

Professional and patient care outcomes of e-learning in healthcare continuing education: A systematic review

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ABSTRACT

Aim: To synthesize evidence on the perceived and objectively measured effectiveness of e-learning for continuing educational purposes among healthcare professionals, with particular attention to professional and patient care-related outcomes

Background: E-learning is increasingly used for continuing healthcare education, yet its perceived effectiveness on professional and patient outcomes has not been summarised.

Design: Systematic review.

Methods: The review protocol was registered in PROSPERO (CRD42024545255) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were followed. MEDLINE-PubMed, CINAHL, Scopus and the Cochrane Library were searched for studies published from January 2016 to June 2024. Eligible studies included quantitative, qualitative and mixed-methods designs, using comparative and non-comparative approaches, assessing e-learning interventions in postgraduate or continuing education for healthcare professionals and reporting professional and/or patient care outcomes. Study quality was appraised using Joanna Briggs Institute tools. Findings were synthesized narratively and organized using the adapted Kirkpatrick/Barr framework.

Results: Seventeen studies from 16 countries were included, nine quasi-experimental, six cross-sectional and two randomized trials. E-learning was consistently perceived as effective in improving knowledge, confidence, attitudes and selected skills, while evidence of practice change was less consistent and only partly documented in routine care. However, only four studies examined patient safety, quality of care, satisfaction, or infection outcomes, using heterogeneous indicators and follow-up periods.

Conclusions: E-learning appears useful for continuing professional development, especially for improving knowledge, confidence, attitudes, perceived competence and selected skills. However, evidence remains largely self-reported and data on sustained practice change and patient-related outcomes are still limited, heterogeneous and inconsistently measured.

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1. Introduction

Given the rapidly evolving nature of healthcare, professionals must engage in lifelong learning to maintain competence and respond to changing clinical practices, emerging challenges and increasing complexity in care delivery (Palese et al., 2023; Vázquez-Calatayud et al., 2021). In this context, e-learning has become an increasingly relevant strategy for continuing education and professional development. Broadly understood as learning delivered partially or fully through digital and communication technologies, e-learning enables health professionals to sustain, refine and extend their knowledge, skills and professional capabilities throughout their careers (Arian et al., 2025; Embo and Valcke, 2017; Vázquez-Calatayud et al., 2021). This is particularly relevant in nursing and midwifery, where continuing professional development is closely linked to competence maintenance, quality of care and responsiveness to evolving patient and system needs (Embo and Valcke, 2017; Vázquez-Calatayud et al., 2021). However, despite its increased use, no summary of the evidence regarding its effectiveness on professional development, practices in healthcare facilities and, more importantly, on patients has been provided to date.

1.1. Background

Historically, e-learning in health professions education has evolved from early delivery-focused models, mainly examined through “online versus face-to-face” equivalence studies, towards more interactive, blended and implementation-oriented forms of digital education. Early meta-analytic evidence showed that internet-based learning could achieve outcomes comparable to conventional teaching, while also indicating that instructional design, rather than modality alone, was a key determinant of effectiveness (Cook et al., 2008). The field subsequently moved towards blended and simulation-supported approaches, with evidence suggesting that these formats may be at least as effective as and sometimes superior to, non-blended education (Liu et al., 2016). In nursing, review-level evidence has also suggested that e-learning can support continuing education and practice development by improving access to learning opportunities, particularly in contexts marked by workload pressures and geographical constraints (Beckett, 2020; Rouleau et al., 2019). More recently, attention has shifted towards implementation-oriented continuing professional development, emphasizing that educational value depends not only on knowledge acquisition but also on whether learning can be transferred into practice within supportive organizational contexts (Al-Omary et al., 2024; Tudor Car et al., 2022; Vázquez-Calatayud et al., 2021).

Currently, the field is entering a new phase characterized by adaptive, Artificial Intelligence (AI)-enabled and immersive approaches, including learning analytics, virtual and augmented reality and generative AI. These developments may support more personalized, data-informed and practice-oriented continuing learning approaches, although the evidence remains heterogeneous and still relies on proximal outcomes rather than long-term or objective measures of impact (Astbury et al., 2026; Bojic et al., 2023; Kyaw et al., 2019; Pham et al., 2025; Tene et al., 2024). Overall, the recent e-learning trajectory in continuing education suggests the need to move beyond simple effectiveness comparisons and to give greater attention to implementation frameworks, immersive technologies, learning analytics and the digital capability of the healthcare workforce, alongside longitudinal outcome assessment (Mikkonen et al., 2026; Tudor Car et al., 2022; World Health Organization [WHO], 2020). In this context, patient care outcomes refer to practice-related effects potentially associated with learning interventions, such as changes in care quality, patient safety, clinical decision-making, adherence to recommended guidelines and other outcomes influenced by professionals’ acquired knowledge and skills.

Within this broader trajectory, the COVID-19 restrictions should be understood less as the origin of digital education than as a major accelerator of its adoption and normalization. The rapid shift from face-

to-face continuing education to remote or hybrid delivery consolidated e-learning as a feasible and, in many settings, routine component of professional development and postgraduate education (Vázquez-Calatayud et al., 2021), allowing continuing education even under constrained conditions.

However, the restrictions also highlighted some limitations: although engagement improved when learning was interactive and multimedia-rich, the rapid transition exposed challenges related to technological infrastructure, digital literacy, learner support and organizational readiness. E-learning is generally viewed positively, but its acceptability and effectiveness may be limited by poor institutional support, time constraints, low motivation and engagement especially in self-directed formats (Alfaleh et al., 2023). Moreover, fully online approaches remain insufficient when hands-on clinical learning is essential, reinforcing the value of blended and simulation-supported models rather than purely remote delivery (Vázquez-Calatayud et al., 2021).

Overall, according to the evidence produced to date, e-learning offers flexible and accessible opportunities to acquire and update knowledge and skills (Kim and Park, 2021; Padilha et al., 2019; Park et al., 2023; Rouleau et al., 2017, 2019). Evidence suggests that it can achieve outcomes comparable to, or better than, traditional face-to-face education while also supporting self-paced learning which is especially valuable in demanding clinical environments (Alfaleh et al., 2023; George et al., 2014; McCutcheon et al., 2018; Rouleau et al., 2019). Nevertheless, its successful integration into continuing education depends on implementation quality (e.g. learner engagement), digital competence of participants, institutional support and the possibility of integrating theoretical learning with hands-on clinical experience (Alfaleh et al., 2023; Vázquez-Calatayud et al., 2021). However, despite the increased production of primary studies, existing reviews have provided data in healthcare professions primarily focusing on heterogeneous populations and educational contexts, with limited attention to professional and patient care-related outcomes (Cook et al., 2008; Rouleau et al., 2019; Tudor Car et al., 2022) and all possible e-learning interventions (Samuel et al., 2021; Sinclair et al., 2016). As a result, a summary of e-learning interventions on practitioners’ professional development and patient care-related outcomes is not available. Therefore, this study aimed to synthesize the evidence on the perceived and objectively measured effectiveness of e-learning for continuing educational purposes among healthcare professionals, with particular attention to professional and patient care-related outcomes.

2. Methods

2.1. Study design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) (Supplementary Table 1). The review protocol was registered in the Prospective Register of Systematic Reviews (PROSPERO) database (CRD42024545255).

2.2. Research question

The primary research question was: “What are the effects of e-learning on healthcare professionals and patient care outcomes as documented to date?” This was structured using the PICO framework (Higgins et al., 2024) as follows:

- Population (P): Healthcare professionals actively engaged in clinical or educational activities, including but not limited to nurses, midwives and physicians.
- Intervention (I): E-learning systems, defined as technology-based or internet-mediated distance learning methods, used in postgraduate and continuing education (Arian et al., 2025).

- Comparison (C): Traditional, classroom-based learning approaches, or no comparator.
- Outcomes (O): Professional-related outcomes such as attitudes, perceptions, knowledge, skills, self-efficacy, behavioral or practice change, other performance-related indicators and patient care-related outcomes (e.g., safety, satisfaction, quality of care, clinical outcomes, or care-process outcomes).

2.3. Eligibility criteria

Eligible studies were: (a) quantitative, qualitative, or mixed-methods evaluations of e-learning; (b) for healthcare professionals in post-graduate or continuing education; (c) published between January 2016 and June 2024, as this timeframe reflects advancements since the previous systematic review by Sinclair et al. (2016); (d) in any language; (e) with accessible abstract and full text; and (f) reporting healthcare professional and/or patient care outcomes. In addition, (g) studies involving different populations in addition to healthcare professionals were included only if specific outcomes were reported separately or could be separately extracted. The presence of a comparison group was not required; both comparative and non-comparative studies were eligible. Studies were excluded if they were unrelated to e-learning, involved non-healthcare professionals or student populations, lacked accessible abstract or full text, or were published as editorials, commentaries, or conference proceedings.

2.4. Search strategy

A comprehensive search strategy was developed to identify relevant studies across four databases: MEDLINE-PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus and Cochrane Library. The search covered publications from January 1, 2016, to June 2024. A combination of keywords and Medical Subject Headings (MeSH), including terms such as “e-learning,” “healthcare professionals,” and “patient outcomes,” was used, linked with Boolean operators (“AND” and “OR”) to maximize retrieval. No additional search methods were used beyond the electronic database search (e.g., backward and forward citation searching, hand searching, or grey literature searching). The detailed search strategy is provided in Supplementary Table 2.

2.5. Study selection process

Records from all databases were imported into Rayyan (<https://rayyan.ai>), where duplicates were identified automatically and verified manually before removal. Two independent reviewers (SD, SC) screened titles and abstracts in a blinded manner using the predefined eligibility criteria, with disagreements resolved by discussion or third-reviewer arbitration (AP). Potentially eligible studies underwent independent full-text assessment by the same reviewers, with exclusion reasons documented and arbitration by AP when needed. The entire selection process was reported using a PRISMA 2020 flow diagram (Page

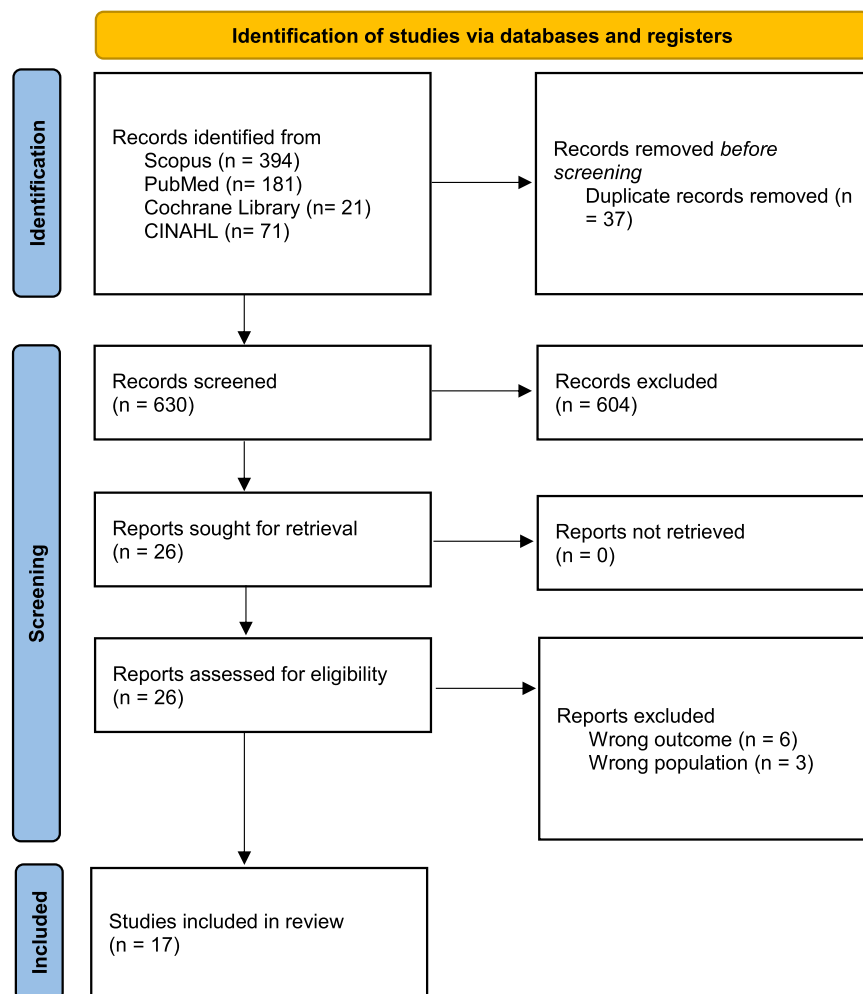


Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for new systematic reviews that included searches of databases and registers only (Page et al., 2021). **Legend:** CINAHL, Cumulative Index to Nursing and Allied Health Literature.

et al., 2021) (Fig. 1).

2.6. Quality assessment

Study quality was appraised to assess methodological rigor and to interpret the weight of the retrieved evidence. Quality assessment findings were not used as exclusion criteria. The Joanna Briggs Institute tools were used, applying design-specific checklists for quasi-experimental, analytical cross-sectional and randomized controlled trial studies (Joanna Briggs Institute, 2020; Supplementary Tables 3–5). Two reviewers (SD, SC) independently assessed included studies, resolving disagreements through discussion or third-reviewer arbitration (AP).

2.7. Data Extraction

Two reviewers (SD, CM) independently performed data extraction using a standardized, piloted extraction grid, with no modifications required after piloting (Allen et al., 2021; Bonney et al., 2023). Extracted data included study identification and design (authors, year, country); population and participant characteristics (including setting); e-learning intervention features (tools, topic/content, duration); outcome measures (instruments or metrics for knowledge, skills, attitudes); and main findings. Disagreements were resolved through discussion or, if necessary, by third-reviewer arbitration (AP). Authors were contacted when data were missing or unclear. Due to the high volume of citations retrieved, specific reasons for exclusion were documented only at the full-text screening stage, when records were assessed in detail against the eligibility criteria.

2.8. Data synthesis

Data were synthesized narratively (Popay et al., 2006). The synthesis first summarized the main study characteristics, then grouped e-learning interventions inductively into three delivery models based on shared features: self-paced asynchronous, interactive application-oriented and supported or facilitated e-learning. Given the heterogeneity of reported outcomes, these were organized using an adapted Kirkpatrick/Barr educational outcomes framework (Kumar et al., 2018) to provide a structured synthesis. Findings were grouped into: (1) learning-related outcomes, including knowledge, attitudes or perceptions, confidence or self-efficacy and skills or competence; (2) behavioral and practice change outcomes; and (3) patient-related outcomes (Yardley et al., 2012). Where studies reported multiple outcomes, findings were classified according to the primary domain addressed by the measure and synthesized across framework levels.

3. Results

3.1. Main characteristics of included studies

Seventeen studies were included (Fig. 1, Table 1). Study designs comprised nine quasi-experimental studies (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016; Gnant et al., 2024; Mackin et al., 2024; Maguire et al., 2019; Monemi and Nematollahi, 2023; Sugavanam et al., 2020), six cross-sectional studies (Allen et al., 2021; Berke et al., 2023; D'Aloja et al., 2020; Hsu et al., 2023; Schwartz et al., 2022; Shalabi and Almurdi, 2024) and two randomized controlled trials (Bonney et al., 2023; Jones et al., 2023). Publication years ranged from 2016 to 2024, with sixteen studies published in the last five years.

The studies were conducted in sixteen countries, with three from Australia (Bonney et al., 2023; Jones et al., 2023; Maguire et al., 2019), three from the Netherlands (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023a, 2023b) and three from the United States (Allen et al., 2021; Berke et al., 2023; Gnant et al., 2024). Additional studies originated

from Taiwan (Chao et al., 2016; Hsu et al., 2023), Canada (Mackin et al., 2024), Iran (Monemi and Nematollahi, 2023), Italy (D'Aloja et al., 2020), Germany (Schwartz et al., 2022) and the United Kingdom (Sugavanam et al., 2020). Eleven studies were conducted in hospital settings (Allen et al., 2021; Bonney et al., 2023; Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016; D'Aloja et al., 2020; Gnant et al., 2024; Hsu et al., 2023; Mackin et al., 2024; Schwartz et al., 2022; Sugavanam et al., 2020), two in community care centers (Berke et al., 2023; Shalabi and Almurdi, 2024) and three in academic or hybrid environments (D'Aloja et al., 2020; Gnant et al., 2024; Mackin et al., 2024).

Reported data-collection periods ranged from July 2010–May 2011 (Chao et al., 2016) to September 2021–December 2022 (Berke et al., 2023), with most studies conducted between 2016 and 2022. Several studies collected data across multi-year intervals (e.g., Bos-Bonnie et al., 2017; D'Aloja et al., 2020; Maguire et al., 2019; Sugavanam et al., 2020), while others reflected more recent periods, including 2019–2020 (Allen et al., 2021), multiple periods in 2020 (Bonney et al., 2023) and 2021–2022 (Hsu et al., 2023; Monemi and Nematollahi, 2023; Schwartz et al., 2022; Mackin et al., 2024; Shalabi and Almurdi, 2024). One study did not report the data-collection period (Gnant et al., 2024).

The included studies targeted a wide range of healthcare professionals, including physician-only samples (e.g., general practitioners, oncologists, hospital physicians), nurse-focused samples (Chao et al., 2016; Hsu et al., 2023; Monemi and Nematollahi, 2023), physiotherapists (Shalabi and Almurdi, 2024) and various multidisciplinary groups (Maguire et al., 2019; D'Aloja et al., 2020; Berke et al., 2023; Bos-van den Hoek et al., 2023a; Mackin et al., 2024). A minority of studies also included patients, either through a distinct patient cohort alongside clinicians or by collecting patient outcomes in parallel with staff outcomes (Chao et al., 2016; Sugavanam et al., 2020).

Sample sizes ranged from 33 participants in quasi-experimental studies (Bos-van den Hoek et al., 2023a) to 21,532 in a large-scale cross-sectional study (D'Aloja et al., 2020). The mean age of participants, when reported, ranged from 30 to 50 years, with variations depending on the target population. The proportion of female participants ranged from 36% to 90.3%, with substantial variability by professional group and setting.

3.2. Methodological quality of included studies

The methodological quality of the included studies was heterogeneous overall (Supplementary Table 3–5). Among the quasi-experimental studies (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016; Gnant et al., 2024; Mackin et al., 2024; Maguire et al., 2019; Monemi and Nematollahi, 2023; Sugavanam et al., 2020), strengths included clear cause-effect relationships, consistent outcome measurement and appropriate statistical analyses. The most frequent limitations were the absence of control groups and incomplete comparability or follow-up.

Among the cross-sectional studies (Allen et al., 2021; Berke et al., 2023; D'Aloja et al., 2020; Hsu et al., 2023; Schwartz et al., 2022; Shalabi and Almurdi, 2024), inclusion criteria, study setting and statistical analyses were generally adequately reported, but confounding factors were often insufficiently identified or addressed. The randomized controlled trials (Bonney et al., 2023; Jones et al., 2023) demonstrated the strongest methodological profile overall, although some limitations in allocation concealment and blinding remained.

Quality assessment indicates predominantly moderate methodological quality, with greater confidence in the randomized evidence and a more cautious interpretation warranted for quasi-experimental, cross-sectional and self-report-based studies.

3.3. Characteristics of e-learning interventions

Studies assessed online modules (Bos-Bonnie et al., 2017; D'Aloja

Table 1

Data extraction of the included articles (n = 17).

Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
Allen et al. The Efficacy of a Web-Based, Educational Quality Improvement Project on Hand Hygiene to Reduce Post-Cesarean Birth Surgical Site Infection. 2021 United States of America Journal of Nursing Practice Applications & Reviews of Research	Cross Sectional Study 2019–2020 Midwest, Tertiary Hospital Evaluate the impact of a web-based educational training initiative on HH for reducing post-cesarean SSI	Purposive sampling of staff from Women's Care Department (labor/delivery, PACU, mother-baby units) Inclusion: Employed staff providing patient care, ≥ 18 years, English-speaking 28 completed responses (19.5% response rate) Range age: from 30 to 59 years, only one above 60 years Approximately 60% completed 4-year college or graduate degree	Web-based HH education based on WHO guidelines Duration: 30-minute presentation, pre-test, post-test, and demographic survey Topics: improving infection control knowledge, attitude, and behavior among care staff	Changes in SSI rates, HH knowledge, and attitudes assessed pre- and post-intervention	WHO 23-item HH questionnaire measuring knowledge (binary scale), attitude, and behavior (Likert scale 1–5) Data collected pre-, post-intervention, and at 1–6 weeks post-intervention	SSI rates decreased significantly: pre-intervention SSI (4 cases in 126 caesarean sections, 3.2%) vs. post-intervention (1 case in 124 caesarean sections, 0.82%, $p < 0.05$) No significant changes in HH knowledge or attitude scores observed ($p > 0.05$)	Reduction in SSI rates attributed to a combination of training and heightened infection control awareness during the COVID-19 pandemic Further interventions recommended for long-term HH compliance and behavior change
Berke et al. New ways to impact primary palliative care practices using online continuing education 2023 United States of America Palliative Care & Social Practice	Cross-Sectional Study Sep 2021- Dec 2022 Rural and Frontier Settings Assess the impact of an online primary palliative care CE series on healthcare professionals' knowledge, competence, performance, and practice habits	158 HPs (41% nurses, 22% social workers) Majority had > 10 years of healthcare experience, only 23% had > 10 years in palliative care Age: both under 18 to elderly Participants represented 9 United States states, mostly from rural and frontier areas	Primary Palliative Care CE Series, fully online and self-paced format. 11 modules delivered via an online learning management system Duration: 1 h/module Topics: advance care planning, symptom management, communication, cultural aspects, self-care, and ethics CE credits offered across multiple disciplines (e.g. nursing, social work)	Outcomes were measured using post-evaluation surveys completed after each module, assessing changes in knowledge, competence, performance, teamwork skills, and intentions to change practice habits Long-term follow-up surveys were also conducted to evaluate the implementation of practice changes over time	Post-Evaluation Surveys: assessed knowledge, competence, performance, and ability to improve patient outcomes (Likert scale: 1–5) CTC: evaluated intended and actual practice changes Long-Term Evaluation: follow-up surveys at 30-, 60-, and 90-days post-module completion	High satisfaction and significant improvement in teamwork skills Moderate improvements in knowledge and competence Participants reported a greater likelihood of implementing practice changes, particularly in patient education and interprofessional communication	Indirect evidence: 41.4% believed education would improve patient outcomes, but no direct measures of clinical or patient-level outcomes were included
Bonney et al. Randomized trial of general practitioner online education for prescribing and test ordering 2023 Australia BMJ Open Quality	Randomized Controlled Trial Jan - Aug 2020, Jun - Aug 2020, Sep - Nov 2020 NR Evaluate the impact of online education on reducing potentially inappropriate prescriptions and low-value diagnostic testing	106 GPs randomized into prescribing (n = 35), pathology (n = 36), and imaging (n = 35) arms Average GP age: 49 years 36% female GPs worked in urban (69%) and rural areas (30%) Inclusion: Australian Pharmaceutical Benefits Scheme prescriber, Medicare provider number, clinical work at least 1 day/week having compatible electronic health	Online education based on Choosing Wisely guidelines. Duration: 6 h over 3 months Topics: rational prescribing, test ordering, and the use of a national health record system (My Health Record) Required peer-to-peer interaction and structured learning	No significant difference in cost or test rates in intention-to-treat analysis Per protocol, pathology test costs decreased significantly by \$187 per 100 consultations ($p = 0.03$) Imaging and prescribing costs showed no significant change	Costs and rates of prescribing, pathology, and imaging requests assessed pre- and post-intervention for 6 months Costs were compared using multilevel regression models Economic analyses included cost-benefit evaluations	Demonstrated potential for scalable online education to reduce low-value pathology testing in GPs Pathology test ordering showed the highest impact; prescribing and imaging ordering required further support	NR

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Table 1 (continued)

Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
		records with PenCS (health analytics company) installed and My Health REcord access Exclusion: absence from clinical work for more than 8 weeks					
Bos-Bonnie et al. Effectiveness of an individual, online e-learning program about sexually transmitted infections: A prospective cohort study 2017 Netherlands BMC Family Practice	Quasi-Experimental Study 2013–2016 NR Evaluate if the online module improves GPs' knowledge, attitude, and behavior regarding STI consultations	2192 Dutch GPs: 33.6% male Mean age: 38.9 Inclusion: All Dutch GPs 249 completed follow-up questionnaires	The STI-consultation e-learning using CtC-method Topics: STI consultation guidelines, testing, treatment Duration: around 2 h, flexible completion	Statistically significant improvement in 5/11 knowledge/attitude measures ($p < 0.05$) Evaluation of changes in learning points (601 points; 97.2% implemented) Intended changes (261 proposed; 34.3% fully implemented, 62.9% partially, 2.8% not implemented)	11-question quick scan (4-point Likert scale) Evaluation: Pre-intervention and 2 years post-program introduction CME-credits awarded upon full completion	Lasting improvements in knowledge, attitude, and behavior up to 2 years post-program Improved STI testing, sexual history-taking practices, and treatment procedures among GPs	NR
Bos-van den Hoek et al. (a) A blended learning for general practitioners and nurses on skills to support shared decision-making with patients about palliative cancer treatment: A one-group pre-post-test study 2023 Netherlands Patient Education and Counselling	Quasi-Experimental Study NR Academic and Non-Academic Hospitals Evaluate the impact of blended learning on GPs and nurses' SDM skills for palliative cancer care	Recruitment from academic and non-academic hospitals 33 participants: 17 GPs (76.5% male, mean age 53.3 years), 16 nurses (100% female, mean age 42.8 years) Inclusion: Experience in oncology care	Blended learning Duration: 1-hour e-learning (4 modules) + 3–3.5-hour interactive training session (in-person or online) Topics: SDM theory, communication strategies, palliative care, and patient needs Role-playing with actors included	SDM Support (Triple-S): Significant improvement (+1.93 points, 95%CI 0.56–3.29, $p = 0.007$) Knowledge: Significant Increased (+1.57 points, 95%CI 0.96–2.17, $p < 0.001$) Observers' Ratings: Overall SDM support improved significantly (+1.19, 95%CI 0.61–1.78, $p < 0.001$) Beliefs about Capabilities: Medium effect size improvement (+0.36, 95%CI 0.13–0.60, $p = 0.001$) SDM Scores: OPTION12 improved (+15.2 points, $p = 0.000$) Knowledge: Increased significantly by + 1.09 points (range: 0–12, $p = 0.012$) Satisfaction: Mean score improved by + 8.63 points ($p < 0.001$) Behavioral Intentions: Only	SDM Skills: Triple-S tool (0–24 scale; measures "checking", "complementing", and "enabling" SDM) Decision Support: DSAT-10 tool (0–10 scale; evaluates decision-making skills) Knowledge: Self-developed 12-item test Satisfaction: 5-point Visual Analogue Scale	Improved SDM skills and knowledge for GPs and nurses Medium to large effects observed in SDM application and observer evaluations Training rated positively (mean: 7.9/10) No significant effects on broader behavioral intentions or satisfaction	Authors note potential long-term benefits for patient-centered decision-making in palliative care
Bos-van den Hoek et al. (b) Blended online learning for oncologists to improve skills in shared decision making about palliative chemotherapy: a pre-post-test evaluation 2023 Netherlands Supportive Care in Cancer	Quasi-Experimental Study Apr - Jun 2022 Academic and Non-Academic Hospitals Evaluate the effectiveness of blended online learning in improving oncologists' SDM skills in palliative chemotherapy	Recruited from academic (52.9%) and non-academic hospitals 17 oncologists (70.6% staff, 64.7% female) Mean age: 42.8 + - 9.68 years, mean experience: 10.2 years Inclusion: regularly conducting SDM in palliative care"	Blended Online SDM Training: combined asynchronous e-learning (~1 h) with synchronous instructor-led online training (3 h). Duration: 4.5 h Topics: SDM theory, application in palliative care, and role-plays with actors Follow-up included	SDM Scores: OPTION12 improved (+15.2 points, $p = 0.000$) Knowledge: Increased significantly by + 1.09 points (range: 0–12, $p = 0.012$) Satisfaction: Mean score improved by + 8.63 points ($p < 0.001$) Behavioral Intentions: Only	Primary Tool: OPTION12 and 4SDM scales assessed observed SDM (video-recorded SPAs) Secondary Tools: Self-reported knowledge and behavioral intentions (12-item Continuing Professional Development tool) Satisfaction measured using a	Effective in improving observed SDM, knowledge, and satisfaction Less effective in changing broader behavioral intentions Training rated positively (mean score: 7.9/10) No increase in consultation time (mean duration: 30 mins)	NR

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Table 1 (continued)

Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
Chao et al. Effects of the Advanced Innovative Internet-Based Communication Education Program on Promoting Communication Between Nurses and Patients with Dementia 2016 Taiwan The Journal of Nursing Research	Quasi- Experimental Study July 2010 - May 2011 Long-Term Care Facilities Evaluate the effects of the AIICE program on nurses' communication knowledge, attitudes, and performance when caring for patients with dementia, and its impact on patient outcomes	Convenience sampling of 105 nurses from long- term care facilities in Southern Taiwan Mean age: 36.1 + - 9.79 years 10.9 years of overall clinical experience 3.9 months of dementia care experience	a pocket guide on SDM steps and phrases AIICE Program: integrated classroom and online learning Duration: 16 weeks with post-tests at 4 and 16 weeks (8 h/ module) Topics: advanced communication strategies, reminiscence therapy, and assessment skills for dementia care Modules included video scenarios, peer discussions, reflective journaling, and 360-degree feedback Emphasized advanced communication strategies and behavioral management in dementia care	beliefs about capabilities improved (+0.41 points, $p = 0.007$) SPA Decision Postponement: Postponement likelihood increased significantly (OR=7.76, $p = 0.039$) Knowledge: significant improvement (baseline: 62.4 +- 13.88; 16-week: 73.3; $p < .001$) Competency: improved significantly by the 16-week test (baseline: 87.3 +- 11.87; 16-week: 90.8; $p < .001$) Attitudes: no significant change (baseline: 102.9 +-8.80; 16- week: 104.1; $p = .11$) Patient Outcomes: memory and behavior problems decreased significantly by the 16th week ($p = .05$)	modified PSQ scale (0–100) Knowledge (CKS- C): scored on a 10- item scale (10–100) Competency (CCS): assessed via frequency and effectiveness of communication (28–112) Patient Outcomes: memory and behavioral issues (RMBP-C) and depressive symptoms (CSDD- C) Pre- and post-tests analyzed with GEE models and Cohen's d for effect sizes	Memory and Behavioral Problems (RMBP- C): mean decreased significantly (baseline: 51.9 +- 15.38; 16-week: 49.5; $p = .04$) Depressive Symptoms (CSDD- C): significant reduction (baseline: 14.1 +- 6.39; 16-week: 12.1; $p = .001$)	The findings indicate that the memory and behavior- related problems and the depressive symptoms of patients had decreased significantly by the 16th-week post-test
D'Aloja et al. Acceptance of e- Learning Programs for Maternity Health Care Professionals Implemented by the Italian Obstetric Surveillance System. 2020 Italy Journal of Continuing Education in the Health Professions	Cross-Sectional Study 2014–2017 Antenatal, intra- natal, and postpartum care Evaluate participation, satisfaction, and perceived quality of case-based e- learning courses on PPH and HDP	21,532 participants: 65.9% midwives, 17.2% obstetricians, 8.8% anesthesiologists, 8.1% other medical specialists Inclusion: Italian healthcare professionals involved in maternity care Mean age: 35.1 (midwives), 48.8 (obstetricians), 45.4 (anesthesiologists)	Free online case- based CME courses. 2 online courses on PPH and one on HDP Duration: 12 h each Topics: - PPH: Definition, prevention, diagnosis, and management of minor/major PPH - HDP: Preeclampsia; hemolysis, elevated liver enzymes, and low platelet count syndrome; and eclampsia Included handbooks, clinical vignettes, problem- solving questions, and discussion forums Required 75% correct answers for CME credits.	High completion rate (85%, 18,310 participants) 86% rated courses as "very/very much relevant, effective, and of quality" 98% of 3500 feedback messages were positive ("Useful/very useful" was the most frequent qualitative feedback term)	Post-course satisfaction measured using a 5- item Likert scale Open-ended feedback analyzed qualitatively Completion and engagement rates	Broad nationwide reach. High acceptance and perceived quality Effective in spreading evidence-based clinical practices but lacked direct assessment of clinical skill improvement or patient outcomes	NR

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Table 1 (continued)

Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
Gnant et al. Assessing Knowledge, Competence, and Performance Following Web-Based Education on Early Breast Cancer Management: Health Care Professional Questionnaire Study and Anonymized Patient Records Analysis 2024 Austria, Malaysia, Australia, Taiwan, United Kingdom, Germany, Brazil JMIR Formative Research	Quasi-Experimental Study NR Europe - excluding United Kingdom, Latin America, Asia-Pacific Evaluate the impact of two web-based CME activities on knowledge, competence, and performance of HCPs in EBC management	7047 participants in touchMDT 8989 in touchPANEL DISCUSSION (oncologists, nurses, radiologists, and pathologists) Majority from Italy, Brazil, France, and Spain	Web-Based CME Activities - touchMDT: Focused on shared decision-making (42 min) - touchPANEL DISCUSSION: Focused on risk stratification and novel treatments (39 min) Both programs included videos, interactive case studies, and quizzes Expert-led, CME-accredited modules delivered via a multilingual platform - Topics: SDM, risk stratification, novel treatments. - Translated into 6 languages. - Free access for 1 year. - Duration: 40 min per module with 7-question quizzes for evaluation	Knowledge: significant improvement in correct responses (e.g., touchMDT: median 4–5.5, $P < .001$) Competence: Improved clinical decision-making scores (e.g., 6/50–22/50 best clinical answers, $P < .001$) Performance: Enhanced use of risk stratification methods	Knowledge and Competence: pre- and post-questionnaires (50 participants/module) Performance: evaluated using anonymized patient records Satisfaction: 5-point Likert scale	Improvements in knowledge and competence were consistent across specialties and regions Satisfaction was high (touchMDT: 82%; touchPANEL: 88%) Approximately 50% of participants intended to change clinical practice	Patient record analysis revealed no significant changes in treatment patterns but improved risk stratification methods
Hsu et al. Effect of involvement and motivation on self-learning: Evaluating a mobile e-learning program for nurses caring for women with gynecologic cancer 2023 Taiwan Nurse Education in Practice	Cross-Sectional Study Mar - Aug 2021 Obstetrics and Gynecology wards Evaluate the learning effects of a mobile e-learning program for nurses caring for women with gynecologic cancer and explore the effects of involvement and motivation	102 nurses participated, 84 completed the program (completion rate: 82.35%) Mean age: 29.25 $\pm$ 7.06 years, 69% aged 20–29 92.9% with a university degree, 64.3% with in-service cancer care training	Mobile e-learning program focused on gynecologic cancer care Duration: NR Topics: illness representation, exercise, and principles of chemotherapy/radiation therapy Virtual mentor and interactive activities were incorporated to enhance involvement and motivation	Cognitive involvement: - Attention $p = 0.015$ - Relevance $p = 0.001$ - Confidence $p = 0.010$ - Satisfaction $p < 0.001$ Motivation elements: - Attention $p = 0.008$ - Relevance $p = 0.037$ 81.9% of the variance in learning effects was explained by involvement and motivation	Revised Personal Involvement Inventory (RPII) (Likert scale 1–7) ARCS motivation model (Attention, Relevance, Confidence, Satisfaction; Likert scale 1–5) Learning effects measured via a structured questionnaire (Likert scale 1–5)	Mobile e-learning enhanced motivation and learning effects, particularly through perceived attention and relevance Cognitive involvement was more impactful than affective involvement Program effectiveness highlighted for enhancing self-directed learning among nurses	NR
Jones et al. eLearning improves allied health professionals' knowledge and confidence to manage medically unexplained chronic fatigue states: A randomized controlled trial 2023 Australia Journal of	Randomized Controlled Trial Oct 2016 - Jun 2017 Nationwide, allied health settings Evaluate the impact of eLearning on allied health professionals' knowledge and confidence in managing medically	239 participants randomized (eLearning: $n = 119$, control: $n = 120$) Majority were exercise physiologists and psychologists, mean clinical experience: 9.6 years Mean age: NR	Interactive eLearning program delivered via SmartSparrow platform Duration: 4 weeks Topics: seven modules (e.g., psychoeducation, graded exercise therapy, CBT for mood and anxiety). Required 8.8 h on average to complete	Knowledge Scores: Improved in eLearning group by 8.6% (95% CI 5.9–11.4) compared to control (baseline to post, $p < 0.001$). Retained at follow-up, still 6% (95% CI 3.7–8.3) higher than baseline ($p < 0.001$). Confidence in Knowledge:	Knowledge Assessment: Total score out of 100 based on multiple-choice and short-answer questions linked to clinical vignettes. Scores analyzed pre- and post-intervention and at follow-up. Confidence Assessment: 5-point Likert scale evaluating knowledge (e.g.,	Effective in enhancing knowledge and confidence for fatigue states management among allied health professionals High satisfaction (91% would recommend the course) Changes in clinical practice behavior were minimal,	NR

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Psychosomatic Research	unexplained chronic fatigue states			Median increase of 1.2 in eLearning group vs. 0 in control (p < 0.001). Confidence in Clinical Skills: Median increase of 1.0 in eLearning group vs. 0.1 in control (p < 0.001). Adherence: 87% of eLearning participants completed all modules Satisfaction: 91% would recommend the program	diagnostic skills) and clinical skills (e.g., patient education). Engagement Metrics: Time spent per module, adherence (completion rate), and satisfaction scores tracked. Open-ended feedback collected post-intervention	requiring further intervention	
Mackin et al. Online palliative care education and mentorship in Nepal: Project ECHO - a novel approach to improving knowledge and self-efficacy among interprofessional health-care providers 2024 Canada Palliative and Supportive Care	Quasi-Experimental Study Jan - Apr 2022 Government, hospice, and university hospitals Evaluate the impact of the Project ECHO virtual palliative care training program in Nepal on knowledge, comfort, and attitudes of participants	42 participants (22 nurses, 20 physicians) Majority worked in government hospitals (69%) and urban settings (90%) Specialties included oncology (38%), general practice (24%), and internal medicine (19%)	Project ECHO Palliative Care Training: interactive virtual format using Zoom, content tailored to local healthcare needs and cultural considerations Duration: 12 weekly 1-hour sessions Topics: pain management, grief, end-of-life care, and ethics Video recordings, downloadable resources, and session summaries, and WhatsApp group for discussions Focused on mentorship and building communities of practice (COP)	Knowledge: significant improvement in all areas (e.g., pain management) Comfort: improved in 12/12 areas, e.g., discussing transitions to palliative care Attitudes: significant improvement in 6/8 areas, e.g., understanding opioids (p < .05) Satisfaction: 93% found the program a supportive COP, and 89% would recommend it	Knowledge & Comfort: Likert-scale surveys before and after sessions Attitudes: assessed changes in attitudes toward palliative care Program Acceptability: surveys on satisfaction, barriers, and use of learning materials	Participants reported improved communication and comfort in discussing palliative care but felt additional clinical training was needed	Participants noted improved confidence and ability to provide palliative care but no direct measures of patient-level outcomes were reported
Maguire et al. Evaluating the effectiveness of an evidence-based online training program for health professionals in eating disorders 2019 Australia Journal of Eating Disorders	Quasi-experimental Study Oct 2013 - Jul 2018 Nationwide, with limited international participants Evaluate the impact of an online training program (The Essentials) on improving knowledge, skills, and attitudes of health professionals treating EDs	1813 participants - 90.3% female - 52.5% metropolitan - 44.3% regional/rural Professions: psychologists (29.7%), nurses (21.7%), dietitians (15.4%), social workers (11%) Most (87.8%) had prior ED cases, 62% had ≤ 5 h of training	The Essentials Program, an online, evidence-based training initiative aimed at improving the capacity of health professionals to manage eating disorders (EDs) Duration: 17.5 h (3.5 h per module) Topics: five interactive modules covering ED diagnosis, treatment, and management (e.g., AN, BN, BED). Included quizzes, role-plays, videos, and case-based	Confidence: Significant improvement in confidence (+1.1 points on 5-point scale, p < 0.001) - Knowledge: Increased from 2.67 to 3.73 (+1.1 points, p < 0.001) - Skills: Improved by 1.28 points (p < 0.001) - Stigma: Decreased by 0.33 points (p < 0.001) - Willingness: No significant change (pre: 4.11, post: 4.17)	Pre/Post Questionnaires: assessed willingness, confidence, knowledge, skills, attitudes, and stigma (Likert scale 1–5)	Effective in improving knowledge, skills, and confidence among health professionals across settings Stigma reduction was notable High satisfaction: 90.5% were satisfied with the program, 96.8% met expectations, 99.1% would recommend the program. Limited effects on willingness (no significant increase in the	NR

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Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
Monemi and Nematollahi Online education and improvement of caring behaviors of nurses in pediatric wards: a quasi-experimental study. 2023 Iran BMC Nursing	Quasi-Experimental Study Mar - May 2021 Pediatric intensive care units and wards Evaluate the impact of online education on pediatric nurses' caring behaviors	70 nurses: 35 interventions, 35 controls Range age: 20–30 years Inclusion: Bachelor's degree, ≥ 6 months pediatric experience Exclusion: Missing > 4 h of sessions	learning Designed for health professionals in diverse disciplines. Online education via virtual classrooms (Sky Room) and WhatsApp Duration: 3 days a week for 4 weeks Topics: Pediatric nursing care principles, communication, advanced procedures	Statistically significant improvement in caring behaviors (mean score: 275.69 ± 6.52) vs. control (254.21 ± 3.15), (P = 0.001) Significant improvements in all Care-Q subscales (e.g., "trusting relationship," "comforts")	Care-Q questionnaire with 57 items (5-point Likert scale) Evaluation: Pre- and post-intervention (1 month apart)	willingness, p = 0.740) Enhanced caring behaviors and professional skills among pediatric nurses Demonstrated effectiveness of virtual education for improving clinical competence and caring behaviors.	NR
Schwartz et al. Palliative Care e-Learning for Physicians Caring for Critically Ill and Dying Patients during the COVID-19 Pandemic: An Outcome Evaluation with Self-Assessed Knowledge and Attitude 2022 Germany International Journal of Environmental Research and Public Health	Cross-Sectional Study Apr - Jun 2022 University Hospital Düsseldorf, physicians caring for critically ill and dying patients during the COVID-19 pandemic Evaluate the feasibility and impact of an e-learning tool on knowledge and attitudes of physicians caring for critically ill and dying patients during the COVID-19 pandemic	80 physicians contacted (35 intensivists, 34 gastro-oncologists, 11 uro-oncologists) Mean age: 35–44 years Range age: 18–64 42% female	PallPan: E-Learning Tool, fully online and asynchronous Duration: 60 min/Section (8 section) Topics: palliative care basics, symptom control, communication skills (e.g., digital conversations), interprofessional collaboration, and end-of-life care Included videos, checklists, and quizzes	Knowledge Gains: highest gains for understanding palliative care integration and interprofessional collaboration (CSA +78%) Attitude Gains: lowest gains in dealing with mortality (CSA +27%). Significant gains in 23/24 items Feasibility: 96% overall satisfaction; 100% found the tool useful for work	Questionnaire: 42 items (24 for knowledge/attitude, 14 for feasibility, 4 demographics) Knowledge & Attitude: CSA method with German school grading scale (1 = excellent, 6 = unsatisfactory)	24 completed the study (30% response rate) Demonstrated high feasibility and significant knowledge gains among participants Attitude changes were less pronounced, particularly in existential topics like dealing with mortality Tool rated highly for relevance and usability	NR
Shalabi and Almurdi Satisfaction and attitudes towards online continuous medical education and its impact on clinical practice among physiotherapists 2024 Kingdom of Saudi Arabia BMC Medical Education	Cross-Sectional Study Oct 2021- Jan 2022 Rehabilitation Sciences Department, College of Health and Rehabilitation Science Assess satisfaction, attitudes, and clinical impact of OCME among PTs in Saudi Arabia	127 PTs 37.8% female mean age: 44.1 range age 24–30 years Inclusion: PTs currently or previously enrolled in OCME programs Exclusion: Non-completion of survey	OCME programs for PTs delivered nationwide via flexible online courses Duration: NR Topics: Musculoskeletal, neurological, and rehabilitation practices Focused on improving clinical decision-making and patient care Tutor-guided interactive discussions provided Evaluation: 20-item survey addressing quality, tutor support, content, flexibility, and practical application	Satisfaction: 57.5% satisfied overall; high scores for content (54.3%) Attitudes: 63.8% agreed OCME improves knowledge; 55.1% reported improved patient outcomes Impact: Older PTs and those specializing in musculoskeletal disorders reported significantly higher scores	Survey Design: 20-item validated questionnaire (I-CVI: 1 for 19 items; S-CVI/Ave: 0.99) Scales: Likert scale (1–5) for satisfaction, attitudes, and impact	High satisfaction and positive attitudes toward OCME Significant perceived improvements in knowledge (63.8%) and patient outcomes (55.1%) Clinical skill improvement rated lower (46.5%). Age and specialization strongly associated with higher satisfaction and impact	Indirect improvements reported in patient outcomes attributed to increased confidence and knowledge

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Table 1 (continued)

Authors Title Year Country Journal	Study Design Data collection Year Setting Principal aim(s)	Sampling method/ sample size Inclusion criteria Participants Main characteristics	Intervention delivered and/or measured Tool characteristics Duration Topic	Outcomes	Outcomes' measures	Results	Patients' outcome
Sugavanam et al. Evaluation of the implementation of the Back Skills Training (BeST) programme using online training: a cohort implementation study 2020 United Kingdom, Canada Physiotherapy	Quasi-Experimental Study Mar 2016 - Aug 2018, Mar 2016 - May 2019 NHS Trusts Evaluate the implementation of the BeST program through online training for clinicians and its impact on patient outcomes in LBP management	Stage 1: 1324 clinicians (94% physiotherapists) from 157 NHS Trusts; median experience > 10 years Stage 2: 923 patients (68% female) mean age of 55.2 years mean LBP duration of 12.8 years	BeST Online Training Program: developed using Adobe Captivate and hosted on Amazon Web Services Adaptation of the CBA for LBP from the BeST trial 10 interactive modules, including videos, quizzes, case vignettes, and downloadable therapist/patient materials Duration: 10 h Topics: pain education, goal setting, pacing, and psychosocial risk factors Clinicians required to score $\geq 80\%$ to earn certification	Significant shift toward biopsychosocial attitudes (median change: -4 on biomedical, $+2$ on psychosocial scales). 57% intended to implement BeST; 33% actually implemented it Barriers: lack of time, managerial support, and suitable patients	Stage 1 (Clinicians): PABS for biomedical and psychosocial attitudes Confidence and intention assessed via PCS and follow-up surveys Stage 2 (Patients): NRS for pain, PSFS for function, and GROc for recovery	Pain: Small effect size (0.34, 95% CI 0.23–0.45) for pain improvement at 12 months Function: medium to large effect size (0.56, 95% CI 0.42–0.71) 77% of patients reported improvement post-treatment Satisfaction: > 80% satisfaction with the program	Pain Reduction: small but significant improvement in pain scores (NRS), with an effect size of 0.34 (95% CI 0.23–0.45) at 12 months Functional Improvement: medium to large improvement in function (PSFS), with an effect size of 0.56 (95% CI 0.42–0.71) Global Recovery: 77% of patients reported improvement post-treatment based on GROc Satisfaction: over 80% of patients were satisfied with the program

AIICE: Internet-based communication education; AN: Anorexia Nervosa; BeST: Back Skills Training; BED: Binge Eating Disorders; BN: Bulimia Nervosa; CBA: Cognitive Behavioral Approach; CBT: Cognitive Behavioral Therapy; CCS: Communication Competency Scale; CD-ROM: Compact Disc Read Only Memory; CE: Continuing Education; CKS-c: Communication Knowledge Scale-Chinese version; CME: Continuing Medicine Education; CPD: Continuing Professional Development; COVID-19: Corona Virus Disease 2019; CSA: Comparative Self-Assessment; CSDD-C: Cornell Scale for Depression in Dementia-Chinese version; Ctc: Commitment-to-Change; DSAT-10: Brief Decision Support Analysis Tool; EBC: Early Breast Cancer; ECHO: Extensions for Community Health Care Outcomes; EDs: Eating Disorders; GEE: Generalized Estimating Equation; GP: General Practitioner; GROc: Global Rating of Change; HCPs: Healthcare Professionals; HDP: Hypertensive Disorders of Pregnancy; HH: Hand Hygiene; HIC: High Income Countries; HP: Health Professional; I-CVI: Item Content Validity Index; LBP: Low Back Pain; LMIC: Low- and Middle-Income Countries; mLearning: Mobile Learning; NR: Not Reported; NRS: Numerical Rating Scale; OCME: Online Continuous Medical Education; OPTION 12: Observing Patient Involvement Scale; OR: Odds Ratio; OSAT: Objective Structured Assessment of Training; PABS: Pain Attitude and Belief Scale; PACU: Pediatric Acute Care Unit; PallPan: Palliative Care in Pandemic Times; PCS: Perceived Competence Scale; PICU: Pediatric Intensive Care Unit; PPH: Postpartum Hemorrhage; PSFS: Patient-Specific Functional Scale; PSQ: Patient Satisfaction Questionnaire; PTs: Physiotherapists; RCT: Random Clinical Trial; RMBP-C: Revised Memory and Behavior Problems Checklist-Chinese Version; S-CVI: Scale Content Validity Index; SDM: Shared Decision-Making; SPA: Simulated Consultations; SSI: Surgical Site Infection; STI: Sexual Transmitted Infection; WHO: World Health Organization

et al., 2020; Gnant et al., 2024; Maguire et al., 2019; Sugavanam et al., 2020), mobile learning applications (Hsu et al., 2023), virtual classrooms (Monemi and Nematollahi, 2023; Mackin et al., 2024) and blended learning approaches (Bos-van den Hoek et al., 2023a, 2023b). E-learning intervention duration ranged from 30 min (Allen et al., 2021) to several months (Mackin et al., 2024; Maguire et al., 2019; Sugavanam et al., 2020). The most frequent topics were oncology, pediatric nursing, palliative care, sexual health, infection control and low back pain management, although several studies (e.g., Bos-Bonnie et al., 2017) addressed broader competencies and cross-cutting themes such as maternity emergencies (e.g., D'Aloja et al., 2020), dementia communication (e.g., Chao et al., 2016), medically unexplained fatigue (e.g., Jones et al., 2023) and low-value care (e.g., Bonney et al., 2023).

Regarding e-learning delivery models:

- Seven studies adopted a self-paced, asynchronous e-learning model, often framed as online continuing medical education (CME) (Allen et al., 2021; Berke et al., 2023; Bos-Bonnie et al., 2017; Gnant et al., 2024; Maguire et al., 2019; Schwartz et al., 2022; Sugavanam et al.,

2020). These interventions were typically delivered through web-based platforms or learning management systems and organized as single sessions or multi-module curricula. Instructional design generally combined didactic content with quizzes or tests.

- Five studies adopted interactive, application-oriented e-learning, operationalized through case-based or vignette-driven activities, structured clinical problem solving and platform-enabled interactivity aimed at strengthening decision-making and guideline-concordant practice (Bonney et al., 2023; D'Aloja et al., 2020; Jones et al., 2023; Maguire et al., 2019; Sugavanam et al., 2020). Some programs (e.g., D'Aloja et al., 2020) incorporated explicit completion standards or structured engagement requirements.
- Seven studies adopted supported or facilitated models, integrating facilitation and ongoing interaction into the intervention (Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016; Hsu et al., 2023; Mackin et al., 2024; Monemi and Nematollahi, 2023; Shalabi and Almurdi, 2024). These included blended interventions, mentorship-oriented synchronous virtual programs and tutor-guided

online formats emphasizing feedback, peer discussion, role-play and community-of-practice features.

3.4. Learning-related outcomes

Table 2 summarizes the outcome category, outcome measure type (self-report, observed, or objective), follow-up length and main direction of findings. Outcomes were predominantly assessed using self-administered questionnaires (e.g., Berke et al., 2023), most often capturing perceived changes in knowledge, competence, attitudes, motivation and confidence (e.g., Hsu et al., 2023). Objective skills observation, routine administrative indicators (e.g., Bonney et al., 2023) and patient-level outcomes (e.g., Allen et al., 2021) were reported less frequently.

Regarding follow-up timing, most evaluations were conducted immediately post-intervention, although some included longitudinal assessment. Allen et al. (2021) collected data pre-intervention, immediately post-intervention and at 1–6 weeks post-intervention. Berke et al. (2023) included follow-up at 30, 60 and 90 days. Bos-Bonnie et al. (2017) assessed outcomes at a 2-year timepoint. Chao et al. (2016) used repeated post-testing at 4 and 16 weeks. Monemi and Nematollahi (2023) assessed outcomes pre- and post-intervention approximately one month apart.

3.4.1. Knowledge

Knowledge-related outcomes were the most frequently measured, either through brief pre-/post-tests or self-rated knowledge items (Allen et al., 2021; Berke et al., 2023; Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016; Gnani et al., 2024; Jones et al., 2023; Mackin et al., 2024; Maguire et al., 2019; Schwartz et al., 2022). Metrics ranged from structured questionnaires, such as the WHO 23-item hand hygiene questionnaire used by Allen et al. (2021), to study-developed knowledge tests, including the 12-item test used in Bos-van den Hoek et al. (2023a) and vignette-linked scoring systems

such as the total knowledge score out of 100 reported by Jones et al. (2023). Schwartz et al. (2022) used a Clinical Scenario Assessment-based questionnaire with a German grading scale.

Knowledge acquisition consistently emerged as an outcome in several studies. In Italy, case-based CME courses on maternity care had an 85% completion rate, with 86% of participants rating the training as very relevant and effective and 98% providing positive feedback (D'Aloja et al., 2020). Nurses in Taiwan completing a mobile learning program on gynecologic cancer care showed a statistically significant increase in cognitive involvement and motivation, with learning effects explaining 81.9% of the variance in knowledge improvement (Hsu et al., 2023). Among physiotherapists, online continuing medical education was associated with positive perceived impact, including 63.8% agreeing it improved knowledge (Shalabi and Almurdi, 2024). One study reported more structured learning gains, such as a statistically significant increase of +1.09 points on a 12-item shared decision-making scale among oncology professionals in the Netherlands (Bos-van den Hoek et al., 2023b). Allen et al. (2021) also reported increased SSI-prevention knowledge following a web-based education program in the United States.

3.4.2. Attitudes, perceptions, confidence and self-efficacy

Attitudes, motivation, acceptability and satisfaction were commonly captured as secondary outcomes, largely via self-report. Eight studies reported measurable shifts in attitudes, perceptions, confidence, or related constructs following e-learning interventions mainly as self-reported perceptions (Bos-van den Hoek et al., 2023a, 2023b; Gnani et al., 2024; Jones et al., 2023; Maguire et al., 2019; Monemi and Nematollahi, 2023; Schwartz et al., 2022; Sugavanam et al., 2020). An online program on eating disorder management led to a significant reduction in stigma, with a decrease of 0.33 points on a 5-point stigma scale (Maguire et al., 2019). Schwartz et al. (2022) observed moderate improvements in attitudes towards mortality management among physicians participating in the PallPan training, with a 27% gain in dealing

Table 2

Overview of included studies (n = 17) according to study design, outcome category, measure type, follow-up length, and main direction of findings.

Study	Main outcome type*	Outcome measure type	Follow-up length	Main direction of findings
Allen et al., (2021)	Knowledge; patient/system outcome	Mixed: self-report + objective system outcome	Immediate post + 1–6 weeks	Positive
Berke et al., (2023)	Knowledge/competence; intention to change practice	Primarily self-report	30, 60, 90 days	Positive
Bonney et al., (2023)	Behaviour/practice change outcome	Objective report/routine data	6 months	Positive
Bos-Bonnie et al., (2017)	Knowledge; practice change	Mixed: self-report + implementation follow-up	2 years	Positive
Bos-van den Hoek et al., (2023a)	Attitudes/confidence; observed performance	Mixed: self-report + observed performance	Immediate post	Positive
Bos-van den Hoek et al., (2023b)	Knowledge; skills; observed performance; practice change	Mixed, observed component + self-reported	Immediate post	Positive
Chao et al., (2016)	Knowledge; communication competence; patient outcome	Mixed: observed/structured measures + patient outcomes	4 and 16 weeks	Positive
D'Aloja et al., (2020)	Knowledge/perceived effectiveness	Primarily self-report	Immediate post	Positive
Gnani et al., (2024)	Knowledge; intention to change; process/performance	Mixed: self-report + anonymized records	Immediate post / not clearly extended	Positive
Hsu et al., (2023)	Knowledge; motivation; learning effects	Primarily self-report	Immediate post	Positive
Jones et al., (2023)	Knowledge/attitudes; recommendation	Primarily self-report	Immediate post	Positive
Mackin et al., (2024)	Skills/communication competence; patient/family satisfaction	Primarily self-report, with patient/family report	Several months / program duration; exact post timing not fully clear	Positive
Maguire et al., (2019)	Attitudes; skills; knowledge	Primarily self-report	Immediate post	Positive
Monemi and Nematollahi, (2023)	Attitudes; technical/caring skills	Structured scales, largely self-report/scale-based	About 1 month	Positive
Schwartz et al., (2022)	Knowledge; attitudes	Primarily self-report / structured questionnaire	Immediate post	Positive
Shalabi and Almurdi, (2024)	Perceived knowledge and patient impact	Primarily self-report	Immediate post	Positive
Sugavanam et al., (2020)	Attitudes; intention/implementation; patient outcomes	Mixed: self-report + patient outcome measures	Up to 12 months	Positive

*According to adapted Kirkpatrick/Barr educational outcomes framework (Kumar et al., 2018), including (1) learning-related outcomes, including knowledge, attitudes or perceptions, confidence or self-efficacy, and skills or competence; (2) behavioral and practice change outcomes; and (3) patient-related outcomes.

with existential aspects of care. Pediatric nurses in Iran reported significantly improved attitudes towards patient trust and comfort following a virtual classroom intervention (Monemi and Nematollahi, 2023). In an online fatigue management program, 91% of participants recommended the interventions learnt (Jones et al., 2023). Oncology and palliative care e-training also enhanced clinicians' confidence and beliefs about their capabilities (Bos-van den Hoek et al., 2023a, 2023b). BeST online training shifted clinicians toward a more biopsychosocial orientation (median -4 biomedical; +2 psychosocial) (Sugavanam et al., 2020). Hsu et al. (2023) also operationalized motivational constructs using the Revised Personal Involvement Inventory and the ARCS (Attention, Relevance, Confidence, Satisfaction) model. Some of these studies also reported observed performance outcomes, including improved shared decision-making performance in simulated consultations, with observer-rated SDM support increasing by +1.19 points among GPs and nurses and OPTION12 scores increasing by +15.2 points among oncologists (Bos-van den Hoek et al., 2023a, 2023b). Other performance-related findings included improved communication competence in dementia care, rising from 87.3 to 90.8 at 16 weeks (Chao et al., 2016), improved caring behaviors among pediatric nurses, with higher post-intervention Care-Q scores in the intervention group compared with controls (275.69 ± 6.52 vs. 254.21 (SD 3.15), $P = 0.001$) (Monemi and Nematollahi, 2023) and improved practice implementation, with 97.2% of STI-related learning points implemented and 33% of clinicians actually implementing the BeST program in low back pain care (Bos-Bonnie et al., 2017; Sugavanam et al., 2020). Overall, the direction of results has been positive, suggesting improvements in selected observed or practice-related performance outcomes, although translation into routine and sustained clinical practice remained less consistent.

3.4.3. Skills and competence

Skills and competences were measured in a smaller number of studies. Four relied on self-reported perceptions of competence or learning effects measured with Likert-type scales (Berke et al., 2023; Hsu et al., 2023; Maguire et al., 2019; Shalabi and Almurdi, 2024). In contrast, others included observed performance outcomes: Bos-van den Hoek et al. (2023a) after a blended learning intervention quantified decision support with the Triple-S and DSAT-10 tools, while Bos-van den Hoek et al. (2023b) after a blended online training intervention assessed observed shared decision-making using OPTION12 and 4SDM scales on recorded simulated consultations. In nursing, Chao et al. (2016) measured communication competence with the Communication Competence Scale and Monemi and Nematollahi (2023) assessed caring behaviors using the Care-Q tool.

Four studies measured skill acquisition as a key outcome (Bos-van den Hoek et al., 2023b; Mackin et al., 2024; Maguire et al., 2019; Monemi and Nematollahi, 2023). Some results reflected self-reported perceptions of improved competence. In an online training program for eating disorder management, healthcare professionals demonstrated an average increase of 1.28 points in clinical skills on a 5-point scale (Maguire et al., 2019). In Nepal, virtual palliative care program enhanced communication skills, with 93% of participants reporting increased comfort in discussing palliative care and 89% stating they would recommend the training to colleagues (Mackin et al., 2024). Other studies were based on observed performance outcomes. Oncology professionals undergoing blended learning showed significant improvement in shared decision-making skills, reflected in a +1.19 point increase in observed shared decision-making support ratings (95% CI 0.61–1.78, $P < 0.001$) (Bos-van den Hoek et al., 2023b). Pediatric nurses in Iran demonstrated improvements in technical skills, with statistically significant gains in patient interaction and procedural competencies following their virtual education program (Monemi and Nematollahi, 2023).

3.5. Behavioral and practice change

Behavioral and practice change outcomes were less frequently reported and were assessed using heterogeneous methodologies. A Commitment-to-Change approach was used to capture self-reported intentions to change practice and/or subsequent practice change in two studies (Berke et al., 2023; Bos-Bonnie et al., 2017). Sugavanam et al. (2020) quantified clinicians' intention to implement and actual implementation of the BeST programme. Gnant et al. (2024) reported that approximately 50% of participants intended to change clinical practice after completing the course.

Four studies provided evidence of effects on behavior change (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023a, 2023b; Sugavanam et al., 2020). This evidence included both self-reported intentions to change practice and more concrete indicators of implementation. In the Netherlands, general practitioners participating in an online program on sexually transmitted infections implemented 97.2% of the learning points over two years, with 34.3% of intended changes fully integrated into practice, 62.9% partially implemented and only 2.8% not applied (Bos-Bonnie et al., 2017). In the United Kingdom, the BeST program led to a 57% intention rate among physiotherapists to adopt a biopsychosocial approach to low back pain management, with 33% reporting actual implementation in practice (Sugavanam et al., 2020). In oncology, blended learning was associated with higher observed patient involvement in decision making, reflected in a 15.2-point increase on OPTION12 (Bos-van den Hoek et al., 2023b).

3.6. Patient-related outcomes

Patient-related outcomes were considered in a minority of studies and were heterogeneous in type and measurement. Allen et al. (2021) measured surgical site infection rates pre- and post-intervention alongside hand hygiene outcomes. Sugavanam et al. (2020) included patient outcomes using the Numeric Rating Scale for pain, the Patient-Specific Functional Scale for function and the Global Rating of Change for perceived recovery. Chao et al. (2016) assessed patient outcomes in dementia care, including memory and behavioral problems and depressive symptoms. Mackin et al. (2024) reported increased satisfaction among patients and families following virtual palliative care training. By contrast, Shalabi and Almurdi (2024) primarily reported clinicians' self-reported perceptions of patient impact rather than direct patient-level outcomes and therefore should be interpreted cautiously.

E-learning interventions contributed to improved patient safety in some settings. These findings were based mainly on objective patient/system outcomes. Allen et al. (2021) reported a 74.4% reduction in post-caesarean surgical site infections following a web-based hand hygiene and infection control program, with SSI rates decreasing from 3.2% pre-intervention to 0.82% post-intervention. In Taiwan, Chao et al. (2016) found that patients with dementia receiving care from nurses trained through the AIICE program exhibited a significant reduction in memory and behavioral problems ($P = 0.04$) and depressive symptoms ($P = 0.001$). In the BeST program, downstream patient outcomes improved, with a pain reduction effect size of 0.34 (95% CI 0.23–0.45) and a functional improvement effect size of 0.56 (95% CI 0.42–0.71) at 12 months (Sugavanam et al., 2020).

Patient satisfaction was reported less frequently. Mackin et al. (2024) observed that virtual palliative care training enhanced healthcare providers' communication skills and comfort in delivering end-of-life care, leading to increased satisfaction among patients and families. Sugavanam et al. (2020) found that 77% of patients treated by physiotherapists through the BeST program reported improvement in their condition, accompanied by higher patient-reported satisfaction. Allen et al. (2021) suggested indirect improvements in patient satisfaction associated with reduced post-caesarean SSI rates.

4. Discussion

4.1. Interpretation of the main findings

Overall, review findings suggest that e-learning can support continuing professional development among healthcare professionals, but the strength of the evidence differs substantially according to the outcome level examined. The most consistent effects are observed for proximal educational outcomes especially regarding self-reported knowledge gain, confidence, motivation and perceived competence, understood as immediate or near-term learning-related effects of an educational intervention (Allen et al., 2022). This pattern is consistent with broader digital education literature, which has repeatedly shown that e-learning more often demonstrates benefits on immediate learning-related outcomes than on sustained behavioral change or patient-level effects (Sinclair et al., 2016; Vaona et al., 2018; Tudor Car et al., 2022). Nursing-specific reflections points in the same direction: e-learning appears acceptable and useful for continuing education, but the strongest findings remain concentrated in reactions, knowledge and skills rather than in practice transfer or patient outcomes (Alfaleh et al., 2023; Rouleau et al., 2019).

At the same time, proximal outcomes are mainly self-reported perceptions (Allen et al., 2021; Berke et al., 2023; D'Aloja et al., 2020; Hsu et al., 2023; Jones et al., 2023; Mackin et al., 2024; Maguire et al., 2019; Monemi and Nematollahi, 2023; Schwartz et al., 2022; Shalabi and Almurdi, 2024; Sugavanam et al., 2020) or self-reported intentions to change practice (Berke et al., 2023; Bos-Bonnie et al., 2017; Gnant et al., 2024; Sugavanam et al., 2020) than observed performance outcomes (Bos-van den Hoek et al., 2023a, 2023b; Chao et al., 2016), or objective patient/system outcomes (Allen et al., 2021; Bonney et al., 2023; Chao et al., 2016; Sugavanam et al., 2020). This patterns in the measures suggests that the field is more prone to measure perceptions than at demonstrating objective and durable changes in practice. This interpretation is reinforced by the predominance of quasi-experimental and cross-sectional designs, the frequent use of short follow-up periods and the relatively limited use of objective measures. It is also consistent with broader syntheses in digital health professions education, which show that evidence becomes weaker and more heterogeneous, particularly when long-term impact and transferability across settings are considered (Rouleau et al., 2019; Tudor Car et al., 2022; Vaona et al., 2018).

In terms of temporal distribution, the evidence base included in this review spans both the pre-restrictions and restrictions/post-restrictions periods. Of the 17 included studies, six were conducted before the COVID-19 restrictions, nine during or after the restrictions period and two could not be clearly classified because the data-collection period was not reported or was insufficiently explicit. The restrictions did not introduce e-learning into continuing professional development, as on-line and blended formats had already been evaluated before 2020. However, the predominance of studies conducted during or after the restrictions suggests that COVID-19 accelerated both the implementation and formal evaluation of digital education among healthcare professionals.

This acceleration was both quantitative and qualitative, reinforcing the role of e-learning as a flexible and practice-relevant infrastructure for continuing professional development rather than merely an alternative to in-person education (Ng et al., 2022; Boutros et al., 2023; Alfaleh et al., 2023). This shift is also reflected in the growing use of telehealth teaching, remote clinical participation and telesimulation as more integrated forms of digital professional learning (Jumreornvong et al., 2020; Weber et al., 2021; Yasser et al., 2023). At the same time, the restrictions context may have influenced the outcomes observed in the included studies. Greater familiarity with digital platforms, organizational pressure to maintain training remotely and increased acceptance of online formats may have contributed to favorable perceptions of e-learning. Therefore, the generally positive findings should be interpreted not only as evidence of intervention effectiveness, but also in

light of the broader post-restrictions normalization of digital learning in healthcare education. From this perspective, future evaluations should move beyond short-term learning gains and examine whether e-learning supports implementation, adaptability, workforce digital capability and continuity of care in changing clinical environments (Ogundiya et al., 2024; Kaihlanen et al., 2024).

4.2. Learning-related outcomes, practice changes and patient outcomes

Across the included studies, the clearest and most recurrent gains were observed for learning-related outcomes, particularly knowledge, confidence, perceived competence and attitudes. These improvements were reported across diverse clinical areas, including palliative care, shared decision-making, eating disorders, chronic fatigue states, sexually transmitted infections, dementia care and low back pain management (Bos-Bonnie et al., 2017; Jones et al., 2023; Maguire et al., 2019; Mackin et al., 2024; Sugavanam et al., 2020). Overall, e-learning appeared most consistently effective when outcomes were proximal to the educational intervention, whereas the evidence became less consistent as outcomes moved towards clinical behaviour, care processes and patient-level effects. This suggests a gradient of evidence, with stronger support for educational gains and more limited support for downstream practice and patient-related impact.

Within this more limited evidence base, some studies suggested that e-learning may be associated with practice-related gains (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023b; Gnant et al., 2024; Sugavanam et al., 2020) and, less frequently, with patient-related gains (Allen et al., 2021; Chao et al., 2016; Mackin et al., 2024; Sugavanam et al., 2020). For practice change, however, a distinction between intention and actual implementation is required. Several studies reported participants' intention to change practice after training (Berke et al., 2023; Bos-Bonnie et al., 2017; Gnant et al., 2024; Sugavanam et al., 2020), but fewer documented implementation in routine care (Bos-Bonnie et al., 2017; Bos-van den Hoek et al., 2023b; Sugavanam et al., 2020). From this perspective, e-learning may improve readiness for change, but whether this becomes actual practice change depends on factors beyond the educational intervention itself.

Similarly, evidence for patient or system-level impact remained limited. The strongest evidence came from a small number of studies reporting objective or directly measured patient/system outcomes (Allen et al., 2021; Chao et al., 2016; Sugavanam et al., 2020), whereas other studies inferred patient benefit from patient-reported satisfaction or indirect changes in care delivery (Mackin et al., 2024; Shalabi and Almurdi, 2024; Sugavanam et al., 2020). E-learning is therefore more likely to have long-term impact when linked to clearly defined care processes, integrated into implementation activities and aligned with workflow and opportunities for practical application. This interpretation is consistent with the broader continuing professional development literature, which emphasizes that education alone rarely changes practice unless organizational support, reinforcement and contextual integration are also present (Al-Omary et al., 2024; Cervero and Gaines, 2015).

4.3. Implications for nursing and midwifery practice

Continuing professional development is closely linked to competence maintenance, care quality, patient safety and responsiveness to evolving clinical needs (Vázquez-Calatayud et al., 2021). In both professions, e-learning can widen access to education for professionals working shifts, in understaffed settings, or across geographically dispersed services, while also supporting rapid updating of guideline-based knowledge and scalable access to structured educational resources (Alfaleh et al., 2023). This is especially important in clinical areas where maintaining up-to-date knowledge and decision-making is essential despite limited time for conventional face-to-face training.

At the same time, e-learning should not be considered sufficient. In

nursing, continuing education is often expected to support knowledge acquisition and safer care delivery, but also improved professional confidence and adaptation to changing care pathways (Vázquez-Calatayud et al., 2021; Kurtović et al., 2024). In midwifery, it is particularly important in relation to high-stakes and relatively low-frequency situations, including obstetric emergencies and complication management, where timely updating and rehearsal of knowledge are essential (Musie et al., 2025). In both professions, competence development also depends on relational, contextual and practice-based dimensions that are not fully captured through stand-alone online delivery. Therefore, findings support the use of e-learning as part of broader educational strategies rather than as a replacement for clinically situated learning, with likely greatest value when integrated with supervised practice, simulation, debriefing, feedback, or other blended models that reinforce transfer into real care settings.

A further implication is that effective e-learning in nursing and midwifery depends on organizational and digital readiness. Recent evidence shows substantial variation in digital health competence across professionals and settings, shaped by both individual and organizational factors (Mikkonen et al., 2026). This means that e-learning effectiveness also depends on protected learning time, user-friendly platforms and support for digital skill development. Without these conditions, e-learning may widen rather than reduce inequities in continuing education access.

4.4. Implications for future evaluation and research

Future evaluations should move from predominantly immediate, self-reported outcomes towards multilevel and longitudinal measurement systems. Satisfaction, perceived knowledge, confidence and intentions remain useful, but they should be complemented by objective or externally assessed indicators, such as observed performance, simulated consultations, audit data, clinical documentation, prescribing/testing patterns, adherence to guidelines and care-quality indicators. Outcome measurement should distinguish between learning-related outcomes, behavioral-related outcomes, organizational or process outcomes and patient-related outcomes. Follow-up should also be extended beyond the immediate post-course assessment, with medium- and long-term evaluations, for example at 3, 6 and 12 months, to determine whether learning gains are retained and translated into routine practice.

4.5. Limitations

This review has several limitations. First, only a limited set of databases was considered, and exclusion reasons were documented only at the full-text stage due to the large volume of records screened at the title and abstract level. In addition, some potentially relevant records were excluded because full texts were inaccessible or only abstract-level information was available. Thus, some publication bias and issues with the transparency of the process may have been introduced. Second, although the eligibility criteria were broad, the final evidence summarized quantitative studies, suggesting that the experiential and contextual mechanisms through which e-learning is enabled or constrained were not captured. Third, although the review included some evidence from settings outside high-income contexts, most studies were conducted in settings with stronger digital infrastructure, which limits transferability to environments where connectivity, staffing and institutional support are less favorable. These limitations mirror those identified in the broader e-learning and digital health professions education literature (Vaona et al., 2018; Tudor Car et al., 2022).

5. Conclusion

Continuing education delivered through e-learning is generally perceived by healthcare professionals as effective, with recurrent improvements reported in key professional outcomes, including

knowledge, confidence, attitudes and selected skills, across diverse clinical topics and disciplines. Nonetheless, whether these perceived gains translate into sustained changes in clinical practice and measurable patient-level improvements remains unclear, as such outcomes were evaluated in only a limited subset of studies using heterogeneous metrics and follow-up intervals. The evidence was largely based on self-reported measures, which were the most frequently used assessment approach. Whether these perceived gains translate into sustained changes in clinical practice and measurable patient-level improvements remains unclear, as such outcomes were evaluated in only a limited subset of studies using heterogeneous metrics and follow-up intervals.

Future research should prioritise more standardised and transparent outcome reporting, consistent use of validated measures, longer follow-up and stronger study designs, alongside clearer intervention descriptions, to improve causal inference and identify which e-learning components are most likely to produce durable change.

CRedit authorship contribution statement

Palese Alvisa: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Mazzaccara Alfonso:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Moreau Chiara:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Dentice Sara:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Iurilli Martin:** Writing – review & editing, Writing – original draft. **Magro Gaia:** Writing – review & editing, Writing – original draft. **Dussi Gaia:** Writing – review & editing, Writing – original draft. **Chiappinotto Stefania:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.nepr.2026.104866](https://doi.org/10.1016/j.nepr.2026.104866).

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