Review article

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

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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
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 BCTTv1 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) Participants were healthcare professionals licensed to be credential providing healthcare, employed in a healthcare organization; 2) Interventions aimed to promote eHealth competency; 3) Comparators were any control group, including standard practice or no intervention, or prospective or retrospective baseline measures; 4) Outcome 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) Type 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
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.

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 3544 duplicates, 4322 titles and abstracts were screened potentially relevant studies were identified in the database search. After

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 [32,35–39,41–43,48–50,52–58,60,61], 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, 62].

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].

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 BCTV1 [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, 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,
such as guidelines [33,44,46,48,58,61], 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].

### 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.

### 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 [34,59]                   | 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 [37,48,49,50,61] | 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,c                       |
| Restructuring the physical environment   | Redesigning the user interface [53]                                                       | 247 (2)                          | May improve                | ⨁⨁ LOW a,b,c                       |
|                                          | Repairing errors in the current user interface [48]                                       |                                  |                             |                                   |
|                                          | Delegating some work tasks for support personnel [36]                                    |                                  |                             |                                   |
| Information about others’ approval      | Presenting data from other similar sites that demonstrate their eHealth adoption [52]     | 99 (2)                           | May improve                | ⨁⨁ LOW a,b,c                       |
|                                          | Emphasizing that eHealth is widely used elsewhere in the country [51]                     |                                  |                             |                                   |
| Adding objects to the environment        | Purchasing new eHealth equipment [33,48]                                                   | 338 (8)                          | Probably improves slightly | ⨁⨁⨁ MODERATE a,b,d                  |
|                                          | Installing standardized templates into the user interface [31,29,48,55]                    |                                  |                             |                                   |
|                                          | Installing guidelines into the user interface [34,51,55]                                   |                                  |                             |                                   |
|                                          | Increasing financial resources for learning overtime hours [33]                           |                                  |                             |                                   |
|                                          | Hiring a clerical support person [36]                                                      |                                  |                             |                                   |
| Credible source                          | eHealth experts, super-users, and champions encouraging for change [37,45,46,48,49,51,61] | 4,599 (9)                        | May improve                | ⨁⨁ 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 the effect.

- A narrative synthesis was conducted where estimates are not precise.
- The improved effect sizes were judged to be practically beneficial.
- Concerns about selection bias and confounders.
- Concerns about the extent of bias.
- Concerns about selection bias, confounders, and attrition bias.
- 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 tend to be 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.

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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].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 invisible training[mh] OR medical informatics/education OR motivation[mh] OR motivational interviewing[mh] OR organizational innovation[mh] OR personnel management[mh] OR practice guideline as topic[mh] OR program development[mh] OR staff development[mh]) |                          | 575,923 |
| 5                | (interview [all fields] OR implement*[ti] OR improve*[ti] OR facilitat*[ti] OR encourage*[ti] OR behaviour change[ti] OR behavior change[ti] OR change[ti] OR changing[ti] OR organizational change[ti] OR policy[ti] OR policies[ti] OR practice*[ti] OR procedure*[ti] OR professional development[ti] OR program*[ti] OR strategy*[ti] OR technique*[ti] OR tool*[ti] OR meaningful use[ti] OR quality improvement[ti]) |                          | 2,681,704 |
| 6                | (continuing education[ti] OR educate*[ti] OR teach*[ti] OR coach*[ti] OR guide*[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                | (enable*[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 optimising[ti] OR optimising[ti] OR resources[ti]) |                          | 331,776 |
| 9                | (coercion[ti] OR coercive[ti] OR fine*[ti] OR fining[ti]) |                          | 38,785 |
| 10               | (restructure[ti] OR develop*[ti] OR update*[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 team[ti] OR workshop*[ti] OR benchmark*[ti] OR social support*[ti] OR reinforce*[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[mi] OR telemedicine[mh] OR user computer interface[mh]) |                          | 100,074 |
| 16               | (app[ti] OR e-health[mi] OR eHealth[mi] OR eHealth[ti] OR eHealth*[ti] OR eHealth*[mi] OR eHealth*[ti] OR electronic health record*[ti] OR electronic patient record*[ti] OR e-prescribing[ti] OR health information technology*[ti] OR information technology*[ti] OR information and communication technology*[ti] OR ICT[ti] OR m-health[ti] OR mobile[ti] OR mobile*[ti] OR online[ti] OR remote[ti] OR technology*[ti] OR telehealth[ti] OR telemedicine[ti] OR user interface*[ti] OR interface*[ti] OR computer*[ti] OR computerized[ti] OR computerized*[ti] OR digital[ti] OR digital health competence*[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*[ti] OR accept*[ti] OR attitude*[ti] OR behaviour OR behavior OR belief OR believe*[ti] OR capabilit*[ti] OR comfort*[ti] OR competenc*[ti] OR confidence OR consider*[ti] OR experience*[ti] OR engag*[ti] OR knowledge OR learn*[ti] OR motivat*[ti] OR motivation OR opportunity*[ti] OR perception OR perceive*[ti] OR performanc*[ti] OR satisf*[ti] OR self efficacy OR teamwork OR recall OR recogni*[ti] OR resist*[ti] OR skill*[ti] 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[ti] OR mixed-method[ti] OR cohort OR implementation study OR effectiveness[ti] OR efficacy[ti] OR evidence-based[ti] OR evaluation study OR evaluat*[ti] OR random* OR randomiz*[ti] OR randomly OR trial OR multicenter OR multi center OR multicentre OR multi centre OR controlled OR control group[ti] OR groups OR RCT OR CCT OR (pretest OR pre test) AND (posttest OR post test) OR quasi experiment[ti] 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 |

(continued on next page)
### Table B2 (continued)

| Database: EBSCO | Date: 26/02/2020 | Search term(s) | Number of hits |
|-----------------|------------------|----------------|----------------|
| #5              | intervent* OR 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 strategy 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 prac*).ti. | 508,632 |
| #8              | (enabl* OR motivational change or motivational interviewing or motivat* OR involve* 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             | (restruct* 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 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 reinforce*).ti. | 900,029 |
| #14             | (#4 OR #5 OR 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 patient record* OR e-prescribing or health information technology* 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 abliti* 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 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 random* OR random* 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. | 13,655,059 |
| #24             | (#22 OR #23) | 3,252,055 |
| #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 | Date: 26/02/2020 | Search term(s) | Number of hits |
|------------------|------------------|----------------|----------------|
| #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*).ti. | 383,141 |
| #2               | MI ('staff development' OR 'education, continuing c.' OR 'education, competency-based' OR 'refresher courses' OR teaching OR 'practice guidelines' OR motivation OR 'motivational interviewing' OR 'program development' OR 'personnel management').ti. | 197,876 |
| #3               | intervent* 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 strategy OR technique* OR tool* OR 'meaningful use' OR 'quality improvement').ti. | 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*).ti. | 330,765 |
| #5               | TI (training OR workshop* OR interactive OR interacting OR discuss* OR prac*).ti. | 241,222 |
| #6               | TI (enabl* OR 'motivational change' OR 'motivational interviewing' OR motivat* OR involve* OR participat* OR optimiz* OR optimisation OR optimise OR optimizing OR resources).ti. | 79,891 |
| #7               | TI (coercion OR coercive OR fine* OR fining).ti. | 5,182 |
| #8               | TI (restruct* OR develop* OR develop or development OR update OR updating).ti. | 160,658 |
| #9               | TI (incentive OR incentivisation OR incentivization OR reward*).ti. | 5,034 |
| #10              | TI (modelling OR modeling OR demonstrat* OR opinion leader* OR social network* OR example*).ti. | 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 reinforce*).ti. | 331,654 |
| #12              | (S2 OR S3-11).ti. | 1,759,748 |
| #13              | MI ('computer literacy' OR 'information technology' OR 'electronic health records' OR telemedicine OR 'user-computer interface').ti. | 53,217 |
| #14              | TI (app OR e-health OR health OR electronic OR eHR OR electronic health record* OR electronic patient record* OR e-prescribing OR health information technology* 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. | 112,138 |
| #15              | (S13 OR S14).ti. | 147,045 |
| #16              | S12 AND S15.ti. | 59,561 |
| #17              | MI ('attitude of health personnel' OR 'clinical competence' OR 'computer literacy' OR 'professional knowledge' OR 'attitude to computers' OR 'job satisfaction' OR 'professional competence').ti. | 117,478 |

(continued on next page)
### Table B3 (continued)

| Search term(s) | Number of hits |
|----------------|----------------|
| 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 experience OR engage* OR experience OR knowledge OR learn* OR motivat* OR opinion OR opportunit* OR perception OR perceive* OR performanc* OR sati* OR self-efficacy OR teamwork OR recall OR recogni* OR restrict* OR skill* OR uptake OR burnout OR stress OR willingness) | 2,371,535 |
| 19 (S17 OR S18) | 2,371,535 |
| 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 “pre test” OR “post 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) | 2,099,667 |
| 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, Junnttila K, Liljamo P, Arifulla D, et al. The development process of eHealth strategy for nurses in Finland. Stud Health Technol Inform [Internet]. 2016;225:993.

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

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, Oberpaar 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.

Sonderegard 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.ijmedinfo.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/NXX.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:10.1177/13576633 × 16670479.

Yuan CT, Bradley EH, Nemhaim M. 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, Lh V, 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:10.1177/1062860612454307.

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.2012-1427.

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
Intervention not targeting competency (n = 9)

Andersen 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 Nurs [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/aimajnl-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.pedin.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, Memra 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.walden.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)

Barone 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:10.1177/1745715117742132

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.0b013e3181fa04e8

Gray DC, Rutledge CM. Using new communication technologies: An educational strategy fostering collaboration and telehealth skills in nurse practitioners. J Nurs 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 Skim 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.co m/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/j.1132334

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.ioypress.nl/publication/49105

Stallans 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 telehealth training on mental health practitioner’s knowledge, attitudes, beliefs, and intent to offer tele-mental 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/HTS-174149

**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:10.1016/j.anesth.2019.02.011

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/jnsm.12774

Kulkarni D, Heath J, Kosack A, Jackson NJ, Crumney 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, Taneya 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 K. 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 documentation skills. Comput Inform Nurs [Internet]. 2016;34:254–8. doi:10.1097/CIN.0000000000000238

Quan AML, Steili 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. JMRM Health 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-2011-00333

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/jjun.201405

Pantaleoni JL, Stevens LA, Mailes ES, Godd 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

No-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

Hapel RI, 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.2018-0153-0A

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. JMRM Form Res [Internet]. 2018;2:e10474. doi:1016/1974

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_SelfAssessment_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

Fortmiller 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.0b013e318191dcd8b

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, Odonne 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 |
|----------------|--------|---------|--------------|-----------------|------------|---------|
| Adereti et al. [31], Pre-2019 | | | | | | |
| Ahmed et al. [53], ITS 2011 | | | | | | |
| Archambault et al. [52], 2016 | | | | | | |
| Armstrong et al. [61], 2018 | | | | | | |
| Beanea et al. [33], Pre-2019 | | | | | | |
| Benton et al. [34], CCT 2019 | | | | | | |
| Benwell et al. [55], 2017 | | | | | | |
| Bredfeldt et al. Pre-2013 | | | | | | |
| Contratto et al. ITS 2017 | | | | | | |
| Dastagir et al. Pre-2017 | | | | | | |
| Dennehy et al. [62], 2011 | | | | | | |
| DiAngi et al. [38], Pre-2019 | | | | | | |
| Eskeland et al. [55], 2017 | | | | | | |
| Gardner et al. Pre-2013 | | | | | | |
| Gifford et al. [40], 2012 | | | | | | |
| Hossini et al. [41], 2019 | | | | | | |
| Jalota et al. [55], 2015 | | | | | | |
| Kadish et al. [42], 2018 | | | | | | |
| Kim et al. [43], 2017 | | | | | | |
| Lee et al. [52], 2018 | | | | | | |
| RCT Canada Tertiary care | | | | | | |

(continued on next page)
Table D1 (continued)

| Author(s), year | Method | Setting | Participants | Intervention(s) | Comparator | Effects,* |
|-----------------|--------|---------|--------------|-----------------|------------|----------|
| Levac et al. [44], 2016 | CCT | The United States | Occupational Therapists, Physical Therapists | EHRs | Training ICT Personnel | 2–4 h | Baseline | Knowledge and skills*, Perceived behavioral control*, Intention, Self-efficacy, Attitude, Perceived ease of use |
| Lopez et al. [45], 2016 | CCT | The United States | Community Healthcare Workers | EHRs | SLT | Persuasive | Researchers | 31 h over 3 weeks | Traditional intervention | Knowledge*, Comfort*, Confidence* |
| Mastellos et al. [59], 2018 | Pre-post | Malawi | Physicians | EHRs | SLT | Training | Physician | 1.5 h | No intervention | Attitude*, Knowledge |
| Patel et al. [57], 2019 | Pre-post | Israel | Physicians | EHRs | Non explicit | Training | Physicians | 3 days over 9 weeks | Traditional intervention | Quality of output*, Accuracy*, Number of errors*, Efficiency*, Time* |
| Reis et al. [58], 2013 | Pre-post | Canada | Physicians | EHRs | Non explicit | Training | Physicians | 3 days | Baseline | |
| Robinson et al. [46], 2018 | RPP | Canada | Physicians | EHRs | TAM | Persuasive | Researchers | 2 h | Baseline | Knowledge*, Skills*, Attitude |
| Sieja et al. [48], 2019 | RCT | The United States | Physicians, Midwives, Nurses | EHRs | Non explicit | Training | ICT Personnel, Project Manager, Experts Nurses | 7 h over 5–20 days | Baseline | Time*, Satisfaction*, Emotional exhaustion of burnout* |
| Stacey et al. [51], 2015 | Pre-post | Canada | Nurses | Tele-health | KTA | Enabling | Experts Nurses | 30–60 min | Retrospective baseline | Achievement in learning objectives*, Confidence* |
| van Stiphout et al. [60], 2018 | Pre-post | The Netherlands | 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 | Nurses, Physicians | EHRs | Non explicit | Training | Experts | 10 h | Baseline | Preparedness*, Confidence*, Perceptions of benefits |
| Walsh et al. [50], 2018 | ITS | The United States | 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 |
| Aderet et al. [31]      | M    | M    | W    | W    | W    | n/a  | M    |
| Ahmed et al. [53]       | S    | W    | W    | W    | W    | S    | n/a  |
| Archambault et al. [32] | M    | M    | W    | W    | S    | S    | M    |
| Armstrong et al. [61]   | M    | W    | W    | W    | W    | S    | W    |
| Beaney et al. [33]      | M    | W    | W    | W    | W    | S    | M    |
| Bentzon et al. [34]     | M    | W    | M    | W    | W    | W    | M    |
| Benwell et al. [55]     | M    | W    | M    | M    | W    | W    | M    |
| 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    |
| Dennyby et al. [62]     | M    | W    | n/a  | W    | S    | W    | W    |
| DiAngi et al. [38]      | M    | S    | M    | S    | M    | W    | M    |
| Ekeland 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    |
| Kadih 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    |
| Mastelos et al. [59]    | S    | W    | S    | S    | S    | M    | 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    | W    | 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    | M    |
| 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

| 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,c,d,e,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,c,d,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 narrative synthesis was conducted where estimates are not precise, which downgraded the certainty by one point.
- The improved effect sizes were judged to be practically beneficial, which upgraded the certainty by one point.
- Inconsistent findings between improved effects and an observed little or no difference downgraded the certainty by one point.
- Evidence was inconclusive and rated as very inconsistent, which downgraded the certainty by two points.
- 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.
- Concerns of selection bias and confounders downgraded the certainty by one point.
Appendix G

See Fig. G1

| BCT Category | Percentage of Improved eHealth Competency |
|--------------|------------------------------------------|
| **Behavioral practice and rehearsal** | ![Graph](https://example.com/graph) |
| **Instruction on how to perform a behavior** | ![Graph](https://example.com/graph) |
| **Demonstration of behavior** | ![Graph](https://example.com/graph) |
| **Practical social support** | ![Graph](https://example.com/graph) |
| **Monitoring of behavior without feedback** | ![Graph](https://example.com/graph) |
| **Adding objects to the environment** | ![Graph](https://example.com/graph) |
| **Problem solving** | ![Graph](https://example.com/graph) |
| **Feedback on behavior** | ![Graph](https://example.com/graph) |
| **Social comparison** | ![Graph](https://example.com/graph) |
| **Prompts and cues** | ![Graph](https://example.com/graph) |
| **Emotional social support** | ![Graph](https://example.com/graph) |
| **Action planning** | ![Graph](https://example.com/graph) |
| **Self-monitoring of behavior** | ![Graph](https://example.com/graph) |
| **Reducing negative emotions** | ![Graph](https://example.com/graph) |
| **Monitoring emotional consequences** | ![Graph](https://example.com/graph) |
| **Restructuring the physical environment** | ![Graph](https://example.com/graph) |
| **Reviewing behavior goals** | ![Graph](https://example.com/graph) |
| **New: Participatory approach** | ![Graph](https://example.com/graph) |

Fig. G1. The effect ratio of BCTs on healthcare professionals’ eHealth competence. 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/002/digitaltransformation_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) (2015), 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 BCh 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] M. Kinnunen, T. Heponiemi, E. Rajalahj, O. Ahonen, T. Korhonen, H. Hypponen, Factors related to health information competencies for nurses: results of a national survey, Comput. Inform. Nurs. 37 (8) (2019) 420-429. https://doi.org/10.1097/CNI.0000000000000511 [Internet].

[5] S. Michie, M.M. Van Stralen, R. West, The behavior change wheel: a new method for characterising and designing behaviour change interventions, J. Clin. Nurs. 24 (5-6) (2015) 745-761. https://doi.org/10.1111/j.1365-2702.2010.03417.x [Internet].

[6] 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].

[7] 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. 13 (2018) 827, https://doi.org/10.1186/s13012-018-0833-y [Internet].

[8] N. Wiebe, O. Varela, D.J. Niven, P.E. Ronksley, N. Irigarori, H. Quan, Evaluation of interventions to improve inpatient hospital documentation within electronic health records: a systematic review, J. Med. Inform. Assoc. 26 (11) (2019) 1389-1400, https://doi.org/10.1093/jamia/ocz081 [Internet].

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

[10] L. Virtanen et al., Factors related to health informatics competencies for nurses: results of a national survey, Comput. Inform. Nurs. 28 (5) (2010), https://doi.org/10.1016/j.hin.2010.05.014 [Internet].

[11] S. Michie, M. Johnston, Behaviour change techniques (BCTs): an overview of a taxonomy, Implement. Sci. 5 (2010) 134, https://doi.org/10.1186/1748-5908-6-134 [Internet].

[12] R. Vasjoki, M. Mäkelä, N. Kirkkola, Effects of eHealth technology on nurses, J. Med. Inform. Assoc. 19 (1) (2012) 45-53. https://doi.org/10.1136/amiajnl-2011-000569 [Internet].
psychosocial factors, BMC Health Serv. Res. 47 (1) (2012) 68–85, https://doi.org/10.1186/1475-926X-47-68 [Internet].

[80] T. Heponiemi, S. Kujala, S. Vainiomäki, T. Vehko, T. Laäveri, J. Vänska, 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] 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].

[82] 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].

[83] 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].

[84] 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].

[85] 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].

[86] 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/10.1080/0149296060111051 [Internet].