

# E-learning of evidence-based health care (EBHC) to increase EBHC competencies in healthcare professionals: a systematic review

Anke Rohwer, Nkengafac Villyen Motaze, Eva Rehfuss, and Taryn Young

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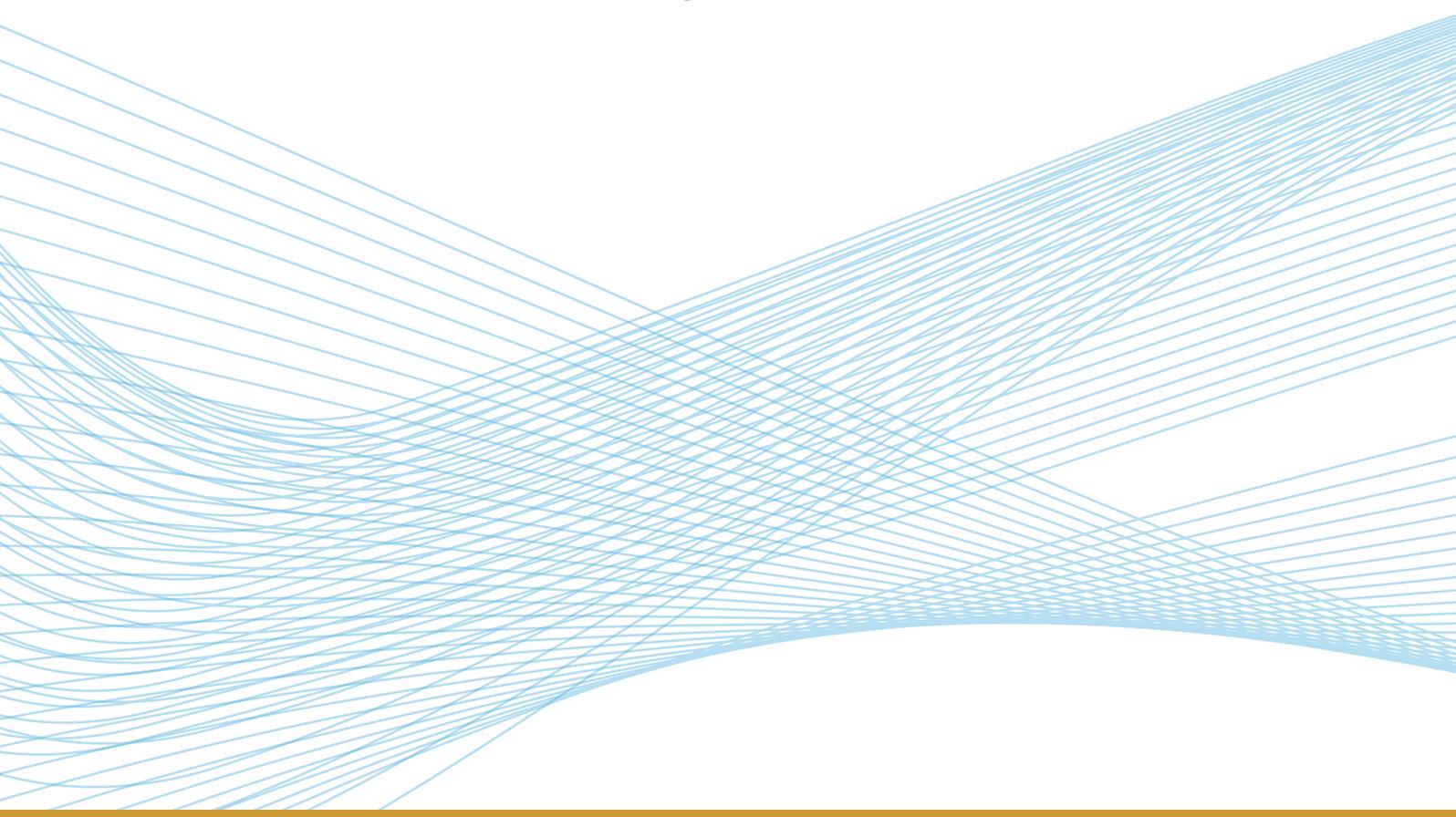
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**Roles and responsibilities** AR, TY and ER conceptualized the question for the review. AR did the searches. AR, NVM, ER and TY were involved in selection of studies, data extraction and risk of bias assessment. AR did the analyses with input from TY, NVM and ER. AR drafted the manuscript. NVM, ER and TY critically engaged with the manuscript and provided input. All authors approved the final manuscript before submission.

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EAR and NVM: none known.

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# Plain language summary

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## **Blended learning is most effective in increasing evidence-based health care competencies of health workers**

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E-learning is a useful strategy to increase EBHC knowledge and skills, and when combined with face-to-face learning, to increase EBHC attitude and behaviour.

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### **The review in brief**

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Evidence-based health care (EBHC) is decision-making for health care, informed by the best research evidence. Doctors, nurses and allied health professionals need to have the necessary knowledge and skills to apply EBHC. The use of electronic learning (e-learning) for EBHC training is increasing.

E-learning, compared to no learning, improves EBHC knowledge and skills but not attitudes and behaviour. There is no difference in outcomes when comparing e-learning to face-to-face learning. Combining e-learning with face-to-face learning (blended learning) has a positive impact on EBHC knowledge, skills, attitude and behaviour.

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### **What did the review study?**

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Evidence-based health care (EBHC) involves phrasing questions based on a knowledge gap, searching for research that can answer the question, critically appraising and interpreting the research, applying the results and auditing the process. Electronic learning (e-learning) has become an increasingly popular method of teaching EBHC.

This review assesses the effectiveness of e-learning of EBHC for increasing EBHC competencies in healthcare professionals. The primary outcomes are EBHC knowledge, skills, attitude and behaviour.

#### **What is the aim of this review?**

This Campbell systematic review examines the effectiveness of e-learning in improving evidence-based health care knowledge and practice.

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## **What studies were included?**

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Eligible studies were randomised controlled trials (RCTs), cluster RCTs, non-RCTs, controlled before-after studies and interrupted time series of any healthcare professional evaluating any educational intervention on EBHC, and that was delivered fully (pure e-learning) or in part (blended learning) via an electronic platform compared to no learning, face-to-face learning or other forms of e-learning of EBHC.

The review included 24 trials, comprising 20 RCTs and four non-RCTs, with a total of 3,825 participants. Participants were medical doctors, nurses, physiotherapists, physician assistants, athletic trainers and a combination of professionals at all levels of education. The studies included a variety of interventions.

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## **What are the main findings of this review?**

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Compared to no learning, pure e-learning improves EBHC knowledge and skills but not attitudes and behaviour. Pure e-learning is no better than face-to-face learning in improving any of the primary outcomes.

Blended learning is better than no learning for improving EBHC knowledge, skills, attitude and behaviour; and is better than face-to-face learning in improving attitudes and behaviour. Compared to pure e-learning, blended learning improves EBHC knowledge. It is not clear which e-learning components are most effective in improving outcomes.

However, the included studies were of moderate to low quality, with a small number of studies included in each analysis, and imprecision and inconsistency of results in all comparisons. These shortcomings need to be taken into consideration when interpreting the results.

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## **What do the findings of this review mean?**

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E-learning of EBHC, whether pure or blended, compared to no learning, improves EBHC knowledge and skills. There is no difference in these outcomes when comparing e-learning to face-to-face learning. Blended learning, which typically comprises multiple interventions, appears more effective than other types of learning in improving EBHC knowledge, skills, attitude and behaviour.

Future research should focus on the different components of e-learning and should adequately report on all the intervention components, the educational context and implementation strategies.

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## **How up-to-date is this review?**

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The review authors searched for studies published until May 2016. This Campbell Systematic Review was published in March 2017.

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# Executive summary

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## BACKGROUND

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It is important that all healthcare professionals acquire the knowledge and skills necessary to make healthcare decisions which are informed by the current best research evidence. Evidence-based health care (EBHC) typically involves phrasing questions based on a knowledge gap, searching for research that can answer the question, critically appraising and interpreting the research, applying the results and auditing the process. Electronic learning (e-learning) has become an increasingly popular method of teaching EBHC but literature on the effectiveness thereof has not been synthesized and it is not clear which e-learning strategies are most useful.

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## OBJECTIVES

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The primary objective of this review was to assess the effectiveness of e-learning of EBHC on increasing EBHC competencies in healthcare professionals. Secondary objectives were to assess the effectiveness of specific dimensions of e-learning in increasing EBHC competencies, to assess how educational context influences the effectiveness of EBHC e-learning, and to assess how implementation approaches influence the effectiveness of EBHC e-learning.

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## SEARCH METHODS

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We searched MEDLINE, EMBASE, ERIC, CINAHL, CENTRAL, SCOPUS, Best Evidence Medical Education (BEME), Web of Knowledge, PsycInfo and dissertation databases (ProQuest) for relevant studies (24 May 2016). We examined reference lists of included studies and contacted experts in the field. We did not apply any language restrictions.

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## SELECTION CRITERIA

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We considered randomised controlled trials (RCTs), cluster RCTs, non-randomised controlled trials (non-RCTs), controlled before-after studies (CBAs) and interrupted time series (ITS) of any healthcare professional at any level of education, evaluating any educational intervention that included any or all of the five steps of EBHC and was delivered fully (pure e-learning) or in part (blended learning) via an electronic platform compared to no learning of EBHC, face-to-face learning of EBHC or other forms of e-learning of EBHC. The primary outcomes were EBHC knowledge, EBHC knowledge and skills, EBHC skills, EBHC attitude and EBHC behaviour.

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## DATA COLLECTION AND ANALYSIS

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Two authors independently screened search results and assessed eligibility of potentially eligible studies, extracted data and made judgments about risk of bias. Discrepancies were resolved through discussion or consultation of a third author. We contacted study authors in case of missing data. Due to high levels of heterogeneity between studies, we pooled results using random-effects meta-analysis and reported on the standardized mean differences (SMD) and 95% confidence intervals for each outcome.

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## RESULTS

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We included 24 studies (20 RCTs and four non-RCTs) with a total of 3825 participants in the review. Participants included medical doctors, nurses, physiotherapists, physician assistants, athletic trainers and a combination of professionals at all levels of education. E-learning interventions were heterogeneous with 17 different intervention components. The interventions of five studies included only one component while the remaining interventions comprised various components in combination and were considered to be multi-faceted.

Overall we judged studies to be at moderate to high risk of selection bias and high risk of attrition bias. Meta-analyses contained a small number of studies and participants. Results were mostly imprecise and inconsistent. Our confidence in the following results is therefore low.

### Primary outcomes

#### *Pure e-learning vs no learning (3 studies)*

Pure e-learning compared to no learning improved EBHC knowledge (SMD 0.71; 95%CI 0.40 to 1.01; 1 study, n=175) and EBHC attitude (SMD 1.05; 95%CI 0.26 to 1.83; 1 study, n=29). There was no difference between groups for EBHC knowledge and skills (SMD 0.47; 95%CI -0.27 to 1.21; 1 study; n=29).

#### *Blended learning vs no learning (5 studies)*

Blended learning compared to no learning improved EBHC knowledge (SMD 0.20; 95%CI 0.13 to 0.86; 1 study; n=119), EBHC knowledge and skills measured at one month post-intervention (SMD 0.90; 95%CI 0.42 to 1.38; 2 studies; n=241) and 3+ months post-intervention (SMD 1.11; 95%CI 0.80 to 1.42; 2 studies; n=186) and EBHC behaviour measured at 3+ months post-intervention (SMD 0.61; 95%CI 0.21 to 1.01; 1 study; n=100). There was no difference between groups for EBHC knowledge and skills measured immediately post-intervention (SMD 1.40; 95%CI -0.06 to 2.85; 2 studies, n=241), EBHC attitude (SMD 0.17; 95%CI -0.09 to 0.43; 2 studies; n=226), EBHC attitude measured at 1 month post-intervention (SMD 0.05; 95%CI -0.34 to 0.44; 2 studies; n=241) and 3+ months post-intervention (SMD 0.32; 95%CI -0.02 to 0.67), and EBHC behaviour measured directly post-intervention (SMD 0.06; 95%CI -0.28 to 0.40; 2 studies; n=207) and 1 month post-intervention (SMD 0.19; 95%CI -0.19 to 0.56; 1 study; n=109).

### *Pure e-learning vs face-to-face learning (6 studies)*

We did not find a difference between groups for EBHC knowledge (SMD -0.03; 95%CI -0.26 to 0.20; 5 studies, n=632), EBHC skills (SMD -0.15; 95%CI -0.34 to 0.04; 2 studies; n=457) or EBHC attitude (SMD 0.11; 95%CI -0.27 to 0.48; 1 study; n=111).

### *Blended learning vs face-to-face learning (5 studies)*

We did not find a difference between groups for EBHC knowledge (SMD 0.28; 95%CI -0.23 to 0.79; 1 study; n=146), EBHC knowledge and skills (SMD -0.22; 95%CI -0.49 to 0.05) and EBHC skills (SMD -0.21; 95%CI -0.68 to 0.26). Scores for participants in the blended learning group were higher for EBHC attitude (SMD 1.07; 95%CI 0.57 to 1.58; 1 study; n=69) and EBHC behaviour (SMD 2.34; 95%CI 1.72 to 2.96; 1 study; n=69).

### *Blended learning vs pure e-learning (3 studies)*

Blended learning compared to pure e-learning improved EBHC knowledge (SMD 0.69; 95%CI 0.40 to 0.99; 2 studies, n=193). For EBHC skills, results favoured pure e-learning for the non-RCT and blended learning for the RCT. There was thus significant heterogeneity between studies and the pooled effect showed no difference between groups (SMD -0.53; 95%CI -2.31 to 2.25; 2 studies; n=218).

### *Pure e-learning vs pure e-learning (3 studies)*

We found that the interventions improved EBHC skills (SMD 1.30; 95%CI 0.68 to 1.93; 2 studies; n=119). Interventions were heterogeneous. One study compared a DVD containing recorded PowerPoints and tutorials, as well as access to online learning material to a standard online distance learning programme. The other compared an online journal club with an asynchronous discussion list to receiving the articles via email and access to journal articles.

## **Secondary outcomes**

Secondary outcomes were poorly reported. Attrition rates of learners were high, but did not differ between groups. Four studies reported on satisfaction of learning but results were not conclusive and both advantages and disadvantages of both methods of learning were identified.

We were unable to address the secondary objectives of our review, as included studies provided insufficient information on educational context and implementation strategies. Meta-analyses generally contained a small number of studies, which prevented us from doing subgroup analyses on different dimensions of e-learning.

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## **AUTHORS' CONCLUSIONS**

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Our findings suggest that e-learning of EBHC, whether pure or blended, compared to no learning, improves EBHC knowledge and skills. We did not find a difference in these outcomes when comparing e-learning to face-to-face learning, suggesting that both methods of learning can be beneficial. It appears that blended learning, which typically comprises multiple intervention components, could be more effective than other types of learning in improving EBHC knowledge, skills, attitude and behaviour. These findings need to be considered in light of the limited number of studies per outcome in each comparison, risk of bias across studies and heterogeneous interventions, as well as inconsistent and imprecise results.

Future research on EBHC e-learning should focus on the effectiveness of various e-learning components and should explicitly report on all the intervention components, educational context and implementation strategies.

---

# 1 Background

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## 1.1 THE PROBLEM, CONDITION OR ISSUE

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### 1.1.1 The need for evidence-based health care competencies

Evidence-based medicine (EBM), introduced in 1991, has its roots in the field of clinical epidemiology and was listed as “*one of the 15 greatest medical milestones since 1840*” in the British Medical Journal (Montori & Guyatt, 2008). The most commonly used definition of evidence-based medicine (EBM) describes it as “*the conscientious, explicit and judicious use of the current best evidence in making decisions about the care of individual patients*” (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). It thus requires practitioners to bring together external evidence that informs about the effects of new tests, treatments and interventions; clinical judgement and expertise of the clinician; and the patient’s clinical state, values, preferences, needs and predicament.

These days, EBM is commonly referred to as evidence-based practice (EBP) or evidence-based health care (EBHC), as EBM is not limited to medical doctors, but should be adopted by all healthcare practitioners. Practicing EBHC typically involves five steps: i) Formulating an answerable question from a healthcare problem; ii) finding the best available evidence applicable to the question; iii) critically appraising the evidence for validity, clinical relevance and applicability; iv) applying the results of the evidence in the healthcare setting; and v) evaluating the performance (Dawes et al., 2005). An important aim of EBHC is that beneficial, effective health care practices are adopted and that harmful and ineffective ones are abandoned. Consequently, this requires healthcare professionals to recognise their deficiencies in knowledge and to adopt a philosophy of life-long learning, which is the backbone of practicing EBHC (Greenhalgh, 1997).

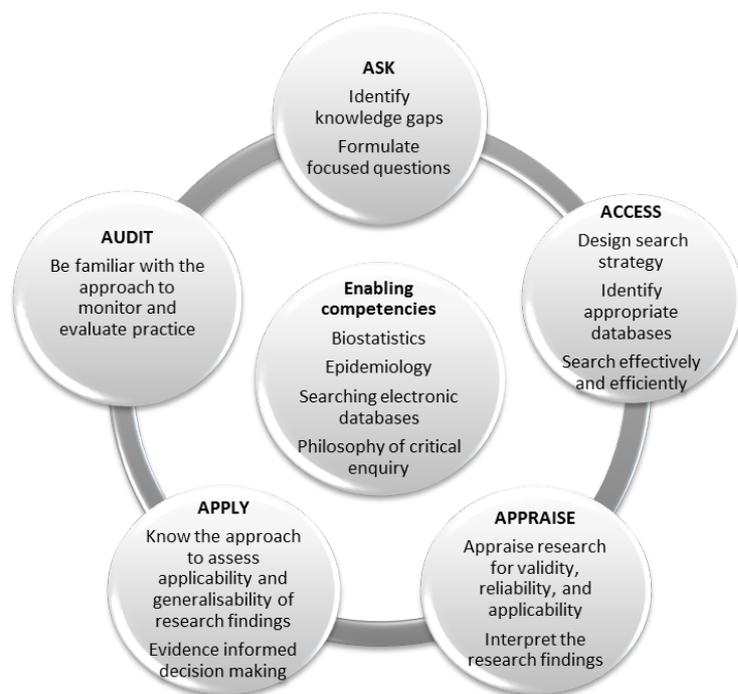
The importance of the knowledge, skills and attitude learnt through the principles of EBHC are also highlighted in the Lancet report on the health professional for the 21<sup>st</sup> century (Frenk et al., 2010), which proposes that healthcare professional training should become transformative. One of the fundamental shifts of transformative learning aligns almost perfectly with the steps of EBHC; the shift from memorization of facts to “*critical reasoning that can guide the capacity to search, analyse, assess and synthesise information for decision-making*” (Frenk et al., 2010).

In addition, Glasziou and colleagues (2011) have urged educational institutions to teach medical students skills which enable them to become life-long learners so that they are able to combine external evidence from research with their own expertise and their patients’ values and preferences. They emphasize that teaching EBHC skills should form an integral part of the medical

curriculum and be re-iterated and practiced throughout undergraduate and postgraduate training (Glasziou, Burls, & Gilbert, 2008; Glasziou, Sawicki, Prasad, & Montori, 2011).

In an evaluation of an online module of EBM, we have proposed a set of EBHC competencies that all healthcare professionals should ideally possess once they graduate (Rohwer, Young, & van Schalkwyk, 2013). These competencies comprise five key competencies that mirror the five steps of EBHC; and enabling competencies which include basic knowledge of epidemiology and biostatistics. Figure 1 is a graphic representation of the EBHC competencies.

**Figure 1: EBHC enabling and key competencies**



A number of systematic reviews have explored the effects of teaching EBHC to healthcare professionals, both at an under- and postgraduate stage. From the results, it is evident that teaching EBHC to students and health care professionals leads to increased EBHC knowledge and skills (Young, Rohwer, Volmink, & Clarke, 2014). The question is therefore no longer *whether* we should be teaching EBHC; but rather *how* we should be teaching it. Khan and Coomarasamy (2006) have proposed a hierarchy of teaching EBHC, where integrated and interactive teaching is seen as the most effective way of teaching EBHC (Khan & Coomarasamy, 2006). This, however, only refers to traditional lecture-based or face to face teaching of EBHC and does not include the increasingly popular method of electronic learning.

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## 1.2 THE INTERVENTION

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### 1.2.1 Electronic learning (e-learning)

Electronic learning or e-learning (as the term is widely used) strategies have been widely adopted by educators around the world and it is not surprising that it has also become a buzz word amongst medical educators. E-learning, also called web-based learning, online learning, distributed

learning, computer-assisted instruction and internet-based learning, can be defined as the delivery of training material via information and communication technology (ICT), including the internet, CD-ROM, DVD, smartphones and other media, both inside and outside of the classroom (Frehywot et al., 2013; Ruggeri, Farrington, & Brayne, 2013; Ruiz, 2006).

Pure e-learning refers to the use of e-learning materials only, without any face-to-face classroom methods. Although it seems to be synonymous to completely online learning, the difference between pure e-learning and fully-online learning refers to the delivery platform. While online learning relies on a web-based delivery platform and requires internet access, pure e-learning can take place without internet access, for example, by using DVDs to deliver the educational content. Blended learning combines e-learning components with other traditional face-to-face, lecture-based learning in and outside of the classroom (Frehywot et al., 2013).

Advantages of e-learning include improved accessibility of educational materials at a time convenient to the learner; individualised or personalised learning, where the learner decides on the amount, pace and place, which allows personal tailoring of the learning experience and meeting of individual learner objectives; lower training costs; collaborative learning environments; the ability to track learner activity; and provision of consistent and standardized training to a larger number of learners all over the world (Clark, 2002; Ruggeri et al., 2013; Ruiz, 2006; Welsh, Wanberg, Brown, & Simmering, 2003).

Disadvantages of e-learning include costs related to the technologies as well as the staff needed, although most costs seem to occur at the development stage of e-learning courses; and social isolation or the lack of interaction among the participants of the e-learning activity or course. The lack of face-to-face networking and peer interaction can be seen as a huge drawback, making e-learning less attractive and less useful. Poor instructional design, technical problems and de-individualised instruction can also be regarded as disadvantages of e-learning (Cook, 2007; Welsh et al., 2003).

E-learning is a complex intervention with multiple components and dimensions that interact, in a linear or non-linear way, in a specific context (Wong, Greenhalgh, & Pawson, 2010). In the literature, different components, levels, dimensions and categories of e-learning have been described.

Ruiz et al. (2006) describe the components of e-learning as being i) the development of content ii) management of the content and iii) delivery of the content. Regarding development of content, digital learning objects, i.e. *“any grouping of digital materials structured in a meaningful way and tied to an educational objective”*, are the fundamental components of lessons, modules and curricula; created with the help of instructional design and pedagogical principles. Examples of digital learning objects include tutorials, case-based learning scenarios, hypermedia, simulations and game-based learning modules (Ruiz, 2006).

Management of content encompasses the administrative functions (storing, indexing, cataloguing) needed to make content available to learners through portals, repositories, digital libraries, learning management systems, search engines and e-Portfolios (Ruiz, 2006).

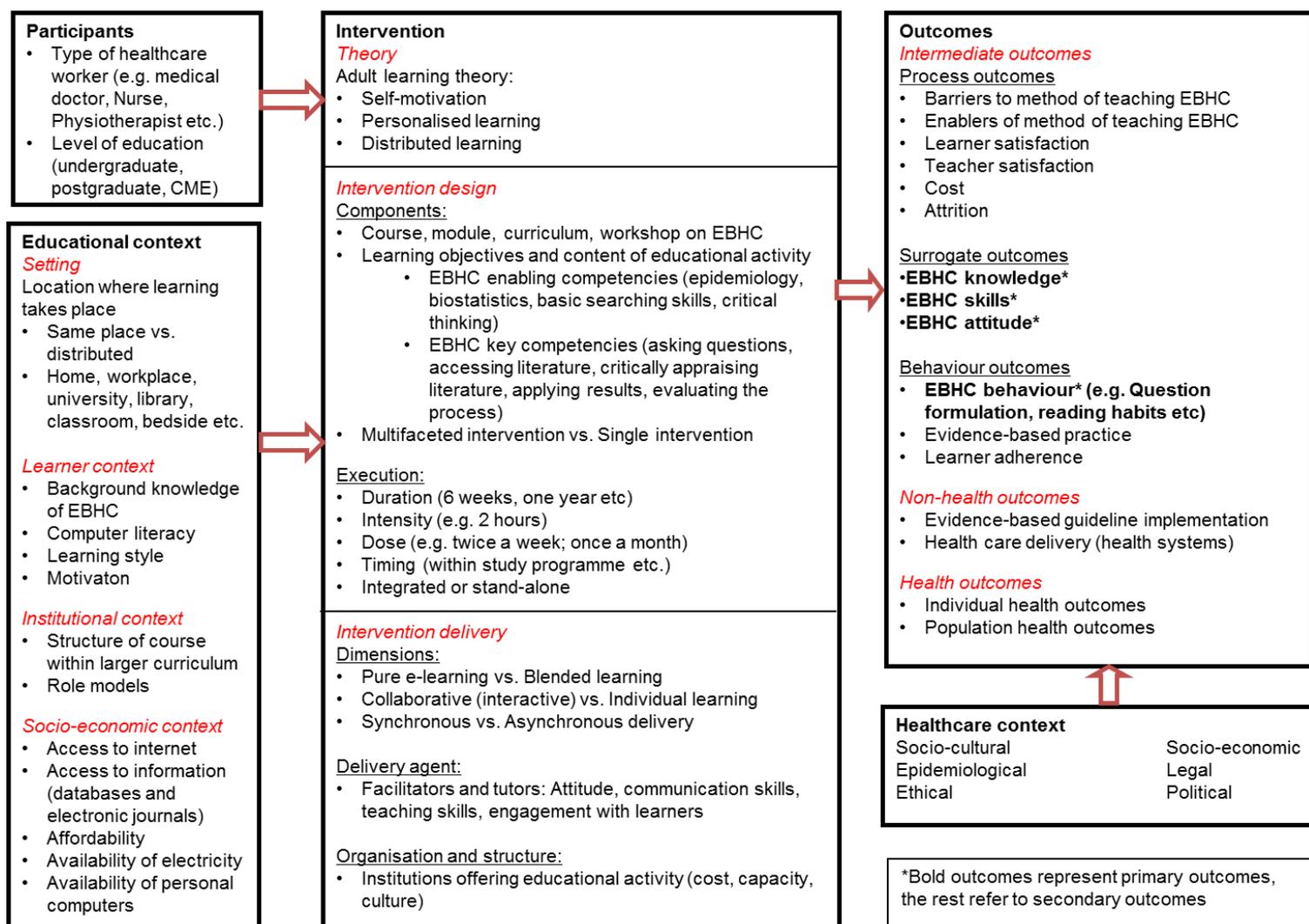
Content can be delivered in a synchronous or asynchronous way. Synchronous delivery of content refers to real time, instructor-led learning, where all learners receive information simultaneously and communicate and interact directly with other learners by logging onto platforms like virtual classrooms (e.g. teleconferencing, internet chat forums, instant messaging). Asynchronous delivery of content occurs when the transmission and receipt of information occurs at different time points. It can include pre-recorded presentations or podcasts, PowerPoint slides, or even more sophisticated applications like simulations. While asynchronous communication is done by means of email, online bulletin boards, listservs, newsgroups, wikis or weblogs, it enables learners to participate in the learning activity at any time of day, from any desired location (Ruiz, 2006; Welsh et al., 2003).

Ruggeri et al. (2013) describe the different dimensions and attributes of e-learning programmes under four headings: Synchronicity (asynchronous vs synchronous), location (same place vs distributed), independence (individual vs collaborative) and mode (electronic-only vs blended) (Ruggeri et al., 2013).

Cook (2005) describes four levels of instructional design in computer-based learning: Medium, which refers to the mode of delivery of instruction (e.g. textbook, face to face, computer-based, television); configuration, referring to the “big picture” differences within a given media format (e.g. computer: web-based discussion board, web-based or CD-ROM-based tutorial vs face to face: small-group discussion, lecture); instructional method, referring to teaching techniques that support learning processes (e.g. learning activities, self-assessment questions, clinical cases, simulations, group discussions); and presentation, referring to elements of the given medium that enhance the intervention, but do not qualify as instructional methods (e.g. hyperlinks, multimedia, font simulation fidelity etc.) Cook (2005).

We developed a system-based logic model of e-learning of EBHC, based on a template from Rohwer et al. (2016) depicting the different components, contextual factors and interactions that are needed to achieve the desired outcomes ([Figure 2](#)). In an effort to tease out the characteristics and dimensions of e-learning interventions in order to be combined meaningfully, we have only listed the broad categories that we thought of as being most important.

**Figure 2: Systems-based logic model of e-learning of EBHC**



## 1.3 HOW THE INTERVENTION MIGHT WORK

### 1.3.1 How e-learning may work

A number of systematic reviews have been conducted in various fields of medical and health science education, examining the effect of different types of e-learning on knowledge, skills and behaviour.

A systematic review conducted by the WHO evaluated the effectiveness of e-learning for undergraduate health professions education (Al-Shorbaji, Atun, Car, Majeed, & Wheeler, 2015). They included 209 studies and concluded that e-learning is similar to traditional face-to-face learning in terms of knowledge and skill acquisition. The majority of included studies were judged to be at high risk of bias.

Cook et al. (2008) conducted a systematic review to determine the effectiveness of internet-based learning for health professionals compared to no intervention or non-internet interventions. The

authors pooled data in a random-effects meta-analysis and found significant results favoring internet-based learning for knowledge, skills, as well as behaviour and patient effects when compared to no learning. But when internet-based learning was compared to alternative methods of learning, there was no difference in results between groups. In a subsequent analysis on instructional design variations in internet-based learning, the authors concluded that interactivity, practice exercises, repetition and feedback appeared to be associated with improved learning outcomes (Cook et al., 2010). A review by Booth and colleagues (2009) found that presentation and design, flexibility, peer communication, support and knowledge validation were effective e-learning techniques for enhancing the learning experience of students.

Liu et al. (2016) conducted a systematic review on the effectiveness of blended learning compared to no or other learning amongst health professionals. They included 56 studies and results favored blended learning when compared to no learning and to other learning. However, authors caution that high levels of heterogeneity should be taken into account when interpreting results.

Another recent systematic review assessed the effectiveness of internet-based e-learning on health care professional behaviour and patient outcomes (Sinclair, Kable, Levett-Jones, & Booth, 2016). The authors found 7 studies that assessed behaviour of healthcare professionals and no studies that reported on patient outcomes. They were unable to pool results in meta-analysis due to substantial heterogeneity between studies. Although results from individual studies showed that e-learning was just as effective as face-to-face learning and better than no learning, authors concluded that there was currently insufficient evidence to answer their question.

Other studies have examined *how* e-learning works, focusing more on the essential components for successful learning, as well as certain contextual factors that influence learning. A realist review by Wong et al. (2010), looking at “*what works, for whom and in what circumstances*” when considering internet-based medical education, concluded that online courses need to engage the learners to use the technology, which is more likely to happen when the technology is perceived as being useful and easy to use; and that interactivity should be a key characteristic of an online course, since learners want to be able to enter a dialogue with tutors and peers (Wong et al., 2010).

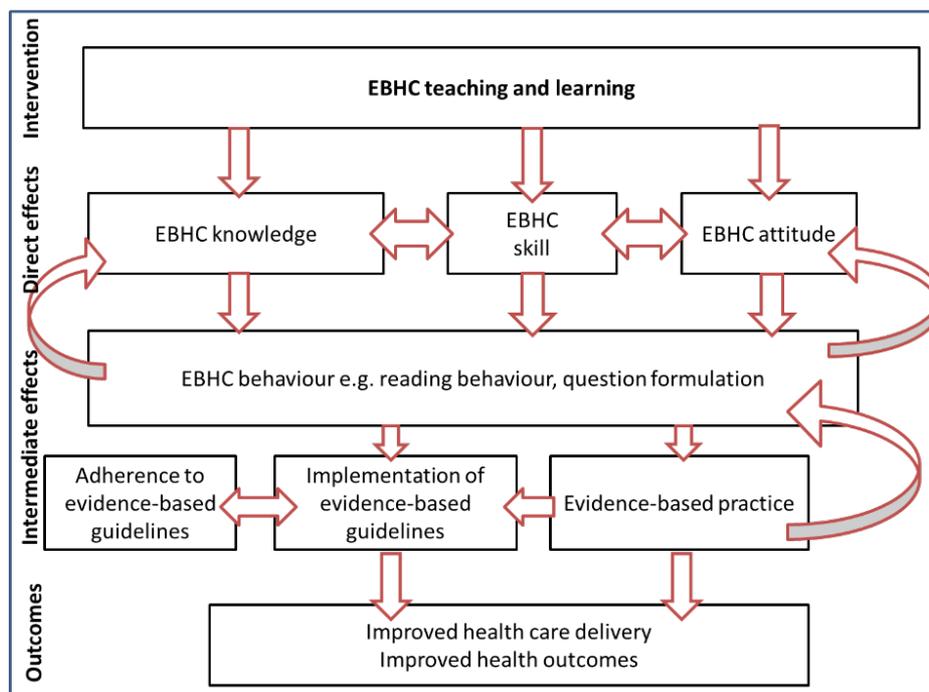
E-learning technologies afford a new learner paradigm based on the adult learning theory, explaining that adults learn by relating new information to past experiences; tailoring learning to their unique needs (open learning); and applying learning in practice, resulting in more effective and efficient learning experiences. The attributes of accessibility and convenience (distributed learning) personalise the learning, because students decide when and where they are receptive to learning. Learning becomes an individual experience where adults learn because they want to learn – not because they are told to learn. This shift from “expert-led teaching to user-lead learning” results from intrinsic motivation and offers a much stronger learning stimulus. Some evidence suggests that learning by means of e-learning is more efficient and that learners gain knowledge faster, which in turn translates back to improved motivation and enhanced learning. (Clark, 2002; Dabbagh, 2005; Ruggeri et al., 2013; Ruiz, 2006).

When considering these attributes and pedagogical underpinnings of e-learning, one can argue that these fit perfectly within the EBHC paradigm. Enhanced learning occurs through internal motivation, rather than external drivers and requires acknowledgement of shortcomings

(knowledge gaps) and adoption of a reflective approach towards one's own practice. This alignment between attributes of e-learning and EBHC foci suggests that making use of e-learning in this context could be of value.

The pathway from EBHC e-learning activities to the desired outcomes, i.e. increased knowledge, skill, attitude and behaviour, as well as health outcomes is depicted in Figure 3, a process-oriented logic model, based on the template by Rohwer et al. (2016).

**Figure 3: Process-oriented logic model showing the pathway from EBHC learning to desired outcomes**



It is important to note that this pathway does not take place in a vacuum, but that ultimately, improved health care delivery and improved health outcomes do not only rely on evidence-based practice, but are influenced by a variety of other factors within the healthcare context e.g. socio-cultural, socio-economic, epidemiological, legal, ethical and political factors on a national and international level (See Figure 2).

## 1.4 WHY IT IS IMPORTANT TO DO THE REVIEW

A number of systematic reviews assessing the effectiveness of e-learning for healthcare professionals at various levels have been published in recent years. As described above, these reviews assessed e-learning of any content related to health professions education (Al-Shorbaji et al., 2015; Cook et al., 2008; Liu et al., 2016; Sinclair et al., 2016). Generally, systematic reviews concluded that e-learning was better than no learning, but neither superior nor inferior to other methods of learning. Although these reviews do not represent a comprehensive list of all published reviews in this area, they are an indication of the current interest in this field.

When examining the literature on EBHC learning, we also found a number of recently published studies. A recent overview of systematic reviews (Young et al., 2014) that included 16 systematic reviews examining the effects of educational activities on EBHC, found that when comparing single interventions (a workshop, journal club, lecture or e-learning) with multifaceted interventions (a combination of different strategies e.g. lectures, tutorials, e-learning, journal clubs, etc.) multifaceted clinically integrated educational activities were more likely to increase EBHC knowledge, skills, attitude and behaviour. Although some of the studies included in the systematic reviews related to e-learning activities, it is still unclear whether e-learning of EBHC leads to increased knowledge, skills, attitude and behaviour. The need to synthesise studies specifically evaluating the effect of EBHC e-learning was therefore identified.

Another recent systematic review (Ilic & Maloney, 2014) that aimed to determine what type of educational methods was most effective in increasing EBHC knowledge and skills found that there was no difference between the various educational methods for EBHC. It is therefore still unknown whether some e-learning strategies are more useful and effective than others.

This review considers e-learning of EBHC to be a complex intervention and aims to address the effectiveness of the interventions, as well as identify the implementation and contextual factors that are important in delivering the intervention. In teasing out these issues, we hope to be able to formulate evidence-based recommendations for EBHC teachers and program developers.

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## 2 Objectives

### Primary objective:

- To assess the effectiveness of e-learning of EBHC on increasing EBHC competencies in healthcare professionals

### EBHC competencies include ([Figure 1](#))

- Enabling competencies: biostatistics, epidemiology, basic searching skills, philosophy of critical enquiry
- Key competencies: asking clear questions, accessing the literature to find the best available evidence, critically appraising the evidence for validity and interpreting results, applying the results, and auditing the process

### Secondary objectives:

- To assess the effectiveness of specific dimensions of e-learning in increasing EBHC competencies
- To assess how educational context influences the effectiveness of EBHC e-learning
- To assess how implementation approaches influence the effectiveness of EBHC e-learning

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## 3 Methods

The protocol for this systematic review has been published in the Campbell Library (Rohwer, Rehfuss, & Young, 2014).

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### 3.1 CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

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#### 3.1.1 Types of studies

We followed the guidance of the Effective Practice and Organisation of Care (EPOC) review group of Cochrane. We included randomised controlled trials (RCTs), cluster randomised controlled trials and non-randomised controlled trials (non-RCTs) in the review. In addition, we considered controlled before-after studies (CBAs) with at least two intervention and two control sites; and interrupted time series (ITS) with a clearly defined point in time when the intervention occurred with at least three data points before and three data points after the intervention.

In addition, we included studies supporting the included intervention studies that yielded information on the process of implementation. These studies were either quantitative (e.g. process evaluations, quantitative interview studies) or qualitative in nature (e.g. focus groups, qualitative interview studies). The information gathered was either reported within the above included intervention studies, or cited within these and published separately. We did not include these supporting studies in the data synthesis, but rather reported relevant results separately.

We excluded studies without a comparison group.

#### 3.1.2 Types of participants

We included all healthcare professionals, including doctors, dentists, nurses, occupational therapists, physiotherapists, dieticians, audiologists, mental health professionals, psychologists, counsellors, social workers at undergraduate, postgraduate (e.g. residents) or continuing medical education (CME) level; working in primary, secondary or tertiary environments.

#### 3.1.3 Types of interventions

##### 3.1.3.1 Interventions

We included any educational intervention (a co-ordinated educational activity) that included any or all of the 5 steps of EBHC (asking questions, searching the literature, critically appraising the literature, applying the results, evaluating the process) and was delivered via an electronic platform (e-learning only), or made use of e-learning in a supplementary way (blended learning). E-learning

(web-based learning, online learning, distributed learning, computer-assisted instruction) was regarded as: delivery of training material via any electronic media (internet, CD-ROM, DVD, smartphones and other media), independent of the delivery platform.

### **3.1.3.2 Comparisons**

Comparisons included no educational intervention (no EBHC learning); any educational intervention that included any or all of the 5 steps of EBHC (asking questions, searching the literature, critically appraising the literature, applying the results, evaluating the process) that was delivered via an electronic platform, but with different components than the intervention (e.g. interactivity vs no interactivity; synchronicity vs asynchronicity); and any educational intervention that included any or all of the 5 steps of EBHC (asking questions, searching the literature, critically appraising the literature, applying the results, evaluating the process) and was delivered via face-to-face learning, with no e-learning components.

### **3.1.4 Types of outcome measures**

#### *Primary outcomes*

- EBHC knowledge (as measured by study authors, for example, evaluating knowledge scores with a validated pre-and post-training questionnaire such as Fresno test (Ramos, Schafer, & Tracz, 2003) or Berlin test (Fritsche, Greenhalgh, Falck-Ytter, Neumayer, & Kunz, 2002) )
- EBHC knowledge and skills measured as a composite outcome as measured by study authors
- EBHC skills (as measured by study authors, for example, evaluating skill scores with a validated pre-and post-training questionnaire such as Fresno test (Ramos et al., 2003) or Berlin test (Fritsche et al., 2002))
- EBHC attitude (as measured by study authors, for example, with Likert-scale questions pre-and post-training)
- EBHC behaviour (as measured by study authors, for example, self-reported behaviour changes, amount of questions formulated, amount of searches done; or more objective measurements, for example, proportion of clinical cases where evidence was consulted)

#### *Secondary outcomes*

- Process outcomes
  - Satisfaction of students with method of learning (as measured by study authors, for example, Likert-scale questions post-training, or open-ended questions yielding qualitative data)
  - Satisfaction of educators with method of learning (as measured by study authors, for example, with Likert-scale questions post-training, or open-ended questions yielding qualitative data)

- Enablers of the method of learning EBHC (as measured by study authors, for example, with Likert-scale questions post-training, or open-ended questions yielding qualitative data)
- Barriers to the method of learning EBHC (as measured by study authors, for example, with Likert-scale questions post-training, or open-ended questions yielding qualitative data)
- Cost (a sum of all the monetary cost involved in the training)
- Attrition of learners (measured quantitatively by looking at the proportion of learners that complete the training)
- Behaviour outcomes
  - Learner adherence (measured either quantitatively by looking at the proportion of learners that adhere to the prescribed learning, or qualitatively by asking learners whether about their learning experience)
  - Evidence-based practice (measured qualitatively through self-report of practitioners)
- Non-health outcomes
  - Evidence-based guideline implementation (for example, measured quantitatively by looking at practice audits)
  - Health care delivery (measured qualitatively through self-report of practitioners)
- Health outcomes
  - Individual health outcomes (these refer to clinical patient-orientated outcomes, measured quantitatively)
  - Population health outcomes (these refer to health outcomes of the community or the entire population measured quantitatively, for example, disease incidence rates)

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## **3.2 SEARCH METHODS FOR IDENTIFICATION OF STUDIES**

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### **3.2.1 Electronic searches**

We developed a comprehensive search strategy consisting of relevant terms ([Table 9.1](#)) and searched electronic databases (MEDLINE via PubMed, EMBASE via Ovid, ERIC, CINAHL, CENTRAL, SCOPUS, Best Evidence Medical Education (BEME), Web of Knowledge, PsycInfo) and dissertation databases (ProQuest) up to 24 May 2016 for relevant studies. We did not apply any language restrictions.

### **3.2.2 Searching other resources**

We complemented our search with a thorough examination of reference lists of identified studies and contacted experts in the field to identify any on-going or unpublished studies. We also searched trial registries (ICTRP) for on-going studies (24 May 2016).

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## **3.3 DATA COLLECTION AND ANALYSIS**

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### **3.3.1 Selection of studies**

Two authors (AR and either TY, ER or NVM) independently screened the search outputs and abstracts for relevant studies. We retrieved full texts of studies with seemingly relevant abstracts and two authors (AR and TY, ER or NVM) independently assessed them for eligibility using the pre-specified inclusion criteria. We resolved discrepancies through discussions and consultations with a third author before classifying studies as included, excluded, or on-going.

### **3.3.2 Data extraction and management**

Two authors (AR and either NVM, TY or ER) extracted data from relevant studies independently and in duplicate using piloted, electronic data extraction forms. Discrepancies were resolved through discussions and consultations with a third author. We contacted authors in case of missing data.

We extracted data related to study design (type of study, duration of study, country), participants (number of participants, type of health care professionals, level of education), interventions (learning theory, educational content, duration, intensity, dose and timing of intervention, delivery of interventions), outcomes (primary and secondary outcomes, measurement details and time point at which outcomes were measured), results (measures of effect with 95% confidence intervals, qualitative data) and educational context (setting, learner context, institutional context and socio-economic context). We considered the term “learning theory” in a broad way, to describe a body of implicit or explicit ideas about how learning works (May et al., 2007; Wells, Williams, Treweek, Coyle, & Taylor, 2012). We extracted theories, models or learning approaches, as defined by study authors.

We broadly categorised interventions and controls into pure e-learning, blended learning, face-to-face learning or no learning. In addition, we indicated whether interventions were single or multi-faceted interventions, whether EBHC learning was stand-alone or integrated, and for all e-learning interventions, whether they required individual or collaborative learning.

In addition, we compiled a matrix of the intervention components related to the included interventions and comparisons in order to compare the components across studies. The matrix was informed by components identified from the included studies and grouped according to mode of delivery, for example, e-learning components and face-to-face components.

### **3.3.3 Assessment of risk of bias in included studies**

For each included study, two authors (AR and either NVM, TY, or ER) independently assessed the risk of bias according to the Cochrane Effective Practice and Organisation of Care's (EPOC) suggested risk of bias criteria (EPOC, 2015) for the following domains: selection bias, performance bias, detection bias, attrition bias, contamination (when participants in the comparison group are exposed to the intervention and vice versa), reporting bias, other bias ([Table 9.2](#)).

In addition, we assessed the possibility of additional biases for cluster RCTs according to the Cochrane handbook (Higgins & Green, 2008).

- **Recruitment bias:** We described whether participants were recruited before or after randomization of clusters. We regarded studies as having low risk of recruitment bias if participants were recruited before randomization of clusters; high risk of bias if they were recruited after randomization; and unclear risk of bias if information about the timing of recruitment is unclear.
- **Baseline imbalance:** We described any baseline imbalances between individuals and clusters
- **Loss of clusters:** We described the number of clusters lost as well as reasons for attrition
- **Incorrect analysis:** We described whether analysis was adjusted for clustering
- **Compatibility with RCTs randomised by individuals:** We described whether the intervention effects may be systematically different from individually randomised controlled trials i.e. whether it was likely that the effect size was over- or underestimated.

We resolved discrepancies through discussion and consultation with a third author if needed.

### **3.3.4 Measures of treatment effect**

#### **3.3.4.1 Dichotomous data**

We presented rates of attrition of learners as risk ratios (RR) with their respective 95% confidence intervals (CI).

#### **3.3.4.2 Continuous data**

Continuous outcomes included EBHC knowledge and skill scores; EBHC attitude scores and EBHC behaviour. We presented continuous data as the standardised mean difference (SMD) with 95% confidence intervals, to take into account differences related to various measurement tools. We interpreted the size of the effect as follows, based on Sawilowsky (2009):

- SMD 0.01-0.19: very small effect
- SMD 0.2-0.49: small effect
- SMD 0.5-0.79: medium effect
- SMD 0.8-1.19: large effect

- SMD 1.2-1.99: very large effect
- SMD 2.0 and above: huge effect

### **3.3.4.3 Other data**

Outcomes not measured numerically were reported narratively. These outcomes included EBHC behaviour, satisfaction with the method of learning, and barriers and enablers to the method of learning EBHC.

### **3.3.5 Unit of analysis issues**

In cluster RCTs, where authors had appropriately adjusted results for clustering, we included the adjusted effect estimates and standard errors using the generic inverse-variance method in RevMan. For outcomes where authors had not appropriately adjusted for clustering, we adjusted the data by calculating the 'effective sample size' of each intervention group in the cluster RCT. This was done by dividing the original sample size of an intervention group by the design effect (Higgins & Green, 2008). We then included the adjusted data in the meta-analysis.

For multi-arm studies, which contributed multiple comparisons to a particular meta-analysis, we split the 'shared' group (e.g. two intervention groups and one control group) as appropriate to avoid the inclusion of data from the same patient more than once in the same analysis.

### **3.3.6 Dealing with missing data**

We contacted authors in case of missing data. Where authors did not respond, we calculated the means and standard deviations (SD) according to the methods described in the Cochrane Handbook (Higgins & Green, 2008). The mean difference (MD) and SD were then converted to a SMD, standard error (SE) and corresponding 95% confidence intervals (CIs) with RevMan software (RevMan, 2011).

For continuous outcomes, we only included participants for whom outcomes were measured, i.e., per-protocol analysis. For rates of attrition of learners, we used intention to treat analysis, i.e., we included all participants that were randomised to a specific group as the denominator in the analysis.

### **3.3.7 Assessment of heterogeneity**

We assessed heterogeneity by describing variability among studies regarding participants, interventions and outcomes (educational heterogeneity), as well as variability in study design and risk of bias (methodological heterogeneity).

Educational heterogeneity was explored by clearly documenting the characteristics of participants; all components of the intervention relating to intervention design and delivery; as well as outcomes and measurement of outcomes in table format. In addition, the educational context (setting, learner context, institutional context, socio-economic context), in which the intervention was delivered, was explored and reported. See Figure 2.

Methodological heterogeneity was explored by clearly documenting study design as well as risk of bias for each study.

We assessed statistical heterogeneity by looking at the  $I^2$  statistic as well as the  $\text{Chi}^2$  test statistic. We considered an  $I^2$  value of more than 30%, and a p-value of less than 0.10 for the  $\text{Chi}^2$  test for heterogeneity to be an indicator of important heterogeneity. In case of considerable heterogeneity, we performed random-effects meta-analysis instead of fixed-effect meta-analysis or reported outcomes in tabular or narrative format.

### **3.3.8 Assessment of reporting biases**

We did not assess reporting biases with funnel plots, since we had less than 10 included studies per outcome.

### **3.3.9 Data synthesis**

Due to important heterogeneity related to the participants, interventions and outcome measurements, we used random-effects meta-analysis to pool results using RevMan. For continuous outcomes, we converted means and standard deviations reported at follow-up to SMD and SEs, and reported the pooled SMD with 95% CIs. For studies where outcomes were reported as mean change scores, we calculated follow-up means from baseline means and used baseline SDs for follow-up SDs before converting to SMDs (Higgins & Green, 2008). For dichotomous outcomes, we reported the pooled risk ratio (RR) with 95% CIs. Studies were grouped under six main comparisons:

1. Pure e-learning vs no learning
2. Blended learning vs no learning
3. Pure e-learning vs face-to-face learning
4. Blended learning vs face-to-face learning
5. Blended learning vs pure e-learning
6. Pure e-learning vs pure e-learning

### **3.3.10 Subgroup analysis and investigation of heterogeneity**

We performed the following subgroup analysis on primary outcomes:

1. Study design: Non-RCTs vs RCTs

### **3.3.11 Sensitivity analysis**

We did not perform sensitivity analysis on primary outcomes, as the number of included studies per outcome was very small.

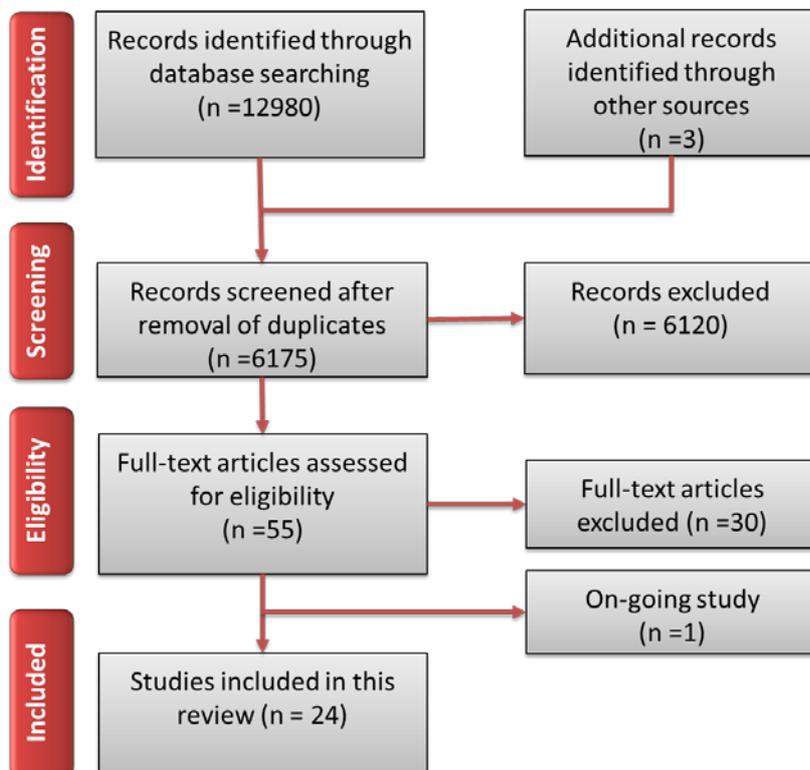
# 4 Results

## 4.1 DESCRIPTION OF STUDIES

### 4.1.1 Results of the search

Our search of the databases yielded 12980 citations (24 May 2016) and we identified three further citations from screening references of included studies and experts. After removal of duplicates, we screened 6175 titles and abstracts, of which we identified 55 as being potentially eligible. We assessed eligibility of these by obtaining and screening the full texts of the studies. We included 24 studies (Table 9.3), classified one study as ongoing (Table 9.4) and excluded 30 studies (Table 9.5) (Figure 4).

**Figure 4: Flow diagram of included studies**



### **4.1.2 Included studies**

We included 24 studies with a total of 3825 participants in the review. Details of individual studies can be found in the table of characteristics of included studies ([Table 9.3](#)). [Table 9.6](#) summarises the characteristics of included studies.

#### **4.1.2.1 Study designs**

Thirteen included studies were individually randomised controlled trials (Bergold et al., 2013; Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Forsetlund et al., 2003; Horiuchi et al., 2009; Kamin et al., 2001; Macrae et al., 2004; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014), seven studies were cluster RCTs (Hadley et al., 2010; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; McLeod et al., 2010) and four were quasi-randomised trials (Fernandez et al., 2014; Ilic et al., 2013; Ramos-Morcillo et al., 2015; Schilling et al., 2006). We did not identify any eligible CBAs or ITS.

#### **4.1.2.2 Participants**

Participants of 14 included trials were medical doctors (Bergold et al., 2013; Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Forsetlund et al., 2003; Hadley et al., 2010; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Macrae et al., 2004; McLeod et al., 2010; Schilling et al., 2006). Of these, five trials included undergraduate students (Bradley et al., 2005; Davis et al., 2008; Ilic et al., 2013; Ilic et al., 2015; Schilling et al., 2006), six trials included qualified clinicians (Bergold et al., 2013; Davis et al., 2007; Forsetlund et al., 2003; Hadley et al., 2010; Kok et al., 2013; Macrae et al., 2004), and three trials included residents; that is, postgraduate students with a basic medical degree who are specialising (Kulier et al., 2009; Kulier et al., 2012; McLeod et al., 2010). Six trials included nurses (Brettle & Raynor, 2013; Fernandez et al., 2014; Horiuchi et al., 2009; Laibhen-Parkes, 2014; Ramos-Morcillo et al., 2015; Saunders et al., 2016), of which one study included undergraduate (Brettle & Raynor, 2013) and one postgraduate (Fernandez et al., 2014) students; and four trials included practicing nurses. The remaining four trials included practicing physiotherapists (Dizon et al., 2014), undergraduate physician assistants (Kamin et al., 2001), athletic trainers (Welch, Van Lunen, & Hankemeier, 2014) and a combination of healthcare professionals, clinicians, methodologists, policy makers and trainees (Brouwers et al., 2011).

#### **4.1.2.3 Location of studies**

Most studies were conducted in high-income countries, four in the UK (Brettle & Raynor, 2013; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010), four in the USA (Kamin et al., 2001; Laibhen-Parkes, 2014; McLeod et al., 2010; Schilling et al., 2006) two in Norway (Bradley et al., 2005; Forsetlund et al., 2003), two in Canada (Brouwers et al., 2011; Macrae et al., 2004), one each in Germany (Bergold et al., 2013), The Netherlands (Kok et al., 2013), Spain (Ramos-Morcillo et al., 2015), Finland (Saunders et al., 2016), Australia (Ilic et al., 2013) and Japan (Horiuchi et al., 2009). Three studies were conducted in more than one high-income country, one in the UK and The Netherlands (Kulier et al., 2009), one in Australia and Hong Kong (Fernandez et al., 2014),

and one in Australia and Malaysia (Ilic et al., 2015). The remaining two studies were conducted in low-and middle-income countries, one in the Philippines (Dizon et al., 2014) and one had multiple study sites in Argentina, Brazil, Democratic Republic of Congo, India, Philippines, South Africa and Thailand (Kulier et al., 2012). One study did not report where participants were based, since they were members of the national athletics trainers' association (NATA) which is a worldwide association (Welch, Van Lunen, & Hankemeier, 2014). Attempts to contact the authors for additional information were not successful.

#### **4.1.2.4 Interventions**

All but two studies had two study arms. One study had three arms (Brouwers et al., 2011) and one had four study arms (Fernandez et al., 2014). Interventions were heterogeneous and are described in detail in the table of characteristics of included studies ([Table 9.3](#)), with the intervention components summarised in [Table 9.7](#).

Thirteen studies (Bradley et al., 2005; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Kamin et al., 2001; Laibhen-Parkes, 2014; Macrae et al., 2004; McLeod et al., 2010; Schilling et al., 2006; Welch, Van Lunen, & Hankemeier, 2014) included interventions that were pure e-learning interventions, while eleven studies evaluated blended learning (Bergold et al., 2013; Brettle & Raynor, 2013; Dizon et al., 2014; Fernandez et al., 2014; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Ramos-Morcillo et al., 2015; Saunders et al., 2016). Amongst the pure e-learning interventions, ten required individual learning only (Bradley et al., 2005; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Laibhen-Parkes, 2014; Welch, Van Lunen, & Hankemeier, 2014) and four incorporated collaborative learning in the intervention (Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010; Schilling et al., 2006). Amongst the blended learning interventions, six required individual learning (Bergold et al., 2013; Brettle & Raynor, 2013; Dizon et al., 2014; Kulier et al., 2009; Kulier et al., 2012; Saunders et al., 2016) and five included collaborative learning activities (Forsetlund et al., 2003; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Ramos-Morcillo et al., 2015). Four of the pure e-learning interventions delivered the content via CD-ROM or DVD (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014), whereas all other interventions were delivered asynchronously via an online learning platform or email.

In eight studies the interventions were regarded as single-component interventions and delivered as stand-alone teaching (Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Horiuchi et al., 2009; Laibhen-Parkes, 2014; Welch, Van Lunen, & Hankemeier, 2014). The remaining interventions were multi-faceted, comprising more than one component. Of these, six were delivered as stand-alone teaching (Brouwers et al., 2011; Fernandez et al., 2014; Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010; Ramos-Morcillo et al., 2015), while ten were integrated into clinical practice (Bergold et al., 2013; Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Saunders et al., 2016; Schilling et al., 2006).

Intervention components of included studies differed across studies ([Table 9.7](#)). The most common e-learning component was recorded PowerPoint presentations, which was included in twelve

studies (Bergold et al., 2013; Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2015; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Schilling et al., 2006), five of which had this as the only intervention component (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Laibhen-Parkes, 2014). Eight studies included access to an online teaching site and learning materials (Brouwers et al., 2011; Dizon et al., 2014; Fernandez et al., 2014; Forsetlund et al., 2003; Ilic et al., 2013; Ilic et al., 2015; Kamin et al., 2001; Ramos-Morcillo et al., 2015), but they all had at least one other component. These other e-learning components included online tutorials (Brettle & Raynor, 2013; Brouwers et al., 2011; Fernandez et al., 2014; Saunders et al., 2016; Schilling et al., 2006), online exercises, assignments and clinical scenarios (Bergold et al., 2013; Horiuchi et al., 2009; Kamin et al., 2001; Kulier et al., 2009; McLeod et al., 2010; Ramos-Morcillo et al., 2015; Saunders et al., 2016), online support by a tutor and feedback (Brouwers et al., 2011; Dizon et al., 2014; Forsetlund et al., 2003; Ramos-Morcillo et al., 2015; Saunders et al., 2016), use of online tools such as checklists and calculators (Dizon et al., 2014; Schilling et al., 2006), asynchronous discussion lists (Forsetlund et al., 2003; Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010; Ramos-Morcillo et al., 2015), and online journal clubs (Macrae et al., 2004; McLeod et al., 2010). Receiving an electronic newsletter (Forsetlund et al., 2003), access to databases (Forsetlund et al., 2003) and mobile learning at the bedside (Ilic et al., 2015) are intervention components that were each included in only one study. Two studies did not clearly describe the intervention components only referring to it as an “interactive online course” in Kok et al. (2013), and a “web-based module” in Welch, Van Lunen, and Hankemeier (2014).

Face-to-face intervention components that formed part of blended learning included classroom-based as well as clinical activities. The most commonly included classroom-based component was an interactive workshop, which was part of the intervention in five studies (Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013). Five studies included didactic lectures (Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2015; Ramos-Morcillo et al., 2015; Saunders et al., 2016), three included small group discussions (Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013) and two included hands-on computer-based training (Brettle & Raynor, 2013; Kok et al., 2013). Clinical activities and assignments formed part of the intervention in four studies (Bergold et al., 2013; Ilic et al., 2013; Kulier et al., 2009; Kulier et al., 2012), with three of these also including access to a tutor or facilitator in the clinical field (Bergold et al., 2013; Kulier et al., 2009; Kulier et al., 2012).

Content covered by interventions mostly related to EBHC key competencies (Table 9.8). Four studies focussed on asking questions and accessing the literature (Brettle & Raynor, 2013; Kamin et al., 2001; Ramos-Morcillo et al., 2015; Schilling et al., 2006), while the content of three others only related to critical appraisal (Brouwers et al., 2011; Macrae et al., 2004; McLeod et al., 2010). The learning content of one study related to the first three key competencies (asking questions, accessing the literature and critical appraisal) (Hadley et al., 2010), while the remaining studies included the four key competencies: asking questions, accessing the literature, critical appraisal and applying the results (Bergold et al., 2013; Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Fernandez et al., 2014; Forsetlund et al., 2003; Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014). Of these, five studies

also included the fifth key competency, evaluating the process of EBHC (Bradley et al., 2005; Fernandez et al., 2014; Ilic et al., 2015; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014), while another four (Dizon et al., 2014; Ilic et al., 2013; Ramos-Morcillo et al., 2015; Schilling et al., 2006) included certain enabling competencies (epidemiology, biostatistics and basic searching skills).

**Table 9.7: Intervention components**

Study ID	Intervention														Comparison														
	E-learning components							Face-to-face components							Face-to-face components				E-learning components										
	Recorded PowerPoint presentations	Online tutorial	Online exercises/assignments/Clinical scenarios	Access to databases	Online support (tutor/feedback)	Online tools (e.g. checklists, calculators)	Asynchronous discussion list	Online journal club	Access to online site/teaching material/learning package	Newsletter	Mobile learning at bedside	Clinical activities/assignments	Access to clinical tutor/facilitator	Didactic lectures	Interactive workshop	Small-group discussion	Hands-on computer-based training	No EBHC learning	Didactic lectures	Interactive workshop	Small group discussions	Hands-on computer-based training	Journal club	Recorded PowerPoint presentations	Access to databases/journals	Teaching material received via email	Access to facilitator on demand	Access to online site/teaching material	
<b>Pure e-learning vs no learning</b>																													
Laibhen-Parkes 2014	X																	X											
Shilling 2006	X	X				X												X											
Welch 2014								X										X											
<b>Blended learning vs no learning</b>																													
Bergold 2013	X		X								X	X						X											
Dizon 2014					X	X		X					X	X				X											
Forsetlund 2003				X	X		X	X						X	X			X						X					
Kok 2013								X					X	X	X	X		X											
Ramos-Morcillo 2015			X		X		X	X					X	X				X											
<b>Pure e-learning vs face-to-face learning</b>																													
Bradley 2005	X																			X									
Davis 2007	X																		X										
Davis 2008	X																		X										
Hadley 2010	X																		X										
Horiuchi 2009	X		X																X		X								
McLeod 2010			X				X	X														X				X			
<b>Blended learning vs face-to-face learning</b>																													
Brettle 2013		X														X		X			X								
Ilic 2013								X			X			X	X			X	X	X									
Ilic 2015	X							X		X			X	X	X			X	X	X									
Kulier 2009	X		X								X	X						X	X										
Saunders 2016		X	X		X								X					X											
<b>Blended learning vs pure e-learning</b>																													
Fernandez 2014 (1)																													
Fernandez 2014 (3)	X	X						X														X							X
Fernandez 2014 (4)																			X										X
Kamin 2001			X				X	X													X								X
Kulier 2012	X										X	X											X			X			
<b>Pure e-learning vs pure e-learning</b>																													
Brouwers 2011 (1)		X						X																					
Brouwers 2011 (2)		X			X			X																		X			
Fernandez 2014 (2)	X	X																											X
MacRae 2004							X	X																	X				

**Table 9.8: EBHC learning content of interventions**

Study ID	Enabling competencies				Key competencies					
	Epidemiology	Biostatistics	Basic searching skills	Critical thinking	General EBHC	Asking questions	Accessing the literature	Critical appraisal	Applying the results	Evaluating EBHC process
<b>Pure e-learning vs no learning</b>										
Laibhen-Parkes 2014						X	X	X	X	
Shilling 2006	X		X			X	X		X	
Welch 2014						X	X	X	X	X
<b>Blended learning vs no learning</b>										
Bergold 2013						X	X	X	X	
Dizon 2014	X				X	X	X	X	X	
Forsetlund 2003					X	X	X	X	X	
Kok 2013					X	X	X	X	X	
Ramos-Morcillo 2015			X		X	X	X			
<b>Pure e-learning vs face-to-face learning</b>										
Bradley 2005						X	X	X	X	X
Davis 2007						X	X	X	X	
Davis 2008						X	X	X	X	
Hadley 2010						X	X	X		
Horiuchi 2009					X	X	X	X	X	
Kamin 2001						X	X			
McLeod 2010								X		
<b>Blended learning vs face-to-face learning</b>										
Brettle 2013							X			
Ilic 2013										
Ilic 2015					X	X	X	X	X	X
Kulier 2009						X	X	X	X	
Saunders 2016					X		X	X	X	X
<b>Blended learning vs pure e-learning</b>										
Fernandez 2014					X	X	X	X	X	X
Kulier 2012						X	X	X	X	
<b>Pure e-learning vs pure e-learning</b>										
MacRae 2004								X		
Brouwers 2011								X		

#### **4.1.2.5 Duration of the interventions**

Duration of interventions in included studies ranged from a single, one hour session in two studies (Davis et al., 2007; Davis et al., 2008) to a journal club addressing one article per month and running over eight months in two studies (Macrae et al., 2004; McLeod et al., 2010). In one study, the intervention period was two weeks, consisting of five half day sessions (Bradley et al., 2005), while in another, the intervention consisted of two one-hour sessions which were one month apart (Brettle & Raynor, 2013). In nine studies, interventions were delivered over a three to eight week period, with learners progressing according to their own needs (Bergold et al., 2013; Brouwers et al., 2011; Hadley et al., 2010; Horiuchi et al., 2009; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Ramos-Morcillo et al., 2015; Saunders et al., 2016; Schilling et al., 2006; Welch, Van Lunen, & Hankemeier, 2014). One study only specified that the intervention was delivered during the “fall quarter” and that participants accessed the learning material according to their own needs (Kamin et al., 2001). In one study with three intervention arms, the interventions were delivered over a period of 15 weeks, with 10 hours per week allocated to studying the content. In one of the intervention arms, participants received three additional workshops of two hours each (Fernandez et al., 2014). The interventions in two studies comprised ten two-hour sessions delivered over two periods of two months each (Ilic et al., 2013; Ilic et al., 2015), while the intervention of another consisted of five contact days spread over a period of six months (Kok et al., 2013). Two studies with blended learning interventions included an initial workshop followed by a period of online support, during which participants engaged with the content according to their own needs. In one of these, (Dizon et al., 2014) the one day workshop consisted of six lectures and four practical sessions, while the period of online support lasted three months. In the other, the duration of the workshops varied from one to five days, while the entire intervention period lasted 18 months (Forsetlund et al., 2003).

#### **4.1.2.6 Learning theories**

In ten studies, the intervention was explicitly based on a learning theory or on one or more learning approaches. Three studies referred to distributed learning (Bergold et al., 2013; Bradley et al., 2005; Horiuchi et al., 2009), another three based their intervention on the adult learning theory (Dizon et al., 2014; Macrae et al., 2004; Schilling et al., 2006), and two interventions made use of a learner centred approach (Bergold et al., 2013; Kulier et al., 2012). Other theories and learning approaches included the SPICES framework (Bergold et al., 2013), the constructivist model of learning (Fernandez et al., 2014), the innovation-diffusion process (Forsetlund et al., 2003), novice to expert theory and theory of planned behaviour (Laibhen-Parkes, 2014), just-in-time learning (Kulier et al., 2012), and the utility of reflective learning and collaborative learning (Schilling et al., 2006).

#### **4.1.2.7 Comparisons**

Comparisons included no EBHC learning, face-to-face learning of EBHC and e-learning of EBHC. Three studies compared pure e-learning to no learning (Laibhen-Parkes, 2014; Schilling et al., 2006; Welch, Van Lunen, & Hankemeier, 2014), while five studies compared blended learning to no learning (Bergold et al., 2013; Dizon et al., 2014; Forsetlund et al., 2003; Kok et al., 2013; Ramos-Morcillo et al., 2015). Seven studies compared pure e-learning to face-to-face learning

(Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Horiuchi et al., 2009; Kamin et al., 2001; McLeod et al., 2010) and five studies compared blended learning to face-to-face learning (Brettle & Raynor, 2013; Ilic et al., 2013; Ilic et al., 2015; Kulier et al., 2009; Saunders et al., 2016). Three studies compared blended learning to pure e-learning (Fernandez et al., 2014; Kamin et al., 2001; Kulier et al., 2012) and two studies compared pure e-learning to other purely e-learning interventions (Brouwers et al., 2011; Macrae et al., 2004).

Amongst the sixteen trials that compared e-learning interventions to either face-to-face, blended or other e-learning interventions, there were nine single-component (Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Hadley et al., 2010; Macrae et al., 2004; Saunders et al., 2016) and nine multi-faceted (Fernandez et al., 2014; Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kamin et al., 2001; Kulier et al., 2009; Kulier et al., 2012; McLeod et al., 2010) comparisons. Comparisons of all included studies were delivered via stand-alone teaching as opposed to integrated teaching. Four of the control interventions involved collaborative learning (Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kamin et al., 2001), while the rest relied on individual learning.

Amongst the face-to-face and blended learning interventions, didactic lectures were the most common intervention component (Brettle & Raynor, 2013; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kulier et al., 2009; Saunders et al., 2016). For four of these (Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Saunders et al., 2016), it was the only intervention component. Other face-to-face components were small group discussions (Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kamin et al., 2001), an interactive workshop (Bradley et al., 2005; Ilic et al., 2015; Kulier et al., 2009), hands-on computer training (Brettle & Raynor, 2013; Fernandez et al., 2014) and a journal club (McLeod et al., 2010). The most common e-learning component of blended comparisons was access to the online teaching site and materials (Fernandez et al., 2014; Kamin et al., 2001). Other components included receiving teaching material via email (Brouwers et al., 2011; McLeod et al., 2010), access to databases and journals (Forsetlund et al., 2003; Macrae et al., 2004) access to a tutor on demand (Kulier et al., 2012) and recorded PowerPoint presentations (Kulier et al., 2012).

The content and duration of the control interventions was the same in both intervention and comparison groups.

#### **4.1.2.8 Outcomes**

##### *Primary outcomes*

Twelve trials reported on EBHC knowledge (Bergold et al., 2013; Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Fernandez et al., 2014; Forsetlund et al., 2003; Hadley et al., 2010; Horiuchi et al., 2009; Kamin et al., 2001; Kulier et al., 2009; Kulier et al., 2012; Welch, Van Lunen, & Hankemeier, 2014). Six trials reported on EBHC knowledge and skills as a combined outcome (Dizon et al., 2014; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Laibhen-Parkes, 2014; Ramos-Morcillo et al., 2015). Across studies, knowledge was measured with various validated tools or adaptations of these. The most commonly used tools were the Berlin questionnaire and the Fresno

test. Four studies used a questionnaire based on both the Fresno test and the Berlin questionnaire (Davis et al., 2007; Davis et al., 2008; Kulier et al., 2009; Kulier et al., 2012), four studies used an adapted version of the Fresno test (Bergold et al., 2013; Dizon et al., 2014; Kok et al., 2013; Laibhen-Parkes, 2014), and two studies made use of the Berlin questionnaire or adaptations thereof (Ilic et al., 2013; Ilic et al., 2015). Both these studies made use of additional assessments to measure EBHC knowledge, (Ilic et al., 2013) made use of two assignment tasks, while (Ilic et al., 2015) used the validated ACE tool. Two studies (Bradley et al., 2005; Hadley et al., 2010) made use of a questionnaire validated by Taylor et al. (Taylor et al., 2001). Ramos-Morcillo et al. (2015) used a Spanish version of the Evidence-based Practice Questionnaire (EBPQ) and Saunders et al., (2016) measured EBHC knowledge as part of the Evidence-based Readiness Inventory (ERI). Two studies measured knowledge with questionnaires developed by the study authors or working group (Kamin et al., 2001; Welch, Van Lunen, & Hankemeier, 2014), another (Forsetlund et al., 2003) measured self-reported knowledge on a Likert scale. In a further study knowledge scores were based on assignment marks (Fernandez et al., 2014).

Eight studies reported on EBHC skills (Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Fernandez et al., 2014; Kulier et al., 2012; Macrae et al., 2004; McLeod et al., 2010; Schilling et al., 2006). In four studies participants had to critically appraise an article and were given scores for their appraisals (Bradley et al., 2005; Brouwers et al., 2011; Macrae et al., 2004; McLeod et al., 2010). Two studies scored the searches of participants (Brettle & Raynor, 2013; Schilling et al., 2006) and one study used an objective, structured clinical examination to measure EBHC skills (Kulier et al., 2012).

Thirteen studies reported attitude towards EBHC (Bradley et al., 2005; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2013; Ilic et al., 2015; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Ramos-Morcillo et al., 2015; Schilling et al., 2006). All the studies made use of Likert scale questionnaires.

Five trials evaluated EBHC behaviour (Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2015; Kok et al., 2013; Ramos-Morcillo et al., 2015), of which two (Ilic et al., 2015; Ramos-Morcillo et al., 2015) measured behaviour with the Evidence-based Practice Questionnaire (EBPQ), requiring participants to rate their EBHC behaviour using a 7-point Likert scale.

Dizon et al. (2014) made use of activity diaries. EBHC behaviour of physiotherapists measured through activity diaries was categorized into evidence-based practice (EBP) behaviours (formulating PICO questions, logging PICO questions, searching research for evidence, appraising evidence and applying evidence) and non-EBP behaviours (asking colleagues, asking medical doctors and reading textbooks). This was reported for new or unique cases as well as for usual cases.

One study (Forsetlund et al., 2003) analysed the content of the local health service reports and asked participants to complete a hypothetical assignment and a questionnaire on self-reported behaviour. Scores (1-5) for the assignments were based on the extent to which the document reflected EBHC elements.

Kok et al. (2013) assessed the frequency of evidence of sufficient quality in disability evaluation reports through six indicators – presence of evidence; a discernible EBM question; search strategy; EBM source; and evaluation of quality.

Eight studies measured outcomes after the intervention only (Bradley et al., 2005; Brouwers et al., 2011; Fernandez et al., 2014; Ilic et al., 2013; Ilic et al., 2015; Laibhen-Parkes, 2014; Macrae et al., 2004; McLeod et al., 2010), while all other studies measured outcomes both before and after the intervention.

### *Secondary outcomes*

Satisfaction with learning was reported in four studies (Bergold et al., 2013; Brouwers et al., 2011; Horiuchi et al., 2009; Ilic et al., 2015) and enablers and barriers of EBHC learning in one study (Ilic et al., 2015). Attrition of learners was reported in 17 trials (Bergold et al., 2013; Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Davis et al., 2008; Dizon et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Macrae et al., 2004; McLeod et al., 2010; Saunders et al., 2016).

#### **4.1.2.9 Educational context**

Educational context in terms of learner context, institutional context and socio-economic context was not explicitly addressed, although for some studies, having access to a computer and internet was a pre-requisite to participating in the study.

#### **4.1.3 Ongoing studies**

We identified one study (Schneider et al., 2014) that is still on-going ([Table 9.4](#)).

#### **4.1.4 Excluded studies**

From those studies subjected to full-text screening we excluded 30 studies. Reasons for exclusion are listed in the table of excluded studies ([Table 9.5](#)).

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## **4.2 RISK OF BIAS IN INCLUDED STUDIES**

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Overall, we judged risk of bias to be moderate. Details of our judgement of risk of bias are presented as part of the characteristics of included studies ([Table 9.3](#)). The risk of bias across studies is summarised in [Figure 5](#) and [Figure 6](#).

#### **4.2.1 Selection bias**

In 17 RCTs the allocation sequence was adequately generated (Bergold et al., 2013; Bradley et al., 2005; Brettle & Raynor, 2013; Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Forsetlund et al., 2003; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Laibhen-Parkes, 2014; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014). Four non-RCTs did not make use of randomisation

(Fernandez et al., 2014; Ilic et al., 2013; Ramos-Morcillo et al., 2015; Schilling et al., 2006) and three studies did not describe how the allocation sequence was generated so they were judged as having unclear risk of selection bias (Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010). Allocation concealment was adequate in eight RCTs (Bergold et al., 2013; Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012), not done in the four non-RCTs (Fernandez et al., 2014; Ilic et al., 2013; Ramos-Morcillo et al., 2015; Schilling et al., 2006) and not described and thus judged as unclear in 12 studies (Brettle & Raynor, 2013; Brouwers et al., 2011; Forsetlund et al., 2003; Hadley et al., 2010; Kamin et al., 2001; Laibhen-Parkes, 2014; Macrae et al., 2004; McLeod et al., 2010; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014).

Baseline outcome measurements were similar between groups in 10 trials (Bergold et al., 2013; Brettle & Raynor, 2013; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; Ramos-Morcillo et al., 2015; Welch, Van Lunen, & Hankemeier, 2014) and not adequately reported in 13 studies (Bradley et al., 2005; Brouwers et al., 2011; Fernandez et al., 2014; Forsetlund et al., 2003; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2013; Ilic et al., 2015; Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010; Saunders et al., 2016; Schilling et al., 2006). In one study (Laibhen-Parkes, 2014) there was a significant difference in EBHC attitudes between groups at baseline.

Baseline characteristics were similar between groups in six studies (Bradley et al., 2005; Kok et al., 2013; Kulier et al., 2012; Laibhen-Parkes, 2014; Ramos-Morcillo et al., 2015; Schilling et al., 2006), not similar in four studies (Brouwers et al., 2011; Davis et al., 2007; Forsetlund et al., 2003; Saunders et al., 2016), not measured in three studies (Ilic et al., 2013; Ilic et al., 2015; Kulier et al., 2009) and unclear in 11 studies (Bergold et al., 2013; Brettle & Raynor, 2013; Davis et al., 2008; Dizon et al., 2014; Fernandez et al., 2014; Hadley et al., 2010; Horiuchi et al., 2009; Kamin et al., 2001; Macrae et al., 2004; McLeod et al., 2010; Welch, Van Lunen, & Hankemeier, 2014).

#### **4.2.2 Attrition bias**

Fourteen studies (Brouwers et al., 2011; Davis et al., 2008; Dizon et al., 2014; Forsetlund et al., 2003; Hadley et al., 2010; Horiuchi et al., 2009; Ilic et al., 2015; Kok et al., 2013; Kulier et al., 2009; Laibhen-Parkes, 2014; Macrae et al., 2004; McLeod et al., 2010; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014) were judged as having high risk of attrition bias, due to significant loss to follow up. Five studies (Fernandez et al., 2014; Kamin et al., 2001; Kulier et al., 2012; Ramos-Morcillo et al., 2015; Schilling et al., 2006) did not adequately describe the flow of all participants and were judged as having unclear risk of attrition bias, whereas five studies (Bergold et al., 2013; Bradley et al., 2005; Brettle & Raynor, 2013; Davis et al., 2007; Ilic et al., 2013) were judged as having low risk of attrition bias.

#### **4.2.3 Detection bias**

Eleven studies (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Dizon et al., 2014; Forsetlund et al., 2003; Ilic et al., 2015; Kamin et al., 2001; Kok et al., 2013; Laibhen-Parkes, 2014; Macrae et al., 2004; Schilling et al., 2006) adequately blinded outcome assessors and were judged as having low risk of detection bias. We judged three studies (Fernandez et al., 2014; Ilic et al.,

2013; McLeod et al., 2010) as having high risk of detection bias, since outcome assessors were not adequately blinded. The remaining 10 studies (Bergold et al., 2013; Brettle & Raynor, 2013; Brouwers et al., 2011; Hadley et al., 2010; Horiuchi et al., 2009; Kulier et al., 2009; Kulier et al., 2012; Ramos-Morcillo et al., 2015; Saunders et al., 2016; Welch, Van Lunen, & Hankemeier, 2014) did not adequately report on blinding and were judged as having unclear risk of detection bias.

#### **4.2.4 Contamination**

Eight trials (Brouwers et al., 2011; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Ilic et al., 2015; Kulier et al., 2009; Kulier et al., 2012; McLeod et al., 2010) were adequately protected against contamination. We judged two trials as having high risk of contamination (Bergold et al., 2013; Saunders et al., 2016;); in the remaining 14 trials (Bradley et al., 2005; Brettle & Raynor, 2013; Dizon et al., 2014; Fernandez et al., 2014; Forsetlund et al., 2003; Horiuchi et al., 2009; Kamin et al., 2001; Kok et al., 2013; Laibhen-Parkes, 2014; Macrae et al., 2004; Schilling et al., 2006; Welch, Van Lunen, & Hankemeier, 2014) the risk of contamination was unclear.

#### **4.2.5 Reporting biases**

We judged one study (Kulier et al., 2012) as having unclear risk of reporting bias, since the authors only reported the baseline measurements for one of the outcomes. The remaining studies all reported on pre-specified outcomes and were judged as having low risk of reporting bias.

#### **4.2.6 Other bias**

We judged five studies (Bergold et al., 2013; Fernandez et al., 2014; Kamin et al., 2001; Kulier et al., 2012; Laibhen-Parkes, 2014) as having unclear risk of other bias and the remaining studies as low risk of other bias.

#### **4.2.7 Additional risk of bias in cluster RCTs**

##### ***4.2.7.1 Recruitment bias***

Three cluster randomised trials (Hadley et al., 2010; Kok et al., 2013; McLeod et al., 2010) had low risk of recruitment bias, since participants were recruited before randomisation of clusters. For three studies (Ilic et al., 2015; Kulier et al., 2009; Laibhen-Parkes, 2014) it was unclear whether participants were recruited before or after randomisation of clusters, and one trial (Kulier et al., 2012) was at high risk of recruitment bias, since participants were recruited after randomisation.

##### ***4.2.7.2 Baseline imbalance***

In three studies (Kok et al., 2013; Kulier et al., 2012; Laibhen-Parkes, 2014), baseline characteristics were not significantly different between groups whereas in two other studies (Hadley et al., 2010; McLeod et al., 2010), it was unclear whether there were baseline imbalances between groups. Two studies (Ilic et al., 2015; Kulier et al., 2009) did not measure baseline characteristics and were judged as having high risk of baseline imbalances.

#### **4.2.7.3 Loss of clusters**

One study (Kulier et al., 2012) lost more than 20% of clusters and was judged as having high risk of bias. Five studies (Hadley et al., 2010; Ilic et al., 2015; Kok et al., 2013; Laibhen-Parkes, 2014; McLeod et al., 2010) had unclear risk of bias, since loss of clusters was not reported, and one study (Kulier et al., 2009) had low risk of bias.

#### **4.2.7.4 Incorrect analysis**

We judged five studies as having low risk of bias (Hadley et al., 2010; Kok et al., 2013; Kulier et al., 2009; Kulier et al., 2012; McLeod et al., 2010), since authors reported that adjustment for clustering was done. Two studies (Ilic et al., 2015; Laibhen-Parkes, 2014) did not adjust results for clustering and we judged them as having high risk of bias.

#### **4.2.7.5 Compatibility with individually randomised controlled trials**

Results from five cluster RCTs were compatible with the individually randomised trials and had low risk of bias. Two studies that did not adjust results for clustering were judged as not being compatible with individually randomised studies (Ilic et al., 2015; Laibhen-Parkes, 2014).

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### **4.3 SYNTHESIS OF RESULTS**

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Twenty-three studies were included in the synthesis of results. One study (Bergold et al., 2013) was excluded from the synthesis because the timing of measurement of outcomes differed for the intervention and comparison group. EBHC knowledge and skills scores were measured at baseline and after the intervention in the intervention group. For the waitlist-control group, however, baseline scores were only measured at three months.

We pooled results using random-effects meta-analysis and report on the pooled standardised mean difference for each outcome. A summary of the results is presented in Table 9.9. Interventions differed considerably between studies, so the overall mean effect may not be an accurate reflection of the impacts for any particular intervention type.

#### **4.3.1 Pure e-learning vs no learning**

One non-randomised trial (Schilling et al., 2006) and two RCTs (Laibhen-Parkes, 2014; Welch et al., 2014) compared pure e-learning to no learning ([Table 12.1](#)). Overall, results favoured pure e-learning interventions.

##### **4.3.1.1 Primary outcomes**

###### **4.3.1.1.1 EBHC knowledge**

One RCT (Welch et al., 2014) reported on EBHC knowledge ([Analysis 1.1](#)). EBHC knowledge scores were higher for participants in the group that received pure e-learning compared to the group that received no learning (SMD 0.71 95%CI 0.40 to 1.01; 1 study, n=175). The SMD of 0.71 can be interpreted as a medium effect size.

#### *4.3.1.1.2 EBHC knowledge and skills*

One RCT (Laibhen-Parkes, 2014) reported on EBHC knowledge and skills. There was no significant difference between groups in post-intervention knowledge and skills scores (SMD 0.47 95%CI - 0.27 to 1.21, 1 study, n=29) ([Analysis 1.2](#)).

#### *4.3.1.1.3 EBHC skills*

One non-RCT (Schilling et al., 2006) reported on EBHC skills. The mean MEDLINE searching score for the intervention group was 2.9 (n=74) compared to 2.1 (n=58) in the control group (p<0.05). The authors did not report standard deviations (SD) or 95%CI for the means. Participants in the intervention group had greater odds of calculating the number needed to treat (NNT) correctly, compared to the control group (OR 5.4 95%CI 2.7 to 11.0, n=179).

#### *4.3.1.1.4 EBHC attitude*

One non-RCT (Schilling et al., 2006) and one RCT (Laibhen-Parkes, 2014) reported on EBHC attitude. Post-intervention attitude scores, adjusted for pre-intervention scores, were higher for the intervention group compared to the control group (SMD 1.05 95% CI 0.26 to 1.83; 1 study, n=29) ([Analysis 1.3](#)). The SMD of 1.05 can be interpreted as a large effect size.

In Schilling et al. (2006), the MD in change of attitude scores from baseline to post-intervention, was significantly higher (p<0.05) in the intervention group for seven of the eight statements related to EBHC attitude.

#### *4.3.1.1.5 EBHC behaviour*

None of the studies comparing EBHC pure e-learning to no intervention reported on EBHC behaviour outcomes.

### **4.3.1.2 Secondary outcomes**

#### *4.3.1.2.1 Satisfaction of students with method of learning*

No studies reported on this outcome.

#### *4.3.1.2.2 Satisfaction of educator with method of learning*

No studies reported on this outcome.

#### *4.3.1.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.1.2.4 Barriers to the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.1.2.5 Cost*

No studies reported on this outcome.

#### *4.3.1.2.6 Attrition of learners*

Two studies reported on attrition rates (Laibhen-Parkes, 2014; Welch, Van Lunen, & Hankemeier, 2014). There was no difference in attrition rates between the intervention and control group for this comparison (RR 1.03; 95% CI 0.9 to 1.18;  $\chi^2=1.58$ ,  $P=0.21$ ;  $I^2=37\%$ ;  $n=531$ ) ([Analysis 1.4](#)).

#### *4.3.1.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.1.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.1.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.1.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.1.2.11 Individual health outcomes*

No studies reported on this outcome.

#### *4.3.1.2.12 Population health outcomes*

No studies reported on this outcome.

### **4.3.2 Blended learning vs no learning**

One non-RCT (Ramos-Morcillo et al., 2015) and four RCTs (Bergold et al., 2013; Dizon et al., 2014; Forsetlund et al., 2003; Kok et al., 2013) compared blended learning with no learning ([Table 12.2](#)). Overall, results favoured blended learning interventions for EBHC knowledge and skills.

#### **4.3.2.1 Primary outcomes**

##### *4.3.2.1.1 EBHC knowledge*

One RCT (Forsetlund et al., 2003) reported on EBHC knowledge. Knowledge scores were higher in the blended learning group compared to the control group (SMD 0.50 95%CI 0.13 to 0.86; 1 study,  $n=119$ ) ([Analysis 2.1](#)). The SMD of 0.5 can be interpreted as a medium effect size.

##### *4.3.2.1.2 EBHC knowledge and skills*

One non-RCT (Ramos-Morcillo et al., 2015) and two RCTs (Dizon et al., 2014; Kok et al., 2013) reported on EBHC knowledge and skills. These trials measured scores at multiple time points, i.e.

directly post-intervention as well as one month (Kok et al., 2013; Ramos-Morcillo et al., 2015), 3 months (Dizon et al., 2014) and 6 months (Kok et al., 2013) after the intervention. We report on the short term as well as long term EBHC knowledge and skills scores separately.

For EBHC knowledge and skills scores measured immediately post-intervention we included two trials (Dizon et al., 2014; Ramos-Morcillo et al., 2015) in the random-effects meta-analysis ([Analysis 2.2](#)). Although results from both trials favoured blended learning, the pooled effect showed no difference in EBHC knowledge and skills scores (SMD 1.40 95%CI -0.06 to 2.85, 2 studies, n=163). Heterogeneity was high (Tau<sup>2</sup>=1.02; Chi<sup>2</sup>=13.80, P=0.0002; I<sup>2</sup>=93%) and the test for subgroup differences was significant (p=0.0002; I<sup>2</sup>=92%). The SMD of 1.4 can be interpreted as a very large effect size, although the results are not statistically significant.

For EBHC knowledge and skills scores measured one month after the intervention, we included two trials (Kok et al., 2013; Ramos-Morcillo et al., 2015) in the random-effects meta-analysis ([Analysis 2.3](#)). EBHC knowledge and skills scores were higher amongst participants in the blended learning group, compared to the group that received no learning (SMD 0.9 95%CI 0.42 to 1.38, 2 studies, n=141). Heterogeneity was high (Tau<sup>2</sup> = 0.08; Chi<sup>2</sup> = 3.25, P = 0.07; I<sup>2</sup> = 69%) with a significant test for subgroup differences (p=0.07; I<sup>2</sup>=69.2%). The SMD of 0.9 can be interpreted as a large effect size.

For EBHC knowledge and skills scores measured more than 3 months after the intervention, we included two trials (Dizon et al., 2014; Kok et al., 2013) in the random-effects meta-analysis ([Analysis 2.4](#)). EBHC knowledge and skills scores remained higher in the blended learning group compared to the group that received no learning (SMD 1.11 95%CI 0.80 to 1.42, 2 studies, n=186). Heterogeneity was high (Chi<sup>2</sup> = 5.33, P = 0.02; I<sup>2</sup> = 81%). The SMD of 1.11 can be interpreted as a large effect size.

#### 4.3.2.1.3 *EBHC skills*

No studies reported on EBHC skills.

#### 4.3.2.1.4 *EBHC attitude*

One non-RCT (Ramos-Morcillo et al., 2015) and three RCTs (Dizon et al., 2014; Forsetlund et al., 2003; Kok et al., 2013; Ramos-Morcillo et al., 2015) reported on post-intervention attitude scores. Three trials measured scores at multiple time points i.e. directly post-intervention as well as one month (Kok et al., 2013; Ramos-Morcillo et al., 2015), 3 months (Dizon et al., 2014) and 6 months (Kok et al., 2013) after the intervention.

For EBHC attitudes measured directly post-intervention we included one non-RCT (Ramos-Morcillo et al., 2015) and one RCT (Forsetlund et al., 2003) in the random-effects meta-analysis ([Analysis 2.5](#)). There was no difference in EBHC attitude scores between groups (SMD 0.17 95%CI -0.09 to 0.48, 2 studies, n=226). Heterogeneity was absent (Tau<sup>2</sup> = 0.00; Chi<sup>2</sup> = 0.15, P = 0.70; I<sup>2</sup> = 0%).

For EBHC attitude scores measured one month post-intervention, we included one non-RCT (Ramos-Morcillo et al., 2015) and one RCT (Kok et al., 2013) in the random-effects meta-analysis

([Analysis 2.6](#)). There was no difference in EBHC attitude scores between groups (SMD 0.05 95%CI -0.34 to 0.44). Heterogeneity was moderate but non-significant ( $\text{Tau}^2 = 0.05$ ;  $\text{Chi}^2 = 2.36$ ,  $P = 0.12$ ;  $I^2 = 58\%$ ).

One RCT (Kok et al., 2013) measured EBHC attitude six months post-intervention and found no difference between groups (SMD 0.32 95%CI -0.02 to 0.67, 1 study, n=132) ([Analysis 2.7](#)).

In Dizon et al. (2014), attitude scores (3-point Likert scale) in the blended learning group were significantly different compared to the wait-list control group for two of the six attitude statements (“I would lack confidence in undertaking a literature search” and “I would feel confident in undertaking a critical appraisal”) immediately post-intervention and three months post intervention. For the statement “I would find it difficult to change what I already do in clinical practice”, there was a significant difference between groups immediately post-intervention, but not at three months post-intervention.

#### 4.3.2.1.5 EBHC behaviour

One non-RCT (Ramos-Morcillo et al., 2015) and three RCTs (Dizon et al., 2014; Forsetlund et al., 2003; Kok et al., 2013) reported on EBHC behaviour. Dizon et al. (2014) and Kok et al. (2013) measured behaviour 3 months after the intervention. Forsetlund et al. (2003) only measured behaviour directly after the intervention, while Ramos-Morcillo et al. (2015) measured EBHC behaviour directly after, as well as 40 days after the intervention.

For EBHC behaviour measured directly post intervention, we included one non-RCT (Ramos-Morcillo et al., 2015) and one RCT (Forsetlund et al., 2003) in the random-effects meta-analysis ([Analysis 2.8](#)). Overall, there was no difference between groups (SMD 0.06 95%CI -0.28 to 0.40, 2 studies, n=207). Heterogeneity was low ( $\text{Tau}^2 = 0.02$ ;  $\text{Chi}^2 = 1.53$ ,  $P = 0.22$ ;  $I^2 = 35\%$ ) and there was no difference between subgroups ( $p=0.22$ ,  $I^2=34.8\%$ ).

For EBHC behaviour measured one month post intervention, we included one non-RCT (Ramos-Morcillo et al., 2015) in the random-effects meta-analysis ([Analysis 2.9](#)). There was no significant difference between groups (SMD 0.19 95%CI -0.19 to 0.56, 1 study, n=109).

For EBHC behaviour measured 3+ months post-intervention, we included one RCT (Kok et al., 2013) in the random-effects meta-analysis ([Analysis 2.10](#)). Behaviour scores were greater for the blended learning compared to no learning results (SMD 0.61 95%CI 0.21 to 1.01, 1 study, n=100). The SMD can be interpreted as a medium effect size.

In Dizon et al. (2014), 18 participants in the intervention and 19 in the wait-list control group submitted activity diaries three months post-intervention. There was a significant difference in EBHC behaviour between groups for all categories when faced with a new or unique case (n=24), and significant differences for all but one category (logging PICO questions) when participants were faced with usual cases (n=19). For non-EBP behaviour, there was a significant difference between groups for two (asking medical doctors and reading textbooks) of the three categories when faced with a new case, but no significant difference between groups when faced with a usual case.

### **4.3.2.2 Secondary outcomes**

#### *4.3.2.2.1 Satisfaction of students with method of learning*

No studies reported on this outcome.

#### *4.3.2.2.2 Satisfaction of educator with method of learning*

No studies reported on this outcome.

#### *4.3.2.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.2.2.4 Barriers to the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.2.2.5 Cost*

No studies reported on this outcome.

#### *4.3.2.2.6 Attrition of learners*

Three studies (Bergold et al., 2013; Dizon et al., 2014; Kok et al., 2013) reported on attrition rates. Random-effects meta-analysis ([Analysis 2.11](#)) showed no significant difference in attrition of learners between groups (RR 0.82 95%CI 0.55 to 1.20; n=306;  $\text{Chi}^2=0.75$ ,  $P=0.69$ ;  $I^2=0\%$ ).

#### *4.3.2.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.2.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.2.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.2.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.2.2.11 Individual health outcomes*

No studies reported on this outcome.

#### *4.3.2.2.12 Population health outcomes*

No studies reported on this outcome.

### **4.3.3 Pure e-learning vs face-to-face learning**

Six RCTs (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Horiuchi et al., 2009; McLeod et al., 2010) compared pure e-learning to face-to-face learning ([Table 12.3](#)). Overall, there was no difference between groups for any of the outcomes.

#### **4.3.3.1 Primary outcomes**

##### *4.3.3.1.1 EBHC knowledge*

Five RCTs reported on EBHC knowledge (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Horiuchi et al., 2009) and were included in the random-effects meta-analysis ([Analysis 3.1](#)). There was no difference in knowledge scores between pure e-learning compared to face-to-face learning (SMD -0.03 95%CI -0.26 to 0.20; 5 studies, n=632).

Heterogeneity was moderate ( $\text{Tau}^2 = 0.03$ ;  $\text{Chi}^2 = 7.74$ ,  $P = 0.10$ ;  $I^2 = 48\%$ ) and caused by one outlier (Davis et al., 2008). A possible reason for Davis et al. (2008) being the only study where results favoured face-to-face learning is the attrition rate amongst participants in the pure e-learning group (44/114; 39%) compared to the face-to-face learning group (6/115; 5%). When removing this trial from the analysis, the effect does not change (SMD 0.05 95%CI -0.14 to 0.25) and heterogeneity is reduced ( $\text{Tau}^2 = 0.00$ ;  $\text{Chi}^2 = 3.24$ ,  $P = 0.36$ ;  $I^2 = 7\%$ ).

##### *4.3.3.1.2 EBHC knowledge and skills*

No studies reported on this outcome.

##### *4.3.3.1.3 EBHC skills*

Two RCTs reported on EBHC skills (Bradley et al., 2005; McLeod et al., 2010) and were included in the random-effects meta-analysis ([Analysis 3.2](#)). There was no difference in EBHC skills scores between groups (SMD -0.15 95%CI -0.34 to 0.04; 2 studies, n=457), with no significant heterogeneity ( $\text{Tau}^2 = 0.00$ ;  $\text{Chi}^2 = 1.04$ ,  $P = 0.31$ ;  $I^2 = 4\%$ ).

##### *4.3.3.1.4 EBHC attitude*

Three RCTs (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008) reported on EBHC attitude. Data from one RCT (P. Bradley et al., 2005) showed no difference in EBHC attitude scores between groups (SMD 0.11 95%CI -0.27 to 0.48, 1 study, n=111) ([Analysis 3.3](#)). Change in EBHC attitude from baseline to post-intervention was similar between groups in Davis et al. (2007) and Davis et al. (2008). Authors did not report on means and SDs.

##### *4.3.3.1.5 EBHC behaviour*

No studies reported on this outcome.

#### **4.3.3.2 Secondary outcomes**

##### *4.3.3.2.1 Satisfaction of students with method of learning*

One study (Horiuchi et al., 2009) explored learners' satisfaction with the learning modality and reported selected quotes from both groups. The intervention group felt that learning at their own pace and in their own time was very convenient, but some also felt that they at times lacked motivation to engage with the content. The face-to-face learning group enjoyed the interaction and small group discussions during the sessions but some could not fit the sessions into their schedule.

#### *4.3.3.2.2 Satisfaction of educator with method of learning*

No studies reported on this outcome.

#### *4.3.3.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.3.2.4 Barriers to the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.3.2.5 Cost*

No studies reported on this outcome.

#### *4.3.3.2.6 Attrition of learners*

Six studies reported on attrition rates (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Hadley et al., 2010; Horiuchi et al., 2009; McLeod et al., 2010). In Davis et al. (2007), no participants were lost to follow-up.

Random-effects meta-analysis ([Analysis 3.4](#)) of the attrition rates showed no difference for attrition rates between e-learning and face-to-face learning groups (RR 1.24 95% CI 0.59 to 2.59; 5 studies n=1175;  $\text{Tau}^2 = 0.55$ ;  $\text{Chi}^2 = 35.20$ ,  $P < 0.00001$ );  $I^2 = 89\%$ ).

#### *4.3.3.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.3.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.3.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.3.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.3.2.11 Individual health outcomes*

No studies reported on this outcome.

#### 4.3.3.2.12 Population health outcomes

No studies reported on this outcome.

### 4.3.4 Blended learning vs face-to-face learning

One non-RCT (Ilic et al., 2013) and four RCTs (Brettle & Raynor, 2013; Ilic et al., 2015; Kulier et al., 2009; Saunders et al., 2016) compared blended learning to face-to-face learning ([Table 12.4](#)). Overall, results were similar between groups for EBHC knowledge and skills, but favoured the blended learning approach for EBHC attitude and behaviour.

#### 4.3.4.1 Primary outcomes

##### 4.3.4.1.1 EBHC knowledge

Two RCTs reported on EBHC knowledge (Kulier et al., 2009; Saunders et al., 2016) and were included in the random-effects meta-analysis ([Analysis 4.1](#)). Results from Kulier et al. (2009) showed no difference in EBHC knowledge scores between groups (SMD 0.28 95%CI -0.23 to 0.79; 1 study, n=61).

Saunders et al. (2016) did not provide means and SDs and we were thus not able to include these in the meta-analysis. We contacted authors and are awaiting their response.

##### 4.3.4.1.2 EBHC knowledge and skills

One non-RCT (Ilic et al., 2013) and one RCT (Ilic et al., 2015) reported on EBHC knowledge and skills and were included in the random-effects meta-analysis ([Analysis 4.2](#)). There was no difference in EBHC knowledge and skills scores between groups (SMD -0.23 95%CI -0.52 to 0.06; 2 studies; n=208). Heterogeneity was low (Tau<sup>2</sup> = 0.00; Chi<sup>2</sup> = 0.01, P = 0.93; I<sup>2</sup> = 0%) and there was no significant difference between subgroups (p=0.93, I<sup>2</sup>=0%).

##### 4.3.4.1.3 EBHC skills

One RCT reported on EBHC skills (Brettle & Raynor, 2013). Post-intervention searching scores were not significantly different between groups after the first session (SMD -0.21 95%CI -0.68 to 0.26; n=70) ([Analysis 4.3](#)).

##### 4.3.4.1.4 EBHC attitude

One non-RCT (Ilic et al., 2013) and two RCTs (Ilic et al., 2015; Kulier et al., 2009) reported on EBHC attitude, but only Ilic et al. (2015) reported sufficient data to be included in a meta-analysis. EBHC attitude scores were significantly higher in the blended learning group compared to the face-to-face learning group (SMD 1.07 95%CI 0.57 to 1.58; 1 study, n=82) ([Analysis 4.4](#)). The SMD of 1.08 can be interpreted as a large effect size.

In Ilic et al. (2013) attitude scores in the blended learning group were significantly higher compared to the face-to-face group for the statement “*I believe that I will use my EBM skills during my clinical career*” (p=0.03), but not for the statement “*I believe that practicing evidence based medicine is critical in being a good clinician*” (p=0.08).

There was no statistically significant difference in attitudinal gain between blended learning and face-to-face learning groups in Kulier et al. (2009).

#### *4.3.4.1.5 EBHC behaviour*

One study (Ilic et al., 2015) reported on EBHC behaviour using the self-reported Evidence-based Practice Questionnaire, which contains six questions related to EBHC behaviour. Data was analysed for 17% (44/263) of participants from the blended learning group and 16% (38/234) of participants from the face-to-face learning group.

EBHC behaviour scores were significantly greater for participants in the blended learning group (SMD 2.34 95%CI 1.72 to 2.96; 1 study, n=82) ([Analysis 4.5](#)). The SMD of 2.35 can be interpreted as a huge effect.

### **4.3.4.2 Secondary outcomes**

#### *4.3.4.2.1 Satisfaction of students with method of learning*

One non-RCT (Ilic et al., 2013) and one RCT (Ilic et al., 2015) reported on satisfaction of participants with the method of learning.

Ilic et al. (2013) found that learners in the blended learning group were significantly more satisfied with the method of learning compared to the face-to-face learning group, with three of the five statements related to satisfaction being statistically significant. Learners preferred the blended learning approach.

Ilic et al. (2015) found that students preferred a blended learning approach. Learners felt that didactic lectures were useful for acquiring new knowledge, but that it did not matter whether these were delivered face-to-face or online. They also perceived small group activities to be useful in acquiring new skills, which also motivated them to apply these in the clinical context. Learners in the face-to-face learning group, however, found the content to be “dense and dry” and felt that the learning approach only supported superficial learning.

#### *4.3.4.2.2 Satisfaction of educator with method of learning*

No studies reported on this outcome.

#### *4.3.4.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.4.2.4 Barriers to the method of learning EBHC*

One RCT reported on the enablers of the method of EBHC learning (Ilic et al., 2015). These included variations in methods of implementation of learning across study sites and the difficulty to apply the learned concepts in clinical practice. Learners also felt that EBHC teaching would have greater value in subsequent clinical years.

#### *4.3.4.2.5 Cost*

No studies reported on this outcome.

#### *4.3.4.2.6 Attrition of learners*

One non-RCT (Ilic et al., 2013) and four RCTs (Brettelle & Raynor, 2013; Ilic et al., 2015; Kulier et al., 2009; Saunders et al., 2016) reported on attrition of learners. In Ilic et al. (2013) there was no loss to follow-up in either group. The four RCTs were included in the random-effects meta-analysis ([Analysis 4.6](#)) and showed similar attrition rates between blended learning and face-to-face learning groups (RR 1.50 95%CI 0.79 to 2.85; n=729; Tau<sup>2</sup> = 0.17; Chi<sup>2</sup> = 4.59, P=0.20; I<sup>2</sup> = 35%).

#### *4.3.4.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.4.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.4.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.4.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.4.2.11 Individual health outcomes*

No studies reported on this outcome.

#### *4.3.4.2.12 Population health outcomes*

No studies reported on this outcome.

### **4.3.5 Blended learning vs pure e-learning**

One non-RCT (Fernandez et al., 2014) and two RCTs (Kamin et al., 2001; Kulier et al., 2012) compared pure e-learning to blended learning ([Table 12.5](#)). In Fernandez et al. (2014), the pure e-learning intervention (DVD group) was compared to three control groups: the standard distance group (pure e-learning), the computer lab group (blended learning) and the didactic lectures group (blended learning). We included the two blended learning groups for this comparison. Overall, results favoured blended learning.

### **4.3.5.1 Primary outcomes**

#### *4.3.5.1.1 EBHC knowledge*

Two RCTs (Kamin et al., 2001; Kulier et al., 2012) reported on EBHC knowledge and were included in the random-effects meta-analysis ([Analysis 5.1](#)). EBHC knowledge scores were significantly higher in the blended learning group compared to the pure e-learning group (SMD 0.69 95%CI 0.40 to 0.99; 2 studies, n=193). Results were consistent across the two studies with low levels of heterogeneity ( $\text{Tau}^2 = 0.00$ ;  $\text{Chi}^2 = 0.97$ ,  $P = 0.32$ ;  $I^2 = 0\%$ ). The SMD of 0.69 can be interpreted as a medium effect size.

#### *4.3.5.1.2 EBHC knowledge and skills*

No studies reported on this outcome.

#### *4.3.5.1.3 EBHC skills*

One non-RCT (Fernandez et al., 2014) and one RCT (Kulier et al., 2012) reported on EBHC skills. In Fernandez et al. (2014), participants had to submit two assignments. The first assignment measured EBHC skills related to formulating PICO questions, searching the literature and identifying the level of evidence, while the second assignment measured critical appraisal skills. We included critical appraisal scores in the random-effects meta-analysis ([Analysis 5.2](#)). Overall, there was no difference between blended learning and pure e-learning (SMD -0.53 95%CI -2.31 to 1.25; 2 studies, n=218). There was a significant difference between subgroups ( $p < 0.00001$ ,  $I^2 = 96.2\%$ ), with results for the non-RCT (Fernandez et al., 2014) favoring pure e-learning (SMD -1.46 95%CI -2.08 to -0.84) and results for the RCT (Kulier et al., 2012) favouring blended learning (SMD 0.36 95%CI 0.05 to 0.67).

We report the remaining results from Fernandez et al. (2014) related to PICO, searching and levels of evidence in [Analysis 5.3](#). Overall, results favoured the pure e-learning group.

#### *4.3.5.1.4 EBHC attitude*

Although authors of one RCT (Kulier et al., 2012) stated that they measured EBHC attitude, they only reported baseline scores, and not those at follow-up.

#### *4.3.5.1.5 EBHC behaviour*

No studies reported on this outcome.

### **4.3.5.2 Secondary outcomes**

#### *4.3.5.2.1 Satisfaction of students with method of learning*

No studies reported on this outcome.

#### *4.3.5.2.2 Satisfaction of educator with method of learning*

No studies reported on this outcome.

#### *4.3.5.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.5.2.4 Barriers to the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.5.2.5 Cost*

No studies reported on this outcome.

#### *4.3.5.2.6 Attrition of learners*

One RCT (Kulier et al., 2012) reported on attrition of learners. In the blended learning group, 25/123 (20.3%) of learners were lost to follow-up, compared to 13/81 (16%) in the pure e-learning group (RR 1.27, 95%CI 0.69 to 2.33, 1 study, n=204) ([Analysis 5.4](#)).

#### *4.3.5.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.5.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.5.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.5.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.5.2.11 Individual health outcomes*

No studies reported on this outcome.

#### *4.3.5.2.12 Population health outcomes*

No studies reported on this outcome.

### **4.3.6 Pure e-learning vs pure e-learning**

One non-RCT (Fernandez et al., 2014) and two RCTs (Brouwers et al., 2011; Macrae et al., 2004) compared pure e-learning to another form of pure e-learning ([Table 12.6](#)). Brouwers et al. (2011) compared three intervention groups. The first group received an online tutorial on AGREE II and was granted access to a PDF copy of the AGREE II tool, the second group received the online

tutorial plus a practical exercise and feedback, and the third group received the AGREE II manual. For Fernandez et al. (2014), we included the comparison between the DVD group and the standard distance group. In MacRae et al. (2004) the intervention group participated in an online journal club that included an asynchronous discussion list, while the control group only received the articles per email and had access to electronic journals.

#### **4.3.6.1 Primary outcomes**

##### *4.3.6.1.1 EBHC knowledge*

##### *4.3.6.1.2 No studies reported on this outcome. EBHC knowledge and skills*

No studies reported on this outcome.

##### *4.3.6.1.3 EBHC skills*

One non-RCT (Fernandez et al., 2014) and two RCTs (Brouwers et al., 2011; Macrae et al., 2004) reported on EBHC skills. We included critical appraisal skills for one non-RCT (Fernandez et al., 2014) and one RCT (Macrae et al., 2004) in the random-effects meta-analysis ([Analysis 6.1](#)). Results favoured the intervention (SMD 1.30 95%CI 0.68 to 1.98, 2 studies, n=119) with moderate levels of heterogeneity (Tau<sup>2</sup> = 0.12; Chi<sup>2</sup> = 2.45, P = 0.12; I<sup>2</sup> = 59%). The test for subgroup differences was not significant (p=0.12, I<sup>2</sup>=59.2%). The SMD of 1.30 can be interpreted as a very large effect. Interventions comprised a DVD containing all the learning material compared to the standard distance learning programme in Fernandez et al. (2014) and an online journal club with an asynchronous discussion list compared to receiving the journal articles via email in MacRae (2004).

Brouwers et al. (2011) calculated the distance function, which is the difference between participants and experts in scores for each domain of the AGREE II tool. There was no statistically significant difference in distance function between any of the three pure e-learning intervention groups.

EBHC skills related to PICO, searching the literature and levels of evidence are reported in [Analysis 6.2](#). Overall, participants in the DVD group achieved higher scores compared to the standard distance learning group.

##### *4.3.6.1.4 EBHC attitude*

No studies reported on this outcome.

##### *4.3.6.1.5 EBHC behaviour*

#### **4.3.6.2 No studies reported on this outcome. Secondary outcomes**

##### *4.3.6.2.1 Satisfaction of students with method of learning*

One study (Brouwers et al., 2011) reported on satisfaction with the method of learning. There was no statistically significant difference in satisfaction scores between the three pure e-learning groups.

#### *4.3.6.2.2 Satisfaction of educators with method of learning*

No studies reported on this outcome.

#### *4.3.6.2.3 Enablers of the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.6.2.4 Barriers to the method of learning EBHC*

No studies reported on this outcome.

#### *4.3.6.2.5 Cost*

No studies reported on this outcome.

#### *4.3.6.2.6 Attrition of learners*

Two studies (Brouwers et al., 2011; Macrae et al., 2004) reported on attrition rates. Random-effects meta-analysis showed that attrition rates were similar between groups (RR 1.43 95%CI 0.89 to 2.31; n=170;  $\text{Chi}^2 = 0.89$ ,  $P=0.64$ ;  $I^2=0\%$ ) ([Analysis 6.3](#)).

#### *4.3.6.2.7 Learner adherence*

No studies reported on this outcome.

#### *4.3.6.2.8 Evidence-based practice*

No studies reported on this outcome.

#### *4.3.6.2.9 Evidence-based guideline implementation*

No studies reported on this outcome.

#### *4.3.6.2.10 Health care delivery*

No studies reported on this outcome.

#### *4.3.6.2.11 Individual health outcomes*

No studies reported on this outcome.

#### *4.3.6.2.12 Population health outcomes*

No studies reported on this outcome.

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## 5 Discussion

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### 5.1 SUMMARY OF MAIN RESULTS

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Twenty-four studies with a total of 3806 participants comprising 13 individually randomised trials, seven cluster RCTs and four non-RCTs met the inclusion criteria for our systematic review.

Participants included under- and postgraduate students, as well as practicing health care professionals of various health professions with medicine being the most common profession (14/24 studies). Studies were mainly conducted in high-income countries including the USA, Australia and various countries in Europe with only two trials conducted in LMICs – one in the Philippines and one in multiple countries: Argentina, Brazil, Democratic Republic of Congo, India, Philippines, South Africa and Thailand.

E-learning interventions were heterogeneous. Although the content of the interventions generally covered the first four steps of EBHC (asking questions, accessing the literature, critically appraising the literature, and applying the results), we identified 17 different categories of intervention components. The interventions of five studies included only one component (single intervention), while the remaining interventions comprised various components in combination and were considered to be multi-faceted. Duration of interventions ranged from a single, one-hour session to a journal club addressing one article per month and running over eight months. Ten studies explicitly referred to educational theories or learning approaches underpinning the interventions but did not report results in light of these.

Studies mostly reported on EBHC knowledge and skills, with some reporting on EBHC attitude and only five assessing EBHC behaviour. Outcomes were measured at different time points and with various tools, including validated questionnaires, self-perceived knowledge scores, hypothetical assignments and critical appraisal of studies. Outcomes were typically measured and compared after the intervention. Most studies reported outcomes at follow-up, with only a few adjusting results for baseline outcome measurement. Secondary outcomes were rarely reported. Four studies reported on satisfaction of learning, while one study explored barriers to EBHC learning. Rates of the attrition of learners were reported in 16 studies and we were able to pool these results using meta-analysis.

Due to these variations in populations, interventions and measures of outcome assessments across included studies, heterogeneity was considered to be substantial. We therefore pooled results in a random-effects meta-analysis using the SMD for continuous outcomes. Due to the limited number of studies included per comparison, we were unable to explore remaining heterogeneity through

subgroup analysis. Heterogeneity due to the different interventions needs to be taken into consideration when interpreting results. In an effort to tease out the differences and similarities between interventions, we compiled a matrix showing the different intervention components for all the included studies ([Table 9.7](#)). The EBHC content of each intervention is summarised in [Table 9.8](#).

We summarised results for each comparison in [Tables 12.1 to 12.6](#). We found that pure e-learning, compared to no learning, improved EBHC knowledge and attitude. However, studies in this comparison had high risk of selection and attrition bias, sample sizes were small and results imprecise. For each outcome, only one study provided data for the meta-analysis.

Blended learning compared to no learning improved EBHC knowledge, EBHC knowledge and skills one month post-intervention, and 3+ months post-intervention. We did not find significant differences between groups for EBHC attitude and EBHC behaviour. One study assessed EBHC behaviour 3 months after the intervention and found a significant difference in scores, favouring the blended learning group. There was high risk of selection and/or attrition bias across studies, inconsistency in results and imprecision for most outcomes.

There was no difference in results for pure e-learning compared to face-to-face learning for EBHC knowledge, skills and attitude. Results for outcomes in this comparison were more precise compared to other comparisons, there was high risk of attrition bias and moderate heterogeneity for the outcome EBHC knowledge, caused by one outlier.

There was no difference in EBHC knowledge and skills scores when comparing blended learning to face-to-face learning. We found a significant difference between groups for EBHC attitude and behaviour, although only one study with high risk of attrition bias was included in the analysis. In addition, authors did not adequately adjust for clustering.

Blended learning compared to pure e-learning improved EBHC knowledge. There was unclear risk of selection and attrition bias and high risk of recruitment bias and loss of clusters. For EBHC skills, the two studies included in the analysis had inconsistent results. While results for the non-RCT favoured pure e-learning, results for the cluster RCT favoured blended learning. Confidence intervals were thus very wide and the results imprecise.

When comparing various pure e-learning interventions, the pooled effect was imprecise and heterogeneity between studies was high. One study compared a DVD containing recorded PowerPoints and tutorials, as well as access to online learning material (intervention) to a standard online distance learning programme. The other compared an online journal club with an asynchronous discussion list (intervention) to receiving the articles via email and access to journal articles. Studies had high risk of selection, attrition and detection bias.

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## **5.2 OVERALL COMPLETENESS AND APPLICABILITY OF EVIDENCE**

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We found substantial heterogeneity between interventions related both to intervention components and delivery of interventions, as has been shown in a previously conducted systematic review (Sinclair et al 2016). We were unable to perform planned subgroup analysis on the different

dimensions of e-learning, due to the limited number of included studies per meta-analysis. Studies that reported significant differences between groups typically included multi-faceted interventions (interventions comprising more than one intervention component), intervention components that required participants to interact with one another (e.g. asynchronous discussion lists), and integration of learning with clinical practice by including e.g. mobile bedside learning, exercises related to clinical cases, and access to clinical facilitators. These findings are in line with international literature and recommendations on effective teaching of EBHC (Khan & Coomarasamy, 2006; Young et al., 2014). In addition, our results suggest that blended learning is a more effective strategy than pure e-learning, since it includes multiple components by definition and follows a “best of both worlds” approach.

These suggestions also resonate with other literature on e-learning. A systematic review on instructional design variations in internet-based learning, found that interactivity, practice exercises, repetition and feedback appeared to be associated with improved learning outcomes (Cook et al., 2010). A review by Booth and colleagues (2009) found that presentation and design, flexibility, peer communication, support and knowledge validation was effective e-learning techniques for enhancing the learning experience of students.

Educational context was poorly reported in all included studies. As learning does not occur in a vacuum, it is essential to take into consideration the context within which learning takes place (Figure 2). E-learning is a complex process where the learner, the technology and the context interact (Sandars & Lafferty, 2010). Factors such as learner motivation and the presence of role models in the clinical field can impact significantly on the acquisition of knowledge and skills, as well as learners’ attitude towards EBHC. Unfortunately, educational context was poorly reported in all included trials and we were therefore unable to take setting, learner, institution and socio-economic background into consideration in interpreting the results.

Although some studies did show significant differences in EBHC knowledge and skills scores between groups, the post-intervention scores for intervention groups were generally low, especially when measured with either the Fresno test or the Berlin test. Both these tools have been validated to measure all four steps of EBHC (Shaneyfelt et al., 2006) and are commonly used. In Dizon et al. (2014), for example, EBHC knowledge and skills were measured with an adapted Fresno test and the mean post-intervention score in the intervention group was 64.3/156 (41%). In Ilic et al. (2015), the Berlin test was used and the mean post-intervention score in the intervention group was 8.2/15 (57%). This raises questions about the actual effectiveness of the interventions in terms of knowledge gain and whether obtaining half (or less than half) of the maximum score is considered adequate when learning a new skill. In addition, knowledge and skills scores are the measurable, direct effects of the intervention. Increased knowledge and skills do not automatically translate to behaviour change and evidence-informed decision-making, which would be the ultimately desired outcome (Figure 3).

EBHC behaviour is a complex outcome and it is difficult to measure it objectively (Shaneyfelt et al., 2006; Strauss et al., 2004; Tilson et al., 2011). Only five of the included studies reported on this outcome. In two of these (Kok et al., 2012; Forsetlund et al., 2003), EBHC was measured objectively, while the other three (Ilic et al., 2015; Ramos-Morcillo et al., 2015; Dizon et al., 2014)

used self-reported measures. Tilson et al. (2011), as part of the Classification Rubric for EBP Assessment Tools in Education (CREATE) Framework, propose that EBP behaviour should be assessed through activity monitoring. They highlight the lack of adequate tools to measure EBP behaviour and recommend that “valid, practicable methods are needed for monitoring learners’ EBP behaviours that can be used for both formative and summative purposes”. Indeed they also encourage researchers to use a common set of tools when assessing outcomes related to EBHC.

Satisfaction with learning was only addressed in four studies. Learner satisfaction is linked to learner motivation and drive and is thus an important factor to consider when developing EBHC modules. Our results were not conclusive regarding preferences of participants. In two studies, focus group discussions were held with some of the participants and reported on the results as part of the article (Ilic et al., 2013; Ilic et al., 2015), while two other studies (Bradley et al., 2005; Welch, Van Lunen, & Hankemeier, 2014) conducted qualitative interviews alongside the respective quantitative investigation, but published on these results in separate articles. Bradley and colleagues (2005) explored the experiences of students and tutors regarding directed and self-directed learning, but included data from 40% of students that did not participate in the trial. Welch and colleagues explored the perceived effectiveness of the e-learning module, but only included participants from the experimental group in the interviews (Welch, Van Lunen, Hankemeier, et al., 2014).

Attrition rates were high for most studies, even though they were similar between groups for all comparisons. Attrition of learners poses a significant threat to sustainability of e-learning programmes, since initial enthusiasm to learn decreases over time, especially in qualified professionals, who have limited free time to spend on e-learning. The benefits of e-learning in terms of learning at one’s own convenience, time and place can become a disadvantage, especially if it is not linked to assessment or a formal certificate.

The studies included in this review were mostly undertaken in high income countries, with only two studies conducted in LMICs. One study was conducted in the Philippines, while the other was a multisite RCT conducted in various LMICs. Problems with internet connectivity, availability of PCs and access to databases are important challenges that will need to be addressed when implementing e-learning programmes in these countries. The studies conducted in LMICs did not assess these factors, on the contrary, in Kulier et al. (2012) adequate access to computers and databases was a part of the eligibility criteria for participation.

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### **5.3 QUALITY OF THE EVIDENCE**

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We included 13 individually randomised controlled trials, seven cluster RCTs and four non-RCTs. Most comparisons only comprised one or two studies. We summarised results for each comparison in [Tables 12.1 to 12.6](#) and commented on limitations related to the analyses. We made judgements about risk of bias according to the EPOC criteria and made additional judgements on risk of bias for cluster RCTs. Overall, the risk of bias in included studies was moderate. Only eight of the 24 included trials were judged as having low risk of selection bias, having used adequate methods for both random sequence generation and allocation concealment. In addition, baseline characteristics were either not reported or showed significant differences between groups for seven of the included

studies. Fourteen studies were judged as having high risk of attrition bias, since loss to follow-up rates were very high. When making judgements about blinding, we only considered blinding of outcome assessors (detection bias), since blinding of participants and personnel (performance bias) is usually not possible for educational interventions. Three studies were judged as having high risk of detection bias, while ten studies did not report on blinding and were judged as having unclear risk of detection bias. We were unable to make a judgement regarding contamination for most individually randomised trials, since authors did not report how contamination was avoided. Of the cluster RCTs, two trials did not adjust results for clustering, limiting their compatibility with individually randomised trials. One study was judged as having high risk of recruitment bias, since participants were recruited after randomisation of clusters.

These limitations in quantity and quality of the evidence need to be taken into consideration when interpreting results.

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#### **5.4 LIMITATIONS AND POTENTIAL BIASES IN THE REVIEW PROCESS**

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We attempted to minimize bias in the review process. We conducted a comprehensive search across multiple medical and educational databases and did not apply any limits with regards to language or publication status. Two authors independently screened search results, selected studies for inclusion, extracted data and made risk of bias assessments. We also contacted authors in an attempt to obtain missing data. We were unable to produce funnel plots to assess reporting bias, since we did not include more than 10 studies per outcome in the meta-analysis.

The main limitation of our review is that we were unable to address our secondary objectives, because our included studies provided insufficient information on educational context and implementation strategies. In addition, we were unable to perform planned subgroup analysis on the effects of specific dimensions of e-learning. This was due to inadequate reporting of the included interventions and the small number of included trials per comparison. Phillips et al. (2016) recently published a guideline for reporting evidence-based practice educational interventions and teaching (GREET), in which they highlight the need to report details of the intervention. These include describing the educational theories or approaches, the learning objectives and EBHC content, learning materials and educational strategies, modes of delivery and educational environment. Indeed, we planned to extract data related to all these issues, but found that interventions were generally poorly described.

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#### **5.5 AGREEMENTS AND DISAGREEMENTS WITH OTHER STUDIES OR REVIEWS**

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EBHC e-learning is embedded in two domains, namely teaching EBHC and e-learning.

In terms of teaching EBHC, the findings of our review echo the results of an overview of systematic reviews on the effectiveness of EBHC teaching and learning, which included 16 systematic reviews (Young et al., 2014). This review recommends that teaching and learning strategies should be multi-faceted and clinically integrated and that they should incorporate assessment. We found that

effective EBHC e-learning interventions were multi-faceted, contained interactive components and were integrated into clinical practice. Blended learning appeared to be more effective than pure e-learning.

The systematic review by Ilic & Maloney (2014) that aimed to determine which types of educational methods were most effective in increasing EBHC knowledge and skills included four of the studies included in our review (Bradley et al., 2005; Davis et al., 2007; Davis et al., 2008; Schilling et al., 2006) but compared a variety of educational methods (e.g. lectures, workshops, small group learning, problem-based learning, online learning, computer-assisted learning) and did not focus on e-learning compared to other types of learning. They found no difference in knowledge and skills between various educational methods.

In terms of e-learning, our review is also in accordance with the results of other relevant studies. When comparing e-learning (pure e-learning or blended learning) to no learning, our results were similar to those of other systematic reviews, favoring pure e-learning for knowledge and skills (Al-Shorbaji et al., 2015; Cook et al., 2008; Liu et al., 2016) and blended learning for EBHC behaviour (Sinclair et al., 2016).

When comparing e-learning (pure e-learning and blended learning) to other methods of learning (face-to-face learning or pure e-learning), our results were similar to those from other systematic reviews for pure e-learning compared to face-to-face learning, showing no difference in EBHC knowledge, skills, attitude (Al-Shorbaji et al., 2015; Cook et al., 2008; Liu et al., 2016) and behaviour (Sinclair et al., 2016). Our results favoured blended learning for EBHC attitude and behaviour when compared to face-to-face learning, and for EBHC knowledge when compared to pure e-learning.

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## 6 Authors' conclusions

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### 6.1 IMPLICATIONS FOR PRACTICE AND POLICY

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Our findings suggest that e-learning of EBHC, whether pure or blended, compared to no learning, improves EBHC knowledge and skills. We did not find a difference in these outcomes when comparing e-learning to face-to-face learning, suggesting that both methods of learning can be beneficial. It appears that blended learning, which typically comprises multiple intervention components, could be more effective than other types of learning in improving EBHC knowledge, skills, attitude and behaviour.

These findings need to be considered in light of the limited number of studies per outcome in each comparison, risk of bias across studies and heterogeneous interventions, as well as inconsistent and imprecise results.

Importantly, e-learning as such is not a panacea and the principles that apply to EBHC teaching in general (e.g. interactive, clinically integrated teaching) should be considered when developing e-learning training initiatives. Other factors such as resources, feasibility and preference of learners need to be taken into consideration when planning EBHC learning activities.

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### 6.2 IMPLICATIONS FOR RESEARCH

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Future research on EBHC e-learning should focus on the effectiveness of various e-learning components and should aim to identify a combination of minimum components for effective e-learning. Interventions should be based on suitable learning theories, and explicitly reported. In addition, studies should evaluate the educational context as part of the intervention, explore learners' experience with learning and include outcomes related to short- and long term EBHC behaviour and cost of the intervention. Comprehensive reporting of these aspects in primary studies will be critical, if an updated systematic review is to provide more in-depth insights. There is a need to conduct studies on e-learning in LMICs in order to address the challenges unique to these settings.

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## 8 Information about this review

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## 8.2 ROLES AND RESPONSIBILITIES

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Please give brief description of content and methodological expertise within the review team. The recommended optimal review team composition includes at least one person on the review team who has content expertise, at least one person who has methodological expertise and at least one person who has statistical expertise. It is also recommended to have one person with information retrieval expertise.

Who is responsible for the below areas? Please list their names:

- Content: Anke Rohwer, Taryn Young, Eva Rehfuess
- Systematic review methods: Anke Rohwer, Eva Rehfuess, Nkengafac Villyen Motaze, Taryn Young
- Statistical analysis: Anke Rohwer, Eva Rehfuess, Nkengafac Villyen Motaze, Taryn Young
- Information retrieval: Anke Rohwer

AR, TY and ER conceptualized the question for the review. AR did the searches. AR, NVM, ER and TY were involved in selection of studies, data extraction and risk of bias assessment. AR did the

analyses with input from TY, NVM and ER. AR drafted the manuscript. NVM, ER and TY critically engaged with the manuscript and provided input. All authors approved the final manuscript before submission.

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### 8.3 SOURCES OF SUPPORT

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#### **Internal funding:**

Centre for Evidence-based Health Care, Stellenbosch University, South Africa

Institute for Medical Informatics, Biometry and Epidemiology, University of Munich, Germany

#### **External funding:**

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### 8.4 DECLARATIONS OF INTEREST

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AR and TY are authors on the following overview of systematic reviews that is relevant to this systematic review:

Young, T., Rohwer, A., Volmink, J., & Clarke, M. (2014). What are the effects of teaching evidence-based health care (EBHC)? Overview of systematic reviews. *PLoS One*, 9(1), e86706. doi:10.1371/journal.pone.0086706.

EAR and NVM: none known

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### 8.5 PLANS FOR UPDATING THE REVIEW

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We plan to update the review after three years, if funding permits.

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## 8.6 AUTHOR DECLARATION

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### Authors' responsibilities

By completing this form, you accept responsibility for maintaining the review in light of new evidence, comments and criticisms, and other developments, and updating the review at least once every five years, or, if requested, transferring responsibility for maintaining the review to others as agreed with the Coordinating Group. If an update is not submitted according to agreed plans, or if we are unable to contact you for an extended period, the relevant Coordinating Group has the right to propose the update to alternative authors.

### Publication in the Campbell Library

The Campbell Collaboration places no restrictions on publication of the findings of a Campbell systematic review in a more abbreviated form as a journal article either before or after the publication of the monograph version in *Campbell Systematic Reviews*. Some journals, however, have restrictions that preclude publication of findings that have been, or will be, reported elsewhere, and authors considering publication in such a journal should be aware of possible conflict with publication of the monograph version in *Campbell Systematic Reviews*. Publication in a journal after publication or in press status in *Campbell Systematic Reviews* should acknowledge the Campbell version and include a citation to it. Note that systematic reviews published in *Campbell Systematic Reviews* and co-registered with the Cochrane Collaboration may have additional requirements or restrictions for co-publication. Review authors accept responsibility for meeting any co-publication requirements.

**I understand the commitment required to update a Campbell review, and agree to publish in the Campbell Library. Signed on behalf of the authors:**

**Form completed by:**

**Anke Rohwer**

**Date:**

**27.01.2017**

# 9 Tables

## 9.1 SEARCH STRATEGY

<p>Medline via PubMed</p>	<p>(((((("computer-assisted" OR "computer assisted" OR "internet-based" OR "internet based" OR internet OR "web 2.0" OR "web-based" OR "web based" OR online OR electronic OR e-learning OR computer OR "computer-based" OR virtual OR "social media" OR mobile))) AND ((Education, Medical [MeSH] OR "medical education" OR Education, Medical, Graduate [MeSH] OR "graduate medical education" OR Education, Medical, Undergraduate [MeSH] OR "undergraduate medical education" OR Education, Medical, Continuing [MeSH] OR "continuing medical education" OR "continuing professional development" OR course OR training OR module OR workshop OR curriculum OR education OR instruction))) AND (((("critical appraisal" OR "journal club"))) OR (((("evidence-based practice" OR "evidence based practice" OR "evidence-based medicine" OR "evidence based medicine" OR "evidence-based health care" OR "evidence-based healthcare" OR "evidence based health care" OR "evidence based healthcare" OR "evidence-based dentistry" OR "evidence based dentistry" OR "evidence-based nursing" OR "evidence based nursing")))) OR (((("Evidence-Based Practice"[Mesh] OR "Evidence-Based Practice/education"[Mesh] OR "Evidence-Based Medicine"[Mesh] OR "Evidence-Based Dentistry"[Mesh] OR "Evidence-Based Nursing"[Mesh])))))</p>
<p>EMBASE via Ovid</p>	<ol style="list-style-type: none"> <li>1. *evidence based dentistry/ or *evidence based medicine/ or *evidence based practice/ or *evidence based nursing/</li> <li>2. *nursing education/ or *paramedical education/</li> <li>3. *online system/</li> <li>4. exp *medical education/</li> <li>5. (evidence adj2 (health or medic* or nurs*OR pract* or dentist*)).ti,ab.</li> <li>6. (critical* adj1 apprais*).ti,ab.</li> <li>7. (journal adj1 club*).ti,ab.</li> <li>8. (continuing adj1 (profession* or medic* or nurs* or health*) adj1 (development or education)).ti,ab.</li> <li>9. ((medic* or nurs* or dentist* or health*) adj2 (educat* or train* or teach*)).ti,ab.</li> <li>10. 1 or 5 or 6 or 7</li> <li>11. 2 or 4 or 8 or 9</li> <li>12. "e-learning".ti,ab.</li> <li>13. ((online or web or internet or computer or virtual or media or mobile or electronic*) adj2 (learn* or teach* or educat* or course or workshop or train* or instruct* or curricul* or module*)).ti,ab.</li> <li>14. 3 or 12 or 13</li> <li>15. 10 and 11 and 14</li> <li>16. ("computer-assisted" or "computer assisted" or "internet-based" or "internet based" or internet or "web 2.0" or "web-based" or "web based" or online or electronic or e-learning or computer or "computer-based" or virtual or "social media" or mobile).ti,ab.</li> <li>17. ("medical education" or "graduate medical education" or "undergraduate medical education" or "continuing medical education" or "continuing professional development" or course or training or module or workshop or curriculum or education or instruction).ti,ab.</li> </ol>

	<p>18. ("critical appraisal" or "journal club" or "evidence-based practice" or "evidence based practice" or "evidence-based medicine" or "evidence based medicine" or "evidence-based health care" or "evidence-based healthcare" or "evidence based health care" or "evidence based healthcare" or "evidence-based dentistry" or "evidence based dentistry" or "evidence-based nursing" or "evidence based nursing").ti,ab.</p> <p>19. 10 or 18  20. 11 or 17  21. 14 or 16  22. 19 and 20 and 21</p>
<p>CENTRAL,  SCOPUS,  CINAHL, Web  of Science,  PsychNet,  ProQuest</p>	<p>("computer-assisted" OR "computer assisted" OR "internet-based" OR "internet based" OR internet OR "web 2.0" OR "web-based" OR "web based" OR online OR electronic OR e-learning OR computer OR "computer-based" OR virtual OR "social media" OR mobile) AND ("medical education" OR "graduate medical education" OR "undergraduate medical education" OR "continuing medical education" OR "continuing professional development" OR course OR training OR module OR workshop OR curriculum OR education OR instruction) AND ("critical appraisal" OR "journal club" OR "evidence-based practice" OR "evidence based practice" OR "evidence-based medicine" OR "evidence based medicine" OR "evidence-based health care" OR "evidence-based healthcare" OR "evidence based health care" OR "evidence based healthcare" OR "evidence-based dentistry" OR "evidence based dentistry" OR "evidence-based nursing" OR "evidence based nursing" )</p>

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## 9.2 RISK OF BIAS ASSESSMENT FOR RCTS AND NON-RCTS

We answered the following questions with “yes” (low risk of bias), “no” (high risk of bias) or “unclear” (unclear risk of bias) to make judgments of risk bias for RCTs and non-RCTs.

Domain	Yes	No	Unclear
Was the allocation sequence adequately generated?	Low risk of selection bias if the sequence generation was truly random (e.g. computer-generated table of random numbers, tossing a coin)	High risk of bias if sequence generation contained a non-random component (e.g. alternate randomisation, randomisation by birth date)	Unclear risk of bias if the randomisation process was not clearly described
Was the allocation adequately concealed?	Low risk of selection bias if allocation was truly concealed (e.g. central allocation of participants, use of sequentially numbered, opaque, sealed envelopes)	High risk of bias if the allocation process was not concealed (e.g. open randomisation, unsealed or non-opaque envelopes). We will score CBAs as “high risk”	Unclear risk of bias if the process of concealing allocation was not described sufficiently to make a judgement
Were baseline outcome measurements similar?	Low risk of bias if performance or patient outcomes were measured prior to the intervention, and no important differences were present across study groups. We will score RCTs as having low risk of bias if an imbalance is present, but authors appropriately adjusted the results (e.g. Analysis of covariance).	High risk of bias if important differences were present and not adjusted for in analysis.	If RCTs have no baseline measure of the outcome, we will score the study as having unclear risk of bias.
Were baseline characteristics similar?	Low risk of bias if baseline characteristics of the study and control providers are reported in the study and are similar.	High risk of bias if there is no report of participant characteristics in the text or tables; or if there are differences between the control and intervention providers.	Unclear risk of bias if characteristics were not clearly reported in the paper (e.g. characteristics are mentioned in the text but no data were presented).
Were incomplete outcome data adequately addressed?	Low risk of attrition bias if there was no missing data or if missing data was balanced across groups	High risk of bias if there was missing data or if missing data was more prevalent in one of the groups and likely to bias the results	Unclear risk of bias if it is not specified in the paper. We will not assume a 100% follow-up rate, unless it is explicitly stated.
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk of detection bias if they were blind to knowledge about which intervention the participants received; or if outcomes were objective	High risk of bias if blinding was absent	Unclear risk if blinding was not specified in the paper

Was the study adequately protected against contamination?	Low risk of bias if allocation was by community, institution or practice and it is unlikely that the control group received the intervention	High risk of bias if it is likely that the control group received the intervention	Unclear risk of bias if professionals were allocated within an institution or practice and it is possible that communication between intervention and control professionals could have occurred (e.g. physicians within practices were allocated to intervention or control)
Was the study free from selective outcome reporting?	Low risk of reporting bias if it is evident that all pre-specified outcomes have been reported on (e.g. all relevant outcomes in the methods section are reported in the results section).	High risk of bias if it is evident that some outcomes were omitted in the report;	Unclear risk of bias if it is unclear whether all outcomes have been reported on
Was the study free from other risks of bias?	Low risk of bias if there is no evidence of other risks of bias	High risk of bias if there is evidence of other risks of bias (e.g. conflict of interest)	Unclear risk of bias if it is not clear from the paper whether other biases are present

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## 9.3 CHARACTERISTICS OF INCLUDED STUDIES

### 1. Bergold 2013

<b>Methods</b>	RCT - wait list control group
<b>Participants</b>	<ul style="list-style-type: none"> <li>Medical junior doctors, continuing medication (interns)</li> <li>n=120</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>Medical doctors at start of their work at a university hospital during first year (Johann Wolfgang Goethe University, Frankfurt)</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning (blended)</b></p> <ul style="list-style-type: none"> <li>German-language self-directed, independent and tutor-assisted online learning course comprising five sequential modules and designed within EU EBM project</li> <li>Multifaceted intervention, integrated EBHC learning</li> <li>Individual learning, blended learning</li> <li>asynchronous</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying the results</li> </ul> </li> <li>Course delivered over a period of 5 weeks (self-directed)</li> <li>Learning theory: <ul style="list-style-type: none"> <li>SPICES framework</li> <li>Participant-centred approach</li> <li>Distributed learning</li> </ul> </li> </ul> <p><b>Control: No learning</b></p> <ul style="list-style-type: none"> <li>no learning (wait list)</li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>EBHC knowledge <ul style="list-style-type: none"> <li>Knowledge score (0-13), assessed through 13 module-specific questions in sets 1 and 2. Validated questions adapted and pilot-tested; questions sets comparable</li> <li>measured pre- and post-course (at 3, 6, and 12 months)</li> </ul> </li> <li>Satisfaction with learning <ul style="list-style-type: none"> <li>Post course</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: Germany</li> <li>Conflict of interest: not mentioned</li> <li>Ethics approval: not mentioned</li> <li>Funding: Johann Wolfgang Goethe University, Frankfurt</li> <li>Author contacted via email to request SDs for mean values in Table 1, and knowledge scores at 0 months for the control group. No response</li> </ul>

#### 1.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Telephone-randomised wait-list design; computer-generated randomisation list
Was the allocation adequately concealed?	Yes	Participants immediately randomised after recruitment; provision of recruitment information to external site (by telephone), not involved with study
Were baseline outcome measurements similar?	Yes	Intervention group: median 5 (CI 4-6); mean 4.9 Control group: median 4 (CI 4-5); mean 4.9

		no statistical tests performed; no narrative description of baseline results
Were baseline characteristics similar?	Unclear	No table of baseline characteristics. Information on age and gender of participants in text only
Were incomplete outcome data adequately addressed?	Yes	Loss to follow-up was minimal and similar in both groups: Intervention: 3% Control: 6%
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Blinding of researchers, participants and outcome assessors not described at all; blinding of participants highly unlikely, given waitlist design
Was the study adequately protected against contamination?	No	Relatively small participant group, all young newly recruited medical doctors who probably interact frequently with their peers
Was the study free from selective outcome reporting?	Yes	All outcomes pre-specified in the methods section reported on
Was the study free from other bias?	Unclear	Possible selection/response bias: 120 out of 219 eligible young medical doctors agreed to participate and may have more time or be more passionate about learning than non-participants

## 2. Bradley 2005

<b>Methods</b>	RCT
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Undergraduate medical students</li> <li>• n=175</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- All students that attended the first day of the 10<sup>th</sup> semester or gave reason for absence in advance and completed consent and baseline characteristic forms at the University of Oslo</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning</b></p> <ul style="list-style-type: none"> <li>• EBHC course <ul style="list-style-type: none"> <li>- Self-directed: Computer-assisted (CD-ROM) on five steps of EBM</li> </ul> </li> <li>• Single intervention, stand-alone EBHC learning</li> <li>• Individual learning, pure e-learning learning</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the process of EBHC</li> </ul> </li> <li>• Execution:</li> <li>• Duration: 2 weeks</li> <li>• Intensity: 5 times</li> <li>• Dose: half a day</li> <li>• Timing: First two weeks of the 10th semester (20 weeks)</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Encouraged to be autonomous in their learning and to choose the tie, place and speed of learning (distributed learning)</li> </ul> </li> <li>• <b>Control: face-to-face learning</b></li> <li>• Workshop on five steps of EBM <ul style="list-style-type: none"> <li>- directed learning</li> </ul> </li> <li>• Single intervention, stand-alone EBHC learning</li> </ul> <p>EBHC components:</p> <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul>

	<ul style="list-style-type: none"> <li>- Evaluating the process of EBHC</li> <li>• Execution:</li> <li>• Duration: 2 weeks</li> <li>• Intensity: 5 times</li> <li>• Dose: half a day</li> <li>• Timing: First two weeks of the 10th semester (20 weeks)</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Social learning theory</li> </ul> </li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge <ul style="list-style-type: none"> <li>- MCQ with 6 stem questions and 3 sub-questions (validated questionnaire by Taylor et al.)</li> <li>- post-test only at week 20 (end of semester) – compulsory examination</li> </ul> </li> <li>2. EBHC skills <ul style="list-style-type: none"> <li>- Critical appraisal skills; students had to critically appraise a paper. Checklist given to students</li> <li>- post-test only at week 20 (end of semester) - compulsory examination</li> </ul> </li> <li>3. EBHC attitude <ul style="list-style-type: none"> <li>- Questionnaire consisting of 7 statements which student had to rate using a Likert scale (validated questionnaire by Taylor et al.)</li> <li>- Completed during week 3-17, non-compulsory</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Norway</li> <li>• Conflict of interest: yes. none declared</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: no funding received</li> </ul>

### 2.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Yes	Authors used random number tables
Was the allocation adequately concealed?	Yes	Numerically ordered, sealed, opaque envelopes were used
Were baseline outcome measurements similar?	Unclear	No baseline measurement of outcomes
Were baseline characteristics similar?	Yes	There were more female students in the directed group, but we do not think this would have an impact on the results. All other baseline characteristics were similar
Were incomplete outcome data adequately addressed?	Yes	Loss to follow up was minimal and similar for both groups: For knowledge questionnaire: Intervention: 2% Control: 6% Skills questionnaire: Intervention: 4% Control: 2% Attitude questionnaire: (this was a secondary outcome) Intervention: 33% Control: 54%
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Blinding of participants and teachers not possible. Outcome assessors were blinded
Was the study adequately protected against contamination?	Unclear	Attendance registers were kept. 2 of the self-directed group attended 1 session of the directed group. Difficult to prevent directed group from accessing CD ROMs in self-directed group

Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified

### 3. Brettle 2013

<b>Methods</b>	RCT
<b>Participants</b>	<ul style="list-style-type: none"> <li>Nurses, undergraduate</li> <li>n=77</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>New intake in March 2008 (Students not contaminated by previous IL sessions, studying a module that required a large element of IL) at Salford University</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning</b></p> <ul style="list-style-type: none"> <li>Online information literacy tutorial</li> <li>Singe intervention, stand-alone EBHC learning</li> <li>Individual learning, blended learning</li> <li>asynchronous</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Accessing the literature</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>Duration: not described</li> <li>Intensity: 2 sessions, 1 month apart.</li> <li>Dose: 1 hour each for the initial session and follow-up session</li> <li>Timing: First module of foundation training</li> <li>Learning theory: <ul style="list-style-type: none"> <li>not mentioned</li> </ul> </li> </ul> <p><b>Control: face-to-face learning</b></p> <ul style="list-style-type: none"> <li>Face-to-face session on information literacy</li> <li>Singe intervention, stand-alone EBHC learning</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Accessing the literature</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>Duration: not described</li> <li>Intensity: 2 sessions, 1 month apart.</li> <li>Dose: 1 hour each for the initial session and follow-up session</li> <li>Timing: First module of foundation training</li> <li>Learning theory: <ul style="list-style-type: none"> <li>not mentioned</li> </ul> </li> </ul>
<b>Outcomes</b>	<p>1. EBHC skills:</p> <ul style="list-style-type: none"> <li>Search skills (score out of 10)</li> <li>Pre- and post-test for initial and follow-up sessions</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: UK</li> <li>Conflict of interest: not declared</li> <li>Ethics approval: approval obtained</li> <li>Funding: not mentioned</li> </ul>

#### 3.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Students were allocated using an online random number generator
Was the allocation adequately concealed?	Unclear	Authors report that the allocation was concealed but do not describe the method used

Were baseline outcome measurements similar?	Yes	No significant difference between baseline scores
Were baseline characteristics similar?	Unclear	No table of baseline characteristics provided, only description in text
Were incomplete outcome data adequately addressed?	Yes	Loss to follow-up similar in both groups: Intervention: 12.5% Control: 9%
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Participants could not be blinded and it is not mentioned if the outcome assessors were blinded
Was the study adequately protected against contamination?	Unclear	Control group participants were granted access to the online material and intervention group participants had face-to-face sessions. But participants were recruited from the same institutions.
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported
Was the study free from other bias?	Yes	No other source of bias identified

#### 4. Brouwers 2011

<b>Methods</b>	RCT 3 groups
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Participants from various backgrounds (doctors, nurses, physiotherapists, occupational therapists, methodologists, policy makers and trainees)</li> <li>• n=87</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- No or limited experience to the original AGREE instrument or the AGREE II. Participants were sought from guideline programs, professional directories, and the Guideline-International-Network (G-I-N) community</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning</b></p> <p><b>Group 1:</b></p> <ul style="list-style-type: none"> <li>• Online tutorial on AGREEII (multimedia tutorial presentation) and granted access to a PDF copy of the AGREEII to review</li> <li>• Single intervention, stand-alone EBHC learning</li> <li>• Individual learning, Pure e-learning</li> <li>• asynchronous</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Critical appraisal</li> </ul> </li> <li>• Execution: <ul style="list-style-type: none"> <li>- Once off (presentation was 7 minutes long)</li> </ul> </li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul> <p><b>Group 2:</b></p> <ul style="list-style-type: none"> <li>• Online tutorial on AGREE II tool plus exercise and immediate feedback as well as formative feedback if scores fell out of range</li> <li>• Multifaceted intervention, stand-alone EBHC learning</li> <li>• Individual learning, Pure e-learning</li> <li>• asynchronous</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Critical appraisal</li> </ul> </li> <li>• Execution: <ul style="list-style-type: none"> <li>- Once off: presentation was 7 minutes long, not reported how long it took participants to complete exercise.</li> </ul> </li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul> <p><b>Control: e-learning</b></p> <p><b>Group 3:</b></p>

	<ul style="list-style-type: none"> <li>• Participants were given AGREE II manual</li> <li>• Single intervention, stand-alone EBHC learning</li> <li>• Individual learning, pure e-learning</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Critical appraisal</li> </ul> </li> <li>• Execution: <ul style="list-style-type: none"> <li>- Self-directed</li> </ul> </li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul>
<b>Outcomes</b>	1. EBHC skills <ul style="list-style-type: none"> <li>- Performance (using AGREE II to critically appraise a PG) directly after intervention (post-test only)</li> </ul> 2. Satisfaction with learning (directly after intervention)
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Canada</li> <li>• Conflict of interest: declared no conflicts of interest</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: Canadian Institutes of Health Research</li> </ul>

#### 4.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Yes	Computer-generated randomisation sequence
Was the allocation adequately concealed?	Unclear	Not mentioned
Were baseline outcome measurements similar?	Unclear	Post-test only
Were baseline characteristics similar?	No	Participants with PhDs: Group 1: 25%; Group 2: 15%; Group 3: 5% (control) % with health research methods training: Group 1: 85%; group 2: 85%; group 3 (control): 100% Use of AGREE as a tool to evaluate PG - Never: Group 1: 71%; Group 2: 61%; Group 3: 48% (control) Use of AGREE II as a tool to inform PG reporting – Never: Group 1: 97%; Group 2: 100%; Group 3: 84% (control)
Were incomplete outcome data adequately addressed?	No	Loss to follow up: Group 1: 17% Group 2: 23% Group 3: 14% (control)
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Participants were blinded to study conditions, blinding of outcome assessors not reported
Was the study adequately protected against contamination?	Yes	All three groups had online learning and participants did not interact with each other and came from various organisations and backgrounds
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other bias identified

## 5. Davis 2007

<b>Methods</b>	RCT
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors (interns), continuing medical education</li> <li>• n=55</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Newly qualified doctors (interns) in six postgraduate centres in the UK West Midlands participating in the foundation program for newly qualified doctors</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning</b></p> <ul style="list-style-type: none"> <li>• Short, computer-based session on EBM (CD-ROM) consisting of recorded PowerPoint presentations</li> <li>• Single intervention, stand-alone EBHC learning</li> <li>• Individual learning, pure e-learning</li> <li>• asynchronous</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Intensity: a single session</li> <li>• Dose: 60 minutes (40 minutes for the session and 10 min each for the pre- and post-questionnaire)</li> <li>• Timing: Foundation training of newly qualified doctors</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul> <p><b>Control: face-to-face learning</b></p> <ul style="list-style-type: none"> <li>• Face-to-face lecture on EBM with similar content, structure and duration as intervention, using same PowerPoint slides and the same tutor</li> <li>• Single intervention, stand-alone EBHC learning</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Intensity: a single session</li> <li>• Dose: 60 minutes (40 minutes for the session and 10 min each for the pre- and post-questionnaire)</li> <li>• Timing: Foundation training of newly qualified doctors</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge <ul style="list-style-type: none"> <li>- Questionnaire based on validated assessment tools (Berlin and Fresno) 5 questions with pre-determined marking scheme (two structured questions and 3 MCQ)</li> <li>- Immediately pre- and post-intervention</li> </ul> </li> <li>2. EBHC attitude <ul style="list-style-type: none"> <li>- Questions based on validated assessment tools, 6 questions on five point Likert scale</li> <li>- Immediately pre- and post-intervention</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: UK</li> <li>• Conflict of interest: yes, no conflicts of interest declared</li> <li>• Ethics approval: ethics exemption obtained</li> <li>• Funding: West Midlands Deanery</li> </ul>

### 5.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Computer-generated sequence
Was the allocation adequately concealed?	Yes	Sealed envelopes coded by third party, but not mentioned whether they were opaque and sequentially numbered
Were baseline outcome measurements similar?	Yes	Yes, Intervention group had an average score of 69%; comparison group had an average score of 63% (no p-values or confidence intervals reported)
Were baseline characteristics similar?	No	The table of baseline characteristics does not contain results of a statistical test. More participants (almost double the amount) in the lecture group had education in epidemiology and statistics
Were incomplete outcome data adequately addressed?	Yes	All participants accounted for, no loss to follow up
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Not possible to blind teachers and students, but outcome assessors were blinded
Was the study adequately protected against contamination?	Yes	Both sessions were delivered at the same time, in the same institution. Pre and post-test questionnaires completed during this time
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other bias identified

### 6. Davis 2008

<b>Methods</b>	RCT
<b>Participants</b>	<ul style="list-style-type: none"> <li>Medical doctors, undergraduate</li> <li>n=229</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>Not described, undergraduate medical students at the University of Birmingham Medical School</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning</b></p> <ul style="list-style-type: none"> <li>Short, computer-based session on EBM (CD-ROM) consisting of recorded PowerPoint presentations</li> <li>Singe intervention, stand-alone EBHC learning</li> <li>Individual learning, pure e-learning</li> <li>Asynchronous</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>Intensity: a single session</li> <li>Dose: 60 minutes (40 minutes for the session and 10 min each for the pre- and post-questionnaire)</li> <li>Timing: Foundation training of newly qualified doctors</li> <li>Learning theory: <ul style="list-style-type: none"> <li>not mentioned</li> </ul> </li> </ul> <p><b>Control: face-to-face learning</b></p> <ul style="list-style-type: none"> <li>Face-to-face lecture on EBM with similar content, structure and duration as intervention, using same PowerPoint slides and the same tutor</li> </ul>

	<ul style="list-style-type: none"> <li>• Single intervention, stand-alone EBHC learning</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Intensity: a single session</li> <li>• Dose: 60 minutes (40 minutes for the session and 10 min each for the pre- and post-questionnaire)</li> <li>• Timing: Foundation training of newly qualified doctors</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Not mentioned</li> </ul> </li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge</p> <ul style="list-style-type: none"> <li>- Questionnaire based on validated assessment tools (Berlin and Fresno) 5 questions with pre-determined marking scheme (two structured questions and 3 MCQ)</li> <li>- Immediately pre- and post-intervention</li> </ul> <p>2. EBHC attitude</p> <ul style="list-style-type: none"> <li>- Questions based on validated assessment tools, 6 questions on five point Likert scale</li> <li>- Immediately pre- and post-intervention</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: UK</li> <li>• Conflict of interest: not mentioned</li> <li>• Ethics approval: unclear - authors mentioned that study was approved by Birmingham medical school. Not clear whether this refers to ethics approval</li> <li>• Funding: not described</li> </ul>

### 6.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Computer-generated sequence
Was the allocation adequately concealed?	Yes	Sealed envelopes coded by third party, but not mentioned whether they were opaque and sequentially numbered
Were baseline outcome measurements similar?	Yes	Yes, they seem similar: Intervention group: 61%; control group: 63% (no p-values or confidence intervals reported)
Were baseline characteristics similar?	Unclear	The table of baseline characteristics does not contain results of a statistical test. More participants in the lecture group had education in epidemiology and research methods. Not sure whether this is statistically different
Were incomplete outcome data adequately addressed?	No	In the intervention (computer-based) group, loss to follow-up was 39% compared to 5% in the control (lecture-based) group
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Not possible to blind teachers and students, but outcome assessors were blinded
Was the study adequately protected against contamination?	Yes	Both sessions were delivered at the same time, in the same institution. Pre and post-test questionnaires completed during this time
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on

Was the study free from other bias?	Yes	No other bias identified.
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## 7. Dizon 2014

<b>Methods</b>	RCT
<b>Participants</b>	<ul style="list-style-type: none"> <li>Physiotherapists, continuing medical education</li> <li>n=54</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>Licensed Physiotherapists in the Philippines, no previous formal training in EBP</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: E-learning (blended)</b></p> <ul style="list-style-type: none"> <li>EBP training (face-to-face) plus EBP checklist and online support (access to lectures and reference materials; seek assistance in searching for evidence to answer clinical questions; assistance in validity assessments through critical appraisal of the evidence found; ask any queries and provide feedback)</li> <li>Multi-faceted intervention; integrated EBHC learning</li> <li>Individual learning, blended learning</li> <li>asynchronous</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Epidemiology</li> <li>General EBHC</li> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying the results</li> </ul> </li> </ul> <p>Execution (workshop):</p> <ul style="list-style-type: none"> <li>Duration and intensity: one day consisting of 6 lectures interspersed with 4 practical sessions</li> </ul> <p>Execution (online support):</p> <ul style="list-style-type: none"> <li>Duration: 3 months</li> <li>Intensity and dose: self-directed, as needed by participant.</li> <li>Learning theory: <ul style="list-style-type: none"> <li>Adult learning theory</li> </ul> </li> </ul> <p><b>Control: no learning</b></p> <ul style="list-style-type: none"> <li>Wait list</li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>EBHC knowledge: <ul style="list-style-type: none"> <li>Adapted Fresno test: 156 max score</li> <li>Pre- and post-intervention, and at 3 months post intervention</li> </ul> </li> <li>EBHC skills: <ul style="list-style-type: none"> <li>Adapted Fresno test</li> <li>Pre- and post-intervention, and at 3 months post intervention</li> </ul> </li> <li>EBHC attitude <ul style="list-style-type: none"> <li>Validated questionnaire on EBP attitudes, 3 point Likert scale</li> <li>Pre- and post-intervention, and at 3 months post intervention</li> </ul> </li> <li>EBHC behaviour <ul style="list-style-type: none"> <li>Measured by activity diaries – logging activities used to find an answer to a case they were faced with</li> <li>Measured 3 months post intervention</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: Philippines</li> <li>Conflict of interest: yes, none declared</li> <li>Ethics approval: approval obtained</li> <li>Funding: Philippine council for health research and development - department of Science and Technology</li> <li>Authors contacted to obtain mean scores, received response</li> </ul>

### 7.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Computer generated random numbers
Was the allocation adequately concealed?	Yes	Done by an independent researcher, that allocated randomisation sequence to list of participants. "Allocation was concealed from the researchers of this study"
Were baseline outcome measurements similar?	Yes	Yes, no significant differences between baseline knowledge scores
Were baseline characteristics similar?	Unclear	Significant difference btw groups for years in practice and age
Were incomplete outcome data adequately addressed?	No	3 month loss to follow-up in intervention group: 44%, control group: 59%
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Outcome assessors blinded
Was the study adequately protected against contamination?	Unclear	Participants recruited from a database of physical therapists, the network of the Philippine physical therapy association and a list of hospitals. Not clear whether participants had access to each other and discussed the study
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported
Was the study free from other bias?	Yes	No other bias identified

### 8. Fernandez 2014

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Non-RCT</li> <li>• Setting: University of Sydney, University of Hong Kong</li> <li>• Learner context: <ul style="list-style-type: none"> <li>- Students in Hong Kong probably have less background knowledge in EBHC</li> </ul> </li> <li>• Socio-economic context: high-income countries</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Nurses, postgraduate</li> <li>• n= 186</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- All students undertaking the EBN unit in the second session of 2010 and both sessions in 2011</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention: (e-learning)</b></p> <p><b>Group 1 (n=28)</b></p> <ul style="list-style-type: none"> <li>• Evidence-based practice (EBP) DVD: demonstrations of EBP skills provided on a DVD – simulation of computer lab workshops. <ul style="list-style-type: none"> <li>- Standalone EBHC learning, multi-faceted intervention</li> <li>- Pure e-learning, individual learning</li> <li>- Asynchronous</li> </ul> </li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the EBHC process</li> </ul> </li> <li>• Execution: <ul style="list-style-type: none"> <li>- EBHC module</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>- Duration and dose: 15 weeks, 10 hours per week in the Spring and Autumn semesters</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Constructivist model of learning: new information is absorbed by learners by building on pre-existing knowledge and learners accept responsibility for their own learning and are self-motivated to engage in deeper learning</li> </ul> </li> </ul> <p><b>Control:</b></p> <p><b>Group 2 (n=36), e-learning</b></p> <ul style="list-style-type: none"> <li>• Standard distance method: access to e-learning site and learning package <ul style="list-style-type: none"> <li>- standalone EBHC learning, multi-faceted intervention</li> <li>- pure e-learning, individual learning</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBHC module</li> <li>• Duration and dose: 15 weeks, 10 hours per week in the Spring and Autumn semesters</li> </ul> <p><b>Group 3 (n=24), blended learning:</b></p> <ul style="list-style-type: none"> <li>• Computer Lab teaching method (on campus) – practical interactive computer-based training with immediate feedback plus standard access to e-learning site and learning packages) <ul style="list-style-type: none"> <li>- Standalone EBHC learning, multi-faceted intervention</li> <li>- Blended learning, individual learning</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBHC module</li> <li>• Duration and dose: 15 weeks, 10 hours per week in the Spring and Autumn semesters</li> <li>• Additional workshop:</li> <li>• Intensity and dose: 3 workshops in the 15 week period, @ 2 hours each</li> </ul> <p><b>Group 4 (n=99) blended learning</b></p> <ul style="list-style-type: none"> <li>• Face to face didactic classroom teaching method – classroom teaching with access to e-learning site and learning package</li> <li>• Standalone, multi-faceted learning</li> <li>• Blended learning, individual learning</li> <li>• Asynchronous</li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBHC module</li> <li>• Duration: 15 weeks</li> <li>• Intensity and dose: Lectures in week 1,2,6,7, 3.25 hours each; tutorials in week 4 and 9, 2.5 hours each</li> <li>• Delivery agent: lecturer</li> <li>• EBHC components (all control groups) <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the EBHC process</li> </ul> </li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge and skills</p> <ul style="list-style-type: none"> <li>- Assessed using students' assignment marks</li> <li>- post-test only</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Australia and Hong Kong</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: College of Health and Science University of Western Sydney</li> <li>• Authors contacted: No</li> </ul>

### 8.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	No	Non-randomised study
Was the allocation adequately concealed?	No	Non-randomised study
Were baseline outcome measurements similar?	Unclear	No baseline measurement of outcomes
Were baseline characteristics similar?	Unclear	No table or description of baseline characteristics, but one arm of the study (face-to-face didactic lecture group) was based in Hong Kong, where learners are not necessarily English mother tongue speakers and where previous teaching in EBP is unlikely. Difficult to compare to Australian setting
Were incomplete outcome data adequately addressed?	Unclear	No flow diagram or description of participant flow or follow up
Was knowledge of the allocated interventions adequately prevented during the study?	No	Some of the outcomes were assessed by study authors
Was the study adequately protected against contamination?	Unclear	No measures described to prevent contamination
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Unclear	Sample sizes: group that had face-to-face teaching three times as big as other groups. When comparing DVD group to this group, there might be issues with statistical analysis

### 9. Forsetlund 2003

<b>Methods</b>	<ul style="list-style-type: none"> <li>• RCT</li> <li>• Duration of study: April 1999 to January 2001</li> <li>• Setting: workplace (not specified)</li> <li>• Learner context: <ul style="list-style-type: none"> <li>- Background knowledge of EBHC: In the intervention group, 24% had attended session(s) on searching and 42% on critical appraisal. In the control group, 23% had attended session(s) on searching and 30% on critical appraisal</li> </ul> </li> <li>• Socio-economic context: <ul style="list-style-type: none"> <li>- 17/8 (discrepancy btw table and text) physicians (7 in intervention group and 10 in control group) did not have access to internet and were sent copies of the reports that were made by the team in the web-based question and answer service</li> </ul> </li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors (Public Health), continuing medical education</li> <li>• n= 148</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- All public health physicians working in municipalities in Norway that had more than 3000 inhabitants</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=73), blended learning</b></p> <ul style="list-style-type: none"> <li>• EBM workshop with access to databases, library service and participation in asynchronous discussion list</li> <li>• Multi-faceted intervention, integrated learning</li> <li>• Blended learning, collaborative learning</li> </ul>

	<ul style="list-style-type: none"> <li>Asynchronous discussion list</li> <li>EBHC components: <ul style="list-style-type: none"> <li>General EBHC</li> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>Intervention lasted 1.5 years. Workshop was between 1 and 5 days long</li> <li>Learning theory: Innovation-diffusion process</li> <li>Delivery agent: 2 public health physicians and 2 librarians</li> </ul> <p><b>Control (n=75): no learning</b></p>
<b>Outcomes</b>	<p>Primary outcome:</p> <p>1. EBHC behaviour</p> <ul style="list-style-type: none"> <li>Measured by analyzing the contents of local health service reports and a hypothetical assignment, by a postal survey, a telephone survey and questionnaire</li> <li>post-intervention</li> </ul> <p>Secondary outcomes:</p> <p>1. EBHC knowledge</p> <ul style="list-style-type: none"> <li>Measured with questionnaire: Mean additive score of 0=unknown, 1=known, but not used, 2=read, 3=used in a public health decision-making situation</li> <li>post intervention</li> </ul> <p>2. EBHC attitude</p> <ul style="list-style-type: none"> <li>Measured with questionnaire: 7 point Likert scale</li> <li>Post intervention</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: Norway</li> <li>Conflict of interest: reported, none declared</li> <li>Ethics approval: not reported</li> <li>Funding: The Norwegian Research Council</li> <li>Authors contacted: No</li> </ul>

### 9.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Done by an independent researcher using computer software
Was the allocation adequately concealed?	Unclear	Not described
Were baseline outcome measurements similar?	Unclear	Not clear whether outcomes were measured at baseline
Were baseline characteristics similar?	No	Imbalance for the following variables: sex, number of years as a public health physician, specialist status, previous exposure to courses in critical appraisal (Intervention group: 42%; control group: 30%) and number of advisory reports written during the previous year
Were incomplete outcome data adequately addressed?	No	Loss to follow-up more than 20% for all outcome measures
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Blinding of outcome assessors done
Was the study adequately protected against contamination?	Unclear	Public health physicians from all Norwegian municipalities were invited to participate and individual randomisation was done. Contamination could have been avoided by using a cluster randomised design

Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other bias identified

## 10. Hadley 2010

<b>Methods</b>	<ul style="list-style-type: none"> <li>Cluster RCT</li> <li>Unit of randomization: Teaching hospitals</li> <li>Duration of study: Between May and September 2007</li> <li>Setting: 7 teaching hospitals in the UK West Midlands region</li> <li>Socio-economic context: High-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>Medical doctors, continuing medical education</li> <li>n= 237; 7 clusters</li> <li>Inclusion criteria: Foundation year 2 doctors</li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=122; 4 clusters) e-learning</b></p> <ul style="list-style-type: none"> <li>Clinically integrated teaching of EBM: Recorded PowerPoint slides on three modules on EBM (asking questions, accessing literature, appraising literature). Unlimited access for six weeks <ul style="list-style-type: none"> <li>integrated learning, multifaceted intervention</li> <li>pure e-learning, individual learning</li> <li>asynchronous delivery</li> </ul> </li> <li>EBHC components: <ul style="list-style-type: none"> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>EBM course of 6 weeks duration; access according to individual needs</li> <li>Learning theory: not mentioned</li> <li>Delivery agent: self-directed</li> </ul> <p><b>Control (n=115; 3 clusters), face-to-face learning:</b></p> <ul style="list-style-type: none"> <li>Standalone, three hour face-to-face lecture (same content as intervention), same PowerPoint slides <ul style="list-style-type: none"> <li>standalone learning, single intervention</li> </ul> </li> <li>EBHC components: <ul style="list-style-type: none"> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>Once off session of 3 hours</li> <li>Learning theory:</li> <li>Delivery agent: Lecturer</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge</p> <ul style="list-style-type: none"> <li>Measured with previously validated MCQs</li> <li>Pre- and post-intervention</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: UK</li> <li>Conflict of interest: none declared</li> <li>Ethics approval: not obtained ( not applicable according to authors)</li> <li>Funding: European Union Leonardo da Vinci project</li> <li>Authors contacted: no</li> </ul>

### 10.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	computer generated

Was the allocation adequately concealed?	Unclear	not described
Were baseline outcome measurements similar?	Unclear	Baseline scores presented, but no significance test done Intervention: Mean 22.9 SD 7.0 n=88 Control: Mean 24.7 SD 3.9 n=72
Were baseline characteristics similar?	Unclear	No table of baseline characteristics
Were incomplete outcome data adequately addressed?	No	Loss to follow-up: Intervention: 25% Control: 31%
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not able to blind teachers and participants. Not described whether outcome assessors were blinded
Was the study adequately protected against contamination?	Yes	Cluster randomised study
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified
Recruitment bias	Low risk	Randomisation was performed after recruitment and after consent was obtained
Baseline imbalance	Unclear	No table of baseline characteristics
Loss of clusters	Unclear	not mentioned
Incorrect analysis	Low risk	adjusted for clustering
Compatibility with RCTs randomised by individuals	Low risk	yes, results are similar to RCTs with individual randomisation

## 11. Horiuchi 2009

<b>Methods</b>	<ul style="list-style-type: none"> <li>• RCT</li> <li>• Duration: August 2005 to November 2006</li> <li>• Setting: Nursing College in Tokyo (for face-to-face group)</li> <li>• Learner context: <ul style="list-style-type: none"> <li>- Background knowledge of EBHC:</li> <li>- Face-to-face group scored higher on pre-test (73.5%) compared to web-based group (64.1%) p=0.1</li> </ul> </li> <li>• Socioeconomic context: high-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Nurses, continuing medical education</li> <li>• n=93</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Registered nurses or midwives, with at least one year of clinical experience and presently working in a clinical area; understood and agreed with the aims of the study; had an interest in evidence-based nursing (EBN) techniques, and expressed a desire for ongoing education; access to a broadband internet connection either at home or work</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=45) e-learning:</b></p> <ul style="list-style-type: none"> <li>• E-learning of EBM divided into four parts, distributed according to individual progress <ul style="list-style-type: none"> <li>- Standalone learning, single intervention</li> <li>- Individual learning, pure e-learning</li> <li>- Asynchronous delivery</li> </ul> </li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> </ul>

	<p>Execution:</p> <ul style="list-style-type: none"> <li>• EBHC course, 1 month according to individual's rate of progress.</li> <li>• Learning theory: <ul style="list-style-type: none"> <li>- Distributed learning: not explicitly mentioned but described through: participants were expected to access material when convenient for them</li> </ul> </li> <li>• Delivery agent: self-directed</li> </ul> <p><b>Control (n=48), face-to-face learning:</b></p> <ul style="list-style-type: none"> <li>• Face-to-face EBM teaching divided into one evening lecture per week <ul style="list-style-type: none"> <li>- Standalone learning, single intervention</li> </ul> </li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBHC course of 4 weeks, 90 minute lecture once a week.</li> <li>• Learning theory: not mentioned</li> <li>• Delivery agent: Tutor (not described in detail)</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge</p> <ul style="list-style-type: none"> <li>- Measured through MCQ tests developed by authors, six questions, based on content covered</li> <li>- Pre-test: after recruitment, before randomization; question and answer sheet sent via email, participants had to return answer sheet within one week.</li> <li>- Post-test: sent via email after one month for intervention group, administered after 4<sup>th</sup> lecture for face-to-face group</li> </ul> <p>2. Satisfaction of students with method of learning</p> <ul style="list-style-type: none"> <li>- Measured access to and utilization of course</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Japan</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: Japanese ministry of education</li> <li>• Authors contacted: no</li> </ul>

### 11.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Computerised random number generators
Was the allocation adequately concealed?	Yes	"Concealed opaque envelopes containing the randomised allocations" produced by research assistant (not mentioned that they were sealed and sequentially numbered)
Were baseline outcome measurements similar?	Unclear	Baseline scores: Intervention: Mean 64.1 SD 26.6 Control: Mean 73.5 SD 20.7 p=0.1
Were baseline characteristics similar?	Unclear	Table of baseline characteristics does not contain p-values. Characteristics for "age" are not similar, the web-based group seems to be older
Were incomplete outcome data adequately addressed?	No	31% lost to follow up in face-to-face group; 18% lost to follow-up in e-learning group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Blinding of participants and teachers not possible, blinding of outcome assessors not reported

Was the study adequately protected against contamination?	Unclear	not described
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes were reported on
Was the study free from other bias?	Yes	No sources of other bias identified

## 12. Ilic 2013

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Non-RCT</li> <li>• Students attending the Peninsula clinical site received the intervention, students across remaining three sites received control</li> <li>• Duration of study: not reported</li> <li>• Setting: Monash University in Australia</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors, undergraduate (2<sup>nd</sup> year graduate MBBS programme)</li> <li>• n=61</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Second year Monash graduate MBBS student at the time of the study</li> </ul> </li> <li>• Exclusion criteria: <ul style="list-style-type: none"> <li>- Students who were unwilling to participate in the study or did not wish to provide consent</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=34 ): blended learning</b> of EBM consisting of:</p> <ul style="list-style-type: none"> <li>• Workshop <ul style="list-style-type: none"> <li>- Block day</li> </ul> </li> <li>• Online learning <ul style="list-style-type: none"> <li>- Access to learning content via the Monash University website</li> <li>- Self-directed learning</li> </ul> </li> <li>• Clinical activities <ul style="list-style-type: none"> <li>- Applying principles of EBM to patient case</li> </ul> </li> <li>• Tutorials <ul style="list-style-type: none"> <li>- Presentation of patient case and EBM content</li> <li>- Quasi-journal club</li> </ul> </li> <li>• Integrated learning, multifaceted intervention</li> <li>• Collaborative learning, blended learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components <ul style="list-style-type: none"> <li>- Biostatistics</li> <li>- General searching skills</li> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>- Course for 2nd year medical students doing first clinical rotation (graduate students of MBBS programme)</li> <li>- Ten 2 hour sessions</li> </ul> <p>Learning theory:</p> <ul style="list-style-type: none"> <li>- Peer-to-peer learning</li> <li>- Problem-based learning</li> </ul> <p><b>Control (n=27): Face-to-face learning</b> (didactic learning)</p> <ul style="list-style-type: none"> <li>• Classroom activities <ul style="list-style-type: none"> <li>- Ten 2 hour tutorials</li> <li>- Presentations of EBM concepts (didactic lectures)</li> <li>- Small group tasks</li> <li>- Large group discussions</li> <li>- Structured learning activities</li> </ul> </li> <li>• Standalone learning, multifaceted intervention</li> </ul>

	<ul style="list-style-type: none"> <li>• EBHC components <ul style="list-style-type: none"> <li>- Biostatistics</li> <li>- General searching skill</li> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Course for 2nd year medical students doing first clinical rotation (graduate students of MBBS programme)</li> <li>• Ten 2 hour sessions</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge and skills</p> <ul style="list-style-type: none"> <li>- Berlin questionnaire</li> <li>- Two assessment tasks</li> <li>- Post intervention only</li> </ul> <p>2. EBHC attitude</p> <ul style="list-style-type: none"> <li>- Survey</li> <li>- Post intervention</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Australia</li> <li>• Conflict of interest: Declared: DI is the coordinator of the EBM program for the MBBS degree at Monash University. PF and EV coordinate the EBM teaching program delivered through the Gippsland Medical School.</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: not reported</li> <li>• Authors contacted: no</li> </ul>

### 12.1 Risk of bias

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	No	Non-randomised study. Students attending the Peninsula clinical site received the intervention, students across remaining sites received control
Was the allocation adequately concealed?	No	Non-randomised study
Were baseline outcome measurements similar?	Unclear	Outcomes were not measured at baseline
Were baseline characteristics similar?	No	Not reported - no table of baseline characteristics.
Were incomplete outcome data adequately addressed?	Yes	No participants lost to follow-up
Was knowledge of the allocated interventions adequately prevented during the study?	No	"Both assignments were graded by EBM tutors participating in this study". Not mentioned that they were unaware of group allocation
Was the study adequately protected against contamination?	Unclear	Although students were at different sites, they were all part of the same programme and not mentioned how contamination was avoided
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other potential biases identified

### 13. Ilic 2015

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Cluster RCT</li> </ul>
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	<ul style="list-style-type: none"> <li>• Unit of randomisation: Tutorial group</li> <li>• Duration of study: not reported</li> <li>• Setting: Monash University in Australia and Malaysia</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors, undergraduate</li> <li>• n=497 (24 clusters)</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Participants were third year medical students, who were all entering their first year of clinically based training and first year of formal EBM training (graduate entry or undergraduate)</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=263): blended learning</b> of EBM consisting of:</p> <ul style="list-style-type: none"> <li>• Classroom activities <ul style="list-style-type: none"> <li>- 10 2-hour teaching sessions: formal EBM concepts delivered by tutor/lecturer. Sessions commence with a formal presentation, followed by small group activity – critical appraisal of an article relating to study design that was covered in the presentation. Therapy, harm, prognosis and diagnosis</li> </ul> </li> <li>• Online learning <ul style="list-style-type: none"> <li>- Online lectures available on You Tube, which students had to watch before the respective 2 hour teaching block</li> <li>- Resources delivered via Monash Library website</li> </ul> </li> <li>• Mobile learning <ul style="list-style-type: none"> <li>- Incorporated in bedside teaching when students were interacting in the wards</li> <li>- Access evidence related to specific patient</li> <li>- Integrated learning, multifaceted intervention</li> <li>- Collaborative learning, blended learning</li> <li>- Asynchronous delivery</li> </ul> </li> <li>• EBHC components <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the process</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Module for third year medical students doing first clinical rotation</li> <li>• Ten 2 hour sessions</li> </ul> <p><b>Control (n=234): Face-to-face learning</b> (didactic learning)</p> <ul style="list-style-type: none"> <li>• Classroom activities</li> <li>• 2-hour teaching sessions: formal EBM concepts delivered by tutor/lecturer. Sessions commence with a formal presentation, followed by small group activity – critical appraisal of an article relating to study design that was covered in the presentation. Therapy, harm, prognosis and diagnosis <ul style="list-style-type: none"> <li>- Standalone learning, multifaceted intervention</li> </ul> </li> <li>• EBHC components <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the process</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Module for third year medical students doing first clinical rotation</li> <li>• Ten 2 hour sessions</li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge and skills <ul style="list-style-type: none"> <li>- ACE tool</li> <li>- Berlin questionnaire</li> <li>- One month post intervention</li> </ul> </li> <li>2. EBHC attitude</li> <li>3. EBHC behaviour</li> <li>4. EBHC self-efficacy</li> </ol>

	<ul style="list-style-type: none"> <li>- Evidence-Based Practice Questionnaire (EBPQ) – self-reported measures related to implementation of EBM</li> <li>- One month post intervention</li> </ul> <p>5. Satisfaction of students with method of learning</p> <ul style="list-style-type: none"> <li>- Focus group discussions with selected participants</li> </ul> <p>6. Enablers of method of EBHC learning</p> <ul style="list-style-type: none"> <li>- Focus group discussions with selected participants</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Australia and Malaysia</li> <li>• Conflict of interest: Yes. DI coordinates the EBM program for the MBBS degree at Monash University.</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: Australian Government Office for Learning and Teaching.</li> <li>• Authors contacted: yes – response obtained <ul style="list-style-type: none"> <li>- Over which period of time were the ten 2-hour EBM sessions delivered?</li> <li>- Which baseline characteristics did you measure and do you have a table comparing these between groups?</li> <li>- Did you adjust the results for clustering?</li> <li>- How many groups were randomised to intervention/control?</li> </ul> </li> </ul>

### 13.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Yes	Computerised random numbers
Was the allocation adequately concealed?	Yes	Randomisation done by an independent researcher
Were baseline outcome measurements similar?	Unclear	No pre-intervention measurement of outcomes done
Were baseline characteristics similar?	No	No table of baseline characteristics present, no baseline characteristics measured (information supplied by author)
Were incomplete outcome data adequately addressed?	No	Intervention group: 190/263 (72%) and in control group 160/234 (68%) of students did not complete the outcome assessment and were not analysed
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Blinding of educators and students not possible; outcome assessors and analysts were blinded to allocation of participants
Was the study adequately protected against contamination?	Yes	Cluster RCT
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified
Recruitment bias	Unclear risk	Not clear whether participants were first allocated to groups and groups were then randomised or vice versa
Baseline imbalance	High risk	No table of baseline characteristics present
Loss of clusters	Unclear	Not reported
Incorrect analysis	High risk	Results not adjusted for clustering (information supplied by author)
Compatibility with RCTs randomised by individuals	High risk	Results are not comparable to individually randomised RCTs since they were not adjusted for clustering

## 14. Kamin 2001

<b>Methods</b>	<ul style="list-style-type: none"> <li>• RCT</li> <li>• Duration of study: Fall 1998</li> <li>• Setting: University of Colorado Health Sciences Centre</li> <li>• Learner context: Intervention group had additional training on using the software</li> <li>• Socio-economic context: high-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Physician assistants, undergraduate</li> <li>• n=29</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- 2<sup>nd</sup> year physician assistant students</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=?), e-learning:</b></p> <ul style="list-style-type: none"> <li>• EBM course with computer-mediated communication using asynchronous discussion software. Assignments, online discussions: weekly discussion topics; access to course website <ul style="list-style-type: none"> <li>- standalone EBHC learning, multifaceted intervention</li> <li>- Pure e-learning, collaborative learning</li> </ul> </li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBM course, during fall quarter of second year, according to individual needs</li> <li>• Learning theory: not reported</li> <li>• Delivery agent: Facilitator for discussions, otherwise self-directed</li> </ul> <p><b>Control (n=?): blended learning</b></p> <ul style="list-style-type: none"> <li>• EBM course with face-to-face discussions in mentor groups. Assignments and discussions: weekly discussion topics; Access to course website (details not described) <ul style="list-style-type: none"> <li>- standalone learning, multifaceted intervention</li> <li>- blended learning, collaborative learning</li> </ul> </li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• EBM course during fall quarter of second year, once weekly discussions.</li> <li>• Learning theory: not mentioned</li> <li>• Delivery agent: Instructor/facilitator for discussions; self-directed (website)</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge</p> <ul style="list-style-type: none"> <li>- Measured with questionnaire</li> <li>- Pre-and post-test. Pre-test was a subset of final examination (11 questions requiring short answers)</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: USA</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: not reported</li> <li>• Funding: University of Colorado Health Science Center Office of Education mini-grant program</li> <li>• Authors contacted: no</li> </ul>

### 14.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear	Method of randomisation not explicitly described
Was the allocation adequately concealed?	Unclear	not described

Were baseline outcome measurements similar?	Unclear	Baseline scores appear similar, but no p-values reported Intervention: mean 41 SD 12.4 Control: mean 37 SD 12.3
Were baseline characteristics similar?	Unclear	No table of baseline characteristics, “no significant differences existed between groups in any assessed parameter”
Were incomplete outcome data adequately addressed?	Unclear	Not reported how many of the 27 participants were allocated to each group; flow of participants not reported
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	“Grader was blind to the identities of the group type until after the scores had been calculated”
Was the study adequately protected against contamination?	Unclear	All students attended the same course, the only difference was the small group discussion sessions. Not described how contamination was prevented
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Unclear	Very small sample size.

### 15. Kok 2013

<b>Methods</b>	<ul style="list-style-type: none"> <li>Cluster RCT</li> <li>Unit of randomisation: case-based learning groups</li> <li>Duration of study: 12 months</li> <li>Setting: Not reported where training took place</li> <li>Socio-economic context: High-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>Medical doctors, continuing medical education</li> <li>n=132; 54 clusters</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>Physicians belonging to a case-based learning groups from the Dutch National Institute of Benefit Schemes</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=67; 27 clusters): Blended learning:</b></p> <ul style="list-style-type: none"> <li>Introductory, interactive e-learning course on EBM workshop with didactic and interactive sessions</li> <li>Integrated learning, multifaceted learning</li> <li>Blended learning, collaborative learning</li> <li>Asynchronous delivery</li> <li>EBHC components: <ul style="list-style-type: none"> <li>General EBHC</li> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>EBM course with 5 contact days (full day) spread over 6 months</li> <li>Learning theory: not mentioned</li> <li>Delivery agent: Experts and teachers from the Dutch Cochrane Centre, the Netherlands School of Public and occupational health, the Coronel Institute of Occupational health and the Library of the Academic Medical Centre</li> </ul> <p><b>Control (n=65; 27 clusters) no learning:</b></p> <ul style="list-style-type: none"> <li>Waiting list</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge and skills</p> <ul style="list-style-type: none"> <li>Adapted Fresno test, scores ranging from 0-212</li> <li>Measured at baseline, 7 months and 12 months</li> </ul> <p>2. EBHC attitude</p> <ul style="list-style-type: none"> <li>Likert scale 1-5</li> <li>Measured at baseline, 7 months and 12 months</li> </ul>

	<p>3. EBHC behaviour</p> <ul style="list-style-type: none"> <li>- Evidence-based disability evaluation – indicated by the frequency in use of evidence of sufficient quality in the disability evaluation reports. 6 quality indicators (max score: 6):             <ol style="list-style-type: none"> <li>1) Presence of evidence</li> <li>2) Discernible EBM question</li> <li>3) Search strategy</li> <li>4) EBM source</li> <li>5) Evaluation of the quality of evidence</li> </ol> </li> <li>- Actual use of evidence in underpinning of the conclusion</li> <li>- Measured 3 months after course (9 months after baseline)</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: The Netherlands</li> <li>• Conflict of interest: declared no conflict of interest</li> <li>• Ethics approval: exemption obtained</li> <li>• Funding: National institute of Benefit Schemes as part of the Research Centre for Insurance Medicine</li> <li>• Authors contacted: no</li> </ul>

### 15.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Computer generated list of random numbers
Was the allocation adequately concealed?	Yes	Independent researcher was provided with a sequentially numbered list of the case-based learning groups and assigned the random sequence to this list. It was given to a research assistant. No changes to the list were allowed
Were baseline outcome measurements similar?	Yes	Baseline outcomes similar for both groups
Were baseline characteristics similar?	Yes	No baseline imbalances
Were incomplete outcome data adequately addressed?	No	Loss to follow-up >20% in both groups, but similar for both groups: Intervention 24% Control: 25%
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Blinding of outcome assessors done
Was the study adequately protected against contamination?	Unclear	Cluster RCT, but case-based learning groups, not described how they were kept from speaking to one another or where these groups were based
Was the study free from selective outcome reporting?	Yes	all pre-specified outcomes reported on
Was the study free from other bias?	Yes	no other sources of bias identified
Recruitment bias	Low risk	Recruitment occurred before randomisation
Baseline imbalance	Low risk	No baseline imbalances
Loss of clusters	Unclear risk	2 clusters (7%) lost in intervention group vs 0 clusters in control group
Incorrect analysis	Low risk	adjusted for clustering
Compatibility with RCTs randomised by individuals	Low risk	Results similar to individually randomised studies

## 16. Kulier 2009

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Cluster RCT</li> <li>• Unit of randomisation: teaching hospitals</li> <li>• Study duration: August to December 2007</li> <li>• Setting: Clinical teaching hospitals in the UK and the Netherlands</li> <li>• Learner context: baseline EBHC knowledge similar btw groups</li> <li>• Socio-economic context: high-income countries</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors, postgraduate</li> <li>• n=61; 6 clusters</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Junior medical doctors who had not previously received formal EBM teaching in their postgraduate training</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=34; 3 clusters), blended learning</b></p> <ul style="list-style-type: none"> <li>• Clinically integrated EBM course with self-directed e-learning components and clinically relevant activities under the guidance of a facilitator (Knowledge needs identification in the clinical setting; independent study by using e-learning modules; interaction with facilitator throughout the course)</li> <li>• Integrated learning, multi-faceted intervention</li> <li>• Individual learning, blended learning</li> <li>• Asynchronous</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• 4-6 week self-directed course during postgraduate training</li> <li>• Learning theory: not mentioned</li> <li>• Delivery agent: self-directed, interaction with facilitator throughout course</li> </ul> <p><b>Control (n=36; 3 clusters), face-to-face learning</b></p> <ul style="list-style-type: none"> <li>• Lectures on EBM, using PowerPoint slides (same as in e-learning). Interaction with tutor during lectures</li> <li>• Standalone learning, single intervention</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> <li>• Execution: <ul style="list-style-type: none"> <li>- 4-6 week EBM course. Not reported how often and for how long</li> </ul> </li> <li>• Learning theory: not reported</li> <li>• Delivery agent: Tutor</li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge <ul style="list-style-type: none"> <li>- Measured with questionnaire with maximum of 62 points. Adapted from Berlin and Fresno test</li> <li>- Pre-and post- intervention</li> </ul> </li> <li>2. EBHC attitude <ul style="list-style-type: none"> <li>- Questions on 5 point Likert scale from strongly agree to strongly disagree</li> <li>- Pre- and post-intervention</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: UK and The Netherlands</li> <li>• Conflict of interest: yes, none declared</li> <li>• Ethics approval: obtained</li> <li>• Funding: not reported</li> <li>• Authors contacted: no</li> </ul>

### 16.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Random sequence generated by computer
Was the allocation adequately concealed?	Unclear	Not described
Were baseline outcome measurements similar?	Yes	Figure 2 – no difference between baseline scores
Were baseline characteristics similar?	No	No table of baseline characteristics and no mention of participant characteristics in text
Were incomplete outcome data adequately addressed?	No	Loss to follow-up in intervention group: 8% Loss to follow-up in control group: 18%
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not reported whether outcome assessors were blinded
Was the study adequately protected against contamination?	Yes	Cluster randomisation. Participants did not rotate between clusters during the study period
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other source of bias identified
Recruitment bias	Unclear risk	Recruitment of participants not described, not known whether randomisation occurred before or after recruitment
Baseline imbalance	High risk	Baseline characteristics not reported
Loss of clusters	Low risk	Loss of clusters not reported, but max of 6 participants lost to follow up
Incorrect analysis	Low risk	Results adjusted for clustering
Compatibility with RCTs randomised by individuals	Low risk	Results are similar to results from individually randomised RCTs

### 17. Kulier 2012

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Cluster RCT</li> <li>• Unit of randomisation: Obstetrics and Gynaecological training units</li> <li>• Duration of study: April 2009 to November 2010</li> <li>• Setting: teaching hospitals in 7 LMICs</li> <li>• Learner context: access to internet and information were preconditions for being included in study</li> <li>• Socio-economic context: Low- and middle-income countries</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors, postgraduate</li> <li>• n= 204</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- To be eligible, the training unit had to be delivering EBM courses, defined as opportunities to learn about the techniques of EBM and its application in clinical practice, in the unit's residency programme. Units had to have at least 4 residents who had not yet been exposed to formal EBM training and who were available for the duration of the trial to undertake the course and the assessment. They had to appoint a facilitator, a current clinical staff member knowledgeable about basic EBM principles to facilitate on the job training throughout the trial period. Appropriate computer equipment and access to relevant databases were a precondition.</li> </ul> </li> </ul>
<b>Interventions</b>	<b>Intervention (n=123; 31 clusters) blended learning:</b>

	<ul style="list-style-type: none"> <li>• Clinically integrated EBM e-learning course containing recorded presentations but incorporating learning activities, assignments and assessments in clinical practice. Clinical trainer involved in face-to-face teaching.</li> <li>• Integrated learning, multifaceted intervention</li> <li>• Blended learning, individual learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Week course during obstetrics and gynaecology rotation, self-directed learning</li> <li>• Learning theory: learner-centred; just-in-time learning</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Clinical facilitator; self-directed</li> </ul> </li> </ul> <p><b>Control (n=81; 29 clusters), e- learning</b></p> <ul style="list-style-type: none"> <li>• Self-directed EBM teaching package containing recorded presentations. Access to facilitator that could be consulted on demand</li> <li>• Standalone learning; single intervention</li> <li>• Pure e-learning; individual learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Week course during obstetrics and gynaecology rotation, self-directed learning</li> <li>• Learning theory: not mentioned</li> <li>• Delivery agent: self-directed</li> </ul>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge <ul style="list-style-type: none"> <li>- Measured with previously validated questionnaire; MCQs with a maximum of 62 points</li> <li>- Pre-intervention and 4 weeks post intervention</li> </ul> </li> <li>2. EBHC skills <ul style="list-style-type: none"> <li>- Evaluated using an objective structured clinical examination (score: 0-14)</li> <li>- Post-intervention only</li> </ul> </li> <li>3. EBHC attitude <ul style="list-style-type: none"> <li>- Validated tool: 7 questions, using 5 point Likert scale from strongly agree to strongly disagree</li> <li>- Pre-intervention (and post?)</li> </ul> </li> </ol>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: 7 LMICs (Argentina, Brazil, Democratic Republic of Congo, India, Philippines, South Africa, Thailand)</li> <li>• Conflict of interest: yes, declared no conflicts of interest</li> <li>• Ethics approval: approval obtained</li> <li>• Funding: WHO</li> <li>• Authors contacted: Yes – missing data for attitude score post intervention.</li> </ul>

### 17.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Yes	Computer-generated random numbers

Was the allocation adequately concealed?	Unclear	not adequately described
Were baseline outcome measurements similar?	Yes	Baseline knowledge scores not statistically different
Were baseline characteristics similar?	Yes	No differences in baseline characteristics
Were incomplete outcome data adequately addressed?	Unclear	Denominator for attrition rates in both groups is the number of participants that received the intervention. Number of participants randomised was not reported Intervention : 20% Control: 16%
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not reported
Was the study adequately protected against contamination?	Yes	Cluster RCT
Was the study free from selective outcome reporting?	Unclear	For attitude, scores were only reported at baseline and not after the intervention
Was the study free from other bias?	Unclear	Sample size of groups quite different Intervention:123 Control: 81
Recruitment bias	High risk	Participants only consented to taking part in the study after randomisation
Baseline imbalance	Low risk	No differences in baseline characteristics
Loss of clusters	High risk	7 clusters lost after randomisation per group
Incorrect analysis	Low risk	Adjusted for clustering
Compatibility with RCTs randomised by individuals	Low risk	Results similar to individually randomised studies

## 18. Laibhen-Parkes 2014

<b>Methods</b>	<ul style="list-style-type: none"> <li>Cluster RCT</li> <li>Allocation by units within hospital</li> <li>Duration of study: 10 weeks</li> <li>Setting: acute care, free-standing paediatric hospital in Southwestern USA</li> <li>Learner context:</li> <li>Socio-economic context: high-income countries</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>Nurses, continuing nursing education</li> <li>n= 58 (6 clusters)</li> <li>Inclusion criteria: <ul style="list-style-type: none"> <li>“Eligible participants for this study included BSN-prepared paediatric nurses who self-reported (a) having access to a computer that met the basic requirements for retrieving the modules, (b) having basic computer literacy skills, (c) having access to the Internet, (d) not working on the excluded campus of this paediatric hospital, (e) not participating in any formal EBP training program during the study timeline, and (f) not having participated in the earlier version of the Web-based module piloted at this hospital”</li> </ul> </li> <li>Exclusion criteria: <ul style="list-style-type: none"> <li>“Nurses who worked on the excluded campus were not eligible to participate in this study because an earlier version of the EBP module had been piloted on this campus.”</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=33, 3 clusters) Pure e-learning:</b></p> <ul style="list-style-type: none"> <li>Web-based modules on EBP with active links to instrumentation.</li> <li>Stand-alone learning, single intervention</li> <li>Pure e-learning, individual learning</li> </ul>

	<ul style="list-style-type: none"> <li>Asynchronous delivery</li> <li>EBHC components: <ul style="list-style-type: none"> <li>Asking questions</li> <li>Accessing the literature</li> <li>Critical appraisal</li> <li>Applying results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>2-hour module comprised of four units (20-30 minutes each) that were delivered via the Internet, in which participants were encouraged to review within 4 weeks</li> </ul> <ul style="list-style-type: none"> <li>Learning theory: Novice to expert theory (cognitive change) and theory of planned behaviour (behaviour change)</li> <li>Delivery agent: self-directed</li> </ul> <p><b>Control (n=25, 3 clusters): no EBHC learning</b></p> <ul style="list-style-type: none"> <li>Attention control module</li> </ul>
<b>Outcomes</b>	<p>1. EBHC knowledge and skills</p> <ul style="list-style-type: none"> <li>Measured with adapted Fresno test</li> <li>Post-intervention only</li> <li>Pre-intervention and 4 weeks post intervention</li> </ul> <p>2. EBHC attitude (beliefs)</p> <ul style="list-style-type: none"> <li>Evidence-based Practice Beliefs (EBPB) scale</li> <li>Pre- and post-intervention</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: USA</li> <li>Conflict of interest: yes, declared no conflicts of interest</li> <li>Ethics approval: approval obtained</li> <li>Funding: Jonas Nurse Leader's Scholarship, Georgia Baptist College of Nursing that matched the funds from the Jonas Scholarship, and Nurse Faculty Loan Program</li> <li>Authors contacted: Yes – response obtained <ul style="list-style-type: none"> <li>How allocation of units was decided</li> <li>Whether outcome assessors were blind</li> <li>Whether results were adjusted for clustering</li> </ul> </li> </ul>

### 18.1 Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Used online randomisation tool (information provided by author)
Was the allocation adequately concealed?	Unclear	Not clear whether allocation sequence was concealed
Were baseline outcome measurements similar?	No	Significant difference between EBP beliefs at baseline. EBHC knowledge and skills only tested post-intervention.
Were baseline characteristics similar?	Yes	Table of baseline characteristics present, no significant differences between groups
Were incomplete outcome data adequately addressed?	No	Lost to follow-up: Intervention: 58% (19/33) Control: 40% (10/25)
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Outcome assessors were blind
Was the study adequately protected against contamination?	Unclear	Nurses from same hospitals were allocated to intervention/control. Although allocation was done per unit
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on

Was the study free from other bias?	Unclear	Small sample size
Recruitment bias	Unclear	Not clear whether participants were recruited before or after randomization
Baseline imbalance	Low risk	No differences in baseline characteristics
Loss of clusters	Unclear	Loss of clusters not reported
Incorrect analysis	High risk	Not adjusted for clustering
Compatibility with RCTs randomised by individuals	High risk	Results are not comparable to individually randomised RCTs since they were not adjusted for clustering

## 19. Macrae 2004

<b>Methods</b>	<ul style="list-style-type: none"> <li>• RCT</li> <li>• Duration of study: October 2001 to May 2002 (plus 6 weeks to complete exam)</li> <li>• Setting: home/hospital</li> <li>• Learner context: not described</li> <li>• Socio-economic context: high-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors (surgeons); continuing medical education</li> <li>• n=83</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Members of the Canadian Association of General Surgeons with access to internet and email, need to agree to be randomised and to complete a written examination</li> </ul> </li> <li>• Exclusion criteria: <ul style="list-style-type: none"> <li>- Surgeons with postgraduate training in clinical epidemiology</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=44): (e-learning)</b></p> <ul style="list-style-type: none"> <li>• Online journal club made up of 8 packages emailed to participants, each package containing one clinical and one methodological article. Asynchronous discussions on list serv, moderated by facilitator. Received methodological review and clinical review prepared by experts (methods and content respectively), also discussed on list serv.</li> <li>• Standalone learning, multifaceted intervention</li> <li>• Pure e-learning, collaborative learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- critical appraisal</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Journal club over 8 months, 1 article discussed per month</li> <li>• List-serv discussion for 1 week on methodology; participants emailed methodological review and clinical review after which the list serv was open for another week</li> <li>• Learning theory: Adult learning theory</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Moderator for first week of list serv: general surgeon with training in clinical epidemiology</li> <li>- Moderator for second week of list serv discussion: Surgeon with clinical epidemiology training and surgeon with expert knowledge in relevant content</li> </ul> </li> </ul> <p><b>Control (n=37) e-learning:</b></p> <ul style="list-style-type: none"> <li>• Participants received 8 clinical articles per email and were given access to main medical and surgical journals some of which included articles on critical appraisal</li> <li>• Standalone learning, single intervention</li> <li>• Pure e-learning, individual learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components:</li> </ul>

	<p style="text-align: center;">- Critical appraisal</p> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Journal club over 8 months</li> <li>• Participants were sent reminders to read the article at the beginning of every month</li> <li>• Learning theory: no</li> <li>• Delivery agent: self-directed</li> </ul>
<b>Outcomes</b>	<p>1. EBHC skills (Critical appraisal skills)</p> <ul style="list-style-type: none"> <li>- Post-test only: participants in both groups read 2 articles and completed rating scales on quality and gave free text responses to questions on methodology, validity and applicability of results. They had 6 weeks to complete this and could use any available resource (open-book)</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Canada</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: obtained</li> <li>• Funding: Educational grant from Ethicon and Ethicon Endo-surgery</li> <li>• Authors contacted: No</li> </ul>

### 19.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Unclear	Authors made use of blocked randomisation (blocks of 10) but did not specify how sequence was generated
Was the allocation adequately concealed?	Unclear	The complete list of assignments was sent to research assistant for implementation. No changes were made to the assignment
Were baseline outcome measurements similar?	Unclear	No baseline assessment of outcomes
Were baseline characteristics similar?	Unclear	Only looked at average number of years since graduation and whether they worked in the community or academic setting. There was no difference for these two variables
Were incomplete outcome data adequately addressed?	No	Loss to follow-up in intervention group: 42% Loss to follow-up in control group: 24%
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Outcome assessors were blinded
Was the study adequately protected against contamination?	Unclear	Although both interventions were internet-based, it is not clear where all the participants were based and whether they had the opportunity to discuss the articles.
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified

### 20. McLeod 2010

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Cluster RCT</li> <li>• Unit of randomisation: general surgery training programmes</li> <li>• Duration of study: October 2008 to June 2009</li> <li>• Setting: Hospital/home, USA</li> <li>• Socio-economic context: high-income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors (surgeons), continuing medical education</li> <li>• n=441</li> <li>• Inclusion criteria:</li> </ul>

	<ul style="list-style-type: none"> <li>- General surgery training programmes in the United States that did not use Evidence based Reviews in Surgery (EBRS) packages in their journal club, with at least 10 residents in their programme who were agreeable to participating in the trial.</li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=225; 6 clusters) e-learning:</b></p> <ul style="list-style-type: none"> <li>• Online journal club made up of 8 packages emailed to participants, each package containing one clinical and one methodological article. Asynchronous discussions on list serv, moderated by facilitator. Clinical scenarios included in discussions</li> <li>• Standalone learning, single intervention</li> <li>• Pure e-learning, collaborative learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Critical appraisal</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Journal club over 8 months; 1 article package per month</li> <li>• During general surgery training</li> <li>• Self-directed</li> <li>• Learning theory: no</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Self-directed. Asynchronous discussions facilitated by methodological and clinical experts</li> </ul> </li> </ul> <p><b>Control (n=216; 6 clusters) face-to-face learning:</b></p> <ul style="list-style-type: none"> <li>• Monthly face-to-face journal club using same articles, led by general surgical faculty member</li> <li>• Standalone learning, single intervention</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Critical appraisal</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Journal club over 8 months, once a month</li> <li>• during surgical residency</li> <li>• Learning theory: no</li> <li>• Delivery agent: General surgical faculty member</li> </ul>
<b>Outcomes</b>	<p>1. EBHC skills</p> <ul style="list-style-type: none"> <li>- Critical appraisal test at designated examination room. Test consisted of 2 articles which participants had to read and then complete a series of short-answer questions and 7-point Likert scales to assess study quality. Score for each article was 48 (total 96)</li> <li>- Within one month of completion of EBRS (post-test only)</li> </ul> <p>2. Satisfaction of students with method of learning</p> <ul style="list-style-type: none"> <li>- Likert scale questions from 1-5 (5=very satisfied)</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: USA</li> <li>• Conflict of interest: declared no conflicts of interest</li> <li>• Ethics approval: obtained</li> <li>• Funding: Physician Services incorporated</li> <li>• Authors contacted: No</li> </ul>

### 20.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear	Cluster randomisation done. Not described how sequence was generated
Was the allocation adequately concealed?	Unclear	Not reported
Were baseline outcome measurements similar?	Unclear	no measurement of baseline outcomes

Were baseline characteristics similar?	Unclear	No table of baseline characteristics and no description in text
Were incomplete outcome data adequately addressed?	No	Intervention (internet) group loss to follow up: 42% Control (face-to-face) loss to follow up: 27%
Was knowledge of the allocated interventions adequately prevented during the study?	No	The critical appraisal test was marked by one of the investigators
Was the study adequately protected against contamination?	Yes	Through cluster randomisation
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified
Recruitment bias	Low risk	Participants recruited before randomisation
Baseline imbalance	Unclear risk	No table of baseline characteristics and no description in text
Loss of clusters	Unclear risk	Loss to follow up assessed on an individual basis and loss of clusters not described
Incorrect analysis	Low risk	They mention that their analysis was “design adjusted”
Compatibility with RCTs randomised by individuals	Low risk	Intervention effects are not much different from individually randomised RCTS

## 21. Ramos-Morcillo 2015

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Non-RCT</li> <li>• Duration of study: not reported</li> <li>• Setting: Not well described – courses offered by the Nursing Council of Jaen</li> <li>• Socio-economic context: high income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Nurses, continuing medical education</li> <li>• n= 109</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- Convenience sample of nursing professionals who attended free continuing education courses. Most from teaching hospitals and all had a Bachelor’s degree</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=54) Blended learning</b></p> <ul style="list-style-type: none"> <li>• EBP course consisting of 2 face-to-face sessions (5h each) and 30 hours of online learning - repository of learning material, exercises, discussion forum, consultations plus feedback</li> <li>• Stand-alone learning, multifaceted intervention</li> <li>• Blended learning, collaborative learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Basic searching skills</li> <li>- General EBHC</li> <li>- Asking questions</li> <li>- Accessing the literature</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• Not specified. 10 hours face-to-face and 30 hours online learning</li> <li>• Theory: Theory of planned behaviour</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Not reported</li> </ul> </li> </ul> <p><b>Control (n=55): no learning – course with non EBHC content</b></p>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. EBHC knowledge and skills</li> <li>2. EBHC attitude</li> <li>3. Practice</li> </ol>

	All outcomes measured with the Spanish version of the validated EBP questionnaire before the course (O1), 21 days after (O2) and 60 days after (O3). The questionnaire consists of 19 items, each item scored on a Likert scale from 1-7, a higher score indicating a more positive outcome
<b>Notes</b>	<ul style="list-style-type: none"> <li>Country: Spain</li> <li>Conflict of interest: not reported</li> <li>Ethics approval: obtained</li> <li>Funding: Nursing Council of Jaen</li> <li>Authors contacted: No</li> </ul>

### 21.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	No	Non-randomised trial. Not described how participants were allocated
Was the allocation adequately concealed?	No	Non-randomised trial
Were baseline outcome measurements similar?	Yes	No significant differences between EBP knowledge & skills, attitude and practice at baseline.
Were baseline characteristics similar?	Yes	See table 2. No significant differences btw baseline characteristics
Were incomplete outcome data adequately addressed?	Unclear	Not reported
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not reported
Was the study adequately protected against contamination?	Unclear	Not clear. Nurses from various hospitals attended the course. Contamination can therefore not be completely excluded
Was the study free from selective outcome reporting?	Yes	All outcomes reported in the methods section have been addressed in the results section
Was the study free from other risks of bias?	Yes	No other bias identified

### 22. Saunders 2016

<b>Methods</b>	<ul style="list-style-type: none"> <li>RCT</li> <li>Duration of study: 12 months</li> <li>Setting: University hospital system, Finland</li> <li>Socio-economic context: high income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>Nurses, continuing professional development</li> <li>n= 85</li> <li>Inclusion criteria:</li> </ul>

	<ul style="list-style-type: none"> <li>- Be a practicing RN at the university hospital system in any professional nursing role</li> <li>- Work full- or part time as an RN in any unit of the university hospital system</li> <li>- Be aged 21 or older and</li> <li>- To be able to fluently read and understand Finnish</li> <li>- These RNs were previously asked to complete a survey and asked to indicate whether they wanted to participate in an educational programme on EBP (n=379)</li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=50) blended learning</b>  Didactic EBP education session (4hours) plus EBP mentoring intervention and interactive e-learning module (4-hour live EBP education session, interactive clinical case situations for application of EBP into practice, interactive EBP review questions and answers)</p> <ul style="list-style-type: none"> <li>• integrated learning, multifaceted intervention</li> <li>• Blended learning, individual learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- General EBHC</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> <li>- Evaluating the process of EBP</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>• 8 weeks course – once off 4 hour lecture and online learning</li> <li>• Theory: The Stevens Star Model of Knowledge Transformation and the advancing Research and clinical Practice through close collaboration model (ARCC)</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Advanced practice nurse</li> </ul> </li> </ul> <p><b>Control (n=35): face-to-face learning on research utilisation</b></p> <ul style="list-style-type: none"> <li>• Although this is not defined as EBP – when looking at the content it is very similar to EBP (authors also point this out in the discussion)</li> <li>• Once off 4 hour didactic lecture</li> <li>• Content: <ul style="list-style-type: none"> <li>- Effective searching for evidence</li> <li>- What is best available research evidence?</li> <li>- Critical appraisal</li> <li>- Summarising research evidence for decision-making</li> <li>- Understanding, measuring and evaluating a research-based practice change</li> <li>- Disseminating the results of a research-based practice</li> </ul> </li> </ul>
<b>Outcomes</b>	<p>1. EBHC self-efficacy</p> <ul style="list-style-type: none"> <li>- As part of the</li> <li>- Measuring confidence in EBP</li> </ul> <p>2.EBHC Knowledge</p> <ul style="list-style-type: none"> <li>- Measured as part of the Evidence-based Readiness inventory</li> <li>- 15 MCQ questions</li> </ul> <ul style="list-style-type: none"> <li>• Outcomes measured at <ul style="list-style-type: none"> <li>- T0: pre-intervention</li> <li>- T1: Post-intervention (within 1 week)</li> <li>- T2: within 8 weeks</li> <li>- T3: 4 months after</li> </ul> </li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: Finland</li> <li>• Conflict of interest: none declared</li> <li>• Ethics approval: obtained</li> <li>• Funding: Finnish Nurses' Education Foundation, Finnish Nurses' Association, Saastamoinen Foundation, Finnish Work Environment Fund. Early Stage Researcher grant from University of Eastern Finland</li> </ul>

	<ul style="list-style-type: none"> <li>• Authors contacted: Yes – to obtain means and SDs for knowledge outcomes. Awaiting response</li> </ul>
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### 22.1 Risk of bias table

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Yes	Randomisation done by simple coin toss
Was the allocation adequately concealed?	Unclear	Not described
Were baseline outcome measurements similar?	Unclear	Not well reported – Figure 5. Contacted author, awaiting response
Were baseline characteristics similar?	No	Proportion of nurse managers was significantly higher in intervention group (p=0.001) and the intervention group had more participants with a master's degree (p=0.008)
Were incomplete outcome data adequately addressed?	High	LTFU: 14% in intervention group vs 3% in control group. Reasons for LTFU in intervention group likely to be related to the outcome
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not reported whether outcome assessors were blinded
Was the study adequately protected against contamination?	No	Participants were from the same university hospital complex, educational interventions were delivered by the same APNs in control and intervention groups. Research utilisation is very similar to EBP
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified

### 23. Schilling 2006

<b>Methods</b>	<ul style="list-style-type: none"> <li>• Non-RCT</li> <li>• Duration of study: 21 months</li> <li>• Setting: Boston University, department of Family Medicine. Clerkship took place in community setting</li> <li>• Socio-economic context: high income country</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Medical doctors, undergraduate</li> <li>• n= 238</li> <li>• Inclusion criteria: <ul style="list-style-type: none"> <li>- 3<sup>rd</sup> year medical students enrolled in a clinical clerkship</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=134) e-learning:</b></p> <ul style="list-style-type: none"> <li>• Web-based modules on searching and selecting best evidence and calculating NNT within Family Medicine clerkship</li> <li>• Integrated learning, multifaceted intervention</li> <li>• Pure e-learning, collaborative learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components: <ul style="list-style-type: none"> <li>- Epidemiology</li> <li>- Basic searching skills</li> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p>

	<ul style="list-style-type: none"> <li>• 6 weeks module</li> <li>• According to individual needs, 40-60 minutes for the first two weeks (content only)</li> <li>• 3rd year medical students in Family Medicine Clerkship</li> <li>• Learning theory: Adult learning concepts and the utility of reflective learning and collaborative or peer-driven learning</li> <li>• Delivery agent: <ul style="list-style-type: none"> <li>- Faculty moderated discussions</li> </ul> </li> </ul> <p><b>Control (n=104): no learning</b></p>
<b>Outcomes</b>	<p>1. EBHC skills</p> <ul style="list-style-type: none"> <li>- Analysis of students' MEDLINE search strategies (measured by Librarians with Likert scale)</li> <li>- Analysis of retrieved articles identified as providing best evidence to address a clinical case study (measured by Librarians with Likert scale)</li> <li>- NNT test (self-reported)</li> <li>- Pre-and post-survey on students' perceptions regarding their skills</li> <li>- During 6<sup>th</sup> week, students were given clinical case and had to search and select best article (objectively measured)</li> </ul> <p>2. EBHC attitude</p> <ul style="list-style-type: none"> <li>- Measured with Likert scale from strongly disagree to strongly agree</li> <li>- Pre-and post-survey</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: USA</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: obtained</li> <li>• Funding: The Robert Wood Johnson Foundation</li> <li>• Authors contacted: No</li> </ul>

### 23.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	No	Alternate blocks of clerks were assigned to the intervention group
Was the allocation adequately concealed?	No	Alternate blocks of clerks were assigned to the intervention groups
Were baseline outcome measurements similar?	Unclear	Performance outcomes only measured after course
Were baseline characteristics similar?	Yes	No table of baseline characteristics, but adequate description in paragraph
Were incomplete outcome data adequately addressed?	Unclear	No flow diagram of participants. Not all blocks allocated to intervention and control groups received all the questionnaires. Overall attrition: 14.5% (not reported per group)
Was knowledge of the allocated interventions adequately prevented during the study?	Yes	Librarians who graded the searching skills were blinded to the group allocation
Was the study adequately protected against contamination?	Unclear	Students attending same university, and possibly have contact to other students in different rotations
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified

## 24. Welch 2014

<b>Methods</b>	<ul style="list-style-type: none"> <li>• RCT</li> <li>• International study (all members of the National Athletic Trainer Association)</li> <li>• Countries of origin of participants and socio-economic contexts not reported.</li> </ul>
<b>Participants</b>	<ul style="list-style-type: none"> <li>• Athletic trainers (“health care professionals who collaborate with physicians. The services provided by ATs comprise prevention, emergency care, clinical diagnosis, therapeutic intervention and rehabilitation of injuries and medical conditions” <a href="http://www.nata.org/sites/default/files/Athletic_Trainer_Profile.pdf">http://www.nata.org/sites/default/files/Athletic_Trainer_Profile.pdf</a>)</li> <li>• Undergraduate, postgraduate and CME</li> <li>• n= 473</li> <li>• Inclusion criteria:             <ul style="list-style-type: none"> <li>- All members of the National Athletic Trainer Association (NATA) were eligible to participate</li> </ul> </li> </ul>
<b>Interventions</b>	<p><b>Intervention (n=237) Pure e-learning:</b></p> <ul style="list-style-type: none"> <li>• Web-based modules on EBP</li> <li>• Standalone learning, single intervention</li> <li>• Pure e-learning, individual learning</li> <li>• Asynchronous delivery</li> <li>• EBHC components:             <ul style="list-style-type: none"> <li>- Asking questions</li> <li>- Accessing the literature</li> <li>- Critical appraisal</li> <li>- Applying the results</li> </ul> </li> </ul> <p>Execution:</p> <ul style="list-style-type: none"> <li>- 4 weeks module</li> <li>- According to individual needs, 10 learning modules lasting 25 minutes each</li> <li>• Learning theory: not mentioned</li> </ul> <p><b>Control (n=104): no learning</b></p>
<b>Outcomes</b>	<p>1. EBHC Knowledge</p> <ul style="list-style-type: none"> <li>- Web-based assessment developed by the research team, consisting of multiple-choice questions on each module</li> <li>- Maximum of 60 marks</li> <li>- Pre-and post-test</li> </ul>
<b>Notes</b>	<ul style="list-style-type: none"> <li>• Country: various</li> <li>• Conflict of interest: not reported</li> <li>• Ethics approval: obtained</li> <li>• Funding: NATA board of directors</li> <li>• Authors contacted: No</li> </ul>

### 24.1 Risk of bias table

<b>Bias</b>	<b>Authors' judgement</b>	<b>Support for judgement</b>
Was the allocation sequence adequately generated?	Yes	Using a random number generator (SPSS)
Was the allocation adequately concealed?	Unclear	Participants were sent individualised emails informing them which group they belonged to. Not reported who sent the emails and whether they had access to the randomisation sequence.
Were baseline outcome measurements similar?	Yes	Baseline score intervention: mean 30.99 SD 5.93 Baseline score control: mean 30.12 SD 5.73
Were baseline characteristics similar?	Unclear	Table of baseline characteristics present, but without p-values

Were incomplete outcome data adequately addressed?	No	Attrition rates very high in both groups: Intervention: 63% (149/237) Control:63% (149/236)
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear	Not reported whether outcome assessors were blinded
Was the study adequately protected against contamination?	Unclear	Not clear where participants were from. NATA is an international network, so it is assumed that participants were from all over the world but it is also possible that most of them were from one country or the same institution. Not clear whether they have opportunities to contact each other.
Was the study free from selective outcome reporting?	Yes	All pre-specified outcomes reported on
Was the study free from other bias?	Yes	No other sources of bias identified

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## 9.4 CHARACTERISTICS OF ONGOING STUDIES

### 1. Schneider 2015

<b>Study name</b>	DELIVER
<b>Methods</b>	This study has two parts: 1) Online national survey on EBHC attitudes, skills and use of evidence in clinical practice 2) a prospective randomised wait-list controlled trial
<b>Participants</b>	Chiropractors in the US
<b>Interventions</b>	Intervention: - structured online educational module on EBP Control: - wait list
<b>Outcomes</b>	EBHC skills and attitudes
<b>Starting date</b>	?
<b>Contact information</b>	Michael Schneider: mjs@pitt.edu
<b>Notes</b>	The study was identified through a conference abstract. The author was contacted. The first phase of this study has been published (baseline survey) while the data for the randomised trial is currently being analysed.

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## 9.5 CHARACTERISTICS OF EXCLUDED STUDIES

<b>Study ID</b>	<b>Reason for exclusion</b>
Ahmadi 2011	Intervention not eligible: learning content not EBHC
Allen 2015	Study design not eligible: No control group
Amsellem 2007	Intervention not eligible: learning content not EBHC
Badgett 2001	Intervention not eligible: not delivered via e-learning
Bell 2008	Intervention not eligible: learning content not EBHC
Boyd 2015	Study design not eligible: No control group, descriptive study
Bradley 2002	Intervention not eligible: not delivered via e-learning
Buchanan 2014	Intervention not eligible: not delivered via e-learning
Casebeer 2008	Intervention not eligible: learning content not EBHC
Grad 2005	Intervention not eligible: not delivered via e-learning

Gupta 2014	Study design not eligible: descriptive study, not experimental
Hammond 2006	Study design not eligible: no control group, this is a descriptive study
Johnston 2004	Study design not eligible: cross-sectional study
Kobt 2015	Study design not eligible: No control group
Leathers 2013	Intervention not eligible: Training on using website containing practice guidelines, not EBHC knowledge and skills
Leung 2003	Intervention not eligible: not delivered via e-learning
Long 2016	Outcomes not eligible: EBHC outcomes were only measured in the intervention group
Lewis 2007	Study design not eligible: descriptive study, not experimental
Maloney 2015	Intervention not eligible: Learning content not EBHC
Mary 2013	Study design not eligible: descriptive study, not experimental
Murtaugh 2005	Intervention not eligible: learning content not EBHC
Nelson 2007	Intervention not eligible: learning content not EBHC
Phillips 2015	Intervention not eligible: Learning content not EBHC
Qureshi 2015	Study design not eligible: No control group
Ruzafa-Martinez 2016	Intervention not eligible: not delivered via e-learning
Schifferdecker 2008	Intervention not eligible: learning content not EBHC
Stewart 2005	Intervention not eligible: learning content not EBHC
Webber 2010	Study design not eligible: no experimental study
Whittaker 2015	Intervention not eligible: Learning content not EBHC
Widayahening 2012	Intervention not eligible: not delivered via e-learning

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## 9.6 SUMMARY OF CHARACTERISTICS OF INCLUDED STUDIES

### 9.6.1 Pure e-learning vs no learning

Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Laibhen-Parkes 2014	USA	58	Cluster RCT	Nurses	Web-based module on EBP	Attention control module (no EBHC)	<ul style="list-style-type: none"> <li>• EBHC knowledge</li> <li>• EBHC skills</li> <li>• EBHC attitude</li> </ul>
Shilling 2006	USA	134	Non-RCT	Undergraduate medical students	Web-based modules on searching and selecting best evidence and calculating NNT within Family Medicine clerkship	Traditionally structured Family Medicine clerkship, no modules on EBM	<ul style="list-style-type: none"> <li>• Searching skills</li> <li>• Attitude</li> </ul>
Welch 2014	Not reported	473	RCT	Athletic trainers	Web-based module on EBP	No learning (waiting list)	<ul style="list-style-type: none"> <li>• EBHC knowledge</li> </ul>

### 9.6.2 Blended learning vs no learning

Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Bergold 2013	Germany	120	RCT	Junior doctors	Online EBM course consisting of presentations and exercises. EBM tutor was available for questions on content and technology	No learning (waiting list)	<ul style="list-style-type: none"> <li>• EBM knowledge</li> <li>• Usefulness of EBM course</li> </ul>
Dizon 2014	Philippines	54	RCT	Physiotherapists	EBP training (face-to-face) plus EBP checklist and online support	No learning (waiting list)	<ul style="list-style-type: none"> <li>• EBM knowledge</li> <li>• EBM skills</li> <li>• EBM attitude</li> <li>• EBM behaviour</li> </ul>
Forsetlund 2003	Norway	148	RCT	Public health physicians	EBM workshop with access to databases and participation in asynchronous discussion list	Access to databases for one year (no learning)	<ul style="list-style-type: none"> <li>• EBP behaviour</li> <li>• EBP attitudes</li> <li>• EBP knowledge</li> </ul>
Kok 2013	Netherlands	132 (54 clusters)	Cluster RCT	Physicians	Blended learning: introductory, interactive e-learning course on EBM workshop with didactic and interactive sessions	No learning	<ul style="list-style-type: none"> <li>• EBM behaviour</li> <li>• EBM knowledge</li> <li>• EBM skills</li> <li>• Self-efficacy</li> </ul>
Ramos-Morcillo 2015	Spain	109	Non-RCT	Nurses	EBP course: two face-to-face sessions with additional online learning	No learning (course on different topic)	<ul style="list-style-type: none"> <li>• EBP knowledge and skills</li> <li>• EBP attitude</li> <li>• EBP practice</li> </ul>

### 9.6.3 Pure e-learning vs face-to-face learning

Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Bradley 2005	Norway	175	RCT	Undergraduate medical students	Computer-assisted (CD-ROM) on five steps of EBM	Workshop on five steps of EBM	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>EBM skills</li> <li>EBM attitudes</li> </ul>
Davis 2007	UK	55	RCT	Medical interns	Short, computer-based session on EBM (CD-ROM)	Lecture on EBM with similar content structure and duration as intervention	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>EBM attitude</li> </ul>
Davis 2008	UK	229	RCT	Undergraduate medical students	Short, computer-based session on EBM (CD-ROM)	Lecture on EBM with similar content structure and duration as intervention	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>EBM attitude</li> </ul>
Hadley 2010	UK	237 (7 clusters)	Cluster RCT	Medical interns	Clinically integrated teaching of EBM: Three modules on EBM (asking questions, accessing literature, appraising literature). Unlimited access for six weeks	Standalone, three hour face-to-face lecture (same content as intervention)	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>EBM skills</li> </ul>
Horiuchi 2009	Japan	93	RCT	Nurses	E-learning of EBM divided into four parts, distributed according to individual progress	EBM teaching divided into one evening lecture per week (for one month)	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>Satisfaction with learning</li> </ul>
McLeod 2010	USA	441 (12 clusters)	Cluster RCT	Surgical residents	Online journal club made up of 8 packages emailed to participants, each package containing one clinical and one methodological article. Asynchronous discussions on list serv, moderated by facilitator. Clinical scenarios included in discussions	Monthly face-to-face journal club using same articles, led by general surgical faculty member.	<ul style="list-style-type: none"> <li>Critical appraisal skills</li> </ul>

### 9.6.4 Blended learning vs face-to-face learning

Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Brettle 2013	UK	77	RCT	Nurses (pre-registration diploma)	Online tutorial on searching within the "Foundations in Nursing" module	Lecture on searching (same content as online tutorial) within the "Foundations in Nursing" module	<ul style="list-style-type: none"> <li>• Searching skills</li> </ul>
Ilic 2013	Australia	61	Non-RCT	Undergraduate medical students	Blended learning consisting of a face-to-face workshop, self-directed learning via the Monash University's website, presentations of patient-based EBM cases	Didactic lectures/tutorials with small group tasks and discussions	<ul style="list-style-type: none"> <li>• EBM knowledge</li> <li>• EBM skills</li> <li>• EBM attitude</li> </ul>
Ilic 2015	Australia and Malaysia	497	Cluster RCT	Undergraduate medical students	Blended learning consisting of classroom activities (formal lectures and small group activities), online lectures on You Tube, access to resources on the library website and mobile access to the evidence at the bedside.	Face-to-face learning consisting of classroom activities (formal lectures and small group activities)	<ul style="list-style-type: none"> <li>• EBM knowledge and skills</li> <li>• EBM attitude</li> <li>• EBM self-efficacy</li> <li>• Satisfaction with learning</li> <li>• Enablers of method of learning</li> </ul>
Kulier 2009	UK and Netherlands	61 (6 clusters)	Cluster RCT	Obstetrics and gynaecology residents	Clinically integrated EBM course with self-directed e-learning components and clinically relevant activities	Lectures on EBM, using PowerPoint slides (same as in e-learning). Interaction with tutor during lectures	<ul style="list-style-type: none"> <li>• EBM knowledge</li> <li>• EBM attitude</li> </ul>
Saunders 2016	Finland	85	RCT	Nurses	Educational intervention on EBP consisting of didactic lectures, interactive online EBP module and EBP mentorship	Didactic lectures on research utilisation (very similar content to EBP)	<ul style="list-style-type: none"> <li>• EBP self-efficacy</li> <li>• EBP knowledge</li> </ul>

### 9.6.5 Blended learning vs pure e-learning

Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Fernandez 2014	Australia and Hong Kong	187	Non-RCT	Postgraduate nursing students	Evidence-based practice (EBP) DVD: demonstrations of EBP skills provided on a DVD	1) Standard distance method 2) Computer Lab teaching method (on campus) – practical interactive computer-based training with immediate feedback 3) Face to face didactic classroom teaching method – classroom teaching	<ul style="list-style-type: none"> <li>EBP knowledge</li> <li>EBP skills</li> </ul>
Kamin 2001	USA	27	RCT	Undergraduate physician assistants	Online EBM course with computer-mediated communication using asynchronous discussion software	Online EBM course with face-to-face discussions in mentor groups	<ul style="list-style-type: none"> <li>EBM knowledge</li> </ul>
Kulier 2012	Argentina, Brazil, Democratic Republic of Congo, India, Philippines, South Africa, Thailand	204 (60 clusters)	Cluster RCT	Obstetrics and gynaecology residents	Clinically integrated EBM e-learning course containing recorded presentations but incorporating learning activities, assignments and assessments in clinical practice. Clinical trainer involved in face-to-face teaching.	Self-directed EBM teaching package containing recorded presentations. Access to facilitator that could be consulted on demand.	<ul style="list-style-type: none"> <li>EBM knowledge</li> <li>EBM skills</li> <li>EBM attitudes</li> <li>Educational environment</li> </ul>

### 9.6.6 Pure e-learning vs pure e-learning

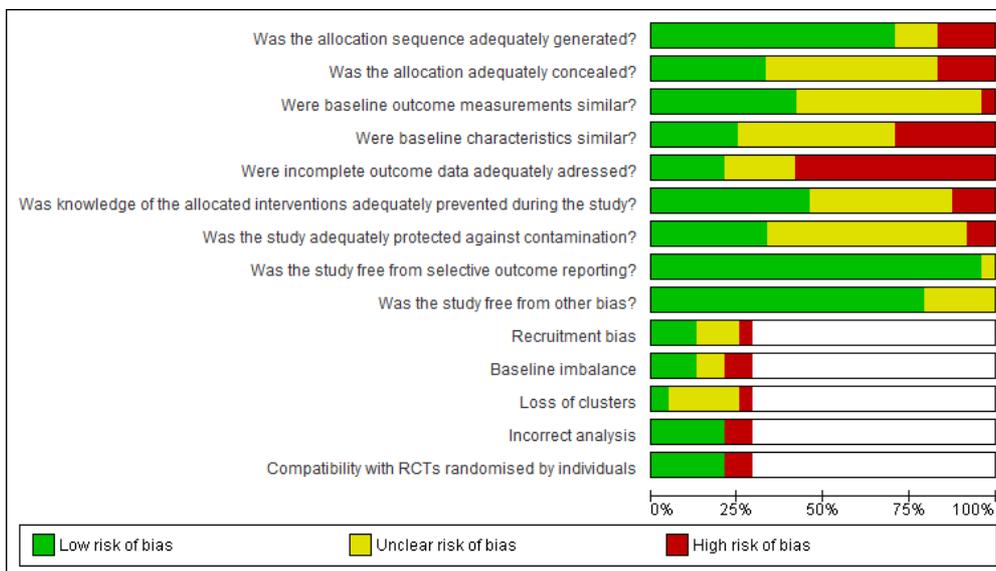
Study ID	Country	Sample size (n)	Study design	Participants	Intervention	Comparison	Main outcomes
Brouwers 2011	Canada	87	RCT	Healthcare professionals, Clinicians, methodologists, policy makers and trainees	1) Online tutorial on AGREEII tool 2) Online tutorial on AGREE II tool plus practice feedback	Participants were given the AGREE II manual	<ul style="list-style-type: none"> <li>EBM skills (appraising a guideline)</li> <li>Satisfaction with learning</li> <li>Self-efficacy</li> <li>Attitudes</li> </ul>
MacRae 2004	Canada	81	RCT	Surgeons	Online journal club made up of 8 packages emailed to participants, each package containing one clinical and one methodological article. Asynchronous discussions on list serv, moderated by facilitator	Participants also received 8 packages per email and were given access to main medical and surgical journals.	<ul style="list-style-type: none"> <li>Critical appraisal skills</li> </ul>

## 9.9 SUMMARY OF RESULTS

		Comparison					
		Pure e-learning vs no learning	Blended learning vs no learning	Pure e-learning vs face-to-face learning	Blended learning vs face-to-face learning	Blended learning vs pure e-learning	Pure e-learning vs pure e-learning
Outcome SMD (95% Confidence Intervals)	<b>EBHC knowledge</b>	0.71 (0.40 to 1.01) 1 study, n=175	0.50 (0.13 to 0.86) 1 study, n=119	-0.03 (-0.26 to 0.20) 5 studies, n=632	0.28 (-0.23 to 0.79) 1 study, n=146	0.69 (0.40 to 0.99) 2 studies, n=193	not reported
	<b>EBHC knowledge &amp; skills</b>	0.47 (-0.27 to 1.21) 1 study, n=29	1.40 (-0.06 to 2.85) 2 studies, n=163	not reported	-0.23 (-0.52 to 0.06) 2 studies, n=184	not reported	not reported
	<b>EBHC knowledge &amp; skills (1 month)</b>	not reported	0.90 (0.42 to 1.38) 2 studies, n=241	not reported	not reported	not reported	not reported
	<b>EBHC knowledge &amp; skills (3+ months)</b>	not reported	1.11 (0.80 to 1.42) 2 studies, n=186	not reported	not reported	not reported	not reported
	<b>EBHC skills</b>	Not reported	not reported	-0.15 (-0.34 to 0.04) 2 studies, n=457	-0.21 (-0.68 to 0.26) 1 study, n=70	-0.53 (-2.31 to 1.25) 2 studies, n=218	1.30 (0.68 to 1.93) 2 studies, n=119
	<b>EBHC attitude</b>	1.05 (0.26 to 1.83) 1 study, n=29	0.17 (-0.09 to 0.43) 2 studies, n=226	0.11 (-0.27 to 0.48) 3 studies, n=111	1.07 (0.57 to 1.58) 1 study, n=69	not reported	not reported
	<b>EBHC attitude (1 month)</b>	not reported	0.05 (-0.34 to 0.44) 2 studies, n=241	not reported	not reported	not reported	not reported
	<b>EBHC attitude (3+ months)</b>	not reported	0.32 (-0.02 to 0.67) 1 study, n=132	not reported	not reported	not reported	not reported
	<b>EBHC behaviour</b>	not reported	0.06 (-0.28 to 0.40) 3 studies, n=207	not reported	2.34 (1.72 to 2.96) 1 study, n=69	not reported	not reported
	<b>EBHC behaviour (1 month)</b>	not reported	0.19 (-0.19 to 0.56) 1 study, n=109	not reported	not reported	not reported	not reported
	<b>EBHC behaviour (3+ months)</b>	not reported	0.61 (0.21 to 1.01) 1 study, n=100	not reported	not reported	not reported	not reported

# 10 Figures

**Figure 5: Summary of risk of bias across all included studies**



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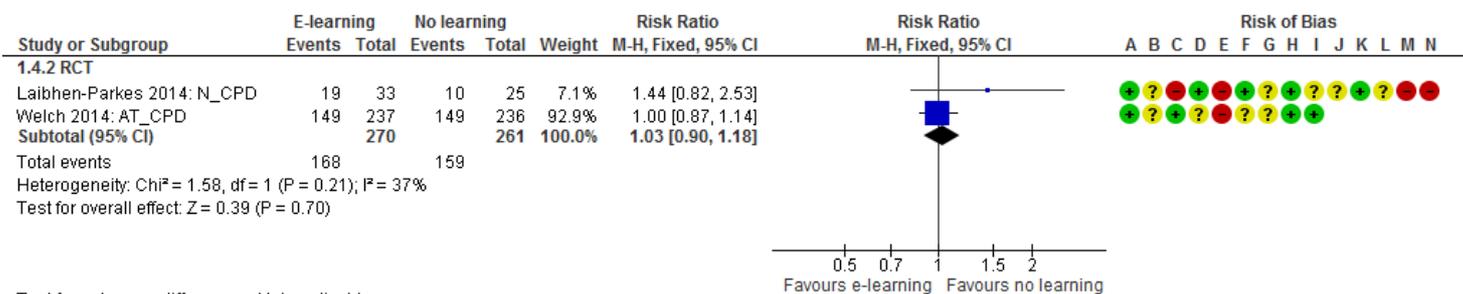
**Figure 6: Risk of bias judgement per included study**

	Was the allocation sequence adequately generated?	Was the allocation adequately concealed?	Were baseline outcome measurements similar?	Were baseline characteristics similar?	Were incomplete outcome data adequately addressed?	Was knowledge of the allocated interventions adequately prevented during the study?	Was the study adequately protected against contamination?	Was the study free from selective outcome reporting?	Was the study free from other bias?	Recruitment bias	Baseline imbalance	Loss of clusters	Incorrect analysis	Compatibility with RCTs randomised by individuals
Bergold 2013	+	+	+	?	+	?	-	+	?					
Bradley 2005	+	+	?	+	+	+	?	+	+					
Brettell 2013	+	?	+	?	+	?	?	+	+					
Brouwers 2011	+	?	?	-	-	?	+	+	+					
Davis 2007	+	+	+	-	+	+	+	+	+					
Davis 2008	+	+	+	?	-	+	+	+	+					
Dizon 2014	+	+	+	?	-	+	?	+	+					
Fernandez 2014	-	-	?	?	?	-	?	+	?					
Forsetlund 2003	+	?	?	-	-	+	?	+	+					
Hadley 2010	+	?	?	?	-	?	+	+	+	+	?	?	+	+
Horiuchi 2009	+	+	?	?	-	?	?	+	+					
Ilic 2013	-	-	?	-	+	-	?	+	+					
Ilic 2015	+	+	?	-	-	+	+	+	+	?	-	?	-	-
Kamin 2001	?	?	?	?	?	+	?	+	?					
Kok 2013	+	+	+	+	-	+	?	+	+	+	+	?	+	+
Kulier 2009	+	?	+	-	-	?	+	+	+	?	-	+	+	+
Kulier 2012	+	?	+	+	?	?	+	?	?	-	+	-	+	+
Laibhen-Parkes 2014	+	?	-	+	-	+	?	+	?	?	+	?	-	-
Macrae 2004	?	?	?	?	-	+	?	+	+					
McLeod 2010	?	?	?	?	-	-	+	+	+	+	?	?	+	+
Ramos-Morcillo 2015	-	-	+	+	?	?	?	+	+					
Saunders 2016	+	?	?	-	-	?	-	+	+					
Schilling 2006	-	-	?	+	?	+	?	+	+					
Welch 2014	+	?	+	?	-	?	?	+	+					





### 11.1.4 Analysis 1.4: Attrition of learners



Test for subgroup differences: Not applicable

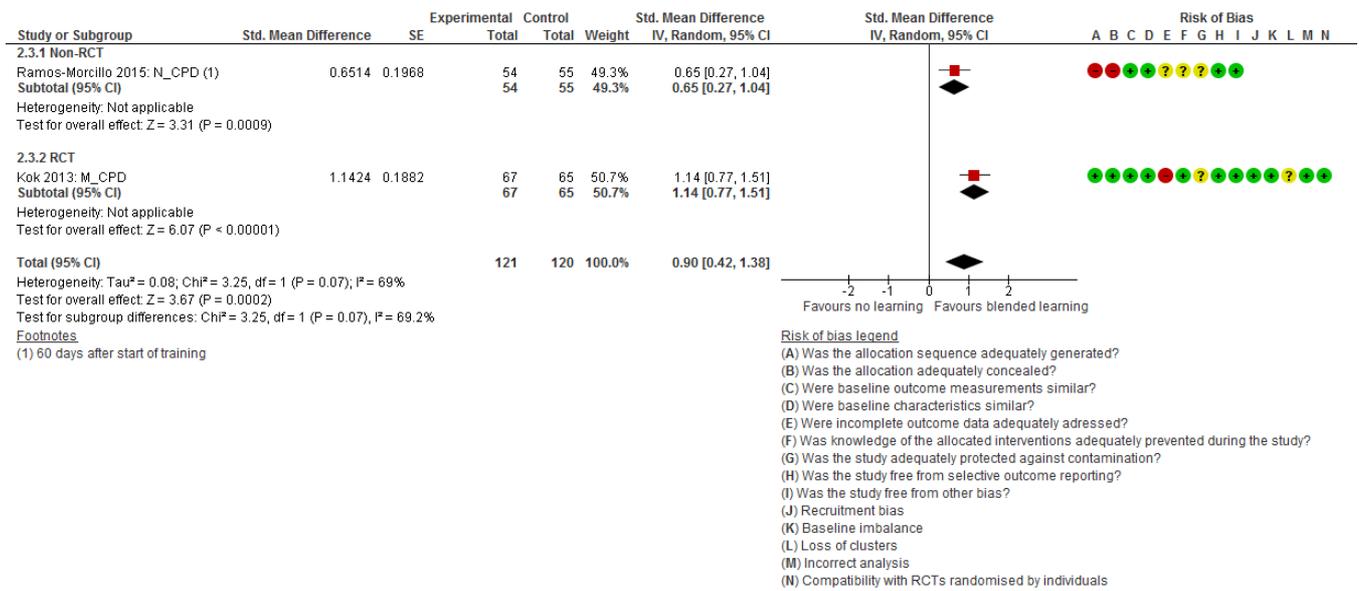
**Risk of bias legend**

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

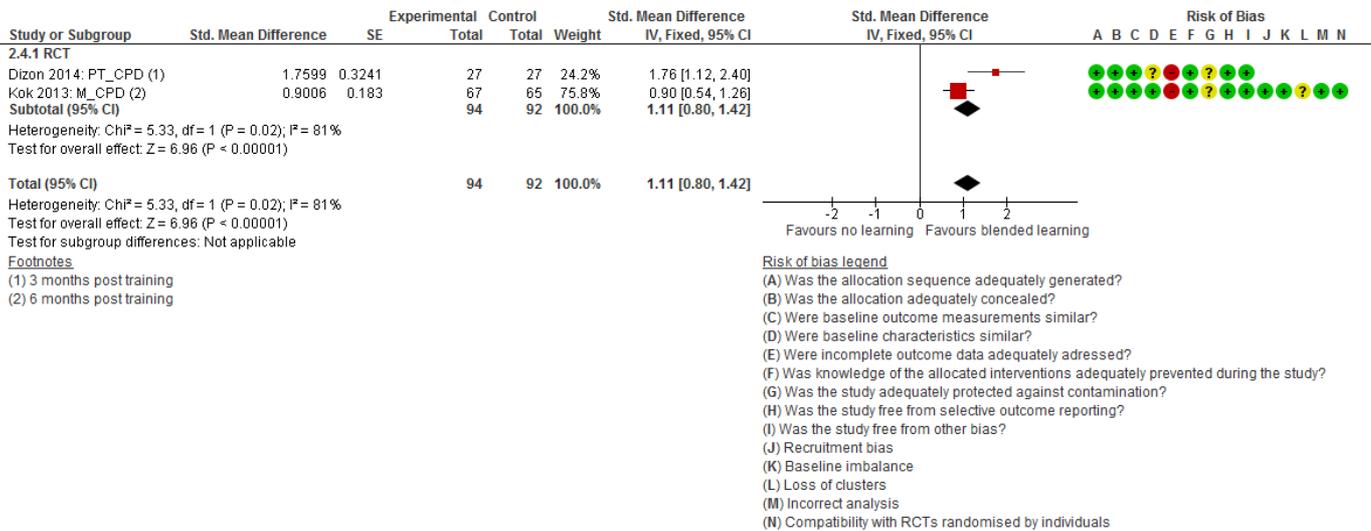
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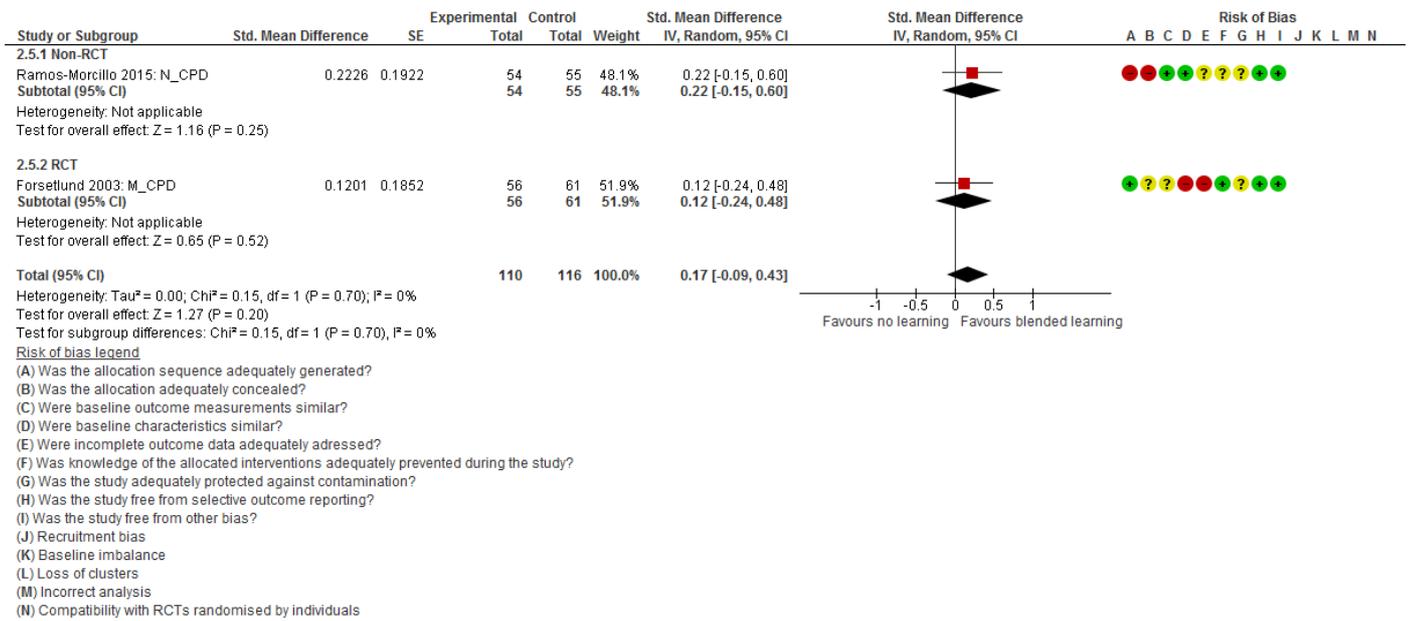
### 11.2.3 Analysis 2.3: EBHC knowledge and skills (1 month post-intervention)



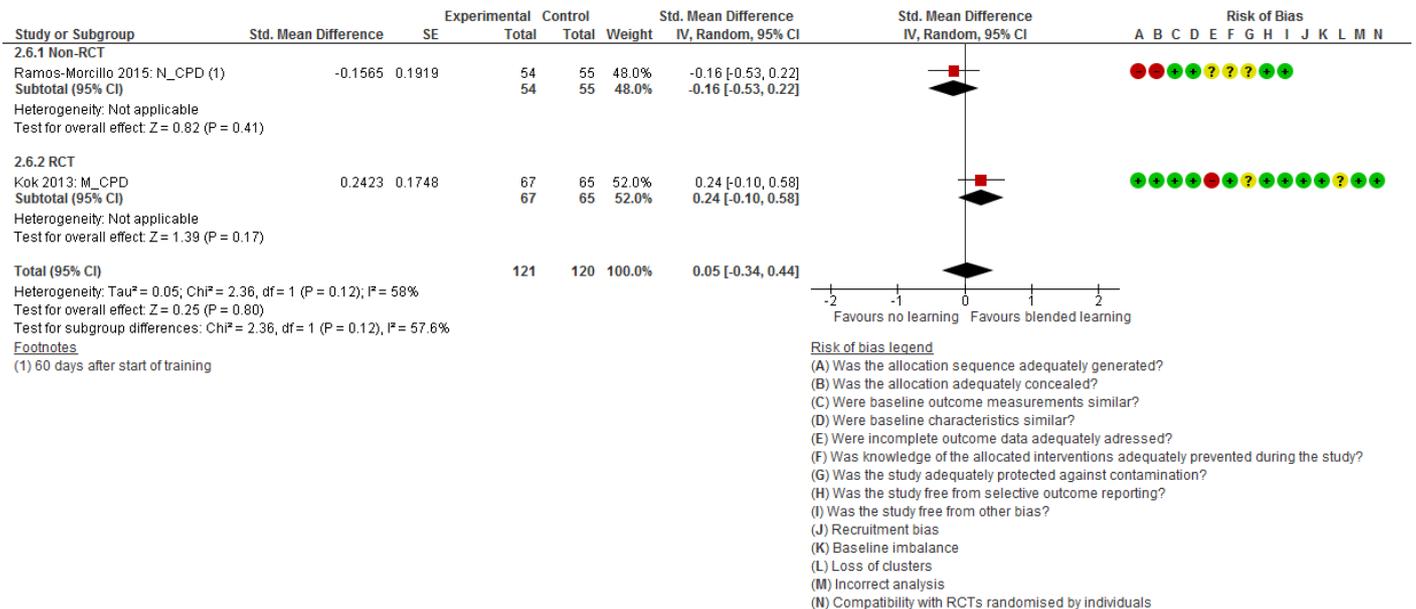
### 11.2.4 Analysis 2.4: EBHC knowledge and skills (3+months post-intervention)



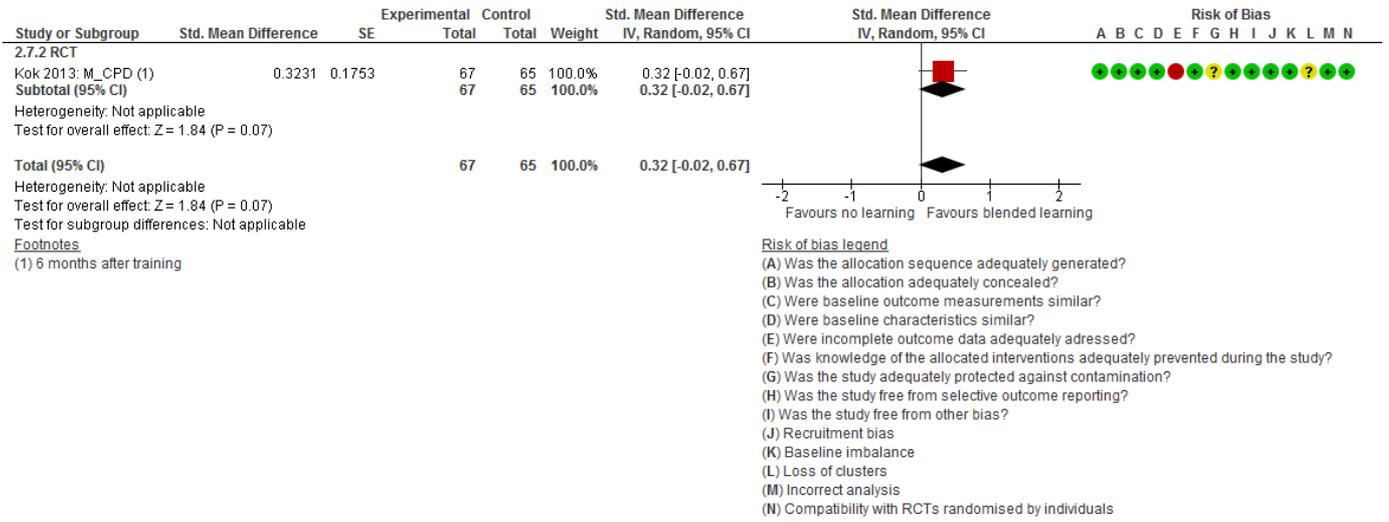
## 11.2.5 Analysis 2.5: EBHC attitude



## 11.2.6 Analysis 2.6: EBHC attitude (one month post-intervention)

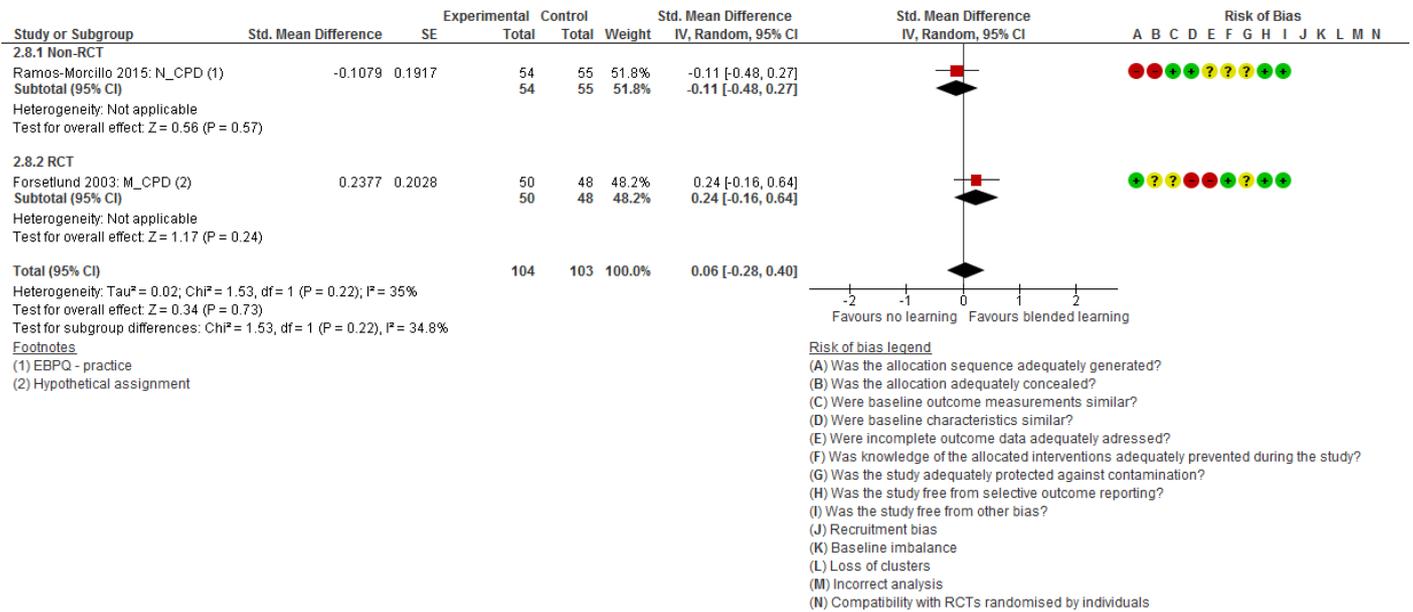


### 11.2.7 Analysis 2.7: EBHC attitude (3+ months post-intervention)

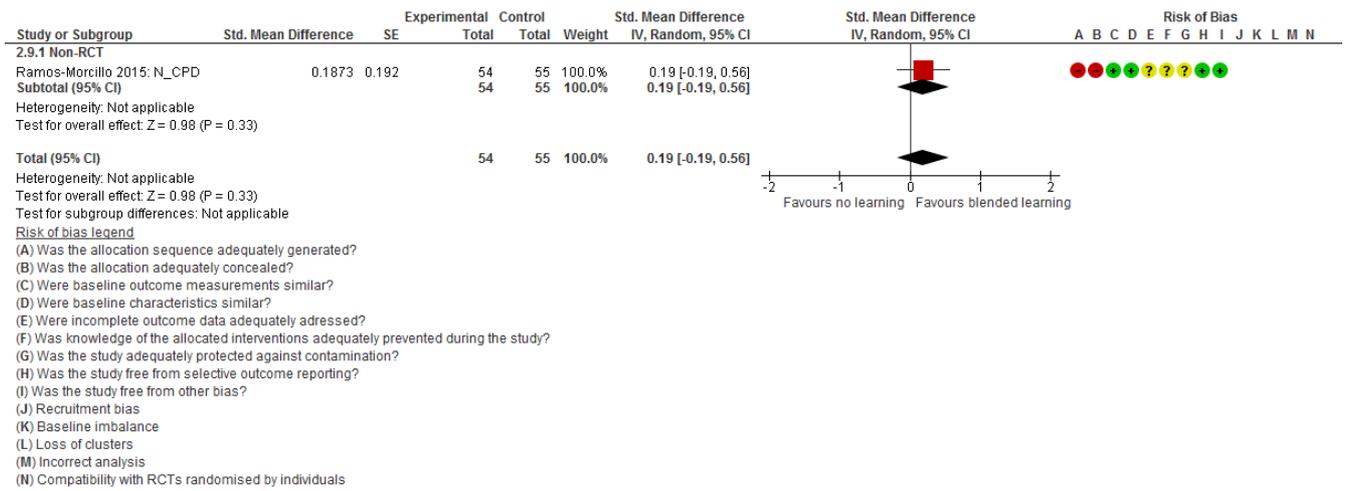


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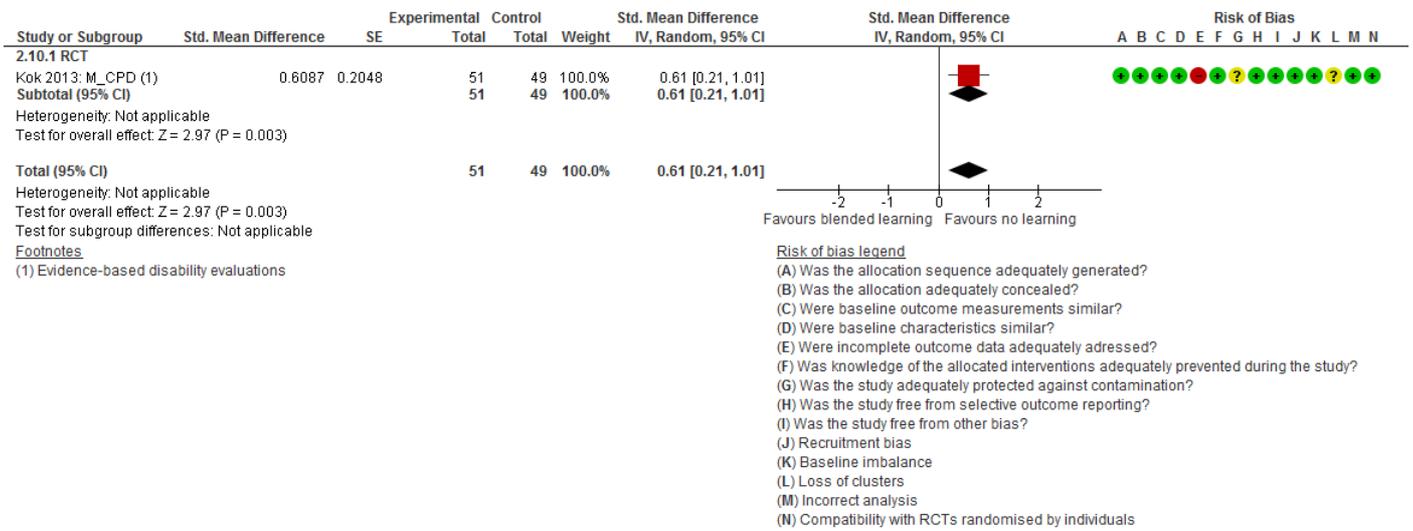
### 11.2.8 Analysis 2.8: EBHC behaviour



### 11.2.9 Analysis 2.9: EBHC behaviour (one month post-intervention)

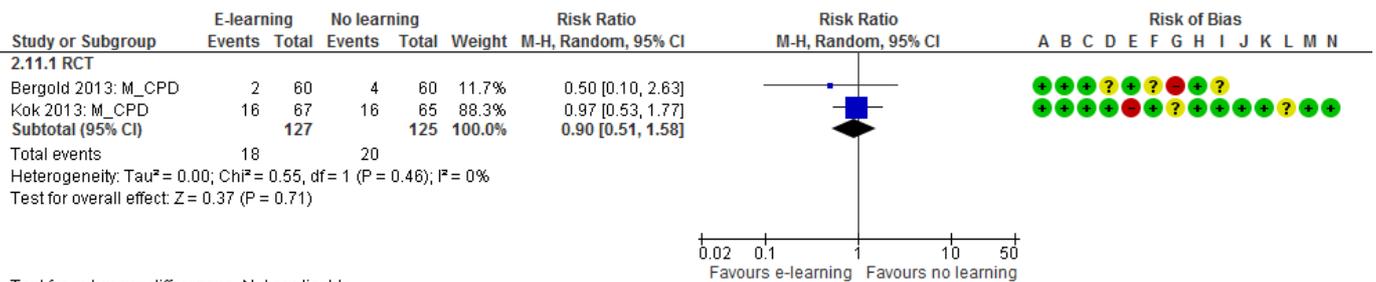


### 11.2.10 Analysis 2.10: EBHC behaviour (3+ months post-intervention)



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### 11.2.11 Analysis 2.11: Attrition of learners



Test for subgroup differences: Not applicable

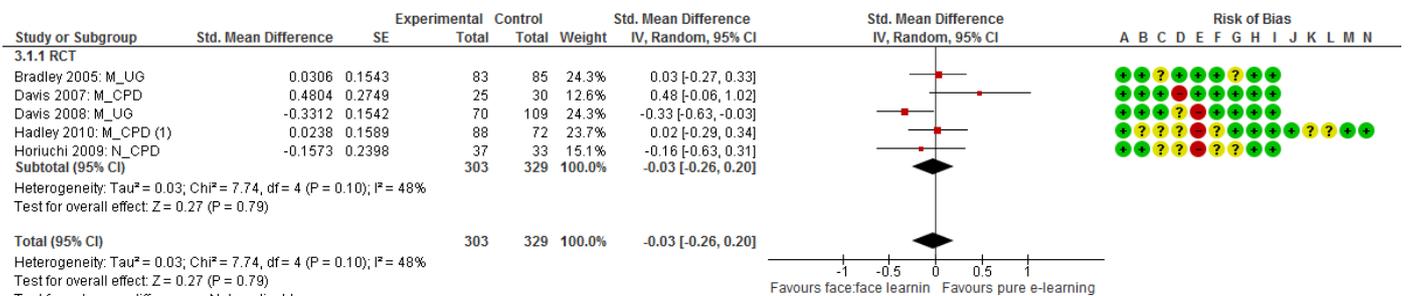
Risk of bias legend

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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## 11.3 PURE E-LEARNING VS FACE-TO-FACE LEARNING

### 11.3.1 Analysis 3.1: EBHC knowledge



Footnotes

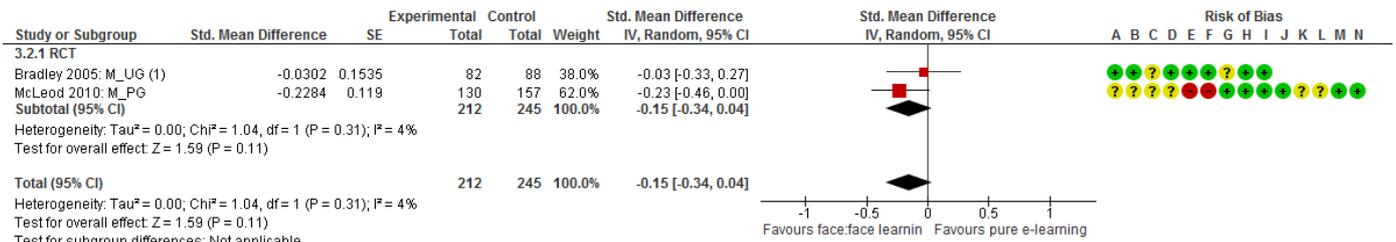
(1) Adjusted for clustering and baseline score

Risk of bias legend

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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### 11.3.2 Analysis 3.2 EBHC skills



Footnotes

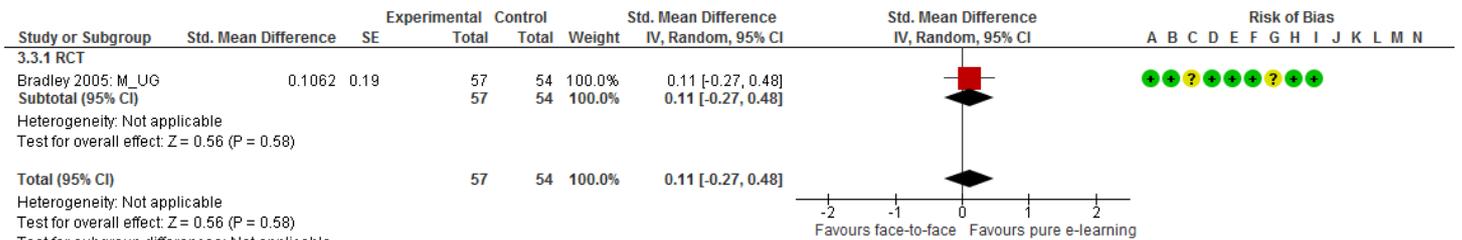
(1) Critical appraisal skills

Risk of bias legend

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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### 11.3.3 Analysis 3.3: EBHC attitude

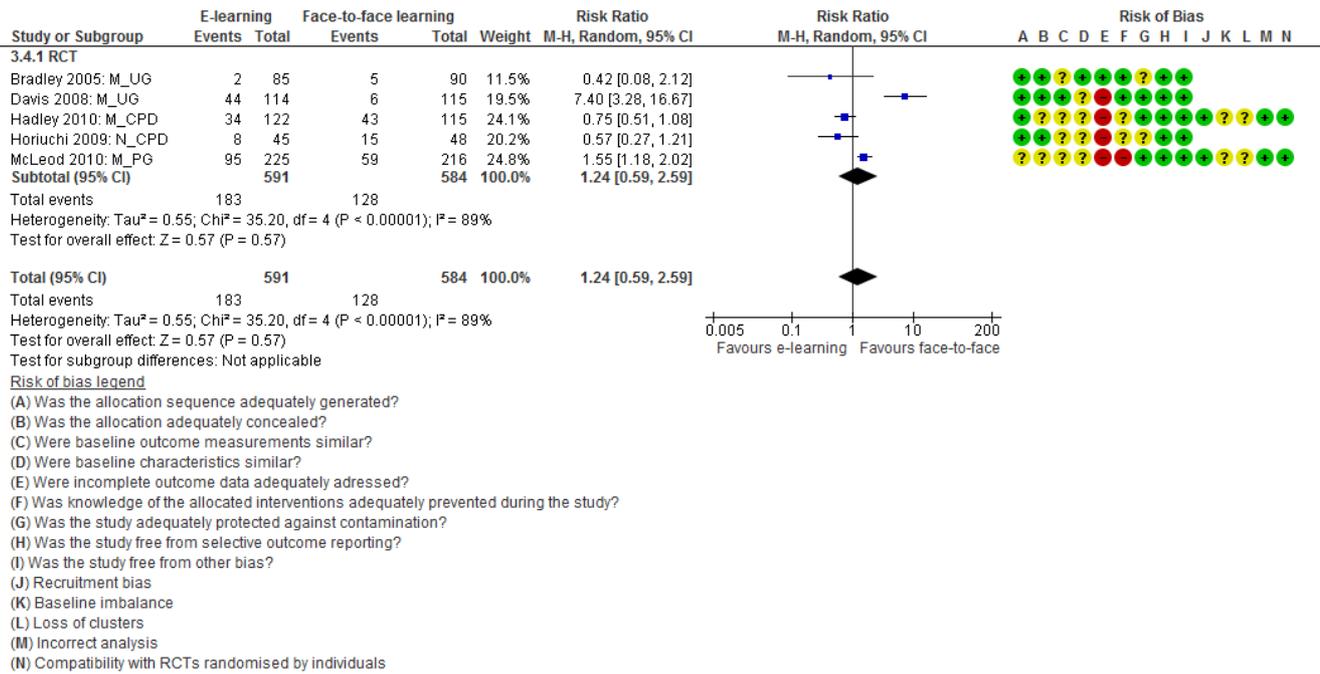


Risk of bias legend

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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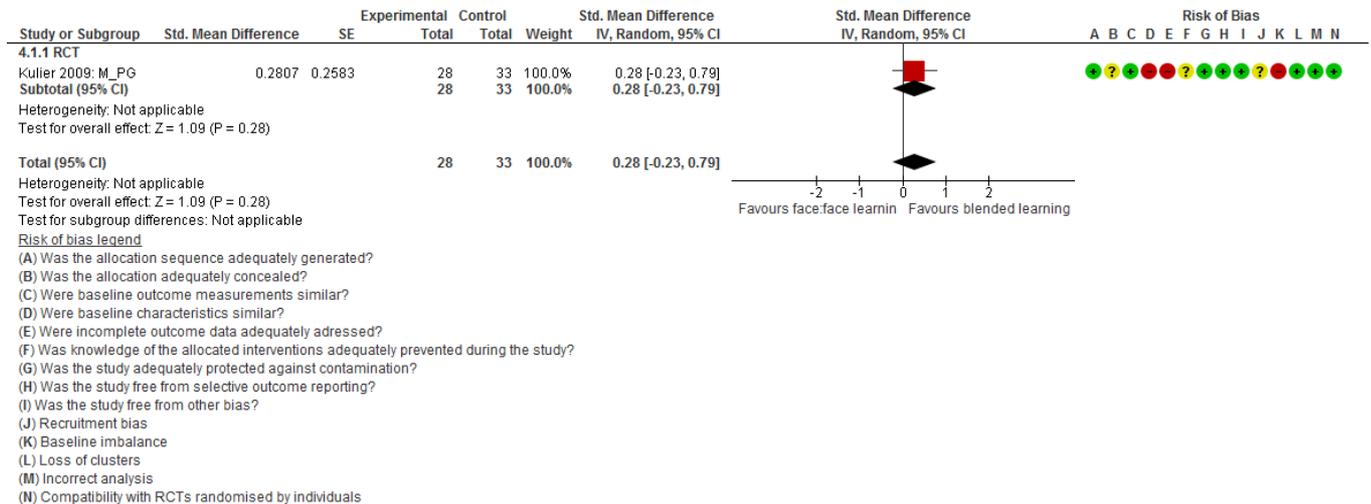
### 11.3.4 Analysis 3.4: Attrition of learners



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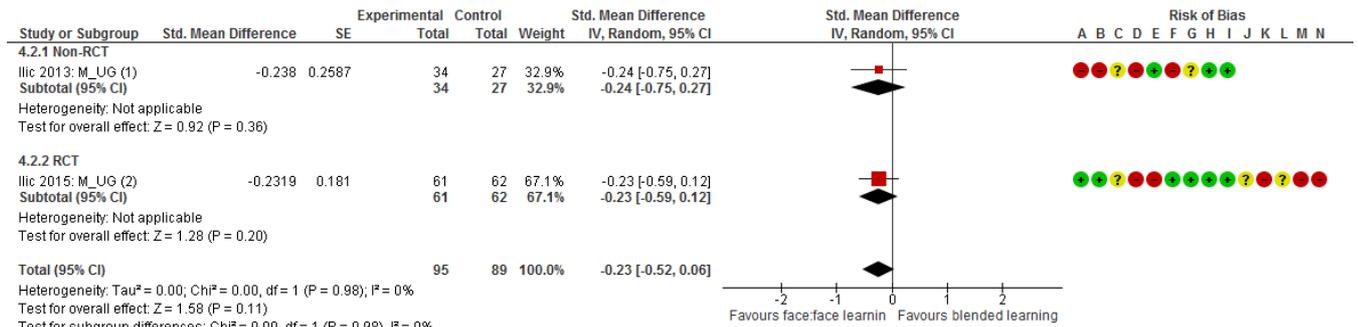
## 11.4 BLENDED LEARNING VS FACE-TO-FACE LEARNING

### 11.4.1 Analysis 4.1: EBHC knowledge



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### 11.4.2 Analysis 4.2: EBHC knowledge and skills



**Footnotes**

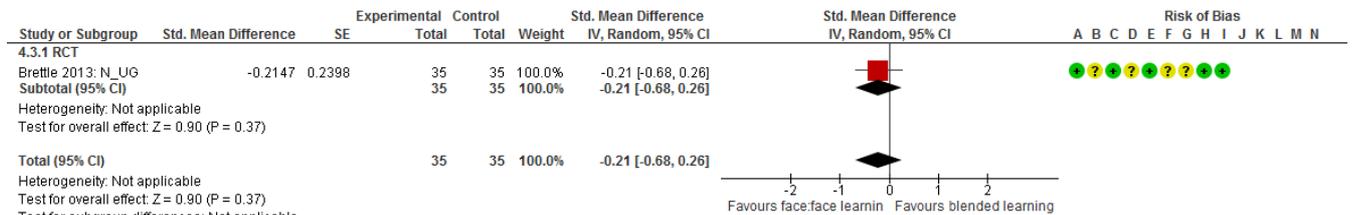
- (1) Berlin tool
- (2) Berlin tool - adjusted for clustering with DE of 1.199 (ICC 0.01)

**Risk of bias legend**

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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### 11.4.3 Analysis 4.3: EBHC skills



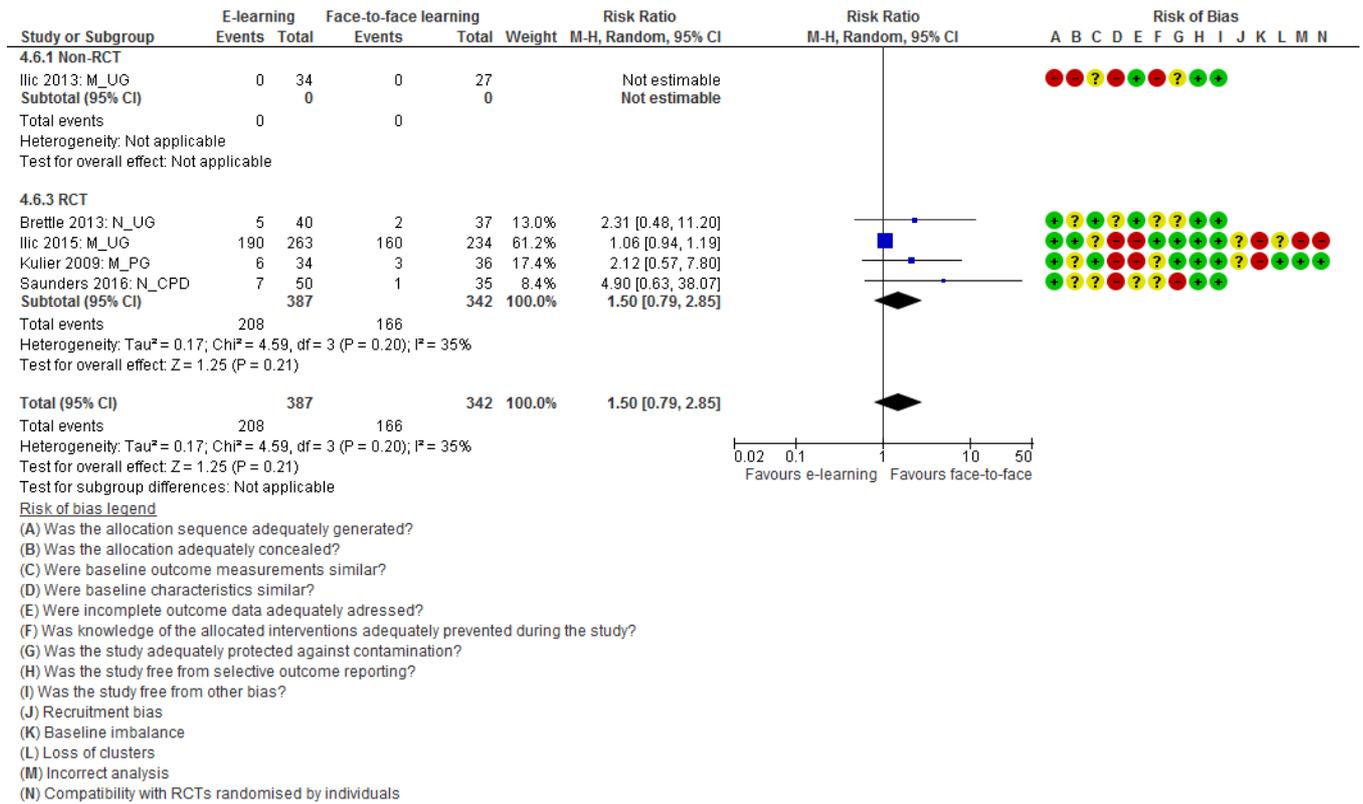
**Risk of bias legend**

- (A) Was the allocation sequence adequately generated?
- (B) Was the allocation adequately concealed?
- (C) Were baseline outcome measurements similar?
- (D) Were baseline characteristics similar?
- (E) Were incomplete outcome data adequately addressed?
- (F) Was knowledge of the allocated interventions adequately prevented during the study?
- (G) Was the study adequately protected against contamination?
- (H) Was the study free from selective outcome reporting?
- (I) Was the study free from other bias?
- (J) Recruitment bias
- (K) Baseline imbalance
- (L) Loss of clusters
- (M) Incorrect analysis
- (N) Compatibility with RCTs randomised by individuals

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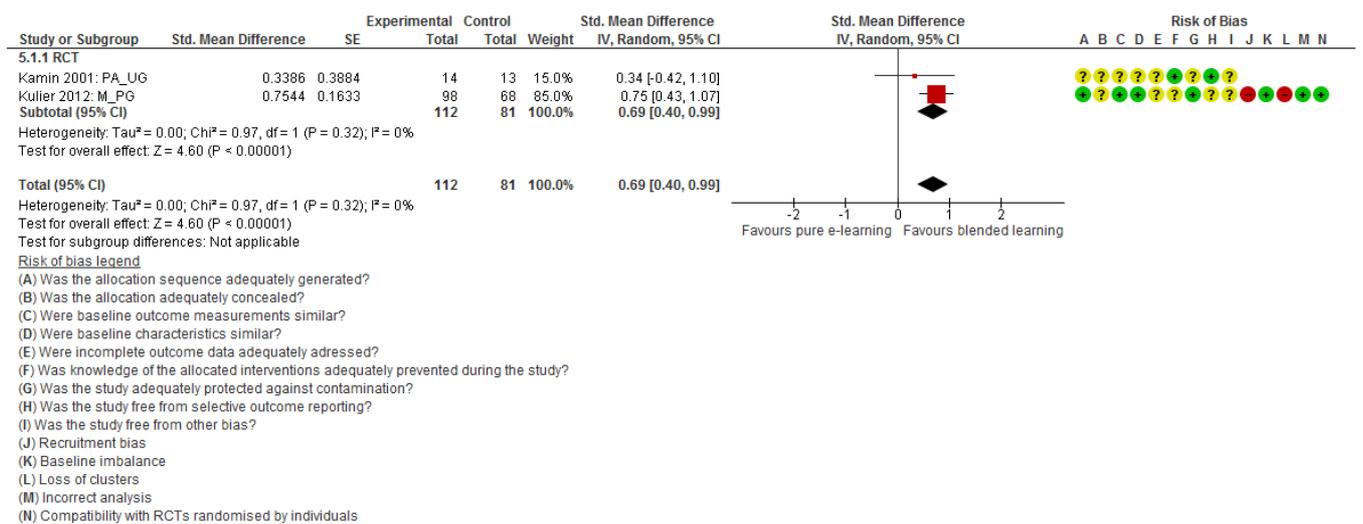
## 11.4.6 Analysis 4.6: Attrition of learners



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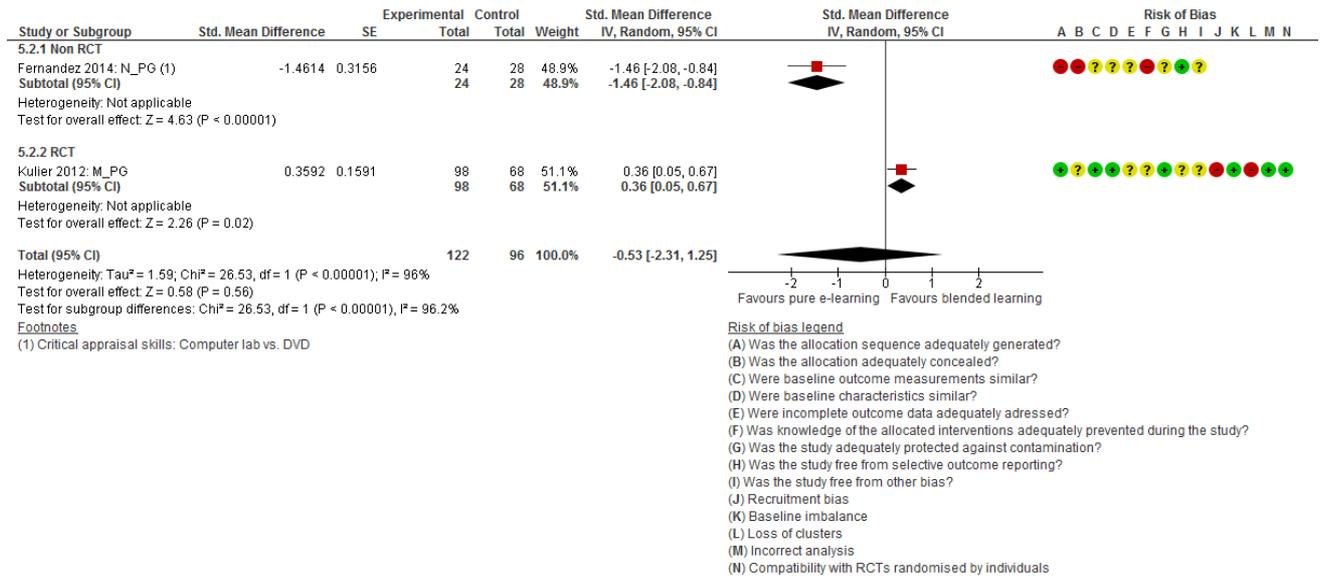
## 11.5 BLENDED LEARNING VS PURE E-LEARNING

### 11.5.1 Analysis 5.1: EBHC knowledge

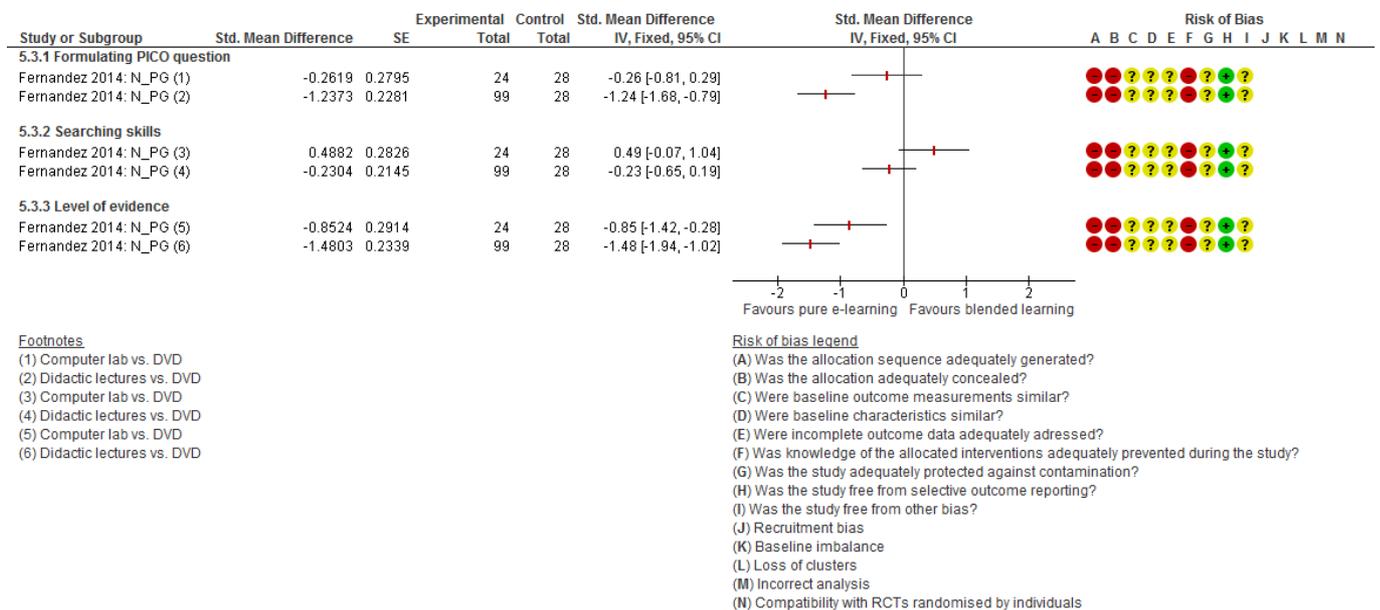


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## 11.5.2 Analysis 5.2: EBHC skills



## 11.5.3 Analysis 5.3: EBHC skills (additional results)



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## 12 Summary of findings

Abbreviations:

CPD: Continuing professional development

UG: Undergraduate

PG: Postgraduate

### 12.1 PURE E-LEARNING VS NO LEARNING (3 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC knowledge	0.71 (0.40 to 1.01)	n=175 (1 study)	- Web-based module on EBP	- Athletic trainers (CPD); country unknown	- High risk for attrition bias, unclear risk of selection and detection bias - Imprecision: size of the effect ranges from small to large
EBHC knowledge and skills	0.47 (-0.27 to 1.21)	n=29 (1 study)	- Web-based module on EBP	- Nurses (CPD); USA	- High risk for selection and attrition bias - Results not adjusted for clustering - Small sample size and imprecision
EBHC skills	MD 0.8 (p<0.05)	n=134 (1 study)	- Web-based module on searching	- Medical doctors (UG); USA	- High risk of selection bias - Authors did not report SDs or 95%CI - Small sample size
EBHC attitude	1.05 (0.26 to 1.83)	n=29 (1 study)	- Web-based module on EBP	- Nurses (CPD), USA	- High risk for selection and attrition bias - Results not adjusted for clustering - Small sample size and imprecision: effect ranges from small to very large

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## 12.2 BLENDED LEARNING VS NO LEARNING (5 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC knowledge	0.50 (0.13 to 0.86)	n=119 1 study	- EBM workshop with access to databases and asynchronous discussion list	- Medical doctors (CPD); Norway	- Imprecision: size of the effect ranges from very small to large - High risk of attrition and selection bias
EBHC knowledge and skills	1.40 (-0.06 to 2.85)	n=163 2 studies	- EBP training (face-to-face) plus EBP checklist and online support - EBP course (face-to-face) with additional online learning	- Physiotherapists (CPD); Philippines - Nurses (CPD); Spain	- High risk of selection and attrition bias - Significant heterogeneity between non-RCT and RCT - Although both studies show significant effects favouring blended learning, the pooled effect is non-significant with a very wide confidence interval
EBHC knowledge and skills (1 month post-intervention)	0.90 (0.42 to 1.38)	n=241 2 studies	- EBP course (face-to-face) with additional online learning - Interactive e-learning course on EBM plus workshop (face-to-face)	- Nurses (CPD); Spain - Medical doctors (CPD); Netherlands	- High risk of selection and attrition bias - Significant heterogeneity between non-RCT and RCT - Imprecision: effect ranges from small to very large
EBHC knowledge and skills (3+ months post-intervention)	1.11 (0.80 to 1.42)	n=186 2 studies	- EBP training (face-to-face) plus EBP checklist and online support - Interactive e-learning course on EBM plus workshop (face-to-face)	- Physiotherapists (CPD); Philippines - Medical doctors (CPD); Netherlands	- High risk of attrition bias - Significant heterogeneity
EBHC attitude	0.17 (-0.09 to 0.43)	n=226 2 studies	- EBP course (face-to-face) with	- Nurses (CPD); Spain	- High risk for selection and attrition bias

			<ul style="list-style-type: none"> <li>additional online learning</li> <li>- EBM workshop with access to databases and asynchronous discussion list</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (CPD); Norway</li> </ul>	
EBHC attitude (1 month post-intervention)	0.05 (-0.34 to 0.44)	n=241 2 studies	<ul style="list-style-type: none"> <li>- EBP course (face-to-face) with additional online learning</li> <li>- Interactive e-learning course on EBM plus workshop (face-to-face)</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (CPD); Spain</li> <li>- Medical doctors (CPD); Netherlands</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection and attrition bias</li> <li>- Heterogeneity moderate</li> </ul>
EBHC attitude (3+ months post-intervention)	0.32 (-0.02 to 0.67)	n=132 1 study	<ul style="list-style-type: none"> <li>- Interactive e-learning course on EBM plus workshop (face-to-face)</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (CPD); Netherlands</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of attrition bias</li> </ul>
EBHC behaviour	0.06 (-0.28 to 0.40)	n=207 2 studies	<ul style="list-style-type: none"> <li>- EBP course (face-to-face) with additional online learning</li> <li>- EBM workshop with access to databases and asynchronous discussion list</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (CPD); Spain</li> <li>- Medical doctors (CPD); Norway</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection and attrition bias</li> </ul>
EBHC behaviour (1 month post-intervention)	0.19 (-0.19 to 0.56)	n=109 1 study	<ul style="list-style-type: none"> <li>- EBP course (face-to-face) with additional online learning</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (CPD); Spain</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection bias, unclear risk of attrition bias</li> </ul>
EBHC behaviour (3+ months post-intervention)	0.61 (0.21 to 1.01)	n=100 1 study	<ul style="list-style-type: none"> <li>- Interactive e-learning course on EBM plus workshop (face-to-face)</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (CPD); Netherlands</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of attrition bias</li> <li>- Imprecision: Effect size ranges from small to large</li> </ul>

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### 12.3 PURE E-LEARNING VS FACE-TO-FACE LEARNING (6 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC knowledge	-0.03 (-0.26 to 0.20)	n=632 5 studies	<ul style="list-style-type: none"> <li>- Recorded PowerPoints on CD-ROM or available online</li> <li>- One study had additional online exercises</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Norway, UK</li> <li>- Medical doctors (CPD); UK</li> <li>- Nurses (CPD); Japan</li> </ul>	<ul style="list-style-type: none"> <li>- High risk for attrition bias, unclear risk of selection bias</li> <li>- Moderate heterogeneity (1 study with high attrition rates in the intervention group is an outlier)</li> </ul>
EBHC skills	-0.15 (-0.34 to 0.04)	n=457 2 studies	<ul style="list-style-type: none"> <li>- Recorded PowerPoints on CD-ROM</li> <li>- Online journal club with asynchronous discussion group</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Norway</li> <li>- Medical doctors (PG); USA</li> </ul>	<ul style="list-style-type: none"> <li>- High risk for detection and attrition bias, unclear risk of selection bias</li> </ul>
EBHC attitude	0.11 (-0.27 to 0.48)	n=111 1 study	<ul style="list-style-type: none"> <li>- Recorded PowerPoints on CD-ROM</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Norway</li> </ul>	<ul style="list-style-type: none"> <li>- Two studies did not report adequate data for attitude and were not included in the random-effects meta-analysis</li> </ul>

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### 12.4 BLENDED LEARNING VS FACE-TO-FACE LEARNING (5 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC knowledge	0.28 (-0.23 to 0.79)	n=146 1 study	<ul style="list-style-type: none"> <li>- Recorded PowerPoint presentations, online exercises, clinical activities, access to clinical tutor</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (PG); UK and Netherlands</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection and attrition bias</li> <li>- Imprecision: wide 95% confidence intervals</li> <li>- One study did not report means and SDs, awaiting author response</li> </ul>
EBHC knowledge and skills	-0.23 (-0.52 to 0.06)	n=184 2 studies	<ul style="list-style-type: none"> <li>- Face-to-face workshop, self-directed, online learning, presentation of</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Australia and Malaysia</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection, detection and attrition bias</li> <li>- Only crude results reported for the cluster RCT. Results adjusted</li> </ul>

			<p>patient-based EBM cases</p> <ul style="list-style-type: none"> <li>- Lectures and small group activities in classroom, online lectures on YouTube, access to resources and library, mobile access to evidence at bedside</li> </ul>		<p>by calculating effective sample size post-hoc</p>
EBHC skills	-0.21 (-0.68 to 0.26)	n=70 1 study	<ul style="list-style-type: none"> <li>- Online tutorial plus hands-on computer-based training</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (UG); UK</li> </ul>	<ul style="list-style-type: none"> <li>- Unclear risk of selection and detection bias</li> <li>- Small sample size</li> </ul>
EBHC attitude	1.07 (0.57 to 1.58)	n=69 1 study	<ul style="list-style-type: none"> <li>- Lectures and small group activities in classroom, online lectures on YouTube, access to resources and library, mobile access to evidence at bedside</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Australia and Malaysia</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of attrition bias, unclear risk of selection bias</li> <li>- Only crude results reported for the cluster RCT. Results adjusted by calculating effective sample size post-hoc</li> <li>- Only 17% (44/263) of participants from the blended learning group and 16% (35/234) of the face-to-face learning group completed the questionnaire</li> <li>- Imprecision: Effect size ranges from medium to very large</li> <li>- Two studies did not report data sufficiently to be included in the meta-analysis</li> </ul>
EBHC behaviour	2.34 (1.72 to 2.96)	n=69 1 study	<ul style="list-style-type: none"> <li>- Lectures and small group activities in classroom, online lectures on YouTube, access to resources and library, mobile access to evidence at bedside</li> </ul>	<ul style="list-style-type: none"> <li>- Medical doctors (UG); Australia and Malaysia</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of attrition bias, unclear risk of selection bias</li> <li>- Only crude results reported for the cluster RCT. Results adjusted by calculating effective sample size post-hoc</li> <li>- Only 17% (44/263) of participants from the blended learning group and 16% (35/234) of the face-to-face learning group completed the questionnaire</li> </ul>

## 12.5 BLENDED LEARNING VS PURE E-LEARNING (3 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC knowledge	0.69 (0.40 to 0.99)	n=193 2 studies	<ul style="list-style-type: none"> <li>- Access to online learning site plus face-to-face small group discussions vs Access to online learning site, online exercises and asynchronous discussion list</li> <li>- Recorded PowerPoint presentations plus clinical activities and access to clinical tutor vs recorded PowerPoint and access to online facilitator on demand</li> </ul>	<ul style="list-style-type: none"> <li>- Physician assistants (UG); USA</li> <li>- Medical doctors (PG); various LMICs</li> </ul>	<ul style="list-style-type: none"> <li>- Unclear risk of selection and attrition bias</li> <li>- High risk of recruitment bias and loss of clusters for the cluster RCT</li> <li>- Size of the effect ranges from small to large</li> </ul>
EBHC skills	-0.53 (-2.31 to 1.25)	n=218 2 studies	<ul style="list-style-type: none"> <li>- Computer-lab teaching plus access to online learning site vs DVD containing recorded PowerPoints and tutorials and access to online learning material</li> <li>- Recorded PowerPoint presentations plus clinical activities and access to clinical tutor vs recorded PowerPoint and access to online facilitator on demand</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (PG); Australia and Hon Kong</li> <li>- Medical doctors (PG); various LMICs</li> </ul>	<ul style="list-style-type: none"> <li>- High risk for selection and attrition bias for non-RCT</li> <li>- High risk of recruitment bias and loss of clusters for the cluster RCT</li> <li>- Inconsistency: significant heterogeneity between studies. Results favour pure e-learning for the non-RCT and blended learning for the cluster RCT</li> <li>- Imprecision: very wide confidence intervals - results favour pure e-learning for the non-RCT and blended learning for the cluster RCT</li> </ul>

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## 12.6 PURE E-LEARNING VS PURE E-LEARNING (3 STUDIES)

Outcome	SMD (95% CI)	No of participants (studies)	Interventions	Participants (level of education); Country	Limitations
EBHC skills	1.30 (0.68 to 1.93)	n=119 2 studies	<ul style="list-style-type: none"> <li>- DVD containing recorded PowerPoints and tutorials and access to online learning material vs standard distance learning (online)</li> <li>- Online journal club with asynchronous discussion list vs emails containing the articles plus access to journals</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses (PG); Australia and Hon Kong</li> <li>- Medical doctors (CPD); Canada</li> </ul>	<ul style="list-style-type: none"> <li>- High risk of selection, attrition and detection bias</li> <li>- Imprecision: effect size ranges from medium to very large</li> <li>- High levels of heterogeneity</li> <li>- One study did not report data in a way that it could be incorporated in the meta-analysis</li> </ul>

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# 13 Differences between protocol and review

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## 13.1 OUTCOMES

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In the protocol, we pre-specified the following primary outcomes:

1. EBHC knowledge
2. EBHC skills
3. EBHC attitudes
4. EBHC behaviour

In the review, we added an extra outcome “EBHC knowledge and skills”, since many of the included trials measured this as a composite outcome. Therefore, the primary outcomes in the review are as follows:

1. EBHC knowledge
2. EBHC knowledge and skills
3. EBHC skills
4. EBHC attitudes
5. EBHC behaviour

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## 13.2 SUBGROUP ANALYSIS

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In the protocol, we pre-specified the following subgroup analysis:

1. Type of healthcare professional (e.g. medical vs allied healthcare professionals)
2. Level of education of healthcare professionals (undergraduate vs postgraduate vs continuing medical education)
3. Measurement tool used for outcomes (e.g. Fresno test vs Berlin test)
4. Synchronicity (synchronous vs asynchronous delivery)
5. Duration of the intervention

In the review, due to the limited number of included studies per outcome, we were only able to conduct the following subgroup analysis:

1. Study design (non-RCTs vs RCTs)

## About this review

Evidence-based health care (EBHC) involves phrasing questions based on a knowledge gap, searching for research that can answer the question, critically appraising and interpreting the research, applying the results and auditing the process. Electronic learning (e-learning) has become an increasingly popular method of teaching EBHC.

This review assesses the effectiveness of e-learning of EBHC for increasing EBHC competencies in healthcare professionals. The primary outcomes are EBHC knowledge, skills, attitude and behaviour. E-learning, compared to no learning, improves EBHC knowledge and skills but not attitudes and behaviour. There is no difference in outcomes when comparing e-learning to face-to-face learning. Combining e-learning with face-to-face learning (blended learning) has a positive impact on EBHC knowledge, skills, attitude and behaviour.