Behavior change techniques to promote healthcare professionals' eHealth competency : A systematic review of interventions

Virtanen, Lotta

2021-05

Virtanen , L , Kaihlanen , A-M , Laukka , E , Gluschkoff , K & Heponiemi , T 2021 , ' Behavior change techniques to promote healthcare professionals' eHealth competency : A systematic review of interventions ' , International Journal of Medical Informatics , vol. 149 , 104432 . https://doi.org/10.1016/j.ijm

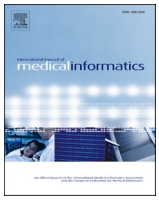
http://hdl.handle.net/10138/339401
https://doi.org/10.1016/j.ijmedinf.2021.104432

International Journal of Medical Informatics 149 (2021) 104432

Contents lists available at ScienceDirect

International Journal of Medical Informatics

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



Review article

Behavior change techniques to promote healthcare professionals' eHealth competency: A systematic review of interventions

Lotta Virtanen [a,*], Anu-Marja Kaihlanen [a], Elina Laukka [a,b], Kia Gluschkoff [a,c], Tarja Heponiemi [a]

[a] Finnish Institute for Health and Welfare, Helsinki, Finland
[b] Research Unit of Nursing Science and Health Management, University of Oulu, Oulu, Finland
[c] Department of Psychology and Logopedics, University of Helsinki, Helsinki, Finland

ARTICLE INFO

Keywords:
Competency
eHealth
Healthcare professional
Intervention
Organizational change

ABSTRACT

Introduction: The use of eHealth is rapidly –>increasing; however, many healthcare professionals have insufficient eHealth competency. Consequently, interventions addressing eHealth competency might be useful in fostering the effective use of eHealth.
Objective: Our systematic review aimed to identify and evaluate the behavior change techniques applied in interventions to promote healthcare professionals' eHealth competency.
Methods: We conducted a systematic literature review following the Joanna Briggs Institute's Manual for Evidence Synthesis. Published quantitative studies were identified through screening PubMed, Embase, and CINAHL. Two reviewers independently performed full-text and quality assessment. Eligible interventions were targeted to any healthcare professional and aimed at promoting eHealth capability or motivation. We synthesized the interventions narratively using the Behavior Change Technique Taxonomy v1 and the COM-B model.
Results: This review included 32 studies reporting 34 heterogeneous interventions that incorporated 29 different behavior change techniques. The interventions were most likely to improve the capability to use eHealth and less likely to enhance motivation toward using eHealth. The promising techniques to promote both capability and motivation were *action planning* and *participatory approach*. *Information about colleagues' approval*, *emotional social support*, *monitoring emotions*, *restructuring* or *adding objects to the environment*, and *credible source* are techniques worth further investigation.
Conclusions: We found that interventions tended to focus on promoting capability, although motivation would be as crucial for competent eHealth performance. Our findings indicated that empathy, encouragement, and user-centered changes in the work environment could improve eHealth competency as a whole. Evidence-based techniques should be favored in the development of interventions, and further intervention research should focus on nurses and multifaceted competency required for using different eHealth systems and devices.

1. Introduction

The increasing use of eHealth in the organization, production, and delivery of healthcare is changing the work culture in healthcare organizations [1]. Although healthcare professionals regularly use eHealth in their work, studies show that their eHealth competency is not developed to the optimal level [2–4]. eHealth competency consists of four components, which are (a) psychological capability and (b) physical capability to perform professional tasks related to eHealth, and (c) automatic motivation and (d) reflective motivation toward using eHealth [5,6]. In other words, eHealth competency requires adequate eHealth knowledge, skills, and associated social and communication skills to provide high-quality care; and willingness and positive attitudes toward eHealth [6].

Implementing eHealth without simultaneously ensuring a competent workforce may have unfortunate consequences for the functioning of healthcare organizations, and thus patient health. New working methods that lack competency can disrupt workflow efficiency [7–9]. The challenges related to eHealth competency, such as inadequate human-technology interaction, have been associated with safety and

Abbreviations: BCT, behavior change technique; BCTTv1, Behavior Change Technique Taxonomy version 1; CPOE, computerized provider order entry system; EHR, electronic health records; ICT, information and communication technology.

* Corresponding author at: Finnish Institute for Health and Welfare, P.O. Box 30, Helsinki, 00271, Finland.
E-mail address: lotta.virtanen@thl.fi (L. Virtanen).

https://doi.org/10.1016/j.ijmedinf.2021.104432
Received 7 September 2020; Received in revised form 18 February 2021; Accepted 21 February 2021
Available online 23 February 2021

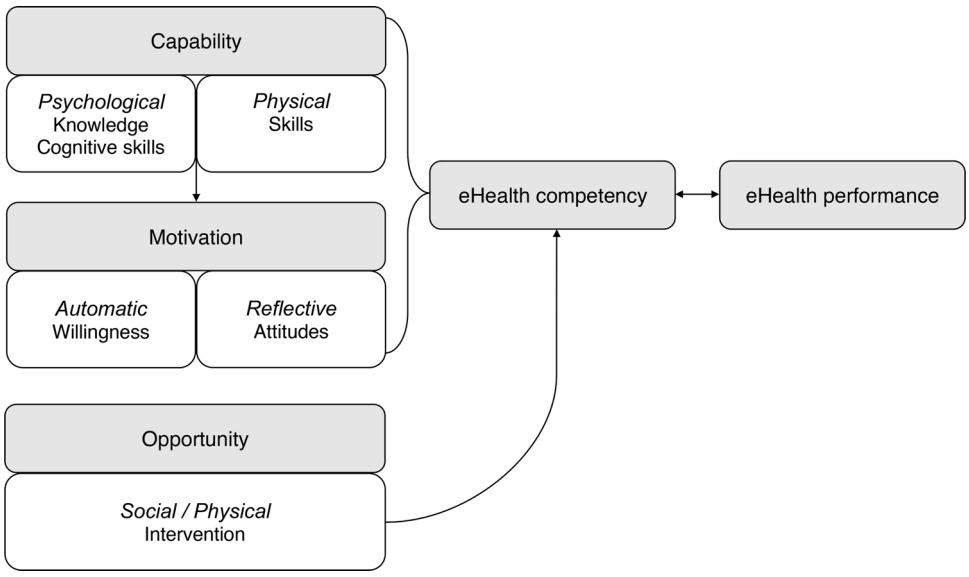


Fig. 1. The COM-B model for eHealth performance, adapted from Michie et al. [5]; content based on Konttila et al. [6].

privacy incidents, for example, with incompletely recorded patient data, diagnostic results assigned to a wrong patient, and medication errors [10–12].

Behavioral theory, the COM-B model [5], proposes that in addition to capability (C) and motivation (M), individuals need to have an opportunity (O) to perform a behavior (B). Opportunity refers to the optimal social and physical environment that enables behavior. Hence, based on the theory, it can be assumed that effective interventions implemented in healthcare organizations might be useful to foster healthcare professionals' eHealth competency. Fig. 1 depicts the COM-B model for eHealth performance in the course of an organizational intervention.

Previous systematic reviews of interventions promoting healthcare professionals' eHealth performance have focused only on electronic health records (EHRs) and a specific healthcare setting [13,14] or type of intervention [15,16]. The review by Gagnon et al. [17] focused on interventions promoting eHealth adoption, but more than ten years have passed from its data collection. Additionally, previous reviews [13–17] have not interpreted which practices could be effective in healthcare organizations because the interventions reviewed were complex, involving various interacting components. Given the rapidly increasing use of eHealth and the uncertainty of effective interventions in previous research, there is a need for using a taxonomy to examine the behavior change techniques (BCTs) for healthcare professionals in the context of the digitalization of healthcare.

This systematic review aimed to synthesize and evaluate the latest behavior change interventions to promote healthcare professionals' eHealth competency through the Behavior Change Technique Taxonomy version 1 (BCTTv1) by Michie et al. [18]. The BCCTv1 is a reliable and valid method for synthesizing the content of interventions as it labels and comprehensively describes 93 BCTs potentially applied in interventions [18]. A BCT is an observable, replicable measure, which directly applies to both the target population and behavior [19]. Identification of BCTs in heterogeneous interventions allows analyzing which common BCTs are associated with effective outcomes [18].

Our specific objectives for the review were to identify (a) which BCTs are applied in interventions to promote healthcare professionals' eHealth competency, (b) which components of healthcare professionals' eHealth competency (i.e. psychological capability, physical capability, automatic motivation, or reflective motivation) can be influenced the most by intervention, and (c) which BCTs, if any, are associated with improvement in healthcare professionals' eHealth competency.

2. Methods

We conducted a systematic review following the Joanna Briggs Institute's (JBI) Manual for Evidence Synthesis in systematic reviews of effectiveness [20], which includes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [21]. Our method focused on quantitative studies and allowed to investigate the extent to which eHealth competency can be improved by implementing BCTs.

2.1. Eligibility criteria

Appendix A outlines the inclusion and exclusion criteria for the study selection. We defined eligibility criteria according to the PICOT framework [22]: 1) **P**articipants were healthcare professionals licensed to be credential providing healthcare, employed in a healthcare organization; 2) **I**nterventions aimed to promote eHealth competency, 3) **C**omparators were any control group, including standard practice or no intervention, or prospective or retrospective baseline measures; 4) **O**utcome was eHealth competency [6], including (a) eHealth knowledge and cognitive skills, (b) physical eHealth skills, including associated social and communication skills; and (c) willingness and attitudes toward eHealth. Additionally, a measurement that could imply eHealth competency, such as output quality or efficiency, was also considered; and 5) **T**ype of studies included all original peer-reviewed studies with experimental and non-experimental designs. Although qualitative studies could have provided in-depth experiences of interventions, we decided to keep our review focused.

We limited the search to papers published between January 2010 and February 2020 due to the rapid pace of change in the field of information and communication technologies (ICT) and to update the evidence from the previous review [17]. Eligible literature required an English abstract and English, Finnish, Danish, or Swedish full text.

2.2. Search strategy

We used PubMed, Embase (Ovid), and CINAHL (EBSCO) as the primary information sources. A three-step search strategy was followed [20]. At first, a limited search was performed on PubMed and CINAHL (EBSCO) to identify the index terms and words from the title and abstract. We consulted a research librarian with expertise in healthcare to optimize the search terms and develop database-specific strategies. We

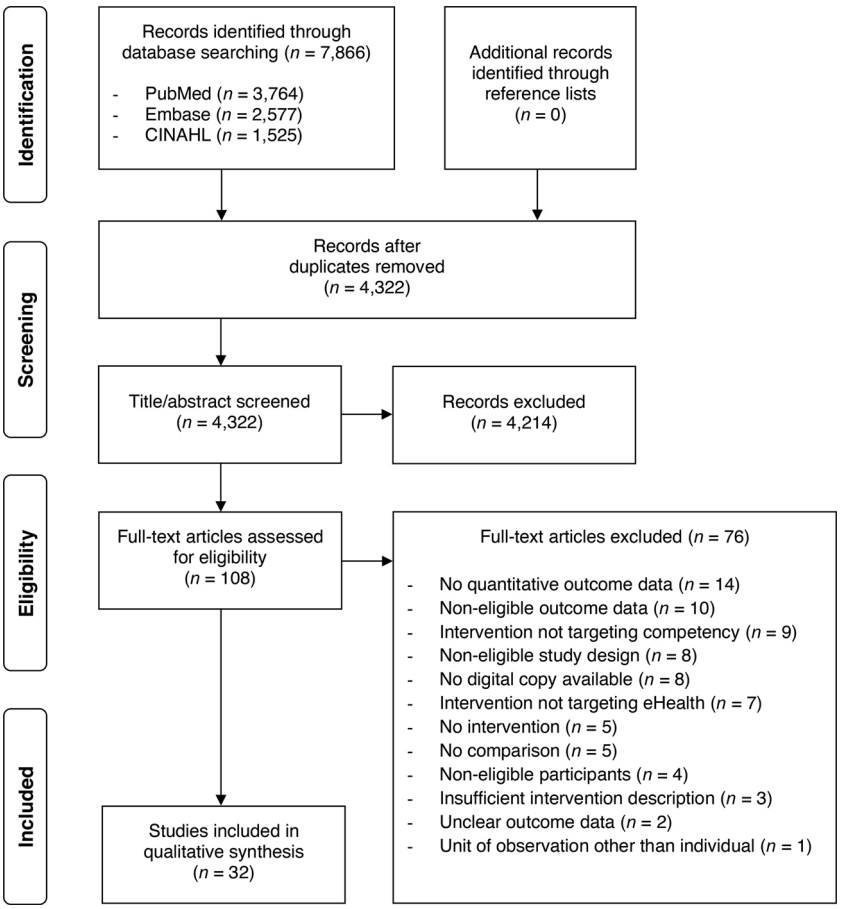


Fig. 2. PRISMA flow diagram of the study selection adapted from Moher et al. [21].

decided to use search terms broadly because the terminology for eHealth or interventions is not yet standardized. Secondly, we implemented the final search strategy, presented in Appendix B, by searching for each included information source. We performed the searches in February 2020 in English. Thirdly, the reference lists of the included full-text publications were screened for additional studies.

2.3. Study selection

We collated identified publications from the information sources and removed duplications using EndNote X9 [23]. One reviewer (LV) screened titles and abstracts. Two reviewers (LV and AK) then independently screened the full text of the included publications from the first screening phase and reported the reasoning for exclusion. A kappa value of 0.81 in the full-text screening showed an almost perfect level of agreement [24].

2.4. Critical appraisal

Two reviewers (LV and AK) independently appraised the quality of the studies using the Quality Assessment Tool for Quantitative Studies, which had previously been validated [25]. A discussion followed to resolve any disagreements in the rating. No authors of studies were contacted for additional data. The average strength of preventing (a) the extent of bias, (b) selection bias, (c) detection and performance bias, (d) confounders, (e) threats to reliability and validity, and (f) attrition bias in the studies was computed.

Regardless of the quality level, we included each appraised study to the review to achieve a comprehensive synthesis of the latest interventions [26]. One reviewer (LV) performed a sensitivity analysis by excluding methodologically weak studies to examine the robustness of the results.

2.5. Data extraction

Our data extraction instrument included details about (a) the author (s) and publication year, (b) methodology, (c) setting, (d) participants, (e) intervention (the type of eHealth, theoretical basis, content, the facilitator(s), and duration), (f) comparator, and (g) outcomes (indicators and effects on eHealth competency).

2.6. Data synthesis

Before synthesizing data, one reviewer (LV) completed the BCTTv1 training [27] to improve the interpretation of the content of interventions against the standardized BCT definitions. The training was based on a tutorial which has shown to improve coding skills [28]. To code a BCT, the content of the intervention described in the study had to indicate the presence of the BCT either beyond all reasonable doubt or all probability.

The outcomes from each study were categorized based on their correspondence under one of the four components of eHealth competency in the COM-B model (Fig. 1) [5]. We chose the COM-B model over technology-specific models because it allowed analyzing intervention effects on competency and combining several outcome indicators with flexible components. Outcomes indicating solely cognitive capability, such as knowledge, fell under *psychological capability*. Since physical capability also requires psychological capability, distinguishing them would not be appropriate. Thus, physical capability was named as *physical and psychological capability*, and outcomes indicating physical

skills were categorized under it. Outcomes indicating motivation, such as reactions and self-efficacy, were categorized under *automatic motivation* or *reflective motivation*, respectively.

The identified BCTs and effects on each outcome category were tabulated, and their frequencies calculated. Subsequently, the frequencies of improved effects on eHealth competency associated with each identified BCT were measured. We considered a BCT to be worth further investigation when two or more interventions that applied the technique demonstrated positive evidence. If the certainty of positive evidence was at least moderate (see 2.7.), we considered the technique as promising to promote eHealth competency. We synthesized the results narratively, using standardized statements [29] because heterogeneity between studies impeded the pooling of data in a meta-analysis.

2.7. Assessing the certainty of evidence

Following the GRADE guidelines [30], the certainty of evidence was evaluated for the intervention effects on eHealth competency, and the effects of the BCTs on eHealth competency. The assessment was based on the strength of prevention of bias in the studies and the accuracy, consistency, directness, detection, and practical benefits of the evidence.

3. Results

3.1. Study selection

Fig. 2 illustrates the flow of the study selection. A total of 7866 potentially relevant studies were identified in the database search. After removal of 3544 duplicates, 4322 titles and abstracts were screened against eligibility criteria of which 4214 were excluded. The remaining 108 articles were retrieved for full-text examination against eligibility criteria. Of the 108 articles, 76 were further excluded, which are listed in Appendix C. The references of the eligible studies yielded no additional articles. The screening resulted in 32 eligible studies.

3.2. Study characteristics

The 32 studies reported a total of 34 interventions promoting healthcare professionals' eHealth competency. The study characteristics are described in Appendix D.

The studies utilized mostly pre-post designs [31–50], but also retrospective pre-post designs [51,52], controlled clinical trials [53–58], randomized controlled trials [59,60], and interrupted time series [61,62] were used. A majority (n = 20) were from the United States [34,35–43,45,48–50,52–54,56,57,61,62], five from Canada [43,44,46,47,51], and single studies from Australia [46], England [33], Israel [58], the Netherlands [60], Malawi [59], Nigeria [31], and Norway [55]. Studies were performed in various clinical settings, including primary [33,36,38,39,41,43,45–48,52,55–59,61,62], secondary [32,34,38,40,42,46,48–50,53,57,60,61], and tertiary care [31,35,44,46,61]. They composed a total of 6630 (Mean = 207) healthcare professionals with samples ranging from three [39] to 3500 [46]. Most studies involved physicians [32,35–39,41–43,45–50,52–58,60,61], following nurses [31,33,34,39,41,42,49–51,61,62], and other professions [40,44,48,49,62], such as midwives, physical therapists, and psychologists.

Interventions were heterogeneous in content and structure. Following the Behavior Change Wheel categorization [5], interventions could be categorized according to their primary function as training (n = 22), enabling (n = 8), and persuasive interventions (n = 4). Training interventions provided training to use eHealth [31,32,35,37,38,40,43,44,47,49–52,54–61]. Interventions defined as enabling interventions implemented resources that facilitated competency development [34,36,39,41,48,53,62]. Persuasive interventions utilized social support and goal setting to motivate eHealth use [33,42,45,46].

A majority (71 %) addressed competency related to EHRs [31,35–39,41–43,45–50,52–54,56–58,62]. The others focused on telehealth [33,40,51], mHealth [61], eReferral [34,55], computerized provider order entry system (CPOE) [60], electronic database [32], virtual reality system [44], and eHealth in general [59]. Interventions were delivered predominantly by healthcare professionals and researchers, but also clinician informaticists, ICT analysts, programmers, and ICT support staff were involved. Intervention duration ranged from one 20 min session [50] to 3 years period, which included a 3-h session every trimester each year [43].

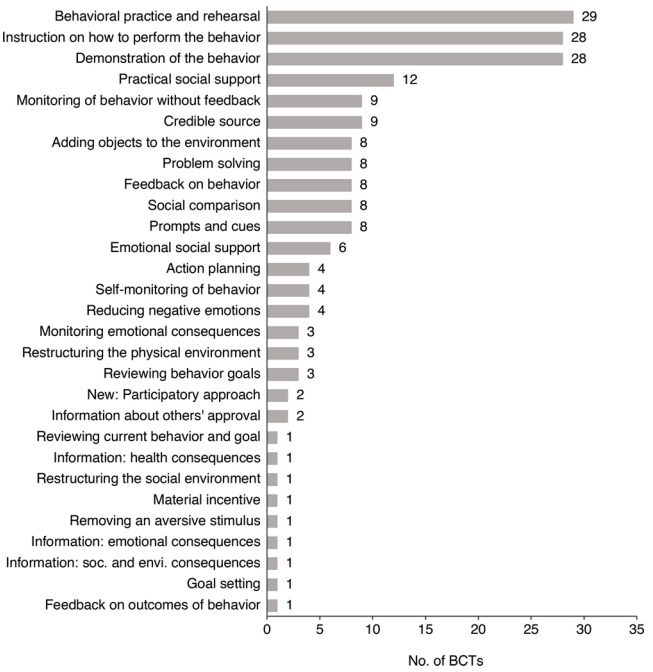


Fig. 3. Frequencies of the identified BCTs in interventions.

3.3. Methodological quality

The appraised methodological quality is detailed in Appendix E. Of the studies, 63 % had moderate prevention of bias [32,34,36,38–41,43,44,46–49,51–56,58], 28 % weak prevention of bias [31,33,35,37,42,45,50,61,62], and 9 % strong prevention of bias [57,59,60].

3.4. BCTs applied in interventions

Of the 93 BCTs [18], 28 were identified from the interventions. On average, each intervention applied six BCTs, ranging from three [59] to 12 [48]. Additionally, one technique not previously classified in the BCTTv1 [18] was identified and named as a *participatory approach*. The BCTs were primarily considered being present beyond all reasonable doubt. Fig. 3 illustrates the frequencies of the BCTs.

The most commonly included BCTs were *behavioral practice and rehearsal*, *demonstration of behavior*, *instruction on how to perform behavior*, and *practical social support*.

Behavioral practice and rehearsal included eHealth practicing offsite of the clinical setting through interactive discussions [46,57,59], exercises [32,35,37–39,49,59,60], and hands-on training [31,41,42,44–46,48,61,62]. The training was also organized in clinical –>[52,54] or equivalent circumstances, such as in a built simulation [34,47,49,53,56,58] or role-playing clinical scenarios [40,43,51]. Thirty-eight percent of the training involved one-to-one sessions, where the content was tailored to meet individual needs [31,37,38,42,44–46,49,58,60,61].

In *demonstration of behavior*, eHealth performance was demonstrated by didactic teaching [31,35,37–39,42,43,45,48,49,51,52,54,61,62], giving presentations [32,50,51], and distributing educational materials,

Summary table

What was already known on the topic?

- Implementing eHealth without ensuring a competent workforce can affect the efficiency of work, quality of care, and patient safety.
- Behavior change interventions might be useful in promoting eHealth capability and motivation.

What this study added to our knowledge?

- This is the first systematic review using taxonomy and theory to examine interventions addressing insufficient eHealth competency in healthcare professionals.
- Interventions tend to focus more on improving capability than motivation although both are crucial for competent eHealth performance.
- Empathic support, encouragement, and user-centered changes in the work environment could improve eHealth competency as a whole.

such as guidelines [33,44,46,48,54,58,61], video clips [40,44,48,57,59], and e-learning modules [35,44,47,56,60]. Some interventions that applied *demonstration of behavior* also involved *instruction on how to perform behavior* so the same didactic lectures [31,35,37–39,42,43,45,48,49,51,52,54,61,62], presentations [32,50,51], and educational materials [33,35,48,54,61] were used to advise healthcare professionals on eHealth use.

Practical social support included support for eHealth performance provided by facilitators [33,44,49,55], super users, champions, peers [37,48,49,61], ICT personnel [56], or experts [36,46,48,62].

Table 1
BCTs applied in–> interventions associated with improvement in healthcare professionals' eHealth competency.–>

BCT	Examples from interventions	Participants,n (Interventions,n)	Effect on eHealth competency	Certainty of the evidence (GRADE)
Action planning	Planning concrete steps for change with facilitators [33,39,45,51]	137 (4)	Probably improves	⨁⨁⨁◯ MODERATE [a,b,d]
New: Participatory approach	Involving healthcare professionals in the development of change [34,39]	37 (2)	Probably improves	⨁⨁⨁◯ MODERATE [a,b,f]
Emotional social support	Empathic eHealth super-users and champions from the site supporting those who experience challenges [37,45,48,50,61] Sharing experiences with each other [51]	1,012 (6)	May improve	⨁⨁◯◯ LOW [a,b,c]
Monitoring emotional consequences	Asking to monitor feelings related to eHealth use [36,53,62]	36 (2)	May improve	⨁⨁◯◯ LOW [a,b,e]
Restructuring the physical environment	Redesigning the user interface [53] Repairing errors in the current user interface [48] Delegating some work tasks for support personnel [36]	247 (2)	May improve	⨁⨁◯◯ LOW [a,b,e]
Information about others' approval	Presenting data from other similar sites that demonstrate their eHealth adoption [62] Emphasizing that eHealth is widely used elsewhere in the country [51]	99 (2)	May improve	⨁⨁◯◯ LOW [a,b,g]
Adding objects to the environment	Purchasing new eHealth equipment [33,48] Installing standardized templates into the user interface [31,39,48,55] Installing guidelines into the user interface [34,51,55] Increasing financial resources for learning overtime hours [33] Hiring a clerical support person [36]	338 (8)	Probably improves slightly	⨁⨁⨁◯ MODERATE [a,b,d]
Credible source	eHealth experts, super-users, and champions encouraging for change [37,45,46,48,49,51,61]	4,599 (9)	May improve slightly	⨁⨁◯◯ LOW [a,b,h]

Note. The certainty of evidence is based on the GRADE Working Group [29] definitions: high-certainty: there is confidence that the true effect lies close to that of the estimate of the effect; moderate-certainty: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different; low-certainty: the true effect may be substantially different from the estimate of the effect; very-low-certainty: the true effect is likely to be substantially different from the estimate of effect.

[a] A narrative synthesis was conducted where estimates are not precise.
[b] The improved effect sizes were judged to be practically beneficial.
[c] Serious concerns of confounders, reliability and validity of the outcome instruments, and attrition bias.
[d] Concerns about selection bias and confounders.
[e] Serious concerns of selection bias and confounders.
[f] Concerns about the extent of bias.
[g] Serious concerns about selection bias, confounders, and attrition bias.
[h] Serious concerns about selection bias, confounders, reliability and validity of the measurement instruments, and attrition bias.

3.5. Influence of interventions on the components of eHealth competency

Appendix F presents the intervention effects on the four components of healthcare professionals' eHealth competency by the indicators used in the studies.

Psychological capability to perform with eHealth was influenced by 92 % of the interventions with moderate-certainty evidence. Eleven interventions demonstrated probably improving psychological capability [38,40,45,47–49,51,52,60,61]. Only one intervention [59] suggested the probability for little or no difference in psychological capability.

Physical and psychological capability to perform with eHealth was influenced the most (96 %) by the interventions with moderate-certainty evidence. Twenty-three interventions demonstrated probably improving physical and psychological capability [31,34–37,39,41–44,42–48,50,52–58,60]. However, one intervention [38] proposed the probability to improve control over eHealth workload with little or no difference in the time spent with eHealth.

Automatic motivation toward eHealth was least influenced (50 %) by the interventions. However, the evidence was inconclusive and of very-low-certainty, as four interventions [33,34,39,48] improved automatic motivation, whereas the other four [32,38,41,44] suggested little or no difference.

Reflective motivation toward eHealth was influenced in 58 % of the interventions with low-certainty evidence. Eleven interventions [34,39,42,45,48,49,51,58,59,62] demonstrated that an intervention may improve reflective motivation, whereas three [41,47,56] showed little or no difference. Five interventions [32,44,49,57,60] suggested that an intervention may slightly improve reflective motivation, but their results were highly inconsistent with each other, particularly in attitudes toward eHealth and confidence in using eHealth.

3.6. BCTs associated with improvement in eHealth competency

The interventions suggested an association between six BCTs identified in two or more interventions and improvement in healthcare professionals' eHealth competency as illustrated in Appendix G. Two BCTs were promising as there was moderate-certainty evidence that *action planning* [33,39,45,51] and *participatory approach* [34,39] probably improve eHealth competency. The other four BCTs were worth further investigation as there was low-certainty evidence that *emotional social support* [37,45,48,50,61], *monitoring emotional consequences* [36,53,62], *restructuring the physical environment* [34,36,39,50,51], and *information about others' approval* [51,62] may improve eHealth competency.

Additional two BCTs were worth further investigation as they were prevalent in interventions that relatively frequently (88 %–89 %) improved eHealth competency. Thus, *adding objects to the environment* [31,33,34,36,39,48,51,55] probably improves slightly eHealth competency with moderate-certainty evidence. *Credible source* [37,45,46,48,50,51,61] may improve slightly eHealth competency with low-certainty evidence.

Table 1 summarizes these eight BCTs and the specific techniques applied in the interventions.

4. Discussion

This systematic review examined behavior change interventions promoting healthcare professionals' eHealth competency through taxonomy [18] and behavioral theory [5]. The BCTTv1 [18] ratings demonstrated that different techniques were applied to promote eHealth competency in the reviewed 34 interventions. However, the interventions tended to primarily focus on techniques for practicing, instructing, and demonstrating eHealth performance. Interventions were most likely to improve psychological and physical capability and less likely to enhance automatic or reflective motivation toward using eHealth. We identified two promising BCTs: *action planning* and *participatory approach*. Additional six BCTs, *information about colleagues' approval,emotional social support,monitoring emotions,restructuring* or *adding objects to the environment*, and *credible source*, were considered worth further investigation.

Intervention functions have not changed substantially over time, as Gagnon et al. [17] review more than a decade ago similarly found that training was most often used to promote–> eHealth adoption. The focus on the type of eHealth seems to have shifted from electronic databases in Gagnon et al. [17] review toward EHRs as in our review. The widespread implementation of EHRs in the 2010s, partly related to regulations and provisions that promoted implementation [63,64], and the challenges in the adoption such as counterintuitive design [65,66] probably explain the recent focus on EHRs. EHRs can be considered as a catalyst for expanded developments in digitalized patient care. Thus, today's interventions should bend to being multifaceted to address the competency required for different eHealth systems and devices, such as CPOE, patient portals, mobile applications, and wearables. Experiences from interventions focusing on EHRs might be useful in other eHealth areas.

Thus far, Presseau et al. [67] study seems to be the only other study that uses the BCTTv1 for techniques targeting healthcare professionals. Although they addressed professionalism in diabetes care, they identified 17 same BCTs as our review. Our collective findings convince that BCTTv1 [18] can be used to synthesize interventions for healthcare professionals. However, both our review and Presseau et al. [67] study identified less than one-third of the BCTs classified in the BCTTv1, which suggests that some techniques might be more relevant for other target groups than healthcare professionals. Without modification, the taxonomy may be too excessive and time-consuming to evaluate interventions for healthcare professionals.

The main result of our review is that an intervention probably improves healthcare professionals' eHealth knowledge and skills but may overlook the efforts to address their negative attitudes toward digitalization. Although the COM-B model [5] postulates that capability may influence motivation, only 66 % of the reviewed interventions that included behavioral practice improved both capability and motivation to use eHealth. These findings suggest that an intervention that successfully improves capability may not have sufficient effect on enhancing motivation, which is equally crucial for competent eHealth performance.

Self-Determination Theory [68] claims that often some degree of motivation explains human behavior. Motivation in the COM-B model refers to the self-determined, intrinsic motivation. A sense of duty to comply with external demands can create extrinsic motivation for behavior change, which may explain why some interventions improved capability but not motivation. However, without any intrinsic motivation, maintaining the change is unlikely [68,69]. An intervention may provide longer-term benefits if it succeeds in inspiring participants to find a passion for professional development in eHealth [69].

The techniques that we discovered as promising to comprehensively improve eHealth competency or worth further investigation emphasize the importance of the social environment, namely the empathy, encouragement, and acceptance of eHealth shown by competent colleagues [37,45,46,48,50,51,61,62]. The essential role of opinion leaders in motivating the adoption of innovations has also been acknowledged elsewhere [70–72].

Social support can also be informational, such as providing feedback [73], but the interventions applied surprisingly little BCTs related to feedback. We did not find an association between feedback and improved eHealth competency. However, previous research has indicated that feedback generally promotes small but potentially essential changes in healthcare professionals' behavior [74].

Techniques related to the modifications in the work environment were scarcely represented in the reviewed interventions. It is recognized that workplace interventions, particularly in the field of health promotion [75], tend to "blame the victim," where employees' behavior is seen

as an object of change rather than the environment. We showed, however, that the techniques changing the work environment could promote eHealth competency, particularly by repairing or improving the systems [53], adding supportive elements [31,34,39,48,51,55], and enabling healthcare professionals to participate in the redesign process [34,39].

Our findings suggest that training can be inefficient if incompetency is related to an inadequate digital work environment. The usability researcher, Nielsen [76] has explicitly stated that if the users were not able to use the system, the problem would be in an improperly designed system instead of in the users themselves. Nielsen [77] has, thus, stressed that the user interfaces must be both suitable for the user environment and pleasant to use, which better motivates to use the system. In addition to affecting efficiency and psychological wellbeing of healthcare professionals [78–80], the usability of the eHealth systems is vital for safe patient care [81]. If the software or device was sufficiently intuitive, and therefore, experienced easy and meaningful to use, fewer interventions would be needed [82].

Despite the prominence of the single techniques identified, in practice, there may be a synergistic influence of the BCTs combined. The intervention facilitator, dose received, and participant characteristics may affect the results and explain some of the observed inconsistency in the effects. We also discovered that the latest interventions targeted physicians twice as often as nurses, which was a similar finding as a decade ago [17]. It is evident that also other professional groups than physicians are using eHealth in their daily work, and thus, need eHealth competency. An increasing trend for a skill-mixed work community in healthcare organizations [83] implies that even more work tasks can be shared between, for example, physicians and nurses. Therefore, interventions should be targeted at all personnel to ensure the sustainability of the health workforce. Interventions should yet address the potential differences in the challenges created by eHealth between professional groups.

4.1. Limitations

This review has limitations. The reliability of the identified BCTs is dependent on the reported details of interventions within the studies, which is a common limitation in reviews that code BCTs [84,85]. In our review, a single reviewer extracted the BCTs and effects, which may predispose the results to subjective interpretation. However, comprehensive training for the BCT coding and adherence with the pre-defined methodology mitigated selective reporting. We may have undermined the internal validity and omitted some relevant records with our decision to use only databases with papers from biomedical, nursing, and allied health disciplines and not to include grey literature to ensure the scientific nature of studies [86]. Lastly, the outcomes may be context-dependent, hampering the external validity, as most studies were from North America, focused on EHRs competency, and targeted physicians.

4.2. Implications for practice

Although an intervention for busy providers is challenging to implement, staff would be eager to improve eHealth competency, and the more feasible intervention is compact in duration [42,50–52]. In addition to eHealth training, we recommend that healthcare organizations provide empathic and patient support and encouragement for professionals to improve their motivation in digital changes. Recruited eHealth experts or competent colleagues identified from the staff could emphasize the benefits of eHealth and listen and provide support when challenges arise. We recommend that interventions would be based on behavioral theory to facilitate understanding of and responding to the insufficiencies in the components of eHealth competency. Furthermore, potential deficiencies in the user interfaces and equipment should be addressed.

Future development of eHealth technologies should aim at pursuing a user-centered design [87,88], which is based on the wishes and needs of healthcare professionals. eHealth implementation should incorporate effective techniques to ensure from the beginning that healthcare professionals have adequate capability and motivation to use eHealth effectively. The support for eHealth should, however, be ongoing, which requires that support from ICT personnel, managers, and the work community is always present. Overall, the organizational changes due to digitalization require careful planning and commitment of top management to be successful [89].

4.3. Implications for research

We recommend further research on interventions promoting both eHealth capability and motivation. As previous intervention studies have mostly focused on physicians, we propose further research on interventions for other professional groups, such as nurses, to improve understanding whether different groups would need particular support for digitalization. The rapid development of eHealth requires research on interventions promoting multifaceted competency to address the competency needed for also other eHealth solutions than EHRs.

A further review could explore qualitative studies on the experienced efficiency of interventions to understand their role in competency development. Forthcoming systematic reviews could investigate whether certain combinations of BCTs, specific intervention characteristics or participant characteristics, including individual learning styles [90] and orientation to technology, are associated with improved eHealth competency.

5. Conclusion

The present systematic review has identified 29 different BCTs of the recently implemented interventions to address insufficient eHealth competency in healthcare professionals. Our reviewed interventions tended to improve eHealth capability, but they overlooked the importance of motivation which is also crucial for competent eHealth performance and its maintenance. We have indicated that empathy, encouragement, and user-centered changes in the work environment could improve eHealth competency comprehensively. Evidence-based techniques, such as *action planning* and *participatory approach*, should be favored in the development of interventions. Additionally, *information about colleagues' approval*, *emotional social support*, *monitoring emotions*, *restructuring* or *adding objects to the environment*, and *credible source* are techniques worth further investigation. Intervention research can be strengthened by focusing on nurses and multifaceted competency required for the effective use of different eHealth solutions.

Funding

This review was supported by the Strategic Research Council at the Academy of Finland under Grant [number 327145]. The funding source had no involvement in the study design, data collection, analysis, interpretation of data, writing or decision whether to submit the article.

Authors' contributions

All authors have made a substantial, direct, intellectual contribution to this systematic literature review. LV designed the review under the supervision of AK, EL, KG, and TH. LV conducted database searches. LV and AK screened the records and appraised the quality. LV was responsible for data extraction, synthesis and interpretation of results, and drafting of the manuscript. AK, EL, KG, and TH critically revised the draft for important intellectual content. All authors approved the final version –>of the manuscript.

Summary table

What was already known on the topic?

- Implementing eHealth without ensuring a competent workforce can affect the efficiency of work, quality of care, and patient safety.
- Behavior change interventions might be useful in promoting eHealth capability and motivation.

What this study added to our knowledge?

- This is the first systematic review using taxonomy and theory to examine interventions addressing insufficient eHealth competency in healthcare professionals.
- Interventions tend to focus more on improving capability than motivation although both are crucial for competent eHealth performance.
- Empathic support, encouragement, and user-centered changes in the work environment could improve eHealth competency as a whole.

Declaration of Competing Interest

The authors report no declarations of interest.

Appendix A

See Table A1

Table A1
Eligibility –>criteria according to the PICOT framework.

Criterion	Inclusion	Exclusion
Participants	Licensed healthcare professionals with employment relationship in a healthcare organization	Medical students
Intervention	Behavior change intervention to develop novel or improve existing eHealth competency	Unknown delivery, content, or structure
Comparator	Control group receiving standard practice or no intervention; or Prospective or retrospective baseline measure	No comparator
Outcome	eHealth competency as (a) eHealth knowledge or cognitive skills, (b) eHealth skills or associated social and communication skills, (c) willingness and attitudes toward eHealth, or (d) an outcome implying a–c	None of the eligible outcome indicators measured eHealth usage as the only outcome
Measurement details	Individuals as the unit of observation A relevant quantitative instrument measuring objective or subjective data	Organizational level data Qualitative instrument
Type of studies	Experimental and non-experimental designs Peer-reviewed	Qualitative study Review Protocol Dissertation
Publication details	Published between January 2010 and February 2020 English abstract English, Finnish, Danish, or Swedish full text Digital copy available	No digital copy available

Appendix B

See Table B1–B3

Table B1
PubMed search strategy.

Database: PubMed Date: 25/02/2020 #	Search term(s)	Number of hits
1	(clinical competence[mh])	91,437
2	(clinician*[ti] OR doctor*[ti] OR professional*[ti] OR provider*[ti] OR personnel[ti] OR physician*[ti] OR practitioner*[ti] OR nurse*[ti] OR end-user*[ti] OR team*[ti] OR staff[ti] OR worker*[ti] OR organization*[ti] OR organisation*[ti])	554,667
3	(#1 OR #2)	625,537
4	(Burnout, Professional/prevention & control OR competency-based education[mh] OR computer user training[mh] OR education, continuing[mh] OR feedback[mh] OR health plan implementation[mh] OR inservice training[mh] OR medical informatics/education OR motivation[mh] OR motivational interviewing[mh] OR organizational innovation[mh] OR personnel management[mh] OR practice guidelines as topic[mh] OR program development[mh] OR staff development[mh])	575,923
5	(interven*[all fields] OR implement*[ti] OR improve*[ti] OR facilitat*[ti] OR encourag*[ti] OR behaviour change[ti] OR behavior change [ti] OR change*[ti] OR changing[ti] OR organizational change*[ti] OR organisational change*[ti] OR policy[ti] OR policies[ti] OR practice* [ti] OR procedure*[ti] OR professional development[ti] OR program*[ti] OR strateg*[ti] OR technique*[ti] OR tool*[ti] OR meaningful use [ti] OR quality improvement[ti])	2,681,704
6	(continuing education[ti] OR educat*[ti] OR teach*[ti] OR coach*[ti] OR guid*[ti] OR instruct*[ti] OR learn*[ti] OR creating[ti] OR lecture*[ti] OR meeting*[ti] OR seminar*[ti] OR session*[ti] OR material*[ti] OR tutor*[ti])	674,567
7	(training[ti] OR workshop*[ti] OR interactive[ti] OR interacting[ti] OR discuss*[ti] OR practic*[ti])	452,000
8	(enabl*[ti] OR motivational change[ti] OR motivational interviewing[ti] OR motivat*[ti] OR involv*[ti] OR participat*[ti] OR optimiz*[ti] OR optimisation[ti] OR optimise[ti] OR optimising[ti] OR resources[ti])	331,776
9	(coercion[ti] OR coercive[ti] OR fine*[ti] OR fining[ti])	38,785
10	(restructur*[ti] OR develop*[ti] OR updat*[ti])	656,459
11	(incentiv*[ti] OR reward*[ti])	17,879
12	(modelling[ti] OR modeling[ti] OR demonstrat*[ti] OR opinion leader*[ti] OR social network*[ti] OR example*[ti])	159,296
13	(persuasion[ti] OR persuasive[ti] OR change management[ti] OR management[ti] OR managing[ti] OR manage[ti] OR leader*[ti] OR leading[ti] OR support*[ti] OR audit[ti] OR feedback[ti] OR champion*[ti] OR communicat*[ti] OR letter*[ti] OR reminder*[ti] OR teamwork*[ti] OR benchmark*[ti] OR social support[ti] OR reinforc*[ti])	741,625
14	(#4 OR #5–13)	5,243,133
15	(computer literacy[mh] OR electronic prescribing[mh] OR information technology[mh] OR medical records systems, computerized[mh] OR telemedicine[mh] OR user-computer interface[mh])	100,074
16	(app[ti] OR e-health[ti] OR ehealth[ti] OR electronic[ti] OR EHR[ti] OR electronic health record*[ti] OR electronic patient record*[ti] OR e-prescribing[ti] OR health information technolog*[ti] OR information technolog*[ti] OR information and communication technolog*[ti] OR ICT[ti] OR m-health[ti] OR mhealth[ti] OR mobile[ti] OR online[ti] OR remote[ti] OR technolog*[ti] OR telehealth[ti] OR telemedicine[ti] OR user-interface[ti] OR interface[ti] OR computer[ti] OR computerized[ti] OR computerised[ti] OR digital[ti] OR digital health competenc*[ti] OR digital health literacy[ti] OR digital literacy[ti])	324,852
17	(#15 OR #16)	392,328
18	#14 AND #17	125,245
19	(Attitude of health personnel[mh] OR clinical competence[mh] OR computer literacy[mh] OR diffusion of innovation[mh] OR health knowledge, attitudes, practice[mh] OR attitude to computers[mh] OR job satisfaction[mh] OR professional competence[mh])	379,077
20	(feedback OR abilit* OR acceptance OR adopt* OR attitude* OR behaviour OR behavior OR belief OR believe* OR capabilit* OR comfort* OR competenc* OR confidence OR consider* OR experienc* OR engag* OR knowledge OR learn* OR motivat* OR opinion OR opportunit* OR perception OR perceive* OR performanc* OR satisf* OR self-efficacy OR teamwork OR recall OR recogni* OR resist* OR skill* OR uptake OR burnout OR stress OR willingness)	12,049,758
21	(#19 OR #20)	12,071,943
22	(adaptive clinical trial[pt] OR Clinical Study[pt] OR clinical trial[pt] OR Controlled clinical trial[pt] OR Guideline[pt] OR multicenter study [pt] OR Pragmatic clinical trial[pt] OR Randomized controlled trial[pt])	1,100,689
23	(Guidelines as topic[mh] OR Randomized controlled trials as topic[mh] OR non-randomized controlled trials as topic[mh] OR interrupted time series analysis[mh])	287,779
24	(case study OR mixed method* OR mixed-method* OR cohort OR implementation study OR effectiveness[ti] OR efficacy[ti] OR evidence-based[ti] OR evaluation study OR evaluat* OR randomis* OR randomiz* OR randomly OR trial or multicenter or multi center or multicentre or multi centre OR controlled OR control group* OR groups OR RCT OR CCT OR ((pretest OR pre test) AND (posttest OR post test)) OR quasi experiment* OR quasiexperiment* OR time series OR repeated measure*)	11,674,792
25	(#22 OR #23 OR #24)	11,785,166
26	#3 AND #18 AND #21 AND #25	5,480
27	(#3 AND #18 AND #21 AND #25) AND 2010:2020/02/25 [dp]	3,764

Table B2
Embase search strategy.

Database: Embase (Ovid) Date: 26/02/2020 #	Search term(s)	Number of hits
1	exp clinical competence/	59,597
2	(clinician* or doctor* or professional* or provider* or personnel or physician* or practitioner* or nurse* or end-user* or team* or staff or worker* or organization* or organisation*).ti.	575,869
3	(#1 or #2)	621,105
4	exp personnel management/ or exp continuing education/ or exp teaching/ or exp practice guideline/ or exp in service training/ or exp motivation/ or exp motivational interviewing/ or exp program development/	854,588

(continued on next page)

Table B2 (*continued*)

Database: Embase (Ovid)	Date: 26/02/2020 Search term(s)	Number of hits
#		
5	interven*.mp. or (implement* or improve* or facilitat* or encouraging or encourage or encouragement or behaviour change or behavior change or change* or changing or organizational change* or organisational change* or policy or policies or practice* or procedure* or professional development or program* or strateg* or technique* or tool*).ti.	3,252,055
6	(continuing education or educat* or teach* or coach* or guid* or instruct* or learn* or creating or lecture* or meeting* or seminar* or session* or material* or tutor*).ti.	750,734
7	(training or workshop* or interactive or interacting or discuss* or practic*).ti.	508,632
8	(enabl* or motivational change or motivational interviewing or motivat* or involv* or participat* or optimiz* or optimisation or optimise or optimising or resources).ti.	387,663
9	(coercion or coercive or fine* or fining).ti.	40,388
10	(restructur* or develop* or updat*).ti.	760,593
11	(incentiv* or reward*).ti.	20,254
12	(modelling or modeling or demonstrat* or opinion leader* or social network* or example*).ti.	173,579
13	(persuasion or persuasive or change management or management or managing or manage or leader* or leadership or leading or support or supportive or supporting or audit or feedback or champion or championing or communicating or communication or letter* or reminder* or teamwork* or benchmark* or social support or reinforc*).ti.	900,029
14	(#4 OR #5–13)	6,251,215
15	exp digital literacy/ or exp electronic prescribing/ or exp information technology/ or exp electronic medical record system/ or exp telemedicine/ or exp computer interface/	80,663
16	(app or e-health or ehealth or electronic or EHR or electronic health record* or electronic patient record* or e-prescribing or health information technolog* or information technolog* or information and communication technolog* or ICT or m-health or mhealth or mobile or online or remote or technolog* or telehealth or telemedicine or user-interface or interface or computer or computerized or computerised).ti.	266,366
17	(#15 or #16)	327,019
18	#14 AND #17	116,519
19	exp health –>personnel attitude/ or exp clinical competence/ or exp digital literacy/ or exp attitude to computers/ or exp job satisfaction/ or exp professional competence/	277,253
20	(feedback or abilit* or acceptance or adopt* or attitude* or behaviour or behavior or belief or believe* or capabilit* or comfort* or competenc* or confidence or consider* or experienc* or engag* or knowledge or learn* or motivat* or opinion or opportunit* or perception or perceive* or performanc* or satisf* or self-efficacy or teamwork or recall or recogni* or resist* or skill* or uptake or burnout or stress or willingness).mp.	12,588,819
21	(#19 OR #20)	12,593,987
22	exp clinical trial/ or exp controlled clinical trial/ or exp randomized controlled trial/ or exp pretest posttest design/	1,469,353
23	(case study or mixed method* or mixed-method* or cohort or implementation study or evaluation study or evaluat* or randomis* or randomiz* or randomly or trial or multicenter or multi center or multicentre or multi centre or controlled or control group* or groups or RCT or CCT or ((pretest or pre test) and (posttest or post test)) or quasi experiment* or quasiexperiment* or time series or repeated measure*).mp. or (effectiveness or efficacy or evidence-based).ti.	13,655,059
24	(#22 OR #23)	
25	(#3 AND #18 AND #21 AND #24)	3,401
26	limit 25 to yr="2010 - 2020"	2,577

Table B3
CINAHL search strategy.

Database: CINAHL (EBSCO)	Date: 26/02/2020 Search term(s)	Number of hits
S		
1	TI (clinician* OR doctor* OR professional* OR provider* OR personnel OR physician* OR practitioner* OR nurse* OR end-user* OR team* OR staff OR worker* OR organization* OR organisation*)	383,141
2	MH ("staff development" OR "education, continuing+" OR "education, competency-based" OR "refresher courses" OR teaching OR "practice guidelines" OR motivation OR "motivational interviewing" OR "program development" OR "personnel management")	197,876
3	interven* OR TI (implement* OR improve* OR facilitat* OR encourag* OR "behaviour change" OR "behavior change" OR change* OR changing OR "organizational change*" OR "organisational change*" OR policy OR policies OR practice* OR procedure* OR "professional development" OR program* OR strateg* OR technique* OR tool* OR "meaningful use" OR "quality improvement")	966,686
4	TI ("continuing education" OR educat* OR teach* OR coach* OR guid* OR instruct* OR learn* OR creating OR lecture* OR meeting* OR seminar* OR session* OR material* OR tutor*)	330,765
5	TI (training OR workshop* OR interactive OR interacting OR discuss* OR practic*)	241,222
6	TI (enabl* OR "motivational change" OR "motivational interviewing" OR motivat* OR involv* OR participat* OR optimiz* OR optimisation OR optimise OR optimising OR resources)	79,891
7	TI (coercion OR coercive OR fine* OR fining)	5,182
8	TI (restructur* OR develop* OR develop OR development OR update OR updating)	160,658
9	TI (incentive OR incentivisation OR incentivization OR reward*)	5,034
10	TI (modelling OR modeling OR demonstrat* OR opinion leader* OR social network* OR example*)	22,803
11	TI (persuasion OR persuasive OR "change management" OR management OR managing OR manage OR leader* OR leadership OR leading OR support OR supportive OR supporting OR audit OR feedback OR champion OR championing OR communicating OR communication OR letter* OR reminder* OR teamwork* OR benchmark* OR social support OR reinforc*)	331,654
12	(S2 OR S3–11)	1,759,748
13	MH ("computer literacy" OR "information technology" OR "electronic health records" OR telemedicine OR "user-computer interface")	53,217
14	TI (app OR e-health OR ehealth OR electronic OR EHR OR electronic health record* OR electronic patient record* OR e-prescribing OR health information technolog* OR information technolog* OR information and communication technolog* OR ICT OR m-health OR mhealth OR mobile OR online OR remote OR technolog* OR telehealth OR telemedicine OR user-interface OR interface OR computer OR computerized OR computerised)	112,138
15	(S13 OR S14)	147,045
16	S12 AND S15	59,561
17	MH ("attitude of health personnel" OR "clinical competence" OR "computer literacy" OR "professional knowledge" OR "attitude to computers" OR "job satisfaction" OR "professional competence")	117,478

(*continued on next page*)

Table B3 (*continued*)

Database: CINAHL (EBSCO)	Date: 26/02/2020 Search term(s)	Number of hits
S		
18	(feedback OR abilit* OR acceptance OR adopt* OR attitude* OR behaviour OR behavior OR belief OR believe* OR capabilit* OR comfort* OR competenc* OR confidence OR consider* OR experienc* OR engag* OR knowledge OR learn* OR motivat* OR opinion OR opportunit* OR perception OR perceive* OR performanc* OR satisf* OR self-efficacy OR teamwork OR recall OR recogni* OR resist* OR skill* OR uptake OR burnout OR stress OR willingness)	2,371,535
19	(S17 OR S18)	2,371,820
20	PT ("adaptive clinical trial" OR "Clinical Study" OR "clinical trial" OR "Controlled clinical trial" OR "Guideline" OR "multicenter study" OR "Pragmatic clinical trial" OR "Randomized controlled trial")	170,202
21	MH ("practice guidelines" OR "randomized controlled trials" OR "interrupted time series analysis")	161,964
22	("case study" OR "mixed method*" OR mixed-method* OR cohort OR "implementation study" OR "evaluation study" OR evaluat* OR randomis* OR randomiz* OR randomly OR trial or multicenter or "multi center" or multicentre or "multi centre" OR controlled OR control group* OR groups OR RCT OR CCT OR ((pretest OR "pre test") AND (posttest OR "post test")) OR "quasi experiment*" OR quasiexperiment* OR "time series" OR "repeated measure*") or TI (effectiveness OR efficacy OR evidence-based)	2,009,667
23	(S20 OR S21 OR S22)	2,063,587
24	S1 AND S16 AND S19 AND S23	2,126
25	24 limiters: Published date 20100101-20200226	1,525

Appendix C

The list of all excluded studies after full-text examination ($n = 76$), categorized by the reasons for exclusion.

No quantitative outcome data ($n = 14$)

Ahonen O, Kouri P, Kinnunen U-M, Junttila K, Liljamo P, Arifulla D, et al. The development process of eHealth strategy for nurses in Finland. Stud Health Technol Inform [Internet]. 2016;225:203–7. doi:10.3233/978-1-61499-658-3-203

Arain MA, Tarraf R, Ahmad A. Assessing staff awareness and effectiveness of educational training on IT security and privacy in a large healthcare organization. J Multidiscip Healthc [Internet]. 2019;12:73–81. doi:10.2147/JMDH.S183275

Bergey MR, Goldsack JC, Robinson EJ. Invisible work and changing roles: Health information technology implementation and reorganization of work practices for the inpatient nursing team. Soc Sci Med [Internet]. 2019;235:112387. doi:10.1016/j.socscimed.2019.112387

Chelsom J, Ahluwalia R, Dogar N. Clinician-led development of electronic health records systems. Stud Health Technol Inform [Internet]. 2013;183:3–8. doi:10.3233/978-1-61499-203-5-3

Gross AH, Leib RK, Tonachel A, Tonachel R, Bowers DM, Burnard RA, et al. Teamwork and electronic health record implementation: A case study of preserving effective communication and mutual trust in a changing environment. J Oncol Pract [Internet]. 2016;12:1075–83. doi:10.1200/JOP.2016.013649

Izumi T, Majima Y. Education methods for improving the ability to use nursing information, with a focus on issues related to the role of the head nurse: A post-workshop evaluation. Stud Health Technol Inform [Internet]. 2016;225:993–4. doi:10.3233/978-1-61499-658-3-993

Lopetegui M, Oberpaur B, Vivent M, Carrasco C, Mauro A. Emergency department information system education and training for clinicians: Lessons learned. Stud Health Technol Inform [Internet]. 2015;216:1001. doi:10.3233/978-1-61499-564-7-1001

Morony S, Weir K, Duncan G, Biggs J, Nutbeam D, Mccaffery KJ. Enhancing communication skills for telehealth: development and implementation of a Teach-Back intervention for a national maternal and child health helpline in Australia. BMC Health Serv Res [Internet]. 2018;18:162. doi:10.1186/s12913-018-2956-6

Søndergaard SF, Lorentzen V, Sørensen EE, Frederiksen K. Danish perioperative nurses' documentation: A complex, multifaceted practice connected with unit culture and nursing leadership. AORN J [Internet]. 2017;106:31–41. doi:10.1016/j.aorn.2017.05.003

Tang T, Lim ME, Mansfield E, McLachlan A, Quan SD. Clinician user involvement in the real world: Designing an electronic tool to improve interprofessional communication and collaboration in a hospital setting. Int J Med Inform [Internet]. 2018;110:90–7. doi:10.1016/j.ijmedinf.2017.11.011

Topaz M, Rao A, Masterson Creber R, Bowles KH. Educating clinicians on new elements incorporated into the electronic health record: theories, evidence, and one educational project. Comput Inform Nurs [Internet]. 2013;31:375–81. doi:10.1097/NXN.0b013e318295e5a5

Vossebeld DM, Puik ECN, Jaspers JEN, Schuurmans MJ. Development process of a mobile electronic medical record for nurses: A single case study. BMC Med Inform Decis Mak [Internet]. 2019;19:11. doi:10.1186/s12911-018-0726-3

Walker L, Clendon J. The case for end-user involvement in design of health technologies. J Telemed Telecare [Internet]. 2016;22:443–6. doi:10.1177/1357633 × 16670479

Yuan CT, Bradley EH, Nembhard IM. A mixed methods study of how clinician 'super users' influence others during the implementation of electronic health records. BMC Med Inform Decis Mak [Internet]. 2015;15:26. doi:10.1186/s12911-015-0154-6

Non-eligible outcome data ($n = 10$)

Cohen MF. Impact of the HITECH financial incentives on EHR adoption in small, physician-owned practices. Int J Med Inform [Internet]. 2016;94:143–54. doi:10.1016/j.ijmedinf.2016.06.017

Hao H, Padman R. An empirical study of opinion leader effects on mobile technology implementation by physicians in an American community health system. Health Informatics J [Internet]. 2018;24:323–33. doi:10.1177/1460458216675499

He P, Yuan Z, Liu Y, Li G, Lv H, Yu J, et al. An evaluation of a tailored intervention on village doctors use of electronic health records. BMC Health Serv Res [Internet]. 2014;14:217. doi:10.1186/1472-6963-14-217

Kargul GJ, Wright SM, Knight AM, McNichol MT, Riggio JM. The hybrid progress note: Semiautomating daily progress notes to achieve high-quality documentation and improve provider efficiency. Am J Med Qual [Internet]. 2013;28:25–32. doi:10.1177/1062860612445307

Leu MG, Morelli SA, Chung O-Y, Radford S. Systematic update of computerized physician order entry order sets to improve quality of care: A case study. Pediatrics [Internet]. 2013;131:S60–7. doi:10.1542/peds.2012-1427g

McKay C, Vanaskie K. Partnering for success: The role of the nurse leader in health information technology implementation for coordination of care. Nurse Lead [Internet]. 2018;16(6):385–8. doi:10.1016/j.mnl.2018.07.012

Senathirajah Y, Kaufman D, Bakken S. User-composable electronic health record improves efficiency of clinician data viewing for patient

case appraisal: A mixed-methods study. EGEMS (Wash DC) [Internet]. 2016;4:1176. doi:10.13063/2327-9214.1176

Sharp K, Williams M, Aldrich A, Bogacz A, Denier S, McAlearney AS. Conversion of provider EMR training from instructor-led training to elearning at an academic medical center. Appl Clin Inform [Internet]. 2017;8:754–62. doi:10.4338/ACI-2017-03-CR-0040

Wang J-N, Chiu Y-L, Yu H, Hsu Y-T. Understanding a nonlinear causal relationship between rewards and physicians' contributions in online health care communities: Longitudinal study. J Med Internet Res [Internet]. 2017;19:e427. doi:10.2196/jmir.9082

Yang H, Zhang X. Investigating the effect of paid and free feedback about physicians' telemedicine services on patients' and physicians' behaviors: Panel data analysis. J Med Internet Res [Internet]. 2019;21:e12156. doi:10.2196/12156

Intervention not targeting competency ($n = 9$)

Anderson RJ, Sparbel K, Barr RN, Doerschug K, Corbridge S. Electronic health record tool to promote team communication and early patient mobility in the intensive care unit. Crit Care Nurse [Internet]. 2018;38:23–34. doi:10.4037/ccn2018813

Baker DW, Persell SD, Kho AN, Thompson JA, Kaiser D. The marginal value of pre-visit paper reminders when added to a multifaceted electronic health record based quality improvement system. J Am Med Inform Assoc [Internet]. 2011;18:805–11. doi:10.1136/amiajnl-2011-000169

Bernier KM, Strobel M, Lucas R. Assessing the effect of an educational intervention on nurses' and patient care assistants' comprehension and documentation of functional ability in pediatric patients with sickle cell disease. J Pediatr Nurs [Internet]. 2018;41:117–22. doi:10.1016/j.pedn.2018.04.001

Douglas TM, Levine AR, Olivieri PP, McCurdy MT, Papali A, Zubrow MT, et al. Brief training increases nurses' comfort using tele-ultrasound: A feasibility study. Intensive Crit Care Nurs [Internet]. 2019;51:45–9. doi:10.1016/j.iccn.2018.11.004

Mango VL, Ha R, Nguyen B, Mema E, Kobeski J, Singh T, et al. RAD-AID Asha Jyoti Mammogram quality assessment in India: Optimizing mobile radiology. J Am Coll Radiol [Internet]. 2016;13(7):831–4. doi:10.1016/j.jacr.2016.03.018

Richard S, Mione G, Varoqui C, Vezain A, Brunner A, Bracard S, et al. Simulation training for emergency teams to manage acute ischemic stroke by telemedicine. Medicine (Baltimore) [Internet]. 2016;95:e3924. doi:10.1097/MD.0000000000003924

Rose RD, Lang AJ, Welch SS, Campbell-Sills L, Chavira DA, Sullivan G, et al. Training primary care staff to deliver a computer-assisted cognitive-behavioral therapy program for anxiety disorders. Gen Hosp Psychiatry [Internet]. 2011;33:336–42. doi:10.1016/j.genhosppsych.2011.04.011

San Jose RL. Educating nurses on workflow changes from electronic health record adoption [dissertation on the Internet]. Minneapolis, MN: Walden University; 2017 [cited 2020 May 15]. Available from: https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=4424&context=dissertations

Sowan AK, Leibas M, Tarriela A, Reed C. Nurses' perceptions of a care plan information technology solution with hundreds of clinical practice guidelines in adult intensive care units: Survey study. JMIR Hum Factors [Internet]. 2019;6:e11846. doi:10.2196/11846

Non-eligible study design ($n = 8$)

Barisone M, Bagnasco A, Timmins F, Aleo G, Sasso L. Approaches to nurse education and competence development in remote telemonitoring of heart failure patients with implanted heart devices in Italy: A cause for concern. Eur J Cardiovasc Nurs [Internet]. 2018;17:388–9. doi:10.1177/1474515117742132

Cantiello J, Cortelyou-Ward KH. The American Recovery and Reinvestment Act: Lessons learned from physicians who have gone electronic. Health Care Manag [Internet]. 2010;29:332–8. doi:10.1097/HCM.0b013e3181fa04c8

Gray DC, Rutledge CM. Using new communication technologies: An educational strategy fostering collaboration and telehealth skills in nurse practitioners. J Nurse Pract [Internet]. 2014;10(10):840–4. doi:10.1016/j.nurpra.2014.06.018

Hess CT. Friendly reminders: 2015 meaningful use attestation and physician quality reporting system. Adv Skin Wound Care [Internet]. 2015;28:336. doi:10.1097/01.ASW.0000466717.49204.36

Lahti M, Groen G, Mwape L, Korhonen J, Breet E, Chapima F, et al. Design and development process of a youth depression screening m-health application for primary health care workers in South Africa and Zambia: An overview of the MEGA project. Issues Ment Health Nurs [Internet]. 2020;41:24–30. doi:10.1080/01612840.2019.1604919

Nearly half of eligible providers have received EHR incentive payments. Derm Times [Internet]. 2013 [cited 2020 May 15];17. Available from: http://images2.advanstar.com/PixelMags/dermatology-times/pdf/2013-06.pdf

Pollack AH, Miller A, Mishra SR, Pratt W. PD-atricians: Leveraging physicians and participatory design to develop novel clinical information tools. AMIA Annu Symp Proc [Internet]. 2017 [cited 2020 May 15];2016:1030–9. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5333342/pdf/2498949.pdf

Seto R, Wakabayashi S, Hosaka R. Redesigned computerized prescribing system to reduce physicians' workload and improve patient safety. Stud Health Technol Inform [Internet]. 2013;192:1225. doi:10.3233/978-1-61499-289-9-1225

No digital copy available ($n = 8$)

Fiato KA. Enhancing electronic medical records (EMR) implementation: Peer support interventions influencing nurses' acceptance and use [dissertation on the Internet]. Atlanta, GA: Argosy University; 2012 [cited 2020 May 15]. Available from: https://about.proquest.com/products-services/pqdtglobal.html

Jordan LA, Sewell C, Rudd J, Evans M, Kerr E, Nieass J, et al. Rural tele-thrombolysis protocol implementation: Nurses leading change. Int J Stroke [Internet]. 2014;9:5–6. doi:10.1111/ijs.12334

Peticolas K, Khairat S, Seashore C, Law J. Physician-led EHR customization tracking assessments for pediatric patients with turner syndrome. Stud Health Technol Inform [Internet]. 2019;262:276–9. doi:10.3233/SHTI190072

Redwood E, Smith R, Garay CR, Truscott R, Umar S, Kaan M, et al. Meeting patient and provider eTechnology needs: A provincial approach. J Clin Oncol [Internet]. 2016;34(7):153. doi:10.1200/jco.2016.34.7_suppl.153

Ronquillo C, Dahinten S, Bungay V, Currie L. The MOBile-Health and Implementation Leadership Evaluation (MOBILE) nurse study: Developing a testable conceptual model. Stud Health Technol Inform [Internet]. 2018 [cited 2020 May 15];250:143. Available from: http://ebooks.iospress.nl/publication/49105

Stalians J. An evaluation of the effectiveness of implementing an electronic medical record documentation tool on documentation rates of patient self-management goals by primary care providers [dissertation on the Internet]. Vermillion, SD: South Dakota University; 2018 [cited 2020 May 15]. Available from: https://about.proquest.com/products-services/pqdtglobal.html

Tubat E. Efficacy of telemental health training on mental health practitioner's knowledge, attitudes, beliefs, and intent to offer telemental health services [dissertation]. Irvine CA: Brandman University; 2017.

Woods L, Cummings E, Duff J, Walker K. Conceptual design and iterative development of a mHealth app by clinicians, patients and their

families. Stud Health Technol Inform [Internet]. 2018;252:170–5. doi:10.3233/978-1-61499-890-7-170

Intervention not targeting eHealth ($n = 7$)

Bowdle TA, Jelacic S, Nair B, Zucker F, Bussey LS, Togashi K, et al. Electronic audit and feedback with positive rewards improve anesthesia provider compliance with a barcode-based drug safety system. Anesth Analg [Internet]. 2019;129:418–25. doi:10.1213/ANE.0000000000003861

Freschi C, Parrini S, Dinelli N, Ferrari M, Ferrari V. Hybrid simulation using mixed reality for interventional ultrasound imaging training. Int J Comput Assist Radiol Surg [Internet]. 2015;10:1109–15. doi:10.1007/s11548-014-1113-x

Gonzalez R, O'Brien-Barry P, Ancheta R, Razal R, Clyne ME. Peer education versus computer-based education: Improve utilization of library databases among direct care nurses. J Nurses Prof Dev [Internet]. 2017;33:E1–E5. doi:10.1097/NND.0000000000000371

Hou YH, Lu LJ, Lee PH, Chang IC. Positive Impacts of Electronic hand-off systems designs on nurses' communication effectiveness. J Nurs Manag [Internet]. 2019;27(5):1055–63. doi:10.1111/jonm.12774

Kulkarni D, Heath J, Kosack A, Jackson NJ, Crummey A. An educational intervention to improve inpatient documentation of high-risk diagnoses by pediatric residents. Hosp Pediatr [Internet]. 2018;8:430–5. doi:10.1542/hpeds.2017-0163

Lear CL, Walters C. Use of electronic nurse reminders to improve documentation: a process improvement for a comprehensive stroke center. Comput Inform Nurs [Internet]. 2015;33:523–9. doi:10.1097/CIN.0000000000000199

Rosenkrantz AB, Begovic J, Pires A, Won E, Taneja SS, Babb JS. Online interactive case-based instruction in prostate magnetic resonance imaging interpretation using prostate imaging and reporting data system version 2: Effect for novice readers. Curr Probl Diagn Radiol [Internet]. 2019;48:132–41. doi:10.1067/j.cpradiol.2018.01.003

No intervention ($n = 5$)

Barrett AK, Stephens KK. Making electronic health records (EHRs) work: Informal talk and workarounds in healthcare organizations. Health Commun [Internet]. 2017;32:1004–13. doi:10.1080/10410236.2016.1196422

Cheng DR, Liddle J, Mailes E, South M. Impact of an integrated electronic handover tool on pediatric junior medical staff (JMS) handover. Int J Med Inform [Internet]. 2017;108:92–6. doi:1016/j.ijmedinf.2017.10.009

Palumbo MV, Sandoval M, Hart V, Drill C. Teaching electronic health record communication skills. Comput Inform Nurs [Internet]. 2016;34:254–8. doi:10.1097/CIN.0000000000000238

Quan AML, Stiell I, Perry JJ, Paradis M, Brown E, Gignac J, et al. Mobile clinical decision tools among emergency department clinicians: Web-based survey and analytic data for evaluation of the Ottawa Rules App. JMIR Mhealth and Uhealth [Internet]. 2020;8:e15503. doi:10.2196/15503

Zandieh SO, Abramson EL, Pfoh ER, Yoon-Flannery K, Edwards A, Kaushal R. Transitioning between ambulatory EHRs: a study of practitioners' perspectives. J Am Med Inform Assoc [Internet]. 2012;19:401–6. doi:10.1136/amiajnl-2011-000333

No comparison ($n = 5$)

Hughes S, Livingston J, Semler R, Hughes A. Improving nurse computer proficiency with a tri-focal educational intervention. Int J Urol Nurs [Internet]. 2014;8(3):161–5. doi:10.1111/ijun.12045

Pantaleoni JL, Stevens LA, Mailes ES, Goad BA, Longhurst CA. Successful physician training program for large scale EMR implementation. Appl Clin Inform [Internet]. 2015;6:80–95. doi:10.4338/ACI-2014-09-CR-0076

Sano JM, Alexander S. Using an evidence-based approach for electronic health record downtime education in nurse onboarding. Comput Inform Nurs [Internet]. 2020;38:36–44. doi:10.1097/CIN.0000000000000582

Smailes PS, Zurmehly J, Schubert C, Loversidge JM, Sinnott LT. An electronic medical record training conversion for onboarding inpatient nurses. Comput Inform Nurs [Internet]. 2019;37:405–12. doi:10.1097/CIN.0000000000000514

Weintraub AY, Deutsch ES, Hales RL, Buchanan NA, Rock WL, Rehman MA. Using high-technology simulators to prepare anesthesia providers before implementation of a new electronic health record module: A technical report. Anesth Analg [Internet]. 2017;124:1815–9. doi:10.1213/ANE.0000000000001775

Non-eligible participants ($n = 4$)

Edirippulige S, Smith AC, Wickramasinghe S, Armfield NR. Examining the influence of e-health education on professional practice. J Med Syst [Internet]. 2018;42:215. doi:10.1007/s10916-018-1084-5

Haspel RL, Ali AM, Huang GC, Smith MH, Atkinson JB, Chabot-Richards DS, et al. Teaching genomic pathology: Translating team-based learning to a virtual environment using computer-based simulation. Arch Pathol Lab Med [Internet]. 2019;143:513–7. doi:10.5858/arpa.2018-0153-OA

van Velsen L, Evers M, Bara C-D, Op den Akker H, Boerema S, Hermens H. Understanding the acceptance of an ehealth technology in the early stages of development: An end-user walkthrough approach and two case studies. JMIR Form Res [Internet]. 2018;2:e10474. doi:10.2196/10474

Vartian CV, Singh H, Russo E, Sittig DF. Development and field testing of a self-assessment guide for computer-based provider order entry. J Healthc Manag [Internet]. 2014 [cited 2020 May 15];59(5):338–52. Available from: https://journals.lww.com/jhmonline/Abstract/2014/09000/Development_and_Field_Testing_of_a_Self_Assessment.7.aspx

Insufficient intervention description ($n = 3$)

Pandya C, Clarke T, Scarsella E, Alongi A, Amport SB, Hamel L, et al. Ensuring effective care transition communication: implementation of an electronic medical record-based tool for improved cancer treatment handoffs between clinic and infusion nurses. JCO Oncol Pract [Internet]. 2019;15:e480–9. doi:10.1200/JOP.18.00245

Pfortmiller DT, Mustain JM, Lowry LW, Wilhoit KW. Preparing for organizational change: Project: SAFETYfirst. Comput Inform Nurs [Internet]. 2011;29:230–8. doi:10.1097/NCN.0b013e3181f9dc8b

Titilayo OD, Okanlawon FA. Assessment of mobile health nursing intervention knowledge among community health nurses in Oyo State, Nigeria. Afr J Med Med Sci [Internet]. 2014 [cited 2020 May 15];43:147–55. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4682913/.

Unclear outcome data ($n = 2$)

Kiepek W, Sengstack PP. An evaluation of system end-user support during implementation of an electronic health record using the Model for Improvement framework. Appl Clin Inform [Internet]. 2019;10:964–71. doi:10.1055/s-0039-3402450

Stephenson LS, Gorsuch A, Hersh WR, Mohan V, Gold JA. Participation in EHR based simulation improves recognition of patient safety issues. BMC Med Educ [Internet]. 2014;14:224. doi:10.1186/1472-6920-14-224

Unit of observation other than individual ($n = 1$)

Damschroder LJ, Reardon CM, Sperber N, Robinson CH, Fickel JJ, Oddone EZ. Implementation evaluation of the Telephone Lifestyle Coaching (TLC) program: Organizational factors associated with successful implementation. Transl Behav Med [Internet]. 2017;7(2):233–41. doi:10.1007/s13142-016-0424-6

Appendix D

See Table D1

Table D1
Characteristics–> of included studies.

Author(s), year	Method	Setting		Participants		Intervention(s)					Comparator	Effects, *a significant change[a]
		Country	Clinical	*n*	Profession	Type of eHealth	Theory	Category	Facilitator(s)	Duration		
Adereti et al. [31], 2019	Pre-post	Nigeria	Tertiary care	16	Nurses	EHRs	Non explicit	Training	Researchers	6 months	Baseline	Quality of output*
Ahmed et al. [53], 2011	ITS	The United States	Secondary care	20	Physicians	EHRs	Non explicit	Enabling	Researchers, Experts, ICT Personnel	One session[b]	No intervention	Task load*, Number* of errors, Time*
Archambault et al. [32], 2016	Pre-post	Canada	Secondary care	28	Physicians	Electronic database	TPB	Training	Healthcare Managers	6 months	Baseline	Intention, Attitude*, Perceived behavioral control
Armstrong et al. [61], 2018	Pre-post	The United States	Primary care, Secondary care, Tertiary care	760	Nurses, Physicians, Psychologists, Others	mHealth	ALT	Training	Experts, Healthcare Professionals	7 h	Baseline	Knowledge*
Beaney et al. [33], 2019	Pre-post	England	Primary care	24	Nurses	Telehealth	Non explicit	Persuasive	Nurses, ICT Personnel	4 months	Baseline	Worriedness*
Benton et al. [34], 2019	CCT	The United States	Secondary care	34	Nurses	eReferral	Non explicit	Enabling	Nurses, Physicians, ICT Personnel	A longer period[b]	Baseline	Effectiveness*, Productivity*, Time*, Satisfaction*, Perceived ease of use*
Benwell et al. [35], 2017	Pre-post	Aus-tralia	Tertiary care	20	Physicians	EHRs	FSMASA	Training	Researchers	3.5 h	Baseline	Proficiency*, Efficiency*, Accuracy*
Bredfeldt et al. [54], 2013	Pre-post	The United States	Unspecified	54	Physicians	EHRs	Non explicit	Training	Physicians, Assistants	8–10 h over 2 days	No intervention	Task management*
Contratto et al. [36], 2017	ITS	The United States	Primary care	7	Physicians	EHRs	Non explicit	Enabling	Assistants	4 months	Baseline	Productivity*, Time*, Symptoms of burnout and depersonalisation*
Dastagir et al. [37], 2012	Pre-post	The United States	Unspecified	155	Physicians	EHRs	Non explicit	Training	Physicians	3 days	Baseline	Skills*
Dennehy et al. [62], 2011	CCT	The United States	Primary care	16	Intervention 1 Nurses	EHRs	UTAUT	Enabling	Experts, ICT Personnel	1 year	Baseline	Attitude*
					Intervention 2 Nurses	EHRs	UTAUT	Enabling	Experts, ICT Personnel	2 years	Baseline	Attitude*
DiAngi et al. [38], 2019	Pre-post	The United States	Primary care, Secondary care	147	Physicians	EHRs	ALT	Enabling	Experts, Coordinator, Physician Advisor	5–10 h over 3 months	Baseline	Knowledge*, Workload*, Time, Satisfaction, Stress level
Eskeland et al. [55], 2017	Pre-post	Norway	Primary care	25	Physicians	eReferral	Non explicit	Training	Researchers, ICT Personnel	Two sessions over 3 months	No intervention	Quality of output*
Gardner et al. [39], 2013	Pre-post	The United States	Primary care	3	Nurses, Physicians	EHRs	TAM	Training	Researchers, ICT Personnel	The first phase lasted 2 weeks[b]	Baseline	Skills*, Reactions*, Perceived ease of use*
Gifford et al. [40], 2012	CCT	The United States	Secondary care	21	Psychologists	Telehealth	Non explicit	Enabling	Experts	3 days	Baseline	Competency*
Hosseini et al. [41], 2019	Pre-post	The United States	Primary care	9	Nurses, Physicians	EHRs	Non explicit	Training	Researchers, ICT Personnel	Two sessions	Baseline	Workload*, Frustration, Effort
Jalota et al. [55], 2015	Pre-post	The United States	Primary care	44	Physicians	EHRs	Situativity Theory	Enabling	Researchers, Physicians, ICT Personnel	3 months	Traditional intervention	Time*, Comfort
Kadish et al. [42], 2018	RPP	The United States	Secondary care	185	Nurses, Physicians	EHRs	Non explicit	Training	Experts	2 h	Baseline	Time*, Confidence*
Kim et al. [43], 2017	Pre-post	The United States	Primary care	18	Physicians	EHRs	Non explicit	Persuasive	Experts	3 years	Baseline	Skills*
Lee et al. [52], 2018	Pre-post	The United States	Primary care	32	Intervention 1 Physicians	EHRs	Non explicit	Training	Researchers	4 h	Retrospec-tive baseline	Knowledge of best practices*, Ability to implement best practices*, Patient-centred skills*
					Intervention 2 Physicians	EHRs	Non explicit	Training	Researchers	1.5 h	Retrospec-tive baseline	Knowledge of best practices*, Ability to implement best practices*, Patient-centred skills*
	RCT	Canada	Tertiary care	11			TPB	Training	Researcher, Physician	5 months	Baseline	

(*continued on next page*)

Table D1 (*continued*)

Author(s), year	Method	Setting		Participants		Intervention(s)					Comparator	Effects, *a significant change[a]
		Country	Clinical	*n*	Profession	Type of eHealth	Theory	Category	Facilitator(s)	Duration		
Levac –>et al. [44], 2016					Occupational Therapists, Physical Therapists	Virtual reality system						Knowledge and skills*, Perceived behavioral control*, Intention, Self-efficacy, Attitude, Perceived ease of use
Lopez et al. [45], 2018	CCT	The United States	Primary care	20	Physicians	EHR	SLT	Training	ICT Personnel	2–4 h	Baseline	Knowledge*, Comfort*, Confidence*
Mastellos et al. [59], 2018	CCT	Malawi	Primary care	40	Community Healthcare Workers	General eHealth	Bloom's Taxonomy	Persuasive	Researchers	31 h over 3 weeks	Traditional intervention	Attitude*, Knowledge
Patel et al. [57], 2019	Pre-post	The United States	Primary care, Secondary care	18	Physicians	EHRs	SLT	Training	Physician	1.5 h	No intervention	Patient–provider communication skills*, Attitude*, Confidence
Reis et al. [58], 2013	Pre-post	Israel	Primary care	36	Physicians	EHRs	Non explicit	Training	Physicians	3 days over 9 weeks	Traditional intervention	Skills*, Patient–provider communication skills*, Attitude*
Robinson et al. [46], 2018	Pre-post	Canada	Primary care, Secondary care, Tertiary care	3,500	Physicians	EHRs	Non explicit	Training	Physicians	3 days	Baseline	Quality of output*, Accuracy*, Number of errors*, Efficiency*, Time*
Shachak et al. [47], 2015	RPP	Canada	Primary care	16	Physicians	EHRs	TAM	Persuasive	Researchers	2 h	Baseline	Knowledge*, Skills*, Attitude
Sieja et al. [48], 2019	RCT	The United States	Primary care, Secondary care	220	Physicians, Midwives, Nurses	EHRs	Non explicit	Training	ICT Personnel, Project Manager, Experts	7 h over 5–20 days	Baseline	Time*, Satisfaction*, Emotional exhaustion of burnout*
Stacey et al. [51], 2015	Pre-post	Canada	Secondary care	107	Nurses	Tele-health	KTA	Enabling	Nurses	30–60 min	Retrospec-tive baseline	Achievement in learning objectives*, Confidence*
van Stiphout et al. [60], 2018	Pre-post	The Nether-lands	Secondary care	124	Physicians	CPOE	TPB	Training	Researchers	2–7 h	Traditional intervention	Knowledge*, Skills*, Self-efficacy, Attitude
Vuk et al. [49], 2015	Pre-post	The United States	Secondary care	387	Nurses, Physicians	EHRs	Non explicit	Training	Experts	10 h	Baseline	Preparedness*, Confidence*, Perceptions of benefits
Walsh et al. [50], 2018	ITS	The United States	Secondary care	517	Nurses, Physicians	EHRs	DOI	Training	Physicians	20 min	Baseline	Knowledge to perform the skill*, Preference*

Note. ALT: Adult Learning Theory; CCT: Controlled clinical trial; CPOE: Computerized provider order entry; DOI: The Diffusion of Innovation Theory; EHRs: Electronic health records; FSMASA: The Five-Stage Model of Adult Skill Acquisition; ITS: Interrupted time series; KTA: The Knowledge-to-Action Framework; RCT: Randomized controlled trial; RPP: Retrospective pre-post study; SLT: Social Learning Theory; TAM: Technology Acceptance Model; TPB: Theory of Planned Behavior; UTAUT: The Unified Theory of Acceptance and Use of Technology.

[a] At statistical and/or practical level.

[b] Unspecified duration.

Appendix E

Table E1 summarizes the appraised methodological quality of the studies. The general methodological weakness in the studies was an inadequate methodological reporting, for example, lacking details of their study design, target population, blinding process, allocation concealment, and validation of the measurement instruments. Another frequent methodological weakness was a weak control of potential confounders distorting the study effects and the usage of non-probabilistic sampling methods. Practical reasons made blinding in the studies challenging, although some reported successfully masking the research aim from the participants or blinding the outcome assessors. Studies also suffered from a low statistical power due to relatively small sample recruited or loss to follow-up. Subjective outcome indicators were used in the majority of the studies and were inevitable in evaluating participants' experiences, but simultaneously introduced a risk of flawed responses. Nevertheless, the prevention of extended bias was, on average, moderately strong due to the study designs utilized.

The sensitivity analysis showed that by excluding methodologically weak studies, three identified BCTs would be missed, namely *goal setting* [33], *reviewing current behavior and goal* [45], and *information about emotional consequences* [50]. Moreover, *information about others' approval* [51,62] would not be a suggested BCT worth further investigation as it appears in only one study of moderate quality [51]. Overall, however, according to our sensitivity analysis, it seems that the effects of the interventions are not substantially sensitive to the study quality.

Table E1
Methodological quality appraisal.

Authors	Strength of prevention of bias						
	Q1	Q2	Q3	Q4	Q5	Q6	*Mean*
Adereti et al. [31]	M	M	W	W	W	n/a	W
Ahmed et al. [53]	S	W	W	W	S	n/a	M
Archambault et al. [32]	M	M	W	W	S	S	M
Armstrong et al. [61]	M	W	W	W	W	W	W
Beaney et al. [33]	M	W	W	W	W	S	W
Benton et al. [34]	W	M	M	W	S	n/a	M
Benwell et al. [35]	M	W	M	W	W	W	W
Bredfeldt et al. [54]	W	W	M	S	W	M	M
Contratto et al. [36]	M	W	M	W	S	S	M
Dastagir et al. [37]	M	M	W	W	W	W	W
Dennehy et al. [62]	M	W	n/a	W	S	W	W
DiAngi et al. [38]	M	S	M	S	M	W	M
Eskeland et al. [55]	S	M	M	S	S	W	M
Gardner et al. [39]	M	W	W	S	S	n/a	M
Gifford et al. [40]	M	W	M	W	W	W	M
Hosseini et al. [41]	M	W	M	W	S	S	M
Jalota et al. [56]	S	M	M	M	M	S	M
Kadish et al. [42]	M	W	W	W	W	W	W
Kim et al. [43]	M	M	M	S	M	S	M
Lee et al. [52]	M	W	M	W	M	n/a	M
Levac et al. [44]	M	W	M	W	S	W	M
Lopez et al. [45]	M	W	M	W	W	W	W
Mastellos et al. [59]	S	W	S	S	M	S	S
Patel et al. [57]	S	W	M	S	S	S	S
Reis et al. [58]	S	W	M	S	S	M	M
Robinson et al. [46]	M	M	M	W	W	W	M
Shachak et al. [47]	M	W	M	W	S	S	M
Sieja et al. [48]	M	W	M	W	W	M	M
Stacey et al. [51]	M	M	M	W	S	S	M
van Stiphout et al. [60]	S	M	S	S	M	M	S
Vuk et al. [49]	M	S	M	W	S	S	M
Walsh et al. [50]	M	W	M	W	W	W	W
Mean	M	W	M	W	M	M	M

Note. Appraised with the Effective Public Health Practice Project [28] quality appraisal tool. Q1: The extent of bias; Q2: Selection bias; Q3: Detection and performance bias; Q4: Confounders; Q5: Threats to reliability and validity; Q6: Attrition bias. S: strong, M: moderate, and W: weak prevention of bias; n/a: not applicable due to the study design.

Appendix F

See Table F1

Table F1
Intervention effects on the components of healthcare professionals' eHealth competency.

Outcome	Indicators (*n*)	Participants, *n* (Interventions, *n*)	Follow-up, range	Effect	Certainty of the evidence (GRADE)
eHealth competency	Frequency of improved effects on combined indicators of psychological capability, physical and psychological capability, automatic motivation, and reflective motivation	7,359 (34)	1 day to 3 years	Twenty-four interventions indicated improved effects on healthcare professionals' eHealth competency, and 10 observed slightly improved effects. It is yet uncertain whether the current interventions improve all components of eHealth competency.	⨁◯◯◯ VERY LOW [a,b,c,d,e,f]
Psychological capability	eHealth knowledge (7), Achievement in learning objectives (1), Competency of knowledge, awareness, and understanding (1); Preparedness (1)	1,346 (12)	1 day to 5 months	Eleven interventions demonstrated that they probably improve healthcare professionals' psychological capability to perform with eHealth. One intervention showed that it probably makes little or no difference in the psychological capability.	⨁⨁⨁◯ MODERATE [a,b,f]
Physical and psychological capability	eHealth skills (5), Associated patient–provider communication skills (2), Associated patient-centered skills (2), Knowledge and skills (1), Knowledge to perform the skill (1), Time (8), Quality of output (3), Accuracy (2), Efficiency (2), Number of errors (2), Productivity (2), Workload (2), Effectiveness (1), Proficiency (1), Task load (1), Task management (1)	4,550 (25)	1 day to 3 years	Twenty-three interventions indicated that they probably improve healthcare professionals' physical and psychological capability to perform with eHealth. One intervention suggested that it probably improves slightly physical and psychological capability.	⨁⨁⨁◯ MODERATE [a,b,f]
Automatic motivation	eHealth satisfaction (3), Intention (2), Frustration (1), Reactions (1), Worriedness (1)	476 (8)	5 days to 6 months	Four interventions showed improved effects on automatic motivation toward eHealth. The other four interventions observed little or no difference in automatic motivation. It is thus uncertain whether an intervention improves automatic motivation toward eHealth.	⨁◯◯◯ VERY LOW [a,b,d,f]
Reflective motivation	eHealth attitude (9), Confidence (5), Perceived ease of use (3), Comfort (2), Self-efficacy (2), Perceived behavioral control (2), Effort (1), Perceptions of benefits (1), Preference (1)	976 (19)	1 day to 2 years	Eleven interventions demonstrated that they may improve reflective motivation toward eHealth. Three interventions observed that they may have little or no difference in reflective motivation. Five interventions showed that they may improve slightly reflective motivation with inconsistent effects: two showed that they may improve attitudes toward eHealth, whereas the other two suggested little or no difference in attitudes; one showed that it may improve perceived eHealth-related behavioral control while another suggested little or no difference in control; one indicated that it may improve confidence in using eHealth, but another suggested little or no difference in long-term confidence.	⨁⨁◯◯ LOW [a,b,e,f]

Note. The certainty of evidence is based on the GRADE Working Group [29] definitions: high-certainty: there is confidence that the true effect lies close to that of the estimate of the effect; moderate-certainty: there is moderately confidence in the effect estimate, i.e. the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different; low-certainty: the confidence in the effect estimate is limited, i.e. the true effect may be substantially different from the estimate of the effect; very-low-certainty: there is very little confidence in the effect estimate, i.e. the true effect is likely to be substantially different from the estimate of effect.

[a] A narrative synthesis was conducted where estimates are not precise, which downgraded the certainty by one point.

[b] The improved effect sizes were judged to be practically beneficial, which upgraded the certainty by one point.

[c] Inconsistent findings between improved effects and an observed little or no difference downgraded the certainty by one point.

[d] Evidence was inconclusive and rated as very inconsistent, which downgraded the certainty by two points.

[e] Inconsistent findings with some sub-indicators showing improved effects in one study while the difference was not observed in another study downgraded the quality by one point.

[f] Concerns of selection bias and confounders downgraded the certainty by one point.

Appendix G

See Fig. G1

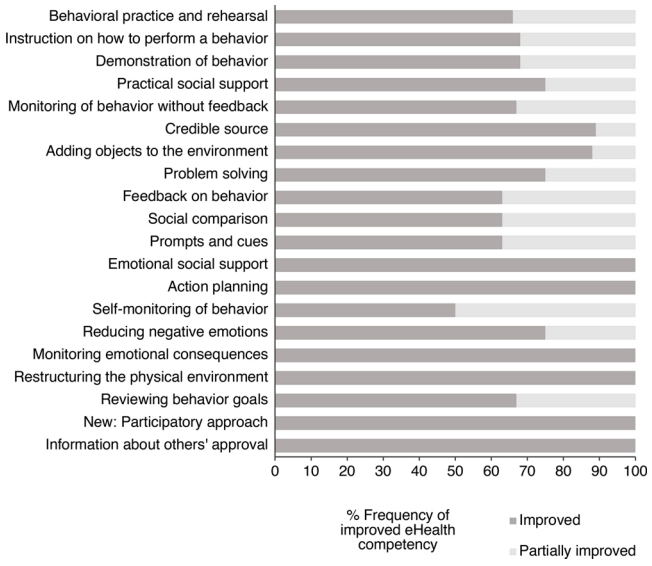


Fig. G1. The effect ratio of BCTs on healthcare professionals' eHealth competency. BCTs are presented in the frequency order with the most frequently identified BCTs of the interventions on the top. Only BCTs identified in two or more interventions are presented.

References

[1] Expert Panel on Effective Ways of Investing in Health. Assessing the impact of digital transformation of health services: Report of the Expert Panel on Effective Ways of Investing in Health [Internet]. Luxembourg: Publication Office of the European Union; 2019 [cited 2020 Jun 5]. Available from: https://ec.europa.eu/health/expert_panel/sites/expertpanel/files/docsdir/022_digitaltransfo rmation_en.pdf.

[2] A. Barakat, R.D. Woolrych, A. Sixsmith, W.D. Kearns, H.S. Kort, eHealth technology competencies for health professionals working in home care to support older adults to age in place: outcomes of a two-day collaborative workshop, Med 20 2 (2) (2013), e10, https://doi.org/10.2196/med20.2711 [Internet].

[3] J. Clark, B. Baker, D. Baker, Getting eHealth into basic nursing education: report of the RCN information in nursing project, in: K. Saranto, P.F. Brennan, H.-A. Park, M. Tallberg, A. Ensio (Eds.), Connecting Health and Humans, IOS Press, Amsterdam, 2009, pp. 534–539, https://doi.org/10.3233/978-1-60750-024-7-534 [Internet].

[4] U.-M. Kinnunen, T. Heponiemi, E. Rajalahti, O. Ahonen, T. Korhonen, H. Hyppönen, Factors related to health informatics competencies for nurses: results of a national survey, Comput. Inform. Nurs. 37 (8) (2019) 420–429, https://doi.org/10.1097/CIN.0000000000000511 [Internet].

[5] S. Michie, M.M. Van Stralen, R. West, The behaviour change wheel: a new method for characterising and designing behaviour change interventions, Implement. Sci. 6 (42) (2011), https://doi.org/10.1186/1748-5908-6-42 [Internet].

[6] J. Konttila, H. Siira, H. Kyngäs, M. Lahtinen, S. Elo, M. Kääriäinen, et al., Healthcare professionals' competence in digitalisation: a systematic review, J. Clin. Nurs. 28 (5–6) (2019) 745–761, https://doi.org/10.1111/jocn.14710 [Internet].

[7] L.A. Baumann, J. Baker, A.G. Elshaug, The impact of electronic health record systems on clinical documentation times: a systematic review, Health Policy 122 (8) (2018) 827–836, https://doi.org/10.1016/j.healthpol.2018.05.014 [Internet].

[8] J. Ross, F. Stevenson, R. Lau, E. Murray, Factors that influence the implementation of e-health: a systematic review of systematic reviews (an update), Implement. Sci. 11 (1) (2016) 146, https://doi.org/10.1186/s13012-016-0510-7 [Internet].

[9] Karhinen J, Taipale S, Tammelin M, Hämäläinen A, Hirvonen H, Oinas T. Vanhustyö ja teknologia. Jyväskylän yliopiston vanhustyön kyselytutkimus 2019: Katsaus tutkimusaineistoon [Elderly care and technology. A study on elderly care by University of Jyväskylä in 2019: A literature review; Internet]. Jyväskylä: University of Jyväskylä; 2019 [updated 2019 Sep 23; cited 2020 May 18]. Available from: https://jyx.jyu.fi/handle/123456789/65649.

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

[11] F. Magrabi, M.-S. Ong, W. Runciman, E. Coiera, Using FDA reports to inform a classification for health information technology safety problems, J. Am. Med. Inform. Assoc. 19 (1) (2012) 45–53, https://doi.org/10.1136/amiajnl-2011-000369 [Internet].

[12] N.R. Samaranayake, S.T. Cheung, W.C. Chui, B.M. Cheung, Technology-related medication errors in a tertiary hospital: a 5-year analysis of reported medication incidents, Int. J. Med. Inform. 81 (12) (2012) 828–833, https://doi.org/10.1016/j.ijmedinf.2012.09.002 [Internet].

[13] D. Lorenzetti, H. Quan, K. Lucyk, C. Cunningham, D. Hennessy, J. Jiang, et al., Strategies for improving physician documentation in the emergency department: a systematic review, BMC Emerg. Med. 18 (1) (2018) 36, https://doi.org/10.1186/s12873-018-0188-z [Internet].

[14] N. Wiebe, O. 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, J. Am. Med. Inform. Assoc. 26 (11) (2019) 1389–1400, https://doi.org/10.1093/jamia/ocz081 [Internet].

[15] C. Arditi, M. Rège-Walther, J.C. Wyatt, P. Durieux, B. Burnand, Computer-generated reminders delivered on paper to healthcare professionals; effects on professional practice and health care outcomes, Cochrane Database Syst. Rev. (2012) 7, https://doi.org/10.1002/14651858.CD001175.pub4 [Internet] CD001175-CD.

[16] R. Vuokko, P. Mäkelä-Bengs, H. Hyppönen, M. Lidqvist, P. Doupi, Impacts of structuring the electronic health record: results of a systematic literature review from the perspective of secondary use of patient data, Int. J. Med. Inform. 97 (2017) 293–303, https://doi.org/10.1016/j.ijmedinf.2016.10.004 [Internet].

[17] M.P. Gagnon, F. Légaré, M. Labrecque, P. Frémont, P. Pluye, J. Gagnon, et al., Interventions for promoting information and communication technologies adoption in healthcare professionals, Cochrane Database Syst. Rev. 1 (2009), CD006093, https://doi.org/10.1002/14651858.CD006093.pub2 [Internet].

[18] S. Michie, M. Richardons, M. Johnston, C. Abraham, J. Francis, W. Hardeman, et al., The Behaviour Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behaviour change interventions, Ann. Behav. Med. 46 (1) (2013) 81–95, https://doi.org/10.1007/s12160-013-9486-6 [Internet].

[19] S. Michie, M. Johnson, Behaviour change techniques, in: M.D. Gellman, J.R. Turner (Eds.), Encyclopaedia of Behavioral Medicine, Springer, New York, NY, 2013, pp. 182–187.

[20] C. Tufanaru, Z. Munn, E. Aromataris, J. Campbell, L. Hopp, Systematic reviews of effectiveness, in: E. Aromataris, Z. Munn (Eds.), JBI Manual for Evidence Synthesis, JBI, 2020, https://doi.org/10.46658/JBIMES-20-04 [Internet]. Chapter 3 [place unknown].

[21] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, PLoS Med. 6 (7) (2009), e1000097, https://doi.org/10.1371/journal.pmed1000097 [Internet].

[22] C. Heneghan, D. Badenoch, Evidence-Based Medicine Toolkit, BMJ Books, London, 2002.

[23] Clarivate Analytics. EndNote, X9 ed [computer program]. Philadelphia, PA: Clarivate Analytics; 2019 [cited 2020 Mar 18]. Available from: https://endnote.com/.

[24] M.L. McHugh, Interrater reliability: the kappa statistics, Biochem Medica 22 (3) (2012) 276–282, https://doi.org/10.11613/BM.2012.031 [Internet].

[25] B.H. Thomas, D. Ciliska, M. Dobbins, S. Micucci, A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions, Worldviews Evid. Nurs. 1 (3) (2004) 176–184, https://doi.org/10.1111/j.1524-475X.2004.04006.x [Internet].

[26] C. Tufanaru, Z. Munn, E. Aromataris, J. Campbell, L. Hopp, Critical appraisal, Chapter 3.2.7, in: E. Aromataris, Z. Munn (Eds.), JBI Manual for Evidence Synthesis, JBI, 2020, https://doi.org/10.46658/JBIMES-20-04 [Internet]. [place unknown].

[27] BCT Taxonomy. B.C.T. Taxonomy v1 online training [Internet]. [place unknown]: BCT Taxonomy; c2020 [cited 2020 May 16]. Available from: https://www.bct-taxonomy.B.C.T.com/.

[28] C.E. Wood, M. Richardson, M. Johnston, C. Abraham, J. Francis, W. Hardeman, S. Michie, Applying the Behaviour Change Technique (BCT) Taxonomy v1: a study of coder training, Transl. Behav. Med. 5 (2) (2015) 134–148, https://doi.org/10.1007/s13142-014-0290-z [Internet].

[29] C. Glenton, N. Santesso, S. Rosenbaum, E. Stromme Nilsen, T. Radar, A. Ciapponi, et al., Presenting the results of Cochrane systematic reviews to a consumer audience: a qualitative study, Med. Decis. Making 30 (5) (2010) 566–577, https://doi.org/10.1177/0272989X10375853 [Internet].

[30] Schünemann H, Brożek J, Guyatt G, Oxman A. GRADE Handbook: Handbook for grading the quality of evidence and the strength of recommendations using the GRADE approach [Internet]. [place unknown]: The GRADE Working Group; 2013 [updated 2013 Oct; cited 2020 Jun 5]. Available from: https://gdt.gradepro.org/app/handbook/handbook.html.

[31] 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, Int. J. Nurs. Knowl. 30 (2019) 219–227, https://doi.org/10.1111/2047-3095.12232 [Internet].

[32] P.M. Archambault, P. Beaupré, L. Bégin, A. Dupuis, M. Côté, F. Légaré, Impact of implementing a wiki to develop structured electronic order sets on physicians' intention to use wiki-based order sets, JMIR Med. Inform. 4 (2016) e18, https://doi.org/10.2196/medinform.4852 [Internet].

[33] P. Beaney, R. Hatfield, A. Hughes, M. Schmid, R. Chambers, Creating digitally ready nurses in general practice, J. Nurs. Manag. 26 (3) (2019) 27–35, https://doi.org/10.7748/nm.2019.e1840 [Internet].

[34] S.E. Benton, R.M. Hueckel, B. Taicher, V.C. Muckler, Usability assessment of an electronic handoff tool to facilitate and improve postoperative communication between anesthesia and intensive care unit staff, Comput. Inform. Nurs. (October) (2019), https://doi.org/10.1097/CIN.0000000000000563 [Internet].

[35] N. Benwell, K. Hird, N. Thomas, E. Furness, M. Fear, G. Sweetman, Effectiveness and efficiency of training in digital healthcare packages: training doctors to use digital medical record keeping software, Aust. Health Rev. 41 (5) (2017) 479–484, https://doi.org/10.1071/AH16090 [Internet].
[36] E. Contratto, K. Romp, C.A. Estrada, A. Agne, L.L. Willett, Physician order entry clerical support improves physician satisfaction and productivity, South. Med. J. 110 (5) (2017) 363–368, https://doi.org/10.14423/SMJ.0000000000000645 [Internet].
[37] M.T. Dastagir, H.L. Chin, M. McNamara, K. Poteraj, S. Battaglini, L. Alstot, Advanced proficiency EHR training: effect on physicians' EHR efficiency, EHR satisfaction and job satisfaction, AMIA Annu. Symp. Proc. (2012) 136–143 [Internet] [cited 2020 Mar 23];2012 Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3540432/.
[38] Y.T. DiAngi, L.A. Stevens, B. Halpern-Felsher, N.M. Pageler, T.C. Lee, Electronic health record (EHR) training program identifies a new tool to quantify the EHR time burden and improves providers' perceived control over their workload in the EHR, JAMIA Open 2 (2) (2019) 222–230, https://doi.org/10.1093/jamiaopen/ooz003 [Internet].
[39] C.L. Gardner, P.F. Pearce, Customization of electronic medical record templates to improve end-user satisfaction, Comput. Inform. Nurs. 31 (3) (2013) 115–121, https://doi.org/10.1097/NXN.0b013e3182771814 [Internet].
[40] V. Gifford, B. Niles, I. Rivkin, C. Koverola, J. Polaha, Continuing education training focused on the development of behavioral telehealth competencies in behavioral healthcare providers, Rural Remote Health 12 (4) (2012) 2108 [Internet] [cited 2020 Mar 23] Available from: https://www.rrh.org.au/journal/article/2108.
[41] M. Hosseini, A. Faiola, J. Jones, D.J. Vreeman, H. Wu, B.E. Dixon, Impact of document consolidation on healthcare providers' perceived workload and information reconciliation tasks: a mixed methods study, J. Am. Med. Inform. Assoc. 26 (2) (2019) 134–142, https://doi.org/10.1093/jamia/ocy158 [Internet].
[42] S.S. Kadish, E.L. Mayer, D.M. Jackman, M. Pomerantz, L. Brady, A. Dimitriadis, et al., Implementation to optimization: a tailored, data-driven approach to improve provider efficiency and confidence in use of the electronic medical record, J. Oncol. Pract. 14 (7) (2018), https://doi.org/10.1200/JOP.18.00093 [Internet] e421–e8.
[43] J.G. Kim, H.P. Rodriguez, K.A. Estlin, C.G. Morris, Impact of longitudinal electronic health record training for residents preparing for practice in patient-centered medical homes, Perm. J. 21 (2017) 16–122, https://doi.org/10.7812/TPP/16-122 [Internet].
[44] D. Levac, S.M.N. Glegg, H. Sveistrup, H. Colquhoun, P.A. Miller, H. Finestone, et al., A knowledge translation intervention to enhance clinical application of a virtual reality system in stroke rehabilitation, BMC Health Serv. Res. 16 (1) (2016) 557, https://doi.org/10.1186/s12913-016-1807-6 [Internet].
[45] C.A. Lopez, R.K. Omizo, J.M. Whealin, Impact of a tailored training on advanced electronic medical records use for providers in a Veterans Health Administration Medical System, JAMIA Open 1 (2) (2018) 142–146, https://doi.org/10.1093/jamiaopen/ooy031 [Internet].
[46] K.E. Robinson, J.A. Kersey, Novel electronic health record (EHR) education intervention in large healthcare organization improves quality, efficiency, time, and impact on burnout, Medicine (Baltimore) 97 (38) (2018), e12319, https://doi.org/10.1097/MD.0000000000012319 [Internet].
[47] A. Shachak, S. Domb, E. Borycki, N. Fong, A. Skyrme, A. Kushniruk, et al., A pilot study of computer-based simulation training for enhancing family medicine residents' competence in computerized settings, Stud. Health Technol. Inform. 216 (2015) 506–510 [Internet] [cited 2020 Mar 18] Available from: http://ebooks.iospress.nl/publication/40260.
[48] A. Sieja, K. Markley, J. Pell, C. Gonzalez, B. Redig, P. Kneeland, et al., Optimization sprints: improving clinician satisfaction and teamwork by rapidly reducing electronic health record burden, Mayo Clin. Proc. 94 (5) (2019) 793–802, https://doi.org/10.1016/j.mayocp.2018.08.036 [Internet].
[49] J. Vuk, M.E. Anders, C.C. Mercado, R.L. Kennedy, J. Casella, S.C. Steelman, Impact of simulation training on self-efficacy of outpatient health care providers to use electronic health records, Int. J. Med. Inform. 84 (6) (2015) 423–429, https://doi.org/10.1016/j.ijmedinf.2015.02.003 [Internet].
[50] K.E. Walsh, J.L. Secor, J.S. Matsumura, M.L. Schwarze, B.E. Potter, P. Newcomer, et al., Secure provider-to-provider communication with electronic health record messaging: an educational outreach study, J. Healthc. Qual. 40 (5) (2018) 283–291, https://doi.org/10.1097/JHQ.0000000000000115 [Internet].
[51] D. Stacey, M. Skrutkowski, M. Carley, E. Kolari, T. Shaw, B. Ballantyne, Training oncology nurses to use remote symptom support protocols: a retrospective pre-/post study, Oncol. Nurs. Forum 42 (2) (2015) 174–182, https://doi.org/10.1188/15.ONF.174-182 [Internet].
[52] W.W. Lee, M.L. Alkureishi, J.H. Isaacson, M. Mayer, R.M. Frankel, D.A. London, et al., Impact of a brief faculty training to improve patient-centered communication while using electronic health records, Patient Educ. Couns. 101 (12) (2018) 2156–2161, https://doi.org/10.1016/j.pec.2018.06.020 [Internet].
[53] A. Ahmed, S. Chandra, V. Herasevich, O. Gajic, B.W. Pickering, The effect of two different electronic health record user interfaces on intensive care provider task load, errors of cognition, and performance, J. Crit. Care Med. 39 (2011) 1626–1634, https://doi.org/10.1097/CCM.0b013e31821858a0 [Internet].
[54] C.E. Bredfeldt, E.B. Awad, K. Joseph, M.H. Snyder, Training providers: beyond the basics of electronic health records, BMC Health Serv. Res. 13 (503) (2013), https://doi.org/10.1186/1472-6963-13-503 [Internet].
[55] S.L. Eskeland, C. Brunborg, C.S. Rueegg, L. Aabakken, T. de Lange, Assessment of the effect of an Interactive Dynamic Referral Interface (IDRI) on the quality of referral letters from general practitioners to gastroenterologists: a randomised cross-over vignette trial, BMJ Open 7 (6) (2017), e014636, https://doi.org/10.1136/bmjopen-2016-014636 [Internet].
[56] L. Jalota, M.R. Aryal, M. Mahmood, T. Wasser, A. Donato, Interventions to increase physician efficiency and comfort with an electronic health record system, Methods Inf. Med. 54 (1) (2015) 103–109, https://doi.org/10.3414/ME14-01-0047 [Internet].
[57] M.R. Patel, A. Smith, H. Leo, W. Hao, K. Zheng, Improving patient-provider communication and therapeutic practice through better integration of electronic health records in the exam room: a pilot study, Health Educ. Behav. 46 (3) (2019) 484–493, https://doi.org/10.1177/1090198118796879 [Internet].
[58] S. Reis, D. Sagi, O. Eisenberg, Y. Kuchnir, J. Azuri, V. Shalev, et al., The impact of residents' training in Electronic Medical Record (EMR) use on their competence: report of a pragmatic trial, Patient Educ. Couns. 93 (3) (2013) 515–521, https://doi.org/10.1016/j.pec.2013.08.007 [Internet].
[59] N. Mastellos, T. Tran, K. Dharmayat, E. Cecil, H.-Y. Lee, C.C.P. Wong, et al., 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 Med. Educ. 18 (1) (2018) 61, https://doi.org/10.1186/s12909-018-1175-5 [Internet].
[60] F. van Stiphout, J.E.F. Zwart-van Rijkom, J. Versmissen, H. Koffijberg, J.E.C. M. Aarts, I.H. van der Sijs, et al., Effects of training physicians in electronic prescribing in the outpatient setting on clinical, learning and behavioural outcomes: a cluster randomized trial, Br. J. Clin. Pharmacol. 84 (6) (2018) 1187–1197, https://doi.org/10.1111/bcp.13540 [Internet].
[61] C.M. Armstrong, R.P. Ciulla, A. Edwards-Stewart, T. Hoyt, N. Bush, Best practices of mobile health in clinical care: the development and evaluation of a competency-based provider training program, Prof. Psychol. Res. Pr. 49 (5/6) (2018) 355–363, https://doi.org/10.1037/pro0000194 [Internet].
[62] P. Dennehy, M.P. White, A. Hamilton, J.M. Pohl, C. Tanner, T.J. Onifade, et al., A partnership model for implementing electronic health records in resource-limited primary care settings: experiences from two nurse-managed health centers, JAMIA Open 18 (6) (2011) 820–826, https://doi.org/10.1136/amiajnl-2011-000117 [Internet].
[63] R.S. Evans, Electronic health records: then, now, and in the future, Yearb. Med. Inform. (Suppl 1) (2016) S48–61, https://doi.org/10.15265/IYS-2016-s006 [Internet].
[64] J. Adler-Milstein, A.K. Jha, HITECH Act drove large gains in hospital electronic health record adoption, Health Aff. (Millwood) 36 (8) (2017) 1416–1422, https://doi.org/10.1377/hlthaff.2016.1651 [Internet].
[65] C. Rathert, T.H. Porter, J.N. Mittler, M. Fleig-Palmer, Seven years after Meaningful Use: physicians' and nurses' experiences with electronic health records, Health Care Manage. Rev. 44 (1) (2019) 30–40, https://doi.org/10.1097/HMR.0000000000000168 [Internet].
[66] L.C. Roman, J.S. Ancker, S.B. Johnson, Y. Senathirajah, Navigation in the electronic health record: a review of the safety and usability literature, J. Biomed. Inform. 67 (2017) 69–79, https://doi.org/10.1016/j.jbi.2017.01.005 [Internet].
[67] J. Presseau, N.M. Ivers, J.J. Newham, K. Knittle, K.J. Danko, J.M. Grismshaw, Using a behaviour change techniques taxonomy to identify active ingredients within trials of implementation interventions for diabetes care, Implement. Sci. 10 (55) (2015), https://doi.org/10.1186/s13012-015-0248-7 [Internet].
[68] E.L. Deci, R.M. Ryan, Intrinsic Motivation and Self-Determination in Human Behavior, Plenum, New York, NY, 1985.
[69] J. Tranquillo, M. Stecker, Using intrinsic and extrinsic motivation in continuing professional education, Surg. Neurol. Int. 7 (Suppl 7) (2016) S197–199, https://doi.org/10.4103/2152-7806.179231.
[70] F.D. Davis, Perceived usefulness, perceived ease of use, and user acceptance of information technology, MIS Q. 13 (3) (1989) 319–339, https://doi.org/10.2307/249008 [Internet].
[71] H. Hao, R. Padman, An empirical study of opinion leader effects on mobile technology implementation by physicians in an American community health system, Health Informatics J. 24 (2018) 323–333, https://doi.org/10.1177/1460458216675499 [Internet].
[72] C. Carpenter, J. Sherbino, How does an opinion leader impact my practice? CJEM 12 (5) (2010) 431–434, https://doi.org/10.1017/s1481803500012586 [Internet].
[73] R.S. Weiss, The provisions of social relationships., in: Z. Rubin (Ed.), Doing Unto Others, Prentice Hall, Englewood Cliffs, NJ, 1983, pp. 17–26.
[74] N. Ivers, G. Jamtvedt, S. Flottorp, J.M. Young, J. Odgaard-Jensen, S.D. French, M. A. O'Brien, M. Johansen, J. Grimshaw, A.D. Oxman, Audit and feedback: effects on professional practice and healthcare outcomes, Cochrane Database Syst. Rev. 13 (6) (2012), CD000259, https://doi.org/10.1002/14651858.CD000259.pub3 [Internet].
[75] W.B. Schaufeli, D. Enzmann, The Burnout Companion to Study and Practice: a Critical Analysis, Taylor & Francis, London, UK, 1998.
[76] J. Nielsen, Heuristic evaluation, in: J. Nielsen, R.L. Mack (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, NY, 1994, pp. 25–62.
[77] Nielsen J. Usability 101: Introduction to usability [Internet]. [place unknown]: Nielsen Norman Group; 2012 [updated 2012 Jan 3; cited 2020 Jun 10]. Available from: https://www.nngroup.com/articles/usability-101-introduction-to-usability/.
[78] T. Heponiemi, H. Hyppönen, T. Vehko, S. Kujala, A.-M. Aalto, J. Vänskä, Finnish physicians' stress related to information systems keeps increasing: A longitudinal three-wave survey study, BMC Med. Inform. Decis. Mak. 17 (147) (2017) 1472–6947, https://doi.org/10.1186/s12911-017-0545-y [Internet].
[79] H. Kuusio, T. Heponiemi, A.-M. Aalto, T. Sinervo, M. Elovainio, Differences in well-being between GPs, medical specialists, and private physicians: the role of

psychosocial factors, BMC Health Serv. Res. 47 (1) (2012) 68–85, https://doi.org/10.1111/j.1475-6773.2011.01313.x [Internet].
[80] T. Heponiemi, S. Kujala, S. Vainiomäki, T. Vehko, T. Lääveri, J. Vänskä, et al., Usability factors associated with physicians' stress related to information systems and distress: a cross-sectional survey study, JMIR Med. Inform. 7 (4) (2019), e13466, https://doi.org/10.2196/13466 [Internet].
[81] R. Koppel, J.P. Metlay, A. Cohen, B. Abaluck, A.R. Localio, S.E. Kimmel, et al., Role of computerized physician order entry systems in facilitating medication errors, JAMA Netw Open 293 (10) (2005) 1197–1203, https://doi.org/10.1001/jama.293.10.1197 [Internet].
[82] J. Øvretveit, T. Scott, T.G. Rundall, S.M. Shortell, M. Brommels, Improving quality through effective implementation of information technology in healthcare, Int. J. Qual. Health Care 19 (5) (2007) 259–266, https://doi.org/10.1093/intqhc/mzm031 [Internet].
[83] Buchan J, Perfilieva G. Making progress towards health workforce sustainability in the WHO European Region [Internet]. Copenhagen: WHO Regional Office for Europe; 2015 [cited 2020 Jun 10]. Available from: https://www.euro.who.int/_data/assets/pdf_file/0005/287456/Making-progress-towards- health-workforce-sustainability-in-the-WHO-European-Region-rev1.pdf?ua=1.
[84] L. Van Rhoon, M. Byrne, E. Morrissey, J. Murphy, J. McSharry, A systematic review of the behaviour change techniques and digital features in technology-driven type 2 diabetes prevention interventions, Digit. Health 6 (2020) 1–27, https://doi.org/10.1177/2055207620914427 [Internet].
[85] K.A. Cradock, G. ÓLaighin, F.M. Finucane, H.L. Gainforth, L.R. Quinland, K. A. Martin Ginis, Behaviour change techniques targeting both diet and physical activity in type 2 diabetes: a systematic review and meta-analysis, Int. J. Behav. Nutr. Phys. Act. 14 (1) (2017) 18, https://doi.org/10.1186/s12966-016-0436-0 [Internet].
[86] E. Aromataris, D. Riitano, Systematic reviews: constructing a search strategy and searching for evidence, Am. J. Nurs. 114 (5) (2014) 49–56, https://doi.org/10.1097/01.NAJ.0000446779.99522.f6 [Internet].
[87] J. Duarte, A. Guerra, User-centred healthcare design, Procedia Comput. Sci. 14 (2012) 189–197, https://doi.org/10.1016/j.procs.2012.10.022 [Internet].
[88] S. Kujala, Effective user involvement in product development by improving the analysis of user needs, Behav Inform Technol 27 (6) (2008) 457–473, https://doi.org/10.1080/01449290601111051 [Internet].
[89] L. Lorenzoni, A. Marino, D. Morgan, C. James, Health Spending Projections to 2030: New Results Based on a Revised OECD Methodology. OECD Health Working Papers, No. 110 [Internet], OECD Publishing, Paris, 2019, https://doi.org/10.1787/5667f23d-en.
[90] C.S. Collins, S. Nanda, B.A. Palmer, A.B. Mohabbat, C.D. Schleck, J.N. Mandrekar, S. Mahapatra, T.J. Beckman, C.M. Wittich, A cross-sectional study of learning styles among continuing medical education participants, Med. Teach. 41 (3) (2019) 318–324, https://doi.org/10.1080/0142159X.2018.1464134 [Internet].