International Journal of Medical Informatics 185 (2024) 105396

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Review article

Educational interventions and their effects on healthcare professionals' digital competence development: A systematic review

E. Kulju [a,1], E. Jarva [a,1,*], A. Oikarinen [a], M. Hammarén [a], O. Kanste [a], K. Mikkonen [b]

[a] Research Unit of Health Sciences and Technology, Faculty of Medicine, University of Oulu, Oulu, Finland

[b] Research Unit of Health Sciences and Technology, University of Oulu, Oulu, Medical Research Center Oulu, Wellbeing Services County of North Ostrobothnia, Oulu, Finland

ARTICLE INFO

Keywords:
Digital health
Healthcare professional
Intervention
Nursing informatics
Professional competence
Telemedicine

ABSTRACT

Introduction: The digitalisation of healthcare requires that healthcare professionals are equipped with adequate digital competencies to be able to deliver high-quality healthcare. Continuing professional education is needed to ensure these competencies.

Objective: This systematic review aimed to identify and describe the educational interventions that have been developed to improve various aspects of the digital competence of healthcare professionals and the effects of these interventions.

Methods: A systematic literature review following the Joanna Briggs Institute's guidelines for Evidence Synthesis was conducted. Five electronic databases (CINAHL, PubMed, ProQuest, Scopus and Medic) up to November 2023 were searched for studies. Two researchers independently assessed the eligibility of the studies by title, abstract and full text and the methodological quality of the studies. Data tabulation and narrative synthesis analysis of study findings were performed. The PRISMA checklist guided the review process.

Results: This review included 20 studies reporting heterogeneous educational interventions to develop the digital competence of healthcare professionals. The participants were mainly nurses and interventions were conducted in various healthcare settings. The length of the education varied from a 20-minute session to a six-month period. Education was offered through traditional contact teaching, using a blended-learning approach and through videoconference. Learning was enhanced through lectures, slide presentations, group work, case studies, discussions and practical exercises or simulations. Educational interventions achieved statistically significant results regarding participants' knowledge, skills, attitudes, perception of resources, self-efficacy or confidence and output quality.

Conclusions: The findings of this review suggest that digital competence education of nurses and allied health professionals would benefit from a multi-method approach. Training should provide knowledge as well as opportunities to interact with peers and instructors. Skills and confidence should be enhanced through practical training. Adequate organisational support, encouragement, and individual, needs-based guidance should be provided.

1. Introduction

The rapid development of digital technologies has led to the development of new services, tools and applications in healthcare and to reforming practices in healthcare systems [12]. The COVID-19 pandemic further increased the use of teleconsultation and various new healthcare applications [3,4]. In 2021 the World Health Organization (WHO) published the global strategy on digital health 2020–2025, which aims to *strengthen health systems through the application of digital health technologies for consumers, health professionals, providers and industry towards empowering patients and achieving the vision of health for all* [5]. Nurses are the largest professional group in healthcare [6], and together with allied health professionals, they play a central role in health service promotion, prevention, treatment, and

* Corresponding author at: Unit of Health Sciences and Technology, Faculty of Medicine, P.O. Box 8000, FI- 90014 University of Oulu.

E-mail addresses: kuljue@gmail.com (E. Kulju), erika.jarva@oulu.fi (E. Jarva), anne.oikarinen@oulu.fi (A. Oikarinen), mira.hammaren@oulu.fi (M. Hammarén), outi.kanste@oulu.fi (O. Kanste), kristina.mikkonen@oulu.fi (K. Mikkonen).

[1] **equal contributions**.

https://doi.org/10.1016/j.ijmedinf.2024.105396

Received 28 August 2023; Received in revised form 9 February 2024; Accepted 24 February 2024

Available online 10 March 2024

rehabilitation and form the backbone of health systems around the globe [7]. It is, therefore, crucial for these providers to be digitally competent in order to be able to use the opportunities offered by digitalisation in their work.

Digital technologies such as electronic health records (EHRs), remote care and monitoring, tools enabling data handling and exchange, and other information and communication technologies can potentially reduce human error and facilitate the coordination of care. Patients can become more involved in their own care and healthcare professionals can reduce time-consuming routines. Artificial intelligence and other new technologies can optimise information management and decision-making and speed up work processes. [8–10]. From a healthcare perspective, it is essential that healthcare professionals have the knowledge and skills required to use digital technologies to deliver good care [11–13].

Digital competence is based on functional skills related to the technical use of information and communication technology (ICT) tools. However, functioning in the knowledge society requires a wide range of other skills, such as critical thinking, ethical and cultural awareness, continuous learning, flexibility, self-direction and attitude [14]. Digital competence is one key competence area for lifelong learning. In addition to technical skills, emphasis is placed on the safe and responsible use of new technologies and the ability to understand the ethical and legal aspects of digitalisation. [15]. The digital competence of healthcare professionals is an evolving and complex entity, as both the potential of digitalisation and the understanding of the phenomenon are increasing [16]. Previous studies have identified that the digital competence of healthcare professionals consists of ICT skills, competencies to use and evaluate digital solutions as part of professional work, interaction skills when using digital tools and environments, ethical skills related to digitalisation, and motivation and willingness to use digital solutions in patient care [12,16,17].

Healthcare professionals' poor digital competence, lack of interest in information systems and human–computer interaction problems can have a negative impact on the safety and quality of patient care such as incorrect or incomplete patient records or medication errors [13,18]. Healthcare professionals' digital competence is closely related to clinical knowledge and skills and digital competence should be considered an integral part of day-to-day activities [12]. Healthcare professionals should also be able to assess whether patients can use digital services and support them in using such technologies [19,20]. New digital communication channels, such as video consultations or text messaging, require healthcare professionals to be competent in interacting with patients using digital tools and to be aware of the ethical implications of communicating digitally in healthcare settings [19,21,22].

The attitudes and experiences of healthcare professionals influence their willingness and motivation to use technology [12]. EHR's poor usability and low reliability were associated with perceived time pressure and psychological distress [23]. The perceived uselessness, lack of digital competence, and lack of infrastructure for new digital tools, such as insufficient user support, cause frustration and negatively affect attitudes toward new digital applications. Health technologies and digitalisation are not only about information technology but also about new work processes and organisational changes [24]. Organisational and collegial support is essential for building positive digitalisation experiences for healthcare professionals [12,25]. Healthcare professionals need continuing education to update and renew their knowledge and skills to provide quality care [26,27]. Today, these competencies also include the ability to understand and use digital tools and solutions in health services [10,28]. To ensure safe and effective healthcare, healthcare professionals should be provided with adequate, individualised training and organisational support and resources regarding the use of health ICT [12,13,24]. Targeted training should be provided especially for staff with poor computer skills, limited computer experience and/or low confidence in using information systems [29].

Previous studies have often focused on investigating a specific area of digital competence or technology [30,31]. A systematic review by Wiebe et al. [30] examined interventions to improve inpatient electronic health record documentation. Ting et al. [31] examined in an integrative review electronic health record education and training for nurses. A systematic review by Alkhaldi et al. [32] classified and evaluated interventions aimed at encouraging healthcare providers to prescribe mHealth apps from a behaviour change perspective.

Less research has been done on interventions aimed at developing digital competence more broadly for healthcare professionals. Virtanen et al. [33] used a systematic literature review to identify interventions aimed at promoting eHealth competency among health professionals from a behavioural change perspective. They found that the majority of the interventions were targeted at physicians. Therefore, more knowledge is needed about the educational interventions targeted to other healthcare professional groups.

The aim of this systematic review was to identify and describe educational interventions developed to improve various aspects of the digital competence of healthcare professionals, with a focus on interventions specifically targeted at nurses and allied health professionals, and the effects of these interventions.

The review questions are:

1. What kind of educational intervention methods have been implemented to develop the digital competence of healthcare professionals?
2. What are the effects of these educational interventions on the digital competence of healthcare professionals?

2. Methods

2.1. Study design

The aim of this systematic review was to produce a comprehensive and unbiased synthesis of relevant high-quality studies [34]. This study followed the Joanna Briggs Institute (JBI) [35] guidelines for conducting systematic reviews. The review is based on original studies and its protocol has been registered in the PROSPERO database of the National Institute for Health Research (CRD42023393551) An evaluation of the systematic review was performed using the PRISMA 2020 checklist of reporting systematic reviews and *meta*-analyses [36].

2.2. Data collection

According to a pre-defined set of inclusion criteria, the electronic databases were searched in November 2022. The PICOS (P = population, I = intervention, C = comparison, O = outcome, S = study design) generated the research questions and key concepts [31]. Study eligibility criteria are described in Table 1.

The search was conducted originally in November 2022 as an electronic search in PubMed, Scopus, CINAHL, ProQuest and Medic reference databases. An information specialist was consulted in search strategy formation [35]. A complementary search was conducted in November 2023 to attain the most recent publications published over the one-year period since research in the area is constantly increasing. The key concepts identified using the PICOS method were used to build search terms and phrases. For PubMed and CINAHL databases, the MeSH (Medical Subject Headings) and CINAHL/MeSH subject headings were used in addition to the free keyword search. Searches were limited to peer-reviewed original articles in Finnish or English up to November 2023 restriction (See Supplementary File 1). Time constraint was not utilised to find all educational interventions developed over the years that aim towards digital competence development. References were collected in the Covidence Systematic Review Software tool.

Table 1
Inclusion and exclusion criteria using PICOS format.

Criteria	Inclusion	Exclusion
Population	Healthcare Professionals (Nurses and allied health professionals)	Studies comprised of students, physicians, or over 50 % are health professionals other than nurses or allied health professionals.
Interventions	Educational interventions targeting to the development of digital competence	Non-educational interventions
Comparators	Another intervention/course/ training or standard activity or no comparison.	–
Outcomes	Digital competence (knowledge, skills, attitude, motivation, capability) development	Not relevant to digital competence
Study design	Quasi-experimental, experimental, randomized controlled (RCT) studies and pre-post design studies	Other types of studies
Publication type	Peer-reviewed original studies	Non peer-reviewed studies
Language	English, Finnish	Language other than English or Finnish

2.3. Study selection

The PRISMA flowchart illustrates the process of selecting studies (Fig. 1). A total of 5124 publications (Scopus, 1969, PubMed 1635, CINAHL 676, ProQuest 697, Medic 147) were retrieved, of which 1522 were duplicates. After removing duplicates 3602 references remained. Two researchers separately screened and assessed the data for title and abstract (n = 3602) and full text (n = 128) against the inclusion criteria [35,37]. After review and discussion 20 original studies were selected by consensus for the final study.

2.4. Quality assessment

The methodological quality of the studies selected for this review was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools [35]. The JBI Criteria for Quasi-Experimental Studies contained nine assessment criteria and the JBI Criteria for Randomized Controlled Trials (RCT) contained 13 assessment criteria. Each criterion was rated as "yes", "no", "unclear" or "not applicable". One point is awarded for each "yes" answer. An overall score was calculated for each study separately. Two researchers carried out the quality assessment independently, after which the results were compared. Differences of opinion were discussed, and the final assessment was based on the consensus of the researchers [35].

2.5. Data extraction and analysis

Data relevant to the review question (author, year, country, setting, purpose of the study, study type, sample size, description of participants, theoretical framework, teaching method, instruments and results) was extracted and tabulated (Table 2) [38]. A narrative synthesis was used to produce a summary and description of the data [37]. Narrative synthesis is a tool for outlining and identifying similarities and differences between different studies. The aim of narrative synthesis is to provide a descriptive, concise and explanatory summary of the results, characteristics and differences between several studies [39]. The narrative synthesis is supported and clarified by tabulating the studies under review [39,40]. Conducting a *meta*-analysis of effect estimates was impossible due to the high heterogeneity among the included studies. The data consisted of studies with varying study designs, instruments and intervention lengths. In addition, most studies did not have a control group [41].

3. Results

3.1. Characteristics of the studies

Twenty studies were selected in this review. The studies were from the United States (n = 12), Iran (n = 2), The Republic of Korea (n = 1), The Netherlands (n = 1), Malawi (n = 1), Finland (n = 1), Nigeria (n = 1) and Canada (n = 1). The studies were conducted between 2002 and 2023. Three studies were carried out between 2002 and 2008, seven from 2011 to 2019 and ten from 2020 to 2023. Eighteen studies were quasi-experimental pre- and post-experimental studies, and one was a randomised controlled trial (RCT). One study implemented a post-experimental research design. The educational interventions were conducted in primary care [42] or in a hospital or outpatient care unit [43–58]. One study employed a multi-setting approach (primary care, homecare and hospital) [59], one study included a training program open to all interested nursing professionals [60] and the training program in one study was open to all nurses working in the same organisation [61].

Six of the 20 studies selected for this review included a control group. In the study by Adereti & Olaogun [45], the control group used a paper-based patient record system and the intervention group used an electronic version. Three studies [49,51,53] compared the intervention group with the non-intervention group. Mastellos et al. [42] compared blended learning with traditional face-to-face education. van Houwelingen et al. [59] compared the impact of an educational intervention on nurses' knowledge, self-efficacy, and usage of telehealth in three settings. The remaining studies selected for this review were pre- and post-design studies of the same group.

The RCT by Mastellos et al. [42] was given a total quality score of eight points out of 13 on the JBI Critical Appraisal Checklist for RCTs. The quasi-experimental studies included in the review were given a total quality score of between four and nine out of nine points on the JBI Critical Appraisal Checklist for Quasi-Experimental Studies (See Supplementary File 2).

3.2. Participants

Nurses were included in 16 studies, and in addition, studies included community health workers [42], respiratory therapists [56], patient care technicians and health unit coordinators [55], nurse managers [46], charge nurses [43] and assistant nurse managers [58]. The total amount of participants was 1444 with the age range from 20 to over 60.

3.3. Description of the studied outcomes related to digital competence and educational intervention methods included in the review

Overall, different aspects of digital competence were examined in a variety of ways in the included studies. Participants' knowledge was assessed or evaluated in 13 studies [42,46,47,49,50–56,59,60]. Skills or participants' performance were assessed in six studies [47,49,51,53,54,58]. Attitude or behavioural intention was investigated in five studies [42,50,54,56,48]. Four studies assessed participants' confidence or self-efficacy in performing or relating to certain skills [47,57,59,61]. Quality of output upon performance was evaluated in four studies [45,49,50,48]. One study [59] measured the objective impact of educational intervention on the number of telehealth activities. In addition, satisfaction or perceived usefulness with the training was evaluated in eight studies [42,43,44,46,55,57,59,61].

Nine of the studies examined the effect of training on competencies related to an EHR system [45,46,49,50,57,43,48] and other health information technology (HIT) tools [55,56]. Four studies addressed the skills and competencies required for telehealth. [44,47,54,59] and seven

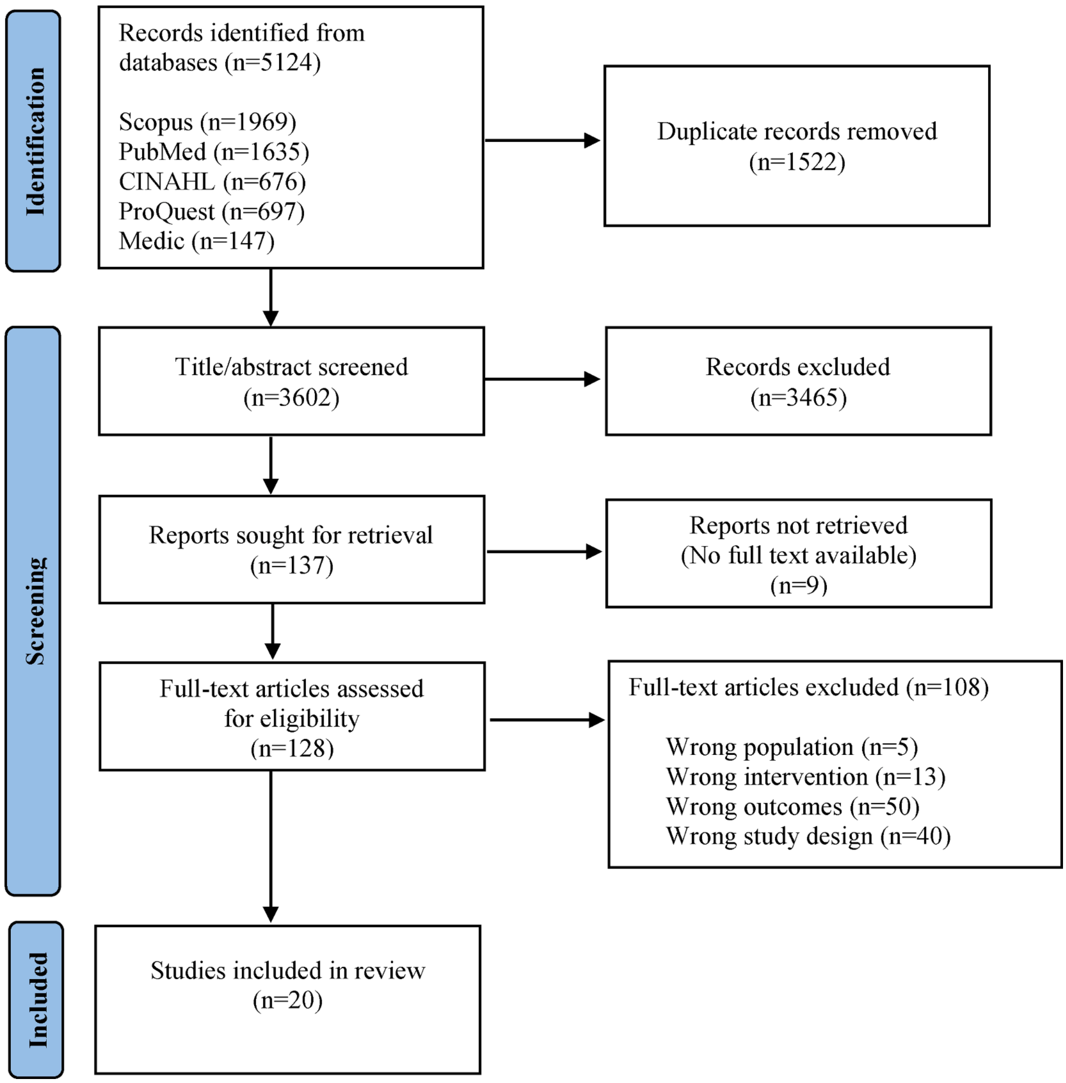

Fig. 1. PRISMA flow diagram of the study selection (Centre for Reviews and Dissemination (CRD), 2009).

studies were related to ICT, informatics, information literacy and computer skills [42,51,52,53,58,60,61].

The length of the educational interventions varied from one 20-minute educational session to six months in total. The teaching methods used are summarised (Table 3). The most used (n = 17) method was traditional face-to-face instruction [42,45–60]. Face-to-face instruction and e-learning were combined in five interventions [42,47,50,55,58]. In a study by Mastellos et al. [42], the intervention group was provided with a 'blended learning'-model, combining face-to-face instruction and e-learning using a computer and mobile phone (m-learning). The training program in the study by Ciccollini et al. [47] included both in-person sessions and independent e-learning on a learning platform. The face-to-face educational intervention of Evatt et al. [50] was designed to supplement an existing e-learning. Lacambra's [55] study included online learning videos and classroom-based learning. In a study by Rosenfeld et al. [58], a web-based tutorial was developed in addition to training sessions.

Lectures, slide presentations, case studies, discussions, questions and answers and small group work were commonly used as teaching methods. Hands-on exercises were also often included, such as using a computer and/or health science databases [42,51,53,58], the electronic health record system [45,46,49,57], the new tablet application [55], the telephone triage system [54] and remote assessment tools [44]. The system training environment was used as a platform for practical training in four studies [46,54,55,57]. Homework (no content description) was mentioned in two studies [51,53]. In addition to the actual classroom training sessions, open (drop-in) training labs or simulated documentation sessions in a test environment were organised. Role play and simulated remote consultation were used in two studies. van Houwelingen et al. [59] used training workshops in which nurses practised nursing telehealth activities, such as videoconferencing in small groups. In the study by Ciccollini et al. [47], at the beginning of the training, nurses performed a simulated patient call with the researcher, which was scored and discussed in the training workshops. After the training, the call was repeated, and performance was scored by the researcher. One educational intervention [43] was organised as a 45-minute tabletop Escape Room to help participants master the EHR downtime process.

Three educational sessions were conducted entirely remotely. In a study by Sevean et al. [44] the training session was organised via videoconferencing. The content of the training was similar to that of the face-to-face classes. The nurses received information on how to organise remote consultations and how to communicate with the patient via video conferencing. The nurses also practised using remote assessment tools such as a digital stethoscope. Bindler et al. [61] delivered statistics learning sessions online through the Microsoft Teams account. One educational intervention [46] was conducted for three separate groups due to the COVID-19 pandemic, with the first group attending face-to-

Table 2
Summary of the included studies.

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
Adereti & Olaogun 2019 [45]	To evaluate the impact of Standardized Nursing Care Plan (SNCP) training on the quality of nurses' documentation and to compare the quality of electronic and paper SNCP documentation	Quasi-experimental Pre-post 6 months total	A governmental owned tertiary health facility Adult inpatient wards Nurses (n = 32) Electronic SNCP (Intervention, n = 16) Paper-based SNCP (Control, n = 16) Nigeria	Classroom training 3 consecutive days in a week 10 h 10 min/module 4 modules The intervention group was trained to use the electronic SNCP and the control group was trained to use the paper SNCP The training was modified based on preintervention knowledge evaluation to meet individual nurses' needs Monthly clinical updates were (case studies prepared by the nurses) held to ensure knowledge update and effective implementation.	The nursing process booklets/ nursing component in the EHR (n = 406) total Quality of nursing diagnoses, interventions and outcomes (Q-DIO) scale (T0) Baseline (T1) 3 months after the intervention (T2) 6 months after the intervention SPSS 20 Friedman's test, independent t-tests, paired t-tests, Shapiro-Wilk test	Overall quality of documentation **Phases of the nursing process** Nursing diagnosis as a process Nursing diagnosis as a product Nursing interventions Nursing outcome	(T0) IG 25.15 ± 11.97 (T0) Control 34.46 ± 14.91	(T1) IG 53.03 ± 22.07 (T2) 52.85 ± 19.96 (T1) Control 42.78 ± 20.77 (T2) 42.63 ± 26.12 **Chi-square value ($\chi 2$)** IG 37.98 Control 8.206 IG 31.29 Control 3.623 IG 39.11 Control 1.581 IG 62.99 Control 0.069	**$p = 0.001$** **$p = 0.05$** **$p = 0.001$** $p = 0.170$ **$p = 0.001$** $p = 0.163$ **$p = 0.001$** $p = 0.454$ **$p = 0.001$** $p = 0.966$	(Q-DIO) higher (T0) **$p = 0.001$** Control (T1) **$p = 0.006$** IG (T2) **$p = 0.001$** IG	The majority of nurses' documentation at preintervention was of poor quality with a higher percentage in the electronic (intervention) ward. The SNLs educational intervention improved nurses' assessment and documentation skills. There was an improvement in documentation quality in both groups after introducing SNCPs with higher quality scores in the intervention ward postintervention. The intervention had a significant effect in the overall documentation of the nursing process in the control group, while it significantly improved documentation of all phases of the nursing process in the intervention group.
Bickford et al. 2005 [60]	To evaluate how the WINI continuing education program changes participants'	Quasi-experimental Pre-post	Nurses from different settings	One weekend (two days) Lectures,	In the beginning, one's level of nursing informatics	Mean total score. Nurses' perception of their knowledge	(T0)70.8 (11.86) (T0)	(T1)87.0 (8.74) (T1)	**$p < 0.001$**	No control group	The mean rating was significantly higher on the post-program survey

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
	perception of their informatics knowledge and their ability to use information technology to influence patient care	One weekend	Total n = 52 (n = 45) (T0 and T1) No control group The United States	facilitated discussions, problem-solving and networking	expertise based on the Informatics Competencies for Nurses at Four Levels of Nursing Practice was identified (beginner, experienced, informatics nurse specialist, informatics innovator) Questionnaire (5-point Likert scale), developed by expert in the field (T0) Baseline(T1) Post intervention (after the end of the workshop) 21 items (first 20 items were identical in the pre-post surveys, the last item's verb tense was changed for the post program survey) Paired t-tests, repeated analysis of variance	and ability in specific areas of nursing informatics, information technology and healthcare information systems	Beginner65.3 (11.17) (T0) Experienced70.3 (9.54) (T0) Specialist/ innovator78.9 (11.21)	Beginner83.6 (9.39) (T1) Experienced88.3 (8.09) (T1) Specialist/ innovator88.5 (9.53)			when compared to the pre-program survey for each of the 20 items. Means of the total scores were lowest for the beginners and highest for the specialists/ innovators on both the pre- and post-program surveys, with beginners demonstrating the largest change. There was a significant difference when pre-program survey scores were compared by level of practice, with beginners having a significantly lower mean pre-program survey score than specialists/ innovators. The change from pre- to post-program scores also differed significantly by level of practice. Those at the experienced and specialist/ innovator levels differed by approximately 8 points on the pre-program survey but had almost the same mean score on the post-program survey.
Bindler et al. 2023 [61]	To implement and evaluate two pilot	Quasi-experimental	Any nurse employed of	1-hour pilot session (twice) on	Survey via Microsoft	Perceived	(T0) Pilot2.3	(T1) Pilot4.5		No control group	Following the pilot sessions,

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
	programs for nursing staff designed to address the documented need for understand and perform statistical analyses	Pre-post Guideline for Reporting Evidence-based Practice Educational Interventions and Teaching (GREET) Approx time span 4 months	who had completed their clinical education at one of the health organization's institutions (Southern California) were allowed to participate Total n = 40 Pilot(T0) n = 12(T1) n = 8 Topic focused (T0) n = 28(T1) n = 24 No control group The United States	statistical overview of nursing research Six 1-hour topic focused sessions conducted fortnightly An active learning (AL) strategy Online virtual sessions (Microsoft Teams) The first 30 to 45 min of the session was preplanned and led by an instructor via the shared screen function. Short, focused explanations of key concepts followed by on-screen tutorials using data from completed projects The remained of the session was for attendees to ask any questions which included bringing their own projects to the group All attendees were asked to complete a short survey which contained matching questions to the pre-survey	SharePoint (T0) Baseline(T1) Post intervention (after the educational intervention) Confidence (1–10 scale) Usefulness (1–10 scale) (T1 only)	confidence doing statistical analysis overall Perceived confidence in understanding your data Perceived confidence in selecting proper analyses for your data Perceived confidence in interpreting results Perceived confidence running necessary analyses Overall class usefulness	(1.6) Topic focused3.6 (1.9) Pilot4 (2.1) Topic focused4.9 (2) Pilot2.3 (1.7) Topic focused4 (2.1) Pilot4.3 (2.5) Topic focused4.6 (2.3) Pilot1.9 (1.1) Topic focused3.5 (2.2)	(3) Topic focused5.1 (1.9) Pilot5 (1.5) Topic focused5.5 (1.9) Pilot4 (2.1) Topic focused4.5 (1.8) Pilot5.5 (1.9) Topic focused5.1 (2) Pilot4 (2.1) Topic focused4.6 (2.1) Pilot8.9 (1.9) Topic focused8.3 (1.6)	**p = 0.05** **p = 0.007** p = 0.28 p = 0.27 p = 0.09 p = 0.39 p = 0.30 p = 0.44 **p = 0.02** p = 0.06		attendees reported a statistically significant improvement in their overall confidence in the objectives of doing statistical analyses and running necessary analyses. Attendees also showed numeric improvement in the objectives of understanding their data, selecting proper analyses and interpreting results, but the change did not reach significance. Due to the small number of attendees at each of the six topic focused sessions, pre-post confidence scores were combined rather than looking at each session independently. After completing all six topic-focused sessions, attendees showed a statistically significant improvement in the objective overall confidence in completing statistical analyses. There were numeric improvements found with all other objective

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
											confidence categories, which did not reach significance. The average overall usefulness was identified as similar to the original pilot. Nurses scored the programs as highly useful.
Carson et al. 2021 [46]	An electronic Health Record (EHR) training class for nurse leaders	Quasi-experimental Pre-post Time span 11 months	Academic Medical center Nurse managers (n = 32) No control group The United States	One face-to-face classroom training (n = 9) 2 h 10 min break EHR training environment, the production environment and a slide presentation Two trainings were conducted virtually (n = 8) (n = 15) due to COVID pandemic, same content	7-item survey on a 5-point Likert scale (T0) Baseline(T1) Post intervention (after the educational session) Open-ended questions were used to solicit qualitative feedback on the pilot Descriptive statistics	Knowledge of basic IHIS terminology	(T0) F to F4.0 (0.53) Virtual14.33 (0.52) Virtual23.4 (0.67)	(T1) F to F4.11 (0.33) Virtual14.75 (0.5) Virtual2 4.44 (0.53)	Not reported	No control group	Results showed that the nurse leader EHR training improved the knowledge of system use for the three sessions of nurse leaders. There was an increase from the pre- to post-education mean for all questions. Knowledge gained was greatest in downtime procedures and creating patient lists to see unit compliance at a glance. The response to the virtual format for the class was positive.
						Confidence in finding information in chart review	F to F3.75 (0.89) Virtual13.83 (0.41) Virtual23.3 (0.95)	F to F4.22 (0.44) Virtual14.75 (0.5) Virtual24.44 (0.53)			
						Understand how to access reports	F to F3.88 (0.35) Virtual13.33 (1.21) Virtual23.2 (0.7)	F to F4.33 (0.5) Virtual14.75 (0.5) Virtual24.22 (0.44)			
						Understand how to monitor documentation compliance	F to F3.38 (0.74) Virtual12.5 (0.83) Virtual22.7 (1.15)	F to F4.0 (0) Virtual14.78 (0.5) Virtual24.11 (0.6)			
						Know basic unit manager workflows	F to F 3.5 (0.76) Virtual12.67 (0.82) Virtual22.4 (0.97)	F to F4.33 (0.7) Virtual14.25 (0.5) Virtual24.33 (0.5)			
						Understand how to create a patient list for nurse	F to F2.75 (1.16) Virtual13.5	F to F 4.44 (0.53) Virtual14.75			

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
						manager workflows	(1.05) Virtual22.6 (1.05)	(0.5) Virtual24.44 (0.53)			
						Know downtime procedures	F to F2.63 (0.92) Virtual13.33 (0.52) Virtual22.6 (1.05)	F to F4.33 (0.5) Virtual14.5 (1.0) Virtual24.22 (0.53)			
Ciccolini et al. 2022 [47]	To determine if a telephone triage educational workshop would improve oncology nurses' knowledge, confidence, and skill over 12 weeks	Quasi-experimental Pre-post The John Hopkins University Evidence-based Practice Model 12 weeks in total	The outpatient department of hematology and oncology at a large cancer center Nurses (n = 13) No control group The United States	Pre-assessment of skills (simulated call) 3-part workshop over 12 weeks (1 h + 2 h + unspecified duration) 1 h video didactic lecture on Thinkific-platform 2 h in-person session reviewing the pretest scenario with moderated questions from three common telephone triage models in nursing (Nursing process, OLDCARTS, SBAR) Group feedback on the pretest case scenario and discussion Records of the sessions and educational tools were available on the Thinkific-platform. It could be printed out for reference.	Literature review guided the tool development A 13-item online survey (Knowledge: 11 multiple choice questions; Confidence: 2 items on a 5-point Likert scale) (T0) Baseline(T1) Post-intervention (immediately after the third educational session) Skills were assessed through a 56-item checklist composed of items from the three telephone triage nursing models The virtual triage was repeated SPSS 26.0 Descriptive statistics, Wilcoxon signed rank tests	 Knowledge Confidence Skill	(T0) 72.7 % (IQR, 18.2) 3.0 (IQR, 2.5) 49.1 % (IQR, 9.8)	(T1) 72.7 % (IQR, 22.7) 4.0 (IQR, 0.8) 73.2 % (IQR, 12.1)	 p = 0.11 **p = 0.008** **p = 0.002**	No control group	Oncology nurses' confidence and skills improved significantly after the educational workshop on using telephone triage models. There was no difference in knowledge scores from the pretest to the post-test. This novel oncology telephone triage education model with e-learning and virtual simulation translates evidence-based strategies into solutions, applies innovation and technology to advance nursing practice, and supports Magnet tenets, optimizing nursing practice.

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
				Structured feedback on the individual participant's pretest skills outcome with virtual triage simulation during pretesting							
Collazo et al. 2023 [48]	To determine if, among pediatric hematology–oncology nursing staff, the implementation of a new diagnosis education checklist, within the EMR, facilitated the documentation of new diagnosis education within a 3-month	Quasi-experimental Pre-post The Program Theory of Change (PToC) model guided the project, integrating evidence-based results and the beliefs and assumptions from nursing staff experiences 3 months total	A children's hospital at a large tertiary medical institution Inpatient unit and outpatient hematology-oncology clinic Nurses (n = 80) (T0) n = 75(T1) n = 37 No control group The United States	New electronic template was implemented in the EHR. A 2-week period to provide in-service training PowerPoint presentation Two reference handbooks easily available in each clinical setting An audible PowerPoint for nursing staff that were not able to attend the staff in-person education sessions Superusers of MiChart (Epic) and nursing staff from the patient education workgroup were trained to assist nursing staff	Survey (T0) Baseline(T1) PostIntervention (following the development and implementation of the new electronic template) No further description of the instruments Electronic Medical Record documentation 54 charts were reviewed pre-implementation (T0) and 26 charts were reviewed post-implementation (T1)	Completing patient education of secondary topic (new diagnosis education) The electronic template improved accessibility to secondary topic education. Would continue to utilize the electronic documentation in the future. Secondary topic documentation completion (new diagnosis education)	(T0) Never 30 % Very rarely 23 % Rarely 21 % <30 %	(T1) Frequently 3 % Occasionally 12 % Strongly agree 11 % Agree 43 % Highly likely 16 % Very likely 41 % >50 %	Not reported	No control group	Creating and standardizing an electronic template for the new diagnosis education checklist increased nursing staff engagement through the ease of document accessibility for both inpatient and outpatient settings. Secondary topic completion and documentation increased 26 % following implementation, and over 40 % of the nursing staff indicated that they were very likely to continue to use the new templates. Nursing staff strongly agreed (11 %) and agreed (43 %) that the electronic template improved accessibility to secondary topic education and highly likely (16 %) and very likely (41 %) would continue to utilize the electronic

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
											documentation in the future. Creating and standardizing an electronic template for the new diagnosis education checklist increased nursing staff engagement through the ease of document accessibility for both inpatient and outpatient settings. This decreased the need for printing, filing, and scanning of paper checklists, eliminating the risk of losing paper checklists.
Do & Kim 2021 [49]	To investigate the effect of nursing record education focusing on the legal aspect of nursing record knowledge and performance among nurses in small- and medium-sized hospitals	Quasi-experimental Pre-post 12 days in total	Two small or medium sized hospitals Nurses Total n = 62 Intervention n = 62 Control n = 30 Republic of Korea	2 h workshop Powerpoint presentations, discussions, interactive activities and practical training 16 participants/ session Team-based learning was carried out in groups of four to carry out tasks during education A handout	A nursing record knowledge evaluation tool, 65 items (yes/no) A revised nursing record performance evaluation tool, 20 items. Each appraiser randomly reviewed four records written by each participant A revised Nursing record behaviour evaluation tool, 16 items. Each appraiser observed participants as they wrote nursing records and rated their	Nursing Record Knowledge	(T0) IG 53.09 ± 5.83 Control 50.90 ± 6.09	(T1) IG 59.44 ± 3.14 Control 54.17 ± 6.14	Difference 6.35 ± 6.22 Correct answer rates for Do's (**p = 0.001**) for Don't's (**p = 0.001**) 3.27 ± 3.45	(T1) **p = 0.019**	After education, the knowledge, performance, and behaviour scores on nursing records were significantly higher in the experimental group than in the control group. Based on this result, nursing record education is an effective intervention to improve nurses' knowledge and performance in writing nursing records in small- and medium-sized hospitals.
						Nursing Record Performance	IG 3.39 ± 0.34 Control 3.21 ± 0.39	IG 3.56 ± 0.26 Control 3.20 ± 0.48	0.17 ± 0.08 0.01 ± 0.09	**p = 0.033**	
						Nursing Record Behavious	IG 3.97 ± 0.34 Control 3.83 ± 0.30	IG 4.21 ± 0.42 Control 3.84 ± 0.30	0.24 ± 0.08 0.01 ± 0.06	**p = 0.018**	

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					behaviour on a 5-point Likert scale (T0) Baseline(T1) Post intervention (after the education) SPSS 25.0 *t*-test, X^2- test. Independent *t*-test, paired *t*-test				p-value not reported		
Evatt et al. 2014 [50]	To improve the timeliness, completeness, and accuracy of Electronic Health Record (EHR) nursing admission assessment documentation by developing, implementing, and evaluating an educational session designed to supplement e-learning content	Quasi-experimental Pre-post 20 min session Total duration not specified	Urban tertiary care institution The medical intensive care unit (MICU) and trauma burn unit (TBU) Nurses (n = 99) No control group The United States	20 min slideshow and face-to-face instruction 10 educational sessions were offered over 2 weeks until all have attended 8–12 per session Laminated cards listing key bullet points of EHR nursing admission assessment documentation was placed at each computer terminal Three nurse super-users were identified from each unit to provide ongoing support and serve as staff resources for situational questions	10-item researcher-designed instrument. Knowledge: 5 multiple choice questions Attitude: 5 items on a Likert scale (T0) Baseline(T1) Post intervention (after the educational session) Chart documentation: EHRs from a convenience sample of patients admitted to the two units before (T0) (n = 100) and after (T1) (n = 100) education Timeliness (the time in minutes from patient admission to the unit to submission of the nursing admission assessment) Completeness (“Never completed,” “Partially completed,” “Fully completed)	 Knowledge Attitude Total Time between patient admission and completion of electronic admission assessment Completed admission assessment Completion of electronic admission assessment subcomponents Accuracy of nurses’ electronic admission assessment accuracy compared with providers’ history & physical (%)	(T0) 7.4 ± 1.7 12 ± 2 19.4 ± 3.4 6.8 ± 13 (Interval in hours) <8 h 84 (84 %) >8 h 16 (16 %) Not accurate 62 % Partially accurate 16 % Completely accurate 22 %	(T1) 8.2 ± 0.9 13.8 ± 1.6 22.1 ± 2.2 3.18 ± 3 (Interval in hours) <8 h 93 (93 %) >8 h 7 (7 %) The greatest areas of improvement were medical and surgical history, fall assessment and cultural assessment Not accurate 18 % Partially accurate 13 % Completely accurate 69 %	 **p < 0.001** **p < 0.001** **p < 0.001** **p = 0.026** **p = 0.046** 11/13 items **p < 0.001** **p < 0.001** **p < 0.001** **p < 0.001**	No control group	Following the educational support session, nursés knowledge and attitude toward Electronic Admission Assessment Documentation improved significantly. Timeliness, completion and accuracy of nursing documentation improved significantly. A hybrid education method that involved blending e-learning with face-to-face educational sessions improved documentation more than e-learning alone. Implementing a hybrid method of initial e-learning supplemented with a brief face-to-face educational session may

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					Accuracy (assessed in regard to the accuracy of the past medical and surgical history) SPSS 21.0. SAS 9.3 chi-square test, Fischer's exact test, t-tests, $p < 0.05$						improve the timeliness, completion, and accuracy of the EHR nursing admission assessment.
Farokhzadian et al. 2021 [51]	To evaluate the impact of a training program on nurses' information literacy skills for Evidence-Based Practice (EBP) in critical care units	Quasi-experimental Pre-post 3 weeks total	Critical care units (ICUs, CCUs, and Dialysis) from three educational hospitals affiliated with Kerman University of Medical Sciences Nurses Total n = 60 Intervention (n = 30) Control (n = 30) Iran	3 x 8 h training sessions over 3 weeks Two groups of 15 participants Lectures, questions and answers, slide presentations, hands-on and online exercises, educational CDs, homework	The use of different information sources: 19 items on a 5-point Likert scale	Use of different information resources (printed, electronic, human)	(T0) IG 2.66 ± 0.70 Control 2.67 ± 0.66	(T1) IG 3.43 ± 0.48 Control 2.76 ± 0.60	**p < 0.001** p = 1.00	(T1) **p < 0.001**	At baseline, the intervention and control groups were similar in terms of demographic characteristics and information literacy skills for EBP. The training program significantly improved all dimensions of information literacy skills of the nurses in the intervention group, including the use of different information resources, information searching skills and the use of different search features, knowledge about search operators and selection of more appropriate search statements compared with the control group.
					Information searching skills and use of different search features: 10 items on a 5-point Likert scale, 4 items with yes/no/not sure options	Information searching skills and use of different search features	IG 2.06 ± 0.76 Control 2.19 ± 0.83	IG 3.85 ± 0.67 Control 1.93 ± 0.70	**p < 0.001** p = 0.25	**p < 0.001**	
						Knowledge about search operators (Boolean and Proximity operators)	IG 0.61 ± 0.23 Control 0.56 ± 0.21	IG 3.74 ± 0.14 Control 0.33 ± 0.12	**p < 0.001** p = 0.84	**p < 0.001**	
					One chooses the most appropriate search statement question (T0) Baseline(T1) 1 month post intervention (1 month after the workshop) SPSS 21. Descriptive statistics, independent samples t-tests, paired t-tests, McNemar test, chi-square, Fischer's exact test. $p < 0.05$	Selecting a more appropriate search statement	n% IG8 (25.80) Control1 (3.20)	n% IG29 (93.50) Control1 (3.20)	**p = 0.001** p = 1.00	**p = 0.001**	

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
Hughes et al. 2014 [52]	To improve computer proficiency and improve nurses' IT skills	Quasi-experimental Pre-post 2 weeks in total	Ambulatory genitourinary oncology practice Nurses Total n = 53 (T0) n = 32(T1) n = 14 No control group The United States	A PowerPoint educational presentation with step-by-step pictorial and written instructions Delivered on four separate occasions The PowerPoint slides were also printed as a handout and e-mailed to the RNs A practical session offered three times weekly for 2 weeks. Small groups or one-on-one sessions	E-mail survey (T0) Baseline, 5 questions. Does the nurse know how to perform certain functions on the computer (yes/no) (T1) Post intervention Same questionnaire + two general questions on work-based computer skills, overall improvement and comfort level A free text section was also added to identify any further educational needs	Know how to register for BCLS class online	(T0) Yes 94 %	(T1) Yes 100 %	Not reported	No control group	The intervention improved RN proficiency in finding items and improved their overall computer skills and comfort level.
						Can find staff meeting minutes online	74 %	66 %			
						Can access the orientation manual online	42 %	56 %			
						Can access patient falls policy online	68 %	70 %			
						Can find NDNQI data online	40 %	50 %			
						Improved work-based computer skills	-	78 %			
						Improved comfort level	-	78 %			
						Will use slides as a reference	-	56 %			
Jouparinejad et al. 2020 [53]	To evaluate the impact of a training program on nursing informatics (NI) competency of critical care nurses	Quasi-experimental Pre-post TIGER recommendations The researchers employed the TIGER competencies as a guide and selected essential nursing informatics competencies 3 weeks total	Critical care units of three hospitals affiliated with a large University of Medical Sciences Nurses Total n = 60 Intervention n = 30 Control n = 30 Iran	3 x 8 h training sessions over 3 weeks. Two groups of 15 participants Lectures, demonstrations, Q&A, slide presentation, hands-on exercise, group discussion and work, online exercise (examples of literature search on topics suggested by nurses), video film and educational CDs, homework	Adapted Nursing Informatics Competency Assessment Tool (NICAT) 30 items on a 5-point Likert scale (T0) Baseline(T1) 1 month post intervention (1 month after the workshop) SPSS 21 Frequencies, percentages, means and standard deviations. Independent samples *t*-test,	Informatics competency total	(T0) IG 78.79 ± 26.52 Control 82.69 ± 19.29	(T1) IG 114.29 ± 20.68 Control 81.76 ± 7.99	**p = 0.001** p = 0.25	(T1) **p = 0.001**	In the pretest stage, both intervention and control groups were competent in terms of the NI competency and its dimensions, and no significant difference was observed between them. In the post-test the NI competency and its dimensions in the intervention group significantly increased with a large effect size compared with the control group.
						Computer literacy: psychomotor skills to use computer tools and basic knowledge of hardware and software functionality	IG 28.46 ± 10.28 Control 28 ± 8.27	IG 39.70 ± 6.78 Control 28.03 ± 8.32	**p = 0.001** p = 0.71	**p = 0.001**	
						Informatics literacy: The nursés abilities to recognize, retrieve, evaluate and use information for	IG 33.51 ± 11.45 Control 34.70 ± 8.33	IG 48.77 ± 9.46 Control 34.43 ± 7.79	**p = 0.001** p = 0.30	**p = 0.001**	

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
				The workshop included theory and practical exercises on each day	paired *t*-test, chi-square test and analysis of covariance	patient care appropriately Information management skills: Apply the data to support clinical decisions, documentation, data integrity, confidentiality and security	IG 17.80 ± 6.78 Control 19.88 ± 5.21	IG 25.80 ± 5.72 Control 19.30 ± 5.40	**p = 0.001** p = 0.20	**p = 0.001**	This difference showed that the intervention group was proficient in the post-test stage. The highest mean difference in the intervention group was associated with the informatics literacy dimension and the lowest mean difference was associated with the informatics management skills dimension.
Kaakinen et al. 2016 [54]	To investigate the effects of a nurse training intervention on the assessment of patients' care needs in telephone triage at an emergency unit	Quasi-experimental Pre-post ~ 8 months total	Emergency department and joint emergency service of the Central Hospital Nurses (n = 43) (T0) n = 28(T1) n = 26 No control group Finland	Educational sessions and computer-based instructions created for the telephone triage 6 h education Use of the computer-based telephone triage program. Examples of the use of telephone triage with training models	Counselling Quality Instrument (CQI) modified for telephone triage The nurse's knowledge (15 items)The nurse's skills (16 items) Nurse's attitudes (15 items) Implementation of the telephone triage (43 items) Resources (12 items) Basis of telephone triage(10 items) and the benefits of telephone triage (25 items) 5-point Likert scale (T0) Baseline(T1) 3 months post intervention (after the training was completed) Predictive	Knowledge (Knowledge on disease and medicines, support groups, patient rights) Skills (skills to assess a caller's need for urgent care) Attitude Patient centredness Interaction Goal orientation Resources (the location and equipment available for telephone triage) Basis of telephone triage	(T0) Good 11 % Poor 89 % Good 7 % Poor 93 % Good 11 % Poor 89 % Good 18 % Poor 82 % Good 50 % Poor 50 % Good 18 % Poor 82 % Good 0 % Poor 100 %	(T1) Good 35 % Poor 65 % Good 31 % Poor 69 % Good 4 % Poor 46 % Good 42 % Poor 58 % Good 77 % Poor 23 % Good 42 % Poor 58 % Good 50 % Poor 50 %	**p = 0.009** **p = 0.003** **p = 0.008** p = 0.058 p = 0.392 p = 0.058 **p = 0.028**	No control group	The intervention improved nurses' skills in evaluating patients' needs and health conditions via the telephone triage. There was a statistically significant difference in the resources, knowledge, skills and attitudes of the nurses between the baseline and post-test measurements. The nurse training intervention improved the quality of telephone triage. During the intervention period resources were invested, for example, in software to help nurses.

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					Analytics Software (PASW 18.0) Fisher's $\chi 2$ test Cronbachs alpha, McNemar's test	Benefits of telephone triage	Good 54 % Poor 46 %	Good 77 % Poor 23 %	p = 0.296		
							Good 21 % Poor 79 %	Good 42 % Poor 58 %	p = 0.080		
Lacambra 2021 [55]	To design, develop, implement, and evaluate a training program that will adequately prepare inpatient nurses, patient care technicians, and health unit coordinators for the successful implementation of new Health InformationTechnology (HIT) tool	Quasi-experimental Pre-post Total duration not specified	Urban acute-care hospital Two inpatient units Total n = 70 Nurses (n = 46) Patient care technicians (n = 11) Health unit coordinators (n = 12) No control group The United States	1 h classroom training The system's training environment was utilized Drop-in practice laboratories were offered a week before the Bedside tablet application went live and throughout the implementation Three online instructional videos for e-learning Daily rounding during the first 2 weeks of Bedside implementation was performed to provide at-the-elbow support, answer staff's questions about Bedside, and escalate issues as needed	A survey tool and a competency assessment were designed to evaluate the effectiveness of the training program, including the training aids and resources created Knowledge (Competency assessment tool) via the learning management system. 10-item assessment tool (T0) Baseline(T1) Post intervention (after the classroom training) Staff perception of the training experience; 13-item survey post intervention (classroom training) and 1 month post Bedside implementation A linear mixed model, *t*-test	Knowledge about the Bedside application	(T0)11.9 (11.33)	(T1)93.2 (8.88) The knowledge score on average, improved by ~ 81 %.	**p < 0.001**	No control group	There was a significant increase in knowledge after the intervention. Most participants agreed that the e-learning videos were helpful. The majority of the participants agreed that the length of the classroom training was adequate. Overall, the majority (68.9 %, after class; 75.9 %, 1 month) were satisfied with the training they received.
Mastellos et al. 2019 [42]	To investigate the feasibility of integrating distance m-Learning as part of a	RCT Pre-post Bloom's taxonomy, mixed	Primary care Health surveillance assistants (HSA)	PowerPoint slides, videos, computers, tablets and smartphones	Two questionnaires (pre- and post-) were developed and tested during	Self-rated ICT knowledge	(T0) Mean values not reported	(T1) Mean values not reported	**p < 0.05**	ICT Knowledge Control vs IG one domain: The ability to	Scores across all scales improved after attending the traditional and blended learning

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
	blended learning programme	rotation model 3 weeks total	Total n = 40 Intervention (Blended) (n = 20): HSA (n = 15), Senior HSA (n = 5) Control (Traditional) (n = 20): HSA (n = 15), Senior HSA (n = 5) Malawi	31 h total in 3 weeks Blended learning group (intervention): 7 seminars, 3 e-Learning workshops 5 off-site m-Learning sessions and 1 tutor-led workshop Traditional group (control) Lectures, seminars, tutored training workshops 31 h face-to-face time in 5 days The blended learning group received the same content as the traditional learning group from the same instructors. The e-Learning content consisted of videos with scripted lectures	a pilot course at Mzuzu University in November 2015 ICT knowledge (self-rated) 10 items on a 5-point Likert scale Actual ICT knowledge 10-item multiple-answer scale. Attitude 10 items on a 5-point Likert scale (T0) Baseline(T1) Post intervention (final training day) Satisfaction with the course 10 items on a 5-point Likert scale STATA (version 12.1) Paired and unpaired t-tests All statistical tests were two-sided	ICT knowledge Attitudes toward computers, tablets, and smartphones Satisfaction with the course	IG Control IG Control IG Control	IG Control IG Control IG Control	ICT Knowledge IG 1 / 10 domain **$p < 0.05$** ICT Knowledge Control 1 /10 domain **$p < 0.05$** Attitude IG 5/10 domains **$p < 0.05$** Attitude Control 2 / 10 domains **$p < 0.05$**	download and save a journal article in a pdf format **$p < 0.05$** Control vs IG "The content of the course was easy to follow"," I enjoyed the course" **$p < 0.05$**	courses. Self-rated ICT knowledge was significantly improved in both groups with significant differences between groups in seven domains. Actual ICT knowledge scores were similar across groups. There were significant pre-post differences in two domains (one per group). There were no significant differences between groups in attitudinal gains. Satisfaction with the course was generally high in both groups. Participants in the blended learning group found it more difficult to follow the content of the course and enjoyed it less. There was no difference between blended and traditional learning in the acquisition of actual ICT knowledge among community healthcare workers in developing countries. Given the human

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
											resource constraints in remote resource-poor areas, the blended learning approach may present and advantageous alternative to traditional learning.
Mussa et al. 2019 [56]	To discover key determinants of the intention of respiratory therapists to use the Modified Early Warning Score (MEWS) and to determine whether an enhanced Technology Acceptance Model is an appropriate model for explaining RT intentions to use the MEWS	Quasi-experimental Pre-post Technology Acceptance Model (TAM) Unspecified duration	Academic medical center Respiratory therapists (RT) Total n = 75 (T0 and T1) n = 46 No control group The United States	An educational session. Lecture and interactive small group Unspecified duration	Survey instrument developed by researchers. Following the LoCurto and Berg development process MEWS knowledge Job relevance Perceived usefulness Perceived ease of use Attitude toward using MEWS Intention to use 22 items on a 5-point Likert scale (T0) Baseline(T1) 24 h −1-week post-intervention (after the educational session) XLSTAT 2017 for Excel (Addinsoft) . Wilcox test < 0.05. Partial least squares. Structural equation modelling.T-tests (path coefficients)	MEWS-knowledge Behavioral intention	(T0) 2.0 3.0	(T1) 4.0 4.0 The perceived ease of use and job relevance was found to explain 73 % of the variance (adjusted R^2 = 0.73 ($p < 0$ 0.001 and $p = 0.002$, receptively) in perceived usefulness The perceived ease of use was found to have a significantly positive effect on attitude (adjusted $R^2 = 0.63$, $p = 0.001$) The attitude was found to have a significantly positive effect on behavioral intention (adjusted $R^2 = 0.85$, $p < 0.001$)	**p < 0.001** **p < 0.001**	No control group	There was a statistically significant median increase in the MEWS knowledge score as in behavioral intention score. Perceived ease of use was associated with the experience of the usefulness of MEWS. Perceived usefulness and perceived ease of use were statistically significantly associated with attitude. The attitude was significantly associated with the intention to use MEWS post-measurement. RTs may be more inclined to incorporate the computer-generated MEWS in their assessment of patients if they are educated about its clinical relevance and if their attitude toward using it is

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
											favorable. The TAM model was suitable for assessing respiratory therapists' perceptions and reactions to the new system.
Poe et al. 2011 [57]	To evaluate the use of trained peer coaches to build bedside nurse skills, knowledge, and experience(intellectual capital) in the use of Electronic Health Record (EHR)	Quasi-experimental Pre-post Johns Hopkins Quality and Safety Research Group (JHQSRG) Translating evidence into practice model 2 months total	Academic medical center Psychiatry department and neurosciences department Nurses Total n = 415 (T0) n = 207(T1) n = 155 No control group The United States	Training Classes Ongoing learning activities Printed guides Quick tip sheets Simulated documentation sessions in the test environment during clinical time	Clinical Information System Implementation Evaluation Scale (CISIES) (T0) Peer coaches at the start of coach training (T0) Nurses prior new EHR activation (T1) 2 months following EHR activation 37 items on a 6-point Likert scale. User's expectations and user's perceived experience of the EHR implementation The survey sample included peer coaches and all staff nurses on pilot units Descriptive statistics	Training was adequate	(T0)1.9 (2.2)	(T1)2.5 (1.8)	Not reported	No control group	The main finding was that using peer coaches seems to increase confidence and satisfaction with the IT learning experience. User feelings of confidence to teach others how to use the system, which was expected to be moderately low pre-implementation, appeared to be better than expected (moderate). The total sample of staff nurses expected to be moderately satisfied with the adequacy of coach-enhanced training and the availability of supportive resources during implementation. Their experiences with these measures were better than expected. Despite
						I feel confident in ability to assist others in using the system	1.6 (2.5)	2.1 (2.2)			
						Adequate resources were available	2.2 (2.1)	3.4 (1.8)			
						People whom I work with daily support me in my use of the system	2.7 (1.9)	2.8 (1.6)			
						Overall, the introduction of the system will be/has been effective	1.7 (2.3)	2.0 (2.2)			
						Overall satisfaction with system implementation. (average score across all 37 items)	1.0 (1.5)	0.8 (1.5)			

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
											experiencing better-than-expected satisfaction with respect to training and go-live support, there did not appear to be an increase in overall satisfaction with implementation after initiating the coach program.
Rosenfeld et al. 2002 [58]	To increase the information literacy skills of staff nurses	Quasi-experimental Pre-post The information literacy competencies, developed by the The New York University's libraries, guided the design of educational sessions to improve the skills and competency levels of staff nurses on the patient unit 6 months total	Intensive care unit Nurses Total n = 32 Assistant nurse managers (n = 3) Bedside nurses (n = 29) Database searches (n = 40) No control group The United State	Unit-based training session Lecture/ demonstration 1 h 5–6 participants 6 weeks until all participants had received hands-on training Weekly 1 h follow-up training sessions. 5–6 participants A Handout a Web-based tutorial	Baseline (T0) "competency assessment tool" Which information sources a participant searched to answer the clinical questions. (no competency, beginner, intermediate, or advanced) Literature search assessment (T0) Baseline(T1) Post Intervention Each search was rated using a self-defined rating scale to determine each participant's level of searching competency (beginner, intermediate, or advanced) Rating system was adapted from a point system used by the Educational	Level of searching competency	(T0) pcs No competency 31 Intermediate 1	(T1) pcs No competency 21 Beginner 4 Intermediate 4 Advanced 3	Not reported	No control group	At the start, the majority of participants evaluated themselves as having no information literacy competencies. This was validated when the medical librarians evaluated the initial computerized searches. The number and quality of the searches increased with time and the level of competence in literature searching improved somewhat. When conceptualizing the educational components, it was believed that training on the unit would increase participation and success because

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					Services Department of the Ehrman Medical Library at the NYU School of Medicine in its assessments of medical students, and reliability or validity has not been established						staff nurses were reluctant to leave the unit for computer training. In the final analysis, it is unclear whether the unit-based concept was effective. The stressful ICU environment was not conducive to learning during training / follow-up sessions and created interruptions in searches by participants.
Rossley et al. 2023 [43]	To evaluate an escape room's impact on electronic health record downtime competence. To measure and evaluate participants' learning from and satisfaction with an escape room designed to help them master the Electronic Health Record (EHR) downtime process. A secondary aim was to evaluate the logistics associated with implementing a large-scale escape room in which a significantly sized audience simultaneously participates	Quasi-experimental Post test only 45 min + debriefing	Academic medical center. Inpatient and outpatient setting Nursing team leaders (i.e., charge nurses) Total n = 75 No control group The United States	Tabletop escape room to escape a zombie invasion 15 teams of 5 participant located in a large ballroom Each team solved a set of clues and tasks The facilitators continuously circulated through the room assisting groups as needed. Each major task directly aligned with learning objectives and essential concepts A debriefing session directly following completion of the escape room. Participants perception of the	Two tools to evaluate learner outcomes (T1) Post intervention A Kirkpatrick Level 1: Reaction survey, which focused on learners' perceptions of learning, achievement, and motivation A learning reflection exercise which prompted participants to consider what actions they could keep doing, start doing, and stop doing to increase EHR downtime competence. No further description of the instruments	Motivated by the escape room Escape room had a noticeable impact on participants learning The escape room met all three learning objectives The escape room was fun, and participants were satisfied with the session A moderate to strong preference for escape room use Rated difficulty level 3/5 Rated difficulty level 4/5		(T1) Agree 54 % Agree or strongly agree 90 % Agree or strongly agree > 85 % Agree 95 % 95 % 43 % 55 %	Not reported	No control group	Results showed 92 % of participants were motivated by the escape room; 90 % reported it significantly influenced their learning. The evaluation data supported the use of an escape room when matched appropriately with an educational need. Furthermore, this event demonstrated NPD practitioners could strategically plan active learning exercises based on relevant content to leverage learner motivation. However, the escape room did not appeal to every learner. The

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
				experience, including how the escape room worked as a teaching strategy Questions relevant to vital concepts Matching the tasks and puzzles with real-life critical steps	Microsoft Excel	Additional qualitative data sourced from a learning reflection exercise					planning committee identified that providing educational material in a second format (postevent) might prove beneficial with future implementations.
Sevean et al. 2008 [44]	To evaluate an educational intervention designed to prepare nurses working in rural and remote settings to perform assessments normally conducted by physicians via telehealth (videoconference) clinics	Quasi-experimental Pre-post 1 day	Nurses working in rural and remote settings from 13 communities Telehealth sites (Oncology and preoperative clinics) Total n = 42 Nurses (n = 37) Pre and post survey Nurse educators (n = 5) Post survey only No control group Canada	The 1-day telehealth workshop by video conferencing A handout. The presentations, reference materials and visual tools that could be posted in the clinics to assist when conducting assessments of patients	Prior to the educational sessions a preworkshop survey to identify learning needs in relationship to the four focus areas: physical assessment, perioperative care, oncology care, and telehealth practice Questionnaire 42-items Demographics and previous experience with telehealth technologies. Likert-type questions to prioritize topics within the four focus areas Post intervention, open-ended questions SPSS to analyse presurvey results. Post survey data were themed using	Open-ended questions about the workshop	Not reported	Not reported	Not reported	Not reported	The majority of the nurses did not have experience working with computer technology on a daily basis before. In general, the nurses indicated that the education sessions exceeded their expectations in terms of being interesting, informative, practical, and well-organized. Nurses reported that the education sessions not only were useful to practice but also provided an opportunity to talk with other nurses doing similar jobs. The nurses indicated that they would be able to use what they had learned and the tools (assessment guidelines) they were provided in daily practice, thereby improving their

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					interpretative analysis to identify patterns related to the overall educational experience of the participants						patient care assessment. Nurses appreciated the multimethod mode of education delivery and stressed that they would like more opportunities to practice hands-on assessment. The educators felt that with more practice delivering telehealth education, they would eventually become more interactive and comfortable with their audience.
van Houwelingen et al. 2021 [59]	To evaluate the effectiveness of training in telehealth competencies on nurses' subjective knowledge, self-efficacy and usage of telehealth	Quasi-experimental Pre-post The nursing telehealth activities and competencies framework developed by the authors was used for the development of a telehealth educational intervention Bandura's strategies to increase self-efficacy were used in the training sessions ~20 weeks total	A multi-setting study Nurses Total n = 37 Primary care (n = 12) Homecare (n = 14) Hospital (n = 11) The Netherlands	Two 2–3 h training sessions 10–14 learners Nurses worked in small groups of three persons and provided each other with (peer) feedback Roleplay. Practicing real-life scenarios using role-playing and providing each other with (peer) feedback A list with relevant questions and answers covering all knowledge items	The questionnaire was constructed by the authors following the guidelines of Artino et al. (2014) Knowledge about telehealth; Questions on a 5-point Likert scale Telehealth self-efficacy; Questions on a 10-point scale (T1) Baseline (Directly before the training)(T2) Directly after the training(T3) 6–10 weeks after the training (T0) 6–10 weeks before intervention (nr.	Telehealth knowledge Telehealth self-efficacy	(T1) Primary care2.9 (2.6–3.6) Homecare3.0 (2.73.1) Hospital3.3 (3.1–3.6) Primary care6.3 (6.07.0) Homecare6.2 (5.7–6.6) Hospital 7.0 (6.3–7.7)	(T2) 3.0 (3.4–3.8) (T3)3.7 (3.4–4.1 4.0 (3.8–4.1) (T3)4.0 (3.8–4.3) 3.8 (3.7–4.0) (T3)3.8 (2.3–3.9) 7.2 (5.9–8.0) (T3)7.0 (6.5–8.2) 7.8 (7.2–8.5) (T3)7.6 (7.3–8.2) 7.7 (6.7–8.2) (T3)7.8	T1 vs T2 **p = 0.002** T1 vs T3 **p = 0.003** T1 vs T2 **p = 0.000** T1 vs T3 **p = 0.000** T1 vs T2 **p = 0.016** T1 vs T3 p = 0.187 T1 vs T2 p = 0.171 T1 vs T3 **p = 0.024** T1 vs T2 **p = 0.001** T1 vs T3 **p = 0.002** T0 vs T1 p = 0.096	Knowledge T1 vs T3 Primary care **p = 0.003** Homecare **p = 0.000** Hospital 0.187 Self-efficacy T1 vs T2 Homecare **p = 0.001** Primary care 0.171 Hospital p = 0.096	In each setting, telehealth knowledge significantly increased during the training sessions. In each setting, nurses' telehealth self-efficacy also significantly increased 6–10 weeks after the training. After the training, the number of remote consultations increased from 2 to 10 in primary care, 12 to 35 in home care and decreased from 28 to 17 in the hospital setting. It was concluded

(*continued on next page*)

Table 2 (*continued*)

Authors, year	Aim of the study	Study Design / Theoretical framework	Setting, Sample, Country	Teaching methods (intervention)	Instruments, follow-up, analysis	Research outcomes	Pre-test Mean (SD)	Post-test Mean (SD)	P-value pre-post	P-value for diff. between groups	Key findings
					of remote consultations)			(7.2–8.4)	T1 vs T2 **p = 0.034**		that training nurses in telehealth activities contribute to their knowledge and self-efficacy.
					Satisfaction; Closed question on a 10-point scale. Perceived usefulness of training: 4 items derived from the 'Training Evaluation Inventory' (scale 1–5)	Number of remote consultations	Primary c.(T0) 2Home c.(T0) 12Hospital (T0) 28	(T3) 10(T3) 35(T3) 17		Remote consultations T0 vs T3 increased in primary- and homecare settings and decreased in hospital setting	
					IBM SPSS 23.0. Non-parametric tests, Mann-Whitney U tests and Wilcoxon Signed-Rank tests. Monte Carlo simulation to assign p-values	Satisfaction and perceived usefulness of the telehealth training		Median (Q1-Q3) Primary care8.0 (7.0–8.0) Homecare9.0 (8.0–10.0) Hospital8.0 (6.5–8.0)			

Table 3
Teaching methods used in the educational interventions

Teaching method	
Face-to-face / Classroom education (n= 17)	Adereti & Olaogun, 2019; Bickford et al. 2005; Carson et al. 2021; Ciccollini et al. 2022; Collazo et al. 2023; Do & Kim 2021; Evatt et al. 2014; Farokhzadian et al. 2021; Hughes et al. 2014; Jouparinejad et al. 2020; Kaakinen et al. 2016; Lacambra, 2021; Mastellos et al. 2018; Mussa et al. 2019; Poe et al. 2011; Rosenfeld et al. 2002; van Houwelingen et al. 2021
Video conference/ Virtual education only (n=3)	Bindler et al. 2023; Carson et al. 2021; Sevean et al. 2008
Blended learning (n=5)	Ciccollini et al. 2022; Evatt et al. 2014; Lacambra, 2021; Mastellos et al. 2018; Rosenfeld et al. 2002
Hands-on training (n=13)	Adereti & Olaogun, 2019; Carson et al. 2021; Do & Kim 2021; Farokhzadian et al. 2021; Hughes et al. 2014; Jouparinejad et al. 2020; Kaakinen et al. 2016; Lacambra, 2021; Mastellos et al. 2018; Poe et al. 2011; Rosenfeld et al. 2002, Sevean et al. 2008; van Houwelingen et al. 2021
Simulation / Roleplay (n=2)	Ciccollini et al. 2022; van Houwelingen et al. 2021
Educational Escape Room (n=1)	Rossley et al. 2023
Lecture/classroom only (n=2)	Bickford et al. 2005; Mussa et al. 2019
Homework (n=2)	Jouparinejad et al. 2020; Farokhzadian et al. 2021
Open training sessions (Drop in) or other open learning opportunities (n=4)	Hughes et al. 2014; Lacambra et al. 2021; Poe et al. 2011; Rosenfeld et al. 2002
Written material (n=9)	Ciccollini et al. 2022; Collazo et al. 2023; Do & Kim, 2021; Evatt et al. 2014; Hughes et al. 2014; Poe et al. 2011; Rosenfeld et al. 2002; Sevean et al. 2008; van Houwelingen et al. 2021
Peer coaches or superusers (n=3)	Collazo et al. 2023; Evatt et al. 2014; Poe et al. 2011

face classroom training and the next two receiving the same training virtually.

In addition to training sessions, supplementary material and support were often provided. Lecture material and / or instructions on using the applications or systems were also available in written form [44,48,49,50,52,57,58,59] or online or on a learning platform [42,47,48,50,55,58]. In two studies of 6 months duration [45,58], additional weekly or monthly follow-up sessions were held, and on-the-job support was also used. In a study by Poe et al. [57] peer coaches were constantly available on the ward and among other responsibilities, monitored IT support calls to identify problems that needed further support in the work unit. In two studies [48,50] EHR nurse super-users provided ongoing support and served as staff resources for situational questions. In a study by Mastellos et al. [42], the intervention group had access to telephone support during the e-learning period.

Educational interventions were provided by researchers in nine studies. Other providers in the remaining studies were medical informatics experts, a medical librarian, telehealth experts, Nursing Professional Development practitioners, PhDs in nursing, nurse educators, accredited trainers, a systems supplier, and trained peer coaches.

3.3.1. Measurements of outcomes

The most common method used to measure outcomes was self-assessment using a Likert-type format [42,46,47,50,51,53,54,56,57,59,60,61]. True/false, yes/no or multiple-choice questions were also used [47,49,50,51,52,42]. Rossley et al. [43] and Collazo et al. [48] used surveys to collect participants' perceptions and opinions but did not describe the instrument further. Also, The Competence assessment tool, developed in a study by Lacambra [55] was not described further. Entries in the electronic health record system were also reviewed. Validated instruments [45,49] or an assessment rating scale developed for the study [50] were used. Collazo et al. [48] monitored chart audits based on staff utilisation of a new electronic template. Rosenfeld et al. [58] assessed nurses' ability to retrieve information from a nursing database using a self-defined rating scale. Participants' behaviour or performance was assessed in two studies. In a study by Ciccollini et al. [47] a simulated patient call was assessed using a rating scale developed for the study. In a study by Do and Kim [49] an observer assessed the nurse's behaviour by using a nursing record behaviour tool as the nurse entered data into an electronic health record system. In a study by Sevean et al. [44] data were collected using open-ended questions after an educational workshop. In a study by van Houwelingen et al. [59] the number of remote consultations before and after the training intervention was also measured.

3.4. Effects of training interventions on the digital competence of healthcare professionals and professionals' satisfaction towards the educational interventions

Thirteen studies found statistically significant results following different educational interventions to promote the digital competence of healthcare professionals. These findings are illustrated in Fig. 2. In the remaining studies ($n = 7$), educational interventions also generally showed positive outcomes on either EHR and HIT, ICT or telehealth competence development. In addition, the participants' satisfaction towards the educational intervention were reported in several studies ($n = 8$).

3.4.1. Educational interventions to teach EHR system and HIT competencies

The EHR or HIT competencies addressed in the educational interventions [43,45,46,48,49,50,55,56,57] included, for example, knowledge or skills or attitudes related to the characteristics and use of a monitoring system or EHR or tablet application, accuracy and correctness of entries in the EHR and knowledge of criteria for the entries.

Statistically significant results were found in five studies of educational interventions related to EHR and HIT competencies [45,49,50,55,56]. Adereti & Olaogun [45] found significant results in the quality of nursing documentation following the educational intervention. There was a significant difference in the quality of documentation at the three time periods in both the intervention ($p = 0.001$) as well as in the control groups ($p = 0.05$). The intervention significantly improved the overall quality of documentation of the nursing process in the control group while it significantly improved the documentation of all phases of the nursing process in the intervention group.

In a study by Do & Kim [49], the knowledge scores of the intervention group improved after the education. There was a significant difference compared to the control group (Nursing Record Knowledge $p = 0.019$). Also, the intervention group's EHR documentation scores (Nursing Record performance) increased after the education. There was a significant difference compared to the control group in the post-test ($p = 0.033$). Do and Kim [49] also evaluated the nurse's behaviour when writing records and found a significant improvement after education between the intervention and control group ($p = 0.018$).

In a study by Evatt, et al. [50] the knowledge of Electronic Admission Assessment Documentation increased significantly ($p < 0.001$) after the educational session. They also found a significant increase in attitudes toward EHR (Electronic Admission Assessment Documentation) ($p < 0.001$) post-intervention. Also, the timeliness ($p = 0.026$), accuracy ($p < 0.001$) and completeness (11/13 items, $p < 0.001$) of assessment documentation improved significantly after the educational session.

Lacambra [55] found that there was a significant increase in

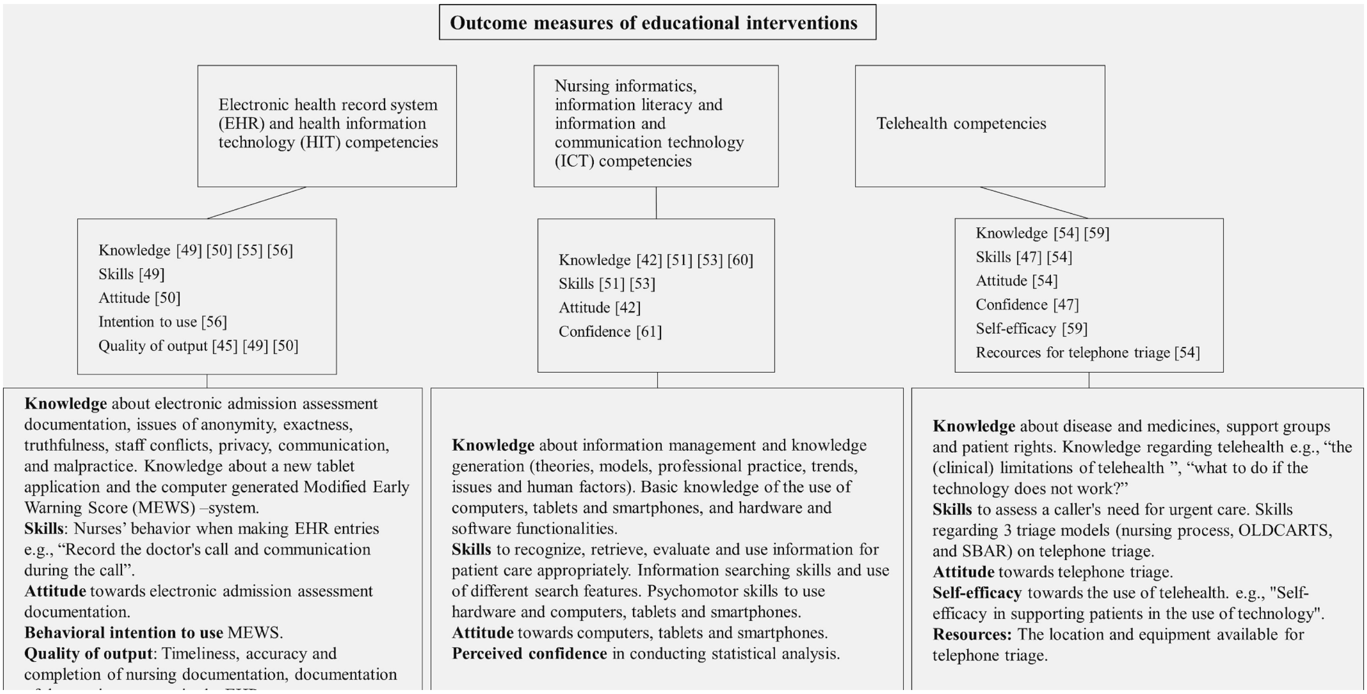

Fig. 2. Statistically significant results in outcome measures related to digital competence.

knowledge about the new tablet application after the education ($p < 0.001$). In a study by Mussa et al. [56] the Modified Early Warning Score (MEWS) knowledge increased significantly ($p < 0.001$) after training. Also, the intention to use the MEWS system increased statistically significantly ($p < 0.001$). Perceived ease of use was found to have a significant effect on perceived usefulness. Perceived ease of use and job relevance explained 73 % of the variance ($p < 0.001$ and $p < 0.002$ respectively) in perceived usefulness. Perceived ease of use also had a significant positive effect on attitude ($p < 0.001$) and attitude had a significant positive effect on intention to use ($p < 0.001$).

Positive outcomes were also found in four other studies aimed at improving competencies related to electronic health records. In a study by Rossley et al. [43] > 85 % of participants agreed or strongly agreed that the escape room training designed to help nursing team leaders manage the EHR downtime process, met all learning objectives. In a study by Carson et al. [46] training sessions improved nurse managers' knowledge of using the EHR system. There was an increase from the pre- to post-education mean for all questions. In a study by Collazo et al. [48] creating and standardising an electronic template for the new diagnostic education checklist increased documentation of patient education by 26 % after implementation. In a study by Poe et al. [57] a peer coach program to support new EHR implementation appeared to increase confidence and satisfaction with the IT learning experience. Participants felt more confident using the system after training and perceived the instruction and support resources to be better than expected.

3.4.2. Educational interventions to teach nursing informatics, information literacy and information and communication technology (ICT)

The nursing informatics, information literacy and ICT competencies addressed in the educational interventions [42,51,52,53,58,60,61] included, for example, perceived confidence with statistical methods and analysis, knowledge, skills and attitudes related to the use of computers, software, smartphones or tablets in general or in a professional context, information management skills, human factors and skills related to searching and evaluating information, and the use of medical and nursing databases.

Statistically significant results were found in five studies which focused on educating professionals in nursing informatics, information literacy and ICT [42,51,53,60,61]. In a study by Mastellos et al. [42] participants' self-rated ICT knowledge scores showed significant increases ($p < 0.05$) in both the intervention and control group after training intervention. Differences in self-rated knowledge scores were higher across participants in the control group compared with the intervention group, with statistically significant differences in seven out of ten domains. However, scores measuring actual ICT knowledge showed significant pre-post differences only in two out of ten domains, with a statistical difference between the groups in only one domain. They also found significant increases in attitude scores towards computers, tablets and smartphones in both intervention and control groups, but no significant differences in attitude scores between groups after the training intervention.

In the study by Farokhzadian et al. [51] the training program significantly ($p < 0.001$) improved all dimensions of information literacy skills in the intervention group compared to the pre-intervention. There was also a significant difference ($p < 0.001$) compared with the control group. In a study by Jouparinejad et al. [53] in the post-test, the nursing informatics competency and its dimensions significantly increased ($p = 0.001$) in the intervention group. There was also a significant difference compared with the control group ($p = 0.001$).

A study by Bickford et al. [60] found that mean total scores of nurses' perception of their knowledge and ability in specific areas of nursing informatics, information technology and healthcare information systems increased significantly ($p = <0.001$) after education. In a study by Bindler et al. [61] participants' perceived confidence in doing statistical analyses overall increased significantly after education, both in the pilot group ($p = 0.05$) and in subsequent sessions ($p = 0.007$). Perceived confidence in running necessary analyses increased significantly only in the pilot group ($p = 0.02$).

Two other studies focusing on nursing informatics, information literacy and ICT showed positive results, although they did not reach statistical significance. Hughes et al. [52] found that an educational intervention improved nurses' proficiency in finding items in the work-related information system and improved their overall computer skills and comfort level. In a study by Rosenfeld et al. [58], an educational intervention aimed at improving the information literacy skills of staff nurses increased the number and quality of literature searches over time.

Also, the level of competence in literature searching improved somewhat.

3.4.3. Educational interventions to teach telehealth competencies

Four studies [44,47,54,59] addressed educational interventions aimed at improving telehealth competencies. The telehealth competencies included, for example, knowledge, skills or self-efficacy related to telephone triage models, assessing or supporting patients remotely or perceptions of resources as well as knowledge related to legal and workplace issues of telehealth.

The telehealth training contents consisted of educational sessions where information about telehealth legislation, protocols and policies [44,54,59], telephone triage, assessment and coordination, hospital guidelines [47] and telephone triage interaction and documentation [54] were provided. The interventions also included orientation to a videoconferencing system [44] and practical training in assessing patients' care needs by using a computer-based telephone triage program [54], a standardised case scenario via Zoom web conferencing [47] and the possibility to practice with specialised digital equipment [44]. Role-playing in small groups was used to rehearse topics such as remote health promotion or patient and family caregiver self-care instruction via videoconferencing [59].

Statistically significant telehealth-related outcomes were found in three studies [47,54,59]. In a study by van Houwelingen et al. [59] telehealth knowledge increased significantly in all three study settings immediately after the training intervention compared to the pre-intervention (primary care $p = 0.002$, home care $p < 0.001$, hospital $p = 0.016$). 6–10 weeks after the training intervention, scores were significantly higher than baseline in primary care ($p = 0.003$) and home care ($p < 0.001$), but no longer in a hospital setting. van Houwelingen et al. also found significant outcomes in telehealth self-efficacy. Telehealth self-efficacy increased significantly immediately after training only in-home care ($p = 0.001$). 6–10 weeks post-intervention, self-efficacy was significantly increased compared to prior to the training in all three settings (primary care $p = 0.024$, home care $p = 0.002$, hospital $p = 0.034$). They also collected the number of remote consultations before and after training and in two of the three units, the number of remote consultations increased after the training intervention. In one setting (hospital) the number of remote consultations decreased.

Ciccollini et al. [47] ($p = 0.002$) and Kaakinen et al. [54] ($p = 0.003$) found significant improvements in telehealth skills. In the study by Ciccollini et al. skills were assessed by the researcher using a simulated phone call as in the Kaakinen et al. study, self-assessment was used in skills assessment. Although in the Ciccollini et al. study participants' skills improved significantly, there was no improvement in telephone triage knowledge ($p = 0.11$). However, Ciccollini et al. found that confidence regarding telephone triage improved significantly after education compared to prior education ($p = 0.008$). In the study by Kaakinen et al. [54], there was a significant increase in telephone triage knowledge ($p = 0.009$) after training intervention. Kaakinen et al. also found that attitudes ($p = 0.008$) towards telephone triage as well as resources for telephone triage ($p = 0.028$) increased significantly after training intervention. In this study, during the intervention period, resources to support telephone triage were invested.

Sevean et al. [44] also found some positive outcomes, although not statistically significant. A one-day videoconferencing telehealth workshop, that prepared nurses working in rural and remote settings to conduct patient assessments via videoconferencing was considered useful for practice. The nurses indicated that they would be able to use the skills learned and the tools provided in daily practice, thereby improving their assessment of patient care.

3.4.4. Satisfaction towards the educational interventions

There was general satisfaction with the training interventions. In a study by Mastellos et al. [42] both the face-to-face and blended learning groups were satisfied with the training. On the other hand, the blended group found it more difficult to follow the course content and enjoyed the course less compared with the control group ($p < 0.05$). The feedback was positive from both face-to-face and virtual settings in a study by Carson et al [46]. Participants in a study by Van Houwelingen et al. [59] were satisfied with the training intervention and found it useful. Homecare nurses valued their satisfaction with the training with a median value of 9.0, whereas the two other settings valued the training with a median of 8.0, both on a 10-point scale. In a study by n a study by Lacambra [55] the length of the classroom training was considered sufficient by the majority and most found the e-learning videos useful. In a study by Poe et al. [57] training and resources for learning were considered adequate, although there did not appear to be an increase in overall satisfaction with system (EHR) implementation. 90 % of participants in a study by Rossley et al. [58] agreed or strongly agreed that the Escape Room had a noticeable impact on learning. In a study by Sevean et al. [44] the training was considered to be useful and well organised and practitioners appreciated the opportunity to learn new skills and share experiences with others working in a similar setting. In a study by Bindler et al. [61] participating nurses consistently rated the course as very useful.

4. DISCUSSION

This systematic review brought together 20 original studies of educational interventions to develop the digital competence of healthcare professionals and their results. There was a considerable degree of heterogeneity in relation to the study design, the length and content of the interventions, the context and the instruments used. When examining complex interventions, it is important to specify the components of the interventions and the contexts in which they were implemented [62,63]. This review also examined the delivery methods of educational interventions and the contents of the educational or training sessions [64]. The results of this study indicate that the training interventions had a significant influence on the digital competence of healthcare professionals by using versatile methods. The interventions included in this review most commonly assessed participants' knowledge, skills or perceptions related to digital technologies. Self-assessment using a Likert scale or multiple choice, true/false, yes/no statements were the most commonly used assessment methods.

Educational interventions addressed a variety of competencies related to EHR, HIT, telehealth, ICT, informatics, information literacy and computer use. In more detail, knowledge, skills, attitudes, self-efficacy, intention to use and confidence related to the use of these digital technologies were evaluated in the included studies. Ethical competence in relation to digitalisation, which has also been previously identified as part of health professionals' digital competence [12,16], was not directly assessed or measured, but the assessment items in some studies included elements related to the ethical aspects of digital health such as the competence to assess the current capabilities and limitations of technology, to describe ways to protect data [60], to not record the subjective judgement of the patient [49], and the participants' subjective knowledge of the laws and regulations concerning the protection and exchange of medical data [59]. Therefore, more education should be targeted to improve the ethical competence in digitalisation and the competence should be more comprehensively assessed.

Although motivation and willingness to use digital solutions in patient care are important components of healthcare professionals' digital competence [12,16,33], only five [42,48,50,54,56] of the studies assessed this dimension and four [42,50,54,56] reported a statistically significant improvement in participants' attitude or intention to use. Previously, Virtanen et al. [33] also found that interventions to promote healthcare professionals' eHealth competence tended to focus on improving skills rather than motivation. Therefore, future research should focus on investigating different ways of enhancing motivation in the use and adoption of digital solutions in healthcare.

Furthermore, interaction skills when using digital tools and environments are part of health professionals' digital competence [12,16,17], but only two of the studies included in this review assessed competencies related to interaction. Educational interventions to promote telehealth competencies by Kaakinen et al. [54] and Ciccollini et al. [47] evaluated participants' skills in assessing callers' needs for care over the telephone. The educational content described in studies by Sevean et al. [44] and van Houwelingen et al. [59] also included telehealth interaction skills but they did not measure the skills achieved. As telehealth solutions become more common, the competence requirements for healthcare professionals are evolving. Professionals should be competent in interacting with patients through digital tools and acknowledge the ethical implications of digital communication in healthcare [19,21,22]. Hence, professionals' digital interaction skills should be assessed more in detail in the future to address these competence requirements and plan adequate education accordingly.

Of the studies included in this review, the majority of educational interventions involved traditional contact teaching. Only two of the interventions [44,61] were designed to be delivered entirely by e-learning (videoconferencing). One educational intervention [46] was modified to a virtual format following the COVID-19 pandemic. Not only the pandemic but also the rapid development of digital technologies has influenced education systems and the use of digital technologies in education has generally increased [65]. This also applies to the education and training of health professionals [66]. In the future, more educational interventions to promote healthcare professionals' digital competence will likely be delivered through e-learning. For example, e-learning has already been used to educate health professionals in pain assessment [67,68] and chronic wound management [69].

Five studies [42,47,50,55,58] included in the review used the blended learning approach, which combines face-to-face contact teaching and e-learning. Of the studies using blended learning, three pre-post studies [47,50,55] reported statistically significant results. In one study [42], actual ICT knowledge scores were similar across blended learning and traditional groups. Similar results have recently been reported in other educational interventions using a blended learning approach for healthcare professionals in statistically significantly improving nurses' knowledge regarding communication skills and perceived self-efficacy [70] as well as confidence in inserting a peripheral intravenous catheter (PIVC) [71] following an educational intervention.

Face-to-face education was used in all except one of the thirteen studies reporting statistically significant results. In most of the studies with significant results, the educational sessions comprised of lectures or demonstrations and discussions or other interactions. Small group exercises, 'hands-on' training or simulation/roleplay were also commonly used. In addition, educational material was often available in written form, on a training platform, or on the web. The content of the education often targeted the area of digital competence needed for the relevant workplace. This result indicates that professional's work tasks and responsibilities should guide the planning of the content of the educational activity which enables the transfer of the newly learned competence to actual practice.

Of the studies reporting statistically significant outcomes regarding participants' skills or performance or quality of output, six out of seven used hands-on training, roleplay or simulation. Feedback from peers [59] or from the instructor [47] based on one's performance, or the opportunity to share personal projects with other learners [61], as well as the opportunity to ask questions and discuss, were common to all three studies reporting significant effects on participants' confidence or self-efficacy.

Educational methods similar to those identified in this review to develop digital competence have also been used in other educational interventions for healthcare professionals to develop different skills and competencies. A systematic review by Oikarinen et al. [72] found that educational interventions with statistically significant outcomes to develop nurses' cultural competence included teaching methods such as lectures, group discussions, case studies, reflective exercises and simulations. An integrative review by Ramjan et al. [73] found that educational programs to improve nurses' knowledge, attitudes and practice in adolescent and young adult health with improvements in participants' knowledge and practice using a mix of face-to-face and digital asynchronous delivery, with multi-strategic approaches to increase accessibility and engagement. In conclusion, a multi-method approach, including face-to-face or online teaching and supplementary material that can be reviewed later or as needed, as well as opportunities to practice new skills and share experiences or questions, appears to be a valid method for providing digital competence education to healthcare professionals, enabling a broad approach to competence development, beyond mere knowledge improvement.

Different roles in healthcare require different operations with information technology [74] and digital health training should focus on competencies relevant to a particular group of health professionals, role, level of seniority and setting [17]. Along with the professionals' motivation and positive attitude towards the use of technology [33], organisational support, adequate resources, and the attitude and support from peers are also essential factors in building the digital competence of healthcare professionals [12,25]. This is consistent with the findings within this review. In the studies in which participants' attitudes or behavioural intentions were statistically significantly improved, organisational support was provided in the form of additional education and training to support nurses with the digital competencies needed in their daily work [50,54] and resources for work were improved [54]. Moreover, participants with little or no previous ICT skills were provided with instruction, equipment and hands-on experience in basic computer skills and the use of smartphones [42]. Thus, organisational factors should be designed to individually assess and promote digital competence building to successfully support the professionals in digital transfer.

Encouragement, empathy, and user-centred changes in the working environment could improve the eHealth competence of healthcare professionals [33]. Sufficient time should be allocated to education and relevant to the competencies required for the work [74]. Changes in workflow and patient interaction, as well as changes in the skills required, can be perceived as threatening and weaken the integration of technology into practice [75,76,77]. To promote health technology adoption and safe use, end-users should be involved in the design and implementation phases [9,78,79]. Familiarity, user experience and interest in new technologies enhance the digital competence of healthcare professionals [19], and especially previous experience with digital health solutions contributes to a positive attitude [80].

4.1. Limitations

This review has several limitations. Since a search for the grey literature was not conducted and only published, peer-reviewed articles in English or Finnish were included, certain important studies might have stayed unidentified. Although the literature search was conducted rigorously there is a risk of selection bias, and it can be possible that relevant studies were not identified in the search strategy.

Two researchers conducted the study screening and quality assessment separately to increase the reliability of the process. Only one researcher conducted the data extraction and narrative synthesis, which may increase the possibility of subjectivity in analysing the results. Considerable heterogeneity was visible in the study design, conditions, settings and the content and length of the educational interventions included in this review and a *meta*-analysis of the evidence was not possible. Most of the included studies were pre-post studies of the same group, only six studies included a control group, and only one of these was an RCT which was conducted in Malawi. Therefore, the conclusions derived from the findings should be interpreted with caution. Also, the methodological quality of the studies varied. The overall quality assessment score for two studies [45,48] was less than half based on the JBI criteria indicating a low methodological quality. Some of the studies also used a non-paired pre-post design, which did not allow for the detection of statistically significant differences. One included study did not report any numerical data on the outcome. The outcomes may also be context-dependent, as many of the interventions were tailored to the setting which limits the generalisability of the results. Many studies also used subjective, self-reported scales, which can introduce reporting and social desirability biases [81]. However, all the eligible studies were included in the narrative synthesis to present an overview of the various interventions and educational methods used to develop digital competence.

5. CONCLUSION

Based on this review, educational interventions to develop the digital competence of healthcare professionals have often combined different methods such as traditional contact teaching, including hands-on training and lectures with supplemental materials. The training interventions were close to practice and provided opportunities for participants to discuss and learn together. Interventions mostly focused on improving participants' knowledge, skills or self-efficacy related to the use of digital technologies in healthcare.

The educational interventions achieved statistically significant results in healthcare professionals' digital competence related to electronic health record systems and health information technology. Appropriate use of systems and correct documentation are essential factors in ensuring safe and high-quality care. It is therefore crucial to ensure that health professionals have the competencies required and that continuing professional development is provided. The interventions also achieved statistically significant results in ICT, informatics and information literacy competencies, which can be considered essential for evidence-based healthcare and navigating in the information society, and as a basis for learning new digital competencies. In the area of telehealth, statistically significant findings were reported in terms of knowledge, skills, attitude, resources and confidence or self-efficacy. Issues related to communication and adequate resources, such as sufficient technology or support and appropriate training in the use of technology, are challenges when providing telehealth services. It is therefore essential that these demands are met through continuing education and organisational support.

The findings of this review suggest that digital competence education for nurses and allied health professionals benefits from a multi-method approach. Training contents should include knowledge provision through educational sessions such as lectures as well as opportunities to interact with peers and instructors. Skills and confidence could be enhanced through practical training or role-playing. A blended approach to education could be used, combining self-paced e-learning with guided hands-on practice. Adequate organisational support and encouragement should be provided. Future research should explore the applicability of e-learning for interventions to promote different areas of healthcare professionals' digital competence. The use of peer coaches and other methods to activate and engage professionals could also be further explored. Digital competence should also be measured in addition to self-assessment on a performance basis. As the included studies had a large variance in methodological quality and study design, the results should be interpreted with caution.

Summary table

What was already known on the topic?

- Healthcare professionals need to have digital competence in order to provide high-quality and safe healthcare.
- Nurses are the largest professional group in healthcare, and together with allied health professionals, they play a central role in health service promotion, prevention, treatment, and rehabilitation.
- Continuing professional education is needed to ensure the digital competence of healthcare professionals.

What this study added to our knowledge.

- Providing tailored and practical training can develop the digital competence of nurses and allied health professionals.
- Training should provide knowledge, practical skills and opportunities to interact with peers and instructors which is enabled by adequate organisational support and necessary resources.
- Ethical competence related to digital solutions and digital interaction skills should be assessed more thoroughly as part of educational activities.

CRediT authorship contribution statement

E. Kulju: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Visualization, Investigation, Formal analysis, Methodology. **E. Jarva:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Visualization, Investigation, Validation, Methodology, Supervision. **A. Oikarinen:** Data curation, Writing – original draft, Writing – review & editing, Investigation, Validation, Methodology. **M. Hammarén:** Data curation, Writing – original draft, Writing – review & editing, Investigation, Validation, Methodology. **O. Kanste:** Data curation, Writing – original draft, Writing – review & editing, Investigation, Validation, Methodology. **K. Mikkonen:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation, Validation, Formal analysis, Methodology, Supervision.

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

[1] Expert Panel on effective ways of investing in Health (EXPH), Assessing the impact of digital transformation of health services, Publications Office of the European Union, Luxembourg, 2019. Available at: https://health.ec.europa.eu/system/files/2019-11/022_digitaltransformation_en_0.pdf.
[2] D. Maguire, H. Evans, M. Honeyman, D. Omojomolo, Digital change in health and social care, The King's Fund, Available, 2018 at: https://assets.kingsfund.org.uk/f/256914/x/67e1f5cd93/digital_change_health_care_summary_2018.pdf.
[3] P. Baudier, G. Kondrateva, C. Ammi, V. Chang, F. Schiavone, Digital transformation of healthcare during the COVID-19 pandemic: Patients' teleconsultation acceptance and trusting beliefs, Technovation 120 (2023) 102547, https://doi.org/10.1016/j.technovation.2022.102547.
[4] E. Getachew, T. Adebeta, S.G.Y. Muzazu, L. Charlie, B. Said, H.A. Tesfahunei, C. L. Wanjiru, J. Acam, V.D. Kajogoo, S. Solomon, M.G. Atim, T. Manyazewal, Digital health in the era of COVID-19: Reshaping the next generation of healthcare, Frontiers in Public Health 11 (2023) 942703, https://doi.org/10.3389/fpubh.2023.942703.
[5] World Health Organization (WHO), Global strategy on digital health: 2020–2025, World Health Organization, Geneva, 2021. Available at: https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf.
[6] World Health Organization (WHO), State of the world's nursing 2020: Investing in education, jobs and leadership, World Health Organization, Geneva, 2020. Available at: https://iris.who.int/bitstream/handle/10665/331677/9789240003279-eng.pdf?sequence=1.
[7] World Health Organization (WHO), *Nursing, midwifery and allied health personnel.* Regional office of the eastern Mediterranean, Retrieved April 8th 2023, Available at (2023), https://www.emro.who.int/nursing/about/.
[8] O. Ali, W. Abdelbaki, A. Shrestha, E. Elbasi, M.A.A. Alryalat, Y.K. Dwivedi, A systematic literature review of artificial intelligence in the healthcare sector: Benefits, challenges, methodologies, and functionalities, Journal of Innovation & Knowledge 8 (1) (2023) 100333, https://doi.org/10.1016/J.JIK.2023.100333.
[9] Y.K. Alotaibi, F. Federico, The impact of health information technology on patient safety, Saudi Medical Journal 38 (12) (2017) 1173–1180, https://doi.org/10.15537/smj.2017.12.20631.
[10] K. Socha-Dietrich, *Empowering the Health Workforce to Make the Most of the Digital Revolution.* OECD Health Working Papers No. 129 (2021), https://doi.org/10.1787/37ff0eaa-en. Available at:.

[11] B. Barbosa, I. Bravo, C. Oliveira, L. Antunes, J.G. Couto, S. McFadden, C. Hughes, P. McClure, A.G. Dias, Digital skills of therapeutic radiographers/radiation therapists - Document analysis for a European educational curriculum, Radiography 28 (4) (2022) 955–963, https://doi.org/10.1016/j.radi.2022.06.017.

[12] J. Konttila, H. Siira, H. Kyngäs, M. Lahtinen, S. Elo, M. Kääriäinen, P. Kaakinen, A. Oikarinen, M. Yamakawa, S. Fukui, M. Utsumi, Y. Higami, A. Higuchi, K. Mikkonen, Healthcare professionals' competence in digitalisation: A systematic review, Journal of Clinical Nursing 28 (5–6) (2019) 745–761, https://doi.org/10.1111/jocn.14710.

[13] L. Salahuddin, Z. Ismail, Classification of antecedents towards safety use of health information technology: A systematic review, International Journal of Medical Informatics 84 (11) (2015) 877–891, https://doi.org/10.1016/j.ijmedinf.2015.07.004.

[14] E. van Laar, A.J.A.M. van Deursen, J.A.G.M. van Dijk, J. de Haan, The relation between 21st-century skills and digital skills: A systematic literature review, Computers in Human Behavior 72 (2017) 577–588, https://doi.org/10.1016/j.chb.2017.03.010.

[15] E. Commission, Directorate-General for Education, Youth, Sport and Culture, Key competences for lifelong learning, Publications Office, Available, 2019 at: https://data.europa.eu/doi/10.2766/569540.

[16] E. Jarva, A. Oikarinen, J. Andersson, M. Tomietto, M. Kääriäinen, K. Mikkonen, Healthcare professionals' digital health competence and its core factors; development and psychometric testing of two instruments, International Journal of Medical Informatics 171 (2023) 104995, https://doi.org/10.1016/j.ijmedinf.2023.104995.

[17] N. Nazeha, D. Pavagadhi, B.M. Kyaw, J. Car, G. Jimenez, L. Tudor Car, A Digitally Competent Health Workforce: Scoping Review of Educational Frameworks, Journal of Medical Internet Research 22 (11) (2020) e22706.

[18] S. Palojoki, M. Mäkelä, L. Lehtonen, K. Saranto, An analysis of electronic health record-related patient safety incidents, Health Informatics Journal 23 (2) (2017) 134–145, https://doi.org/10.1177/1460458216631072.

[19] E. Jarva, A. Oikarinen, J. Andersson, A.M. Tuomikoski, M. Kääriäinen, M. Meriläinen, K. Mikkonen, Healthcare professionals' perceptions of digital health competence: A qualitative descriptive study, Nursing Open 9 (2) (2022) 1379–1393, https://doi.org/10.1002/nop2.1184.

[20] C.T. van Houwelingen, A.H. Moerman, R.G. Ettema, H.S. Kort, O. Ten Cate, Competencies required for nursing telehealth activities: A Delphi-study, Nurse Education Today 39 (2016) 50–62, https://doi.org/10.1016/j.nedt.2015.12.025.

[21] F. Griffiths, C. Bryce, J. Cave, M. Dritsaki, J. Fraser, K. Hamilton, C. Huxley, A. Ignatowicz, S.W. Kim, P.K. Kimani, J. Madan, A.M. Slowther, M. Sujan, J. Sturt, Timely Digital Patient-Clinician Communication in Specialist Clinical Services for Young People: A Mixed-Methods Study (The LYNC Study), Journal of Medical Internet Research 19 (4) (2017) e102. https://www.jmir.org/2017/4/e102/.

[22] A. Ignatowicz, A.M. Slowther, P. Elder, C. Bryce, K. Hamilton, C. Huxley, V. Forjaz, J. Sturt, F. Griffiths, Ethical implications of digital communication for the patient-clinician relationship: analysis of interviews with clinicians and young adults with long term conditions (the LYNC study), BMC Medical Ethics 19 (1) (2018) 11, https://doi.org/10.1186/s12910-018-0250-0.

[23] T. Vehko, H. Hyppönen, S. Puttonen, S. Kujala, E. Ketola, J. Tuukkanen, A. M. Aalto, T. Heponiemi, Experienced time pressure and stress: electronic health records usability and information technology competence play a role, BMC Medical Informatics and Decision Making 19 (1) (2019) 160, https://doi.org/10.1186/s12911-019-0891-z.

[24] S. Frennert, Lost in digitalization? Municipality Employment of Welfare Technologies *Disability and Rehabilitation: Assistive Technology* 14 (6) (2019) 635–642, https://doi.org/10.1080/17483107.2018.1496362.

[25] E. Jarva, K. Mikkonen, J. Andersson, A.-M. Tuomikoski, M. Kääriäinen, M. Meriläinen, A. Oikarinen, Aspects associated with healthcare professionals' digital health competence development – a qualitative study, Finnish Journal of EHealth and EWelfare 14 (1) (2022) 79–91, https://doi.org/10.23996/fjhw.111771.

[26] R. King, B. Taylor, A. Talpur, C. Jackson, K. Manley, N. Ashby, A. Tod, T. Ryan, E. Wood, M. Senek, S. Robertson, Factors that optimise the impact of continuing professional development in nursing: A rapid evidence review, Nurse Education Today 98 (2021) 104652, https://doi.org/10.1016/j.nedt.2020.104652.

[27] M. Mlambo, C. Silén, C. McGrath, Lifelong learning and nurses' continuing professional development, a metasynthesis of the literature, BMC Nursing 20 (1) (2021) 62, https://doi.org/10.1186/s12912-021-00579-2.

[28] European Health Parliament, Digital skills for health professionals, Committee on digital skills for health professionals, Available, 2016 at: https://www.healthparliament.eu/wp-content/uploads/2017/09/Digital-skills-for-health-professionals.pdf.

[29] A. Kuek, S. Hakkennes, Healthcare staff digital literacy levels and their attitudes towards information systems, Health Informatics Journal 26 (1) (2020) 592–612, https://doi.org/10.1177/1460458219839613.

[30] N. Wiebe, L. Otero Varela, D.J. Niven, P.E. Ronksley, N. Iragorri, H. Quan, Evaluation of interventions to improve inpatient hospital documentation within electronic health records: a systematic review, Journal of the American Medical Informatics Association 26 (11) (2019) 1389–1400, https://doi.org/10.1093/jamia/ocz081.

[31] J. Ting, A. Garnett, L. Donelle, Nursing education and training on electronic health record systems: An integrative review, Nurse Education in Practice 55 (2021) 103168, https://doi.org/10.1016/J.NEPR.2021.103168.

[32] O. Alkhaldi, B. McMillan, N. Maddah, J. Ainsworth, Interventions Aimed at Enhancing Health Care Providers' Behavior Toward the Prescription of Mobile Health Apps: Systematic Review, JMIR mHealth and uHealth 11 (2023) e43561.

[33] L. Virtanen, A.M. Kaihlanen, E. Laukka, K. Gluschkoff, T. Heponiemi, Behavior change techniques to promote healthcare professionals' eHealth competency: A systematic review of interventions, International Journal of Medical Informatics 149 (2021) 104432, https://doi.org/10.1016/j.ijmedinf.2021.104432.

[34] Aromataris E, Munn Z. (2020). Chapter 1: JBI Systematic Reviews. In: Aromataris E, Munn Z (Eds.). *JBI Manual for Evidence Synthesis*. JBI. Available at: Doi: 10.46658/JBIMES-20-02 (Retrieved September 27th 2022).

[35] Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. (2020). Chapter 3: Systematic reviews of effectiveness. In: Aromataris E, Munn Z (Eds.). *JBI Manual for Evidence Synthesis*. JBI. Available at: Doi: 10.46658/JBIMES-20-04 (Retrieved December 7th 2022).

[36] M.J. Page, J.E. McKenzie, P.M. Bossuyt, I. Boutron, T.C. Hoffmann, C.D. Mulrow, L. Shamseer, J.M. Tetzlaff, E.A. Akl, S.E. Brennan, R. Chou, J. Glanville, J. M. Grimshaw, A. Hróbjartsson, M.M. Lalu, T. Li, E.W. Loder, E. Mayo-Wilson, S. McDonald, L.A. McGuinness, D. Moher, The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, BMJ (clinical Research Ed.) 372 (2021) n71, https://doi.org/10.1136/bmj.n71.

[37] Centre for Reviews and Dissemination (CDR), Systematic Reviews: CRD's Guidance for Undertaking Systematic Reviews in Healthcare, University of York, York, Centre for Reviews and Dissemination, 2009. Available at: https://www.york.ac.uk/media/crd/Systematic_Reviews.pdf.

[38] Z. Munn, C. Tufanaru, E. Aromataris, JBI's Systematic Reviews: Data Extraction and Synthesis, American Journal of Nursing 114 (7) (2014) 49–54, https://doi.org/10.1097/01.naj.0000451683.66447.89.

[39] Petticrew M. & Roberts H. (2006). Systematic Reviews in the Social Sciences. A Practical Guide. Blackwell Publishing, Oxford, UK. https://doi.org/10.1002/9780470754887.

[40] J. Popay, H. Roberts, A. Sowden, M. Petticrew, L. Arai, M. Rodgers, N. Britten, K. Roen, S. Duffy, Guidance on the Conduct of Narrative Synthesis in Systematic Reviews, Available at: https://www.lancaster.ac.uk/media/lancaster-university/content-assets/documents/fhm/dhr/chir/NSsynthesisguidanceVersion1-April2006.pdf, 2006.

[41] T. Pigott, S. Shepperd, Identifying, documenting, and examining heterogeneity in systematic reviews of complex interventions, Journal of Clinical Epidemiology 66 (11) (2013) 1244–1250, https://doi.org/10.1016/j.jclinepi.2013.06.013.

[42] N. Mastellos, T. Tran, K. Dharmayat, E. Cecil, H.Y. Lee, C.C.P. Wong, W. Mkandawire, E. Ngalande, J.T. Wu, V. Hardy, B.G. Chirambo, J. M. O'Donoghue, Training community healthcare workers on the use of information and communication technologies: a randomised controlled trial of traditional versus blended learning in Malawi, Africa. BMC Medical Education 18 (1) (2018) 61, https://doi.org/10.1186/s12909-018-1175-5.

[43] A. Rossley, A. Loesche, M. Glanert-Kempf, Implementing a Large-Scale Escape Room: An Intervention to Increase Electronic Health Record Downtime Competence, Journal for Nurses in Professional Development 39 (6) (2023) 316–321, https://doi.org/10.1097/NND.0000000000000863.

[44] P. Sevean, S. Dampier, M. Spadoni, S. Strickland, S. Pilatzke, Bridging the distance: educating nurses for telehealth practice, Journal of Continuing Education in Nursing 39 (9) (2008) 413–418, https://doi.org/10.3928/00220124-20080901-10.

[45] C.S. Adereti, A.A. Olaogun, Use of Electronic and Paper-based Standardized Nursing Care Plans to Improve Nurses' Documentation Quality in a Nigerian Teaching Hospital, International Journal of Nursing Knowledge 30 (4) (2019) 219–227, https://doi.org/10.1111/2047-3095.12232.

[46] N. Carson, B. Campbell-Smit, W. Walters, K. Sharp, P. Smailes, Electronic health record training for nurse leaders, Online Journal of Nursing Informatics 25 (2) (2021). https://www.himss.org/resources/online-journal-nursing-informatics.

[47] K. Ciccolini, E.M. Spaulding, T. Boyde, D. Berizzi, B.R. Hansen, Oncology Nursing Telephone Triage Workshop: Impact on Nurses' Knowledge, Confidence, and Skill, Cancer Nursing 45 (2) (2022) E463–E470, https://doi.org/10.1097/NCC.0000000000000978.

[48] C.K. Collazo, N. Tena, E.A. Duffy, Facilitating and Implementing a Process for the Delivery of Pediatric Oncology New Diagnosis Education Among Nursing Staff Through the Electronic Medical Record, Journal of Pediatric Hematology/oncology Nursing 40 (2) (2023) 133–138, https://doi.org/10.1177/27527530211073873.

[49] T. Do, H. Kim, Effects of nursing record education focused on legal aspects at small and medium sized hospitals, The Journal of Korean Academic Society of Nursing Education 27 (2) (2021) 152–162, https://doi.org/10.5977/jkasne.2021.27.2.152.

[50] M. Evatt, D. Ren, P. Tuite, C. Reynolds, M. Hravnak, Development and implementation of an educational support process for electronic nursing admission assessment documentation, Medsurg Nursing 23 (2) (2014) 89–100.

[51] J. Farokhzadian, S. Jouparinejad, F. Fatehi, F. Falahati-Marvast, Improving nurses' readiness for evidence-based practice in critical care units: results of an information literacy training program, BMC Nursing 20 (1) (2021) 79, https://doi.org/10.1186/s12912-021-00599-y.

[52] S. Hughes, J. Livingston, R. Semler, A. Hughes, Improving nurse computer proficiency with a tri-focal educational intervention, International Journal of Urological Nursing 8 (3) (2014) 161–165. https://doi-org.pc124152.oulu.fi:9443/10.1111/ijun.12045.

[53] S. Jouparinejad, G. Foroughameri, R. Khajouei, J. Farokhzadian, Improving the informatics competency of critical care nurses: results of an interventional study in the southeast of Iran, BMC Medical Informatics and Decision Making 20 (1) (2020) 220, https://doi.org/10.1186/s12911-020-01244-5.

[54] P. Kaakinen, H. Kyngäs, K. Tarkiainen, M. Kääriäinen, The effects of intervention on quality of telephone triage at an emergency unit in Finland: Nurses' perspective, International Emergency Nursing 26 (2016) 26–31, https://doi.org/10.1016/j.ienj.2015.09.002.

[55] V.W. Lacambra, Developing and Implementing a Tablet-Based Health Information Technology Tool Training Program. CIN, Computers, Informatics, Nursing 39 (9) (2021) 464–469, https://doi.org/10.1097/CIN.0000000000000826.
[56] C.C. Mussa, A. Al-Raimi, E.A. Becker, Predicting Respiratory Therapists' Intentions to Use the Modified Early Warning Score by Using an Enhanced Technology Acceptance Model, Respiratory Care 64 (4) (2019) 416–424, https://doi.org/10.4187/respcare.06428.
[57] S.S. Poe, P. Abbott, P. Pronovost, Building nursing intellectual capital for safe use of information technology: a before-after study to test an evidence-based peer coach intervention, Journal of Nursing Care Quality 26 (2) (2011) 110–119, https://doi.org/10.1097/NCQ.0b013e31820b221d.
[58] P. Rosenfeld, N. Salazar-Riera, D. Vieira, Piloting an information literacy program for staff nurses: lessons learned. CIN, Computers, Informatics, Nursing 20 (6) (2002) 236–243, https://doi.org/10.1097/00024665-200211000-00009.
[59] T. van Houwelingen, R.G.A. Ettema, N. Bleijenberg, H. van Os-Medendorp, H.S. M. Kort, O. Ten Cate, Educational intervention to increase nurses' knowledge, self-efficacy and usage of telehealth: A multi-setting pretest-posttest study, Nurse Education in Practice 51 (2021) 102924, https://doi.org/10.1016/j.nepr.2020.102924.
[60] C.J. Bickford, K. Smith, M.J. Ball, G. Frantz, T.L. Panniers, S.K. Newbold, K. L. Knecht, H. Farish-Hunt, N. Cortes-Comerer, Evaluation of a nursing informatics training program shows significant changes in nurses' perception of their knowledge of information technology, Health Informatics Journal 11 (3) (2005) 225–235, https://doi.org/10.1177/1460458205055689.
[61] R.J. Bindler, T. Saul, Stats lab: Piloting live digital statistics learning modules for nurses at a multicenter health institution in the Western United States, Teaching and Learning in Nursing 18 (4) (2023) e264–e267, https://doi.org/10.1016/j.teln.2023.07.011.
[62] N. Cullum, J. Dumville, Systematic reviews of the effects of interventions, in: D. A. Richards, I.R. Hallberg (Eds.), Complex Interventions in Health: an Overview of Research Methods, 1st ed., Routledge, Abingdon, 2015, pp. 57–65, https://doi.org/10.4324/9780203794982.
[63] P. Glasziou, I. Chalmers, D.G. Altman, H. Bastian, I. Boutron, A. Brice, G. Jamtvedt, A. Farmer, D. Ghersi, T. Groves, C. Heneghan, S. Hill, S. Lewin, S. Michie, R. Perera, V. Pomeroy, J. Tilson, S. Shepperd, J.W. Williams, Taking healthcare interventions from trial to practice, BMJ 341 (2010) c3852, https://doi.org/10.1136/bmj.c3852.
[64] S. Shepperd, S. Lewin, S. Straus, M. Clarke, M.P. Eccles, R. Fitzpatrick, G. Wong, A. Sheikh, Can we systematically review studies that evaluate complex interventions? PLoS Medicine 6 (8) (2009) e1000086.
[65] A. Haleem, M. Javaid, M.A. Qadri, R. Suman, Understanding the role of digital technologies in education: A review, Sustainable Operations and Computers 3 (2022) 275–285, https://doi.org/10.1016/j.susoc.2022.05.004.
[66] J. Frenk, L.C. Chen, L. Chandran, E.O.H. Groff, R. King, A. Meleis, H.V. Fineberg, Challenges and opportunities for educating health professionals after the COVID-19 pandemic, The Lancet 400 (10362) (2022) 1539–1556, https://doi.org/10.1016/S0140-6736(22)02092-X.
[67] M. Campbell-Yeo, L. Carrier, B. Benoit, T. Kim, M. Bueno, M. Rao, S. Riahi, B. Stevens, Evaluation of the Premature Infant Pain Profile-Revised (PIPP-R) e-Learning Module: Immediate and Sustained Competency, Advances in Neonatal Care 22 (3) (2022) 246–252, https://doi.org/10.1097/ANC.0000000000000922.
[68] T. Costa, I.A. Silva, H.H.C. Peres, E.D. Duarte, M. Bueno, Nurses' Motivation, Knowledge, and Satisfaction with a Neonatal Pain Assessment e-Learning Course, Pain Management Nursing 23 (5) (2022) 576–582, https://doi.org/10.1016/j.pmn.2022.05.002.
[69] L. Martinengo, N.J.Y. Yeo, K.D. Markandran, M. Olsson, B.M. Kyaw, L.T. Car, Digital health professions education on chronic wound management: A systematic review, International Journal of Nursing Studies 104 (2020) 103512, https://doi.org/10.1016/j.ijnurstu.2019.103512.
[70] D. Kerr, S. Milnes, P. Martin, J. Ammentorp, M. Wolderslund, M. Chiswell, Responding to nurses' communication challenges: Evaluating a blended learning program for communication knowledge and skills for nurses, Patient Education and Counseling 105 (7) (2022) 2285–2291, https://doi.org/10.1016/j.pec.2021.11.019.
[71] L. Jacobs, Peripheral Intravenous Catheter Insertion Competence and Confidence in Medical/Surgical Nurses, Journal of Infusion Nursing 45 (6) (2022) 306–319, https://doi.org/10.1097/NAN.0000000000000487.
[72] A. Oikarainen, K. Mikkonen, A. Kenny, M. Tomietto, A.M. Tuomikoski, M. Meriläinen, J. Miettunen, M. Kääriäinen, Educational interventions designed to develop nurses' cultural competence: A systematic review, International Journal of Nursing Studies 98 (2019) 75–86, https://doi.org/10.1016/j.ijnurstu.2019.06.005.
[73] L.M. Ramjan, D. Maneze, E. Krstevska, S.P. Pathrose, P. Lewis, Educational programs to improve nurses' knowledge, attitude, and practice in adolescent and young adult health: An integrative review, Nurse Education Today 118 (2022) 105510, https://doi.org/10.1016/j.nedt.2022.105510.
[74] J. Tolonen, A. Värri, Survey of health informatics education in Finland in 2017, Finnish Journal of EHealth and EWelfare 9 (2–3) (2017) 217–231, https://doi.org/10.23996/fjhw.60999.
[75] U. Sharma, M. Clarke, Nurses' and community support workers' experience of telehealth: a longitudinal case study, BMC Health Services Research 14 (2014) 164, https://doi.org/10.1186/1472-6963-14-164.
[76] J. Brown, N. Pope, A.M. Bosco, J. Mason, A. Morgan, Issues affecting nurses' capability to use digital technology at work: An integrative review, *Journal of Clinical Nurs*Ing 29 (15–16) (2020) 2801–2819, https://doi.org/10.1111/jocn.15321.
[77] S. Hennemann, M.E. Beutel, R. Zwerenz, Ready for eHealth? Health Professionals' Acceptance and Adoption of eHealth Interventions in Inpatient Routine Care, Journal of Health Communication 22 (3) (2017) 274–284, https://doi.org/10.1080/10810730.2017.1284286.
[78] A.J. de Veer, A.L. Francke, Attitudes of nursing staff towards electronic patient records: a questionnaire survey, International Journal of Nursing Studies 47 (7) (2010) 846–854, https://doi.org/10.1016/j.ijnurstu.2009.11.016.
[79] T.F. van de Mortel, Faking It: Social Desirability Response Bias in Self-report Research, The Australian Journal of Advanced Nursing 25 (4) (2008) 40–48. https://search.informit.org/doi/10.3316/informit.210155003844269.