

**Appendix 1: MEDLINE(R) ALL (Ovid) 1946 to August 08, 2025**

#	Searches	Results
1	exp Computer Simulation/	335753
2	Education, Nursing/	35624
3	1 and 2	267
4	((((Augmented or virtual) adj2 Realit*) or ((simulation* or simulator*) adj5 (portable or mobile or virtual or phone* or ipad* or computer* or computer-based or iphone* or point-of-care))).ti,ab,kf.	66128
5	((((educat* or teach* or train* or curriculum) adj12 (simulation* or AR technolog*)) or ((educat* or teach* or train* or curriculum) adj12 ((augmented or virtual) adj3 realit*))).ab,kf,ti.	30065
6	((medical adj3 student*) or physician* or doctor* or new staff* or nurs*).ti,ab,kf.	1221687
7	4 and 5 and 6	2098
8	3 or 7	2251

**CINAHL August 23, 2025 11:42:23 AM**

#	Query	Results
S9	S7 AND S8	2,509
S8	TI ( ((medical N3 student*) or physician* or doctor* or new staff* or nurs*) ) OR AB ( ((medical N3 student*) or physician* or doctor* or new staff* or nurs*) )	1,277,524
S7	S3 AND S6	5,506
S6	S4 OR S5	101,675
S5	TI ( (((educat* or teach* or train* or curriculum) N12 (simulation* or AR technolog*)) or ((educat* or teach* or train* or curriculum) N12 ((augmented or virtual) N3 realit*))) ) OR AB ( (((educat* or teach* or train* or curriculum) N12 (simulation* or AR technolog*)) or ((educat* or teach* or train* or curriculum) N12 ((augmented or virtual) N3 realit*))) )	16,702
S4	(MH "Education, Nursing+")	88,352
S3	S1 OR S2	35,591

S2	TI ( (((Augmented or virtual) N2 Realit*) or ((simulation* or simulator*) N5 (portable or mobile or virtual or phone* or ipad* or computer* or computer-based or iphone* or point-of-care))) ) OR AB ( (((Augmented or virtual) N2 Realit*) or ((simulation* or simulator*) N5 (portable or mobile or virtual or phone* or ipad* or computer* or computer-based or iphone* or point-of-care))) )	12,400
S1	(MH "Computer Simulation+")	30,005

## ERIC August 23, 2025

Set	Search	Results
S5	[S3] AND [S4]	899
S4	title(((medical NEAR/3 student*) or physician* or doctor* or new staff* or nurs*)) OR abstract(((medical NEAR/3 student*) or physician* or doctor* or new staff* or nurs*))	2,643,301
S3	[S1] AND [S2]	12,683
S2	title((((educat* or teach* or train* or curriculum) adj12 (simulation* or AR technolog*)) or ((educat* or teach* or train* or curriculum) NEAR/12 ((augmented or virtual) NEAR/3 realit*)))) OR abstract((((educat* or teach* or train* or curriculum) adj12 (simulation* or AR technolog*)) or ((educat* or teach* or train* or curriculum) NEAR/12 ((augmented or virtual) NEAR/3 realit*))))	12,718
S1	title((((Augmented or virtual) NEAR/2 Realit*) or ((simulation* or simulator*) NEAR/5 (portable or mobile or virtual or phone* or ipad* or computer* or computer-based or iphone* or point-of-care)))) OR abstract((((Augmented or virtual) NEAR/2 Realit*) or ((simulation* or simulator*) NEAR/5 (portable or mobile or virtual or phone* or ipad* or computer* or computer-based or iphone* or point-of-care))))	154,499

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**Appendix 2: Articles included in the final synthesis**

<b>Author Country Study design</b>	<b>Aim of study</b>	<b>Conclusion</b>
Beverly <sup>[15]</sup> 2023 United States Pre/post-test design	Evaluate attitudes toward disability and self-efficacy to identify and manage elder abuse and neglect.	Cinematic virtual reality (Cine-VR) training may increase health care providers' awareness of discrimination and improve self-efficacy toward identifying and managing elder abuse and neglect.
Chiang <sup>[16]</sup> 2022 Taiwan Prospective, comparative, pre/post-test	Compare the effects of text-based materials/training and new VR- based educational materials/training on the self-efficacy of in hospital healthcare providers with respect to their tracheostomy-related knowledge and care skills and on their satisfaction with the training and materials.	The current study suggests that VR materials significantly enhance trainees' self-efficacy (increased familiarity, increased confidence, and reduced anxiety) and their satisfaction with the training, while motivating them to use acquired knowledge and skills in clinical practice.
Clara <sup>[17]</sup> 2025 South Africa Descriptive	Gain an understanding of newly appointed community service nurses' (CSNs) experiences using VR to address and evaluate their experiential knowledge gaps.	The study explored and described CSNs' experiential knowledge gaps and experiences with VR simulations to bridge these gaps.
Forgiarini <sup>[18]</sup> 2024 Italy Qualitative	Evaluate the perceptions and opinions of nurses and doctors attending the continuing medical education (CME) blended learning course with the VR system to train participants in rescuing ST-segment elevation myocardial infarction (STEMI) patients.	All participants perceived the VR system and the blended learning course as a positive experience.
Gillespie <sup>[19]</sup> 2021 United States Qualitative	Describe the self-reported changes in knowledge and/or attitudes and planned behavior changes by healthcare workers for their future care of persons with challenges to their social determinants of health following completion of a first-person virtual reality experience	Findings suggest virtual reality has strong merits for impacting the affective domain of learning demonstrated by increased empathy.
Gunther <sup>[20]</sup> 2025 Germany Quasi-experimental	Evaluate the impact of a Virtual Reality delirium application (VR-A) in comparison to traditional presentation-based training (TPT) on delirium-related empathy and knowledge in nursing.	A VR-A may increase delirium-specific empathy and knowledge, compared to TPT.
Jeon <sup>[21]</sup> 2025 South Korea Mixed methods	Evaluate the effectiveness of an immersive 360° video-based VR simulation program for pressure injury management (VR-SIMPI) and explore new nurses' perceptions and learning experiences qualitatively.	VR-SIMPI significantly enhanced knowledge, confidence, and competency among new nurses.
Jung <sup>[22]</sup> 2024 South Korea Mixed methods	Explore the feasibility of a novel pressure ulcers management VR simulation (PU-VRSim) program using a head-mounted display for novice nurses and to investigate how different types of learning materials (ie, VR or a video-based	The PU-VRSim program developed in this study was found to be effective in improving novice nurses' knowledge of PUs and was positively evaluated as a pleasant experience conducive to learning in an actual hospital-like environment. Therefore, PU-VRSim can be used as an effective educational method for novice nurses, as well as for nursing students and clinical nurses.

	lecture) impact learning outcomes and experiences.	
Kaji <sup>[23]</sup> 2024 Japan Cross-sectional pilot questionnaire	To create a simulation system where experienced ostomates can share proficient stoma self-care techniques with novices through VR imagery, enabling them to engage in simulations at their convenience and as often as needed.	Findings support a VR training system as an acceptable approach for ostomates and their caregivers. Non-wound, ostomy, and continence (WOC) nurses, with fewer opportunities in stoma care compared to WOC nurses, showed a stronger interest in practically implementing this innovative training system.
Kim <sup>[24]</sup> 2025 Republic of Korea Quasi-experimental	Evaluate how effective a 360-degree VR based mechanical ventilation nursing education program is for intensive care unit (ICU) nurses to improve knowledge of mechanical ventilation, self-efficacy, clinical reasoning, learning immersion, educational satisfaction, and whether it has any effect on turnover intention compared to conventional education methods.	A 360-degree VR-based education program effectively enhanced key short-term competencies among ICU nurses, including knowledge, self-efficacy, clinical reasoning, and learning immersion. A 360-degree VR-based education program effectively enhanced key short-term competencies among ICU nurses, including knowledge, self-efficacy, clinical reasoning, and learning immersion.
Phillips <sup>[25]</sup> 2024 United States RCT	Compare the effectiveness of virtual reality simulation (VRS) with traditional education in improving registered nurses (RN) knowledge and behavior related to C. difficile prevention.	The current experimental study found that VRS is a viable educational delivery modality compared to traditional approaches for healthcare education and nursing professional development (NPD). Results validated existing traditional approaches and demonstrated encouraging potential for VRS.
Phillips <sup>[26]</sup> 2024 United States RCT	Compare the effect of VRS and traditional education (i.e., asynchronous lecture module) on C. difficile rates and return on investment (ROI).	This experimental study found that both VRS and traditional education modalities positively impacted C. difficile rates and produced a positive economic ROI to inform future resource allocation. Although VRS was impacted by upfront costs, over time, VRS showed greater potential for ROI than traditional education. The findings showed that VRS is a viable instructional method that yields positive ROI and patient outcomes.
Rowlands <sup>[27]</sup> 2025 United Kingdom Post-test observation	Evaluate whether the VR simulation of a tracheostomy emergency using Trachosim® can be effectively delivered to physicians and allied healthcare professionals from an ICU setting through VR simulation within a clinical environment.	This study showed that Trachosim® has good potential for increasing and improving training around tracheostomy emergencies in ICU.
Shih <sup>[28]</sup> 2023 Taiwan Mixed methods	Examine the effects of a digital learning and VR-based educational course on oncology nurses' knowledge, skills, learning attitude, and learning satisfaction with Port-A catheter management.	A VR-based educational course effectively enhanced nurses' knowledge, skills, learning attitude, and satisfaction.
Stuart <sup>[29]</sup> 2025 United States A virtual-reality (VR) training program.	Develop and evaluate a VR-based training program grounded in the World Health Organization's "My Five Moments for Hand Hygiene" framework, and to assess its effect on nurses' hand hygiene adherence (in the VR simulation) and on behavioural determinants (intention, attitudes, subjective norms, perceived behavioural control/self-efficacy) of hand hygiene.	Findings support VR as an educational tool for enhancing hand hygiene practices of health care workers.
Wang <sup>[30]</sup> 2022 Taiwan	Investigate the effectiveness of an immersive three-dimensional VR teaching	The use of VR improves the learning efficacy of chemotherapy administration in non-oncology nurses.

RCT	of chemotherapy administration operated on a smartphone coupled with a visual and audio device.	
Yamaguchi <sup>[31]</sup> 2022 Japan Non-RCT	Evaluate the effects of a virtual reality intervention for dementia nursing education among acute care nurses in Japan.	The results of the present study suggest that the virtual reality interventions program is an effective approach for improving dementia nursing practice and satisfaction with dementia care.
Zhang <sup>[32]</sup> 2025 China RCT	Develop a non-immersive VR (NIVR) simulation training program for isolation wards and further validate its feasibility and training effectiveness in aiding nurses in adapting to isolation ward settings.	While the NIVR simulation training demonstrates faster performance in certain tasks, it shows no significant differences in theoretical and drill scores compared to traditional training. Nevertheless, its safety, repeatability, and realistic simulated environment suggest potential for pandemic response training. Despite not significantly outperforming traditional training methods, NIVR simulation training can still facilitate the practical application of knowledge and skills by helping nurses familiarize themselves with the ward environment in advance, thus improving their response capabilities.
Zhang <sup>[33]</sup> 2022 China Mixed methods	Explore the experience of utilizing virtual reality for isolation ward training among nurses.	The analysis results of the quantitative and qualitative data showed that VR training was regarded as convenient and useful, and it provided additional intrinsic benefits, such as occupational protection. VR, as acceptable as in-person training, is a feasible training instrument for isolation ward training and might be considered an alternative method for isolation ward training in emergencies.
Pickering <sup>[53]</sup> 2018 United States Educational intervention	Develop a training program that incorporates best practices from elder abuse and neglect (EA/N) training literature and the literature on professional curriculum and continuing education design.	Evaluation data indicate that this interdisciplinary training program was a satisfactory way to learn that produced changes in knowledge and impacted clinical practice. Few implementation barriers were encountered, suggesting it could be replicable.
Ursat <sup>[54]</sup> 2023 France Cohort study	Evaluate diagnostic performance following a theoretical HINTS course incorporating video and image demonstrations plus mannequin-based virtual reality simulation (VertImage) versus the same theoretical course alone among emergency physicians and residents.	In combination with a theoretical course, this tool showed a significant advantage in terms of diagnostic performance over the theoretical course. Physicians could distinguish peripheral from central-type vertigos with higher sensitivity and specificity after the VR training. The follow-up showed good retention over time. VR-trained physicians kept the advantage of higher diagnostic performance 6 months after the session. Despite greater diagnostic performances, self-confidence in the clinical examination was not influenced by the VR training. Training repetition and on-site coaching were necessary to enhance self-confidence.
Bauchwitz <sup>[55]</sup> 2024 United States Quasi-experimental, post-test	Evaluate clinician perceptions of a virtual mass casualty incident (MCI) training simulator's usability, acceptability, fidelity, functionality, and pacing.	The study demonstrated that a smartphone-based MCI simulation was feasible and well received by clinicians, suggesting it can effectively supplement traditional MCI and trauma triage training.
Dwyer <sup>[56]</sup> 2015 Australia Qualitative Exploratory	Pilot an inexpensive, portable, novel high-fidelity humanistic simulation modality for educating nurses and doctors in recognizing and responding to the deteriorating patient.	The simulation promoted engagement with subthemes of realism of the character, believability of the experience, and being more connected.
Hung <sup>[57]</sup> 2025 Taiwan	Compare the effectiveness of VR and AR geriatric oral care modules with traditional	The study found no immediate difference in the effectiveness of VR/AR modules compared to face-to-face oral hygiene training.

Quasi-experimental	teaching methods for training nurses, nursing assistants (NAs), and residents in a residential aged care facility (RACF).	Attitudes toward oral care improved after 3 months.
Kim <sup>[58]</sup> 2024 South Korea Quasi-experimental, pre/post-test	Test the hypothesis that participation in a simulation-based mentoring program (SBMP) enhances new nurses' comfort with bereavement/ end-of-life care, reduces their death anxiety, and improves their competency in compassion.	This study demonstrated enhancements in participants' comfort levels regarding bereavement and end-of-life care, as well as their ability to exhibit compassion after participating in the program. Consequently, it was confirmed that simulation-based care after-death mentoring education utilizing an AR app helped enhance the capabilities of new nurses.
Lee <sup>[59]</sup> 2024 Republic of Korea RCT	Evaluate the effects of a mobile-integrated COVID-19 nursing practice simulation program (mobile video-based education plus simulation training and debriefing) on COVID-19 care knowledge, infection prevention practice confidence, and clinical decision-making anxiety, and confidence among nurses without prior COVID-19 unit experience.	Mobile-integrated COVID-19 nursing practice simulation program was effective in increasing infection control knowledge and infection prevention practice confidence in nurses without COVID-19 care experience.
Reece <sup>[60]</sup> 2021 Canada COVID-19 protected intubation quality improvement simulation program.	Describe the virtually facilitated simulation (VFS) program for addressing COVID-19 preparedness in geographically isolated remote communities, to highlight specific quality improvement outcomes of VFS, and to encourage replication by other rural simulationists.	VFS provided a rapidly mobilizable and cost-effective way of delivering high-quality simulation-based education (SBE) to geographically isolated communities.
Zhang <sup>[61]</sup> 2021 China Quasi-experimental	Develop a virtual reality simulation training program incorporating COVID-19 cases and further verify the effect of the program on improving the response capacity of emergency reserve nurses confronting public health emergencies.	The virtual reality simulation training in combination with technical skills training can improve the response capacity of emergency reserve nurses as compared with conventional training.
Huang <sup>[62]</sup> 2021 Taiwan Pre/post-test intervention comparison	Evaluate the effects of VR-based training, including the thinking-path tracking map method, VR simulations, and bedside assignments on the familiarity, confidence, and anxiety regarding treatment decisions and treatment-related knowledge and service skills of nurses in an oral cancer ward in Taiwan.	VR-based training improved nurses' treatment-related knowledge, familiarity, and confidence while reducing anxiety regarding treatment decisions. High acceptance of the VR educational materials was also reported. The findings suggest that VR-based training may be an effective workplace education strategy for enhancing the knowledge and skills of nurses caring for patients with oral cancer.
Covington <sup>[63]</sup> 2019 United States Pre/post-test design	Evaluate the effects of a multimodal airway emergency training program consisting of an online educational module and interdisciplinary in-situ simulation training on providers' knowledge of airway emergency assessment, recognition, and treatment, and on self-efficacy in performing airway emergency techniques immediately post-intervention and at 6-week and 3-month follow-up.	In-situ simulation and online training, modules are effective methods of educating the outpatient endoscopy staff about anesthesia airway emergencies (increase in short- and long-term self-efficacy and knowledge).
Guerrero <sup>[64]</sup> 2024 Saudi Arabia Quasi-experiment	Evaluate and compare two simulation modalities - High-fidelity simulation (HFS) and virtual simulation (VS) and	HFS and VS training effectively and efficiently advanced nurses' professional competence. The nurses exposed to high-fidelity simulation and virtual simulation gained high levels of

al	their effects on professional nurses' knowledge, skills, self-efficacy, confidence, and satisfaction through a simulated clinical experience involving caring for patients undergoing chemotherapy.	knowledge and skills. Additionally, it increased their sense of happiness, self-worth, and self-efficacy.
New <sup>[65]</sup> 2024 United States Mixed methods	Evaluate the development and validation of a manikin-based hemoptysis simulator constructed using a 3D-printed airway model and standard manikin, and its ability to support assessment of hemoptysis management skills.	The simulator demonstrated high realism and validity, with experts outperforming novices across hemoptysis management tasks and clinicians preferring the manikin-based model over virtual reality simulation. These findings support its use as a feasible training and assessment tool for developing and evaluating management skills in high-acuity, low-occurrence airway emergencies.
Jonson <sup>[34]</sup> 2017 Sweden Quantitative experimental	Examine whether short computer-based simulation exercises improve emergency nurses' self-efficacy and initial incident management skills.	Short CBS exercises improved emergency nurses' self-efficacy and supported development of incident management skills.
Jöud <sup>[35]</sup> 2010 Sweden Mixed method design	Test the feasibility of the Urecath (male urethral catheterization) simulator prototype among nurses, nurse assistants and nurse students and nurse assistant students.	Urecath has advantages in its present design but to be a serious alternative to existing training options, it must be complemented with tactile components, degrees of difficulty, and vocal sounds expressing pain and anxiety.
Marsack <sup>[36]</sup> 2023 United States Pre/post-test design	Develop, implement and evaluate an educational intervention composed of a computer-based training (CBT) module and high-fidelity simulation to increase nurses' knowledge of sepsis, confidence in early recognition of sepsis and compliance with sepsis screening.	CBT combined with high-fidelity simulation was associated with improved sepsis knowledge, confidence, and screening compliance, and was well received by nurses.
Parchami <sup>[37]</sup> 2022 Iran RCT	Determine and compare the effect of written simulation and computer simulation of a virtual patient on the development of moral sensitivity of ICU nurses.	The results of the present study confirm that computer simulation of a virtual patient affects nurses' moral sensitivity, and written simulation affects nurses' moral sensitivity. E-learning methods, such as simulation, are safer ways for nurses and students to achieve their intended academic goals without compromising their health, due to advantages of stimulation of the clinical setting and treatment conditions, without the need for risking themselves by the necessity of a physical presence for their learning.
Roh <sup>[38]</sup> 2013 Republic of Korea Quasi-experimental pre/post-test	Evaluate the efficacy of simulation-based (SB) resuscitation training by assessing two different training modalities (CBS versus mannequin-based simulation (MBS)) with practicing nurses.	The introduction of SB resuscitation training was positively embraced by nurses. Learning through CBS resulted in higher satisfaction in implementing decision making and nursing skills compared to MBS. CBS may be beneficial for acquiring nursing skills and decision-making skills in resuscitation.
Schweiger <sup>[39]</sup> 2023 Germany RCT	Evaluate whether the Visual Blood (VB) 3D animated computer model improves clinicians' interpretation of arterial blood gas (ABG) results compared to conventional text-based printouts.	In this study, VB enabled caregivers to correctly interpret more ABG results with little prior training and increased their perceived diagnostic confidence. The study adds to the growing body of research showing that decision-support tools developed around our human abilities can streamline caregivers' decision-making and help providers reach their full potential.
Hung <sup>[40]</sup> 2015 Hong Kong Experimental	Evaluate the effectiveness of a CBT program, developed to complement conventional personal protective	CBT significantly improved PPE donning and doffing performance compared with control, with higher post-test scores and high procedural accuracy in the intervention group (~95%

	equipment (PPE) instruction, in improving healthcare workers' donning and doffing skills and compliance with PPE procedures before and after training.	donning, 85% doffing). Participants reported high satisfaction, supporting CBT as an effective tool to enhance PPE training.
Ko <sup>[41]</sup> 2024 South Korea RCT	Evaluate whether a virtual SB education program can improve nurses' perceived competence in providing psychological support to patients during infectious disease disasters.	A virtual nursing SB education program for psychological support can overcome limitations of time and space. The program would also be an effective learning resource during infectious disease outbreaks.
Liaw <sup>[42]</sup> 2015 Singapore RCT	Evaluate the effectiveness of an interactive multimedia web-based simulation (including animation videos, instructional materials, virtual patients, and online quizzes) in improving nurses' clinical performance and competencies in acute nursing care compared with a control group.	Web-based simulation significantly improved nurses' clinical performance in acute care compared with baseline and control group, with high participant satisfaction and perceived relevance to practice. Findings support web-based simulation as an effective and scalable tool for developing acute care nursing competencies.
Mastoras <sup>[43]</sup> 2022 Canada Stufflebeam's Context-Input-Process-Product (CIPP) model to guide curriculum development and evaluation	Develop and evaluate a virtual simulation-based curriculum to prepare emergency physicians for making and communicating critical care triage decisions under the "Emergency Standard of Care (ESC) for Major Surge" protocol during the COVID-19 pandemic.	The novel virtual simulation curriculum facilitated rapid dissemination of the ESC for Major Surge to our group of Emergency Physicians despite COVID-19-related constraints on gathering. The active learning afforded by this method improved physician confidence and knowledge with these difficult protocols.
Moule <sup>[44]</sup> 2015 United Kingdom Mixed methods	Develop and evaluate five online Virtual Patient (VP) simulation scenarios to meet the learning needs of nurses and health-care professionals caring for men with prostate cancer.	The VP case studies offered the respondents an opportunity to develop knowledge and confidence in caring for men with prostate cancer. The mode of delivery and the content for less experienced and knowledgeable staff have acceptability. Challenges of isolation and lack of ability to capitalize on peer learning were identified.
Albright <sup>[45]</sup> 2013 United States Quantitative	To evaluate and describe an innovative online game-based simulation (GBS) that uses role-play conversations with virtual humans to train primary care providers (PCP) in the screening, brief intervention, referral, and management of patients with mental health disorders.	Integrating behavioral health into primary care improves patient outcomes and reduces healthcare costs, but requires addressing provider gaps in knowledge, skills, and motivation. Training tools like Kognito's virtual patient simulations offer an efficient, cost-effective way for primary care providers to build communication skills, such as motivational interviewing, to support screening, intervention, and referral.
Chang <sup>[46]</sup> 2020 Taiwan Quasi-experimental, pre/post-test	Evaluate nurses' attitudes towards patients complementary/alternative medicine (CAM) use and their competency in communicating with patients about CAM after interacting with a virtual simulation-based educational app.	We found that after completing an educational app, nurses are able to make correct decisions about CAM use, highlighting the need to implement a training program to improve a nurses' ability to assess the risks and benefits of advising patients. This pilot study highlights the usefulness of a virtual simulation-based educational app that can change nurses' attitudes towards patients' CAM use and improve communication competency with patients about CAM. The app promotes a better understanding by nurses on how to integrate CAM use into disease management as they consider the risk-benefit ratio of CAM use that facilitates nurses having better competency in communicating CAM use in clinical practice.
Lim <sup>[47]</sup> 2025 South Korea	Develop the Mobile Simulation Program for Nursing Delegation (MSP-D) to	The MSP-D is an effective educational tool for improving nurses' delegation skills and may enhance job training for nurses

RCT	enhance nurses' delegation skills and evaluate its effects on nurses' preparedness to delegate, critical thinking disposition and role ambiguity reduction.	collaborating with nursing assistants to improve nursing care quality in a new nursing delivery model. Mobile simulation education significantly improves effectiveness due to its high accessibility and flexibility.
Wang <sup>[48]</sup> 2022 China RCT	Evaluate the effectiveness of a GB mobile application for training healthcare workers in personal protective equipment (PPE) use.	The GB mobile application improved PPE skill performance and reduced procedural errors compared with control training, with repeated practice required to achieve mastery.
Wang <sup>[49]</sup> 2023 China Quasi-experimental	Evaluate the impact of a GB mobile app on improving extracorporeal membrane oxygenation (ECMO) pipeline preflushing skills in intensive critical care specialist nurses.	Game-based mobile app may be more effective for intensive critical care specialist nurses in ECMO pipeline preflushing education than traditional Chinese lecture-practice education. The ECMO pipeline preflushing skill can be mastered by playing the game 17 times.
Iancu <sup>[50]</sup> 2023 Israel Quantitative, pre/post-test intervention	Assess whether participation in virtual patient simulation (VPS) can objectively measure and improve clinical knowledge, decision-making, and competency levels of healthcare providers engaged in continuing medical education (CME) activities.	VPS platform allows not only an objective assessment of the effectiveness of the CME activity but also provides timely and helpful feedback to both learners and providers of a given educational event.
Kow <sup>[51]</sup> 2024 Singapore & Malaysia Pre/post quasi-experimental design	Evaluate the effectiveness of virtual patient simulation in developing clinical reasoning among nurses when assessing and managing clinical deterioration.	Virtual simulations not only provide an effective learning strategy for the development of clinical reasoning, but they also have an impact on nurses' perceived training transfer to the clinical workplace.
Rouleau <sup>[52]</sup> 2022 Canada Mixed methods	Assess the acceptability of a virtual patient simulation to improve nurses' relational skills in a continuing education context.	The simulation contributed to knowledge and skills development on motivational interviewing and enhanced nurses' self-confidence in applying relational skills.
Balian <sup>[66]</sup> 2019 United States Feasibility study	Evaluate the feasibility and usability of an AR cardiopulmonary resuscitation (CPR) training system for health care providers.	Using an AR CPR training system is feasible, well-received, and supports high-quality CPR performance. Health care providers found the AR experience realistic, valuable, and were open to its future use in training.
Heo <sup>[67]</sup> 2022 South Korea RCT	Determine the effectiveness and feasibility of AR-based learning for novices to set up a ventilator by focusing on independently completing the procedures and assessing the degree of assistance required.	AR-based instructions to set up a mechanical ventilator were feasible for novices who had no prior experience with mechanical ventilation or AR. Additionally, participants in the AR group required less assistance compared with those in the manual group, resulting in higher confidence after training.
Leary <sup>[68]</sup> 2020 United States RCT	Examine the use of an AR CPR training application compared with a standard CPR training manikin to determine if the AR technology could improve healthcare provider (HCP) CPR quality defined as chest compression rate and depth.	In the randomized trial of an AR CPR training system (CPReality) compared with a standard audio-visual (AV) feedback CPR training, the AR CPR simulation training produced similar CPR quality overall post-simulation in HCP, but significantly more subjects performed outside of both guideline ranges for CC rate and depth. Determining if technology-enhanced CPR training modalities can improve CPR quality is an important step to improving patient outcomes and one that requires further study.
Sun <sup>[69]</sup> 2024 Taiwan RCT	Determine whether AR for educational applications can significantly improve crash cart learning, learning motivation, cognitive load, and system usability. It focused on a subgroup of nurses with less than 2 years of experience.	This study was conducted in a medical center where all nurses must be university graduates and have completed advanced cardiac life support (ACLS) certifications during their employment. These stringent requirements may have contributed to an artificially higher learning effectiveness, as the participants may have had a more robust foundational knowledge and prior experience.

Arnold <sup>[70]</sup> 2013 United States Pre-post-test, control-group design	Compare effects of three simulation methodologies (low-fidelity, computer-based, and full-scale) on the outcomes of emergency response knowledge, confidence in responding to an emergency, satisfaction and self-confidence with learning, and performance in emergency response	Findings highlight the feasibility and reliability of performance assessment through simulation.
Wang <sup>[71]</sup> 2017 United States RCT	Develop an interprofessional team based high-fidelity simulation program based on TeamSTEPPS to teach contrast reaction management (CR) and teamwork skills (TS) simultaneously and to directly compare its effectiveness to an individualized computer-based training program.	High-fidelity simulation can be used to both train and test interprofessional teams of radiologists, technologists, and nurses for both CR and TS and is more highly rated as an effective educational tool by participants than similar CB training. However, a single session of either type of training may be inadequate for mastering teamwork skills.
Carpico <sup>[72]</sup> 2011 United States Time series, prospective, pilot study	Evaluate the effect of Resuscitation Review Simulation Education (RRSE) on improving adherence to hospital protocols and American Heart Association (AHA) resuscitation standards.	This study supports ongoing monitoring of adherence to ACLS algorithms with feedback to staff. Staff development specialists can use the mock code scenario and response tool to replicate this program, ensuring compliance with the most recent AHA ACLS and CPR standards. This study shows the evaluation of staff adherence to hospital protocols and AHA resuscitation standards in simulated settings.
Sok <sup>[73]</sup> 2020 South Korea Pre/post quasi-experiment al design	Examine the effects of a simulation-based CPR training program on knowledge, performance, and stress of CPR in clinical nurses.	A simulation-based CPR training program improved clinical nurses' knowledge and performance of CPR and decreased nurses' CPR stress.
Fernandez-Avila <sup>[74]</sup> 2018 Colombia RCT	Evaluate the effectiveness of clinical simulation for general physicians, based on rheumatological clinical simulation, for the diagnosis of rheumatoid arthritis and osteoarthritis	Clinical simulation improved the diagnostic approach to rheumatoid arthritis and osteoarthritis.
Han <sup>[75]</sup> 2018 South Korea Pre/ post-test design	Examine the effects of a simulated emergency airway management education program on self-efficacy and clinical performance among nurses in ICUs.	Simulation education effectively improved the self-efficacy and clinical performance of nurses who were working in ICUs.
Page <sup>[76]</sup> 2016 United States Pre/ post-test design	Assess the effectiveness of a quality improvement intervention to reduce central line-associated bloodstream infections (CLABSI) rates in the oncology inpatient unit, using a simulation-based educational intervention for oncology nurses	This intervention was associated with reduced CLABSI rates in oncology patients. This implied a substantial potential impact on quality improvement as well as cost control.
Luo <sup>[77]</sup> 2021 China Quasi-experiment al with post-test intervention measurements	Compare the impact of three types of learning modalities on newly graduated registered nurses (NGRN) clinical judgement, perceptions of self-confidence, and evaluations of the design features of the learning modalities.	The study investigated the impact of three types of learning modality on NGRNs' clinical judgement and perceptions. The VS groups showed a higher level of clinical judgement. All three groups of NGRNs had positive perceptions regarding the simulation methods. NGRNs from the HFS group showed higher confidence. Both HFS and VS were evaluated better in terms of simulation fidelity compared to CS.
Dale-Tam <sup>[78]</sup> 2024 Canada	The primary aim of the Mobile Skills and Simulation Cart (MSSC) was to enhance nurses' knowledge, competence and	The MSSC enhanced nursing knowledge, confidence, and comfort with essential clinical skills presented at MSSC sessions. The MSSC had a positive impact on nursing satisfaction.

Mixed method study design	confidence through accessible skills and simulation training. Improve nursing satisfaction through educational support, with the potential to improve nursing retention at the Ottawa Hospital (TOH).	
Wilfong <sup>[79]</sup> 2020 United States Descriptive	Develop and evaluate a travelling education cart for delivering in-situ simulation-based training to clinical staff.	The travelling education cart was well received and provided flexible, mobile simulation-based education with potential to support cost-effective staff training.