

Retention of CPR skill and knowledge among nurses and nursing students following BLS training – An integrative literature review

Tara Kelly^{a,*}, Linda Devaney^{a,b}

^a School of Nursing, Health Sciences and Disability Studies, St. Angela's College, Atlantic Technological University, Lough Gill, Sligo F91 TCN3, Ireland

^b School of Nursing and Midwifery, Royal College of Surgeons in Ireland (RCSI), University of Medicine and Health Sciences, 123 St Stephen's Green, Dublin 2, Dublin D02 YN77, Ireland

ARTICLE INFO

Keywords:

Cardiopulmonary Resuscitation
Basic Life Support
Nursing Students
Skill Retention
Knowledge Retention
Simulation training
Literature review

ABSTRACT

Aim: This review aimed to critically synthesise the evidence relating to the retention of cardiopulmonary resuscitation (CPR) skills and knowledge following Basic Life Support (BLS) training among nurses.

Background: Nurses' retention of CPR skills is essential for effective patient care during cardiac arrest. Evidence indicates that skills and knowledge decline rapidly post-training, raising concerns about current training practices.

Design: An integrative literature review was conducted to answer the research question.

Data Sources: A comprehensive search was conducted using PubMed, CINAHL and MEDLINE and relevant national and international policies and guidelines related to CPR/BLS training. A five-year timeframe was selected to obtain current evidence. No geographical or methodological restrictions were applied. Only full-text, peer-reviewed articles in English were included.

Review Methods: Articles were screened using predetermined inclusion and exclusion criteria. Study quality was appraised using the Critical Appraisal Skills Programme (CASP) prior to inclusion. Thematic analysis was used to identify key concepts from the findings of included studies.

Results: Thirteen studies met the inclusion criteria, including randomised controlled trials, observational and longitudinal designs. Three themes emerged: skill decay post-training, particularly in compression depth and ventilation accuracy; the impact of training intervals, with shorter, more frequent sessions associated with greater retention; and the effectiveness of technology-enhanced training. Tailored training and real-time feedback supported skill retention.

Conclusion: Traditional two-yearly BLS training may be insufficient to maintain CPR competence. Findings support shorter, spaced training intervals and personalised, technology-enhanced approaches. Further research is needed to examine real-world effects on patient outcomes and feasibility in practice.

1. Introduction

Cardiopulmonary resuscitation (CPR) is a sequence of emergency interventions designed to maintain circulation and oxygen delivery to vital organs during cardiac arrest until spontaneous circulation is restored or advanced treatment becomes available (Goyal et al., 2025). CPR is a core clinical competency within the nursing profession. Nurses are often the first responders to In-Hospital Cardiac Arrest (IHCA) and therefore play a critical role in initiating high-quality CPR, having a direct impact on patient survival and outcomes (Anderson et al., 2019).

While resuscitation protocols vary regionally, guidelines published

every five years by the American Heart Association (AHA) and European Resuscitation Council (ERC) represent some of the most prominent frameworks used internationally, adapting global consensus recommendations from the International Liaison Committee on Resuscitation (ILCOR) (Goyal et al., 2025). These guidelines form the basis for healthcare workers to evaluate and manage patients who may require CPR for in-hospital cardiac arrest. Current AHA guidelines recommend two-year CPR certification, with an emphasis on refresher training between courses. Internationally, CPR recertification practices vary across healthcare systems. In the United States and Canada, AHA-accredited BLS certification is commonly renewed every two years and is

* Corresponding author.

E-mail address: tara.kelly6@hse.ie (T. Kelly).

<https://doi.org/10.1016/j.nepr.2026.104889>

Received 18 February 2026; Received in revised form 28 May 2026; Accepted 30 May 2026

Available online 3 June 2026

1471-5953/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

delivered through instructor-led or blended learning formats. Similar two-yearly recertification models are widely used across Ireland, Qatar and many European healthcare settings following ERC or AHA frameworks. However, the AHA acknowledges that further research is required to determine the optimal training interval for long-term skill retention (American Heart Association., 2025; Cheng et al., 2018).

ILCOR and the ERC define high-quality CPR as compressions delivered at the correct rate (100–120 per minute), depth (5–6 cm) and full chest recoil, combined with minimal interruptions and effective ventilations (Greif et al., 2025). Each of these elements have been shown to positively influence survival outcomes significantly, yet their consistent delivery requires sustained proficiency and regular reinforcement.

From an Irish perspective, a retrospective analysis conducted in 2019 at the largest primary Percutaneous Coronary Intervention (PCI) centre nationally reported the incidence of IHCA is approximately 5.1 per 1000 patients annually, with survival rates reported at 32.8% (Gardiner et al., 2021). In the United States, IHCA survival rates are reported to be approximately 25% when timely and effective resuscitation interventions, including high-quality CPR, are provided (Andersen et al., 2019). These figures illustrate that IHCA outcomes are dependent on the rapid recognition of cardiac arrest and the immediate initiation of effective CPR. The Irish study also found higher survival rates when arrests occurred outside ward environments, suggesting that differences in monitoring, staff expertise and resuscitation preparedness influence outcomes. This emphasises the importance of ongoing CPR training and maintenance of resuscitation skills among healthcare professionals.

Retention of such life-saving skills, including ventilation, is critical for nurses, who are often the first responders in hospital-based cardiac arrest. Retention in the context of CPR is defined by the AHA and ERC as the ability to sustain psychomotor skills in CPR, including factors such as chest compression depth, rate, recoil and compression fraction (Anderson et al., 2019). Despite its importance, evidence consistently demonstrates that CPR skills and knowledge deteriorate rapidly after Basic Life Support (BLS) training (Donoghue et al., 2025; Greif et al., 2025; Cheng et al., 2020). Studies of nurses and nursing students show that measurable declines in psychomotor skills and knowledge occur within 6–12 months post-training (Oermann et al., 2022a; Sand et al., 2021). This raises serious concerns, given that in many healthcare systems, BLS recertification is typically conducted every two years, yet studies indicate that competencies often regress to baseline within 6–12 months, questioning the adequacy of training conducted every two years (Junli et al., 2023).

In response to these issues, several researchers have explored various strategies to improve retention. Evidence from low-dose, high-frequency (LDHF) training programmes (Dudzik et al., 2019; Panchal et al., 2020), short refresher courses (Al Jadidi and Al Jufaili, 2023) and personalised retraining schedules (Oermann et al., 2022b) all suggest that more frequent, spaced sessions significantly improve skill retention compared with traditional two-yearly recertification. Furthermore, simulation-based training and feedback-enhanced methods, such as Resuscitation Quality Improvement® programmes, have demonstrated enhanced competence among nurses and nursing students, with participants showing better adherence to compression depth, rate and recoil standards (Oermann et al., 2024). However, results remain mixed regarding the optimal timing and delivery of these interventions and widespread variation in training standards persists internationally (Abuejheisheh and Darawad, 2024; Veettil et al., 2023). The ERC and ILCOR stress the importance of high-quality CPR and advocate for innovative training models to address skill deterioration, thus reducing the risk of sub-optimal resuscitation efforts (ERC, 2025; ILCOR, 2025).

The purpose of this literature review was to critically analyse and synthesise the evidence relating to CPR skill and knowledge retention among nurses and nursing students following BLS training. In doing so, it addresses a critical gap in the literature relating to the training methods as well as recertification intervals that are most likely to enhance CPR skill and knowledge retention. Therefore, the research

question used to guide this review was “To what extent do nurses and nursing students retain cardiopulmonary resuscitation (CPR) skills and knowledge following Basic Life Support (BLS) training and what factors influence the rate of skill decay over time?”

2. Methodology

2.1. Design

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021) were followed when conducting this literature review. This review of the literature used Whittemore and Knafl, 2005), a systematic five-step process to conduct integrative literature reviews. The steps include the following: The 5-stage integrative review process includes (1) problem formulation, (2) data collection or literature search, (3) evaluation of data, (4) data analysis and (5) interpretation and presentation of results. Applying a systematic approach to the literature review process is vital in ensuring a comprehensive and rigorous review as well as enhancing study reproducibility (Whittemore and Knafl, 2005).

2.2. Search strategy

A comprehensive review of the literature was undertaken to identify studies specific to the retention of CPR skills and knowledge post-BLS training among nurses and nursing students. Three databases were thoroughly and systematically searched in October 2024 and updated in May 2025 (PubMed, MEDLINE and CINAHL plus). A range of acronyms such as CPR, BLS and BCLS as well as keywords “cardiopulmonary resuscitation,” “basic life support,” “training,” “education,” “skill retention,” and “knowledge retention”, were used. Boolean operators AND, OR and NOT were inserted to refine the search. A hand search of reference lists of included studies was also conducted in addition to a thorough search of current international resuscitation guidelines in 2025. The detailed search strategy was developed by both authors (TK & LD). A search timeframe of 5 years was applied to retrieve the most up to date studies. Only primary empirical studies were sought with systematic reviews, meta reviews and scoping reviews, etc., excluded.

2.3. Inclusion and exclusion

Inclusion and exclusion criteria were developed using the PICOS framework (Richardson et al., 1995) (Table 1). Inclusion criteria were full-text peer-reviewed articles published in English from 2019 to 2025, aligning with current resuscitation guidelines (Greif et al., 2025). Non-peer-reviewed works such as dissertations, conference abstracts without a full methods section and studies outside the defined time frame were also excluded. Studies were included where nurses/ nursing students account for greater than 50% of the entire sample. There were no geographical or methodological limitations applied. Table 2 contains the search terms and Boolean operators used to conduct the search.

2.4. Study selection

Following the guide of the PRISMA tool (Page et al., 2021), two reviewers screened the articles against both the PICOS criteria and the

Table 1
PICOS framework.

Population	Registered nurses (all settings), Nursing students (all years and programmes)
Intervention	BLS/ CPR training
Comparison	No comparison was reviewed
Outcome	Retention of CPR knowledge and skill post- BLS training
Study design	All study methodologies/ designs

Table 2
Key search terms and Boolean operators.

Search term 1: Registered Nurse OR Nurs* OR Nursing Students OR Student Nurse* OR Undergraduate Nurs*
Search term 2: Cardiopulmonary Resuscitation OR Basic Life Support OR BLS OR CPR OR Basic Cardiac Life Support OR BCLS OR Heart Resuscitation OR Code blue OR Compression Skill OR Ventilation Skill
Search term 3: Skill Retention OR Skill OR Knowledge OR Knowledge Retention OR Competency OR Proficiency OR Retention OR Retain
Search term 4: Mandatory Training OR Training OR Recertification OR Refresh OR certificate OR education

selected inclusion and exclusion criteria to narrow down the results and exclude ineligible studies. Through systematic searching, 258 studies were initially yielded. After removing 51 duplicates and 173 which did not conform to the PICOS and inclusion criteria, 34 records remained. Title, abstract and full-text review of the 34 studies were conducted to determine the relevance of these studies to the review. This led to the exclusion of an additional ten studies as they did not align with the PICOS. A further 24 full-text articles were sought for retrieval and 2 could not be retrieved. Five were excluded as they were conference abstracts or brief reports, quality initiatives and short-duration studies. Four were excluded as they were deemed to be of low to moderate

quality in terms of CASP quality assessment. In total, 13 studies met the eligibility criteria and were included in the final review. These studies represented a range of methodologies, including randomised controlled trials, longitudinal studies and observational designs. The PRISMA flow diagram illustrates the selection process (Fig. 1).

2.5. Quality appraisal

The quality of the included studies was assessed using two Critical Appraisal Skills Programme tools (CASP, 2024). The quantitative study checklists (cohort and cross-sectional studies) and the randomised

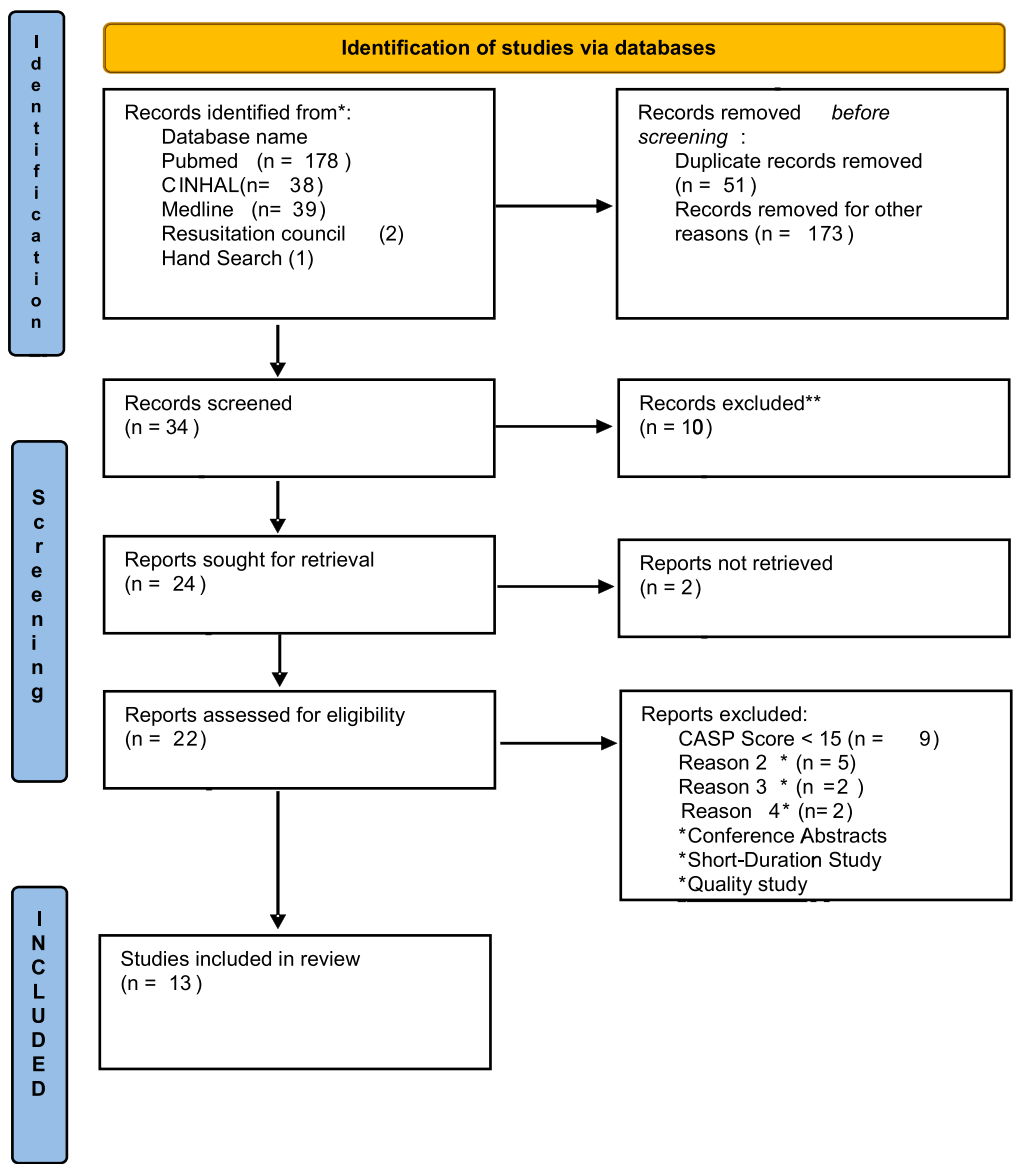


Fig. 1. PRISMA flow chart.

controlled trial (RCT) framework were used to evaluate the trustworthiness, relevance and methodological rigour of the study. All 13 studies included in the review were deemed by both reviewers to be of high quality as a response of “yes” was returned for most questions on the checklists. One study (Dudzic et al., 2019) used a quasi-experimental design; thus, the Joanna Briggs Institute (JBI) 2023 checklist for appraising quasi-experimental designs (Barker et al., 2024) was used to determine the quality of this study. Eight of the nine quality components in this study were answered appropriately; thus it was included in the review.

2.6. Data extraction

Data from all included studies were extracted using a modified version of the Joanna Briggs Institute (JBI) Quantitative data extraction tool and presented in a data extraction summary table (Table 3). Extracted data were categorised as study author and country, aim, sample, data extraction methods, key findings and recommendations. Using a standardised approach to data extraction allowed for consistency and were supported the development of thematic synthesis of review findings.

2.7. Data analysis and synthesis

Due to the heterogeneity across studies in terms of CPR training methodologies, assessment methods of knowledge/skill retention as well as post-intervention follow-up times, narrative synthesis was used to analyse the data (Sakhura, 2022). Each included study was reviewed in detail by both reviewers. Concept maps were used to track key recurring concepts/categories emerging from the findings of each study. Similar descriptive categories were then grouped together to develop themes. The findings relating to the three most frequently occurring themes were critically analysed and synthesised and presented thematically in a narrative synthesis. To reduce the risk of interpretation bias, both researchers independently read the thirteen included studies to ensure emerging concepts were consistent before themes were identified (Buscemi et al., 2006).

3. Results

3.1. Characteristics of included studies

The thirteen studies included in this literature review were published between 2019 and 2024, ensuring the literature reflects current research and aligns with updated resuscitation guidelines. Eight studies used RCT methodologies (Oermann et al., 2020, 2022a, 2022b; Anderson et al., 2019; Sand et al., 2021; Waldolf et al., 2023; Oermann et al., 2024; Al Jadidi et al., 2023), while the remaining five employed a mix of other quantitative methodologies (Charlier et al., 2020; Dudzik et al., 2019; Abuejheisheh and Darawad, 2024; Panchal et al., 2020; Veettil et al., 2023) with a combination of prospective (n = 3), cross-sectional (n = 2), analytical (n = 1), observational (n = 2) and longitudinal (n = 3) approaches. Data collection methods included questionnaires and feedback devices to measure skill accuracy. Sample sizes ranged from 38 to 569 participants. Studies were included if nurses and/or nursing students accounted for the entire sample, or > 50% of the overall sample (Al Jadidi and Al Jufaili, 2023; Dudzik et al., 2019; Panchal et al., 2020; Veettil et al., 2023; Waldolf et al., 2023). The selected studies represent a broad geographical scope, including Canada (n = 2), the United States (n = 6), Belgium (n = 1), Norway (n = 1), Qatar (n = 1), Oman (n = 1) and Palestine (n = 1). This global representation enhances the generalisability of the findings while providing insight into regional variations in CPR training and retention practices.

3.2. Findings

Three prevalent themes emerged relating to nurses' CPR skill and knowledge retention following BLS training in this literature review. (1) Retention of CPR knowledge and skill, (2) Frequency of training intervals and refresher sessions and (3) Efficacy of different CPR training methodologies. The findings relating to each of these themes are discussed below.

3.2.1. Retention of CPR knowledge and skill

Retention of CPR skills is critical to maintaining effective resuscitation performance, yet the literature frequently demonstrates deterioration across both knowledge and psychomotor ability over time. Across several settings, research demonstrates that skill decay appears soon after training, with the most noticeable reductions occurring within the first few months (Charlier et al., 2020; Panchal et al., 2020; Oermann et al., 2020). Common areas of decline include compression depth and ventilation accuracy, which remain difficult to sustain without regular practice. Oermann et al., (2022a) identified measurable deterioration in compression and ventilation performance within 3–6 months following training, while Charlier et al. (2020) noted decreases in knowledge scores from 89% to 72% within four months.

Baseline performance also raised concerns, as several studies showed that many participants failed to meet AHA standards even shortly after initial training. Compression depth, rate and ventilation quality often fell below recommended levels, with only 5–40% of participants achieving adequate compression depth at baseline in some studies (Panchal et al., 2020; Oermann et al., 2020; Anderson et al., 2019). While manikin-based feedback systems strengthened methodological rigour, instructor variability and reliance on simulated settings may limit real-world scenarios. Long-term theoretical knowledge also declined significantly, with scores dropping from 92% to 65% two years after certification in one study, highlighting ongoing challenges in retaining CPR concepts over time (Abuejheisheh and Darawad, 2024).

Although most evidence points to consistent decay, a small number of studies reported more stable baseline performance. Research examining different timings of refresher sessions found slight variation in initial skill levels, suggesting that some participants maintained performance longer than expected (Waldolf et al., 2023). Similarly, work conducted in Oman showed a baseline pass rate of 72.7%, despite subsequent deterioration in the control group without refresher training (Al Jadidi and Al Jufaili, 2023).

Overall, the literature demonstrates that CPR skill retention remains a significant challenge, with rapid decline evident across different populations. However, findings also suggest that how initial training is delivered, along with access to follow-up practice, may influence the extent of skill decay.

3.2.2. Frequency of training intervals and refresher sessions

The frequency and spacing of CPR training sessions appear to influence skill retention, with shorter, more regular intervals generally associated with better outcomes. Current ERC and AHA guidance supports the use of booster sessions (Donoghue et al., 2025; Greif et al., 2025), particularly for providers who are more likely to encounter cardiac arrest in their clinical work areas.

Several of the studies, including nurses and nursing students, identified that more frequent training leads to higher CPR quality over time (Anderson et al., 2019; Panchal et al., 2020). Al Jadidi and Al Jufaili (2023), where nurses accounted for 55.3% of participants, found that refresher CPR training delivered six months after initial training improved psychomotor skill retention at 12 months. Monthly or more frequent training sessions were associated with better retention of compression depth, rate and ventilation accuracy compared with longer intervals, with some studies reporting that 58–95% of participants met AHA compression standards (Anderson et al., 2019; Oermann et al., 2020, Oermann et al., 2022a, Oermann et al., 2022b). Daily and weekly

Table 3
Summary of extracted data.

Study, Citation and Country	Aim	Sample	Data Collection Methods	Key Findings	Recommendations
Oermann et al., (2020) USA	To compare nursing students' CPR skills (compressions and ventilations) with 4 different spaced training intervals, using RQI	N = 475 nursing students in 10 schools of nursing N = 396 participants (83.4%) completed all four training sessions, .	RCT Longitudinal component Nursing students were randomly assigned to one of 4 different spaced training intervals, Participants underwent a pretest, training, and post-test, with real-time feedback. The RQI programme was used to assess CPR performance.	Improved CPR skills, with significant increases in overall compression scores ($p < .001$) Shorter intervals resulting in faster skill acquisition. Participants in the daily and quarterly training intervals had significant differences in overall compression scores and percentage of ventilations with adequate volume by the fourth session. ($p = .044, p < .001$) Real-time feedback on errors can improve performance and refine skills.	Training on consecutive days or weeks may be beneficial: If the goal is to minimise the time to achieve proficiency, daily training intervals may be beneficial.
Oermann et al., (2022a) USA	To examine retention of compression and ventilation skills among nursing students who had different spacing of practice of CPR skills: daily, weekly, monthly, and quarterly.	N = 475 nursing students from 10 nursing programmes N = 201 completed the study through at least five sessions. Retention was assessed at 3months (n = 104) 6months (n = 97)	Longitudinal RCT to evaluate skill retention over time, with multiple data collection points spanning six months.	Compression skills improved through training, with compression depth increasing significantly in all groups ($p < 0.001$) At 6-month retention, the monthly and quarterly groups had better skill retention for compression depth compared to the daily and weekly groups ($p < 0.001$). Longer spacing intervals showed slightly more stable ventilation performance.	The study should be replicated with nursing, medical, and other healthcare students with limited CPR training to confirm findings on spacing CPR practice for learners. Studying practising RNs in a hospital that uses the RQI system or similar equipment would be beneficial. The inability of students to perform ventilations adequately using a bag-mask should be studied further.
Oermann et al., (2024) USA	Assess the retention of adult and infant (CPR) skills by nursing students: 3 and 6 months after they had practiced CPR with real-time feedback using the RQI	238 nursing students from six US schools Experience with CPR: 80.7% had never performed CPR in their jobs, 45.4% had completed a BLS or comparable course prior to entering the nursing programme	Longitudinal study design completing three practice sessions with real-time feedback at baseline, 3 months, and 6 months., The RQI programme included an eLearning course and practical skills activities on manikins, with students practising until they achieved a 75% passing score CPR skills performance data collected via the RQI simulation station RQI Participants received real-time feedback on their CPR skills performance	Baseline Performance: Only 29.4% of students met the compression quality threshold during their first attempt. 3-Month Assessment: Significant improvement in compression depth ($p < 0.001$), recoil ($p = 0.002$), and ventilation quality ($p < 0.001$). 6-Month Assessment: Sustained performance, with over 90% of participants meeting thresholds for compression and ventilation metrics ($p < 0.001$). Improvements were statistically significant across all key psychomotor CPR skills.	Schools of nursing, medicine, and other health care professions should incorporate frequently scheduled CPR practice sessions into their curricula. The RQI programme is an effective tool for maintaining CPR skills, and it should be considered for implementation in nursing education programmes.
Oermann et al., (2022b) USA	To determine whether personalised training schedules improve retention and sustainment of CPR skills compared to fixed retraining intervals in nursing students.	475 nursing students from 10 schools of nursing with BLS training N = 336 completed the retention phase N = 225 completed the sustainment phase N = 140 participants were randomly assigned to the 1-, 7-, and 30-day initial training conditions 165 to the 90-day group	RCT Completed 4 consecutive CPR training sessions spaced by shorter (1 or 7 days) or longer (30 or 90 days) training intervals. Additionally randomised to refresh every 3 months, 6 months, or at a personalised interval prescribed by the Predictive Performance Optimiser (PPO) Data was collected through the RQI system. Metrics such as compression rate, depth, and ventilation quality were recorded at baseline and	Shorter training intervals (days or weeks) lead to higher scores at the end of the initial training period, but this advantage disappears at longer retention intervals (3–6 months). After 1 year, there is no difference in performance between students who had initial training spaced by shorter or longer intervals. The study also found that a personalised scheduling approach is more effective than a fixed schedule in	A two-stage approach to CPR education: an initial phase with closely spaced sessions followed by a sustainment phase with periodic refreshers over extended intervals. Personalised schedules, adjusted based on individual performance

(continued on next page)

Table 3 (continued)

Study, Citation and Country	Aim	Sample	Data Collection Methods	Key Findings	Recommendations
Anderson et al. (2019) Canada	To determine the training interval associated with the highest quality CPR performance at one year.	Registered Nurses BLS were recruited from Health Sciences North Hospital in Sudbury N = 244 participants, N = 167 completed all planned sessions Monthly training group had completion rate at 46% (26/56), 3-month group 69% (46/67), 6-month 78% (47/60), 12-month group had 79% (48/61).	during subsequent reassessments at 3 months, 6 months, or personalised intervals. Randomly assigned to one of four groups: monthly, every 3 months, every 6 months, or every 12 months. Primary outcome measure of participants who performed Excellent CPR at the 12-month time point, defined as 90% of compressions with correct depth, rate, and recoil. Participants completed CPR training on manikins equipped with real-time feedback systems and were recorded using the	maintaining proficiency in CPR skills Only 5% of participants performed Excellent CPR at their first test session. The key findings are that short-duration, spaced CPR training on a manikin with real-time visual feedback is effective in improving CPR performance, with monthly training being more effective than training every 3, 6, or 12 months. Participants who were trained monthly had a significantly higher proportion of Excellent CPR performance (58%) than those in all other groups (26% in the 3-month group, $p = 0.008$; 21% in the 6-month group, $p = 0.002$; and 15% in the 12-month group, $p < 0.001$). The monthly group demonstrated sustained improvements in skill retention over time compared to participants in longer intervals	Future exploration, including determining the optimal frequency and duration of CPR training, examining the costs of training, and investigating the effectiveness of spaced training in real-world clinical settings. More research is needed to determine the predictors of success in CPR training, such as the role of age, height, and gender.
Charlier et al. (2020) Belgium	To determine student nurses' retention of specific BLS knowledge and the corresponding psychomotor skills following training.	N = 114 general nursing students within the first-year cohort 8 classes from 4 schools across Belgium	Observational post-retention test design, quantitative. A standardised 90-minute BLS-AED course delivered face-to-face by certified resuscitation teachers (30 min theory + 60 min hands-on practice). Data Collection Tools: Knowledge: A 7-item multiple-choice questionnaire Skills: Ambu Airway Man W® wireless manikin for real-time feedback and analysis- videotaped for evaluation. Participants were assessed two weeks after the BLS course to assess initial knowledge and skills retention and again at four months after the BLS course to evaluate longer-term retention under observation.	Students' knowledge of BLS subcomponents did not necessarily translate to correct performance of those subcomponents. ($p < 0.05$ for six of seven components). Compression depth only 28% of students achieved the recommended ≥ 5 cm compression depth at four months, indicating persistently poor performance. Ventilation volume: 54% failed to maintain adequate volume due to incorrect head tilt-chin lift. Compression frequency: 37% compressed too fast at retention. Skills such as "time to check respiration" significantly improved over four months ($p = 0.006$). Knowledge of the BLS sequence and compression: ventilation ratio declined between post and retention ($p = 0.029$). Baseline Skill: Participants across all groups performed poorly in several CPR metrics, highlighting the need for retraining. Skill performance was similar between the skill station (SS) and instructor-led (IL) groups at 2 months and 8 months, except for	Prioritise hands-on, stepwise skills training in BLS education, emphasising feedback and repetition. Focus training on critical errors such as maintaining adequate compression depth, ventilation technique, and frequency. Incorporate frequent refresher courses to sustain both knowledge and skill retention over time.
Sand et al. (2021) Norway	The effectiveness of instructor-free skill station training (SS) compared to traditional instructor-led training (IL) in a hospital setting, with a focus on skill retention at 2 and 8 months and the impact of additional retraining at 2 months	129 nurses from 7 wards at Ålesund Hospital were recruited. 119 participated at baseline registration (92.2%). Participants were randomised into three groups: skill station with retraining at 2 months (SS-R), skill	RCT The study groups use skill station training with retraining at 2 months (SS-R), Skill station training without retraining (SS), and instructor-led training (IL). Comparative analysis was used to evaluate the	Baseline Skill: Participants across all groups performed poorly in several CPR metrics, highlighting the need for retraining. Skill performance was similar between the skill station (SS) and instructor-led (IL) groups at 2 months and 8 months, except for	The study suggests that skill stations can be a useful tool for frequent retraining, but the optimal retraining interval or alternative training regimens to maintain high-quality CPR skills are still unknown. Therefore, further research is needed. The study suggests that short

(continued on next page)

Table 3 (continued)

Study, Citation and Country	Aim	Sample	Data Collection Methods	Key Findings	Recommendations
		station without retraining (SS), and instructor-led training (IL). SS-R (42–31 participants), SS (45–34 participants), and IL (42–29 participants).	performance at baseline, 2 months, and 8 months, using metrics such as mean ventilation volumes, proportion of correct ventilations, and chest compressions. CPR skills were recorded automatically by the Rescue Anne skill station	ventilation volume, which was significantly higher in the IL group at 2 months ($p = 0.03$). At 8 months, the SS group demonstrated a higher proportion of correct ventilations compared to the IL group (71% vs. 54%, $p = 0.04$). Skill Retention: At the 8-month mark, skill retention declined across all groups, with low overall pass rates (17% for SS groups, 7% for IL). Effect of Retraining at 2 Months The SS-R showed a significant improvement in compression depth compared to baseline ($p = 0.02$). This highlights the potential benefit of an early retraining session in mitigating skill decay.	refresher courses at intervals of 2–3 months could optimise skill retention and improve outcomes
Panchal et al. (2020) USA	To evaluate the effectiveness of a novel low-dose, high-frequency (LDHF) simulation training method in maintaining CPR skills, participant compliance, and CPR performance during clinical in-hospital cardiac arrest events	Training platform implemented on 2 non-ICU cardiology hospital nursing floors; N = 155 participants completed all 4 quarters of training.	Prospective pre/ post- test intervention study evaluating a new LDHF case-based mobile CPR training platform. One-year duration with four quarterly training modules: Basic life support Compressions only Ventilations only Combined compressions and ventilations Simulation data collected from RQI psychomotor stations with real-time feedback.	Baseline performance indicated many participants did not fully meet the AHA CPR guidelines for compression (depth, rate, or recoil) and ventilation skills, including appropriate tidal volume delivery, were also inconsistent. POST RQI CPR skills were retained over a year with quarterly refreshers Training with a focus on chest compressions led to improved compression quality, but a decrease in ventilation quality. ($p = <0.001$) The use of psychomotor stations integrated with normal clinical activities resulted in high compliance rates of over 95%	Further research is needed to assess the long-term retention of skills and the impact of this training on patient outcomes, specifically in-hospital cardiac arrest morbidity and mortality. Integrate LDHF psychomotor CPR training into clinical workflows for enhanced skill retention. Prioritise spaced, frequent training sessions rather than infrequent certification programmes.
Dudzik et al. (2019) USA	To determine the impact of the RQI programme on healthcare professionals' (HCPs) CPR skills as well as their confidence and satisfaction with the training method compared to traditional Basic Life Support (BLS) certification and maintenance.	The study began in 2016 over 1 year with 294 healthcare providers enrolled in the RQI programme. (nurses = 58%) 165 completed all four quarterly evaluations.	Quasi-experimental design, longitudinal implementation study Quarterly, low-dose, high-frequency CPR training sessions using validated Laerdal QCPR manikins integrated with the RQI programme. Data collected on CPR skills (compression depth, rate, ventilation quality), which were measured at baseline and quarterly using Laerdal manikins with real-time feedback Confidence and satisfaction survey post completion The study compared the results to traditional Basic Life Support (BLS) training. Data was analysed using Stata software for statistical significance	Improved CPR psychomotor compression and ventilation skill performance with higher compression scores (84.0–89.0; $p = 0.0011$) and marked increases in ventilation scores for both first attempts (62.0–84.6; $p < 0.001$) and highest attempts (92.0–98.0; $p < 0.001$). Increased confidence and satisfaction with BLS skills among HCPs 47.4% annual cost reduction for BLS certification using RQI compared to traditional model Improved CPR performance over time, indicating some impact of RQI training	Future research should assess skill retention using a skills assessment without feedback. Additional research could assess RQI scores and learner satisfaction at hospitals where compliance with training is required and closely monitored. More research is needed to confirm these findings at other hospitals, and determine whether RQI can improve IHCA patient survival outcomes

(continued on next page)

Table 3 (continued)

Study, Citation and Country	Aim	Sample	Data Collection Methods	Key Findings	Recommendations
Waldolf et al., (2023) Canada	To determine the optimal timing for CPR skill retention after a BLS course, specifically to investigate whether booster sessions offered at different timepoints within a 10–30 day interval can improve skill retention	N = 86 healthcare providers across four hospitals. Nurses (no=39) Randomised into three groups: early booster (n = 25), late booster (n = 20), and no booster (control, n = 41). A total of 73 participants (early booster: 23; late booster: 16; control: 34) completed the study, resulting in an 85% retention rate.	RCT The study utilised a standardised resuscitation checklist (score n/13) from the Heart and Stroke Foundation to assess performance, which included metrics such as compression depth, rate, and recoil. CPR skills were evaluated using mannequins with real-time feedback. Video recordings of participant performance were rated by blinded assessors using SPSS for statistical analysis	Immediate post-test resuscitation scores were similar: early booster (9.7), late booster (9.2), no booster (8.9). Retention test scores at four months were also comparable: early booster (10.2), late booster (9.8), no booster (9.5). Improvements in performance across all groups post-training were attributed to repeated practice rather than the timing of booster sessions.	Future research should compare feedback vs. no feedback using various booster session timeframes.
Veettil et al., (2023) Qatar	To assess the knowledge, attitude, and proficiency in cardiopulmonary resuscitation (CPR) among healthcare providers in public primary healthcare centres in Qatar.	569 participants for the online survey; 84 participants for CPR skill drills 78.1% were nurses, 21.9% were physicians. Participants had > 5 years of clinical experience.	Cross-sectional design with two components: an online survey and a direct observation of CPR skills. Assessed CPR knowledge and attitudes 23-item questionnaire evaluated CPR skills during routine drills using an adapted checklist based on American Heart Association (AHA) standards Data was collected using a structured self-administered online questionnaire and a skills demonstration checklist.	96% expressed confidence in CPR, and 96.8% had received formal training in Basic Life Support (BLS). The mean total knowledge score was 76.2%. Multiple linear regression analysis revealed that being a nurse was the most significant predictor of a higher knowledge score (p < 0.001) Attending more resuscitation courses and having more clinical experience were also associated with higher knowledge scores. Drill observations: 71.4% of centres required improvement in airway skills, training certificate renewals, and team coordination. Satisfactory performance observed in 28.6% of centres.	Implement regular certification and frequent resuscitation courses Develop targeted training programmes to bridge gaps in CPR confidence and procedural skills. Investigate the impact of workload and lack of routine training on CPR knowledge and skills. Explore the relationship between CPR proficiency and patient outcomes to identify factors influencing success. Examine the effectiveness of different CPR training programmes in improving knowledge and skills.
Al Jadidi et al. 2023 Oman	To investigate the effectiveness of a short refresher Basic Life Support (BLS) on the retention of cardiopulmonary resuscitation (CPR) skills, specifically to assess whether a refresher course six months after initial training can improve the retention of high-quality CPR skills at 12 months	38 healthcare staff in University Hospital 19 in the intervention group: 19 in the control group: 55.3% were nurses, 39.5% were physicians, and 5.3% were paramedics.	RCT Intervention group received refresher training six months after initial training, and a control group that did not. CPR performance assessed at baseline, six months, and 12 months using Little Anne® Q CPR manikins Assessments measured chest compression rate, depth, recoil, ventilation, and interruption time. Data were analysed using SPSS	At baseline, both groups demonstrated similar CPR skills, with a mean overall performance of 12.9% in the intervention group versus 25.2% in the control group (p = 0.638). At six months, both groups showed improvement in overall performance compared with baseline, with mean improvements of 7.2% in the intervention group and 11.1% in the control group (p = 0.682). At 12 months, there was a significant difference in overall performance between the intervention and control groups (93.8 ± 5.9% vs. 79.4 ± 21.3%; p = 0.010). There were significant differences between the two groups in terms of ventilation (p = 0.028) and interruption time (p = 0.020).	A short BLS refresher training course, 6 months after initial training, can improve the retention of CPR-related psychomotor skills Regular refresher training is necessary to maintain high-quality CPR practices
Abuejheisheh and Darawad,	To examine the retention of BLS knowledge among nurses who completed BLS in 2020	108 nurses were recruited from two AHA-ITCs in Palestine	A descriptive cross-sectional design was used to collect data	The results showed a significant difference in BLS knowledge scores between	Nurses must regularly participate in BLS training and attend frequent in-service CPR

(continued on next page)

Table 3 (continued)

Study, Citation and Country	Aim	Sample	Data Collection Methods	Key Findings	Recommendations
(2024), Palestine	and to compare it with their knowledge in 2022. The study also aims to identify the factors that contribute to the decline in BLS knowledge	Data collection was conducted between February 2022 and April 2022 The sample consisted of nurses who had a valid BLS certificate from 2020 to 2021	The instrument consisted of two sections: demographics and knowledge test (25MCQs) The data was collected using a convenience sampling technique The data was analysed using SPSS Paired-sample t-tests were used to examine the mean difference of BLS knowledge in 2020 and 2022	2020 and 2022 ($p < 0.001$) The mean knowledge score in 2020 was 92.09 (SD = 4.01), while in 2022 it was 65.48 (SD = 15.42) Most participants failed the BLS knowledge test in 2022 (85.2%, $n = 92$) Poor retention was noted in depth of chest compressions for children (26.9%) and AED considerations (53.7%). High retention in CPR initiation (95.4%) and chest compression rate (91.7%).	training at least every 6 months to decrease the likelihood of knowledge and skills loss over time Blended learning BLS is one of the methods to retain more knowledge and skills Implement semi-annual refresher courses and utilise simulation-based strategies to improve knowledge retention and patient care quality

training produced strong initial gains but were linked to reduced attendance and fatigue, suggesting that while these intervals are effective for performance, they may be difficult to sustain in practice (Oermann et al., 2020). Quarterly training also showed favourable retention in some cohorts, with high proportions of nursing students maintaining adequate compression depth at three and six months, although ventilation performance declined more quickly over time (Oermann et al., 2022a).

While most studies supported shorter, repeated training intervals, some variations in the findings were evident. Although retraining improved performance, retention remained weaker than in programmes using shorter or more structured intervals. In contrast, one study which evaluated booster sessions found that improvements in performance across all groups post-training were attributed to repeated practice rather than the timing of the booster (Waldolf et al., 2023). This suggests that ongoing exposure may be more important than the precise scheduling of refresher sessions.

Collectively, the findings indicate that shorter, repeated training intervals support better CPR skill retention, while longer gaps lead to noticeable decay. However, very frequent training may reduce motivation and further work is needed to determine practical schedules that support long-term retention in clinical settings.

3.2.3. Efficacy of different CPR training methodologies

Findings across several studies indicate that new and innovative CPR training methodologies can support skill retention more effectively than some traditional approaches.

The Resuscitation Quality Initiative (RQI®) has consistently demonstrated strong outcomes, with research showing that real-time feedback stations help sustain compression and ventilation performance well above passing thresholds over six-month and one-year periods (Oermann et al., 2024; Dudzik et al., 2019). One hundred and sixty-five healthcare workers (58% nurses) maintained scores above the 75% pass rate and in one rural setting, RQI® reduced the number of attempts needed to pass certification, although the absence of a control group and reliance on self-reported data limit the strength of conclusions (Dudzik et al., 2019).

Further research, including 475 student nurses across 10 schools, compared quarterly RQI® sessions with Predictive Performance Optimiser (PPO) training, showed that both systems supported consistent performance, with RQI® users achieving higher compression and ventilation scores than traditional methods ($p < 0.05$) (Oermann et al., 2022b). The PPO model offered personalised feedback and tailored booster intervals, allowing learners to focus on specific weaknesses, with higher compression accuracy and less variability reported than in fixed-interval training. These personalised approaches may help reduce unnecessary repetitions and improve learner motivation.

Self-directed skill stations also demonstrated advantages. A randomised controlled trial by Sand et al. (2021) demonstrated that nurses using self-directed stations achieved higher ventilation accuracy at eight months (71%) than those receiving instructor-led training (54%), suggesting that independent models may outperform standard instruction when resources are limited (Sand et al., 2021). This aligns with findings from RQI® research showing that technology-enhanced and self-directed systems can maintain CPR performance through regular exposure and real-time feedback (Oermann et al., 2024; Dudzik et al., 2019). This suggests that the use of self-directed stations appears to promote more sustained clinical competence through self-paced learning and assessment models while also remaining efficient in terms of resource utilisation. In addition, real-time automated feedback may help focus learner attention on specific performance deficits while providing more consistent and objective guidance than traditional instructor-led approaches.

Traditional instructor-led methods remain widely used. Quarterly low-dose, high-frequency training embedded into clinical workflows improved compression fraction from 83% to 93% and increased compression rate from 109 to 120/min among a sample of 155 healthcare workers (71% nurses) (Panchal et al., 2020). However, instructor oversight may limit scalability and without a control group, the improvements cannot be attributed solely to the intervention. In Norway, instructor-led CPR training produced overall performance outcomes comparable to self-directed skill stations at both 2 and 8 months in a study conducted exclusively among nurses, suggesting that traditional training approaches may still be effective for maintaining CPR competence (Sand et al., 2021).

Overall, these findings demonstrate that frequent training supported by technology, personalised feedback, or self-directed practice can lead to stronger CPR performance than traditional instructor-led methods. However, the heavy reliance on simulation-based environments and the heterogeneity of study populations make direct comparisons challenging and further research is needed on how these methods translate into clinical settings.

4. Discussion

This literature review explores how CPR skills and knowledge are retained by nurses and nursing students following BLS training. The findings affirm that maintaining these life-saving skills can be challenging, particularly the retention of psychomotor competencies such as chest compression depth, rate and ventilation accuracy. Current training models, which rely on two-yearly refresher courses, appear insufficient, with evidence showing that skills begin to decay within just six months of training. One of the key insights from the review is the importance of training intervals. Shorter, more frequent sessions have consistently

supported better retention compared with the traditional two-year model. These findings suggest that adjusting training schedules to fit the needs of nurses could substantially impact their ability to retain CPR skills over time. Innovative training methods also stood out as promising solutions. Technology-enhanced simulations, personalised training plans and self-directed skill stations not only help to sustain skills but also provide flexibility for learners. Real-time feedback tools were especially highlighted for their ability to correct errors instantly, making training more effective and engaging. Furthermore, technology-enhanced simulation may reduce the potential for subjectivity in live trainer feedback by delivering standardised, consistent performance evaluations based on objective criteria. This review highlights the limitations of traditional training models and points to fresh approaches that emphasise frequent, tailored and innovative strategies. By adopting these evidence-based practices, healthcare systems can better equip their providers to deliver high-quality resuscitation care.

The findings from this review form the basis for recommendations aimed at advancing education, practice, policy and research in CPR training. Recommendations emerging highlight the need for more responsive and practice-oriented approaches to resuscitation education. Evidence from simulation-based CPR training studies suggests that repeated practice using realistic scenarios and real-time feedback may help healthcare providers maintain performance and respond more effectively during resuscitation events (Panchal et al., 2020; Anderson et al., 2019). The use of technology-enhanced feedback tools, such as performance optimisation systems, may further strengthen skill acquisition by offering individualised, consistent guidance and enabling targeted performance improvement. In clinical practice, LDHF CPR training appears particularly valuable for enhancing retention, suggesting that brief, repeated sessions embedded into routine workflows may be more effective than infrequent, high-intensity courses. To support sustained competence, institutions may also benefit from providing on-demand access to simulation spaces equipped with feedback devices, ensuring opportunities for continuous practice. The findings from this review may also be pertinent to the way other clinical skills are taught and assessed in nursing. Traditional competency-based approaches often rely on a single assessment or “check-off” to demonstrate competence. However, the rapid deterioration in CPR knowledge and psychomotor skills identified across several studies raises questions regarding whether competency can be sustained over time without ongoing practice and reinforcement. Continuous, practice-oriented educational approaches using simulation and objective feedback may assist in identifying specific skill deficit areas, allowing refresher education to be tailored as needed to support ongoing competence and long-term skill retention. Finally, future research should prioritise establishing the relationship between CPR training performance metrics and patient-related outcomes, thereby determining the real-world impact and cost-effectiveness of contemporary CPR training strategies. Additionally, larger RCTs would also be warranted to determine the most effective methodologies for future training and skill retention.

5. Limitations

This review provides a comprehensive overview of the literature relating to knowledge and skill retention among nurses' and nursing students following BLS training. Several potential limitations must however be considered when reading this literature review. Although an academic supervisor (LD) supported much of the process, including screening, quality assessment, review and editing, much of the process was undertaken by a single reviewer (TK). This may increase the risk of potential bias, thus reducing the validity, reliability and generalisability of the findings. Additionally, this literature review was conducted in part fulfilment of a Bachelor of Nursing Science Degree, therefore, time constraints in line with academic submission deadlines meant that an exhaustive search of all databases, as well as grey literature, was not possible. Furthermore, by including only full-text studies and those

available in English, the risk of publication bias cannot be definitively ruled out.

6. Conclusion

This review highlights the evidence regarding nurses and nursing students' retention of CPR skills and knowledge following BLS training. The literature reveals that while traditional two-year CPR recertification has been standard practice across most geographical settings, it may be insufficient for maintaining optimal knowledge and skill levels. A significant finding that emerged from the literature is the impact of LDHF training methods on long-term skill retention, which challenges conventional training paradigms.

Interestingly, while most studies demonstrated significant skill decay over time, some found minimal deterioration, suggesting that the quality and training methodologies employed may be more influential than frequency alone. This presents an alternative view which merits further exploration. This review also highlights that innovative approaches to BLS training, such as the RQI and PPO programmes show potential for enhancing skill retention through personalised, technology-enabled learning experiences. However, a critical gap remains in understanding how these training methods translate to patient outcomes. While the evidence supporting LDHF training is encouraging, its direct impact on patient survival rates and clinical outcomes requires further investigation.

As healthcare practices continues to evolve, the importance of maintaining high-quality CPR skills must continue to be embedded into healthcare organisations as well as higher education institutions, with consideration given to implementing innovative evidence-based training approaches that balance practical constraints with skill retention. This literature review affirms the necessity for continued innovation in BLS training methodologies while emphasising the importance of validating these approaches through robust clinical outcome data.

Ethics

Ethical approval from a Research Ethics Committee (REC) was not required to conduct this literature review. However, cognisance was given to the fact that the reviewers have an ethical obligation to ensure that a thorough and accurate search of the literature was conducted to retrieve the most relevant studies to answer the research question. Consideration was also given to ensuring that each study was comprehensively assessed to determine its quality and that findings were analysed and presented in a transparent manner. This literature review is an original piece of work conducted in part fulfilment of a Bachelor of Nursing Science Honours Degree. No AI-assisted technologies were used in the development, analysis or writing of this review.

Funding

This research did not receive any funding.

CRediT authorship contribution statement

Tara Kelly: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Linda Devaney:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Abuejheish, A.J., Darawad, M.W., 2024. A national cross-sectional study on the retention of basic life support knowledge among nurses in Palestine'. *BMC Nurs.* 23 (1), 828.
- Al Jaddi, H., Al Jufaili, M., 2023. Effectiveness of a short refresher course on the retention of cardiopulmonary resuscitation-related psychomotor skills (REF-CPR). *Oman Med. J.* 38 (3), e509 e509.
- American Heart Association, 2025. 2025 American Heart Association Guidelines for CPR and Emergency Cardiovascular Care: Executive Summary. Available at: <https://cpr.heart.org/en/resuscitation-science/cpr-and-ecc-guidelines/executive-summary> (Accessed: 30 November 2024).
- Andersen, L.W., Holmberg, M.J., Berg, K.M., Donnino, M.W., Granfeldt, A., 2019. 'In-hospital cardiac arrest'. *JAMA* 321 (12), 1200–1210.
- Anderson, R., Sebaldt, A., Lin, Y., Cheng, A., 2019. Optimal training frequency for acquiring and retaining high-quality CPR skills: a randomised trial'. *Resuscitation* 135, 153–161.
- Barker, T.H., Habibi, N., Aromataris, E., Stone, J.C., Leonardi-Bee, J., Sears, K., et al., 2024. The revised JBI critical appraisal tool for the assessment of risk of bias quasi-experimental studies. *JBI Evid. Synth.* 22 (3), 378–388.
- Buscemi, N., Hartling, L., Vandermeer, B., Tjosvold, L., Klassen, T.P., 2006. 'Single data extraction generated more errors than double data extraction in systematic reviews'. *J. Clin. Epidemiol.* 59, 697–703.
- CASP, 2024. Critical Appraisal Skills Programme. Oxford: CASP. Available at: <https://cas.uk.net/what-is-critical-appraisal/> (Accessed 17 December 2024).
- Charlier, N., Van Der Stock, L., Iserbyt, P., 2020. Comparing student nurse knowledge and performance of basic life support algorithm actions: an observational post-retention test design study' (Available at:). *Nurse Educ. Pract.* 43, 102714. <https://doi.org/10.1016/j.nepr.2020.102714>.
- Cheng, A., Magid, D.J., Auerbach, M., Bhanji, F., Bigham, B.L., Blewer, A.L., Dainty, K.N., et al., 2020. Part 6: resuscitation education science: 2020 American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 142 (16. 2), S551–S579. <https://doi.org/10.1161/CIR.0000000000000903>.
- Cheng, A., Nadkarni, V.M., Mancini, M.B., Hunt, E.A., Sinz, E.H., Merchant, R.M., Donoghue, A., Duff, J.P., Eppich, W., Auerbach, M., Bigham, B.L., 2018. Resuscitation education science: Educational strategies to improve outcomes from cardiac arrest – a scientific statement from the American Heart Association'. *Circulation* 138 (6), e82–e122.
- Donoghue, A.J., Auerbach, M., Banerjee, A., Blewer, A.L., Cheng, A., Kadlec, K.D., Lin, Y., Diederich, E., Sawyer, T., Stallings, D.T., Toft, L.E.B., Wright, J.I., Schexnayder, S.M., Dainty, K.N., 2025. Part 12: resuscitation education science: 2025 American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 152 (2), S719–S750. <https://doi.org/10.1161/CIR.0000000000001374>.
- Dudzik, L.R., Grzybowski, M., Green, J.S., Perryman, R.K., North, D.R., Finn, L.A., 2019. Implementation of a low-dose, high-frequency cardiac resuscitation quality improvement program in a community hospital (Available at:). *Jt. Comm. J. Qual. Patient Saf.* 45 (12), 789–797. <https://doi.org/10.1016/j.jcjq.2019.08.010>. Accessed: 12 December 2024).
- European Resuscitation Council (ERC), 2025. European Resuscitation Council Guidelines 2025: Education for Resuscitation. *Resuscitation* 210, 110720.
- Gardiner, R., Byrne, L., O'Flaherty, N., Farrell, C., Mirza, I., Dunleavy, C., Murphy, R., 2021. 'In-hospital cardiac arrests: a study of incidence and outcomes'. *Ir. J. Med. Sci.* 114 (9), 465–472.
- Goyal, A., Singh, B., Patel, P.H., 2025. Cardiopulmonary resuscitation. *StatPearls*. StatPearls Publ. (<https://www.ncbi.nlm.nih.gov/books/NBK470402/>) Accessed: 30 January 2025).
- Greif, R., Lauridsen, K.G., Djärv, T., Ek, J.E., Monnelly, V., Monsieurs, K.G., Nikolaou, N., Olasveengen, T.M., Semeraro, F., Spartinou, A., Yeung, J., Baldi, E., Biarent, D., Djakow, J., van Gils, M., van Goor, S., Graesner, J.-T., Hogeveen, M., Karageorgos, V., Lott, C., Madar, J., Nabecker, S., de Raad, T., Raffay, V., Rogers, J., Sandroni, C., Schnaubelt, S., Smyth, M.A., Soar, J., Wittig, J., Perkins, G.D., 2025. 'European resuscitation council guidelines 2025 – adult basic life support'. *Resuscitation* 215 (1), 110771. <https://doi.org/10.1016/j.resuscitation.2025.110771>.
- International Liaison Committee on Resuscitation (ILCOR), 2025. Education, Implementation and Teams: 2025 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 210, 110749.
- Junli, A., Isa, S.N.I., Ibrahim, F.S., 2023. Factors of cardiopulmonary resuscitation skills retention among healthcare providers: a scoping review. *Nurse Educ. Pract.* 69, 103617. <https://doi.org/10.1016/j.nepr.2023.103617>.
- Oermann, M.H., Krusmark, M.A., Kardong-Edgren, S., Jastrzemski, T.S., Gluck, K.A., 2020. Training interval in cardiopulmonary resuscitation (Available at:). *PLOS ONE* 15 (1), e0226786. <https://doi.org/10.1371/journal.pone.0226786>.
- Oermann, M.H., Krusmark, M.A., Kardong-Edgren, S., Gluck, K.A., 2022a. Retention in spaced practice of CPR skills in nursing students (Available at:). *MEDSURG Nurs.* 31 (5), 285. <https://doi.org/10.62116/MSJ.2022.31.5.285>. Accessed: 10 December 2024).
- Oermann, M.H., Krusmark, M.A., Kardong-Edgren, S., Jastrzemski, T.S., 2022b. Personalized training schedules for retention and sustainment of cardiopulmonary resuscitation skills (Available at:). *Simul. Healthc. J. Soc. Simul. Healthc.* 17 (1), e59–e67. <https://doi.org/10.1097/SIH.0000000000000559>. Accessed: 8 November 2024).
- Oermann, M.H., VanRiel, Y.M., Wagner, R.W., Whittington, K.D., Baker, M., Stieve, D.E., Crane, P.C., Vermeesch, C.A., 2024. Maintenance of CPR skills among nursing students trained using resuscitation quality improvement® program (Available at:). *Resuscitation* 20, 100782. <https://doi.org/10.1016/j.resplu.2024.100782>.
- Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372, n71. <https://doi.org/10.1136/bmj.n71>.
- Panchal, A.R., Stolz, U., Shofer, F.S., Pepe, P.E., Idris, A.H., Kern, K.B., 2020. Low dose-high frequency, case-based psychomotor CPR training improves compression fraction for patients with in-hospital cardiac arrest (Available at:). *Resuscitation* 146, 26–31. <https://doi.org/10.1016/j.resuscitation.2019.10.034>.
- Richardson, W.S., Wilson, M.C., Nishikawa, J., Hayward, R.S., 1995. The well-built clinical question: a key to evidence-based decisions'. *ACP J. Club* 123 (3), A12–A13.
- Sand, K., Husebø, B., Sjøteland, E., Nilsen, J.E.O., 2021. Cardiopulmonary resuscitation retention training for hospital nurses by a self-learner skill station or the traditional instructor-led course: a randomised controlled trial (Available at:). *Resuscitation* 7, 100157. <https://doi.org/10.1016/j.resplu.2021.100157>.
- Sukhera, J., 2022. Narrative reviews: flexible, rigorous and practical. *J. Grad. Med. Educ.* 14 (4), 414–417. <https://doi.org/10.4300/JGME-D-22-00480.1>.
- Veettil, S.T., Binu, V.S., Krishna, M., Nair, S., Varghese, J., Ibrahim, M., Ismail, M.S., 2023. Knowledge, attitude and proficiency of healthcare providers in cardiopulmonary resuscitation in a public primary healthcare setting in Qatar (Available at:). *Front. Cardiovasc. Med.* 10, 1207918. <https://doi.org/10.3389/fcvm.2023.1207918>.
- Waldorf, R., Burnstein, C., Thompson, J., Hargreaves, S., 2023. The timing of booster sessions may not improve resuscitation skill retention among healthcare providers: a randomised controlled trial' (Available at:). *Can. Med. Educ. J.* <https://doi.org/10.36834/cmej.74401>. Accessed: 8 December 2024).
- Whittemore, R., Knafl, K., 2005. The integrative review: updated methodology. *J. Adv. Nurs.* 52, 546–553.