learning outcome and were reported in 69 of the included papers. In the majority of these studies ($n = 47$), the intervention resulted in significantly higher scores for students' skill performance. There were two trends in this finding: in 17 of the studies, the control group received no treatment, and in nine of the studies, the control group received traditional teaching while the intervention group was mainly treated using a simulated learning experience. Knowledge was a learning outcome in 35 studies designed as randomized controlled trials or quasi experiments. Students in the intervention group had significantly higher knowledge scores in only 13 of these studies. No pattern is discernable as regards type of skill or learning modality in the intervention group. However, in seven of the studies, the control group received no treatment ($n = 5$) or traditional teaching ($n = 2$). Confidence, the third-most common learning outcome, was included in 20 studies. Significant differences in confidence scores between intervention and control groups were found in only seven of these studies.

We found that research on practical skills learning in nursing education focused on which learning modalities resulted in the best learning outcomes. This was often measured by using checklists and questionnaires, as presented in Section 3.3. Studies investigating how learning takes place in the skills centers are lacking. In this review, the focus was on students' learning processes in only 8.5% ($n = 7$) of the included studies. However, in only one of these seven studies was the actual hands-on practical training situation investigated. Ravik et al. (2017b) explored and compared the learning actions students used during peripheral venous cannulation-training and found that the type and extent of students' learning actions depended on the simulation modality. In the other six studies, different methods used to pre-brief or debrief the students were compared. In three of these studies, instructor-led debriefings were compared to peer-led debriefings. Instructor-led debriefings led to the students achieving a better result than peer-led debriefings (Ha and Lim, 2018; Kim and De Gagne, 2018; Roh et al., 2016). In one study, researchers compared video-assisted debriefing with an oral debriefing and found no significant differences between the groups (Ostovar et al., 2019). An extra pre-briefing in addition to traditional pre-briefing enhanced students' learning outcomes significantly in two studies (Jarvill et al., 2018; Roh et al., 2018).

3.3. Assessment of learning outcomes

Twenty-nine different learning outcomes were represented in the included studies, with skill performance ($n = 101$), knowledge (n

Table 4
Type of learning outcome investigated.

No. of studies	Learning outcomes
101	Skill performance
57	Knowledge
34	Confidence
32	Satisfaction
13	Self-efficacy
8	Perception of training
6	Anxiety
3	Communication skills, Comfort, Preparedness
2	Simulation design satisfaction
1	Learning process, Learning actions, Cognitive load, Virtual Reality sickness, Attitude, Stress, Problem-solving ability, Emotional intelligence, Experiences, Listening skill, Nursing competency, Realism, Self-directed learning ability, Learning and teaching strategies, Teamwork, Number of attempts to be successful, Safety (academic and team safety)

= 57), confidence ($n = 34$), and satisfaction ($n = 32$) as the main learning outcomes measured. The remaining 25 learning outcomes are listed in Table 4. More than one learning outcome was measured in 86 of the included studies, and three or more learning outcomes were measured in 42 of them. Various assessment instruments, most of them locally developed, were used to measure learning outcomes. Reliability, validity, or both were reported in 77 studies; however, neither validity nor reliability was reported in 37 studies. Four studies were based on a qualitative approach, and interviews and videos were analyzed using coding and categorization. Two instruments were used in more than three studies: Satisfaction and Self-Confidence in Learning Scale ($n = 11$), and American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care 2020 (AHA guidelines) ($n = 7$).

In 24% ($n = 20$) of the included studies, students practiced on peers or standardized patients. When practicing on peers or standardized patients, students can involve the patient, but this is not always reflected in the learning outcomes in these studies. Only three of the 20 studies had learning outcomes related to interaction and communication between the students and their peers or the standardized patients (Devenney et al., 2018; Ravik et al., 2017b; Sarmasoglu et al., 2016). Jones et al. (2014) found that practicing on peers made students more confident and better prepared than practicing on task trainers. However, it is unclear to what extent the students interacted with their peers while training on them.

The assessment of learning outcomes was mostly performed in a clinical skills center. Transfer of learning, defined as the ability to perform a practical skill on an actual patient, was measured in six studies (Table 1). In four of them, differences in learning modalities influenced the results for outcome measures in the clinical setting, implying transfer of skills learning. Individual simulation was more effective than group simulation in medication administration (Avraham et al., 2018), and simulation was more effective than traditional teaching in cardiac auscultation (Vural Dogru and Zengin Aydin, 2020). Combined simulation and laboratory training were more effective than using only one learning modality in vital signs performance (Eyikara and Baykara 2018). Moulage and simulation were more effective than wound visuals and simulation in pressure injury assessment (Sezgunsay and Basak, 2020). In two other studies, students' scores for confidence in performing obstetric skills (Germain et al., 2018) and students' scores for perception of their level of knowledge, skill, and confidence in neonatal nasogastric tube management (Stoodley et al., 2020) increased from the post-simulation test to the post-clinical test. These were quantitative descriptive studies in which the whole group of students experienced a simulated learning experience.

4. Discussion

The quality of the designs of the included studies varied. The quality assessment indicated that only 10 of the included studies met 100% of the Mixed Method Appraisal Tool criteria. This represents a general problem in nursing education research that is related to following standard norms for research. The first screening question in the Mixed Method Appraisal Tool is "Are there clear research questions?" Due to the lack of research questions in most of the included studies, clear aims were accepted as sufficient for inclusion. Polit and Beck (2021) underscore that a study design is normally decided on the basis of research questions, and this decision will affect the integrity of findings. A widespread tendency to skip the formulation of research questions is therefore problematic.

Almost all of the included studies had a quantitative design, most commonly a quasi-experimental design or randomized controlled trial. Many of these studies had designs where the intervention group received some form of educational treatment, while the control group received no treatment. The conclusion was nearly always that any form of simulation technology resulted in better outcomes than no treatment. Giving educational treatment to the intervention group and nothing to the control group is in line with traditional clinical research with an experimental design (Polit and Beck, 2021). Within a pedagogical frame of reference, more education and training will almost always benefit the students' learning outcomes. The choice of no treatment for the control group in pedagogical research therefore seems to disregard the inherent purpose and effect of teaching and learning. Comparing different teaching methods or learning modalities provides more reliable information and more evidence in this respect.

Another pedagogical issue is related to the lack of significant differences in the scores for knowledge and confidence between intervention and control groups. In only one-third of the studies did the learning modality influence students' knowledge or confidence scores. This lack of change, compared to the considerable change in the scores for skill performance, may be related to the design of the interventions. Laursen (2015) defines a skills center as the "third learning arena", situated between theory and practice. In a skills center, there are no sick and vulnerable patients, so students can practice without fear of hurting another human being. They can experience positive and negative consequences of their own actions and take time to discuss and reflect in the learning environment. This arena is therefore perfect for integrating theory in the students' experiential learning. The lack of any change in students' scores apart from skill performance suggests that it is necessary to address the integration of learning aspects that better target learning outcomes such as knowledge, confidence, communication skills, or self-efficacy. This corresponds to the definition of practical skills offered at the beginning of this article: complex procedures integrating communicative and caring aspects as well as technical and manual aspects (Bjørk et al., 2013).

In light of the above, it is quite remarkable that so few researchers are interested in how students actually learn during simulations in a skills center. Without knowing how students learn, it is difficult to discuss and reform such learning (Bjørk et al., 2015; Bland and Tobbell, 2016). The choice of learning modality also affects learning processes. When practicing on non-human subjects, students can focus on their performance without any disruptive elements. Students can practice the same procedure over and over to develop dexterity and embodied knowledge without harming the patient. Peers or standardized patients can be disruptive elements in the learning situation, and novice learners may not possess the expertise required to manage the complexity of the situation, overwhelming them (Haji et al., 2016; Norman et al., 2012). In a recent study, practicing peripheral venous cannulation on a latex arm versus a fellow student's arm resulted in different learning processes among students (Ravik et al., 2017b). Student-centered learning actions comprising collaboration, discussion, and peer guidance were prevalent in the latex arm group, while students practicing on

each other's arms were more passive but received more support and a qualified theoretical explanation from the teacher during cannula insertion. Other researchers have also reported that social collaboration and support to integrate theory and practice constitute important learning processes during simulation (Bland and Tobbel, 2016; de Lima Lopes et al., 2019). In the present review, learning through debriefing was studied in terms of who supports the debriefing process, instructors or peers. Instructor debriefing was clearly the winner in terms of better outcomes in students. We can speculate whether these findings are a consequence of instructors' ability to support the students' learning processes, leading to more discussion and integration of theory and practice. Further challenges include increasing research that uncovers knowledge about learning processes as such, and, in turn, studying how different learning modalities support important learning processes.

One of our key findings in this study is that technical skills; e.g., cardio-pulmonary resuscitation and peripheral venous cannulation, were investigated more often than skills involving substantial collaboration between patient and nurse; e.g., ambulation or bed bathing. This was also the conclusion in a recent systematic review of the use of virtual reality as a learning modality in nursing education (Rourke, 2020). There are probably several reasons why technical skills are overrepresented in the studies. One factor might be access to available stepwise guidelines that inform most nursing skills performance, from which it is relatively straightforward to develop checklists that can provide easy access to data. Data related to manual/technical performance are more accessible than data related to interaction between students and patients. It is easier to tick a box when students do something right or wrong than to record and interpret aspects of collaboration and communication between students and patients. Studies of skill in cardio-pulmonary resuscitation were most prevalent in this review. Cardio-pulmonary resuscitation is an example of a technical skill where there is easy access to validated data collection instruments. International guidelines have been developed on how to perform cardio-pulmonary resuscitation (e.g., American Heart Association guidelines 2021), and standardized checklists to certify cardio-pulmonary resuscitation performers are derived from these guidelines. In addition, technical support in the form of skill reporters (e.g., Lærdal Resusci Anne Skillreporter) registers and analyzes the nursing students' performance, resulting in easily accessible data.

Another reason for the prevalence of cardio-pulmonary resuscitation, peripheral venous cannulation, blood pressure measurement, and other technical skills in the included studies could be their attractiveness to nursing students. When entering nursing studies, students might have an expectation of being able to save lives, and cardio-pulmonary resuscitation may be the best-known lifesaving procedure. Fundamental skills such as vital signs measurement, peripheral venous cannulation, and performing injections are also skills that students find fun to learn (Hope et al., 2011). Designing studies with attractive practical skills may increase the inclusion of students in research and may also be a factor that explains the high number of studies on technical skills learning. A third reason for the choice of technical skills is the time aspect in practical skills learning. In order to perform practical skills, nurses need dexterity, embodied knowledge, and tacit knowledge. These abilities are acquired through training but take considerable time to acquire. Polanyi (1983) described tacit knowledge as knowledge that cannot be verbally articulated but that is gained through training. Thus, tacit knowledge is implicit in the ability to perform practical skills. For an inexperienced student, attention will be focused on *how* to perform the actual skill. Only once the skill is practiced and embodied can the student's attention be directed to the communicative and caring aspects of the situation. As the time available to learn practical skills in the simulation center is quite limited, students seldom reach the stage where they can practice and learn the communicative and caring aspects of those skills. Including these aspects as outcomes in research on practical skills learning in the educational setting may therefore be futile. Bed bathing is an example of how inexperienced students need to train in the practical steps of a skill, as the 45 steps of performing a bed bath involve 38 practical manual steps that the student is supposed to perform correctly (de Lima Lopes et al., 2019).

Testing in skills centers provides information about practice and performance in a simulated setting. However, it does not provide evidence about the students' ability to transfer what they have learned to a clinical setting. Although many researchers concluded their study reports by emphasizing the need to study the transfer of practical skills, only a handful included data from students' skill performance in the clinical setting. Transfer has been studied within pedagogy and psychology for over a hundred years, since the overarching purpose of education is to provide the learners with knowledge and skills that are relevant in life after education. Already in 1992, Perkins and Salomon referred to abundant evidence in transfer research that showed that the hoped-for transfer was lacking. Lauder et al. (1999) referred to the same problem in nursing education, highlighting the problem of transfer of psychomotor skills. These were poorly researched, since most research on transfer focused on the transfer of cognitive and meta-cognitive skills. Research in clinical settings is of course time-consuming. Difficulties may arise in accessing learning situations in practice or securing patient consent. Video recording is probably a relevant method for capturing students' actual practice (Ravik et al., 2017a, 2017b; Ravik and Bjørk, 2021), but it is laborious in terms of both data collection and data analysis. Both Lauder et al. (1999) and Perkins and Salomon (1992) underscored transfer as a crucial educational issue. Transfer of skill occurred in four of the six experimental studies that included results on transfer. Research is therefore of the utmost importance to establish what aspects of learning modalities and learning processes support transfer of practical skills learning.

Based on our analysis of the studies included in this review, we identified a lack of accumulation of knowledge. Confirmatory strategies are needed in research on nursing education, meaning that studies should build either theoretically or empirically on previous research to provide more reliable knowledge and understanding (Polit and Beck, 2021; Rourke et al., 2010). Rourke et al., 2010) stated the following in their article: "When theoretical frameworks are used to guide the formulation of hypotheses, collection of data, and interpretation of results; a collection of studies can become a coherent body of literature that is unified, generalizable, and progressive." They found that only two of 20 empirical studies on high-fidelity simulation included a theoretical framework. In the present review, so few researchers included a theoretical framework that this information was not included in the analysis. Despite some similarities in the types of learning outcomes and skills investigated in the included studies, the diversity of the interventions and instruments used for measurement also precludes most comparisons of results and thereby the possibility of accumulating knowledge.

The studies on cardio-pulmonary resuscitation may have been an exception, given that they all used instruments based on American Heart Association's guidelines or on data retrieved from manikins. Based on this, one could assume that these studies built on each other, though we found sparse evidence to support this.

5. Limitations

Based on the criteria in the Mixed Method Appraisal Tool, we found the quality of the included studies were generally quite low. To exclude studies on the basis of low quality would have precluded a review, however. Significant heterogeneity in the included studies hindered a detailed presentation of similarities and differences between the studies. The content of the learning modalities and the instruments used to measure outcomes varied considerably, complicating the analysis and synthesis of findings. The initial categorization of the type of study required to perform a quality assessment using the Mixed Method Appraisal Tool criteria could have been reconsidered in relation to the studies that erroneously defined their own design. However, in our opinion, this would not have significantly changed the main results, since the research questions in this review are quite overarching.

6. Conclusion

In this review, we posed three overarching research questions about the range and type of skills, learning activities, and learning outcomes related to practical skills learning. Overall, the quality of included studies was low. We suggest reconsidering the use of traditional medical experimental designs in pedagogical research. The use of no-treatment groups in pedagogical research seems to disregard the inherent purpose and effect of teaching and learning, since any education and training will almost always benefit students' learning outcomes. Quantitative studies are the norm in this research field, measuring learning outcomes such as practical skills, knowledge, and confidence. Students' learning processes were barely touched on in the included studies. It is necessary to focus on this area in further research because the choice of learning modality may affect students' learning processes in significant ways. Researchers preferred to study technical skills, while only sparingly studying valid and reliable measures of communication and collaboration skills. The transfer of skills to the clinical arena where they are supposed to be used is explored in only six studies. Admittedly, research on transfer is time-consuming and complicated, but it is much needed, as suggested by many researchers in the included studies. There is a lack of cumulative research exploring practical skills learning. The heterogeneity of the learning modalities and use of measuring instruments precludes the possibility of building on other research. However, it is possible (although not yet used) to compare and build on prior research when the same practical skills are researched over time.

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