Agenda Item :7
Attachment D
COMMENT #14
Change.org Petition

Oppose! CA RCB Proposed Requirement for LIVE CE for RCPs

RCB STAFF NOTE:
169 Total Signatures
Estimate 105 of those are from
California licensed RCPs

Janet Fantazia started this petition

This petition OPPOSES the California Respiratory Care Board proposal for Amendment 16 CCR 1399.350 Continuing Education Subdivision (c) and the requirement that 15 of the 30 hours of instruction must be earned from live courses or meetings.

Problems:

There is a fiscal impact for the RCP. Live CEs are not readily accessible to all RCPs especially in rural areas. Some RCPs will need to travel (cost of conference, cost of room, cost of food, cost of transportation, cost of time off work, and possibly cost of daycare).

There is a potential fiscal impact on Employers accommodating time off work; we are already short staffed at many facilities, and this could result in increased workloads.

This proposal decreases flexibility for licensees and is not modernizing how we learn. The RCB states “this proposal modernizes the Board’s continuing education system by offering improved flexibility for licensees in how continuing education credit is obtained” (RCB, 2022) when actually it is doing the opposite.

https://www.change.org/p/oppose-ca-rcb-proposed-requirement-for-live-ce-for-rcp

This proposal is not evidence based. There are studies show there is not difference with clinical outcomes, or superiority in learning, when comparing traditional learning and e-learning with healthcare providers. One article in particular is E-Learning for Health Professionals (2022) from the Cochrane Library.

Another article the board should consider reading is Effectiveness of distance learning strategies for continuing professional development (CPD) for rural allied health practitioners: a systematic review (2017). Lastly, Effects of e-learning in a continuing education context on nursing care: a review of systematic qualitative, quantitative and mixed studies reviews (protocol) from BMJ (2017).

It will need to be restructured if we have another pandemic. The board tried to pass this in 2018 and we could not have met the requirements due to Covid-19.

The proposal is written in a way that is confusing and may cause delayed licensing renewals due to the accessibility, and availability, of live courses.

Solutions:

Model the NBRC, or CDPH guidelines which are more effective and less burdensome for monitoring quality of CE programs. The NBRC model states “CEUs may be obtained from accredited providers of continuing education in respiratory care approved by the AARC. We accept all AARC approved providers as well as those providers accepted by state agencies regulating the respiratory care profession.” (NBRC, 2022) The CDPH has a list of accepted online CE providers for CNAs updated in 2022. Links are included.

Action:

The Respiratory Care Practitioners in California have signed this petition requesting the board not to make any live or face-to-face requirements for continuing education. Vote NO on this proposal.

Citation Links for Quick Reference:

E-learning for health professionals. Cochrane Database Syst Rev. 2018 Jan 21;1(1):CD011736. doi: 10.1002/14651858.CD011736.pub2. PMID: 29355907; PMCID: PMC6491176. E-learning for health professionals - PMC (nih.gov)

https://www.change.org/p/oppose-ca-rcb-proposed-requirement-for-live-ce-for-rcp

Effectiveness of distance learning strategies for continuing professional development (CPD) for rural allied health practitioners: a systematic review | BMC Medical Education | Full Text (biomedcentral.com)

Effects of e-learning in a continuing education context on nursing care: a review of systematic qualitative, quantitative and mixed studies reviews (protocol) | BMJ Open

NBRC **NBRC-CMP-Brochure-01102022.pdf**

RCB: **Continuing Education, Continuing Education Providers, Law and Professional Ethics Course, Approved CE Programs, Preceptors, and Citation and Fine Notice**

CDPH **Online Continuing Education Providers**

Cochrane Library

Cochrane Database of Systematic Reviews

E-learning for health professionals (Review)

Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V, Tramacere I, Moja L

Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V, Tramacere I, Moja L.
E-learning for health professionals.
Cochrane Database of Systematic Reviews 2018, Issue 1. Art. No.: CD011736.
DOI: 10.1002/14651858.CD011736.pub2.

www.cochranelibrary.com

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[Intervention Review]

E-learning for health professionals

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Citation: Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V, Tramacere I, Moja L. E-learning for health professionals. *Cochrane Database of Systematic Reviews* 2018, Issue 1. Art. No.: CD011736. DOI: 10.1002/14651858.CD011736.pub2.

ABSTRACT

Background

The use of e-learning, defined as any educational intervention mediated electronically via the Internet, has steadily increased among health professionals worldwide. Several studies have attempted to measure the effects of e-learning in medical practice, which has often been associated with large positive effects when compared to no intervention and with small positive effects when compared with traditional learning (without access to e-learning). However, results are not conclusive.

Objectives

To assess the effects of e-learning programmes versus traditional learning in licensed health professionals for improving patient outcomes or health professionals' behaviours, skills and knowledge.

Search methods

We searched CENTRAL, MEDLINE, Embase, five other databases and three trial registers up to July 2016, without any restrictions based on language or status of publication. We examined the reference lists of the included studies and other relevant reviews. If necessary, we contacted the study authors to collect additional information on studies.

Selection criteria

Randomised trials assessing the effectiveness of e-learning versus traditional learning for health professionals. We excluded non-randomised trials and trials involving undergraduate health professionals.

Data collection and analysis

Two authors independently selected studies, extracted data and assessed risk of bias. We graded the certainty of evidence for each outcome using the GRADE approach and standardised the outcome effects using relative risks (risk ratio (RR) or odds ratio (OR)) or standardised mean difference (SMD) when possible.

Main results

We included 16 randomised trials involving 5679 licensed health professionals (4759 mixed health professionals, 587 nurses, 300 doctors and 33 childcare health consultants).

When compared with traditional learning at 12-month follow-up, low-certainty evidence suggests that e-learning may make little or no difference for the following patient outcomes: the proportion of patients with low-density lipoprotein (LDL) cholesterol of less than 100

mg/dL (adjusted difference 4.0%, 95% confidence interval (CI) −0.3 to 7.9, N = 6399 patients, 1 study) and the proportion with glycated haemoglobin level of less than 8% (adjusted difference 4.6%, 95% CI −1.5 to 9.8, 3114 patients, 1 study). At 3- to 12-month follow-up, low-certainty evidence indicates that e-learning may make little or no difference on the following behaviours in health professionals: screening for dyslipidaemia (OR 0.90, 95% CI 0.77 to 1.06, 6027 patients, 2 studies) and treatment for dyslipidaemia (OR 1.15, 95% CI 0.89 to 1.48, 5491 patients, 2 studies). It is uncertain whether e-learning improves or reduces health professionals' skills (2912 health professionals; 6 studies; very low-certainty evidence), and it may make little or no difference in health professionals' knowledge (3236 participants; 11 studies; low-certainty evidence).

Due to the paucity of studies and data, we were unable to explore differences in effects across different subgroups. Owing to poor reporting, we were unable to collect sufficient information to complete a meaningful 'Risk of bias' assessment for most of the quality criteria. We evaluated the risk of bias as unclear for most studies, but we classified the largest trial as being at low risk of bias. Missing data represented a potential source of bias in several studies.

Authors' conclusions

When compared to traditional learning, e-learning may make little or no difference in patient outcomes or health professionals' behaviours, skills or knowledge. Even if e-learning could be more successful than traditional learning in particular medical education settings, general claims of it as inherently more effective than traditional learning may be misleading.

PLAIN LANGUAGE SUMMARY

Is e-learning more effective than traditional learning for health professionals?

What is the aim of this review?

The aim of this Cochrane Review is to find out whether e-learning, that is, interactive online educational programmes, is more effective than traditional learning (with no access to e-learning) in licensed health professionals for improving patient outcomes or health professionals' behaviours, skills and knowledge. Cochrane researchers collected and analysed all relevant evidence to answer this question and identified 16 studies.

Key messages

When compared to traditional learning, e-learning may make little or no difference for improving patient outcomes or health professionals' behaviours and knowledge, and it is uncertain whether it improves or reduces health professionals' skills.

What was studied in this review?

Modern technologies have created new platforms for advancing medical education. E-learning has gained popularity due to the potential benefits of personalised instruction, allowing learners to tailor the pace and content of courses to their individual needs, increasing the accessibility of information to remote learners, decreasing costs and facilitating frequent content updates.

Previous reviews have not identified differences, but they were limited by the type of participants included (mix of licensed health professionals and medical students) and study types evaluated (randomised together with non-randomised trials).

What are the main results of the review?

The review authors identified 16 relevant studies from 10 different countries, providing data on 5679 participants (4759 mixed health professionals, 587 nurses, 300 doctors and 33 childcare health consultants). Companies funded three studies, whereas government agencies financed six.

One study with 847 health professionals found little or no difference between e-learning and traditional learning on patient outcomes at one year, and two studies with 950 health professionals suggested little to no difference in health professionals' behaviours at 3 to 12 months, as the certainty of the evidence was low. We are uncertain whether e-learning improves or reduces health professionals' skills at 0 to 12 weeks' follow-up, based on the results of six studies with 2912 participants and very low certainty of evidence. E-learning may also make little or no difference on health professionals' knowledge, based on the results from 11 studies with 3236 participants at 0 to 12 weeks follow-up, as the certainty of the evidence was low.

How up-to-date is this review?

The review authors searched for studies that had been published up to July 2016.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Summary of findings: e-learning versus traditional learning for health professionals

E-learning versus traditional learning for health professionals

Patient or population: licensed health professionals (doctors, nurses and allied health professionals fully licensed to practice without supervision)

Settings: postgraduate education in any setting

Intervention: e-learning (any intervention in which clinical content is distributed primarily by the Internet, Extranet or Intranet)

Comparison: traditional learning (any intervention not distributed through the media mentioned above)

Outcomes	Impact*	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
Patient outcomes Follow-up: 12 months	E-learning may make lead to little or no difference between the groups in proportion of patients with LDL cholesterol < 100 mg/dL (adjusted difference 4.0% (95% CI −0.3 to 7.9; 6399 patients) or glycated haemoglobin level < 8% (adjusted difference 4.6%, 95% CI −1.5 to 9.8; 3114 patients)	168 primary care clinics; 847 health professionals (1 study)	⊕⊕⊖⊖ **Low**[a]	—
Health professionals' behaviours Follow-up: 3-12 months	E-learning may make little or no difference between the groups in terms of screening for dyslipidaemia (OR 0.90, 95% CI 0.77 to 1.06, 6027 patients) or treatment for dyslipidaemia (OR 1.15, 95% CI 0.89 to 1.48; 5491 patients)	950 health professionals (2 studies)	⊕⊕⊖⊖ **Low**[b]	Studies reported multiple outcomes without specifying the primary outcome: to assess consistency, we explored 3 other possible combinations between the 2 study indicators.
Health professionals' skills Follow-up: 0-12 weeks	We are uncertain whether e-learning improves or reduces health professionals' skills (SMD 0.03, 95% CI −0.25 to 0.31, I^2 = 61%, 201 participants, 12 weeks' follow-up).	2912 health professionals (6 studies)	⊕⊖⊖⊖ **Very low**[c]	The results from the largest trial and 2 more trials, favouring traditional learning (2640 participants), and from one trial favouring e-learning could not be included in the meta-analysis. The meta-analysis included 2 trials studying different professional skills (drug dose calculation and accuracy in pressure ulcers classification).
Health professionals' knowledge Any follow-up: 0-12 weeks	E-learning may make little or no difference in health professionals' knowledge: 8 trials provided data to the meta-analysis (SMD 0.04, 95% CI -0.03 to 0.11, I^2 = 47%, 3082 participants).	3236 health professionals (11 studies)	⊕⊕⊖⊖ **Low**[d]	3 additional studies (154 participants) reported this outcome but no data were available for pooling.

CI: confidence interval; **LDL**: low-density lipoprotein; **OR**: odds ratio; **SD**: standard deviation; **SMD**: standardised mean difference.

*We interpreted SMDs using the following rules suggested by Higgins 2011a: < 0.40 represents a small effect size; 0.40 to 0.70, a moderate effect size; and > 0.70, a large effect size.

GRADE Working Group grades of evidence:
High quality: further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: we are uncertain about the estimate.

[a]Downgraded for study limitations (risk of bias and imprecision) and imprecision surrounding surrogate outcomes. Important benefits cannot be ruled out.
[b]Downgraded for study limitations (risk of bias) and inconsistency, with main effect estimates going in different directions (out of the five meta-analyses, two were in favour of e-learning and two in favour of traditional learning). Important benefits cannot be ruled out.
[c]Downgraded for study limitations: inconsistency, imprecision and indirectness. Important differences cannot be ruled out.
[d]Downgraded for study limitations (imbalance at baseline and incomplete data) and high inconsistency, with main effect estimates going in different directions (out of the eight studies, five were in favour of e-learning and three in favour of traditional learning). Although the effect estimate is imprecise, large, relevant differences are unlikely.

BACKGROUND

Description of the intervention

E-learning is a broad concept that involves the provision of educational programmes through electronic systems (Clark 2011). Currently, there is no standard or recognised definition of e-learning for research purposes. The Medical Subjects Headings Vocabulary, for example, does not provide a specific item different from 'distance education', which includes correspondence, radio and television in addition to computer networks as media tools.

For the purpose of this review, we define e-learning as any educational intervention that is mediated electronically via the Internet.

The biomedical literature contains numerous examples of terms synonymous with our definition for e-learning: web-based learning or training, online learning or education, computer-assisted or -aided instruction (CAI) or computer-based instruction (CBI), Internet-based learning (Cook 2008a; Ruiz 2006), multimedia learning, technology-enhanced learning and virtual learning. This diverse nomenclature has led to confusion: terms refer to an array of elements addressing a specific part of the e-learning concept such as the medium (e.g. computer-assisted instruction) or the delivery system (e.g. online learning). Although the term e-learning sometimes refers to blended interventions involving electronic systems and face-to-face teaching, it is generally seen as a particular evolution of distance education, that is, the use of information technologies in order to deliver education to remote learners. When these learners are computer-assisted and interconnected through computer networks, accessing online packages for learning, their distance education can unequivocally be referred to as e-learning (Ruiz 2006; Ward 2001).

How the intervention might work

Although e-learning shares many features with traditional learning systems, several aspects are unique (Zimitat 2001). Thus, assessing the quality of e-learning programmes involves more than evaluating the quality and educational design of the course content; it should also involve an analysis of navigability, multimedia approach, degree of interactivity, and other key factors like intervention duration, repetition and feedback or layout impact in the development of an optimal e-learning framework (Cook 2010a; Menon 2012; Straus 2004). The traditional role of trainers is evolving from a 'distributor of content' to a 'facilitator', enhancing the learner-centred characteristics of the educational programme (Wentling 2000).

Applying the latest information technologies to education takes advantage of the increasing availability of Internet access (via optical fibres, WiFi and 3G/4G mobile phone technology), allowing a broad use of content across diverse settings (home, workplaces, and public places such as libraries, parks, and Internet points).

The delivery advantages of an e-learning programme are obvious: some of their most cited benefits include lower costs, widespread distribution, increased accessibility to information, frequent content updates and personalised instruction in terms of content and pace of learning (Wentling 2000). Moreover, the interactivity and ability to link educational programmes with past experiences and specific needs fit the adult learning paradigm (Gibbons 2000).

As a result of these advantages, online learning is becoming more popular, and online courses worldwide are rapidly increasing in number, offering many specialty modules in their portfolios (Coppus 2007; Moja 2007; Ruiz 2007). Potential disadvantages include technology-related costs, cost involved in developing programmes, possible technical problems, limited direct interaction, lack of exchanges and relations with other learners, absence of the physical presence of the teacher, decrease in motivation to learn, need for greater self-discipline, and attenuation of the desire to compete with other learners (Cook 2007; Poon 2015; Welsh 2003). Moreover, equity should be considered carefully: poor access, language barriers, and lack of computer and Internet literacy could limit or prevent the participation of some health professionals, especially in low- and middle-income countries. These limitations might prevent e-learning from becoming the norm.

Previous systematic reviews on the efficacy and efficiency of e-learning focused on the outcomes laid out in Kirkpatrick 1996: satisfaction, knowledge/attitudes, skills (in a test setting), behaviours (in a practice setting) and effects on patients (Cook 2008a; Cook 2010a; Lahti 2014; Lam-Antoniades 2009; Sinclair 2016). Knowledge measurement by standardised tests is the most common outcome for both traditional and e-learning systems. However, the progression from cognitive to behavioural steps – from acquiring knowledge to performing a task in practice – is neither linear nor simple: many other factors influence health professionals' behaviours, including system-related factors (e.g. government incentives, guidelines, laws) and individual-related factors (e.g. patient expectations, relationship with peers) (Rethans 2002).

These reviews found:

- e-learning is associated with large positive effects when compared with no intervention (Cook 2008a);
- e-learning is associated with small positive effects when compared with traditional educational interventions (without access to e-learning), suggesting similar effectiveness (Cook 2008a; Lahti 2014; Sinclair 2016);
- e-learning and traditional educational interventions take similar time to participate in or complete (Cook 2010c);
- insufficient evidence is available comparing e-learning and traditional educational interventions on licensed health professionals' behaviours and patient outcomes (Sinclair 2016)
- interactivity, practice exercises, repetition and feedback play pivotal roles in e-learning and seem to be associated with improved learning outcomes (Cook 2010a).

A further relevant finding was the large heterogeneity in study designs, participants, instructional designs and outcomes. The authors conclude that e-learning is not a single entity, although educators and researchers frequently view it as a single activity or a cluster of single activities, with relatively homogeneous effects (Cook 2010b).

Why it is important to do this review

E-learning is gaining in popularity, and programmes are rapidly increasing in number. Their relatively low costs, high flexibility, and reduced dependence on geographical or site boundaries are attracting the investments of stakeholders (countries, networks,

and universities) and increasing the demands of learners. This review synthesises the evidence for the effectiveness of e-learning versus traditional educational interventions for licensed health professionals: more precise data about the effectiveness of e-learning programmes have the potential to influence future investments regarding continuing medical education (CME) programmes.

OBJECTIVES

To assess the effects of e-learning programmes versus traditional learning in licensed health professionals for improving patient outcomes or health professionals' behaviours, skills and knowledge.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised trials and cluster-randomised trials.

We used the Cochrane definitions for randomised trials (Higgins 2011a).We excluded non-randomised trials (e.g. controlled before-after studies or interrupted time series) as they are prone to a wider range of potential risks of bias and add little value when sufficient evidence is available from randomised trials (EPOC 2013a). Non-randomised quality-improvement intervention trials often overstate the strength of causal inference between intervention and outcomes compared to randomised trials (Li 2009). Conclusions from meta-analyses exploring the causality of e-learning might be undermined if largely based on studies that adopt intrinsically weaker research designs (Banzi 2009).

We included studies published in all languages and providing data about any follow-up periods.

Types of participants

We included studies assessing e-learning programmes aimed at improving patient outcomes or behaviours, skills or knowledge of licensed health professionals (doctors, nurses and allied health professionals). We focused on the license to practice without supervision as a discriminating factor, that is, health professionals who can fully practice a specific health-related profession versus those who cannot. We included only those licensed to practice in this review. If the description was not sufficient, we sent requests to the study authors for additional information before excluding the studies.

We excluded studies recruiting undergraduate students, trainees and residents, or a mix of licensed and unlicensed participants, if data on the eligible participants were not provided by the authors after a formal request by email.

Types of interventions

Definition of e-learning programme

We included any intervention distributing and facilitating access to clinical content primarily by the Internet, Extranet or Intranet: web-based tutorials, virtual clinical vignettes, online discussion groups, Internet-mediated videoconferencing, web seminars, emails, podcasts and virtual social networks. We excluded CD-ROMs and applications not distributed through the media mentioned above. The learners may have had access to interventions through a variety of technologies (e.g. computers, personal digital assistant (PDA), smart phones, etc). We applied no restrictions with regard to the programme length: we included short programmes such as single lectures, workshops and modules as well as more extended educational programmes. We included an intervention if the description was sufficient to allow us to establish whether it could potentially improve knowledge or behaviours by any kind of intervention mentioned above; we also included interventions if the description was sufficient to allow us to establish that it was aimed at improving clinical practice (starting effective treatment or dismissing ineffective or harmful treatment). On the contrary, if the description proved unclear or insufficient, we sent a request to the study authors for additional information before excluding the studies.

We excluded e-learning programmes focusing on non-clinical medical topics (e.g. bio-terrorism), defined as subjects different from the seven roles that all physicians need to have to be better doctors: medical expertise, communication, collaboration, leadership, health advocacy, scholarship and professionalism (The CanMEDS Framework).

We only included interventions in which e-learning is a core or essential element. However, in multifaceted educational interventions (e.g. those applying two or more interventions to change health professionals' practice), the e-learning component may have different degrees of centrality. Thus, we categorised studies into three groups:

1. e-learning alone;
2. e-learning as a core, essential component of a multifaceted intervention;
3. e-learning as a component of a multifaceted intervention, but not considered core and essential.

We classified studies as having 'core' e-learning interventions when e-learning was the main part of the educational intervention (e.g. e-learning together with the dissemination of guideline in a paper format). When learners could use the components other than e-learning in the absence of e-learning, or e-learning was merely added to a multifaceted intervention that could easily be offered in its absence (e.g. audit and feedback interventions), we considered the intervention as 'not core'.

We included trials where the eligible comparators were educational interventions on the same topic without access to e-learning (e.g. print books, face-to-face residential courses, guidelines dissemination) or multifaceted educational interventions without e-learning on the same topic.

Types of outcome measures

We included the following outcome measures: patient outcomes and health professionals' behaviours, skills or knowledge (Kirkpatrick 1996; Straus 2004).

For the purposes of this review, we assessed different components targeted by educational interventions in clinical practice, excluding subjectively assessed outcomes (e.g. learner satisfaction or self-reported knowledge, intentions to do, or beliefs about capabilities).

1. Patient outcomes defined as occurrence of deaths (i.e. mortality) or illness (i.e. morbidity; e.g. pneumonia, myocardial infarction, stroke) or progression of disease or hospitalisation.
2. Health professionals' behaviours, defined as actual professional performance: the incorporation of knowledge and skills into practice, with the adoption of proven treatments and interventions that can potentially improve patients' health.
3. Health professionals' skills, defined as deep learning or competence (what the learner is able to do), for example posing structured clinical questions considering patients, treatments, comparisons and outcomes, and understanding quantitative aspects (e.g. relative or absolute risk reduction, number needed to treat).
4. Health professionals' knowledge defined as factual knowledge or basic learning, for example knowing the benefits and risks of different interventions (e.g. in patients with unstable angina, aspirin is beneficial).

Primary outcomes

Patient clinical outcomes

- Any objective measure of patient clinical outcomes (e.g. blood pressure, number of caesarean sections, medical errors)

Health professionals' behaviour

- Any objective measure of clinical performance (e.g. number of tests ordered, prescriptions for a particular drug).

We assessed primary outcomes at two major time points:

1. immediately after the e-learning intervention; and
2. at the longest duration of follow-up available.

Secondary outcomes

Skills and knowledge are clinical competence dimensions related to the concept of 'know' (knowledge) and 'know-how' (skills) (Miller 1990).

Health professionals' skills

- Any objective measure of skills such as the assessment of learners' ability to demonstrate a procedure or technique (e.g. problem solving, objective structured clinical examination scores)

Health professionals' knowledge

- Any objective measure of learners' knowledge such as assessment of factual or conceptual understanding (e.g. multiple-choice test of knowledge).

Search methods for identification of studies

Electronic searches

The EPOC Information Specialist wrote the search strategies in consultation with the authors. We searched the Cochrane Database of Systematic Reviews (CDSR) and the Database of Abstracts of Reviews of Effects (DARE) (via the Cochrane Library) for related systematic reviews, and the following databases for primary studies:

- Cochrane Central Register of Controlled Trials (CENTRAL; 2016, Issue 6) via Wiley (searched 7 July 2016).
- MEDLINE, Epub Ahead of Print, In-Process & Other Non-Indexed Citations, MEDLINE Ovid Daily and MEDLINE Ovid, OvidSP (1946 to 7 July 2016).
- Embase OvidSP (1980 to 7 July 2016).
- Health Technology Assessment (2016, Issue 2) via Wiley (searched 7 July 2016).
- NHS Economic Evaluation Database (2016, Issue 2) via Wiley (searched 7 July 2016).
- Database of Abstracts of Reviews of Effects (2016, Issue 2) via Wiley (searched 7 July 2016).

Search strategies are comprised of keywords and controlled vocabulary terms. We applied no language or time limits. All strategies used are provided in Appendix 1

Searching other resources

We searched the following trial registries for ongoing and completed trials.

- Word Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/en).
- ClinicalTrials.gov, US National Institutes of Health (NIH).

We examined the reference lists of the included trials and relevant reviews published in the field of e-learning (e.g. Chumley-Jones 2002; Cook 2008a; Lam-Antoniades 2009; Ruiz 2006; Wentling 2000; Wutoh 2004).

Data collection and analysis

Two review authors independently determined the eligibility of the intervention by examining the study report and the description of the intervention. If necessary, we referred to other related papers or reports (e.g. protocol or register records) and sent requests to the study authors for additional information, especially if e-learning programmes were unclear or trialists did not clearly report the measures to monitor outcomes changes.

We collated multiple reports of the same studies so that each study, rather than each report, was the unit of interest in the review.

Where means and standard deviations (SDs) were not reported in the original article, we sent requests to the study authors for additional information.

We examined any relevant retraction statements and errata, and we searched for any key unpublished information that was missing from the reports of the included studies.

We used Review Manager 5 (RevMan 5) software to manage the included studies data (RevMan 2014).

Selection of studies

Two review authors independently screened the titles and abstracts and applied inclusion and exclusion criteria. We searched for complete manuscripts in the cases of uncertainty and resolved disagreements through discussion and consensus.

We documented the studies selection process in a PRISMA flow diagram (Liberati 2009).

Data extraction and management

Two review authors independently extracted data from the included studies, using a data sheet based on a modified version of the EPOC data collection checklist (EPOC 2015).

We extracted the following information.

1. Characteristics of participants: total number at baseline, total number at completion of the study, and type of target health professionals.
2. Interventions and controls: number of groups, interventions applied, frequency, duration and main components.
3. Methods: study design, duration of the study, setting and provider.
4. Outcomes: type of outcome measures, scales of measure, values for means and standard deviations.
5. Results: measures at follow-up (including means and SD/ standard errors (SEs)/confidence intervals (CIs) for continuous data and summary table for dichotomous data), withdrawals and loss to follow-up.

We resolved any disagreement by discussion to reach a consensus. We described any ongoing study, if available, detailing its primary author, research question, methods and outcome measures along with its estimated date of completion.

Assessment of risk of bias in included studies

Two review authors independently assessed the quality of all eligible studies using the EPOC risk of bias criteria (EPOC 2013b). We resolved any discrepancies in quality rating by discussion and consensus. We collected the sources of information (to support our judgments) for each risk of bias assessment (e.g. quotation, summary of information from trial reports, correspondence with investigators). For each study, we assessed the following nine standard criteria for risk of bias.

1. Was the allocation sequence adequately generated?
2. Was the allocation adequately concealed?
3. Were baseline outcome measurements similar?
4. Were baseline characteristics similar?
5. Were incomplete outcome data adequately addressed?
6. Was knowledge of the allocated interventions adequately prevented during the study?
7. Was the study adequately protected against contamination?
8. Was the study free from selective outcome reporting?
9. Was the study free from other risks of bias?

We summarised the overall risk of bias for the single studies, considering the risk of bias for allocation concealment, incomplete outcome data, and blinding of outcome assessors to be key domains (Chan 2004; Dwan 2008; Kirkham 2010; Savovic 2012; Wood 2008). We judged the overall risk of bias at study level to be high if we had rated one of these items as being at high risk of bias and as low if we had judged all the items to be at low risk. We used the risk of bias of the single studies in the sensitivity analysis as detailed below.

Measures of treatment effect

We separately analysed patient outcomes, health professionals' behaviours, skills and knowledge.

When possible, we calculated the outcome measures in accordance with the intention-to-treat principle (i.e. analysing all data according to randomised group assignment, regardless of whether some of the participants violated the protocol, failed to adhere or were lost to follow-up). Accordingly, we contacted study authors to obtain additional primary trial data when necessary.

We based analyses on the consideration of dichotomous (e.g. proportion of patients managed according to e-learning programme) or continuous process measures (e.g. change in learners' knowledge scores). Where studies reported more than one measure for each endpoint, we planned to abstract the primary measure (as defined by the study authors) or the median measure identified. For example, if the comparison reported five continuous knowledge test variables and none of them were denoted as the primary variable, we ranked the effect sizes for the five variables and took the median value.

We extracted the outcomes from each study in natural units. We planned to combine final values if all the studies used the same scale, convert the effect size back into the natural units of the outcome measure most familiar to the target audience, or provide a standardised effect size.

We only included continuous data from a trial in the analyses if:

1. means and SDs were available or could be calculated; and
2. there was no clear evidence of a skewed distribution (e.g. as indicated by the ratio between the difference between the minimum or maximum value of the scale and the SD (Deeks 2011).

Because final value and change scores from baseline to final values should not be combined together as standardised mean difference, for studies providing both measures of treatment effect for continuous outcomes, we privileged the post-test means. Due to randomisation, we did not expect differences between experimental and control group baseline scores (Higgins 2011a).

We planned to use results from both periods of cross-over trials, unless there was a risk of carryover effects from one period to another, which presents a serious flaw. For cross-over trials, we planned to use paired estimates of the effect (e.g. means and its SE), or calculated them from the exact statistical test results (e.g. paired t-test for continuous data or McNemar's test for binary outcomes) (Cook 2008a; Elbourne 2002).

We present binary outcomes using odds ratios (OR) as appropriate and their 95% confidence intervals. For continuous outcomes, we report mean and standard deviation SD and standardised mean differences (SMD) for studies evaluating the same outcome in different ways. We interpreted the magnitude of the SMD as small for values of about 0.2, medium for SMDs of 0.5, and large for SMDs of 0.8 or more (Cohen 1988).

Unit of analysis issues

Studies with more than two arms

If more than one comparison from a study with more than two arms was eligible for the same comparison, we planned to adjust the number of health professionals to avoid double counting. We sought to make the adjustment by dividing the number of health professionals in the shared arm more or less evenly among the comparisons.

Cluster-randomised trials

Owing to the focus on an educational intervention, we expected trials to be randomised by groups of professionals. In cluster-randomised trials, 'clusters' of individuals are randomly allocated to study arms, and investigators measure outcomes based on the individual cluster members. Under such circumstances, it is necessary to adjust the results from primary trials for clustering before they are included in the meta-analysis in order to avoid spurious precision in 95% CIs. We included cluster-randomised trials with adequate definition of participants and clusters, as suggested by the Ottawa Statement for cluster-randomised trials (Weijer 2012).

For the cluster-randomised trials, in order to calculate adjusted (inflated) CIs that account for the clustering, we planned to proceed to an approximate analysis. Our approach was to multiply the SE of the effect estimate (from the analysis ignoring the clustering) by the square root of the design effect. For this, we used intra-correlation coefficients borrowed from an external source (University of Aberdeen 2015).

Performing meta-analyses using studies with unit of analysis errors required us to make a number of assumptions about the magnitude of unreported parameters, such as the intra-correlation coefficients and the distributions of patients across clusters. We planned to re-analyse studies with potential unit of analysis errors where possible, reporting the re-analysed results (observed SEs, P values, or CIs) in an additional table along with the original results. If this was not possible, we reported only the original results and excluded the study from the meta-analyses.

Dealing with missing data

For all included studies, we analysed available data obtained either from publications or following correspondence with the authors. In the Discussion section of the review, we considered the extent to which the missing data could alter our results and conclusions.

For all outcomes across all studies, we carried out analyses as far as possible on an intention-to-treat basis (i.e. we attempted to include all participants randomised to each group in the analyses, regardless of whether or not they received the allocated intervention). If intention-to-treat data were not available or for dichotomous and continuous data that were missing, we made no assumptions about loss to follow-up, but we based analyses on participants completing the trial. If there was a discrepancy between the number randomised and the number analysed in each treatment group, we calculated and reported the percentage of loss to follow-up in each group.

Where standard deviations were not specified, we calculated them using the exact statistical test results (e.g. P value related to t or F statistic) or, if these were not reported, we used differences in change scores, standardised using pretest variance. If neither P values nor any measure of variance were reported, we planned to use the average standard deviation from other similar studies (Cook 2008a).

We considered the impact of missing data separately for each primary and secondary outcome reported in each study.

Assessment of heterogeneity

To assess the contextual heterogeneity of the included trials (the differences in populations, context, interventions, comparators, follow-up), we planned to conduct subgroup analyses according to important clinical and methodological characteristics, such as settings, interventions, comparators, etc. Between-study heterogeneity was planned to be assessed overall and within the subgroups.

We included all the pre-specified outcomes available from the individual studies in the meta-analysis, with heterogeneity reported by the Q (Chi^2) and the I^2 statistics (Deeks 2011). The I^2 describes the percentage of the variability in effect estimates that is due to heterogeneity rather than chance (sampling error). The *Cochrane Handbook for Systematic Reviews of Interventions* gives the following guidance on this decision based on I^2 values to classify the inconsistency of the effect measures across studies (Higgins 2011a).

- 0% to 40%: might not be important.
- 30% to 60%: may represent moderate heterogeneity.
- 50% to 90%: may represent substantial heterogeneity.
- 75% to 100%: considerable heterogeneity.

In cases of moderate/substantial heterogeneity, we performed the analysis using both the fixed-effect and the random-effects model. Where considerable heterogeneity existed, we explored the magnitude and direction of the effects: if I^2 was more than 75%, but the large majority of effect estimates were in the direction of benefit, and a random-effects meta-analysis yielded highly statistically significant benefits, we accepted the results. In this scenario, there would be some uncertainty about the amount of benefit but not its existence; it is safe to conclude that the intervention is beneficial (Virgili 2009). If substantial heterogeneity existed, studies were sparse or directions discordant, we did not pool data from the trials, and we did not conclude in favour of or against the intervention.

Assessment of reporting biases

We planned to use funnel plots to assess the reporting biases. We planned to evaluate the funnel plot asymmetry, not only visually but also with the use of tests for funnel plot asymmetry if we found more than 10 studies to include in the meta-analysis. We planned to use the test proposed by Egger 1997 and by Harbord 2006 for continuous and dichotomous outcomes, respectively. If we detected asymmetry, we discussed possible explanations (e.g. publication bias or poor methodological quality of the studies) on the basis of available information and subsequently performed a sensitivity analysis (Higgins 2011b). We interpreted funnel plots cautiously, as they may be misleading.

Data synthesis

We grouped the studies according to important clinical and methodological (conceptual) characteristics, such as settings, interventions, comparators, etc. Accordingly, we synthesised similar studies reporting homogeneous (similar) outcomes and outcome measures.

We entered outcomes into RevMan 5 as effect sizes and their SEs (RevMan 2014).

We conducted meta-analyses using both random-effects and fixed-effect models.

Subgroup analysis and investigation of heterogeneity

We planned to perform the following subgroup analyses if at least 10 observations (i.e. 10 studies in a meta-analysis) were available for each characteristic modelled (Higgins 2011a).

- Content: e-learning programmes subgrouped by medical, surgical or rehabilitation topics, with the hypothesis that e-learning programmes about medical topics (more likely to be centred on knowledge than skills or behaviours) are more effective than e-learning programmes focused on other topics.
- Health professionals targeted: doctors, nurses or physiotherapists, with the hypothesis that e-learning programmes for doctors are more effective than e-learning programmes for other health professionals.
- Regulation: formally accredited versus non-accredited e-learning programmes, with the hypothesis that accredited e-learning programmes are more effective than non-accredited ones.
- Format:
  - high-interaction programmes (combination of at least three components, e.g. web module, chat, emails) or low-interaction programmes (fewer than three components), with the hypothesis that high-interaction programmes are more effective;
  - short (i.e. less than one week in duration) or long programmes (more than one week in duration), with the hypothesis that short programmes are more effective.

Other authors have identified some of these factors as potentially influencing the effect of educational e-learning programmes (Cook 2008a; Cook 2008b; Ruiz 2006). We undertook the standard test for heterogeneity across subgroup results to investigate the differences between two subgroups (Borenstein 2009). We used these analyses to investigate potential sources of heterogeneity and reported them as post hoc exploratory data analyses only.

Sensitivity analysis

We planned to perform sensitivity analyses:

- excluding studies assessed as at high risk of bias; and
- excluding cross-over trials.

We decided to aggregate studies at unclear risk of bias to those at high risk of bias. We adopted a conservative approach, assuming that an absence of information indicated inadequate quality ('guilty until proven innocent') (Moja 2014).

Summary of findings table

We assessed the certainty of evidence for pre-specified outcomes using GRADEpro software (GRADEpro 2008). We justified all decisions to downgrade or upgrade the rating using footnotes, and we provided comments to aid readers' understanding of the review when necessary, as recommended by Cochrane (Schünemann 2011). Summary of findings for the main comparison includes the overall grading of the certainty of evidence related to each of the outcomes according to the GRADE approach. We graded the certainty of evidence as high, moderate, low or very low; we downgraded the initial level of confidence considering the risk of bias, inconsistency and indirectness of evidence, imprecision of effect estimates and risk of publication bias.

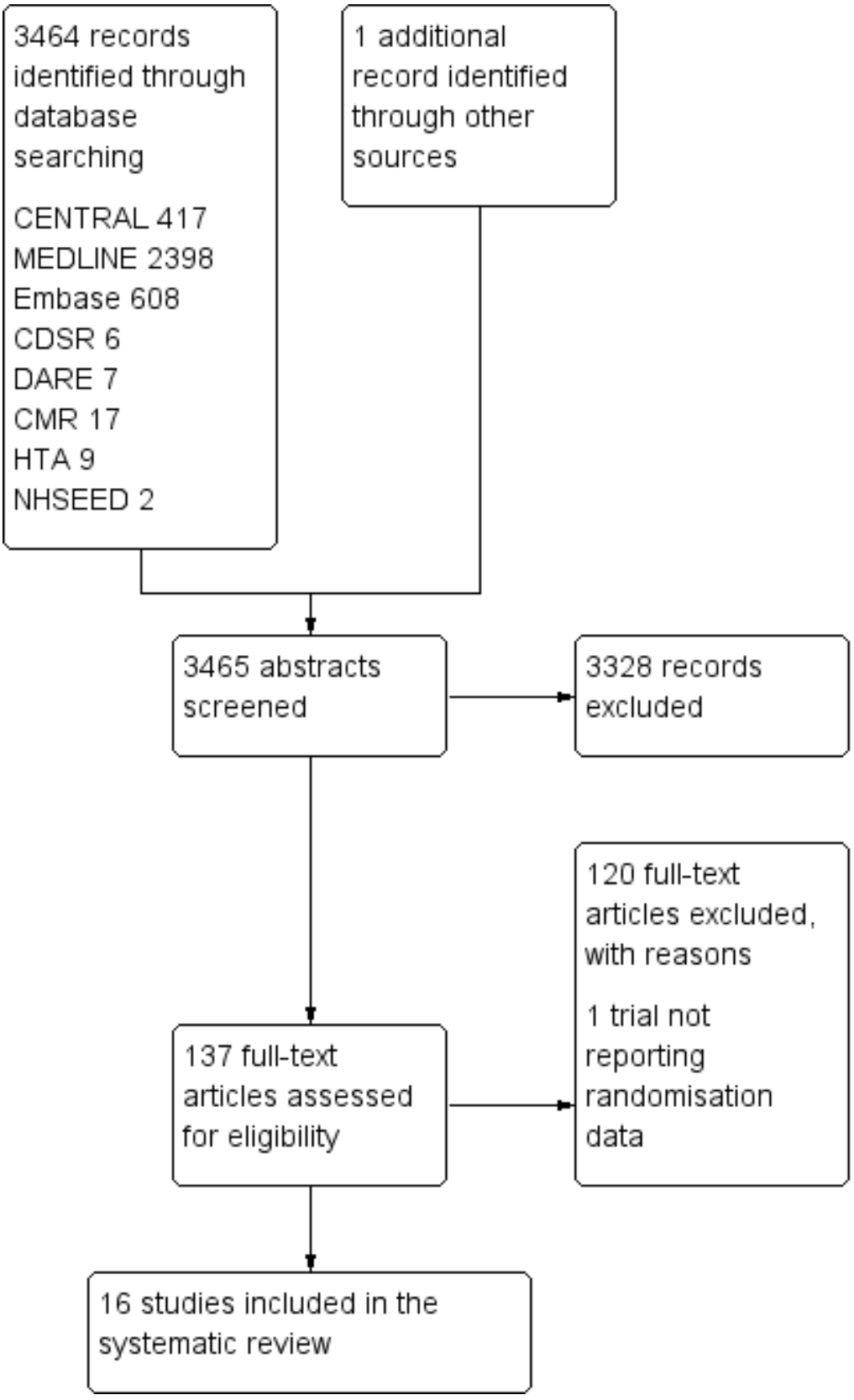
RESULTS

Description of studies

Results of the search

We identified 3464 records through the search strategy (CENTRAL 417, MEDLINE 2398, Embase 608, CDSR 6, DARE 7, CMR 17, HTA 9, NHSEED 2) and one additional article from other reviews. We excluded 3328 articles based on the abstracts (Figure 1).

Figure 1. Study flow diagram



We retrieved the full text of 137 articles to determine their eligibility for inclusion, excluding 121 records and including 16.

Included studies

Sixteen randomised trials providing data on 5679 learner participants met our predefined selection criteria. The trials were all published between 2005 and 2016. The mean sample size was 400 participants, but only 3 trials had more than 150 participants. Six trials took place in the USA (Benjamin 2008; Fordis 2005; Harris 2008; Le 2010; Levine 2011; Wilson-Sands 2015), while the remaining 10 studies were in Japan (Horiuchi 2009), the Netherlands (Hugenholtz 2008), Finland (Mäkinen 2006), Australia (Maloney 2011; Perkins 2012), Brasil (Paladino 2007), the UK (Perkins 2012), Taiwan (Sheen 2008), Norway (Bredesen 2016; Simonsen 2014), and Iran (Khatony 2009); only Perkins 2012 was performed in two countries.

Characteristics of participants and settings

Four trials randomised 4759 mixed health professionals (Levine 2011; Maloney 2011; Perkins 2012; Wilson-Sands 2015), seven trials randomised 587 nurses (Bredesen 2016; Horiuchi 2009; Khatony 2009; Mäkinen 2006; Paladino 2007; Sheen 2008; Simonsen 2014), four trials randomised 300 doctors (Fordis 2005; Harris 2008; Hugenholtz 2008; Le 2010), and one trial randomised 33 childcare health consultants (Benjamin 2008). Four trials took place in a primary care setting (Fordis 2005; Harris 2008; Le 2010; Levine 2011), six trials in a secondary care hospital setting (Horiuchi 2009; Khatony 2009; Mäkinen 2006; Paladino 2007; Sheen 2008; Wilson-Sands 2015), three trials in a mixed setting (Bredesen 2016; Perkins 2012; Simonsen 2014), and one in a rehabilitation setting (Maloney 2011). Two trials were performed in other settings (Benjamin 2008; Hugenholtz 2008).

Characteristics of educational interventions used in the trials

All 16 trials included in our review compared e-learning interventions versus face-to-face residential learning except for two trials comparing e-learning with guideline dissemination or availability (Le 2010; Levine 2011). In five trials, the educational intervention was accredited for CME purposes (Fordis 2005; Harris 2008; Hugenholtz 2008; Le 2010; Levine 2011). In six trials, the duration of the e-learning intervention, in terms of time needed to be spent on learning, was the same as the control intervention (Harris 2008; Hugenholtz 2008; Levine 2011; Maloney 2011; Perkins 2012; Simonsen 2014); in three trials, the duration of the educational session was longer in the control groups than in the e-learning groups (Horiuchi 2009; Mäkinen 2006; Paladino 2007); in the remaining cases, investigators did not describe this information or confused it with the time the intervention was available to the participants. We considered the amount of time needed to be spent on learning as short (less than one week) in all trials except in Le 2010 and Levine 2011. In 11 trials e-learning was administered alone, not in combination with other interventions; in the 5 remaining trials (Fordis 2005; Le 2010; Levine 2011; Maloney 2011; Perkins 2012), we considered e-learning as being a core and essential element of a multifaceted educational intervention. The interactivity of the e-learning tools was high (combination of at least three components) in nine trials and low in seven trials (Bredesen 2016; Harris 2008; Horiuchi 2009; Hugenholtz 2008; Paladino 2007; Sheen 2008; Wilson-Sands 2015).

Outcome assessment

Investigators assessed patient outcomes by analysing administrative data; health professionals' behaviours, by auditing patients' charts and analysing administrative data and health professionals' skills, by administering written skills tests, simulations or objective structured clinical examinations. Trials assessed the 'knowledge' outcome through questionnaires: in four trials, the authors reported that the questionnaire was previously validated (Fordis 2005; Harris 2008; Khatony 2009; Perkins 2012), while the other studies did not specify.

Duration of follow-up and outcome assessment times

The median follow-up time from the conclusion of the educational intervention to the last outcome assessment was 1.5 weeks, ranging from 0 to 52 weeks. During the study, only three trials had more than one outcome assessment (Fordis 2005; Harris 2008; Le 2010).

For additional details on the studies, please refer to the Characteristics of included studies table.

Excluded studies

We excluded 121 studies for the following reasons: control group (no intervention at all, intervention on a different topic or different types of e-learning in the control group), 51 studies; type of participants included (students or trainees), 30 studies; study design (non-randomised trials), 21 studies; type of intervention used (not e-learning, not delivered by the Internet, not core and essential or not compliant with CanMEDS criteria), 12 studies; type of outcome assessed (no outcome of interest or self-reported outcome), 6 studies; incompleteness of data concerning the number of participants randomised per group, as well as the authors' inability to answer our request for clarification, 1 study (Esche 2015).

For additional details on the studies refer to the Characteristics of excluded studies table.

Ongoing trials

We did not identify any ongoing trials.

Risk of bias in included studies

We summarised decisions regarding individual domains within the Cochrane 'Risk of bias' tool in the 'Risk of bias' graph (Figure 2) and summary (Figure 3). We provided full details of review authors' judgments and support for judgments for each study within the 'Risk of bias' tables in the Characteristics of included studies.

Figure 2. Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies.

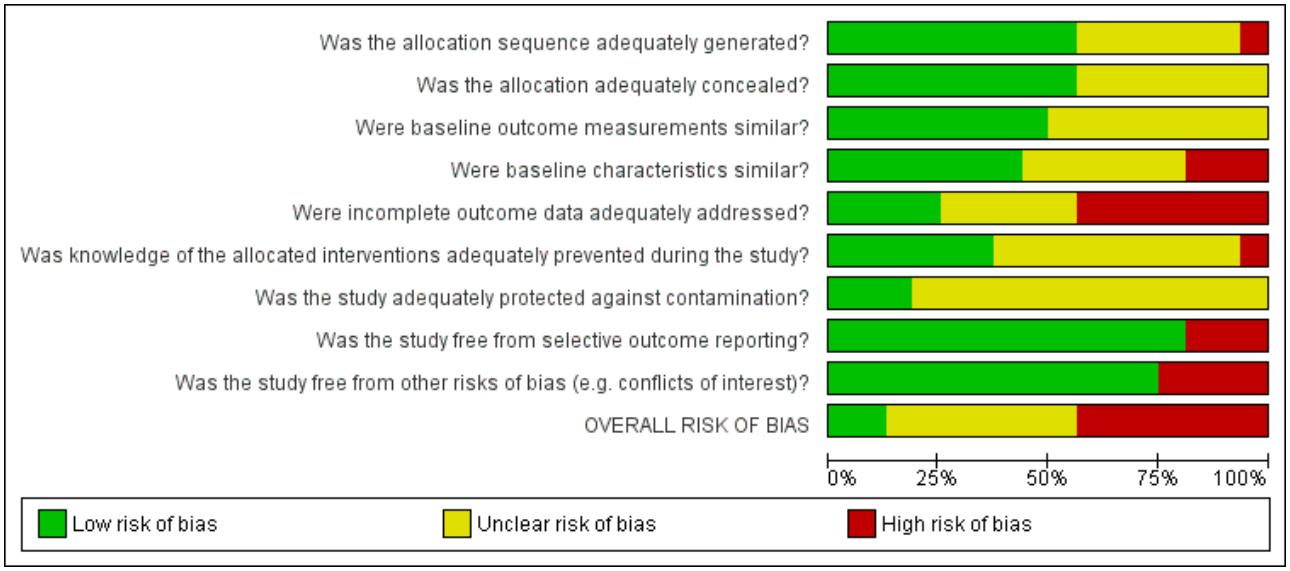


Figure 3. Risk of bias summary: review authors' judgments about each risk of bias item for each included study.

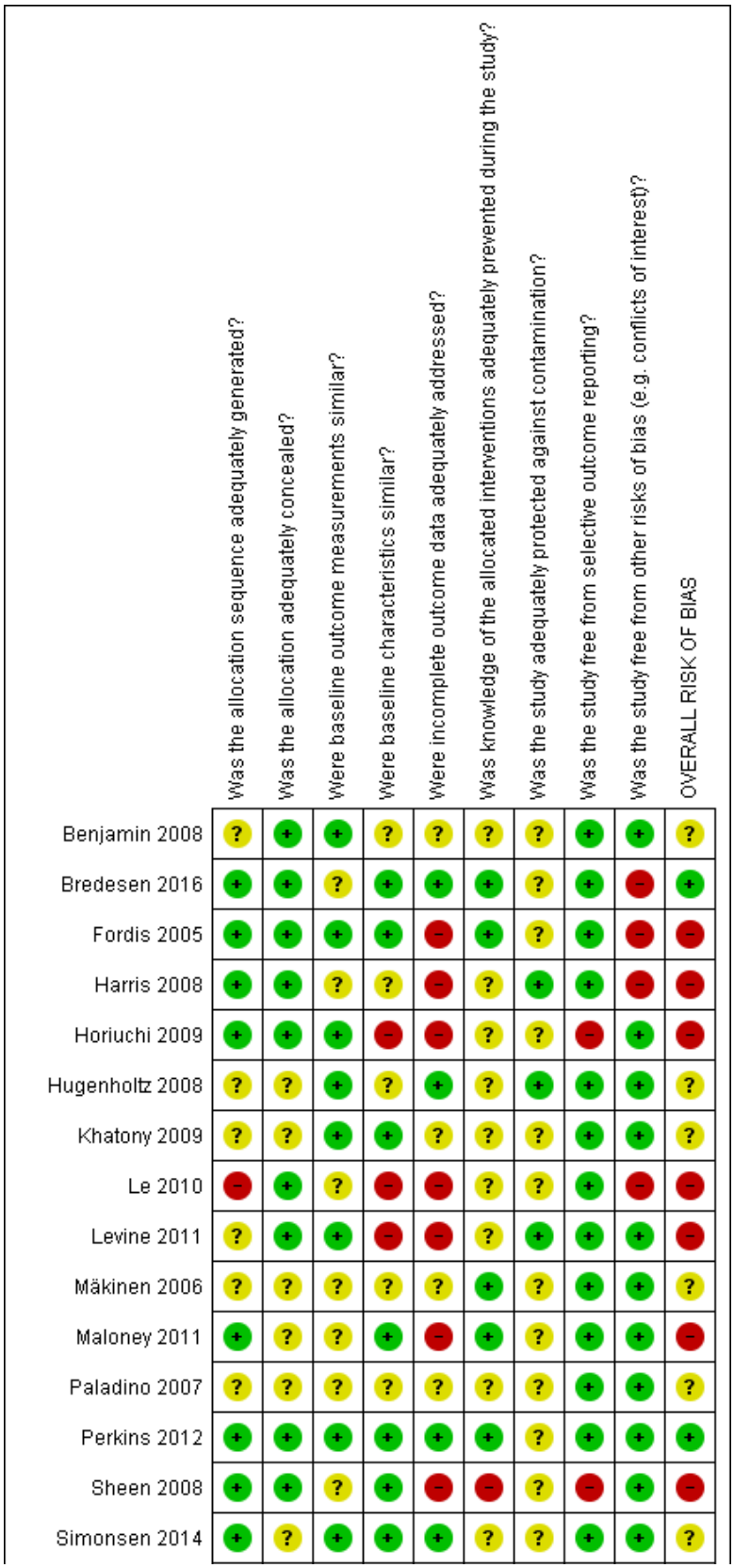
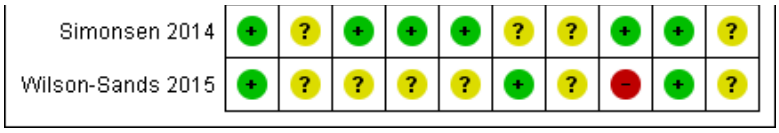


Figure 3. (Continued)



Was the allocation sequence adequately generated?

Nine studies used acceptable methods to generate the allocation sequence, including computerised random number generators (Fordis 2005; Horiuchi 2009; Maloney 2011; Perkins 2012; Simonsen 2014), a blind name draw (Harris 2008), a coin flip (Sheen 2008), or card or envelope shuffling (Bredesen 2016; Wilson-Sands 2015); the remaining trials were at unclear risk of bias with the exception of one study that was at high risk of bias as participants from the same practice were matched into pairs before randomisation (Le 2010).

Was the allocation adequately concealed?

Nine studies clearly explained how the sequence was concealed (Benjamin 2008; Bredesen 2016; Fordis 2005; Harris 2008; Horiuchi 2009; Le 2010; Levine 2011; Perkins 2012; Sheen 2008), while the remaining ones did not mention the methods used by the investigators.

Were baseline outcome measurements similar?

Eight studies clearly reported similar baseline outcome measurements (Benjamin 2008, Fordis 2005, Horiuchi 2009, Hugenholtz 2008, Khatony 2009, Levine 2011, Perkins 2012, Simonsen 2014). We considered the remaining studies at unclear risk of bias because they did not report any information.

Were baseline characteristics similar?

Seven studies reported similar baseline characteristics (Bredesen 2016, Fordis 2005, Khatony 2009, Maloney 2011, Perkins 2012, Sheen 2008, Simonsen 2014) and six were unclear (Benjamin 2008, Harris 2008, Hugenholtz 2008, Mäkinen 2006, Paladino 2007, Wilson-Sands 2015); we considered three trials at high risk of bias because of unbalance in the participants baseline characteristics (Horiuchi 2009, Le 2010, Levine 2011).

Were incomplete outcome data adequately addressed?

We judged seven studies to be at high risk of attrition bias (Fordis 2005; Harris 2008; Horiuchi 2009; Le 2010; Levine 2011; Maloney 2011; Sheen 2008): Sheen 2008 used a per-protocol analysis, and the remaining six studies reported high loss to follow-up, ranging from 15% in Fordis 2005 to 47% in Levine 2011. In four out of these studies, the attrition was bigger in the e-learning group than in the control group (Fordis 2005; Harris 2008; Le 2010; Maloney 2011). We also judged four studies to be at low risk of attrition bias (Bredesen 2016; Hugenholtz 2008; Perkins 2012; Simonsen 2014), while five did not specify anything about loss to follow-up (Benjamin 2008, Khatony 2009, Mäkinen 2006, Paladino 2007, Wilson-Sands 2015).

Was knowledge of the allocated interventions adequately prevented during the study?

Participant blinding is not feasible in educational studies, so performance bias might be unavoidable in this setting. We considered the blinding of assessors, rating the risk of detection bias as high in Sheen 2008 because the authors clearly stated that the assessors were not blind. The study was so small that the assessors could possibly know and remember participants' allocation. Also in Perkins 2012, the authors were unable to ensure the blinding of the outcome assessors. However, this study was so large that we assumed some degree of separation between participants and assessors; besides, the process of measurement was well structured, limiting the risk of bias. Four studies reported that the knowledge of the allocated interventions was adequately prevented (Bredesen 2016, Fordis 2005; Mäkinen 2006; Maloney 2011) and we considered these studies as having low risk of bias. The remaining studies did not report any information on the blinding of the outcome assessors.

Was the study adequately protected against contamination?

Only three trials were clearly reported with respect to the protection against contamination (Harris 2008, Hugenholtz 2008, Levine 2011) while all the others were unclear.

Was the study free from selective outcome reporting?

We found inconsistencies between the outcomes declared in the methods section and the outcomes reported in the results section in three studies (Horiuchi 2009, Sheen 2008, Wilson-Sands 2015).

Was the study free from other risks of bias?

We considered conflicts of interest to be a potential source of bias. Three studies were supported by private sponsor grants (Bredesen 2016; Fordis 2005; Harris 2008), and one received support in terms of evaluation tool or e-learning modules development (Le 2010).

Overall risk of bias

Considering the risk of bias for allocation concealment, incomplete outcome data, and blinding of outcome assessors to be key domains we rated two trials as having a low risk of bias (Bredesen 2016, Perkins 2012), seven trials as having unclear risk of bias (Benjamin 2008, Hugenholtz 2008, Khatony 2009, Mäkinen 2006, Paladino 2007, Simonsen 2014, Wilson-Sands 2015) and the remaining seven trials as having high risk of bias (Fordis 2005, Harris 2008, Horiuchi 2009, Le 2010, Levine 2011, Maloney 2011, Sheen 2008).

Effects of interventions

See: **Summary of findings for the main comparison** Summary of findings: e-learning versus traditional learning for health professionals

The Summary of findings for the main comparison reports the effects of e-learning compared to traditional learning in terms of patient outcomes and health professionals' behaviours, skills and knowledge.

Primary outcomes

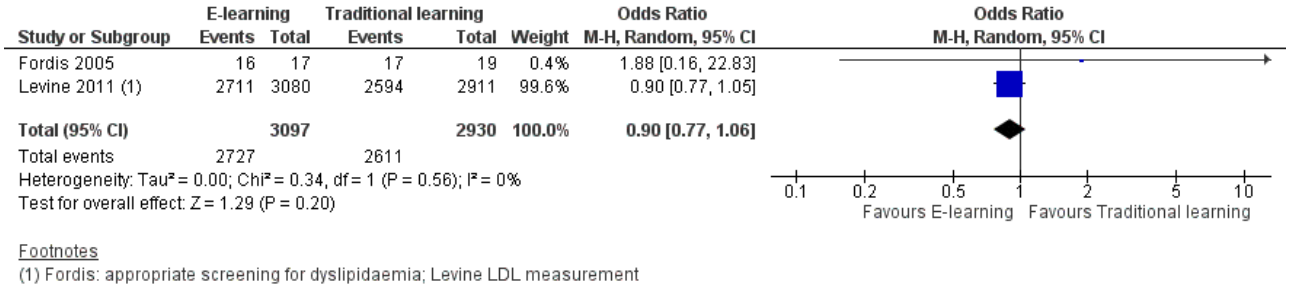
Patient outcomes

One study addressed patient outcomes (Levine 2011). This study randomised 168 primary care clinics (847 health professionals) to highly interactive e-learning versus face-to-face residential learning. After at least 12 months of exposure to the interventions, investigators used a patient administrative data review to compare the groups for two primary patient outcomes indicators. When compared with traditional learning, e-learning may make little or no difference in terms of the proportion of patients with target levels of low-density lipoprotein cholesterol (6399 patients; adjusted difference in improvement between the groups 4.0%, 95% CI −0.3 to 7.9) or the proportion of patients with target levels of glycated haemoglobin (3114 participants patients; adjusted difference in improvement between the groups 4.6%, 95% CI −1.5 to 9.8).

Health professionals' behaviours

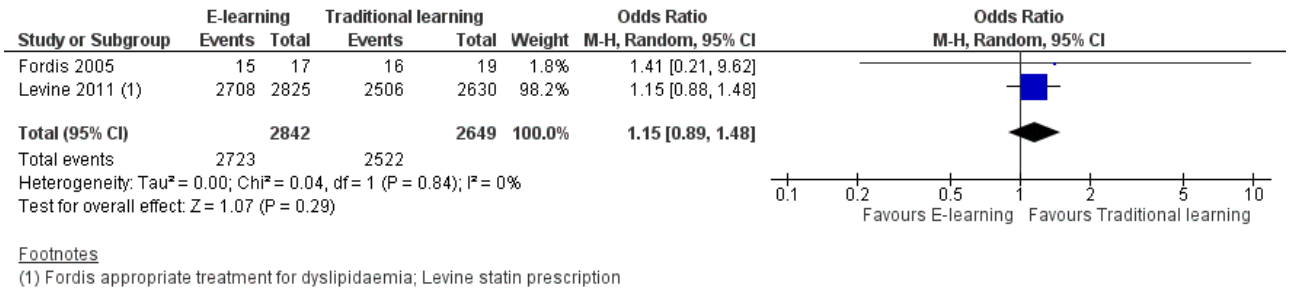
Two studies addressed this outcome in 950 health professionals (Fordis 2005; Levine 2011). Fordis 2005 randomised 103 primary care physicians to highly interactive and multifaceted e-learning versus face-to-face residential learning. After 12 weeks, investigators performed a patient chart review for 20 randomly selected doctors per group, comparing the groups in terms of appropriate screening for and treatment of dyslipidaemia. Levine 2011 reported data from three performance indicators, which we considered as behaviour outcomes: beta-blocker prescription, statin prescription, angiotensin-converting-enzyme (ACE) inhibitor or angiotensin-receptor antagonist prescription. In order to assess consistency, we explored all the possible combinations between the indicators reported by the two studies. When compared with traditional learning, e-learning may make little or no difference in terms of the proportion of patients appropriately screened or treated. In any combination of outcomes in meta-analysis, the resulting 95% CI always included both a beneficial and a harmful effect (Analysis 1.1, Figure 4; Analysis 1.2, Figure 5; Analysis 1.3; Analysis 1.4; Analysis 1.5). These results are from meta-analyses using random-effects models. The fixed-effect model yielded similar results (data not shown).

Figure 4. Forest plot of comparison: 1 Behaviours, outcome: 1.1 Patients appropriately screened (Fordis 2005 - screening for dyslipidaemia; Levine 2011 - LDL measurement).



Footnotes
(1) Fordis: appropriate screening for dyslipidaemia; Levine LDL measurement

Figure 5. Forest plot of comparison: 1 Behaviours, outcome: 1.2 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - statin prescription).



Footnotes
(1) Fordis appropriate treatment for dyslipidaemia; Levine statin prescription

Secondary outcomes

Health professionals' skills

It is uncertain whether e-learning improves or reduces health professionals' skills more than traditional learning, as we assessed the certainty of the evidence as very low: we included six trials in 2912 participants (0 to 12 weeks' follow-up) (Bredesen 2016; Mäkinen 2006; Perkins 2012; Sheen 2008; Simonsen 2014; Wilson-Sands 2015), but we could only pool data for two (Bredesen 2016; Simonsen 2014; Analysis 2.1; SMD 0.03, 95% CI −0.25 to 0.31, I^2 = 61%, 201 participants, 12 weeks' follow-up). We were unable to include the results from the largest trial, Perkins 2012, and two more trials (Mäkinen 2006, Sheen 2008), favouring traditional learning (2640 participants), or one trial favouring e-learning (Wilson-Sands 2015).

Perkins 2012 assessed performance in a cardiac arrest simulation test (CASTest). The full analysis on the mixed population of

participants showed little or no difference between the e-learning and the traditional learning group. However, the study authors provided us with unpublished data (Kimani 2015 [pers comm]) excluding students and participants with missing professional status from the analysis (2562 health professionals, 91% of all the professionals for skill outcomes). A separate analysis on the remaining participants showed that the proportion of health professionals passing the test was higher in the traditional learning group than the e-learning group (OR 1.46, 95% CI 1.22 to 1.76; Analysis 2.2).

Health professionals' knowledge

Eleven trials (3236 participants) assessed this outcome. Three trials in 154 participants reported the data poorly, precluding meta-analysis (Le 2010; Maloney 2011; Sheen 2008), but we could pool results from the remaining eight trials (3082 health professionals). Seven studies (3012 participants) assessed results immediately after the training intervention took place (Benjamin 2008; Fordis 2005; Harris 2008; Horiuchi 2009; Hugenholtz 2008; Khatony 2009; Paladino 2007; Perkins 2012). Three studies in 225 participants carried out the assessment 4 to 12 weeks after the training (Fordis 2005; Harris 2008; Horiuchi 2009): one of these studies assessed the outcome only after 4 weeks (Horiuchi 2009). For each study we used the longest follow-up data available.

E-learning may make little or no difference in health professionals' knowledge. We report results under both a fixed-effect model (SMD 0.04, 95% CI −0.03 to 0.11; Figure 6) and a random-effects model (SMD −0.09, 95% CI −0.27 to 0.09; Figure 7). The heterogeneity among the eight studies contributing to our meta-analyses was moderate (I^2 = 47%).

Figure 6. Forest plot of comparison: 3 Knowledge, outcome: 3.1 At any time (fixed-effect).

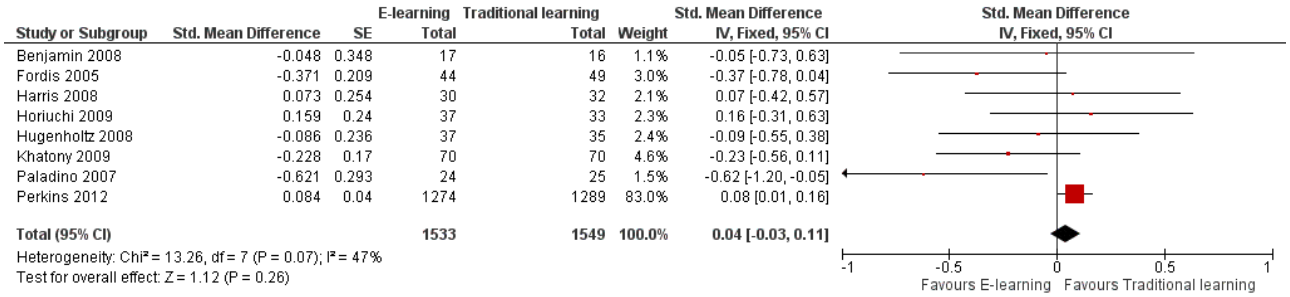
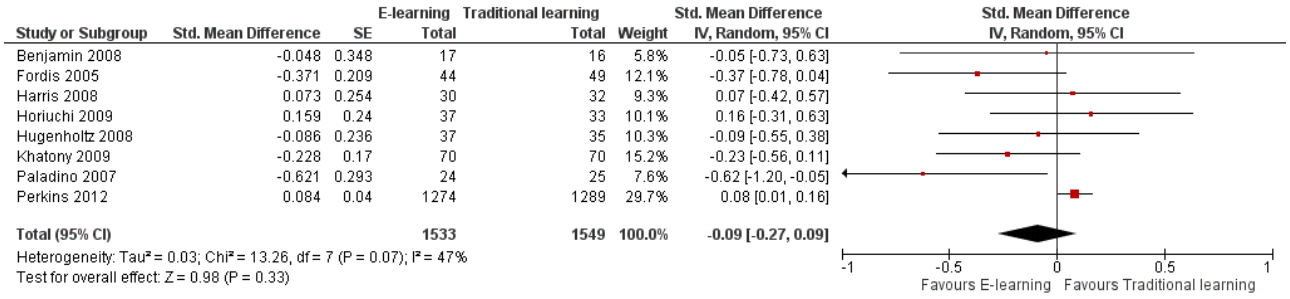


Figure 7. Forest plot of comparison: 3 Knowledge, outcome: 3.2 At any time (random-effects).



Separate analyses of studies with outcome measurement immediately after the training (Analysis 3.3) and after three or more months of follow-up (Analysis 3.4) provided similar results.

Assessment of reporting bias

We did not have enough data to perform reporting bias analyses.

Subgroup analysis and investigation of heterogeneity

Owing to paucity of data, we decided not to perform subgroup analyses.

Sensitivity analysis

Excluding studies assessed as being at overall high or unclear risk of bias was not applicable because we rated all the studies at high or unclear risk of bias except Perkins 2012; we did not identify any cross-over trials.

DISCUSSION

Summary of main results

This systematic review included 16 randomised studies: most of the these were small trials (only three trials involved more than 150 participants) at high or unclear risk of bias due to poor reporting. Our results suggest that compared to traditional learning, e-learning may lead to little or no difference in patient outcomes or health professionals' behaviours (low-certainty evidence), while the effect on health professionals' skills is unclear (very low-certainty evidence). E-learning may also make little or no difference compared to more traditional instructional methods on health professionals' knowledge (low-certainty evidence). In broad terms, e-learning is associated with no important benefits compared to traditional learning. The only large trial considered, at low risk of bias, favoured traditional learning for skills. However, readers

should interpret this noteworthy difference with great caution: our systematic review highlights how results of randomised trials were partially heterogenous, inconclusive and associated with negligible effect sizes.

Overall completeness and applicability of evidence

The randomised trials included in the review seemed to be sufficiently homogeneous in terms of included populations, comparison between e-learning versus traditional learning, and outcome measures. With the exception of one study involving childcare health consultants, all studies included doctors or nurses. However, reporting within the studies was often poor, with few details on educational content, systems and implementation factors. The description of the setting usually lacked information about how innovative e-learning was in the experimental context (e.g. early adoption, standard practice, etc.). In most cases it seems that e-learning was an innovative intervention being compared to the conventional approach.

Twelve trials compared an e-learning intervention with face-to-face learning, and two trials evaluated e-learning against guideline dissemination or availability. We believe these comparisons are relevant for many decisions on whether to choose one educational approach or another.

Certainty of evidence

Overall, we identified several methodological limitations during our assessment of risk of bias, prompting us to downgrade the certainty of evidence to low for all outcomes except health professionals' knowledge (Figure 2; Figure 3; Summary of findings for the main comparison). Incomplete outcome data was the dimension at highest risk of bias in terms of the number of studies assessed at high risk for this item. The number of participants who withdrew from or dropped out of the studies was more than 20% in five trials; in five more studies, authors did not state the percentage. The loss to follow-up may have introduced imbalances between the groups included in the analyses.

Potential biases in the review process

We identified several trials through our search strategy, but we did not search the grey literature or databases that might be relevant for some health professionals but do not primarily focus on randomised trials (e.g. CINAHL). We report differences between protocol and review below. We judge these differences as having no influence on the original objectives of this review, or not as potential sources of bias to our findings.

Agreements and disagreements with other studies or reviews

Previous systematic reviews have found e-learning to be associated with small positive effects compared with traditional educational interventions. In 2008, Cook and McDonald published a quantitative meta-analysis including 201 studies of Internet-based learning (Cook 2008a). The apparent discrepancy between our findings and their findings may be due to differences in the type of studies included: while we only considered randomised trials involving licensed health professionals, Cook 2008a also included non-randomised trials and studies with undergraduate participants. Just 2 of the 76 studies included in Cook's work had the same PICO framework of our review (Fordis 2005; Mäkinen 2006). Only 14% of participants in the studies they included were practicing health professionals (the other participants were all students).

A document from the US Department of Education reported the results of a review and meta-analysis of online learning studies for undergraduate students. They found that on average, the students in online learning environments performed modestly better than those receiving face-to-face instructions. We found little or no effect on learning outcomes, and one might speculate that e-learning tools fare better in younger populations. This phenomenon is well known in social sciences research as a 'cohort effect', defined as "the effect that having been born in a certain time, region, period or having experienced the same life experience (in the same time period) has on the development of a particular group" (Glen 2005).

AUTHORS' CONCLUSIONS

Implications for practice

Our results suggest in broad terms that e-learning does not itself result in major benefits for patient or health professional outcomes. Opting for traditional or e-learning approaches entails complex judgments, relating to the relative efficacy of the methods but also dimensions such as accessibility, usability, retention and costs. Traditional learning may be preferable in some instances, e.g. to improve knowledge or skills in small groups of health professionals when physical attendance is feasible, while e-learning programmes may be a better choice when the aim is to reach a large number of health professionals at a limited cost. Blended courses potentially balance the benefits of the two learning strategies.

The effectiveness of traditional learning means that e-learning is likely to have relatively similar effects, and powerful trials with prohibitively large sample sizes would be needed to show statistical superiority in some domain. Our results do not provide support for the superiority of e-learning. The results do not necessarily outweigh some benefits of e-learning, such as increased accessibility and flexibility. There is insufficient evidence to provide recommendations about accreditation, interactivity and length of e-learning programmes or about targeting of courses towards specific types of participants or contents. We have limited understanding of the characteristics that may influence the effectiveness of different e-learning programmes. Thus, our systematic review provides limited information to guide the choice or optimisation of components of e-learning interventions.

Implications for research

Although 16 randomised trials might seem a limited cohort, trials in education rarely benefit from commercial support, so the included evidence represents a valuable basis. Future trials might focus on additional core components of content, frequency of delivery, duration and intensity of e-learning, which might modify the effects of e-learning beyond those found in this review. There seems to be an opportunity for future trials to evaluate cost-effectiveness: everything being equal, costs and feasibility might represent the dimension where e-learning gains prominence.

Future studies should aim to use randomised designs with appropriate sample sizes, favouring the assessment of patient outcomes and health professionals' behaviours rather than skills or knowledge, and they should focus on the components of e-learning

that can eventually change behaviour as well as knowledge and skills.

Assessing outcomes at multiple time points during the study follow-up can determine the persistence of effects.

All studies, irrespective of the outcomes considered, should use predefined data scales and reporting rules in order to improve the account of the research questions under investigation.

More data are needed to evaluate the relative efficacy of e-learning in specific medical areas or rare conditions (i.e. e-learning programmes assisting in surgical teaching) and the importance of accreditation, interactivity and length of e-learning programmes.

The feasibility of these studies is challenged by the need for a large number of participants and long follow-up, but investigators may take existing educational settings providing training interventions into account as opportunities to override this problem. Finally, it may be more realistic to expect the development of studies that can inform practice using quasi-experimental designs, wait-list controls or stepped-wedged implementation.

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AV would like to dedicate this review to the memory of his brother Andrea, example of research in Economics and life.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Benjamin 2008

Methods	**Study type**: randomised trial **Study arms**: 3
Participants	**Participants type**: childcare health consultants **Number randomised** (e-learning/control): 17/16 **Lost to follow-up**: not reported
Interventions	**E-learning type**: web training using photographs, quizzes and interactive multiple choice questions **E-learning interactivity**: high **E-learning blending**: alone **E-learning duration**: short; completion within 3 weeks (mean time spent on training 120 minutes) **Control type**: face-to-face training **Control duration**: 3 hours **Follow-up** (from the end of the intervention to the last outcome assessment): short - 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: not stated **Setting**: community setting
Outcomes	**Primary**: knowledge (by an non-validated test) **Secondary**: time spent on training **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: August 2005-June 2006 **Funding source**: Centers for Disease Control and Prevention (CDC), North Carolina Division of Public Health, Child Care Bureau **Declaration of interest**: none declared

Benjamin 2008 *(Continued)*

	Country: USA
	Topic: childhood overweight management

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported
Was the allocation adequately concealed?	Low risk	Sealed envelopes with a randomisation sequence developed by the study biostatistician
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	Unclear risk	No information reported
Were incomplete outcome data adequately addressed?	Unclear risk	No information reported
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: low Risk of attrition bias: unclear Risk of detection bias: unclear

Bredesen 2016

Methods	**Study type**: randomised trial
	Study arms: 2
Participants	**Participants type**: nurses
	Number randomised (e-learning/control): 23/21

Bredesen 2016 *(Continued)*

	Lost to follow-up (number(%); (e-learning/control)): 13(56.5%)/13(61.9%)
Interventions	**E-learning type**: patient cases, photos and schematic illustration **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: not reported **Control type**: traditional classroom lecture **Control duration**: 45 minutes **Follow-up** (time from the end of the intervention to the last outcome assessment): 0 weeks (immediately after) and three months later **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: skills **Secondary**: none **Times the outcomes were assessed after the intervention**: 2
Notes	**Study dates**: May 2012-December 2012 **Funding source**: Oslo University Hospital, Norwegian Nurses Organisation, University of Oslo and Sophies Minde Ortopedi AS **Declaration of interest**: no competing interest **Country**: Norway **Topic**: pressure ulcer risk assessment and classification **Other**: authors provided unpublished data regarding pressure ulcer classification (Brendsen 2016 [pers comm])

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Envelope shuffling
Was the allocation adequately concealed?	Low risk	Envelope shuffling
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Low risk	Chi^2/Fisher's Exact test not significant between the 2 groups

Bredesen 2016 *(Continued)*

Were incomplete outcome data adequately addressed?	Low risk	No incomplete data at post-test immediately after the training
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	Outcome is not likely to be influenced by lack of blinding in this study
Was the study adequately protected against contamination?	Unclear risk	Contamination is unlikely
Was the study free from selective outcome reporting?	Low risk	The published report includes all expected outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	High risk	Private sponsor Sophies Minde Ortopedi AS
OVERALL RISK OF BIAS	Low risk	Risk of selection bias: low Risk of attrition bias: low Risk of detection bias: low

Fordis 2005

Methods	**Study type**: randomised trial **Study arms**: 3
Participants	**Participants type**: primary care physicians **Number randomised** (e-learning/control): 52/51 **Lost to follow-up** (number(%); (e-learning/control)): 8(15.4%)/2(3.9%)
Interventions	**E-learning type**: online lecture, interactive cases with feedback, enabling tools, supporting resources, access to expert advice **E-learning interactivity**: high **E-learning blending**: core and essential **E-learning duration**: short - at participants convenience during a 2-week period (mean time spent on training 1.4 hours for 3 session) **Control type**: live lecture interactive cases with feedback, enabling tools, supporting resources, access to expert advice **Control duration**: 1.5-2 hours **Follow-up** (time from the end of the intervention to the last outcome assessment): 12 weeks **CanMEDS framework area**: medical expertise **Regulation**: formally accredited

Fordis 2005 *(Continued)*

	Setting: primary care
Outcomes	**Primary**: knowledge (by a validated test), behaviours (appropriate screening and treatment for dyslipidaemia) **Secondary**: time spent on training, satisfaction **Times the outcomes were assessed after the intervention**: 2
Notes	**Study dates**: August 2001-July 2002 **Funding source**: AstraZeneca Pharmaceuticals **Declaration of interest**: grant support from AstraZeneca and other pharmaceutical companies **Country**: USA **Topic**: cholesterol management **Other**: authors provided single participants data about knowledge as requested (Jason 2015 [pers comm])

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Random number generator
Was the allocation adequately concealed?	Low risk	Centralised randomisation scheme
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	High risk	Major imbalance in missing data between groups: 15.4% in the e-learning group and 5.8% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	Data analyst blinded to the identification of participants
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	High risk	Study supported by a grant from AstraZeneca Pharmaceuticals.

Fordis 2005 *(Continued)*

OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias: low

Harris 2008

Methods	**Study type**: randomised trial **Study arms**: 3
Participants	**Participants type**: primary care physicians **Number randomised** (e-learning/control): 49/50 **Lost to follow-up** (number(%); (e-learning/control)): 19(38.8%)/18(36.0%)
Interventions	**E-learning type**: on-line lectures **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: short - 4 hours **Control type**: live lecture **Control duration**: 4 hours **Follow-up** (time from the end of the intervention to the last outcome assessment): long - 12 weeks **CanMEDS framework area**: medical expertise **Regulation**: formally accredited **Setting**: primary care
Outcomes	**Primary**: knowledge (by a validated test) **Secondary**: time spent on training, satisfaction **Times the outcomes were assessed after the intervention**: 2
Notes	**Study dates**: September 2005 **Funding source**: Small Business Innovation and Research (SBIR) grant **Declaration of interest**: none declared **Country**: USA **Topic**: chronic pain **Other**: we decided to include this study after discussion about the outcome measure used. The know pain 50 assesses a mix of knowledge, attitudes and beliefs but at the end we considered that the most of the items regard knowledge.

Risk of bias

Bias	Authors' judgement	Support for judgement

Harris 2008 *(Continued)*

Was the allocation sequence adequately generated?	Low risk	Blind name draw
Was the allocation adequately concealed?	Low risk	Centralised randomisation scheme
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Unclear risk	No information reported
Were incomplete outcome data adequately addressed?	High risk	Missing data 38.8% in the e-learning group and 36.0% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Low risk	The authors controlled the participants' room change
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	High risk	The development of the online CME programme and the research study were supported by Small Business Innovation and Research (SBIR) grants
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias: unclear

Horiuchi 2009

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses **Number randomised** (e-learning/control): 45/48 **Lost to follow-up** (number(%); (e-learning/control)): 8(17.8%)/15(31.2%)
Interventions	**E-learning type**: four 30-minute online classes **E-learning interactivity**: low **E-learning bending**: alone

Horiuchi 2009 *(Continued)*

	E-learning duration: short - 120 minutes **Control type**: four 90-minute evening lectures **Control duration**: 360 minutes **Follow-up** (time from the end of the intervention to the last outcome assessment): long - 4 weeks **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: knowledge (by an non-validated test) **Secondary**: satisfaction **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: August 2005-November 2006 **Funding source**: Japanese Ministry of Education Scientific Research Grant **Declaration of interest**: none declared **Country**: Japan **Topic**: evidence-based medicine

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Computerised random number generator
Was the allocation adequately concealed?	Low risk	Centralised randomisation scheme and sealed opaque envelopes
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	High risk	Several imbalance between group in the demographics of participants
Were incomplete outcome data adequately addressed?	High risk	Major imbalance in missing data between groups: 17.8% in the e-learning group and 31.2% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Unclear risk	No information reported

Horiuchi 2009 *(Continued)*

Was the study free from selective outcome reporting?	High risk	Inconsistencies between outcomes declared in the Methods and outcomes reported in the Results
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias: unclear

Hugenholtz 2008

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: occupational physicians **Number randomised** (e-learning/control): 37/35 **Lost to follow-up** (number(%); (e-learning/control)): 0/2(5.4%)
Interventions	**E-learning type**: individual e-learning **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: short - 30 minutes **Control type**: live lecture **Control duration**: 30 minutes **Follow-up** (time from the end of the intervention to the last outcome assessment): short - 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: formally accredited **Setting**: occupational medicine
Outcomes	**Primary**: knowledge (by an non-validated test) **Secondary**: none **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: December 2006 **Funding source**: none declared **Declaration of interest**: none declared **Country**: Netherlands

Hugenholtz 2008 *(Continued)*

Topic: Mental health

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported
Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	Unclear risk	No information reported
Were incomplete outcome data adequately addressed?	Low risk	The proportion of missing data was unlikely to overturn the study result: 0% in the e-learning group and 5.4% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Low risk	It is unlikely that communication between intervention and control groups could have occurred
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: low Risk of detection bias: unclear

Khatony 2009

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses **Number randomised** (e-learning/control): 70/70 **Lost to follow-up**: not reported

Khatony 2009 *(Continued)*

Interventions	**E-learning type**: 1 week educational material access, chat room, emailing and telephone availability for answering questions **E-learning interactivity**: high **E-learning blending**: alone **E-learning duration**: long - 1 week **Control type**: face-to-face interactive lecture **Control duration**: 3 hours **Follow-up** (time from the end of the intervention to the last outcome assessment): short - 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: knowledge (by a validated test) **Secondary**: none **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: winter 2007 **Funding source**: none declared **Declaration of interest**: no competing interest declared **Country**: Iran **Topic**: AIDS

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported
Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	Unclear risk	No information reported
Was knowledge of the allocated interventions ade-	Unclear risk	No information reported

Khatony 2009 *(Continued)*

quately prevented during the study?		
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: unclear Risk of detection bias: unclear

Le 2010

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: paediatricians **Number randomised** (e-learning/control): 15/9 **Lost to follow-up** (number(%); (e-learning/control)): 4(26.7%)/0(0%)
Interventions	**E-learning type**: 2 teleconferences, access to a website with 6 interactive multimedia earning modules and a CD-ROM with the same learning modules **E-learning interactivity**: high **E-learning blending**: core and essential **E-learning duration**: long - 6 weeks to complete the modules **Control type**: guidelines dissemination - authors reply on 15 July 2015 (Cabana 2015 [pers comm]) **Control duration**: 0 weeks **Follow-up** (time from the end of the intervention to the last outcome assessment): 32 weeks **CanMEDS framework area**: medical expertise **Regulation**: formally accredited **Setting**: primary care
Outcomes	**Primary**: satisfaction **Secondary**: knowledge (by an non-validated test), attitudes, self-reported prescription, self-reported guidelines familiarity **Times the outcomes were assessed after the intervention**: 2

Le 2010 *(Continued)*

Notes	**Study dates**: February 2007-March 2008 **Funding source**: none declared **Declaration of interest**: no competing interest declared **Country**: USA **Topic**: asthma

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	High risk	Authors matched participants from the same practice into pairs: within each pair, they randomised one participant to the control group and the other to the intervention group
Was the allocation adequately concealed?	Low risk	Unit of allocation was by institution, team or professional and allocation performed on all units at the start of the study
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	High risk	Some imbalance between group in the demographics of participants
Were incomplete outcome data adequately addressed?	High risk	Major imbalance in missing data between groups: 26.3% in the e-learning group and 0.0% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Unclear risk	Participants were allocated within a practice and it is possible that communication between intervention and control professionals could have occurred
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	High risk	Indegene Inc gave assistance in developing the learning modules
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias: unclear

Levine 2011

Methods	**Study type**: cluster-randomised trial

Levine 2011 *(Continued)*

	Study arms: 2
Participants	**Participants type**: healthcare providers (not otherwise specified) **Number randomised** (e-learning/control): 84 clinics (385 providers, 4024 patients)/84 clinics (462 providers, 3727 patients) **Lost to follow-up** (number(%); (e-learning/control)): 180 providers (47%), 944 patients (24.5%)/266 providers (57%), 816 patience (22%)
Interventions	**E-learning type**: multicomponent website (relevant clinical guidelines, monthly summaries of pertinent peer-review manuscripts, downloadable practice tools and patient educational materials) and pushed email cues with educational content **E-learning interactivity**: high **E-learning blending**: core and essential **E-learning duration**: long - 108 weeks **Control type**: clinical guidelines website and the medical letter subscription **Control duratio**n: 108 weeks **Follow-up** (time from the end of the intervention to the last outcome assessment): 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: formally accredited **Setting**: primary care
Outcomes	**Primary**: 7 clinical indicators of performance improvement (5 of health professionals' behaviour, 2 of patient outcomes) **Secondary**: composite clinical indicator score **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: January 2002-December 2008 **Funding source**: Veterans Affairs Health Services Research and Development Grant **Declaration of interest**: none declared **Country**: USA **Topic**: care after myocardial infarction

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported
Was the allocation adequately concealed?	Low risk	Unit of allocation was by team or professional and allocation performed on all units at the start of the study
Were baseline outcome measurements similar?	Low risk	No important differences across study groups

Levine 2011 *(Continued)*

Were baseline characteristics similar?	High risk	Several imbalances between group in several participation measures (participants' providers, website visits, etc)
Were incomplete outcome data adequately addressed?	High risk	Missing patient data: 24.5% in the e-learning group and 22.0% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Low risk	Allocation by clinics
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias: unclear

Maloney 2011

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses, physiotherapists, others health professionals **Number randomised** (e-learning/control): 67/68 **Lost to follow-up** (number(%); (e-learning/control)): 24(36%)/19(28%)
Interventions	**E-learning type**: web-based discussions available even by phone, DVD comprising the multimedia used in the web-based programme, self-directed reading and formative quizzes to interactive skills-practice sessions with feedback opportunities **E-learning interactivity**: high **E-learning blending**: core and essential **E-learning duration**: short - 7 hours **Control type**: face-to-face intervention; copy of the presentation slides, reference to further readings, and a DVD of the assessment procedures to be covered in the seminar **Control duration**: 7 hours **Follow-up** (time from the end of the intervention to the last outcome assessment): 1 week

Maloney 2011 *(Continued)*

	CanMEDS framework area: medical expertise **Regulation**: not specified **Setting**: rehabilitation
Outcomes	**Primary**: knowledge (by an non-validated test) **Secondary**: satisfaction, self-reported change in practice **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: not reported **Funding source**: Department of Health, Victoria, Australia **Declaration of interest**: none declared **Country**: Australia **Topic**: falls prevention exercise

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Computerised random number sequence
Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	High risk	Missing patients data 35.8% in the e-learning group and 27.9% in the control group
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	Blinded outcome assessment
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low

Maloney 2011 *(Continued)*

	Risk of attrition bias: high
	Risk of detection bias: low

Mäkinen 2006

Methods	**Study type**: randomised trial
	Study arms: 3
Participants	**Participants type**: nurses
	Number randomised (e-learning/control): 20/16
	Lost to follow-up: not reported
Interventions	**E-learning type**: multimedia (video clips and pictures), a short written explanation of the multimedia, links to the databases extending the amount of information if needed and questions between the content pages with correct answers presented
	E-learning interactivity: high
	E-learning blending: alone
	E-learning duration: short - 15-30 minutes
	Control type: a certified trainer gave a 4-h basic life support and defibrillation course
	Control duration: 240 minutes
	Follow-up (time from the end of the intervention to the last outcome assessment): 2 weeks
	CanMEDS framework area: medical expertise
	Regulation: not specified
	Setting: secondary (hospital) care
Outcomes	**Primary**: skills (OSCE)
	Secondary: none
	Times the outcomes were assessed after the intervention: 1
Notes	**Study dates**: not reported
	Funding source: none declared
	Declaration of interest: none declared
	Country: Finland
	Topic: basic life support

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported

Mäkinen 2006 *(Continued)*

Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Unclear risk	No information reported
Were incomplete outcome data adequately addressed?	Unclear risk	No information reported
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	Observers blinded to the educational method of the groups
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: unclear Risk of detection bias: low

Paladino 2007

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses **Number randomised** (e-learning/control): 25/24 **Lost to follow-up**: not reported
Interventions	**E-learning type**: e-learning training by PowerPoint **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: short - 40 minutes **Control type**: on-site training by PowerPoint **Control duration**: 120 minutes

Paladino 2007 *(Continued)*

	Follow-up (time from the end of the intervention to the last outcome assessment): short - 0 weeks (immediately after) **CanMEDS framework area**: management **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: knowledge (by an non-validated test) **Secondary**: none **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: not reported **Funding source**: none declared **Declaration of interest**: none declared **Country**: Brazil **Topic**: quality tools

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Unclear risk	No information reported
Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Unclear risk	No information reported
Were incomplete outcome data adequately addressed?	Unclear risk	No information reported
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes

Paladino 2007 *(Continued)*

Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: unclear Risk of detection bias: unclear

Perkins 2012

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: physicians, nurses, students **Number randomised** (e-learning/control): 1843/1889 (1255 vs 1271 without students) **Lost to follow-up** (number(%); (e-learning/control)): 476(25.8%)/523(27.7%)
Interventions	**E-learning type**: 4 e-lectures and 6 interactive workshops **E-learning interactivity**: high **E-learning blending**: core and essential **E-learning duration**: 2 days (short) **Control type**: conventional advanced life support **Control duration**: 2 days **Follow-up** (time from the end of the intervention to the last outcome assessment): 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: pre-hospital care (cardiopulmonary resuscitation)
Outcomes	**Primary**: skills **Secondary**: knowledge (by a validated test) **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: December 2008-October 2010 **Funding source**: Resuscitation Council (UK) **Declaration of interest**: declared on www.apconline.org **Country**: UK, Australia **Topic**: advanced life support **Other**: authors provided unpublished data (Kimani 2015 [pers comm])
Risk of bias	

Perkins 2012 *(Continued)*

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Electronic randomisation
Was the allocation adequately concealed?	Low risk	Centralised randomisation scheme
Were baseline outcome measurements similar?	Low risk	Knowledge pre-course test better in e-learning group. Since the final difference in knowledge is in the opposite direction (favouring traditional learning), there is no indication of a bias.
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	Low risk	The proportion of missing data was unlikely to overturn the study results; the study results were analysed on an intention-to-treat basis
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	The authors were unable to ensure blinding of outcome assessment. However we judged that the outcome measurement was not likely to be influenced by lack of blinding, as the process of measurement was structured.
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Low risk	Risk of selection bias: low Risk of attrition bias: low Risk of detection bias: unclear (the blinding of outcome assessors is not explicitly stated) Considering the low risk of bias across most dimensions, we considered the study to be at an overall minimal risk of bias

Sheen 2008

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses **Number randomised** (e-learning/control): 22/20

Sheen 2008 *(Continued)*

	Lost to follow-up: not reported
Interventions	**E-learning type**: audio, video and PowerPoint presentation format **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: short - 5.5 hours **Control type**: traditional in class programme **Control duration**: not reported **Follow-up** (time from the end of the intervention to the last outcome assessment): short - 0 weeks, (immediately after) **CanMEDS framework area**: medical expertise, communication, management, scholar **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: knowledge (by an non-validated test) and skills in several professional dimensions **Secondary**: satisfaction **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: 2004-2005 **Funding source**: Taiwan National Science Council **Declaration of interest**: none declared **Country**: Taiwan **Topic**: nursing care

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Randomisation by coin flip
Was the allocation adequately concealed?	Low risk	Randomisation by coin flip
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	High risk	Participants who did not complete the courses were excluded and not used in data analysis
Was knowledge of the allocated interventions ade-	High risk	Neither participants nor evaluators were blinded

Sheen 2008 *(Continued)*

quately prevented during the study?		
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	High risk	No result provided
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	High risk	Risk of selection bias: low Risk of attrition bias: high Risk of detection bias:high

Simonsen 2014

Methods	**Study type**: randomised trial **Study arms**: 2
Participants	**Participants type**: nurses **Number randomised** (e-learning/control): 92/91 **Lost to follow-up** (number(%); (e-learning/control)): 17(18.5%)/9(9.9%)
Interventions	**E-learning type**: interactive online tests, hints and suggested solutions; access to a collection of tests with feedback on answers and a printout of the compendium **E-learning interactivity**: high **E-learning blending**: alone **E-learning duration**: short - 2 days **Control type**: conventional classroom and self-study **Control duration**: 2 days **Follow-up** (time from the end of the intervention to the last outcome assessment): 2-4 weeks **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: secondary (hospital) care
Outcomes	**Primary**: skills **Secondary**: certainty **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: September 2007-April 2009

Simonsen 2014 *(Continued)*

Funding source: South-East Norway Health Authorities and Innlandet Hospital Trust

Declaration of interest: commercial interest for one the authors

Country: Norway

Topic: drug dose calculation

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Predefined computer-generated lists
Was the allocation adequately concealed?	Unclear risk	No information reported
Were baseline outcome measurements similar?	Low risk	No important differences across study groups
Were baseline characteristics similar?	Low risk	No important differences across study groups
Were incomplete outcome data adequately addressed?	Low risk	Imbalance in missing data between groups: 18.5% in the e-learning group and 9.9% in the control group but the proportion of missing data was unlikely to overturn the study results and the study results were analysed on an intention-to-treat basis
Was knowledge of the allocated interventions adequately prevented during the study?	Unclear risk	No information reported
Was the study adequately protected against contamination?	Unclear risk	No information reported
Was the study free from selective outcome reporting?	Low risk	No evidence of selective reporting of outcomes
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: low Risk of detection bias: unclear

Wilson-Sands 2015

Methods	**Study type**: randomised trial

Wilson-Sands 2015 *(Continued)*

	Study arms: 2
Participants	**Participants type**: mixed health professionals **Number randomised** (e-learning/control): 25/20 **Lost to follow-up**: not reported
Interventions	**E-learning type**: online interactive patient care scenarios **E-learning interactivity**: low **E-learning blending**: alone **E-learning duration**: not reported **Control type**: instructor led training **Control duration**: not reported **Follow-up** (time from the end of the intervention to the last outcome assessment): 0 weeks (immediately after) **CanMEDS framework area**: medical expertise **Regulation**: not specified **Setting**: pre-hospital care (cardiopulmonary resuscitation)
Outcomes	**Primary**: skills (3 outcome: correct compressions, correct ventilations, correct CPR cycles) **Secondary**: none **Times the outcomes were assessed after the intervention**: 1
Notes	**Study dates**: not reported **Funding source**: not reported **Declaration of interest**: not reported **Country**: USA **Topic**: Basic Life Support

Risk of bias

Bias	Authors' judgement	Support for judgement
Was the allocation sequence adequately generated?	Low risk	Cards shuffling
Was the allocation adequately concealed?	Unclear risk	Cards shuffling
Were baseline outcome measurements similar?	Unclear risk	No information reported
Were baseline characteristics similar?	Unclear risk	Unclear differences across study groups

Wilson-Sands 2015 *(Continued)*

Were incomplete outcome data adequately addressed?	Unclear risk	No information reported
Was knowledge of the allocated interventions adequately prevented during the study?	Low risk	Outcome is not likely to be influenced by lack of blinding in this study
Was the study adequately protected against contamination?	Unclear risk	Contamination is unlikely
Was the study free from selective outcome reporting?	High risk	The results of a written exam is not reported
Was the study free from other risks of bias (e.g. conflicts of interest)?	Low risk	No evidence of other risk of bias
OVERALL RISK OF BIAS	Unclear risk	Risk of selection bias: unclear Risk of attrition bias: unclear Risk of detection bias: low

CME: continuing medical education; **OSCE**: objective structured clinical examination.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Alfieri 2012	Not complying with participants inclusion criteria (residents)
Allison 2005	Not complying with control inclusion criteria (e-learning as a control)
Anderson 2006	Not complying with study type inclusion criteria (no randomisation)
Andolsek 2013	Not complying with study type inclusion criteria (no randomisation)
Bayar 2009	Not complying with control inclusion criteria (no intervention)
Beckley 2000	Not complying with intervention inclusion criteria (not delivered by Internet)
Beeckman 2008	Not complying with participants inclusion criteria (residents)
Bello 2005	Not complying with participants inclusion criteria (residents)
Benedict 2013	Not complying with participants inclusion criteria (students)
Beyea 2008	Not complying with participants inclusion criteria (residents)
Bode 2012	Not complying with participants inclusion criteria (trainees)
Boespflug 2015	Not complying with study type inclusion criteria (no randomisation)

Study	Reason for exclusion
Bonevski 1999	Not complying with intervention inclusion criteria (computerised feedback system)
Browne 2004	Not complying with participants inclusion criteria (trainees)
Buijze 2012	Not complying with control inclusion criteria (no intervention)
Butler 2012	Not complying with control inclusion criteria (no intervention)
Butzlaff 2004	Not complying with control inclusion criteria (no intervention)
Carney 2011	Not complying with control inclusion criteria (no intervention)
Carney 2012	Not complying with control inclusion criteria (no intervention)
Casap 2011	Not complying with study type inclusion criteria (no randomisation)
Chan 1999	Not complying with control inclusion criteria (e-learning as a control)
Chenkin 2008	Not complying with participants inclusion criteria (mixed residents and staff physicians). No answer from the authors to request of separated data (on 5 July 2015)
Chung 2004	Not complying with intervention inclusion criteria (e-learning programmes on bio-terrorism; focusing on non-clinical medical topics defined as subjects different from the CanMEDS 7 physicians roles; mixed residents and staff physicians)
Cook 2008	Not complying with participants inclusion criteria (residents)
Crenshaw 2010	Not complying with intervention inclusion criteria (computerised feedback system)
Curtis 2007	Not complying with intervention inclusion criteria (e-learning not core and essential: audit and feedback in the intervention but not in the control arm)
De Beurs 2015	Not complying with outcome inclusion criteria (self-reported knowledge)
De Beurs 2016	Not complying with control inclusion criteria (e-learning and usual approach vs usual approach alone)
Dimeff 2011	Not complying with control inclusion criteria (e-learning as a control)
Esche 2015	Not providing data about health professionals randomised to the intervention/control groups. Authors stated their inability to provide us you with the requested information (Esche 2015 [pers comm])
Estrada 2010	Not complying with intervention inclusion criteria (e-learning not core and essential)
Estrada 2011	Not complying with intervention inclusion criteria (e-learning not core and essential)
Fary 2015	Not complying with control inclusion criteria (no intervention)
Fisher 2014	Not complying with control inclusion criteria (no intervention)
Foroudi 2013	Not complying with control inclusion criteria (e-learning as a control)
Fox 2001	Not complying with control inclusion criteria (e-learning as a control)

Study	Reason for exclusion
Franchi 2016	Not complying with control inclusion criteria (e-learning in both the arms)
Funk 2010	Not complying with study type inclusion criteria (discussion about PULSE trial). No answer from the authors to request of data (on 5 July 2015)
Gerbert 2002	Not complying with control inclusion criteria (no intervention). No answer from the authors to our request of explanation about control intervention (on 12 April 2015)
Ghoncheh 2014	Not complying with study type inclusion criteria (protocol). No answer from the authors to request of data (on 12 April 2015)
Gordon 2011a	Not complying with control inclusion criteria (no intervention)
Gordon 2011b	Not complying with participants inclusion criteria (trainees)
Gordon 2013a	Not complying with participants inclusion criteria (trainees)
Gordon 2013b	Not complying with study type inclusion criteria (review)
Granpeesheh 2010	Not complying with participants inclusion criteria (trainees)
Gyorki 2013	Not complying with participants inclusion criteria (residents)
Hansen 2007	Not complying with study type inclusion criteria (no randomisation)
Harris 2013	Not complying with control inclusion criteria (no intervention)
Hearty 2013	Not complying with participants inclusion criteria (residents)
Houwink 2014	Not complying with control inclusion criteria (no intervention)
Jensen 2009	Not complying with control inclusion criteria (no intervention)
Kemper 2002	Not complying with control inclusion criteria (no intervention) (Kemper 2015 [pers comm])
Kerfoot 2010	Not complying with control inclusion criteria (no intervention)
Kerfoot 2012	Not complying with control inclusion criteria (e-learning as a control)
Khanal 2014	Not complying with intervention inclusion criteria (the intervention was not distributed by the Internet)
Kim 2014	Not complying with control inclusion criteria (no intervention)
Kobak 2005	Not complying with participants inclusion criteria (mixed residents and staff physicians). No answer from the authors to request of separated data (on 2 July 2015)
Kontio 2011	Not complying with control inclusion criteria (same intervention as in the e-learning group) (Kontio 2015 [pers comm])
Kontio 2013	Not complying with control inclusion criteria (same intervention as in the e-learning group) (Kontio 2015 [pers comm])
Kontio 2014	Not complying with control inclusion criteria (same intervention as in the e-learning group) – as in the authors email received on 17 August 2015

Study	Reason for exclusion
Legris 2011	Not complying with control inclusion criteria (no intervention) (Lalonde 2015 [pers comm])
Liaw 2015	Not complying with control inclusion criteria (no intervention) (Liaw 2016 [pers comm])
Little 2013	Not complying with control inclusion criteria (no intervention)
Liu 2014a	Not complying with control inclusion criteria (no intervention)
Liu 2014b	Not complying with control inclusion criteria (no intervention)
Lu 2009	Not complying with participants inclusion criteria (students)
Maloney 2012	Not complying with study type inclusion criteria (economic analysis)
Markova 2013	Not complying with control inclusion criteria (e-learning intervention)
Marshall 2014	Not complying with outcome inclusion criteria (satisfaction)
McCormack 2012	Not complying with participants inclusion criteria (students)
McCrow 2014	Not complying with control inclusion criteria (no intervention)
Meckfessel 2011	Not complying with participants inclusion criteria (students)
Midmer 2006	Not complying with control inclusion criteria (no intervention). No answer from the authors to request of data (on 31 May 2015)
Moja 2008	Not complying with study type inclusion criteria (protocol). Data still not available (answer from the authors to request of data on 09 January 2018)
Moorthy 2003	Not complying with participants inclusion criteria for participants (trainees)
Moreira 2015	Not complying with control inclusion criteria (no intervention)
NCT00394017	Not complying with control inclusion criteria (no intervention)
NCT00815724	Not complying with control inclusion criteria (no intervention)
NCT00934141	Not complying with participants inclusion criteria (patients)
NCT00962455	Not complying with control inclusion criteria (no intervention)
NCT01326936	Not complying with participants inclusion criteria (trainees)
NCT01427660	Not complying with participants inclusion criteria (community health workers[a])
NCT01834521	Not complying with participants inclusion criteria (patients)
NCT01955005	Not complying with participants inclusion criteria (patients)
Nesterowicz 2015	Not complying with study type inclusion criteria (no randomisation)
Paul 2013	Not complying with study type inclusion criteria (protocol) and with control inclusion criteria (no intervention)

Study	Reason for exclusion
Pearce-Smith 2005	Not complying with participants inclusion criteria (mixed clinicians and managers). No answer from the authors to request of separated data (on 25 July 2015)
Pelayo-Alvarez 2011	Not complying with control inclusion criteria (no specific training was organised for the control group) (Pelayo-Alvarez 2015 [pers comm])
Perkins 2010	Not complying with intervention inclusion criteria (intervention provided by audio recording)
Pham 2013	Not complying with control inclusion criteria (no intervention)
Pham 2016	Not complying with control inclusion criteria (no control group) (Pham 2016 [pers comm])
Platz 2010	Not complying with control inclusion criteria (no intervention)
Rafalski 2004	Not complying with study type inclusion criteria (no randomisation)
Rankin 2013	Not complying with control inclusion criteria (e-learning group as control group): although the on-line tutorial was mandatory just for intervention group participants, all but 2 (out of 67) participants in the control group chose to do the tutorial.
Ruzek 2012	Not complying with study type inclusion criteria (protocol). No answer from the authors to request of data (on 12 April 2015)
Schermer 2011	Not complying with study type inclusion criteria (no randomisation)
Schopf 2012	Not complying with control inclusion criteria (no intervention as a control in the first part and e-learning vs e-learning in the second part)
Sharma 2013	Not complying with participants inclusion criteria for participants (trainees)
Shaw 2011	Not complying with outcomes inclusion criteria (self-reported outcomes)
Simpson 2009	Not complying with study type inclusion criteria (protocol) and with control inclusion criteria (no intervention)
Smeekens 2011	Not complying with control inclusion criteria (no intervention)
Soh 2010	Not complying with participants inclusion criteria (students)
Stein 2015	Not complying with outcome inclusion criteria (patient-reported outcome)
Stewart 2005	Not complying with control inclusion criteria (no intervention)
Sung 2008	Not complying with study type inclusion criteria (no randomisation)
Thompson 2012	Not complying with participants inclusion criteria (trainees)
Tung 2014	Not complying with study type inclusion criteria (no randomisation)
Valish 1975	Not complying with intervention inclusion criteria (not delivered by Internet)
Van de Steeg 2012	Not complying with study type inclusion criteria (protocol) and with control inclusion criteria (no intervention)

Study	Reason for exclusion
Van Stiphout 2015	Not complying with control inclusion criteria (e-learning and usual approach vs usual approach alone)
Veredas 2014	Not complying with participants inclusion criteria (students)
Vidal-Pardo 2013	Not complying with control inclusion criteria (no intervention)
Viguier 2015	Not complying with control inclusion criteria (no intervention)
Wakefield 2014	Not complying with control inclusion criteria (no intervention)
Ward 2005	Not complying with study type inclusion criteria (protocol). No answer from the authors to our request of data (on 28 June 2015, email)
Weaver 2012	Not complying with control inclusion criteria (e-learning as a control)
Wehrs 2007	Not complying with study type inclusion criteria (no randomisation)
Weston 2008	Not complying with control inclusion criteria (no intervention on the same topic)
Worm 2013	Not complying with participants inclusion criteria (trainees)
Yao 2015	Not complying with control inclusion criteria (no intervention)

[a]Community health workers (CHW) are members of a community who are chosen by community members or organisations to provide basic health and medical care to their community.

Characteristics of studies awaiting assessment *[ordered by study ID]*

Vollmar 2010

Methods	
Participants	
Interventions	
Outcomes	
Notes	Not yet assessed

DATA AND ANALYSES

Comparison 1. Behaviours

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Patients appropriately screened (Fordis 2005 - screening for dyslipidaemia; Levine 2011 - LDL measurement)	2	6027	Odds Ratio (M-H, Random, 95% CI)	0.90 [0.77, 1.06]
2 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - statin prescription)	2	5491	Odds Ratio (M-H, Random, 95% CI)	1.15 [0.89, 1.48]
3 Patients appropriately screened (Fordis 2005 - screening for dyslipidaemia; Levine 2011 - HbA1c measurement)	2	3056	Odds Ratio (M-H, Random, 95% CI)	0.85 [0.69, 1.06]
4 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - beta-blocker prescription)	2	6027	Odds Ratio (M-H, Random, 95% CI)	1.12 [0.97, 1.29]
5 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - ACEI/ARB prescription)	2	6027	Odds Ratio (M-H, Random, 95% CI)	1.06 [0.94, 1.19]

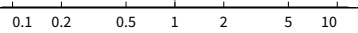
Analysis 1.1. Comparison 1 Behaviours, Outcome 1 Patients appropriately screened (Fordis 2005 - screening for dyslipidaemia; Levine 2011 - LDL measurement).

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Fordis 2005	16/17	17/19		0.41%	1.88[0.16,22.83]
Levine 2011	2711/3080	2594/2911		99.59%	0.9[0.77,1.05]
Total (95% CI)	**3097**	**2930**		**100%**	**0.9[0.77,1.06]**
Total events: 2727 (E-learning), 2611 (Traditional learning)					
Heterogeneity: Tau^2=0; Chi^2=0.34, df=1(P=0.56); I^2=0%					
Test for overall effect: Z=1.29(P=0.2)					

Favours E-learning — Favours Traditional learning

Analysis 1.2. Comparison 1 Behaviours, Outcome 2 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - statin prescription).

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Fordis 2005	15/17	16/19		1.77%	1.41[0.21,9.62]
Levine 2011	2708/2825	2506/2630		98.23%	1.15[0.88,1.48]
Total (95% CI)	**2842**	**2649**		**100%**	**1.15[0.89,1.48]**
Total events: 2723 (E-learning), 2522 (Traditional learning)					



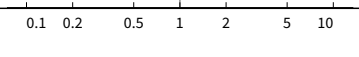
Favours E-learning — Favours Traditional learning

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Heterogeneity: Tau²=0; Chi²=0.04, df=1(P=0.84); I²=0%					
Test for overall effect: Z=1.07(P=0.29)					

Favours E-learning | Favours Traditional learning

Analysis 1.3. Comparison 1 Behaviours, Outcome 3 Patients appropriately screened (Fordis 2005 - screening for dyslipidaemia; Levine 2011 - HbA1c measurement).

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Fordis 2005	16/17	17/19		0.76%	1.88[0.16,22.83]
Levine 2011	1357/1563	1291/1457		99.24%	0.85[0.68,1.05]
Total (95% CI)	**1580**	**1476**		**100%**	**0.85[0.69,1.06]**
Total events: 1373 (E-learning), 1308 (Traditional learning)					
Heterogeneity: Tau²=0; Chi²=0.39, df=1(P=0.53); I²=0%					
Test for overall effect: Z=1.44(P=0.15)					



Favours E-learning | Favours Traditional learning

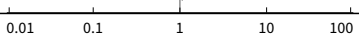
Analysis 1.4. Comparison 1 Behaviours, Outcome 4 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - beta-blocker prescription).

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Fordis 2005	15/17	16/19		0.53%	1.41[0.21,9.62]
Levine 2011	2633/3080	2446/2911		99.47%	1.12[0.97,1.29]
Total (95% CI)	**3097**	**2930**		**100%**	**1.12[0.97,1.29]**
Total events: 2648 (E-learning), 2462 (Traditional learning)					
Heterogeneity: Tau²=0; Chi²=0.05, df=1(P=0.82); I²=0%					
Test for overall effect: Z=1.59(P=0.11)					

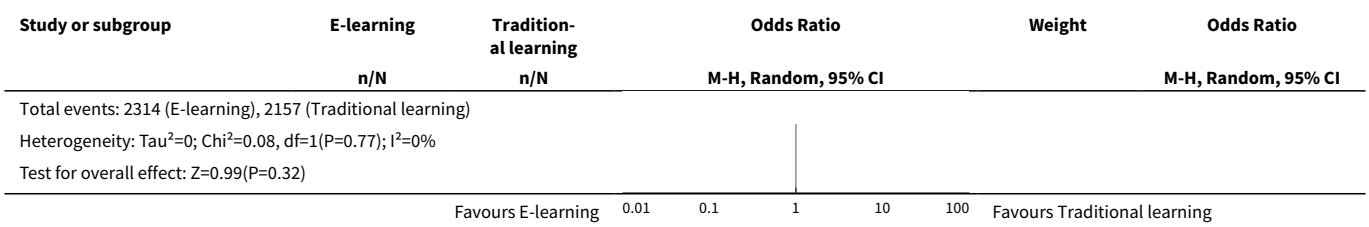
Favours E-learning | Favours Traditional learning

Analysis 1.5. Comparison 1 Behaviours, Outcome 5 Patients appropriately treated (Fordis 2005 - treatment for dyslipidaemia; Levine 2011 - ACEI/ARB prescription).

Study or subgroup	E-learning n/N	Traditional learning n/N	Odds Ratio M-H, Random, 95% CI	Weight	Odds Ratio M-H, Random, 95% CI
Fordis 2005	15/17	16/19		0.36%	1.41[0.21,9.62]
Levine 2011	2299/3080	2141/2911		99.64%	1.06[0.94,1.19]
Total (95% CI)	**3097**	**2930**		**100%**	**1.06[0.94,1.19]**



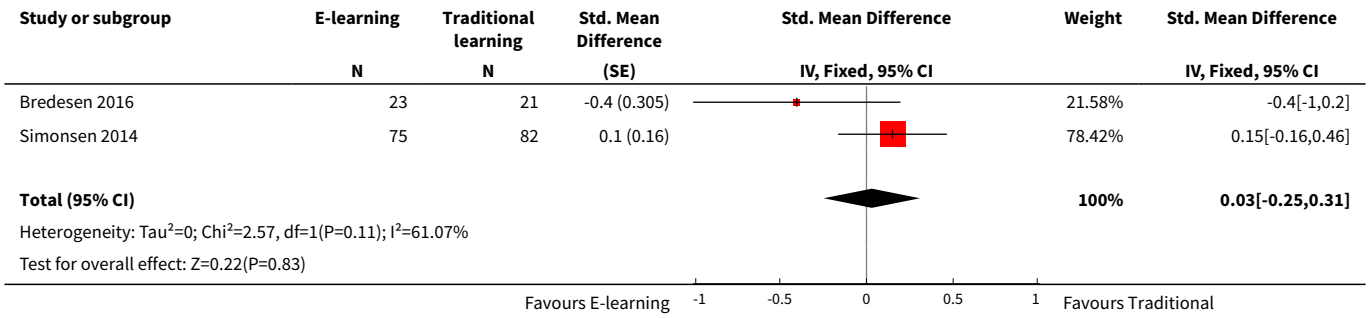
Favours E-learning | Favours Traditional learning



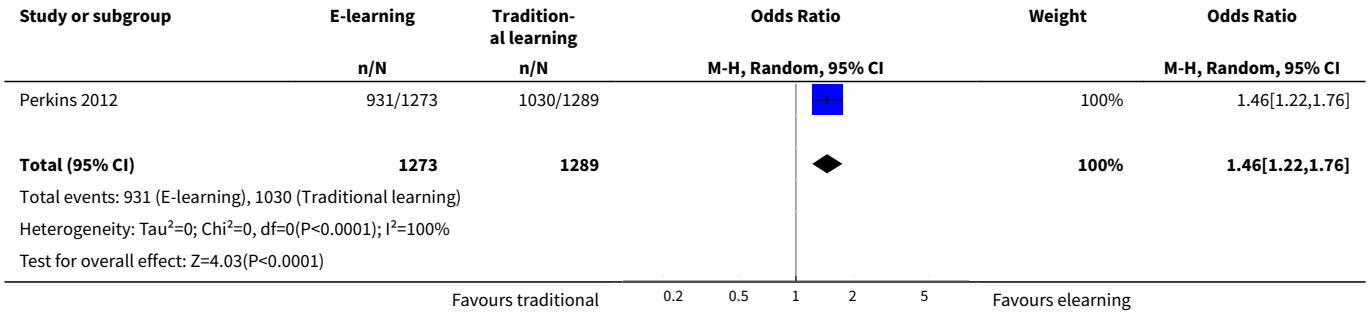
Comparison 2. Skills

Outcome or subgroup title	No. of studies	No. of partici-pants	Statistical method	Effect size
1 Drug dose calculation accuracy (Simonsen 2014); ulcer classification accuracy (Bredesen 2016)	2	201	Std. Mean Difference (Fixed, 95% CI)	0.03 [-0.25, 0.31]
2 Cardiac arrest simulation test (CASTest)	1	2562	Odds Ratio (M-H, Random, 95% CI)	1.46 [1.22, 1.76]

Analysis 2.1. Comparison 2 Skills, Outcome 1 Drug dose calculation accuracy (Simonsen 2014); ulcer classification accuracy (Bredesen 2016).



Analysis 2.2. Comparison 2 Skills, Outcome 2 Cardiac arrest simulation test (CASTest).



Comparison 3. Knowledge

1 At any time (fixed-effect)	8	3082	Std. Mean Difference (Fixed, 95% CI)	0.04 [-0.03, 0.11]
2 At any time (random-effects)	8	3082	Std. Mean Difference (Random, 95% CI)	-0.09 [-0.27, 0.09]
3 Immediately after the training	7	3012	Std. Mean Difference (Random, 95% CI)	-0.10 [-0.29, 0.08]
4 After 3 or more months	3	225	Std. Mean Difference (Random, 95% CI)	-0.07 [-0.41, 0.27]

Analysis 3.1. Comparison 3 Knowledge, Outcome 1 At any time (fixed-effect).

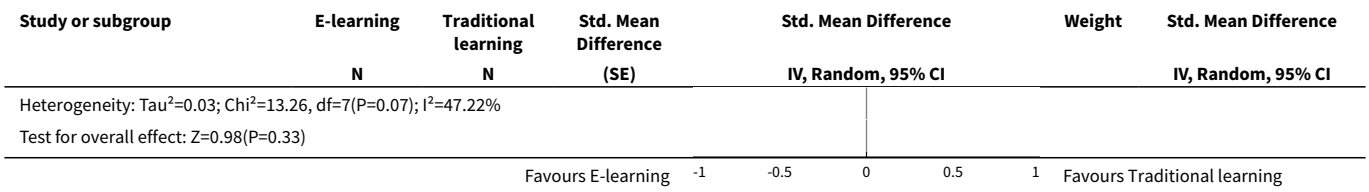
Study or subgroup	E-learning N	Traditional learning N	Std. Mean Difference (SE)	Std. Mean Difference IV, Fixed, 95% CI	Weight	Std. Mean Difference IV, Fixed, 95% CI
Benjamin 2008	17	16	-0 (0.348)		1.1%	-0.05[-0.73,0.63]
Fordis 2005	44	49	-0.4 (0.209)		3.04%	-0.37[-0.78,0.04]
Harris 2008	30	32	0.1 (0.254)		2.06%	0.07[-0.42,0.57]
Horiuchi 2009	37	33	0.2 (0.24)		2.3%	0.16[-0.31,0.63]
Hugenholtz 2008	37	35	-0.1 (0.236)		2.38%	-0.09[-0.55,0.38]
Khatony 2009	70	70	-0.2 (0.17)		4.59%	-0.23[-0.56,0.11]
Paladino 2007	24	25	-0.6 (0.293)		1.55%	-0.62[-1.2,-0.05]
Perkins 2012	1274	1289	0.1 (0.04)		82.98%	0.08[0.01,0.16]
Total (95% CI)					**100%**	**0.04[-0.03,0.11]**
Heterogeneity: Tau²=0; Chi²=13.26, df=7(P=0.07); I²=47.22%						
Test for overall effect: Z=1.12(P=0.26)						

Favours E-learning — Favours Traditional learning

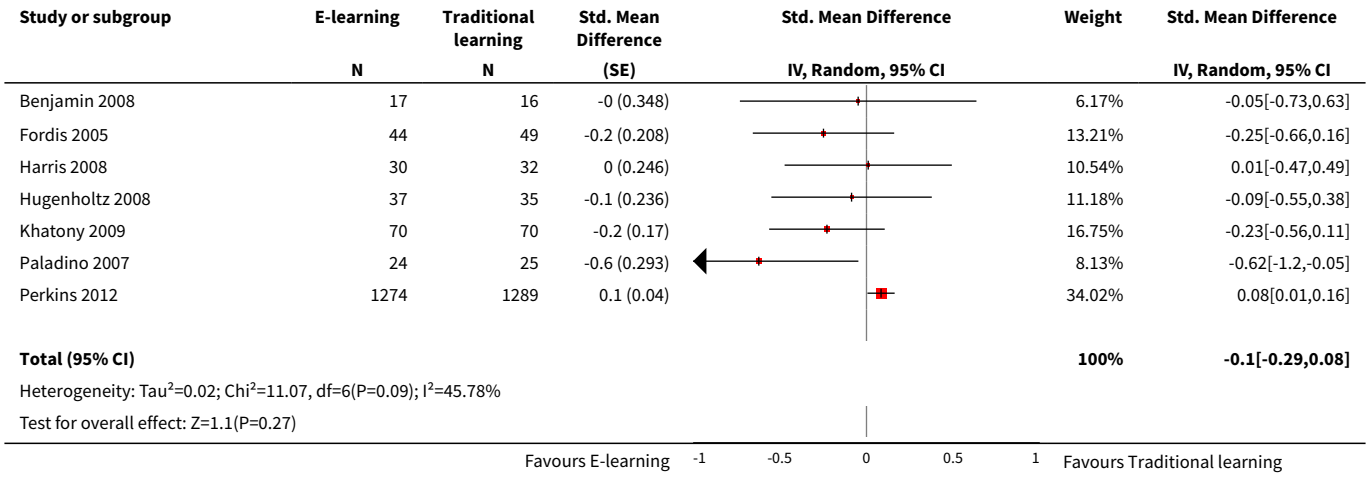
Analysis 3.2. Comparison 3 Knowledge, Outcome 2 At any time (random-effects).

Study or subgroup	E-learning N	Traditional learning N	Std. Mean Difference (SE)	Std. Mean Difference IV, Random, 95% CI	Weight	Std. Mean Difference IV, Random, 95% CI
Benjamin 2008	17	16	-0 (0.348)		5.76%	-0.05[-0.73,0.63]
Fordis 2005	44	49	-0.4 (0.209)		12.05%	-0.37[-0.78,0.04]
Harris 2008	30	32	0.1 (0.254)		9.31%	0.07[-0.42,0.57]
Horiuchi 2009	37	33	0.2 (0.24)		10.07%	0.16[-0.31,0.63]
Hugenholtz 2008	37	35	-0.1 (0.236)		10.3%	-0.09[-0.55,0.38]
Khatony 2009	70	70	-0.2 (0.17)		15.23%	-0.23[-0.56,0.11]
Paladino 2007	24	25	-0.6 (0.293)		7.55%	-0.62[-1.2,-0.05]
Perkins 2012	1274	1289	0.1 (0.04)		29.71%	0.08[0.01,0.16]
Total (95% CI)					**100%**	**-0.09[-0.27,0.09]**

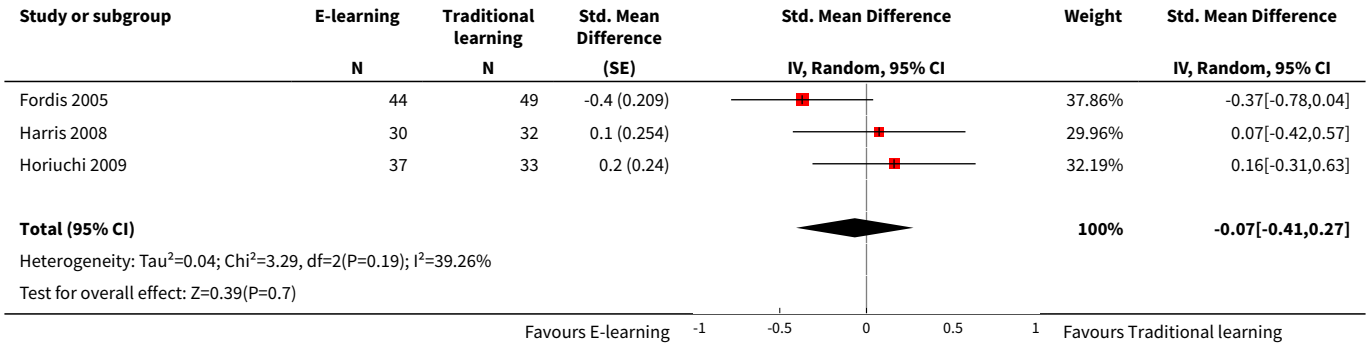
Favours E-learning — Favours Traditional learning



Analysis 3.3. Comparison 3 Knowledge, Outcome 3 Immediately after the training.



Analysis 3.4. Comparison 3 Knowledge, Outcome 4 After 3 or more months.



APPENDICES

Appendix 1. Search strategies

Medline (OVID)

Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to present

No.	Search terms	Results
1	("e-learning" or elearning).ti.	857
2	("e-learning" or elearning).ab.	1376
3	or/1-2	1662
4	*internet/ and *education/	55
5	((electronic or internet or internet-based or online or "on line" or remote or distance or mobile or web or "web 2*" or web-based or web deliver*) adj2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)).ti,ab.	7437
6	((computeri?ed or computer-assisted or computer-mediated* or computer-based) adj2 (class or classes or classroom? or class-room? or course or courses or coursework or course-work or education or inservice or in-service or instruction* or learning or seminar? or teaching or workshop?)).ti,ab.	1743
7	((e-mail* or email* or e-mail-based or email-based) adj2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)).ti,ab.	83
8	(e-education or e-instruction or elearning or "e learning" or "e train*" or "e curricul*" or "e program*" or m-learn*).ti,ab.	1792
9	(virtual adj2 (class or classes or classroom? or course? or education* or in-service or in-service or instruction* or instructor? or learning or seminar? or teacher? or teaching or training or trainer? or workshop*)).ti,ab.	1243
10	((3g or 4g or ipad or iphone or handheld or (tablet adj5 computer?) or android or cell phone or mobile phone) adj4 (educational or class)).ti,ab.	27
11	(distributed adj3 (curricul* or education or learning)).ti,ab.	298
12	spaced learning.ti,ab.	35
13	("remote course*" or "remote education" or "remote seminar?" or "remote learning" or "remote workshop*" or (remote participation adj4 (education? or workshop or course or learning))).ti,ab.	40
14	(virtual or online or web or internet).ti.	51312
15	or/4-14	59766
16	*postgraduate education/ or *continuing education/ or *in service training/ or *professional development/	3449
17	(post-graduate or graduate education or graduate degree? or ((master? or doctoral) adj2 degree?) or doctorate or doctoral or post-professional).ti,ab.	8089
18	(continuing adj2 (medical or nursing or pharmacist? or physician? or doctor? or allied health) adj3 education?).ti,ab.	5321

(Continued)

19	(inservice training or professional development or cme).ti,ab.	11093
20	or/16-19	26273
21	(15 and 20) not 3	913
22	*nurse/ or exp *paramedical personnel/ or exp *physician/ or *medical personnel/	132064
23	(continuing adj2 education?).ti,ab,hw.	62702
24	(and/15,22-23) not (or/3,21)	77
25	*dental education/ or *medical education/ or *nursing education/	68626
26	25 not (undergraduate? or first year or second year or third year or preclinical or pre-clinical).ti,ab,hw.	63971
27	(26 and 15) not (or/3,21,24)	1166
28	controlled clinical trial/ or controlled study/ or randomized controlled trial/	510348
29	randomi?ed.ti. or ((random* or control) adj3 (group? or cohort? or patient? or hospital* or department?)).ab. or (controlled adj2 (study or trial)).ti.	641737
30	(multicenter and (study or trial)).ti.	20362
31	(random sampl* or random digit* or random effect* or random survey or random regression).ti,ab. not randomized controlled trial/	62344
32	(exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/) and (human/ or normal human/ or human cell/)	16144262
33	(exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/) not 32	4275233
34	(or/28-30) not (or/31,33)	841718
35	3 and 34	176
36	21 and 34	58
37	24 and 34	9
38	27 and 34	54
39	or/35-38	297

Embase (OVID)

Embase 1974 to 2016 July 07

No.	Search terms	Results
1	("e-learning" or elearning).ti.	1157
2	("e-learning" or elearning).ab.	2220
3	or/1-2	2597
4	computer-assisted instruction/	62027
5	((electronic or internet or internet-based or online or "on line" or remote or distance or mobile or web or "web 2*" or web-based or web deliver*) adj2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)).ti,ab.	9126
6	((computeri?ed or computer-assisted or computer-mediated* or computer-based) adj2 (class or classes or classroom? or class-room? or course or courses or coursework or course-work or education or inservice or in-service or instruction* or learning or seminar? or teaching or workshop?)).ti,ab.	2086
7	((e-mail* or email* or e-mail-based or email-based) adj2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)).ti,ab.	156
8	(e-education or e-instruction or elearning or "e learning" or "e train*" or "e curricul*" or "e program*" or m-learn*).ti,ab.	2778
9	(virtual adj2 (class or classes or classroom? or course? or education* or in-service or in-service or instruction* or instructor? or learning or seminar? or teacher? or teaching or training or trainer? or workshop*)).ti,ab.	1632
10	((3g or 4g or ipad or iphone or handheld or (tablet adj5 computer?) or android or cell phone or mobile phone) adj4 (educational or class)).ti,ab.	45
11	(distributed adj3 (curricul* or education or learning)).ti,ab.	352
12	spaced learning.ti,ab.	46
13	("remote course*" or "remote education" or "remote seminar?" or "remote learning" or "remote workshop*" or (remote participation adj4 (education? or workshop or course or learning))).ti,ab.	55
14	(virtual or online or web or internet).ti.	59771
15	or/4-14	128433
16	education, medical, continuing/ or education, medical, graduate/ or exp "internship and residency"/ or education, nursing, continuing/ or education, nursing, graduate/ or education, pharmacy, continuing/ or education, pharmacy, graduate/ or pharmacy residencies/ or inservice training/ or staff development/	660488
17	(post-graduate or graduate education or graduate degree? or ((master? or doctoral) adj2 degree?) or doctorate or doctoral or post-professional).ti,ab.	10031

(Continued)

18	(continuing adj2 (medical or nursing or pharmacist? or physician? or doctor? or allied health) adj3 education?).ti,ab.	6614
19	(inservice training or professional development or cme).ti,ab.	15275
20	or/16-19	674033
21	(15 and 20) not 3	49387
22	exp allied health personnel/ or exp *dentists/ or exp medical staff/ or exp nurses/ or pharmacists/ or exp physicians/	907485
23	(continuing adj2 education?).ti,ab,hw.	43200
24	(and/15,22-23) not (or/3,21)	176
25	education, dental/ or education, medical/ or education, nursing/ or education, pharmacy/	537908
26	25 not (undergraduate? or first year or second year or third year or preclinical or pre-clinical).ti,ab,hw.	514219
27	(26 and 15) not (or/3,21,24)	27
28	(randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or clinical trials as topic.sh. or randomly.ab. or trial.ti.	981031
29	exp animals/ not humans.sh.	21860327
30	28 not 29	92471
31	(3 or 21 or 24 or 27) and 30	232

The Cochrane Library (Wiley)

No.	Search terms	Results
#1	("e-learning" or elearning):ti	117
#2	("e-learning" or elearning):ab	188
#3	{or #1-#2}	216
#4	[mh "computer-assisted instruction"]	1039
#5	((electronic or internet or internet-based or online or "on line" or remote or distance or mobile or web or "web 2*" or web-based or web deliver*) near/2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)):ti,ab	656
#6	((computeri?ed or computer-assisted or computer-mediated* or computer-based) near/2 (class or classes or classroom? or class-room? or course or	276

(Continued)

	courses or coursework or course-work or education or inservice or in-service or instruction* or learning or seminar? or teaching or workshop?)):ti,ab	
#7	((e-mail* or email* or e-mail-based or email-based) near/2 (class or classes or classroom? or class-room? or course or courses or course-work or education* or inservice or in-service or instruction* or learning or seminar? or teaching or workshop? or work-shop?)):ti,ab	25
#8	(e-education or e-instruction or elearning or "e learning" or "e train*" or "e curricul*" or "e program*" or m-learn*):ti,ab	275
#9	(virtual near/2 (class or classes or classroom? or course? or education* or in-service or in-service or instruction* or instructor? or learning or seminar? or teacher? or teaching or training or trainer? or workshop*)):ti,ab	174
#10	((3g or 4g or ipad or iphone or handheld or (tablet near/5 computer?) or android or cell phone or mobile phone) near/4 (educational or class)):ti,ab	4
#11	(distributed near/3 (curricul* or education or learning)):ti,ab	15
#12	spaced learning:ti,ab	52
#13	("remote course*" or "remote education" or "remote seminar?" or "remote learning" or "remote workshop*" or (remote participation near/4 (education? or workshop or course or learning))):ti,ab	3
#14	(virtual or online or web or internet):ti	5035
#15	{or #4-#14}	6458
#16	[mh "education, medical, continuing"] or [mh "education, medical, graduate"] or [mh "internship and residency"] or [mh "education, nursing, continuing"] or [mh "education, nursing, graduate"] or [mh "education, pharmacy, continuing"] or [mh "education, pharmacy, graduate"] or [mh "pharmacy residencies"] or [mh "inservice training"] or [mh "staff development"]	2528
#17	(post-graduate or graduate education or graduate degree? or ((master? or doctoral) near/2 degree?) or doctorate or doctoral or post-professional):ti,ab	225
#18	(continuing near/2 (medical or nursing or pharmacist? or physician? or doctor? or allied health) near/3 education?):ti,ab	2
#19	(inservice training or professional development or cme):ti,ab	730
#20	{or #16-#19}	3340
#21	(#15 and #20)	339
#22	[mh "allied health personnel"] or [mh *dentists] or [mh "medical staff"] or [mh nurses] or [mh pharmacists] or [mh physicians]	4047
#23	(continuing near/2 education?):ti,ab,kw	2
#24	#15 and #22 and #23	0
#25	[mh "education, dental"] or [mh "education, medical"] or [mh "education, nursing"] or [mh "education, pharmacy"]	3454

(Continued)

#26	#25 not (undergraduate? or first year or second year or third year or preclinical or pre-clinical):ti,ab,kw	2873
#27	#26 and #15	456
#28	#3 or #21 or #24 or #27	720

FEEDBACK

Serious concerns regarding the conduct of this review, 28 May 2018

Summary

The following is a summary of the comments from Dr Penny Whiting and Assoc. Prof Josip Car.

We have serious concerns regarding the conduct of this review for the following reasons:

1. We are aware of eligible studies that are not included in the review (a list was provided by the commenters)

2. Key databases were not searched (e.g. ERIC)

3. No attempts were made to locate unpublished studies

4. There is ambiguity in inclusion criteria – they could be open to manipulation

5. eLearning term definition lacks clarity making it difficult to apply

6. There is lack of clarity in review question

7. The review was restricted to studies that used traditional learning as the comparison. Other comparisons e.g. to other types of eLearning, or blended learning are equally important

8. Insufficient study details are available, especially regarding interventions

9. Methods to pool data are not appropriate (use of fixed effect model when substantial differences between studies); it is questionable whether pooling is appropriate

10. Differences between studies are not adequately considered

11. Interpretation of data should consider the role of eLearning

The commenters also conducted and shared a more detailed assessment of the review using the ROBIS tool and MECIR criteria. This was sent to the review authors who used it to inform and supplement their response to the main points (listed below).

Reply

Reply from Dr Lorenzo Moja on behalf of all authors.

First of all, we would like to thank Whiting and Car for their in-depth analysis and comments on our review, which we will help improve its relevance and quality for future updates. We provide a point by point response to the points raised in their submitted comments. In addition, we have read their expanded comments including the list of potentially eligible studies.

1. We are aware of eligible studies that are not included in the review (list provided)

The research strategy was designed and developed in agreement with the EPOC Group. It is the result of careful work that included several terms that characterise experimental studies on e-learning. The search strategy was tested and calibrated to achieve comprehensiveness of coverage, while maintaining a certain degree of precision. It is possible that the strategy refinements reduced its exhaustiveness. Moreover, the search strategy was developed to select only a specific population (i.e. licensed health professionals) and comparator (i.e. traditional learning) of a broader intervention type. These elements may have made the research strategy less sensitive.

Whiting et al. suggested that we excluded trials in our review that should have been included. They highlight seven trials, which they cite as includable in accordance with our protocol (Vaona A, Rigon G, Banzi R, Kwag KH, Cereda D, Pecoraro V, Moja L, Bonovas

S. E-learning for health professionals (Protocol). Cochrane Database of Systematic Reviews 2015, Issue 6. Art. No.: CD011736. DOI: 10.1002/14651858.CD011736).

With regards to the studies raised by Whiting and Car, we discuss each study, providing our reasons for exclusion. The studies are presented in alphabetical order.

Bell D S, Fonarow G C, Hays R D, Mangione C M. Self-study from web-based and printed guideline materials. A randomized, controlled trial among resident physicians. Annals of internal medicine 2000;132:938-46.

We identified and excluded this study. Participants were 162 residents. Studies in which participants are residents were excluded. As this is clear from the title, this study is reported among excluded studies in the PRISMA flow diagram.

Estrada Carlos A, Safford Monika M, Salanitro Amanda H, Houston Thomas K, Curry William, Williams Jessica H, et al. A web-based diabetes intervention for physician: a cluster-randomized effectiveness trial. International journal for quality in health care: journal of the International Society for Quality in Health Care / ISQua 2011;23:682-9.

We identified and excluded this study. E-learning was part of a multi-component intervention, which also encompassed audit and feedback, an intervention supported by evidence of effectiveness per se. When e-learning was merely added to a multifaceted intervention that could easily be offered in its absence (e.g. audit and feedback interventions), we considered the intervention as 'not core', and excluded the study; this study is reported in the excluded studies section.

Hemmati Nima, Omrani Soghra, Hemmati Naser. A Comparison of Internet-Based Learning and Traditional Classroom Lecture to Learn CPR for Continuing Medical Education. Turkish Online Journal of Distance Education 2013;14:256-65.

We did not identify this study. This study might meet our inclusion criteria. However, as the report of the study describes it as quasi-experimental, it cannot be included before authors confirm that the allocation followed a true randomisation process.

Franchi C, Tettamanti M, Djade C D, Pasina L, Mannucci P M, Onder G, et al. E-learning in order to improve drug prescription for hospitalized older patients: a cluster-randomized controlled study. British Journal of Clinical Pharmacology 2016;82(1):53-63.

We identified and excluded this study. E-learning was used both in the trial intervention and control arms. As such, the study was excluded. In our review, this study is reported in the excluded studies section.

Girgis Afaf, Cockburn Jill, Butow Phyllis, Bowman Deborah, Schofield Penelope, Stojanovski Elizabeth, et al. Improving patient emotional functioning and psychological morbidity: evaluation of a consultation skills training program for oncologists. Patient education and counselling 2009;77:456-62.

This study was not identified by our search strategy. Participants assigned to the control group did not receive any educational intervention. As our inclusion criteria specified trials in which the eligible comparators were educational interventions on the same topic without access to e-learning, we would have excluded this study.

Kerfoot B Price, Turchin Alexander, Breydo Eugene, Gagnon David, Conlin Paul R. An online spaced-education game among clinicians improves their patients' time to blood pressure control: a randomized controlled trial. Circulation. Cardiovascular quality and outcomes 2014;7:468-74.

We identified and excluded this study (list of excluded studies). Two reviewers agreed to exclude the study based on the abstract, which stated that the control arm participants also received an e-learning intervention.

Legare France, Labrecque Michel, Cauchon Michel, Castel Josette, Turcotte Stephane, Grimshaw Jeremy. Training family physicians in shared decision-making to reduce the overuse of antibiotics in acute respiratory infections: a cluster randomized trial. CMAJ: Canadian Medical Association journal 2012;184:E726-34.

This study was not identified by our search strategy. However, participants assigned to the control group did not receive any educational intervention. Moreover, half of the participants were residents.

We have demonstrated that our study selection was not flawed and that inclusion/exclusion was undertaken with sufficient scientific justification. We also provide clear reasons for exclusion to reduce opportunities for potential ambiguities in the eligible criteria.

2 & 3. Key databases were not searched (e.g. ERIC); No attempts to locate unpublished studies.

MECIR divides standards in mandatory and highly desirable. Searching specialist bibliographic databases, for instance, is highly desirable. We have demonstrated that our review did not have any serious methodological flaws in terms of the methods used to identify and/or select studies. However, we acknowledge the value of the ERIC database. Our information scientist has commented "As noted, 6 of these 7 studies are in Medline. The other study is not indexed in any of the sources that were searched, however it is indexed in ERIC, which has been suggested as a subject specific database to search for this review. ERIC will be added as a complementary source to the databases that were already considered in our search strategy. The studies we did not identify will be useful in creating future iterations of the search strategy.

From the detailed comments the commenters say "There are several instances in the search strategy where "not" does not appear to have been appropriately used leading to potentially missed studies". Our information scientist has reviewed the search strategy and cannot identify any instances where the use of "not" in the searches would have inappropriately restricted the results.

Our literature search was comprehensive, but did not include specific efforts to identify unpublished studies. Although it is possible that a certain amount of unpublished studies could be retrieved, we reasoned a priori that large efforts would not be particularly fruitful in this area. Publication bias, such that positive studies have a much larger chance of being published, might not be generalizable to scientific literature focused on medical education.

We made reasonable efforts to recover incomplete or unpublished data. In cases of uncertainty regarding study designs, we contacted the authors of original RCTs to obtain additional information before considering any study for inclusion or exclusion. All emails are reported in the references section. These correspondences were an additional effort to the thorough online search we conducted, because we wanted to make sure that we were inclusive.

The search end date is July 2016. We acknowledge that searches for all relevant databases should be updated within 12 months before publication of the review. An update of the review is ongoing.

We could not find differences between the hits given in the Medline search strategy and the number reported in the flow diagram.

From the detailed comments the commenters say "Is EPOC methodology filter appropriate in addition to RCT filter?" The EPOC information scientist commented "The inclusion criteria is for randomised trials only hence only a study design filter for randomised trials being used in the search. The search methods in the review have now been amended to reflect this."

4, 5, 6 & 7. Ambiguity in inclusion criteria – open to manipulation; eLearning term definition lacks clarity making it difficult to apply; lack of clarity in review question; The review was restricted to studies that used traditional learning as the comparison. Other comparisons e.g. to other types of eLearning, or blended learning are equally important

We do not find our review ambiguous or feel it has been open to manipulation; we reported the inclusion criteria transparently for all readers to access. However, we will consider providing more operationalization details in an update, particularly when we refer to the inclusion of only interventions in which e-learning is a core or essential element. We stated: "in multifaceted educational interventions (e.g. those applying two or more interventions to change health professionals' practice), the e-learning component may have different degrees of centrality. Thus, we categorised studies into three groups: 1. e-learning alone; 2. e-learning as a core, essential component of a multifaceted intervention; 3. e-learning as a component of a multifaceted intervention, but not considered as core and essential." For example, it would add clarity to report that: a) we considered e-learning as core and essential when authors specified the levels of exposure of participants to the e-learning and other interventions, and b) exposure to e-learning was greater as compared to other interventions.

Our inclusion and exclusion criteria as well as our definition of e-learning were thoroughly discussed with internal and external peer-reviewers. As the commenters observe, there is currently no standardized definition of e-learning. We preferred to adopt a wide and pragmatic definition. We are happy to compare our definition with others, particularly if changes in the definition can alter the cumulative evidence of our review.

Our question compares e-learning to traditional learning. We considered that this is the most important question to be answered, as the compared interventions are at the opposite of a spectrum of educational interventions. We decided to include only interventions in which e-learning is considered a core and essential component of the intervention. In doing so, we did decide to privilege simpler mono-component e-learning intervention over complex multi-component interventions. We acknowledge that blended interventions are popular and may be of interest to several readers. However, if a difference exists, this will likely emerge only by comparing very diverse interventions. We agree with the commenters that, given the advantages of e-learning over standard learning in some dimensions (e.g. feasibility), assessing equivalence might be appropriate. However, Cochrane reviews, including their reporting, are standardized around superiority.

We have no interest in manipulating the inclusion/exclusion of single studies, as we have no preconceived preference, or any interest, in one form of learning being superior to the other.

mLearning (mobile learning) could currently be included as "the learners may have had access to interventions through a variety of technologies (e.g. computers, personal digital assistant (PDA), smart phones, etc.)" and no exclusion was made on the basis of the device used to learn.

We believe that medical topics are the most relevant to assess clinical relevance, and to support knowledge and decision making driven by e-learning. Medical topics are not exclusive to physicians, but are the core curricula elements of other health care professionals. For this reason, we excluded non-medical topics, as they would have increased the heterogeneity without providing added relevance. Examples of non-medical topics are hospital business administration, workplace safety, and using PubMed tutorials. We regarded the differentiation between non-medical and medical topics to be intuitive.

Finally, we considered guideline availability or dissemination as a form of traditional learning. These types of controls were accordingly considered as includable.

8. Insufficient study details available, especially regarding interventions

We collected detailed information about the interventions. Our initial tables were, in fact, more detailed to the point of being judged cumbersome. Within the editorial process, we had to compromise between succinct and more readable versus longer and more comprehensive descriptions. We agreed with the suggestion of editors and reviewers to limit the length of the Characteristics of included studies.

The "other risk of bias" is related to the "conflict of interest," and this additional dimension is presented in the Risk of Bias tables.

9. Methods to pool data not appropriate (use of fixed effect model when substantial differences between studies), questionable whether pooling appropriate

We followed a sound methodology for estimating the effect size across studies. We did not present a fixed effects model only but have presented in the text random effects for our primary outcome (i.e. behaviors), and we acknowledged both fixed and random effects models for an a priori secondary outcome (i.e. knowledge), allowing the reader to compare the results of different meta-analytic models.

We deemed appropriate the use of a fixed effect for the knowledge outcome analysis. Eight studies (3082 participants) were meta-analysed. We faced an unusual situation of the analysis being dominated by a single large trial (2563 participants; SMD 0.08, 95% CI 0.01 to 0.16) at low risk of bias in slight favor of traditional learning. All other studies were small and at high risk of bias. Overall, the observed heterogeneity was moderate (I^2=47%). Our decision to preference the fixed effect model was based on the following considerations: i) our inclusion and exclusion criteria are narrow, so we are confident the studies we selected are sufficiently similar; ii) evaluation of risk of bias is a pillar of Cochrane systematic reviews; if studies are at different risks of bias, studies at low risk of bias should be preferred; and iii) the choice between a fixed-effect and a random-effects meta-analysis should never be made on the basis of a statistical test for heterogeneity. In the random effects model, the weight of Perkins falls from 83% to 29.7%. The small studies gain between 100% to 300% informative power.

Initially, the review reported the results of both fixed and random effect models. However, the results of analyses, and their general interpretations, were not dissimilar. The difference between e-learning and traditional learning is minimal under both models (fixed effect SMD 0.04, 95% CI -0.03 to 0.11; random-effects SMD -0.09, 95% CI -0.27 to 0.09). One of the reviewers noted "ultimately the conclusion remains largely the same: that overall they [the authors] did not detect a difference between e-learning and non-e-learning". The certainty of the evidence was rated as low.

It is worth noting that Higgins and Spiegelhalter discussed a very similar meta-analytic scenario in 2002 – one large trial and several small trials – and the opportunity to use the fixed effects and random effects models (Higgins JP, Spiegelhalter DJ. Being sceptical about meta-analyses: a Bayesian perspective on magnesium trials in myocardial infarction. Int J Epidemiol. 2002;31(1):96-104). The dispute about the superiority of one model to the other was unsolvable, with reasons in both sides.

10. Differences between studies not adequately considered

The vast majority of meta-analyses attempt to cumulate study results even when these are precarious and stretched in the face of large heterogeneity. The most cited meta-analysis on e-learning included and cumulated quasi-experimental designs, such as uncontrolled before-and-after designs (more than half in the Internet-based learning vs no intervention comparison), and experimental studies (Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM. Internet-based learning in the health professions: a meta-analysis. JAMA. 2008;300 (10):1181-1196). *In our meta-analyses, the conceptual, methodological and statistical heterogeneities are more limited. For instance, all included studies adopt the same design, i.e. RCT. Since we adopted strict inclusion criteria, characteristics of studies are similar. Nevertheless, our meta-analyses are bound to have studies that slightly differ with reference to PICO dimensions, e.g. outcomes might be measured at different time points. Unfortunately, the small number of studies included limited our ability to investigate heterogeneity using various sub-group analyses and meta-regressions, shedding light on what can be an effect modifier of study effect.*

11. Interpretation of data should consider role of eLearning

We think that the comment makes an important point: our review includes only RCTs, and the objective is to contrast e-learning versus traditional learning. Any difference between the intervention and control arms can be assumed to be caused by e-learning. When the sample is sufficiently large to exclude important differences, e-learning and traditional learning could be assumed to provide similar benefits. Whiting and Car correctly pointed out that "I would have thought that eLearning being as effective as traditional learning would be what needs to be shown for eLearning to be recommended given the other benefits of eLearning". The reporting of EPOC reviews is standardized, so we had to use the language as per EPOC recommendations (Cochrane Effective Practice and Organisation of Care (EPOC). Reporting the effects of an intervention in EPOC reviews. EPOC Resources for review authors, 2018. Available at: http://epoc.cochrane.org/epocspecific-resources-review-authors). T*he standardized EPOC language has been developed where it is hypothesized that an experimental treatment is superior to a comparison treatment. The same semantic penalizes attempts to determine if the effects of two interventions are not clinically and statistically different from each other. We hope that standardized EPOC language will be revised encompassing cases in which 'therapeutic' equivalence can be hypothesized and discussed. We finally remark that potential advantages of e-learning in dimensions other than those considered by the review, despite not being formally analyzed, are addressed in the introduction and discussion sections.*

Contributors

Dr Penny Whiting (comment author), University of Bristol.

Assoc. Prof Josip Car (comment author), affiliated to Centre for Population Health Sciences, LKC Medicine, NTU Singapore and Global eHealth Unit, Department of Primary Care and Public Health, School of Public Health, Imperial College London, which conduct eLearning research and hold (non-industry) grants to support this work.

Lorenzo Moja (review author)

Paul Miller (EPOC information specialist)

Martin Eccles (EPOC feedback editor)

WHAT'S NEW

Date	Event	Description
7 August 2018	Feedback has been incorporated	Minor amendment to incorporate feedback received 28-May-2018 and the review authors responses. Minor amendment also to the text of the Electronic searches to clarify the methods used.

HISTORY

Protocol first published: Issue 6, 2015
Review first published: Issue 1, 2018

Date	Event	Description
25 April 2018	Amended	Post publication, a study was identified as potentially relevant to the review. This study has been added to 'Studies awaiting classification'.
18 November 2009	Amended	Title change from *E-learning for improving professional practice and patient outcomes* to *E-learning for postgraduate health professionals. W*e restricted the population of interest. This review shares the section dedicated to methods with another systematic review protocol focusing on *E-learning for undergraduate health professionals*.
25 June 2008	Amended	Title change from *E-learning for improving professional practice and patient outcomes* to *E-learning for undergraduate and postgraduate health professionals.*

CONTRIBUTIONS OF AUTHORS

Conception of the study	Cochrane Review Group
Design	LM, RB, DC
Coordinator of the working group and Contact Author	AV
Draft the protocol	AV, LM, RB, VP
Develop and run the search strategy	Trial Search Coordinator

Obtain copies of studies	AV
Revise each draft (text-references ...)	AV
Revise the references and tables	GR, AV
Enter data into RevMan 5 (text)	AV, IT
Enter data into RevMan 5 (references)	AV, IT
Preparation of data sheet for data studies	AV, RB
Select which studies to include	AV, RB, VP, GR, KK, DC
Extract data from studies	AV, RB, VP
Enter data into data sheet	AV, RB, DC
Carry out the analysis	AV, IT, LM
Interpret the analysis	AV, IT, LM
Draft the final review	AV, IT, LM, RB
Update the review	All the authors

DECLARATIONS OF INTEREST

AV: none known.

RB: none known.

KK: none known.

GR: none known.

DC: none known.

VP: none known.

IT: none known.

LM: none known.

SOURCES OF SUPPORT

Internal sources

- EPOC Cochrane Review Group - Editorial base, The Centre for Practice Changing Research, Ottawa Hospital Research Institute (OHRI), Ottawa, Canada.

External sources

- No external source of support, Other.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We changed the protocol title 'E-learning for post-graduate health professionals' into 'E-learning for health professionals' as in many countries health professionals include postgraduate trainees (e.g. residents and fellows), and many trainees are fully licensed. The protocol title might therefore have generated confusion on the target population.

In terms of search strategies, we did not:

- screen individual journals and conference proceedings (e.g. handsearch);
- contact researchers with expertise relevant to the review topic or EPOC interventions (EPOC 2002);
- conduct cited reference searches for all included studies in citations indexes.

We decided to aggregate studies at unclear risk of bias with those at high risk of bias in the sensitivity analysis. We adopted a conservative approach, assuming that the absence of information indicated inadequate quality ('guilty until proven innocent').

Measures of treatment effect: we replaced change scores as the main outcome measures with final scores because we believed that randomisation would adequately prevent differences between experimental and control group baseline scores.

In the protocol we stated, "We took contextual heterogeneity into account and conducted the analyses in subgroups including studies with similar clinical and methodological characteristics: designs, settings, interventions, comparators, outcome scales, effect sizes". This was a misprint, as the sentence was part of a previous draft written when we were still considering also including non-randomised studies.

Changes in the authorship of this Cochrane Review: Irene Tramacere replaced Stefanos Bonovas as statistician.

We decided to perform subgroup analyses if at least 10 observations were available for each characteristic modelled (Higgins 2011a).

INDEX TERMS

Medical Subject Headings (MeSH)

*Internet; Clinical Competence; Education, Distance [*methods]; Health Personnel [*education] [statistics & numerical data]; Randomized Controlled Trials as Topic

MeSH check words

Humans

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COMMENT #14
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BMC Medical Education

RESEARCH ARTICLE Open Access

Effectiveness of distance learning strategies for continuing professional development (CPD) for rural allied health practitioners: a systematic review

Angela Berndt* Carolyn M. Murray, Kate Kennedy, Mandy J. Stanley and Susan Gilbert-Hunt

Abstract

Background: Allied health professionals working in rural areas face unique challenges, often with limited access to resources. Accessing continuing professional development is one of those challenges and is related to retention of workforce. Effectiveness of distance learning strategies for continuing professional development in rural allied healthcare workers has not been evaluated.

Methods: We searched 17 databases and the grey literature up to September 2016 following the PRISMA guidelines. Any primary studies were included that focussed on allied health and distance delivery regardless of education topic or study design. Two independent reviewers extracted data and critically appraised the selected studies.

Results: The search returned 5257 results. With removal of duplicate references, we reviewed 3964 article titles and abstracts; *n* = 206 appeared potentially eligible and were scrutinised via full text screening; *n* = 14 were included. Studies were published between 1997 and 2016, were of varied methodological quality and were predominantly from Australia, USA and Canada with a focus on satisfaction of learners with the delivery method or on measures of educational outcomes. Technologies used to deliver distance education included video conference, teleconference, web based platforms and virtual reality. Early papers tended to focus more on the technology characteristics than educational outcomes. Some studies compared technology based delivery to face to face modes and found satisfaction and learning outcomes to be on par. Only three studies reported on practice change following the educational intervention and, despite a suggestion there is a link between the constructs, none measured the relationship between access to continuing professional development and workforce retention.

Conclusion: Technology based options of delivery have a high utility, however the complex inter-relatedness of time, use, travel, location, costs, interactivity, learning outcomes and educational design suggest a need for more sophisticated consideration by educational providers.

Trial registration: Registration with PROSPERO 30 June 2016: CRD42016041588.

Keywords: Continuing professional development, Allied health professionals, Distance education, Rural health workforce, Education technology

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Background

The context of working in rural allied health is unique. Rural allied health practitioners (AHP) are confronted with a broad range of challenges in daily practice requiring an extensive general skill-base to cope with the diversity and demands of clients, often in an environment where resources are scarce and there are minimal support structures [1–6]. In addition, delivery methods for health services are constantly changing, requiring AHP to be adaptable and responsive to new demands placed upon them. A recent example of changes to health services is the introduction of the National Disability Insurance Scheme (NDIS) in Australia. The NDIS is expected to generate a responsive, person centred service which enables people with disability to choose when and how they receive support from health professionals [7]. In the new scheme, rural AHP may be required to assess individual's needs that previously may not have been part of their practice experience, leading to an even greater need for training and continuing professional development (CPD) opportunities in this group.

CPD is offered by employers or other providers and taken up by AHP to enhance knowledge, skills competence and performance in order to improve patient and client outcomes [8]. CPD is typically offered via educational meetings that are either interactive or didactic and usually utilise printed educational materials or other resources as a component of the intervention [8]. Educational meetings are defined as conferences, lectures, workshops, seminars, symposia and courses with evidence suggesting that mixed interactive and didactic education is more effective than either alone [8]. Lack of access to CPD is known to be problematic for rural AHP [9, 10]. In particular, rural AHP cite additional costs of travel to attend CPD [11], expensive registrations [12] and not being provided with a car or time to travel [9].

Attracting and then retaining a rural AHP work force is itself a challenge [11, 13] with reasons cited including the requirement to be generalist AHP and the need to be both administrators and health service providers [9]. Different methods have been considered for provision of CPD to rural AHP [14] to support recruitment and retention [15]. In particular, transdisciplinary and interdisciplinary approaches have been promoted as there may only be one person from each discipline in rural centres and these approaches allow the exchange of ideas, skills and information amongst the team [16, 17]. CPD provided by distance education is another response to overcome the barriers associated with travel distance and cost.

The availability of distance education, subsidised CPD and use of technology to deliver education or training to rural Australia was thought to allow cost-effective and equitable access to CPD for rural AHP [5, 18, 19]. However, other research suggested that methods utilising technologies for delivery of CPD, while helpful in enabling AHP to learn locally, may not fully meet their needs [4] as they needed 'time out' to learn [10] and it could not replace face-to-face contact [11]. Therefore, while email, video-conferencing and internet-based programs have some place in CPD for AHP, they may not allow full interaction and collaborative learning between the educator and AHP. These limitations of distance education may account for limited uptake in the past [4] and current variability amongst rural AHP [20].

Due to the uniqueness of the experiences and the demands placed on rural AHP, more needs to be known about what technological and learning strategies are most beneficial for supporting the CPD of AHP working in rural settings. For this reason, we undertook a systematic review with the aim of evaluating the effectiveness of distance learning strategies to provide CPD to rural AHP. There are two aspects to this review question; what distance learning strategies are currently used to provide CPD for rural AHP and; how effective are these strategies in improving rural AHP outcomes. Outcomes of interest were practitioner knowledge change; practitioner confidence change; practice change; and practitioner satisfaction with the CPD distance learning model used.

Methods

The systematic review of the effectiveness of distance learning strategies for rural AHP followed the PRISMA statement guidelines [21], and the search protocol was prospectively registered with PROSPERO (registration number CRD42016041588, 30 June 2016). The following databases were searched: Informit health collection; Medline; AMED; Academic Search Premier; Australian and New Zealand Reference Centre; CINAHL; Health Source: Nursing/academic edition; Cochrane library; Scopus; Web of Science; Google Scholar; ERIC; SAGE Health sciences; ProQuest nursing and allied health source; OT Seeker; PEDro. A grey literature search was conducted of the following websites: The Australian Institute of Health and Welfare; Australian College of Rural and Remote Medicine; Australian Rural Health Education Network; Allied Health Professions Australia; CRANAPlus; Health Consumers of Rural and Remote Australia; Health Workforce Australia; National Rural Health Alliance; Rural Health Workforce Australia; Services for Australian Rural and Remote Allied Health. See Appendix for the full search terms as used in the Medline search. These terms were adjusted as necessary to suit each database searched.

For the purpose of this review, AHP were defined as speech and language therapists, nutritionists, dieticians, occupational therapists, physiotherapists, physiotherapy assistants, pharmacist aides, social workers or psychologists. This list of AHP was gleaned from the Australian Government Department of Health website [22]. Included articles

must have over 50% AHP or must report results for AHP separately to other health professionals. Continuing medical education designed for physicians, doctors or nurses were excluded. We included any primary study designs (quantitative, qualitative and mixed methods) that offered distance education via lectures, workshops, seminars, symposia and courses by didactic or interactive means. The reference lists of opinion papers, commentaries and literature reviews were pearled for further relevant articles. Non-English language literature was excluded; no date restrictions were applied. EndNote software [23] and Covidence software [24] was utilised to manage the search results.

Each article was read for relevant data which was extracted into a customised data extraction table that was developed specifically for this systematic review. The extraction table contained key data domains, which were pertinent to the objectives and questions of this review including 1) study design; 2) sample size; 3) setting; 4) health discipline; 5) description of intervention; 6) technology used; 7) method of data collection; 8) outcomes reported and 9) results. The methodological quality of the included intervention studies was assessed using the Critical Appraisal Checklist for an Article on an Educational Intervention Tool [25].

The findings from individual studies were summarised depending on the types of evidence found for each question. Because the studies were heterogenous including qualitative, quantitative and mixed method designs, their findings were synthesised descriptively and emergent findings reported narratively [26]. All stages of the article selection and critical appraisal process were conducted by two independent reviewers; any discrepancies were resolved by discussion. A third independent reviewer made the final decision where discrepancies were not resolved.

Search results

The search of peer reviewed databases returned 5232 articles, a further 14 were found through reference list pearling and 11 reports were found in the grey literature search. After duplicate references were removed, the title and abstracts of 3964 articles were scanned to identify potentially relevant papers of which 206 full text were retrieved for a more detailed examination, and to ensure they met the inclusion criteria. Removal of duplicate publications and those that failed to meet the inclusion criteria resulted in 14 studies being included in this review (see Fig. 1 for PRISMA flow chart).

The 14 included papers were assessed for methodological quality of the study design [25].

The 14 included papers were assessed for methodological quality of the study design [25] (see Table 1 for details).

Findings

Study characteristics

The 14 included studies were published over a 19-year period from 1997 to 2016 (see Table 2). There were multiple studies conducted in Canada, Australia and the USA, while one focused on the needs of rural AHP in Rwanda. All but three studies [27–29] offered education to multi-disciplinary groups. CPD offerings varied and were either needs based, typically within health services or across health networks where topics were identified via surveys [30–32] or via topics selected by the University hosting the course [27]. Studies published prior to 2010 devoted large sections of their paper to describing the technology used for delivery of the education programs compared to more recent papers, which tend to discuss learning outcomes or pedagogies in more detail. All of the interventions were considered resource intensive and would require expense to establish and replicate. The most resource intensive intervention appeared to be Maloney et al. [33] who offered face to face sessions and compared learning outcomes with online delivery. They gave telephone support in addition to web based tutoring and access to the university technology support helpline 12 h a day, five days per week. Also resource intensive was Warugaba et al. [34] who collaborated with a university course design team to convert Massive Online Open Courses (MOOC) resources back into more basic technologies such as USBs and videos that were hand delivered to remote locations. Due to the heterogeneity of the studies, it was not possible to complete a meta-analysis of results and data were synthesised in a narrative form, with descriptive statistics (mean, standard deviation, standard error, number of students before and after intervention, effect size, *p*-value, t-value) reported where available (refer to Table 2 for the included study characteristics).

Critical appraisal

The two studies with the lowest risk of bias demonstrated thorough reporting of method and results but differed in two quality indicators; one reported the behavioural changes post educational intervention while the other provided enough detail for possible adoption of the method [31, 33]. The study with the lowest methodological score was a short report and unable to provide detail [30]. Overall the studies had a clear research question and adequately described the educational context and intervention although not with sufficient detail to enable replicability of the research. Most studies were evaluations thus it was difficult to control for variables in delivery of the intervention and context, making some of the studies quite complex and difficult to report concisely. The clarity of reporting of key results was consistent in most studies but some lacked precision of detail or the discussion of alternate

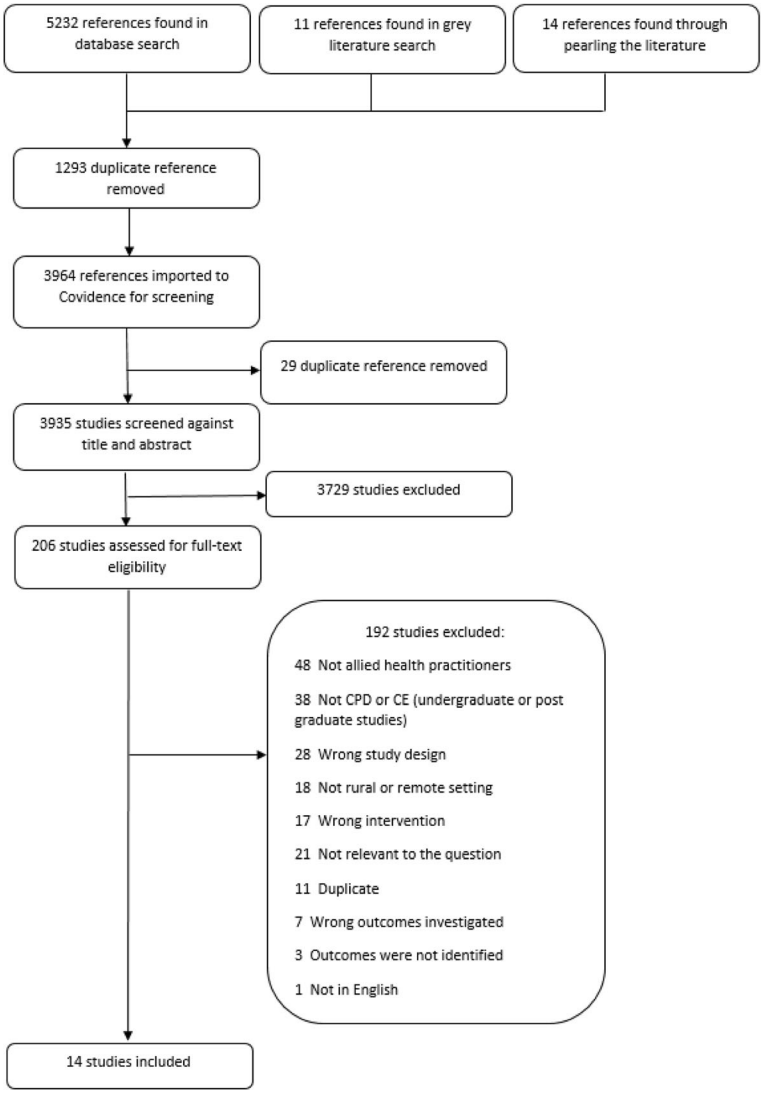

Fig. 1 PRISMA flowchart of search and review process

explanations of results lacked deeper analysis which limited the usefulness of the research.

Outcome measures and methods of distance education

Primarily the studies evaluated domains of knowledge and satisfaction with learning processes or technologies used, while some also measured self-reported practice change. The main method of data collection was through course evaluations conducted by online or pen and paper surveys after the completion of the education. Some studies had both a course evaluation and a pre and post-test evaluation of self-reported knowledge change on a Likert type scale [28, 29, 32] and with open questions [33]. Some had an examination following the intervention [27, 33, 35], or formal assessment of knowledge before and after intervention [28]. Simpler study designs reported on findings from evaluation instruments administered only after delivery of the education [27, 29, 31, 36, 37]. In addition, three studies gathered qualitative data to evaluate learning and the utility of the methods of e-learning [20, 29, 38]. All evaluation instruments were bespoke, designed to ask about learning and specific aspects of the education that the participants did or did not find useful.

Those studies that tested knowledge found positive outcomes from the education programs regardless of method of delivery [28, 33, 35]. When video-conference was compared with face-to-face delivery of material there was a significant change in knowledge for both groups [33, 39]. However, those participating in a day long video-conference reported feeling fatigued, with sore eyes from looking at the screen [39].

There were only three studies [33, 35, 38] that clearly reported practice change following the educational intervention. Because they used self-reported measures of

Table 1 Risk of bias appraisal of included papers

.		Bailey et al. 2005 [30]	Bynum et al. 2010 [31]	Dennis et al. 2010 [32]	DuBose et al. 1997 [27]	Ducat et al. 2014 [20]	Evans & Sachs 2000 [28]	Fahey et al. 2003 [38]	Maloney et al. 2011 [33]	Miller et al. 2008 [39]	Nipp et al. 2014 [35]	Ray et al. 2014 [36]	Shade & Barber 2004 [37]	Steed 2008 [29]	Warugaba et al. 2016 [34]
1	Is there a clearly focused question?	−	+	?	+	+	+	+	+	+	+	+	+	+	−
2	Was there a clear learning need that the intervention addressed?	?	+	+	+	+	+	+	+	+	+	+	+	+	+
3	Was there a clear description of the educational context for the intervention?	−	+	+	+	+	−	+	+	+	+	+	+	+	+
4	Was the precise nature of the intervention clear?	−	+	+	+	−	−	+	+	+	+	+	+	+	+
5	Was the study design chosen able to address the aims of the study?	?	+	?	−	+	+	+	+	+	+	+	+	?	?
6	Were the outcomes chosen to evaluate the intervention appropriate?	?	+	−	+	+	+	+	+	+	−	?	?	+	+
7	Were any other explanations of the results explored by the authors?	−	+	−	+	+	−	−	+	+	−	+	+	−	+
8	Were any unanticipated outcomes explained?	−	+	+	+	+	−	+	+	+	−	+	+	+	−
9	Reported behavioural changes after the intervention linked to measurement of other, more objective measures	−	?	−	−	−	−	+	+	−	+	?	−	−	−
10	Were the results of the intervention clear?*	+	+	+	+	+	+	+	+	+	+	−	+	?	+
11	How precise were the results?	?	+	−	+	+	+	−	+	+	+	−	?	−	−
12	Was the setting sufficiently similar to you own and/or representative of real life?	+	+	+	+	+	+	+	+	+	+	+	+	?	−
13	Does it require additional resources to adopt the intervention?	?	+	−	−	−	−	−	−	−	−	−	−	−	−
	Risk of bias score out of 13	*2*	*12*	*6*	*10*	*10*	*7*	*10*	*12*	*11*	*9*	*8*	*9*	*6*	*6*

Table key: + low risk of bias;? unclear; − high risk of bias; *question reworded for ease of dichotomous scoring (original question: 'What were the results of the intervention?')

Table 2 Characteristics of the studies

Author, year and country	Design and data collection	Study purpose & participants	CPD topic	Outcome measures	Results
Bailey et al. 2005 [30] Australia	Service review (audit) Data collection method NR	AHPs Evaluate VC as a learning method Rural	Child development	Knowledge and clinical process	VC improved access to professional supports from metropolitan team; networking; knowledge in developmental disability and learning difficulties; enhancement of clinical processes
Bynum et al. 2010 [31] USA	Single arm post-test Self-report Likert scale	Total 44,989 with 3230 AHPs Evaluate satisfaction with education program using VC Rural	Varied, needs driven	Satisfaction with program length, presentation, effectiveness & convenience of technology. Satisfaction with impact on patient care	Rural participants reported highest satisfaction with technology convenience ($p < 0.01$), predictors of program satisfaction were program year, male ($p < 0.01$), African American ($p < 0.01$), healthcare discipline (nursing), community size (smallest) and travel mileage from originating site. Women ($p < 0.01$), Hispanics ($p < 0.01$) and dental professionals ($p < 0.01$) recorded greater increases in knowledge, and needs match. Multiple regression showed combined variables of program year, gender, ethnicity, healthcare discipline, home community size, and travel mileage to training site were significant predictors of program satisfaction, accounting for 5% of the variance ($R^2 = 0.05$, $p < 0.01$). The strongest single predictor of satisfaction was program year
Dennis et al. 2010 [32] USA	Longitudinal cohort Self-reported pre-and post-Likert scale and end-of-year reflections	132 AHPs Evaluate learning from VC structured discussions Rural	Needs based journal club - critical appraisal	Critical appraisal skills; access to research and implementation	Access to research pre-to post 2006 to 2009 change of 3.10 to 3.88; critical appraisal skills change of 2.80 to 3.76; implementation change of 3.09 to 3.98
DuBose et al. 1997 [27] USA	Cross sectional cohort Examination and satisfaction evaluation (5 point Likert scale)	31 medical sonographers Evaluate education program comparing VC and FTF Rural and metro	Sonographic anatomy	Knowledge by rural versus classroom; overall; level of experience of participants & satisfaction	Students in remote sites did as well as those in classroom ($p > 0.05$), more years of experience had a small significant effect ($p < 0.05$, $R^2 = 0.42$); satisfaction evaluation was generally good (mean 3.7, range 4.9 to 2.7). However, significant difference in satisfaction between rural and classroom ($p < 0.05$) with rural indicating feelings of isolation from other students and instructor.
Ducat et al. 2014 [20] Australia	Descriptive Qualitative Semi-structured interviews	42 AHPs Evaluate education program using blended delivery (TC, VC, FTF) Rural and remote	8 domains in line with the Allied Health Capability framework	Enablers and barriers	Barriers: Competing time demands; clinical work takes precedence; difficulty accessing the equipment for VC participation.

Table 2 Characteristics of the studies *(Continued)*

					Enablers: Access to VC was cost effective; no need for travel; efficiencies with staff time.
Evans & Sachs 2000 [28] USA	Cross sectional cohort Pre-and post-knowledge assessment with follow-up survey	378 sonographers Evaluate a TC with an expert panel Rural and urban	Ultrasound equipment developments	Satisfaction; relevance; knowledge	Overall satisfaction mean 4.5 (SD 0.60); relevance mean 4.55 (SD 0.61); between groups (managers and radiologic technologists) difference in satisfaction (p = 0.02) and relevance (p = 0.01); no gender differences in satisfaction p = 0.72 or relevance p = 0.94; satisfaction and relevance were correlated p < 0.001; knowledge scores improved from 85% to 95%
Fahey et al. 2003 [38] Australia	Cross sectional cohort Post session evaluation, surveys and interviews	38 AHPs Evaluate 12 session VC program Rural	Child psychological development	Knowledge; changes to practice; satisfaction with technology	Questionnaires: 80% felt the sessions were informative and self-report practice change would occur; 86% comfortable with technology; 12% discomfort; several stated 'nothing replaces person in the room'. 80% rated online medium as excellent or very good, 1% unsatisfactory / poor. Acceptance consistently high from session 5 onward. Interviews (n = 16): 11 reported gains in knowledge in developmental frameworks and actual change in history taking & assessment; managers reported observed increased ability to spot problems; Networking was valued.
Maloney et al. 2011 [33] Australia	Head-to-head randomised trial Electronic survey for self-reported (Likert scale) satisfaction and self-reported change in practice, 1 h knowledge test, assignment	166 AHPs (attrition brought the final number to 96) Compare 1 day FTF workshop including video and written supports with web-based delivery over 4 weeks with discussion boards Rural and urban	Falls prevention using exercise	Participant reaction; knowledge; change in behaviour	Satisfaction content & relevance no difference (p = 0.75); satisfaction course facilitation & support no difference (p = 0.25); web group spent more time on compulsory & additional learning materials (p = 0.002); knowledge and assignment comparable between web and FTF (p = 0.07, p = 0.61); change in practice same (p = 0.89); difference in practice change between groups: web group changes in motivational interviewing while FTF changed exercise prescription. Both changed in assessment. Comfort with web based learning improved from 24% apprehensive to 80% willing to do another web based program.
Miller et al. 2008 [39] Canada	Non-equivalent control group design Self-reported pre-test and post-test and follow up survey for feedback using 5 point Likert scale, yes &	44 AHPs Compare 1 day FTF workshop with VC delivered simultaneously Remote	Training in scoring guidelines for stroke assessment	Effectiveness acceptability & monetary costs	VC performed as well as FTF on pre-post-test of competency in scoring stroke assessment. Significant change in both groups between pre and post test scores p = 0.001) (i.e. learning

Table 2 Characteristics of the studies *(Continued)*

	no and open ended questions				occurred). 33% of FTF group thought training was excellent compared with 8% in VC group. Satisfaction in mode of participation was the same across both groups - the presence of the VC in the room did seem to impact the experience for the FTF attenders (i.e. reluctant to speak out as wanted to give VC chance to speak). VC was more cost effective
Nipp et al. 2014 [35] USA	quasi-experimental cohort Pre-and post-knowledge tests and follow up survey for practice change	28 AHPs Evaluate 5 continuing education modules delivered online Rural	Low vision assessment and treatment	Knowledge pre-and post-test; knowledge by years of practice experience	Change in knowledge was significant (p = 0.01). On follow up 73.7% indicated they consistently considered vision when planning treatment; 50% reported often screen for vision now and 15/19 participants now consider environment & vision. However, 63.2% did not use any of the screening assessments covered; 78% reported increase in comfort levels for providing interventions for low vision including increased activity visibility, increased contrast & organisation of work stations.
Ray et al. 2014 [36] Australia	Cross-sectional cohort Electronic survey using self-report Likert scales	Total 101, AHPs 20 Evaluate VCs with experts delivered monthly for 16 months Rural	16 Palliative care (PC) topics	Content usefulness, confidence of palliative care delivery & influence on practice	Content usefulness: significant difference in ratings between AHPs and MDs/students (p = 0.018) and nurses (p = 0.018); AHPs found content less useful than MDs and nurses. Practice location, years of working and number of clients seen were not significant. Confidence: AHP significantly lower confidence in topics than both nurses (p = 0.008) and MDs (p = 0.013); Overall confidence improved mean 0.54 (SD 0.46). Those who had more palliative care clients were more confident but years of experience had no effect. Change in confidence greater in those with no previous education than those with post-grad (p = 0.44) and short course experience (p = .014).
Shade & Barber 2004 [37] USA	Cohort Electronic survey after each course	58 AHPs Evaluate an adaptation of FTF education to online and video courses with peer support discussions Rural	Individualised gerontology instruction	Knowledge; satisfaction; ease of use; content, usefulness and application	Reported 'average' computer skills on program completion; high speed internet was an advantage. Not all course content translated easily to online environment; time consuming to design interactive experiences to compensate for no live facilitator; topics that were time-sensitive took effort to

Table 2 Characteristics of the studies *(Continued)*

					maintain but more static material was easier. Participants working together from a single agency enriched the learning experience and learner interaction.
Steed 2008 [29] USA	Mixed method case series Electronic survey after experience using Likert scale and open-ended questions	7 OTs Evaluate second life virtual reality as a learning method Rural and remote	Cultural competency	Attitudes about clients from a different culture perception of learning environment	4 themes: sense of presence - embodiment as an African American; Sense of co-presence - self in the environment with others; place presence - natural engagement supporting visual and kinaesthetic learning styles; sense of play - learning through fun - authentic and goal oriented.
Warugaba et al. 2016 [34] Rwanda	Cohort study Electronic survey after the education program	Total 38 completed: 17 were AHPs Evaluate an adaptation of a massive open online course including FTF support Rural and remote	Global health	Attendance at in-person classes; use of online forum, number of quizzes taken, time required, opinions whether course helps work and career advancement & learning	10 / 20 completers used online forums, 18 did up to 7 quizzes; 16 course was helpful to work, 18 course contributes to career advancement; 16 spend 2–5 h a week on course. Relationship between attendance at in-person classes and course completion statistically significant ($p = 0.013$).

Key: AHPs = Allied health practitioners; FTF = face to face; VC = videoconference; TC = teleconference; NR = not reported; MD = Medical Doctor

changes in knowledge or confidence, it cannot be assumed that there were resultant changes in practice. One study found that only half of their occupational therapy participants screened vision during assessments following education, meaning that whilst they were reported to be more confident, there was limited change in practice [35]. Nipp et al. [35] suggested that the limited change in practice could be due to the lack of interaction with facilitators and other students to promote learning. They recommended adding more interactive elements to e-learning courses to improve this outcome [35].

Some studies focused on evaluation of satisfaction with the CPD delivery method rather than the learning outcomes as their aim [20, 29, 30, 39]. Satisfaction with access, experience or usefulness of technology and subsequent learning processes varied across studies. Participants reported that they appreciated education that had an interactive component including contact with facilitators and other learners because it mirrored the kind of learning that occurs in the classroom and supported their engagement [29, 34, 36, 37]. The comparison of satisfaction with videoconference groups and face to face groups found no difference [39]. However, DuBose et al. [27] found there was a difference in satisfaction between rural participants and those in the classroom, with rural learners feeling isolated from the instructor and other students. In the Warugaba et al. [34] example, course completion was significantly related to attendance at the in-person classes that were an adapted addition to the original MOOC design. Multimedia delivery of content appeared to be favourable, possibly because this suited different learning styles [37]. The virtual reality experience in Steed [29] appeared to create immersion and a playful experience. However, the author indicated further data needed to be collected to determine if improvement in cultural sensitivity of participants occurred potentially highlighting the limitations of the education method.

Interactivity between learners supported networking between participants within rural areas or teams [37] and between rural and metropolitan participants [30]. However, interactivity was also cited as a negative indicator of satisfaction in some studies [27, 38], or a perceived constraint for verbal contribution when participants who were in the room with the facilitators felt the need to hold back to allow those who were at a distance to speak [39]. Shade and Barber [37] cautioned that designing interactive experiences that compensate for the absence of a live facilitator was time consuming.

The technologies used to deliver the distance education differed. Video-conference was a popular medium [20, 30–32, 36, 38, 39] including the oldest study in the review [27]. One study used relatively simple technology via teleconferences [28] with another creating a more complex intervention via a virtual reality situated learning experience [29]. Others used stand-alone or one topic offerings that were not administered through the internet such as videos [37] and narrated power-point presentations [35]. Other education was delivered through the internet using web-based systems that have multiple in built learning tools, such as Blackboard [37] or Moodle [33], to create online courses including asynchronous discussion boards [33, 37] and to

offer MOOCs [34]. In a very remote region of Rwanda the online resources were not a suitable method of sole delivery and face to face supports were also provided [34].

Video-conferencing was found to be cost efficient in comparison to traveling to a larger city to attend a workshop [20, 39] and the relationship between distance and travel requirement was a finding in several studies. Bynum et al.'s [31] rural participants reported the highest satisfaction with technology convenience compared to videoconference users' closer to the city from where the content was delivered. However, the duality of saved time, efficiencies and travel savings versus competing clinical demands and precedence when studying in situ was highlighted in Ducat et al.'s [20] analysis of the barriers and enablers of blended delivery methods.

Reduction in satisfaction was indicated by issues with readiness of learners to use the technology for education delivered via the internet or when they reported issues with bugs in the program, lag time, having to refresh the internet connection [29, 34, 37] and having limited access to the equipment needed [20]. This disruption affected the experience for learners and required patience for them to be supported in learning the technology as well as the content [29, 33]. Comfort with technology improved markedly in the Maloney [33] study from 24% *apprehensive* to 80% *willing to do another web based program*, suggesting offering support for technology use is a helpful addition to the suite of CPD options. However, actual satisfaction comparisons between the course facilitation and support in the face to face and web based offerings in the Maloney [33] study were not different.

Discussion

Through conducting this review, once education targeted at medical practitioners was excluded, we found a surprisingly small range of research with variable methodological quality. This finding was surprising because of the many drivers for providing CPD for rural AHP including mandated professional registration requirements, the need to be professionally current [40], and to manage diverse practice demands [4]. Opportunities for engagement in CPD also minimises professional isolation, enhances quality improvement, and supports staff recruitment and retention [17]. In addition, CPD can inform rural AHP about product advancements and advancements in knowledge via implementation of research outcomes [41].

The research in this review was predominantly cross sectional with a mix of pre and post and quantitative measures and qualitative evaluations focusing primarily on knowledge development, satisfaction and utility with methods of education delivery and to a small degree on behaviour change and client outcomes. The almost 20-year span of the literature indicated that interest in effective modes of distance education is well established yet technology use is no longer novel. A pertinent observation was the trend of earlier publications to dwell extensively on descriptions of the technology, perhaps in an effort to enhance replicability, but to the detriment of the detail of the actual educational content or method. Both elements of the educational content and the method of delivery require attention to enhance replicability of the research. However, future efforts may benefit from giving more attention to the match between the method of delivery and the learning objectives of the program. For example, Evans and Sachs [28] demonstrated that for a straightforward session on new developments in a particular form of regularly used equipment, a low technology option of a teleconference could produce both knowledge gains and high satisfaction. Conversely, complex practice based courses may lend themselves more readily to either online or videoconference modes [33, 35, 36]. Similarly, education that requires a change in values and beliefs such as cultural sensitivity may require face-to-face contact for in-depth discussion [29], a finding congruent with studies of continuing medical education that indicate educational meetings alone are not effective for complex behaviour or practice changes [8].

Knowledge gains were a primary outcome of interest and all studies reported positive results regardless of the measures used, mode of technology, teaching and learning method, CPD topic or multi or sole disciplinary context. This finding suggests that AHP who opt to undertake CPD are likely to learn regardless, and perhaps the mode of delivery is not the most important aspect if knowledge alone is the desired outcome. The literature does not advance an understanding of the depth, longevity or application of that knowledge in practice despite efforts to measure practice change in two of the later Australian studies [33, 36].

Similarly, while it is suggested that provision of CPD is a strategy to retain staff [8], and while most studies measured satisfaction, none reported on retention as an outcome. It could be assumed that elements of the design of the different educational offerings may be of most benefit to retention of AHP in rural sectors. For example, studies with interactivity between participants and the facilitator appeared to have a higher satisfaction outcome, which is consistent with studies asking rural AHP about their CPD needs [10, 11] and evidence of strategies that produce the highest educational impact [8]. Therefore, it could be concluded that education that has an interactive element between the educator and the learner is better regarded by the recipient because they have the opportunity to discuss their learning. However, the nature of interactivity between participants was an intriguing finding of this review that deserves further research to determine which aspects of interactivity are most effective and how they may be facilitated via distance.

For example, networking opportunities through interactive means of education delivery were cited as beneficial

[30, 38] but it appeared that if the education included videoconference participants off site as well as in class participants synchronously, those at a distance felt more isolated [27]. Presumably the goal of a CPD strategy for rural AHP is to reduce feelings of isolation rather than increase them therefore there is a need to carefully consider the best location mix of participants in each educational design.

With the exception of one paper, the research was conducted in USA, Canada or Australia, which are countries with vast distances between rural and metropolitan centres. The CPD strategies had similar purposes to reduce travel time and costs for rural AHP, which were established as achievable outcomes. However, the issue of travel is multifaceted; while reduced travel time was valued [20, 31], staying on site at the workplace to study could also be a barrier when competing clinical demands overtook time use [20]. Face to face versus distance modes was the focus of studies with comparative designs, testing the assumption that face to face learning produces better outcomes, which was not in fact supported when knowledge and satisfaction were both measured [33, 39].

A key new understanding from this review is the notion of the dynamic interaction between time use, travel, location, costs, interactivity, learning outcomes and educational design. On the surface, the results indicate distance education is well established and will produce good knowledge outcomes regardless of delivery mode. However, other aligned benefits such as professional networking opportunities, reducing rural isolation through building communities of practice virtually or in small local clusters deserve further consideration; the latter particularly when seeking to move from knowledge gains to changed practice behaviours and improved client outcomes. Further, simple modifications to design, such as potentially offering education via technology but in off work site locations away from clinical demands (e.g. in libraries or university rural departments) may reap additional benefits for recipients.

Limitations and recommendations for future research

Given that existing literature supports the notion that access to CPD can aid in the retention of allied health practitioners in the rural workforce [13], it is a limitation of this review that no papers reported on retention as an outcome of engagement in distance CPD. An exploration of the relationship between availability of distance CPD and workforce retention is an area that is recommended for attention in future research. In addition, as this was secondary analysis of published research, we were not in a position to report on the motives of the participants for engagement with CPD and we did not know if participation was self-funded or employer funded. As evidence suggests that attendance is related to education outcomes, those who are most interested may also be those already performing well, and conversely those least interested may not attend and may need the CPD most [8] further research into the enablers and motivators for participation is important. Similarly, we were not aware of the motives of the CPD providers. This contextual information would be useful to interpretation and analysis of learning outcome data and is recommended for inclusion in reporting of future studies.

This study is limited by the lack of quality studies about distance CPD for rural allied health practitioners. In order to capture sufficient relevant studies, we had no date restriction on our search. This resulted in studies that spanned a 19 year period during a time of significant technological advancements. Comparisons were made about the different assumptions and emphases of authors from different periods of time, but comparisons between the different technologies need to made with caution and with understanding of the challenges that existed at those times (i.e. slower internet connections). It is recommended that future studies report detailed information about both the technology used and the educational intervention outcomes to advance understanding of the benefits and barriers to use of technology for distance delivery of CPD to rural allied health practitioners.

Schoo et al. [17] suggested that CPD for rural AHP should be based on core principles of professional group needs, adult learning principles and flexible delivery. The findings of this review suggest that these principles require deeper reflection, particularly the meaning of flexibility. Technology based delivery options appear to have high utility but perhaps flexibility and adult learning principles require more consideration above delivering distance education to a rural AHP desk top. Finally, while the studies showed some limited results, the extent and manner in which distance education CPD should be supported by additional knowledge translation strategies for change in practice, is of benefit to clients or improved service quality and whether it does in fact contribute to improve AHP retention in rural practice remains equivocal and is ripe for further prospective research.

Conclusion

In this review, we have examined both published and grey literature describing the range of current distance learning strategies in use for providing CPD to rural AHP, in addition to evaluating effectiveness. The review has revealed a shift in focus from reporting on technology to reporting user satisfaction but evaluations of impact on practice are limited. Future studies could be enhanced by including detailed descriptions in order to enable replication, and further exploration of the complex relationships between instructional design, time use and location.

Appendix

Medline search

Table 3 Medline search. An academic librarian from the University of South Australia independently validated the search strategy

No#	Search terms	Results
1	((rural or remote or nonmetropolitan or non metropolitan or suburb*) and (health or health care or health servic*)).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	89,254
2	*Rural Health Services/ or Rural Health/ or Suburban Health.mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	29,743
3	1 or 2	89,254
4	(((education or training) and (program or intervention or meeting or session or strategies or workshop or lecture or symposium or course)) or ((education or training) and (distance or remote or online or e-learning)) or Continuing professional education or Continuing professional development or CPD or CPE).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	249,428
5	*education, continuing/ or education, pharmacy, continuing/ or education, professional, retraining/	5287
6	4 or 5	252,704
7	((allied health and (personnel or professional)) or occupational therap* or ((physical or occupational) and (therap* or assista*)) or physical therap* or physiotherapist or (speech and (therap* or patholog*)) or dietitian or dietician or diet* technician or pharmacist or (pharmacy and (technologist or technician))).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	177,831
8	*allied health personnel/ or nutritionists/ or pharmacists' aides/ or physical therapist assistants/ or physical therapists/ or Occupational Therapy/ or Pharmacists/	32,198
9	7 or 8	186,116
10	6 and 9	16,212
11	3 and 10	497

*Truncation symbol for boolean search

T3

Abbreviations
AHP: Allied Health Practitioner(s); CPD: Continuing Professional Development; MOOC: Massive Online Open Course(s); NDIS: National Disability Insurance Scheme; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Authors' contributions
All authors made substantial contribution to the conception of the systematic review. KK performed the search, all authors were involved in selection of papers, CM and AB made substantial contributions to the data extraction and interpretation. All authors contributed to drafting and reviewing the manuscript and read and approved the final manuscript.

Ethics approval and consent to participate
not applicable.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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BMJ Open

Effects of e-learning in a continuing education context on nursing care: a review of systematic qualitative, quantitative and mixed studies reviews (protocol)

Attachment D
COMMENT #14
Change.org Petition
REFERENCE #3

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ABSTRACT

Introduction Continuing education (CE) is imperative to the future of professional nursing. The use of e-learning by registered nurses for CE is spreading. A review of systematic reviews will be conducted to develop a broad picture of the effects of e-learning in a CE context on nursing care.

Methods and analysis Systematic qualitative, quantitative and mixed studies reviews published in English, French or Spanish from 1 January 2006 will be included. The outcomes of interest will be extracted and analysed inductively and deductively from the Nursing Care Performance Framework; some themes include nursing resources, nurses' practice environment, processes, professional satisfaction, and nursing sensitive outcomes. Three reviewers will independently screen first the title and abstract of the papers, and then the full texts in order to assess eligibility. Two teams of two reviewers will extract the selected reviews' characteristics and data. The results from various types of reviews will be integrated using a data-based convergent synthesis design. We will conduct a thematic synthesis and transform all quantitative and mixed data into qualitative data.

Ethics and dissemination Ethics approval is not required for review of systematic reviews. We will summarise evidence concerning the negative, neutral and positive effects of various forms of e-learning on different aspects of nursing care. If we find gaps in the literature, we will highlight them and suggest ideas for further research. We will also focus on positive effects and present, if possible, the components and characteristics of e-learning interventions that were found to be successful. We will present this protocol and results in international conferences in nursing, medical, and health informatics domains. We will also submit the results of our work for peer-review publication in a journal indexed in the international bibliographic database of biomedical information.

Strengths and limitations of this study

- Review of systematic qualitative, quantitative and mixed studies reviews is an innovative and emerging type of research synthesis. The inclusion of reviews using multiple research designs and a diversity of data is justified by the possibility of broadening the repertoires of effects of e-learning on nursing care.
- To the best of our knowledge, this is the first review of systematic reviews that uses the Nursing Care Performance Framework to draw a broad, multidimensional and systems-based perspective on the dimensions and indicators of nursing care that can be impacted by e-learning interventions.
- Review of systematic reviews is still in its infancy regarding reporting, assessment of methodological quality, risks of bias and quality of evidence, especially for the qualitative and mixed studies reviews.
- One of the limits of reviews of systematic reviews is the lack of granularity of information provided by the review authors.

INTRODUCTION

Continuing education (CE), a term often used interchangeably with continuing professional development, lifelong learning and staff development,[1] is an imperative for the future of professional nursing.[2] In many countries, CE is mandated by professional or regulatory bodies, which encourages nurses to participate in these activities.[3] CE is an opportunity to acquire knowledge, improve performance, support growth and development as a nursing profession, expand the nursing role and introduce, develop and advance professional competencies/skills.[3 4] Ultimately, CE is intended to improve quality of care and patients' health status due to changes in healthcare provider practice.[5]

Nurses may engage in CE activities for myriad reasons; some seek opportunities voluntarily, whereas others complete CE credits for specialisation or licensure. While

there is a breadth of nursing-specific CE activities, nurses searching for CE may face many barriers in terms of work schedule/commitments, lack of support (from coworkers, employers and organisation), geographic distance, time away from work and activity cost.[6–8] The use of electronic (eg, computer and web-based) and mobile devices (eg, smartphones and tablets) to support learning (ie, e-learning and m-learning) is a promising avenue to face these challenges.

e-Learning is an umbrella term that encompasses various concepts and technologies related to learning, such as distance, digital, electronic, online, web based and mobile learning.[9] For this work, we will use 'e-learning' as the terminology entailing a variety of electronic, digital or mobile devices used to support learning. e-learning has many advantages; it reduces travel time, is flexible and accessible, can be cost-effective and can allow learners to learn at their own pace and from the place of their choice.[10 11] Furthermore, e-learning has the potential to provide tailored content and instructional methods based on the individual needs of learners and can present a variety of multimedia components such as text, audio, still and motion visuals to support acquisition of knowledge and skills.[10] Even if there is no strong evidence to prove that e-learning is superior to traditional learning, results of systematic reviews (SRs) support that this is an effective alternative way to learn.[11–13] Moreover, it has positive impacts on nurses' knowledge, skills, level of self-efficacy and satisfaction.[13 14]

However, e-learning is not a panacea.[15] Learners can encounter barriers, like skill requirement for using a particular device, low level of technological literacy, loss of time when the system/device does not work properly or the reduction of social contact compared with face-to-face learning.[16 17] Clark and Mayer[10] summarised drawbacks surrounding e-learning, including too many multimedia components interacting at the same time, a lack of features that promote learning, a loss of an exploratory learning environment and a lack of guidance for learners. The authors highlighted an interesting point: learning is better supported by effective instructional methods than by delivery medium (eg, virtual classroom and face-to-face classroom). Furthermore, we have to keep in mind that the process of knowledge translation into clinical practice is embedded in a complex and challenging phenomenon, which can be influenced by various elements such as: the nature of knowledge to be transferred, the expected outcomes of the educational intervention, the way the knowledge is transferred (eg, the instructional methods/implementation strategies, the use of tailored and individualised educational approaches and the medium) and the target audience.[18]

E-learning technologies have been studied extensively in nursing, especially for students in an academic context, as supported in a review of SRs (n=22).[9 12] The results of this review did not lead to robust evidence of the superiority of e-learning over traditional learning, nor did they conclude which technology or medium of e-learning best influenced the acquisition of skills and knowledge for nursing students at undergraduate and postgraduate levels. However, e-learning was shown to reduce the cost related to education and save time for students and lecturers. To the best of our knowledge, there is no review of SRs that focuses on e-learning in a CE context for registered nurses (RNs).

Objective

The objective of this review of SRs is to systematically summarise the best evidence that comes from systematic qualitative, quantitative and mixed studies reviews (MSRs) regarding the effects of e-learning in a nursing CE context on nursing care (ie, resources, services and patients' outcomes). We used the terminology 'review of systematic reviews' because it describes the concept in a simple and specific manner. Other terms are less specific, such as 'overview', which can be used in a generic way.[19]

To meet this objective, we will use a process of data conceptualisation by mobilising both inductive (data driven) and deductive (theory driven) approaches iteratively or simultaneously to guide all the methods and analysis processes. We will be open-minded to allow the emergence of new concepts, but we will also use concepts from an existing framework, the Nursing Care Performance Framework (NCPF),[20] as a tool to extract, synthesise and interpret data. The NCPF is useful to define an important concept of this review, namely, 'nursing care'.

Why it is important to do this review of SRs

- The context of nursing education in an academic setting versus in a workplace setting as a CE opportunity is different. Inexperienced undergraduate students learn a large repertoire of clinical competencies over a short period of time, during their schooling period, whereas practicing nurses engage in a CE context to maintain and reinforce their clinical expertise over the long-term.
- Knowledge synthesis at the third level of research (ie, review of SRs) about the effects of e-learning already exists in an academic context, but there is not one exclusively on nursing workplace and CE.
- To complement existing nursing knowledge, we believe that it could be useful to use a review of SRs with an exploratory lens, as suggested by Caird *et al*.[21] The synthesis it provides is ideal for identifying existing e-learning interventions used by RN in their workplace settings and possible outcomes of interest (based on the NCPF) and their effects (ie, positive, no effect or negative effects). NCPF has never been used as a framework to extract and analyse data for educational interventions among nurses.

NURSING CARE PERFORMANCE FRAMEWORK

The NCPF[20] will be used to conceptualise how e-learning interventions could influence nursing care and impact health outcomes. This is an organisational model, originally composed of 3 subsystems, 14 dimensions and 51

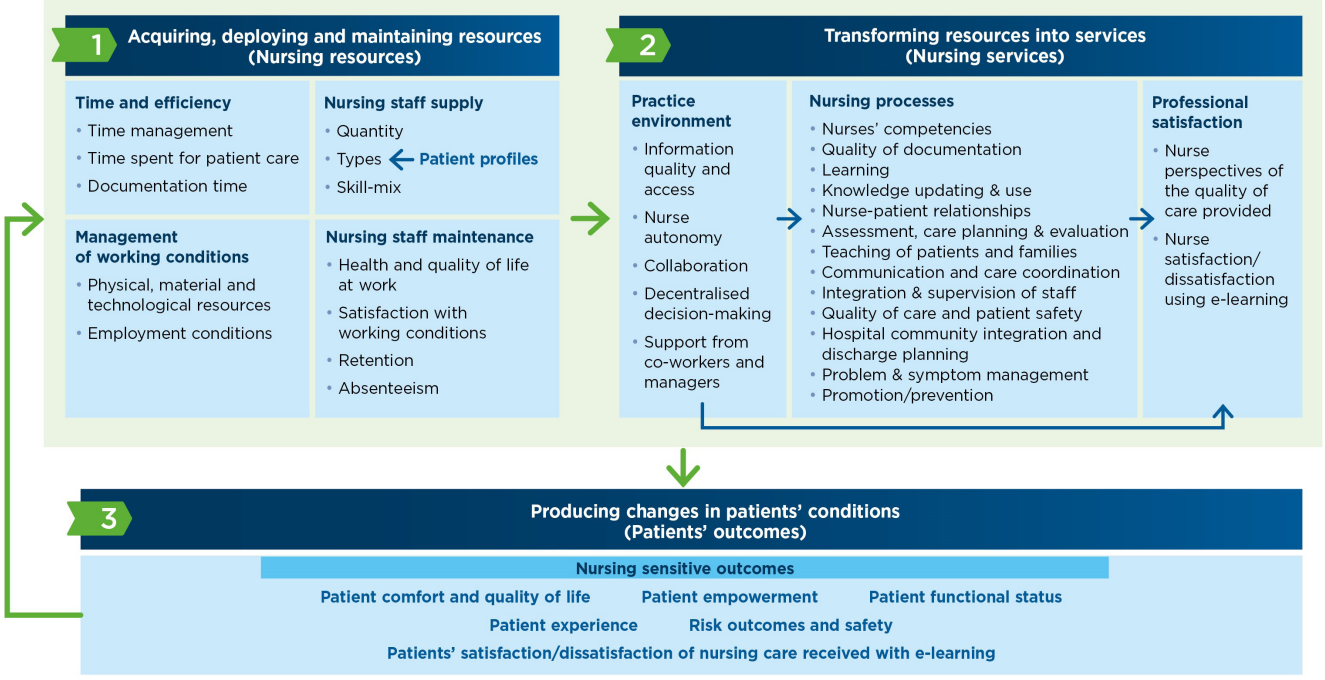

Figure 1 Adapted version of the Nursing Care Performance Framework, which represents the range of possible outcomes for which data will be sought in this review of SRs.

indicators, from which we have juxtaposing elements of the actual scope of nursing practice[22] as well as findings from our previous work[23] carrying out the impact of information and communication technologies (ICTs) on nursing care. Figure 1 presents the adapted version of the NCPF, which represents the range of possible outcomes for which data will be sought in this review of SRs.

The NCPF demonstrates how the interplay of three nursing subsystems (structure, services and patients' outcomes) can operate to achieve three key functions: (1) acquiring, deploying and maintaining nursing resources (structure); (2) transforming nursing resources into nursing services (processes) and (3) producing changes in patients' conditions in response to the nursing services provided ('nursing-sensitive outcomes' or patients' outcomes).

The first function refers to the human and material resources needed to provide effective nursing care, such as nursing staff supply, working conditions, staff maintenance and economic sustainability. The first way e-learning could influence nursing care is by considering it as a resource (ie, the first subsystem of the NCPF). We could pay attention to these elements when we extract data from SRs: exploring whether the availability of e-learning in healthcare settings impacts the quality of life at work for nurses and if e-learning acts as facilitator/motivator to enhance nurses' working conditions or serve as a barrier that inhibits them. Another question could be: to what extent can e-learning create favourable conditions that attracts nurses and reinforces stability in the workforce?

The second function encompasses nursing services (ie, the second subsystem of the NCPF), which are defined in various dimensions: nurses' practice environments (eg, nurse autonomy and collaboration), nursing processes (eg, assessment, care planning and evaluation, and problems and symptom management), nurses' professional satisfaction and patient experience. E-learning can be viewed as a resource that has the potential to influence all dimensions of nursing services at different levels. E-learning can be seen as way to support nursing work and create a professional practice environment for nurses by, for instance, facilitating collaborative practice. eElearning could impact what nurses do, for instance, nursing interventions (processes), or the ability of nurses in using their competencies to provide healthcare. Resulting from these two dimensions, e-learning could influence nurses' professional satisfaction in terms of quality of care provided, satisfaction or dissatisfaction of nurses using e-learning and/or patient experience.

The desirable end result of the interactions between nursing resources and nursing services is to improve patients' conditions. The third function is then described as the positive changes that can be detected among patients (also called 'nursing-sensitive outcomes', ie, the third subsystem of the NCPF). As other models used in the learning domain,[5 24] we could speculate that if e-learning changes nursing resources and nursing services, patients' outcomes could be potentially affected. Examples of indicators in the NCPF are: patient comfort and quality of life, risk outcomes and safety, empowerment and functional status.

The NCPF has been chosen to fit in the scope of this review of SRs for many reasons: (1) it was useful as an extraction and analytical tool in previous work;[23] (2) it offers a broad, multidimensional and system-based perspective on the dimensions and indicators of nursing care that can be impacted by e-learning interventions; and (3) it can highlight many indicators that could be relevant to document and measure ways in which nursing care performance is impacted by CE.

METHODS

The protocol of this review of SRs has been registered at the International prospective register of systematic reviews (PROSPERO), with registration number CRD42016050714. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) checklist to guide the elaboration of this protocol (see online supplementary appendix 1).[25]

Design

We will conduct a review of systematic qualitative, quantitative and MSRs which is, to the best of our knowledge, an innovative and emerging type of research synthesis. The inclusion of SRs using multiple research designs is justified by the possibility of broadening the repertoires of effects of e-learning on nursing care.

As underlined by Lunny *et al*,[26] methods to conduct, interpret and report review of SRs are in their infancy. To the best of our knowledge, no unified and integrated tool allows a comprehensive reporting of a review of systematic qualitative, quantitative and MSRs. We will follow the general methods for Cochrane reviews[27] and other relevant works in this domain[26 28 29] to conduct and report the review of SRs.

Eligibility criteria

The scope in this review of SRs is formulated using PICOS (participants, interventions, comparisons, outcomes and study design).[30 31]

Type of reviews

We will include all types of systematic qualitative, quantitative and MSRs that evaluate the influence of e-learning used by nurses on nursing care in a CE context that have been published in French, English or Spanish from 1 January 2006.

Publication type

To be included, the reviews have to be 'systematic':[32]

- clear and unambiguous;
- include a type of research and one or a combination of method(s);
- have specific research question(s), precise inclusion criteria, a comprehensive search strategy, a quality appraisal process and a rigorous synthesis.

The systematic qualitative, quantitative and MSRs must be published in peer-reviewed journals. Reports that outline a systematic methodology are included. We will exclude grey literature (eg, conference proceedings, trial registries and dissertations) and non-SRs such as literature reviews.

Population

We will include RNs according to the professional legislation of each country. Reviews that target RNs and other health professionals (eg, physicians) will be included as long as it is possible to differentiate nurses and to extract these participants' data. Patients receiving care from qualified RNs through the medium of e-learning will be part of this work, as long as nursing-related outcomes are discussed. We will exclude undergraduate nursing students in an academic context.

Intervention

All types of e-learning delivered through different devices are targeted. Blended learning interventions will be included as long as they have an 'electronic' or 'digital' component. Any types of simulation, including with a 'physical' mannequin (eg, high-fidelity simulation and technology-enhanced simulation) will be excluded. However, simulation could be included if it is done through virtual reality (ie, in an electronic learning environment).

Comparisons

We will include these types of comparisons: face-to-face learning, any other e-learning intervention and blended learning.

Outcomes

The outcomes will include but are not limited to the three subsystems (ie, nursing resources, nursing services and nursing sensitive outcomes), dimensions (eg, working conditions, time and efficiency, nurses' practice environment, nursing processes, professional satisfaction and nursing sensitive outcome) and indicators (eg, learning, nurse–patient relationship and knowledge access) showed in the adapted version of the NCPF in figure 1.

Definitions and/or examples of components are presented (see online supplementary appendix 2) related to each outcome of interest. The purpose is not to provide 'standardised' definitions but to offer a guidance for the data extraction process. No 'standardised' definition is available for the outcome of interest based on the fact that included SRs may have: diversity in terms of the nature of data (qualitative, quantitative and mixed), heterogeneity in e-learning interventions and various possible outcomes. Furthermore, the data synthesis approach is abductive. This means that we will use the NCPF as a starting point to extract the data and analyse them, but we will let new data emerge from the reviews. If stable and fixed definitions are provided, the inductive part can be compromised.

The main outcomes of interests are those targeting the effects of e-learning on nursing resources and services. Then, if the outcomes belonging to these dimensions are found in the SRs, patients' outcomes will be extracted.

We will exclude SRs that focus only on patients' outcomes without discussing nursing resources or services. At least one nurse-related outcome need to be present in order to include a publication. Determinants of e-learning use (eg, intended use) without reporting 'actual use' of e-learning will also be excluded.

Search methods for the identification of systematic reviews

Publications will be searched through general health sciences (PubMed and Embase), nursing (CINAHL) and Joanna Briggs Institute electronic databases. Structured search strategies will be developed using the thesaurus terms of each database and using free text, targeting the 'title' and 'abstract' fields. The strategies will be adapted to the other databases. The search strategy will be developed by the research team and validated by a health information specialist. The results of each database search will be collected in a single reference database, and duplicate citations will be removed. An example of the search strategy in PubMed is presented (see online supplementary appendix 3). This strategy will be adapted and refined according to the specificities of the databases. Furthermore, to obtain additional SRs, we will hand search for relevant ones, contact authors to find other relevant works in this domain and will consult reference lists of included SRs.

DATA COLLECTION AND ANALYSIS

Selection of systematic reviews

The research team will use DistillerSR, a web-based SR software from Evidence Partners (Ottawa, Canada), to perform the overall tasks related to the realisation of a review of SRs. Citations retrieved from the searches will be imported into a reference management software such as Endnote. The database containing all the references will then be imported in DistillerSR. Three reviewers (GR, JPG and EH) will independently screen the title and abstract of the papers in order to assess their eligibility. Each paper will be reviewed twice. The reviewers will compare their results and discuss them in case of discrepancies. If a consensus cannot be reached, arbitration with a third review author will be required. After the first round of screening, full text copies of publications that meet the pre-established inclusion criteria will be retrieved. In cases when the information regarding the eligibility of a review is limited or incomplete (eg, when only an abstract is available), we will contact authors to request the full text or further details. We will use the PRISMA flow diagram to show the overall process of reviews selection.[33]

Data extraction and management

The coding process will be done by four independent reviewers (GR, JPG, EH and JBP). We will use the NCPF to code, organise and classify the data according to the three subsystems (ie, resources, services and outcomes), the dimensions and the indicators. This is the deductive part of the synthesis. Additional codes will be generated inductively by the four reviewers from the text of the articles without fitting them into the existing model. The four reviewers will begin by coding a set of the same three articles independently in order to ensure consistency during the coding and data extraction process. The independently developed frameworks or 'coding plan' will then be compared and combined into a single integrated framework.[26] Any conflict arising through this extraction process will be discussed between the four reviewers. After a general agreement on coding and data extraction, the remaining articles will be divided equally between two teams of two reviewers.

The four reviewers will summarise general characteristics about SRs: purpose, type of review (qualitative, quantitative or mixed), examples of topics covered, number of studies included, target populations, search dates and context (eg, mandatory CE and workplace). Details about e-learning interventions, comparisons and outcomes will also be extracted as follows: examples of e-learning interventions, devices or media used, examples of educational strategies and material, theory used to develop and evaluate interventions (eg, learning theory and behavioural change), examples of comparison interventions, dimensions and indicators based on adapted version of NCPF, effects of e-learning as reported by authors and nature of the effects (qualitative, quantitative or mixed). Any disagreements arising during the data extraction process will be resolved by discussion and consensus involving the two reviewers or will involve a third review author if needed.

Methodological quality assessment of included systematic reviews

In this review of SRs, we will include different designs. The array of underlying types of SRs combining qualitative, quantitative and mixed method evidence can render reporting and assessing the quality of reviews of SRs more complex. At the time of this review of SRs, we found no reporting guidelines on assessing methodological quality of qualitative and MSRs.

One of the most commonly used tools for authors of quantitative SRs using a randomised controlled trial design is the Assessment of Multiple Systematic Reviews (AMSTAR).[34 35] AMSTAR is an 11-item checklist from which reviewers assign one point when the criterion is met. Quality is characterised at three levels: 8–11 is high quality (ie, minor or no methodological limitations), 4–7 is medium quality (ie, moderate methodological limitations) and 0–3 is low quality (ie, major methodological limitations).[36] AMSTAR items provide an assessment of methodological criteria such as the comprehensiveness of the search strategy and whether the quality of included studies was evaluated and accounted for.[37] Although AMSTAR has limitations (eg, inappropriateness of applying some criteria to MSRs and qualitative reviews), as underlined in previous work,[23] the four reviewers (GR, JPG, EH and JBP) will apply the tool

to all SRs in order to use the same criteria for quality assessment.

Risks of bias and quality of evidence

Others challenges encountered for authors of reviews of SRs are the assessment of limitations (risk of bias) as well as the quality of evidence in SRs[38] A tool has been recently published, named ROBIS, to assess or avoid the risk of bias in SRs.[38] It has been developed for guideline developers and authors of reviews of SRs. Three steps can be filled in when using the tool: (1) assessment of relevance (optional) between a review question and its fit/match with the review of SRs question, (2) identification of research steps where bias may be introduced into the SR process (ie, eligibility criteria, identification and selection of SRs, data collection and review appraisal, and synthesis and findings) and (3) overall judgement of risk of bias. Bias appears if limitations in the design, conduct or analysis of a review alter the results. Two reviewers will then assess independently the risk of bias with ROBIS tool and will compare their results.

We found no tool or guidance to perform the quality of evidence assessment for authors of reviews of SRs. The Grades of Recommendation, Assessment, Development and Evaluation (GRADE) has been largely adopted as a tool to judge the overall quality of evidence for each individual outcome (ie, consideration of within-study risk of bias, directness of evidence, heterogeneity, precision of effect estimates and risk of publication bias) in the context of quantitative primary studies, especially those using experimental or quasiexperimental designs.[39 40] When the unit of analysis is SRs and not primary studies, it is not always possible to extract GRADE ratings because data can be missing, not reported adequately or reported in different ways across the SRs. The use of a tool to assess the quality of evidence has to be modified for use in reviews of SRs.[41] Recently, two tools have been published to assess both the confidence in qualitative review findings (methodological quality or dependability) and the potential influence of study quality on the review findings: confidence of synthesised qualitative findings, named ConQual,[42] and Confidence in the Evidence from Reviews of Qualitative research, called CERQual.[43] They both aim to provide a qualitative equivalent to the GRADE approach and both present a final ranking,[44] but they are not currently considered as gold standard. We found no tool to assess the quality of evidence in MSRs. In this review of SRs, we will report the assessment of quality of evidence and risk of bias performed by original systematic quantitative, qualitative and MSRs authors who used GRADE, ConQuaL, CERQual or other approaches. In other words, only the quality indicators used by the authors of the original SRs will be reported, and no additional evaluation will be done.

Finally, another element to consider in a review of SRs is the risk of biased results caused by the repetition of primary studies that are included more than once (ie, overlaps) across the SRs.[45] It is important to calculate the actual degree of overlap in reviews of SRs with the corrected covered area method in order to report these overlaps properly.[45] As suggested by Studziński *et al*,[46] one reviewer will generate a matrix that will cross-link the SRs (columns) with primary studies included in the reviews (rows), and a second reviewer will check the matrix.

Data synthesis

An important challenge of data synthesis is the integration of the systematic qualitative, quantitative and MSRs.[47] In order to integrate the results from various types of SRs, we will perform a qualitative thematic synthesis using a data-based convergent synthesis design.[48 49] We will qualify quantitative data, as we did in our previous work.[23] Qualifying the quantitative data means that we will use a textual and narrative approach to name and qualify the effect. We will then categorise the quantitative effect under a specific theme (eg, knowledge use). Within this theme, subthemes may be created to make a distinction between qualitative, quantitative and MSRs' findings. Aromataris *et al*[50] suggest to present overall effect estimates, numerical data and overall synthetised qualitative findings extracted from each review in a tabular presentation of findings. Under a theme, subthemes could be divided by type of review (ie, qualitative, quantitative or MSRs) to keep the details, and then, an integrated synthesis could be conducted to summarise the effects.

However, if the results of the SR demonstrate that e-learning leads to a significant increase in knowledge, instead of reporting the p-Value, we will qualify the result: positive effect of e-learning on knowledge level. Frantzen and Fetters[47] call this approach 'transformation', in which quantitative data are transformed into qualitative data. We will also organise the results into themes and subthemes according to the specific dimensions of nursing care (eg, practice environment, nursing processes, professional satisfaction and nursing-sensitive outcomes) and their corresponding indicators. Even if this is an uncommon approach, we do believe that this way of synthetising will allow us to keep the richness of the results.

In order to transform all quantitative and mixed data into qualitative data, we will employ Thomas and Harden's approach.[51]We will follow these three steps: (1) coding relevant extracts of each SR line by line, (2) developing descriptive themes and (3) generating analytical themes. This might lead to an adapted version of the NCPF cited earlier. The thematic synthesis will be done in an inductive and deductive way (ie, abductive), which means that some themes will be organised based on the NCPF,[23 24 52] while others will emerge inductively.

CONCLUSION

Results of this review of SRs could be used to understand the dimensions of nursing care that have the potential to be supported, enhanced or constrained by the use of e-learning to sustain CE activities among nurses. This review of SRs is a continuation of previous work that has

been done about the impacts of various types of ICTs (excluding e-learning interventions) on nursing care.[23] Some reviews on e-learning used by nurses or nursing students target specific outcomes, especially knowledge, attitudes, barriers and facilitators, skills and satisfaction regarding the use of e-learning.[13 14 53 54] By using the NCPF to organise, extract and analyse the data, this review of SRs could provide a good starting point to deepen our understanding regarding the dimensions and indicators of nursing care that can be impacted by e-learning. With the growing presence of digital devices in nursing care systems, we think it is important to document the interaction of e-learning and nursing care dimensions and indicators. We believe that if we better understand the effects of these e-learning interventions, we can deploy strategies to facilitate their implementation and integration into nursing care, nursing research, management and education. Consequently, we can overcome their negative effects and optimise positive ones in order to use them to their full potential as tools to support nursing practice and, ultimately, improve patient outcomes.

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NBRC
The National Board for Respiratory Care

Credential Maintenance Program

Maintaining Your Respiratory Care Credentials

Attachment D
COMMENT #14
Change.org Petition
REFERENCE #4

For individuals holding a credential with an expiration date.

EXCELLENCE
defines us.

The NBRC Credential Maintenance Program

For everyone whose mission involves protecting patient lives by ensuring quality respiratory care in the field, we all have one thing in common: EXCELLENCE defines us. At The National Board for Respiratory Care, our commitment to excellence includes providing the tools, options and support you need to maintain your credentials through our Credential Maintenance Program.

Each credential issued by the NBRC is awarded for a term of five years, calculated from the end of the calendar month in which the credential was issued. An exact expiration date will be contained on credentialing certificates, clearly indicating the requirement of the individual to maintain the credential through the Credential Maintenance Program.

If you were a CRT, RRT, CRT-NPS, RRT-NPS, CRT-SDS, RRT-SDS, RRT-ACCS, CPFT, or RPFT credentialed by the NBRC on or after July 1, 2002, you must participate in the Credential Maintenance Program to maintain your NBRC credential. CRT, RRT, CRT-NPS, RRT-NPS, CRT-SDS, RRT-SDS, RRT-ACCS, CPFT, and RPFT credentials awarded prior to July 1, 2002 are not subject to the Credential Maintenance Program. All individuals holding the AE-C credential are required to participate in the Credential Maintenance Program for credential maintenance.

Three Options for Credential Maintenance

You may choose from the following three options to maintain and recertify your credentials every five years.

Option 1

Complete assessments (assessments are not available for AE-C) and/or submit CE.

Beginning January 1, 2020, quarterly assessments are a component of the CE option to maintain credentials. The assessment component is key in our goal of strengthening the relationship between competencies of credential holders and expectations linked to those credentials. Content will focus on tasks that put patients at risk and have a high pace of change.

The number of CE required is based on assessment performance and categorized in three zones: Green, Yellow, and Red. Strong performance on the assessments will place you in the Green or Yellow Zones, eliminating or reducing the amount of CE required.

Your personal dashboard in the practitioner portal will automatically keep track of assessment progress and will display your current CE requirement.

Visit nbrc.org to view required CE subject matter and credit requirements for each credential held, as well as combinations for those who hold multiple credentials.

Acceptable education requires participation in an educational activity directly related to respiratory therapy, pulmonary function or diagnostics technology, neonatal/pediatric, sleep testing and interventions, adult critical care, and asthma education depending on your credential(s). This includes any of the following:

- **Lecture** – A discourse given for instruction before an audience or through teleconference
- **Panel** – A presentation of multiple views by several professionals on a given subject with none of the views considered a final solution

- **Workshop** – A series of meetings for intensive, hands-on study or discussion in a specific area of interest
- **Seminar** – An advanced study or discussion in a specific field of interest
- **Symposium** – A conference of more than a single session organized for discussing a specific subject from various viewpoints and by various presenters
- **Online Education** – Includes materials such as text, Internet or CD, provided the proponent has included an independently scored test as part of the learning package

At the NBRC, we intend for the completion of CE credit to coordinate with the requirements of state licensure agencies, which means you may submit the same CE hours to satisfy requirements for the state as well as NBRC credential maintenance. You may also use credits from the American Association for Respiratory Care Continuing Respiratory Care Education Program (AARC-CRCE®) to fulfill the NBRC Credential Maintenance Program requirements. Submitting and tracking your CEUs is fast and easy with the NBRC online practitioner portal.

For AE-C recertifcation, continuing education requires that CEUs be in content areas applicable to asthma education. See the detailed content outline online at nbrc.org. Accredited continuing education (CE) providers include, but are not limited to the Recognized Provider List located on our website and include accredited and approved educational institutions, and State Boards of Nursing.

AE-C continuing education activities (but not academic credit-granting courses) provided through accredited academic institutions within the United States or its territories granting degrees related to professional practice are also accepted (e.g., continuing education activity provided by an accredited academic institution's School of Nursing, Nutrition, Social Work, Medicine, Pharmacy, etc.).

Several state boards of licensure require AE-C continuing education for renewal of licensure. Acceptance by a state board of licensure does not guarantee that a continuing education program

meets NBRC's criteria. The state board of licensure MUST be accredited or approved by one of the NBRC recognized provider(s) for an activity to be considered for NBRC renewal of certification.

Option 2

Retake and pass the respective examination for the highest credential held that is subject to the Credential Maintenance Program. AE-C credential holders must retake and pass the AE-C examination to comply with the CMP.

To recertify using this option, you must retake the examination during the last year of your five-year credential period. A new five-year period will begin on the date you successfully pass the examination. If you hold multiple credentials from the NBRC and elect to maintain your credentials through the examination option, you must successfully complete the examination for the highest level credential held that is subject to the Credential Maintenance Program.

Option 3

Pass an NBRC credentialing examination not previously completed. This option does not apply to AE-C.

Passing an NBRC credentialing examination that you did not previously complete automatically extends the recredentialing period of all NBRC credentials you hold for an additional five years (starting when you earn a new NBRC credential). As a result, all of your NBRC credentials will have the same expiration date, allowing you to simultaneously maintain all credentials in the future.

Continuing Education Documentation

If you choose Continuing Education (Option 1) to maintain your credential(s), you must submit your continuing education units (CEUs) and pay applicable fees online at nbrc.org prior to your credential expiration date. Failure to comply by the deadline will result in the expiration of your credential(s).

Program Fees

If you choose to maintain your credential(s) by taking the examination for the highest level credential held (Option 2), or by taking another NBRC credentialing examination not previously completed (Option 3), you will not be required to submit Credential Maintenance Program compliance information; you need only to pay the examination fee. The examination application and fee serve as the required documentation for credential maintenance.

If you choose to maintain your credential(s) through the CE route (Option 1), you will be required to submit all CE information and payment online. The Credential Maintenance Program (CMP) fee is $125 collected annually in $25 increments over the 5-year credential term. If you do not pay the CMP fee annually, you will be required to submit payment of $25 per year for which payment was not made. The Credential Maintenance Program fees for the CE option are listed in the following table:

STATUS	DESCRIPTION	FEE
Paid annually	Individuals who pay their CMP fee each year of the five-year credential term	$25 per year
Not paid annually	Individuals who do NOT pay their CMP fee each year of the five-year credential term	$25 per year not paid during the 5 year credential term
Lapsed within 6-month grace period	Individuals whose credentials have lapsed but are within 6-months of credential expiration	$250 reinstatement fee
Lapsed more than 6 months	Individuals who do not complete one of the CMP options before their expiration date	Current examination fee

Completion of the Credential Maintenance Program

Once you have completed your Credential Maintenance Program option, a new certificate and wallet card will be mailed to you within 30 days.

Verification of Compliance

To ensure ongoing excellence for all credentialed practitioners, we audit a random sample of Credential Maintenance Program compliance documentation and confirm the validity of all submitted information with the appropriate parties. Information that appears to be falsified will be referred to the NBRC's Judicial and Ethics Committee for investigation and possible disciplinary action.

The Importance of Compliance

By maintaining your credential, you help ensure your continuous improvement and ongoing excellence in respiratory care. Once your credentials expire, they can no longer be used because they are federally registered trademarks reserved for use by individuals who successfully complete the examination(s) and participate in the mandatory Credential Maintenance Program. Therefore, any use of a credential designation – whether using it to sign a patient chart or medical document, applying for a state license as an individual holding the credential, or seeking employment as a credentialed respiratory care practitioner – violates the NBRC's Judicial and Ethics Policies, and can result in disciplinary action by the NBRC.

The status of your credential may also affect your state-issued license to practice respiratory care. Many states require you to maintain your NBRC credential in order to keep your license. By allowing your NBRC credential(s) to expire, you may be putting your state license to practice and your opportunity for continued employment at risk. Please check with your state licensure agency to confirm their requirements for maintaining your license. A directory of all state licensure agencies is available on nbrc.org.

If Your Credential Expires...

If you are within six months of credential expiration, you have the option of entering your CEUs online and paying a $250 reinstatement fee. Any CMP fees paid annually become void once your credential expires and your CEUs must have been earned during your five-year credential term. CEUs obtained after your credential expiration are not accepted. If your credential is expired more than six months, you must apply for testing to reinstate your credential. You must meet the admission policies in effect at the time you apply and will be required to pay the new application fee. If you successfully complete the examination, your credential will be reinstated. If you have more than one expired credential, you must apply for and pass all examinations to reinstate your expired credentials.

Notification Procedures

To support you in maintaining your NBRC credentials, expiration reminders will be posted in your Message Center within the online practitioner portal. Additionally, we mail credential expiration reminders, including deadlines and credentialing maintenance requirements, via USPS at the following times:

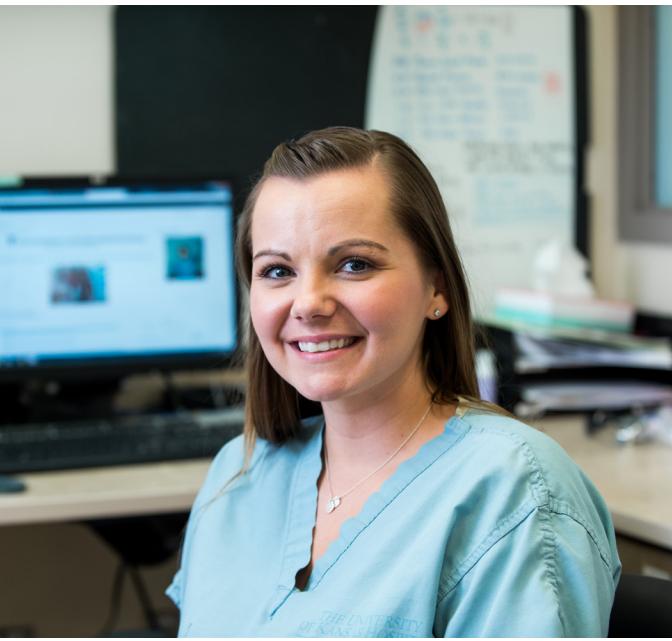
- One year before the expiration date of your credential.
- Six months before your credential's expiration date.
- 90 days before your credential's expiration date.
- 30 days before your credential's expiration date - final reminder.

Credentialed practitioners who allow their credentials to expire will be sent an email reminder before the 6-month grace period ends.

The NBRC will consider individual requests for extensions of the credentialing maintenance period due to personal emergencies or other extenuating circumstances on a case-by-case basis.

For More Information or Assistance

Please contact our Customer Care Specialists at the NBRC Executive Office using the contact information provided on the back of this brochure.



NBRC
The National Board for Respiratory Care

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EXCELLENCE defines us.

Attachment D
COMMENT #14
Change.org Petition
REFERENCE #5

Online Continuing Education Providers

Certified Nurse Assistants (CNAs) must complete 48 hours of continuing education every 2 years. CNAs must comply with State and Federal law, including in-service and continuing education hours. Pursuant to Health & Safety Code, Section 1337.6 (a)(1), "…At least 12 of the 48 hours of in-service training shall be completed in each of the two years. Twenty-four of the 48 hours of in-service training may be obtained through online computer training program approved by the Licensing and Certification Division of the state department." CNAs must indicate the number of completed in-service or continuing education on the renewal (CDPH283C).

Below is a list of providers offering courses in continuing education, approved by the California Department of Public Health (CDPH), Training Program Review Unit (TPRU). Contact individual providers for information related to specific courses, course content, and fees.

Online Continuing Education Providers are added after they are approved by TPRU.

Provider Name	Website Link
Access CE	Access CE website (accessce.com)
CareAcademy	CareAcademy website (careacademy.com)
CareerSmart Learning	CareerSmart Learning website (careersmart.com)
CEUfast, Inc.	CEUfast website (ceufast.com)
CnaZone	cnaZone website (cnazone.com)
Coastline Community College	Coastline Community College website (coastline.edu/index.php)
Community Care Options	Community Care Options website (communitycareoptions.com)
Flex Ed	Flex Ed website (flexed.com)
Healthcare Academy	Healthcare Academy website (healthcareacademy.com)
Home Care Pulse LLC	Home Care Pulse website (learn.knowingmore.com)
LeadingAge California Foundation	Leading Age California website (leadingageca.org)
Mariposa Training, Inc.	Mariposa Training website (mariposatraining.com)
Medcom, Inc.	Medcom website (medcominc.com)
MyFreeCE	MyFreeCE website (myfreece.com)
National Union of Healthcare Workers	NUHW website (nuhw.org/member-resources/continuing-education)
NetCE	NetCE website (NetCE.com)

Nevvon LLC	NEVVON website (Nevvon.com)
Pedagogy	Pedagogy website (pedagogyeducation.com)
Relias LLC	Relias Academy website (reliasacademy.com)
STEAM Learning Center	STEAM Learning Center Website (nurse.moodle.school)
Texas Tech University Health Sciences Center	Texas Tech University Health Sciences Center website (ttuhsc.edu/health.edu)
Vasco Career College	cnaBASE website (cnabase.com)
West Haven Center for Nursing Education and Training	West Haven Center website (courses.westhavenuniv.edu/login/login)
YAYA Medical Training Institute	YAYA Medical Training Institute website (nurseassistantschoolyaya.com)

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