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Web-based distance learning for nurse education: a systematic review

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Background: Web-based distance learning is considered a promising approach to replace or supplement conventional nursing instruction. However, no systematic review has been seen to explore the effect of web-based distance education in nursing.
Aim: To examine the efficacy of the web-based distance education for nursing students and employed nurses.
Methods: A systematic review of randomized controlled studies was undertaken. Multiple search strategies were performed in PubMed and Embase until July 2012. Two reviewers independently selected trials, conducted quality critical appraisal, and extracted the data from the included studies.
Results: Nine randomized controlled trials met inclusion criteria, among which five studies were rated as A quality level, and the other four studies as B quality level. The results showed that web-based distance learning has produced equivalent or better effects in knowledge acquisition. For nursing skill performance, four studies revealed a positive role for the new teaching mode, and one study showed a negative viewpoint. This review also demonstrated that participants generally accepted web-based education with high satisfaction rates. Two studies reported a more positive trend for self-efficacy in performing nursing skills in the experiment group compared with control group. Some negative feedbacks were also expressed.
Conclusion: Web-based education has encouraging effects in improving both participants' knowledge and skills performance, and in enhancing self-efficacy in performing nursing skills, with a high satisfaction rate expressed by participants. More rigorous experimental studies are advocated.

Keywords: Learning Styles < Education, Continuing Education < Education, Information Technology < Information Technology

Background

Globally, web-based distance education has gained new ground as instructional methods replacing or supplementing traditional education. Traditional teaching approaches have shown their limitations in nursing. Many factors, including the large

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number of nursing staff looking for continuing education, difficulties for employed nurses in following regular education procedures (Horiuchi et al. 2009), the shortage of nurse educators (Billings 2007), increasingly diverse learning content (Jeffries 2001), all make it reasonable to explore innovative educational strategies. Web-based distance education has been considered one of the possible ways (Greenhalgh 2001; Le & Stein 2001).

As a delivery mechanism, distance education involves the separation of the educator and learner in time and space, and is used primarily to assure access and convenience for learners

(Billings 2007). Web-based learning is defined as one teaching strategy 'in which the web is used to provide the materials and interactions between the students and teachers' (Paulsen 2003). Students may find using web-based learning more convenient to acquire knowledge and increase confidence in using information technology, thereby supporting independent and distance learning (Häggström et al. 2009).

According to McKimm et al. (2003), features of typical web-based learning are listed as follows: (a) course information, notice board, timetable; (b) curriculum map; (c) teaching materials such as slides, handouts, articles; (d) communication via email and discussion boards; (e) formative and summative assessments; (f) student management tools (records, statistics, student tracking); and (g) links to useful internal and external websites, including library, online databases and journals. In addition, teleconferencing (Reid et al. 2012), case-based learning (Kopp & Smith 2011) and online credit-based courses (Cohen et al. 2011) are also important methods in web-based distance education. Many tools are used to support web-based distance education: (a) synchronous tools: chat room and desktop conferencing; and (b) asynchronous tools: online discussion, email, Bulletin Board or forum, stream video, stream audio and online testing (Billings & Rowles 2001).

Because of the diversity of educational tools, web-based instructional designs vary from fully online courses to hybrid or blended instruction with traditional approaches; however, it was found that course modality does not impact the dimensionality by which students evaluate their course experiences (Dziuban & Moskal 2011). So it is possible to compare the different effects between the full and blended designs.

The role of web-based distance education in medical education has been widely discussed, including diabetes education (Bell et al. 2006), prenatal breastfeeding education (Huang et al. 2007; Lewin & O'Connor 2012), anaesthesiology (Doyle 2008), nutrition (Oenema et al. 2001; Underbakke et al. 2006), etc. Moreover, a series of reviews have been performed. To evaluate and translate findings related to student outcomes into educational practice, a recent integrative review (Patterson et al. 2012) revealed that both cognitive outcomes (student learning, learning process and technology proficiency) and affective outcomes (personal and professional growth, satisfaction, and connectedness) emerged. Chumley-Jones et al. (2002) showed that web-based distance education was a valuable addition to present education approaches, but it could not replace traditional methods because web-based programs were not found to be superior to traditional methods in terms of gains in learning or learners' satisfaction. Curran & Fleet (2005) concluded in a review of evaluation outcomes of web-based continuing medical education that not enough evidence existed to support the effectiveness of any particular type or format of web-based continuing medical education in improving participants' clinical performance or patients' outcomes.

For nursing education, web-based distance education has been advocated for nearly two decades (Billings 2007). The American Association of Colleges of Nursing (1999) published a white paper named 'Distance Technology in Nursing Education' in 1999, which states that modern advances of information technology have supplied new opportunities to improve dramatically the quality of and access to web-based nursing education.

So far, many benefits have been attributed to web-based education technology. Many students have expressed their positive attitudes towards web-based distance education, including time flexibility, convenience and lack of transportation worries (Lu et al. 2009; Yu & Yang 2006). In addition, the new technology has also played an important role in easing the shortage of nursing educators (Billings 2007). Another appreciation is that all students are able to share information via Internet (Billings & Rowles 2001).

There are also some negative feedbacks. First, poor information literacy might result in inappropriate operation of web learning, which was significant at the beginning stage (Billings 1999; Lu et al. 2009). Another discomfort is that students might feel isolated in web-based education (Adams & Timmins 2006). Possible loss of the social process of learning would be one of consequences (McAllister & Mitchell 2002). Other concerns included the time and skills required to develop learning materials (Bloomfield et al. 2008), huge expense involved, and lack of research-produced proof (Chiu et al. 2009).

Based on such information, there is a question to be discussed: Do the advantages outweigh the disadvantages for web-based distance learning in nursing education? Specifically, the following questions are proposed: Is web-based distance learning effective in increasing knowledge learning, in improving skills performance and in increasing professional growth? All the questions are expected to be explored for further clarification, and a systematic review (SR) based on randomized controlled trials (RCTs) is one of the possible resources. To our knowledge, however, no SR has been published. Therefore, we performed this SR to explore the effectiveness of web-based distance learning in nursing.

Aim

To examine the efficacy of the web-based distance education for nursing students and employed nurses in terms of knowledge learning and (or) skill performance as primary outcome(s). To capture the main role of web-based distance education at a wider perspective, we did not limit specific topic of knowledge

and (or) skill performance. If possible, other outcomes (e.g. students' satisfaction and professional growth) would also be examined as secondary indicators.

Methods

Search strategy

With no time limit, the English medical electronic databases PubMed and Embase were checked until July 2012 with the following MeSH (medical subject heading) terms and text words: ('Internet' OR 'distance learning' OR 'e-learning' OR 'online learning' OR 'computer' OR 'www' OR 'web' OR 'case-based learning') AND ('education, nursing') AND ('randomized controlled trial' OR 'random*'). Supporting Information Appendix S1 shows the exact searching strategy. Finally, a snowball search was done.

Inclusion criteria

To reach evidence of high grade level, peer-reviewed RCTs in English were selected as eligible (Harbour & Miller 2001). Further, these studies should meet the following inclusion criteria (PICO format):

P (Population): Based on the study of Bloomfield et al. (2008), to capture the main trend of the role of distance education in disseminating nursing knowledge, studies that examined nurses at either pre- or post-registration level were included.

I (Intervention): Studies of interventions that adopted web-based distance education as experimental teaching strategies were included. According to Ryhänen et al. (2010), we defined web-based distance education as the use of World Wide Web or with modem connections to a central server for communication. Specifically, qualified distance web-based education programs should lay emphasis on following essential elements (Patterson et al. 2012; Ryhänen et al. 2010): (a) physical separation of teachers and learners is involved in time and space, (b) web technique is used as the modality to perform teaching and learning activities between teachers and learners, and (c) learners have access to content module via Internet at their convenient time and locations, not limited in any assigned places. Exclusion criteria included sole use of interactive computer-assisted learning (e.g. use of the computer with CD-ROMs, videos) which were not integrated with Internet for distance delivery (Patterson et al. 2012).

C (Comparison): Web-based distance nursing education program should be compared against two control forms: traditional teaching methods or placebo/waiting-list/blank control.

O (Outcome): Because of previous findings (Billings 2000; Bloomfield et al. 2008; Patterson et al. 2012), we defined that each eligible trial should take knowledge learning and (or) skill performance as primary outcome(s). Other outcomes, such as student satisfaction, personal and professional growth (e.g. self-efficacy), would be considered as secondary indicators.

Articles selection

In the first stage, searches were conducted in the two databases and relevant titles/abstracts were retrieved. After the duplicate studies were identified and deleted, one reviewer (SZD) screened the title and abstract of candidate articles for potential articles, and a second reviewer (ZXL) separately read a random sample of titles and abstracts. After the full texts of potential studies had been obtained, two reviews (SZD and ZXL), working independently, evaluated and selected the articles according to the inclusion criteria for quality critical appraisal. Finally, a snowball search was done.

During the processes, any disagreements between the two reviewers were resolved through consensus. If consensus could not be reached, the third reviewer (HYY) was consulted for a final decision.

Quality critical appraisal

The quality of the selected studies was scored using a quality critical appraisal list for RCTs which was recommended by the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0 (Higgins & Green 2011). The list included six items on randomization, allocation concealment, blinding, dropout/attrition, intention-to-treat analysis and baseline comparability. The items on the list were rated as 'met', 'unmet' or 'unclear'. Because it would not be possible to use blinding of participants or persons delivering the interventions in educational studies, we modified the standards of qualified blinding. Proper single blinding of the outcome assessors was considered as 'met' for blinding in our review.

According to Higgins & Green (2011) for one candidate study, if all or most of the six criteria were met and the experiment design was very rigorous, its quality would be defined as A level, which stands for the low risk of bias. If one or more criteria were partly met, the article's quality would be defined as B level representing moderate risk of bias. If one or more criteria were not met, the article's quality would be defined as C level, which means high risk of bias. Considering that the high risk of bias would seriously weaken the confidence of the results, articles labelled as C level would be excluded.

The critical appraisal process was conducted by two independent reviewers (SZD and ZXL). The inter-rater agreement between the two reviewers would be calculated with Cohen's kappa (Cohen 1960). Agreement was resolved by consensus

meeting between the two reviewers. If disagreement persisted after consensus meeting, a third reviewer (HYY) made the final decision.

Data extraction and analysis

From all eligible studies, information about subjects, intervention (including program design method, program content, and whether interactive design was involved in) and comparison was extracted using a standardized extraction form. Thus, the details of the data were tabulated and analysed. The data extraction was conducted by two independent reviewers (SZD and ZXL) with discrepancies resolved through consensus.

In SR, an overall statistic can be reached by meta-analysis to summarize the effectiveness by integrating the results of several experiments, which will take a broader perspective in a meta-analysis than in a single experiment (Higgins & Green 2011). However, meta-analysis should only be performed when a group of studies is homogeneous enough in terms of subjects, interventions and outcomes to provide a meaningful summary; otherwise, a meaningless result will be obtained by 'bringing apples and oranges together' (Higgins & Green 2011). In our study, it was inappropriate to combine results across the studies due to the variability of interventions and outcome measures. Therefore, no meta-analysis was attempted (Higgins & Green 2011).

Results

Search process

The results of search process are presented in Supporting Information Fig. S1. The literature search of databases resulted in 403 potentially relevant articles. Excluded on duplicate, title and abstract were 332 articles, leaving 71 articles requested for full texts. With 2 studies that could not be found, 69 articles with full text were available. These retrieved articles were subsequently evaluated according to the inclusion criteria, with 61 articles excluded at this stage. Meanwhile, another one article was selected based on the snowball search (Fernández Alemán et al. 2011). As a result, nine studies were passed on to quality critical appraisal (Bloomfield et al. 2010; Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Horiuchi et al. 2009; Lu et al. 2009; Mäkinen et al. 2006; McMullan et al. 2011; Smeekens et al. 2011).

Critical appraisal of quality

According to the recommended standards in the Cochrane Handbook, we defined five studies as A quality level, and four studies as B quality level. Cohen's kappa for overall agreement between the reviewers was $K = 0.769$ ($P = 0.018$), which is considered to represent a substantial agreement (Landis & Koch 1977). Full agreement for all criteria ($K = 1.00$) was reached during the consensus meeting. The third assessor did not come into operation.

What should be specially addressed is that, among included nine studies, two RCTs (Lu et al. 2009; McMullan et al. 2011) applied the unit of allocation at the cluster level, rather than at the individual level to avoid contamination between experimental and the control groups.

The methodological quality of the nine studies is described in Table 1.

Characteristics of eligible RCTs included for analysis

A total of nine RCTs were considered eligible and included for analysis in this study (Bloomfield et al. 2010; Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Horiuchi et al. 2009; Lu et al. 2009; Mäkinen et al. 2006; McMullan et al. 2011; Smeekens et al. 2011). The information of their characteristics was listed in Table 2.

Overall, the included nine RCTs were from UK (2) (Bloomfield et al. 2010; McMullan et al. 2011), Taiwan, China (2) (Chiu et al. 2009; Lu et al. 2009), Finland (1) (Mäkinen et al. 2006), Japan (1) (Horiuchi et al. 2009), Thailand (1) (Gerdprasert et al. 2010), Spain (1) (Fernández Alemán et al. 2011) and the Netherlands (1) (Smeekens et al. 2011), respectively. The published dates of the nine studies ranged from 2006 to 2011.

Participants in five of the nine studies were students studying nursing courses at college or university (Bloomfield et al. 2010; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Lu et al. 2009; McMullan et al. 2011). The other four studies involved registered nurses (RNs) and midwives employed in hospital ward settings, including geriatric hospital (Mäkinen et al. 2006), neurological ward (Chiu et al. 2009), emergency department (Smeekens et al. 2011), and unspecified RNs or midwives with at least 1 year of clinical experience and presently working in a clinical area (Horiuchi et al. 2009). Demographics (e.g. age, gender, ethnicity and computer experience) were reported for all the nine studies.

A variety of nursing knowledge and clinical skills were investigated, including: basic life support including defibrillation [cardiopulmonary resuscitation-defibrillation (CPR-D)] (Mäkinen et al. 2006), assessment ability of neurological function (Chiu et al. 2009), evidence-based nursing (Horiuchi et al. 2009), intramuscular injection skill (Lu et al. 2009), handwashing theory and skills (Bloomfield et al. 2010), process and mechanism of labour (Gerdprasert et al. 2010), medical surgical

Table 1 Quality scores of the nine studies passed on to quality critical appraisal

Study	Random allocation	Allocation concealment	Blinding	Dropout/ attrition	ITT analysis	Baseline comparability	Quality level
Bloomfield et al. 2010	+	+	+†	+	−	+	A
Chiu et al. 2009	+	−	−	+	−	+*	B
Fernández Alemán et al. 2011	?	−	−	+	−	+	B
Gerdprasert et al. 2010	+	−	−	−	NA	+	A
Horiuchi et al. 2009	+	+	−	+	−	+*	A
Lu et al. 2009	+	−	−	+	−	+*	A
Mäkinen et al. 2006	?	−	+	+	−	+	B
McMullan et al. 2011	?	−	−	+	−	+	B
Smeekens et al. 2011	+	−	+	+	+‡	+	A

'+' = criteria 'met'; '−' = criteria 'unmet'; '?' = criteria 'unclear' (There is insufficient information to make a judgment of whether the item meets the criteria.)
A level represents the low risk of bias. (All or most of the six criteria were met and the experiment design was rigorous enough.) B level represents moderate risk of bias. (One or more criteria were partly met.)
ITT analysis, intention-to-treat analysis. NA: There was no dropout in the experiment, and ITT analysis is not applicable.
*As there were some significant differences in demographics between the experiment group and the control group, an independent sample of one-way analysis of covariance was used to control the confounding factor for data analysis.
†Handwashing skill performance was evaluated by trained examiners with blinding.
‡Both ITT with the pre-test score carried forward and a multiple imputation analysis were performed. As the results were not essentially altered by these analyses, the analysis of the participants who performed the post-test was presented.

nursing theory (Fernández Alemán et al. 2011), drug calculation (McMullan et al. 2011) and detection of child abuse (Smeekens et al. 2011).

Studies varied in size. The 9 RCTs, with sample size varying from 36 (Mäkinen et al. 2006) to 231 (Bloomfield et al. 2010), totally allocated 1125 participants, including 829 nursing students, 296 RNs and midwives.

The follow-up periods of the nine studies also varied, with 2 weeks (3) (Gerdprasert et al. 2010; Mäkinen et al. 2006; Smeekens et al. 2011), 4 weeks (or 1 month) (2) (Chiu et al. 2009; Horiuchi et al. 2009), 6 weeks (1) (Lu et al. 2009), 8 weeks (1) (Bloomfield et al. 2010), 10 weeks (1) (Fernández Alemán et al. 2011) and 12 weeks (1) (McMullan et al. 2011), respectively.

Comparative interventions
Eight studies compared web-based online education modality with conventional teaching methods such as face-to-face lecture and tutorial, skill demonstration, and handout support materials (Bloomfield et al. 2010; Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Horiuchi et al. 2009; Lu et al. 2009; Mäkinen et al. 2006; McMullan et al. 2011), and one study used blank control as comparator (Smeekens et al. 2011).

For experimental web-based learning modalities, all the included nine studies adopted free access to learning contents and participants were encouraged to visit the site as often as they wished. The participants in the experimental groups can access the course any time at their home or workplace. Most studies used asynchronous tools (e.g. text, video, pictures, multimedia, email, Bulletin Board) to accommodate learning needs. Two of the nine studies (Fernández Alemán et al. 2011; Lu et al. 2009) have also applied course module software, which were respectively named Wisdom Master version 2.4 (Sun Net Technology, Taipe, Taiwan) and Mooshak (http://mooshak.dcc.fc.up.pt/), which is a free and public system for managing programming contests on the web, acting as a full contest manager and automatic judge for answers of medical–surgical nursing problems (Fernández Alemán et al. 2011; Leal & Silva 2003).

Interaction is another important element in experimental programs. Among nine studies, there are seven experiments (7/9) that explicitly adopted interactive design to facilitate the online communication between students and teachers (Table 2). The interaction forms were presented in terms of email, Bulletin Board, chat room, and the teaching system such as Mooshak.

Evaluation of web-based distance learning for nursing education
The results of main outcome measures of nine eligible studies, including knowledge, skill performance, participants' satisfaction, and self-efficacy, are listed in Table 3.

Table 2 Data extraction of randomized controlled trials on distance web-based learning for nursing education

Study (country/year)	Subjects	Intervention — Instructional design	Interactive design	Content	Comparison
Bloomfield et al. UK/2010	231 first-year nursing students; experiment group: n = 118, control group: n = 113	Fully online course	No	Participants worked through a self-directed computer-assisted learning module via an individual computer terminal. Animated multimedia, high-quality photographs, links to relevant websites, and handwashing demonstration video were included.	Participants were taught in an on-campus clinical skills room by experienced nurse lectures.
Chiu et al. Taiwan, China/2009	129 nurses with neurological experience; experiment group: (ICAI group): n = 68, control group (IVLP group): n = 61	Fully online course	Yes	The average length of the ICAI is 50 min. The contents consist of professional information and website links. This instruction aimed to provide all of the narration, interaction, animation and video.	The 70-min IVLP was conducted by a neurologist and the course was based on the NIHSS instruction videotape.
Fernández Alemán et al. Spain/2011	116 second-year nursing students; experiment group: n = 54; control group: n = 62	Fully online course	Yes	Participants worked with Mooshak by watching videos, listening to recordings, reading text, looking at photographs and linking to relevant websites, whereas tutors answered questions through the textitMooshak interface. The judge was accessible 24 h a day from any personal computer connected to the Internet.	Conventional face-to-face lecture and demonstration
Gerdprasert et al. Thailand/2010	85 third-year nursing students undergoing midwifery practice. Experiment group: n = 42; control group: n = 43	Blended with lectures and tutorials	Yes	Based on the 5Es inquiry cycles, participants were supplemented with the web-based unit for 2 weeks. The unit also contained a web-board for posting questions and discussion.	The control group received only lecture and tutorial.
Horiuchi et al. Japan/2009	93 registered nurses or midwives; experiment group: n = 45, control group: n = 48	Fully online course	No	The program comprised a four-part series entitled 'how is EBN applied clinically' and the time required for each part was 30 min. The group required four classes within 1 month. The web-based learning group accessed the course at their home or workplace.	The control group received face-to-face lecture 90 min each per week for 4 weeks.
Lu et al. Taiwan, China/2009	168 second-year nursing students; experiment group: n = 84; control group: n = 84	Blended with class lectures and skills demonstration	Yes	Besides traditionally receiving intramuscular injection knowledge and skill, the group had access to a web-based course. Students were encouraged to access the course website and were able to email, post their questions and comment on the Bulletin Board, and interact in a chat room. The instructor could also monitor students' activities.	The group received the same classroom lectures and skills demonstration.
Mäkinen et al. Finland/2006	36 voluntary nurses working in a geriatric hospital; experiment group (Internet-based CPR-D course): n = 20, control group (traditional CPR-D course): n = 16	Fully online course	Yes	The content of the course has three self-directed stages: content by multimedia, a short written explanation of the multimedia, and links to the databases. The interactive part of the course is carried out by questions between the content pages. The group had free access to the course.	A trainer gave a 4-h CPR-D course to the traditional group.
McMullan et al. UK/2011	229 second-year diploma nursing students. For September cohort: experiment group: n = 92, control group: n = 45. For February cohort: experiment group: n = 58, control group: n = 34	Fully online course	Yes	An interactive, self-contained, Internet-independent e-learning PDF drug calculations package was developed for the program. The group received the e-drug calculations package via self-directed e-learning.	The group received traditional handout support materials.
Smeekens et al. the Netherlands/2011	38 nurses with permanent contract in emergency department. Experiment group: n = 19; control group: n = 19	Fully online course	Yes	The e-learning program contains simulations of clinical cases, video animations and interactive elements. Participants should complete the program in a minimum of 2 h during a 2-week period. Participants were allowed to access the e-learning program more often than the obliged 2 h after they obtained access.	Blank Control

CPR-D, cardiopulmonary resuscitation-defibrillation; ICAI, interactive computer-assisted instruction; IVLP, instructor-led videotaped learning program; NIHSS, National Institute of Health Stroke Scale; OSCE, Objective Structured Clinical Examination.

Table 3 Results of main outcome measures for eligible nine studies

Study/year	Knowledge	Skill performance	Satisfaction	Self-efficacy
Bloomfield et al./2010	No significant differences were detected between the scores of the two groups at immediate follow-up, 2-week follow-up and 8-week follow-up (all $P > 0.05$). No significant differences were detected between the score gains of the two groups at immediate to 2-week follow-up, immediate to 8-week follow-up, and 2- to 8-week follow-up (all $P > 0.05$).	At 2-week follow-up, the median scores for Exp and Ctr were 23 and 22, respectively, with no significant difference ($P = 0.415$). At 8-week follow-up, the median scores for Exp and Ctr were 23 and 22, respectively, with significant difference ($P = 0.024$).	–	–
Chiu et al./2009	There was an insignificant difference between the changes in Exp and Ctr ($P = 0.89$). After using one-way ANCOVA analysis, the Exp's score was significantly higher than that of Ctr ($P = 0.03$).	–	In 12 out of the 16 items of satisfaction scale, Exp scored higher than Ctr.	–
Fernández Alemán et al./2011	1. MSNK: Immediate follow-up test for Exp and Ctr of Group 1: $P = 0.33$; 10-week follow-up test for Exp and Ctr of Group 2: $P = 0.35$. 2. MSNK gain and retention: Exp achieved higher MSNK gain than Ctr at immediate follow-up. Ctr achieved a slightly higher MSNK retention than Exp at the 10-week follow-up.	–	All students (100%) reported they preferred to work at home by using the computer-assisted learning module *Mooshak*.	–
Gerdprasert et al./2010	The post-test scores of factual knowledge in Exp were significantly higher than those in the Ctr (51.00 ± 3.34 vs. 41.70 ± 5.56, $P < 0.001$).	–	Most students agreed that web-based learning unit was appropriate compared with textbooks (4.3 ± 0.69 vs. 4.12 ± 0.70).	–
Horiuchi et al./2009	The mean improvement scores for Exp and Ctr were 12.2 and 5.9, respectively, with no significant difference ($P = 0.35$).	–	Of the six items of course evaluation, five items were detected to be the similar satisfaction. Ctr was more satisfied with tutor support than Exp ($P = 0.03$).	–
Lu et al./2009	No significant difference on the knowledge gain ($P > 0.05$); however, when controlled for the confounding variables, the web-based course had positive effects for Exp ($P < 0.00$).	Exp had significantly higher post-test scores than Ctr (81.67 vs. 76.40, $P < 0.00$).	–	–
Mäkinen et al./2006	–	Exp performed worse than Ctr in CPR-D (median score 34 vs. 28, $P < 0.05$)	–	–
McMullan et al./2011	–	Students in Exp were more able to perform drug calculations than those of Ctr (September group: Exp vs. Ctr = 48.4% vs. 34.7%, $P = 0.027$; February group: Exp vs. Ctr = 47.6% vs. 38.3%, $P = 0.024$).	Students in Exp were more satisfied with the support materials than those in Ctr (29.6 ± 4.3 vs. 26.5 ± 6.1, $P = 0.001$).	For September group: No difference in self-efficacy for performing drug calculation between the two groups. ($52.5\% \pm 18.9$ vs. $43.3\% \pm 16.6$). For February group: Exp was more confident in performing drug calculations than Ctr ($56.7\% \pm 15.8$ vs. $45.8\% \pm 16.8$, $P = 0.022$).
Smeekens et al./2011	–	The total performance during post-test of the Exp was significantly better than that of the Ctr ($P = 0.022$).	–	Exp was reported with higher self-efficacy than Ctr (502 vs. 447).

Exp, experimental group; Ctr, control group; MSNK, medical–surgical nursing knowledge.

Effect of web-based distance learning on knowledge

Six of the included nine studies (6/9, 66.7%) (Bloomfield et al. 2010; Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Horiuchi et al. 2009; Lu et al. 2009) took knowledge gain and retention as one of the outcome measures. Among these studies, the study of Gerdprasert et al. (2010) explicitly showed that the post-test scores of factual knowledge in experimental group were significantly higher than those in the control group (51.00 ± 3.34 vs. 41.70 ± 5.56, $P < 0.001$). Both the studies of Chiu et al. (2009) and Lu et al. (2009) initially showed that there was no significant difference in knowledge gain between the two groups ($P = 0.89$ and > 0.05, respectively); however, after controlling the confounding variables, both the two RCTs revealed that the experimental group scores were significantly higher than those of the control group ($P = 0.03$ and < 0.00, respectively). In addition, there were two studies (Bloomfield et al. 2010; Horiuchi et al. 2009) in which the acquisition of nursing knowledge was similar between experimental and control groups, with insignificant difference. Specifically, Horiuchi et al. (2009) showed a positive trend for interactive computer-assisted instruction to increase the knowledge compared with videotaped instruction ($P = 0.35$), and in the study of Bloomfield et al. (2010) similar scores between the two groups were detected at immediate follow-up, 2-week follow-up, and 8-week follow-up, and similar score gains between the two groups were found at immediate to 2-week follow-up, immediate to 8-week follow-up, and 2- to 8-week follow-up. For the experiment performed by Fernández Alemán et al. (2011), no significant differences in medical–surgical nursing knowledge were found for both immediate follow-up and 10-week follow-up ($P = 0.33$ and 0.35, respectively). For knowledge gain and retention, the experimental group achieved a substantially higher knowledge gain than the control group at the immediate follow-up while the control group achieved slightly higher knowledge retention than experimental group at the 10-week follow-up.

Effect of web-based distance learning on skills performance

Five RCTs (5/9, 55.6%) (Bloomfield et al. 2010; Lu et al. 2009; Mäkinen et al. 2006; McMullan et al. 2011; Smeekens et al. 2011) focused on skill performance in the process of evaluation. Among the five studies, three RCTs (Lu et al. 2009; McMullan et al. 2011; Smeekens et al. 2011) explicitly illustrated that participants in the web-based group showed better skill performance scores than their peers in the control group ($P < 0.00$, $= 0.027$ and 0.024, and $= 0.022$, respectively). In the study of Bloomfield et al. (2010), the effects varied over the follow-up. At 2-week follow-up, the median scores for experimental group and control group were 23 and 22, respectively, with no signifi-

cant difference ($P = 0.415$); at 8-week follow-up, the median scores for experimental group and control group were 23 and 22, respectively, with a significant difference ($P = 0.024$). What should be noted is that Mäkinen et al. (2006) showed that participants receiving long-distance learning performed worse in CPR-D than those of the control group ($P < 0.05$).

Participants' satisfaction

Five studies (5/9, 55.6%) (Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Horiuchi et al. 2009; McMullan et al. 2011) evaluated participants' satisfaction with web-based distance learning. In four RCTs (Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; McMullan et al. 2011), participants showed their satisfaction at different levels. Both Gerdprasert et al. (2010) and McMullan et al. (2011) demonstrated that participants in web-based distance group scored higher in satisfaction scale than those of the control group. Fernández Alemán et al. (2011) showed that all students (100%) reported they preferred to work at home by using the computer-assisted learning module. In Chiu et al. (2009), in 12 out of the 16 items of satisfaction scale, the experiment group scored higher than control group, among which the difference of one item between the two groups reached a significant level ($P = 0.04$). In Horiuchi et al. (2009), of the six items of course evaluation, five items were found the similar satisfaction score between the two groups, and for the sixth item, control group was more satisfied with tutor support than experiment group ($P = 0.03$).

There are also some negative evaluations towards distance web-based learning modality, including lack of know-how for using the web-board, lack of supervision and communication, inadequate instruction, and uncertainty of the correction of acquired knowledge (Horiuchi et al. 2009; McMullan et al. 2011).

Participants' self-efficacy

There were two studies (2/9, 22.2%) (McMullan et al. 2011; Smeekens et al. 2011) that regarded self-efficacy as one of the outcome measures. In Smeekens et al. (2011), the experiment group reported higher self-efficacy score than the control group in detecting child abuse (502 vs. 447). In the experiment of McMullan et al. (2011), no difference in self-efficacy scores was found between the two groups for performing drug calculation in September group, while in February group the experiment group was more confident in performing drug calculations than the control group (56.7% ± 15.8 vs. 45.8% ± 16.8, $P = 0.022$).

Other considerations for web-based learning evaluation

There were also some negative feedbacks for web-based programs. First, hardware and software problems have been

reported as great concerns (Fernández Alemán et al. 2011; Lu et al. 2009). Learning module preparation for web-based learning takes much time and may need professional programmers. Second, students with inadequate information literacy may encounter difficulties in using the web-board for discussing and/or expressing ideas (Fernández Alemán et al. 2011; Gerdprasert et al. 2010). Third, higher dropout rate has been reported in experiment group than that of control group (Horiuchi et al. 2009).

Discussion and conclusions

Discussion

This study, to some extent, shows that web-based distance education may play a more encouraging role compared with conventional teaching strategy in nursing in terms of knowledge acquisition and retention, skill performance, and satisfaction rate, as well as self-efficacy in performing nursing skills. Specifically, for nursing knowledge acquisition and retention, all relevant six studies showed that web-based distance education has produced superior, or at least the same effects to traditional methods. For skill performance, four out of five relevant studies demonstrated better or equivalent performance for web-based learning compared with control group. For participants' satisfaction, most studies reported high satisfaction with web-based learning modality. For self-efficacy, two relevant RCTs (McMullan et al. 2011; Smeekens et al. 2011) showed that the new modality performed better in improving the mediated variable than the control group.

Many factors may explain such an advantageous conclusion. First, many participants have expressed their preference for web-based distance education for its great flexibility, learner independence and time efficiency (Bloomfield et al. 2010; Chiu et al. 2009; Gerdprasert et al. 2010; Horiuchi et al. 2009; Lu et al. 2009). Web-based education is believed to have the capacity to individualize learning by decentralizing the teaching process and facilitating learner independence and self-direction (Greenhalgh 2001). Second, web-based education makes it possible to present the content in text, video and audio formats, which can arouse the interest of the participants and help understand complex knowledge (Gerdprasert et al. 2010; Kenny 2002; Lu et al. 2009). Third, seven of the nine experiments (Chiu et al. 2009; Fernández Alemán et al. 2011; Gerdprasert et al. 2010; Lu et al. 2009; Mäkinen et al. 2006; McMullan et al. 2011; Smeekens et al. 2011) adopted interactive design via email, Bulletin Board and chat room, which can facilitate the communication between students and teachers. One example of such interactive web tools is Mooshak, a robust data management and communication system by which the students submit their answers to the judge, and the judge will send the response to the students (Fernández Alemán et al. 2011). Fourth, because of the connection to Internet or relevant websites, participants have access to more information (Gerdprasert et al. 2010). Lastly, web-based distance learning could create a non-threatening environment for students to express their opinions (Gerdprasert et al. 2010; Lu et al. 2009).

Participants in five of the nine studies were nursing students at college or university, rather than students of graduate programs. The result shows that experiments at graduate level are insufficient, thus calling for more such research.

There are also some negative viewpoints, including more technical and expense support in hardware and software, the dependence on participants' computer skills, and occasional high dropout rate. All these concerns should be considered in designing web-based nursing education programs.

As is illustrated above, some reviews have been performed in medical education. In summary, there was not enough evidence to show that web-based distance education is superior to traditional methods in terms of gains in learning or learners' satisfaction (Chumley-Jones et al. 2002) or in improving participants' clinical performance or patients' outcomes (Curran & Fleet 2005). Our study has added some positive evidence to describe the role of web-based distance education in nursing.

What should be noted is that no RCTs from USA were included. Considering the great contribution made by US organizations and authors, this search result was disconcerting. We speculated that maybe many achievements in web-based distance nursing education in USA have not reported in the format of RCT. In the future, we will pay close attention to such RCTs from USA and update our work in time by integrating new evidence from USA if possible.

Conclusion

In summary, our study has shown a positive role of web-based distance learning in nursing education. Generally, compared with control group, web-based distance education has equivalent, or even better effects in improving participants' knowledge and skills performance, and improving self-efficacy in performing nursing skills. Moreover, participants have expressed their high satisfaction towards online education.

Implications for practice

Web-based distance nursing education may have more encouraging effects than traditional modalities on participants' knowledge and skills performance, and participants are also satisfied with the new modality of teaching. It is advised to integrate Internet technology into conventional teaching. But

we should also keep cautious and avoid embracing the new modality hastily and arbitrarily. Researchers should continue to examine the best way to use web-based resources to optimize participants' outcomes and meet their learning needs, particularly in terms of interactive design, in-time technical support, and cost-effective, convenient and friendly use for nursing students at all levels and employed nurses, especially for graduate students. Experimental studies using comparable outcome measures are in demand to provide more evidence to examine the efficacy of web-based distance education, in which scientific theory frameworks are expected to be applied and developed.

Study limitations

The first limitation of this SR is the heterogeneity brought by combining the two different samples. We included both of them in the purpose of sketching the general picture of the role of distance education in nursing, which inevitably resulted in heterogeneity. The second concerns the limited number of RCTs evaluated. We found only nine eligible studies. Therefore, the conclusions should be cautiously interpreted and generalized. Third, databases searched in this review are limited to PubMed and Embase. However, studies have shown that PubMed (including MEDLINE and PreMEDLINE) and Embase are adequate for searching medical literature (Du et al. 2011; Smith et al. 1992; Zheng et al. 2008).

Conflicts of interest

The authors have no conflict of interest.

Author contributions

SD: Study design, literature review, literature search, critical appraisal of included papers, extraction of data, and manuscript preparation. ZL: Literature search, critical appraisal of included papers, extraction of data. SL: Study design and manuscript preparation. HY: Critical appraisal of included papers, extraction of data, and manuscript checking. GX: Study design and supervision, literature review, and manuscript preparation. HZ: Literature search and manuscript preparation. AW: Literature search.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Fig. S1 Flow chart of selection process

Appendix S1 Search strategy