

## Review Article

## Efficacy of e-technologies in improving breastfeeding outcomes among perinatal women: a meta-analysis

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## Abstract

A growing line of research has highlighted that e-technologies may play a promising role in improving breastfeeding outcomes. The objective of this review was to synthesise the best of available evidence by conducting a meta-analysis to evaluate whether e-technologies have had any effect in improving breastfeeding outcomes among perinatal women. The review was conducted using nine electronic databases to search for English-language research studies from 2007 to 2014. A 'risk of bias' table was used to assess methodological quality. Meta-analysis was performed with the RevMan software. The Q test and  $I^2$  test was used to assess the heterogeneity. The test of overall effect was assessed using z-statistics at  $P < 0.05$ . Of 1842 studies identified through electronic searches and reference lists, 16 experimental studies were selected after applying the inclusion and exclusion criteria. Half of the selected studies had a low risk of bias, from which a total of 5505 women in six countries in these studies were included. Meta-analyses revealed that e-technologies significantly improved exclusive breastfeeding initiation ( $z = 6.90$ ,  $P < 0.00001$ ), exclusive breastfeeding at 4 weeks ( $z = 2.12$ ,  $P = 0.03$ ) and 6 months ( $z = 3.2$ ,  $P = 0.001$ ), breastfeeding attitude ( $z = 3.01$ ,  $P = 0.003$ ) and breastfeeding knowledge ( $z = 4.54$ ,  $P < 0.00001$ ) in subgroup analyses. This review provides support for the development of web-based, texting messaging, compact disc read-only memory, electronic prompts and interactive computer agent interventions for promoting and supporting breastfeeding.

**Keywords:** e-technology, breastfeeding, perinatal women, meta-analysis.

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## Introduction

Electronic technologies (e-technologies) are a revolutionary development in health care services. E-technologies cover a diverse range of information and communication technologies (ICTs) applications for exchanging information and gaining knowledge (Davidesko *et al.* 2014). Such ICT applications include the use of web-based technologies (Huang *et al.* 2007; Hannula *et al.* 2014), mobile technologies (Jiang *et al.* 2014), compact disc read-only memory (CD-ROM)-

based technologies (Labarère *et al.* 2011), interactive computer agent (Edwards *et al.* 2013), electronic prompt (e-prompt; Bonuck *et al.* 2014), etc. The rapid increase in access to e-technologies, particularly web-based systems and mobile devices, is creating new opportunities to enhance functionality, connectivity and manageability. Over 40% individuals worldwide use the service of the Internet and over 95% of individuals worldwide have access to mobile phone services (International Telecommunication Union 2014). Significantly, Internet and mobile access are also high

and growing among the child-bearing demographics (aged 18–40; Doehmel 2012; Waring *et al.* 2014). Studies have shown that the majority of perinatal women have access to the Internet using a computer or mobile phone (Gao *et al.* 2013; Bensley *et al.* 2014). The use of the Internet or mobile phone as a source of education and supportive intervention regarding pre-natal and post-natal care has also become increasingly popular among perinatal women (Cormick *et al.* 2012; Gao *et al.* 2013).

Pregnancy is a unique life experience that evokes a range of emotions ranging from great joy and anticipation to crippling anxiety. These emotions provide a stimulus to use e-technology to search for pregnancy-related information and to seek support for breastfeeding through the development of social networks and self-help systems (Adolfsson & Jansson 2012; Bert *et al.* 2013; Bensley *et al.* 2014). These heightened emotions are likely to drive the demand for sharing experiences with others through instant connectivity, and the demand to seek professional consultation and reassurance. E-technologies thus possess an immense potential to enable perinatal women to communicate, track the progress and alleviate anxieties through interactive and professional consultations and psychological support (Pigott 2012; Song *et al.* 2013).

Breastfeeding (BF) has numerous benefits to mothers, children and communities (McCrary & Murray 2013; Salone *et al.* 2013). The World Health Organization (WHO) recommends that children be breastfed within an hour of birth, to be given exclusive BF up to 6 months, and to continue to be breastfed up to the age of 2 years (World Health Organization 2014). However, low rates of BF initia-

tion and early cessation of BF are prevalent in many countries. Thus, developing an effective programme to promote BF and provide support and intervention to breastfeeding women is essential (Pate 2009b). With the dawn of e-technologies, and worldwide access to instant cyber connectivity, the tradition model of face-to-face interventions needs to accommodate e-technologies into its functioning (Tripp *et al.* 2014). A systematic review showed that e-based interventions had a moderate effect on breastfeeding, whereas face-to-face interventions had very little to no effect on breastfeeding (Pate 2009b). Using e-technologies to deliver evidence-based interventions theoretically allow for the promotion of BF and support to women who are breastfeeding to be implemented with enhanced fidelity at lower cost, and without increasing demands on the time, or training needs, of health care professionals (O'Brien *et al.* 2014; Poorman *et al.* 2014). With the rapid development of e-technological interventions paralleled by the rapid increase in access to the Internet and mobile devices, can e-technologies play a role in promoting BF and providing support on BF to perinatal women?

The borderless nature of the Internet provides greater access to large numbers of people with a wide range of experiences from which women may pick and choose according to what suits them (Cowie *et al.* 2011). Internet-based interventions are an effective way to reach geographically diverse, as well as low-income, populations with similar needs or barriers to behavioural change (Bensley *et al.* 2014). Short message services (SMS) have the potential to affect behavioural change due to their efficiency, low cost and capability of disseminating health information to hard-to-reach populations (International

### Key messages

- The use of e-technologies as a source of education and supportive intervention during perinatal care has become increasingly popular among perinatal women.
- E-technologies significantly improved initiation of exclusive breastfeeding, exclusive breastfeeding at 4 weeks and 6 months, and attitudes about breastfeeding among perinatal women.
- Future studies may focus on randomised control trials with standardised breastfeeding as a successful indicator and exploring the outcomes of exclusive breastfeeding duration at 6 months.
- The following high-priority e-technologies should be considered as interventions to improve breastfeeding outcomes: web-based interventions, text messaging, CD-ROM, e-prompt and interactive computer agents.

Telecommunication Union 2014). The text messaging system offers psychological benefits and promotes health communication by providing health information and encouraging patient–provider communication among perinatal women (Song *et al.* 2013). The CD-ROM, based on laser technologies for writing and reading data, provides a way in which a large amount of multimedia training material can be transferred to users (Labarère *et al.* 2011). CD-ROM-based products can be linked with online information sources and this hybrid approach provides users with access to media-rich, up-to-date information (Laborde *et al.* 2007). An interactive computer agent is a computer-animated character who uses motivational interviewing techniques to provide information and support (Edwards *et al.* 2013). The agent provides a sense of continuity in applications that span long periods of time and incorporate diverse activities, media and modalities in supporting behavioural change (Zhang *et al.* 2014). E-prompts provide support and information in a reminder system that appears in the electronic medical records of patients during their medical visits (Bonuck *et al.* 2009). Each prompt includes 2 to 3 brief open-ended questions directed by the provider to the client to ascertain and clarify information (Bonuck *et al.* 2014).

Recent literature has witnessed a rise in the number of studies assessing the application of e-technology among perinatal women (Edwards *et al.* 2013; Jiang *et al.* 2014; Seguranyes *et al.* 2014). Some systematic reviews have been conducted among perinatal women regarding use of e-technologies to manage dietary and lifestyle (O'Brien *et al.* 2014), to promote health (Poorman *et al.* 2014) and to provide peer support (Niela-Vilén *et al.* 2014); however, only one systematic review has identified the effectiveness of the Internet on breastfeeding outcomes (Giglia & Binns 2014). Similarly, only one study (Huang *et al.* 2007) was found in this systematic review to support the effectiveness of the Internet on breastfeeding outcomes. Hence, further exploration in this area is recommended particularly in light of the rapid improvements in e-technologies globally. While meta-analyses are applied in relation to a wide range of study designs, those that address experimental designs are considered to represent the highest

strength of evidence, and this design has become more prevalent over the years (Pigott 2012). Hence, the time is ripe for conducting a meta-analysis to appraise the current status of efficacy studies and assess the gaps between research data and the perceived clinical validity of e-technology (Pigott 2012). The objective of this review was to synthesise the best of available evidence by conducting a meta-analysis to evaluate the efficacy of e-technologies in improving breastfeeding outcomes among perinatal women.

## Materials and methods

### Search strategy

This study was performed in accordance with the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher *et al.* 2009). Our search strategy is detailed in Appendix 1. The search strategy aimed to find published studies in the English language from 2007 to 2014. The year 2007 was selected as the start date as this decade has witnessed a dramatic shift in e-technology usage with perinatal women to promote breastfeeding (Huang *et al.* 2007). In order to ensure representativeness of the studies, a three-phase search strategy was used. First, a search in PubMed and Google Scholar was undertaken to identify the range and type of studies potentially available for synthesis. The keywords that were used to combine are 'e-technology,' 'internet-based,' 'web-based,' 'computer-based,' 'electronic health (e-health),' 'mobile health (m-health)' or 'telehealth' with 'breastfeeding.' Studies with reasonable potential were identified, and a decision was subsequently made to restrict the search for experimental studies.

The second phase involved searching in more databases including CINAHL, Medline, PsycINFO, Science Direct, Scopus, Web of Science, ProQuest Dissertations and Theses. For a more advanced search, additional keywords such as 'e-education,' 'e-learning,' 'videoconferencing,' 'SMS,' 'texting,' 'CD-ROM based,' 'virtual consultation' and 'exclusive breastfeeding initiation,' 'exclusive breastfeeding duration,' 'breastfeeding attitude,' 'breastfeeding knowledge,' 'breastfeeding awareness,' 'breastfeeding

intention,' 'breastfeeding assessment,' 'breastfeeding confidence,' 'breastfeeding satisfaction,' 'breastfeeding difficulty,' 'breastfeeding intensity,' 'coping with breastfeeding,' 'antenatal women,' 'postnatal women' and 'perinatal women' were included to maximise the scope of the search. The keywords were explored and truncated following the syntax rules of each database.

The third phase of the search involved screening the references of retrieved articles to find any articles that did not appear in the databases search. The bibliographical software package, EndNote version X7 (Thomas Reuters, New York, NY, USA), was used to manage all the references as it facilitates the importation of references and abstracts from studies obtained by the three-phase search process. All duplicate references were removed by the EndNote program and the remaining studies were assessed independently against the inclusion and exclusion criteria by two of the authors of this paper (LY and TP).

### **Inclusion criteria**

Studies that met all of the following criteria were included: (1) published, unpublished and ongoing experimental studies that were either randomised controlled trials (RCTs) or quasi-RCTs; (2) studies that involved e-technological interventions such as web-based/Internet-based, e-learning, e-education, e-prompt, CD-ROM-based, visual interactive computer agent, visual consultation or SMS/texting that offer BF information, support and consultation to perinatal women through health professionals; (3) studies involving interventions given either in the pre-natal, post-natal, combined prenatal and post-natal or period; (4) studies that used usual care as control group; (5) studies that explored the BF outcomes, namely exclusive BF initiation, exclusive BF duration, BF awareness, BF knowledge, BF attitudes, BF intention, BF confidence, BF satisfaction, BF difficulty, BF assessment, BF intensity or coping with BF.

### **Exclusion criteria**

We excluded studies if they (1) were before-after, cohort, cross sectional or qualitative studies; (2) used qualitative data as BF outcomes; (3) used

e-technological approach for data collection, screening, assessment or recording; (4) had abstracts only; (5) were conference papers; (6) involved non-human subjects; (7) were not published in English.

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

After identifying studies that fulfilled the selection criteria and verifying their eligibility by reading the completed articles, the studies were submitted for quality assessment. Two of the authors (LY and TP) independently assessed the overall risk of bias of each study using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins & Green 2011). The following indicators of internal validity specific to the methodology of a RCT were collected: (1) random sequences generation (selection bias); (2) allocation concealment (selection bias); (3) blinding of participants and personnel (performance bias); (4) blinding of outcome assessment (detection bias; patient-reported outcomes), (5) incomplete outcome data [attrition bias; short-term (2–6 weeks)], (6) incomplete outcome data [attrition bias; long-term (>6 weeks)]; (7) selective reporting (reporting bias; Higgins & Green 2011). Two independent reviewers assessed the likely magnitude and direction of the bias and whether it was likely to impact on the findings. Assessment related to the risk biases was assigned a judgment of 'low risk' of bias, 'high risk' of bias, or 'unclear risk' of bias. Full texts were obtained for all articles that were identified and judged. When any differences between the two authors occurred, it was solved by consensus.

### **Data extraction**

Two of the authors (LY and TP) extracted relevant data from all included articles. The following variables were extracted from each study using structured data extraction items based on three sets of variables (Pigott 2012): research characteristics, methodological variables and findings. The articles were compared by countries, design, e-technological intervention, participants, sample size in intervention and usual care groups, and BF outcomes. The two authors (LY and TP) then thoroughly reviewed the summary tables for

accuracy and relevance. If relevant data were missing, the authors of the articles in question were contacted for additional information.

### Data syntheses and analyses

Two of the authors (LY and TP) independently extracted, checked and entered the data using the RevMan software (Review Manager Version 5.3 for Windows from The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). All entries were compared and any disagreement was resolved by discussion. Dichotomous data was analysed using the Mantel-Haenszel (M-H) method; we calculated the relative risks (RR) with 95% confidence interval (CI) and produced forest plots. Continuous data were analysed using the inverse variance (IV) method, which then calculated the mean (M) and standard deviation (SD). The standardised mean difference (SMD) with their corresponding 95% CI was used to combine studies that measured the same outcomes with a different method. The test of overall effect was assessed using  $z$ -statistics at  $P < 0.05$ .

Heterogeneity between studies was evaluated using the Cochrane  $Q$  ( $\chi^2$  test) and  $I^2$  statistics. The statistical significance for heterogeneity using  $\chi^2$  test was set as  $P < 0.10$ . The  $I^2$  statistic was applied to describe the total variation in study estimates because of heterogeneity. Estimates of degree of heterogeneity using  $I^2$  were made by setting 0%, 25%, 50% or 75% for no, low, moderate and high heterogeneity respectively (Higgins *et al.* 2003). The fixed-effects model with weighting of the studies was used when there was a lack of significant heterogeneity ( $P > 0.10$ ), while the random-effects model with weighting of the studies was used when there was heterogeneity between studies ( $P < 0.10$ ) and  $I^2$  values of over 50% (Higgins *et al.* 2003). In case of  $I^2$  values of over 50% for the primary outcomes, sensitivity analyses were conducted to determine the reasons for heterogeneity. If substantial heterogeneity was identified, we investigated it using subgroup analyses and sensitivity analyses. Sensitivity testing to identify the effect of the subgroups was performed by subgroup analysis based on species studies. Subgroup analyses were used to compare the different

e-technologies on different BF outcomes. This was possible due to the similarities between subgroups and low levels of statistical heterogeneity.

### Results

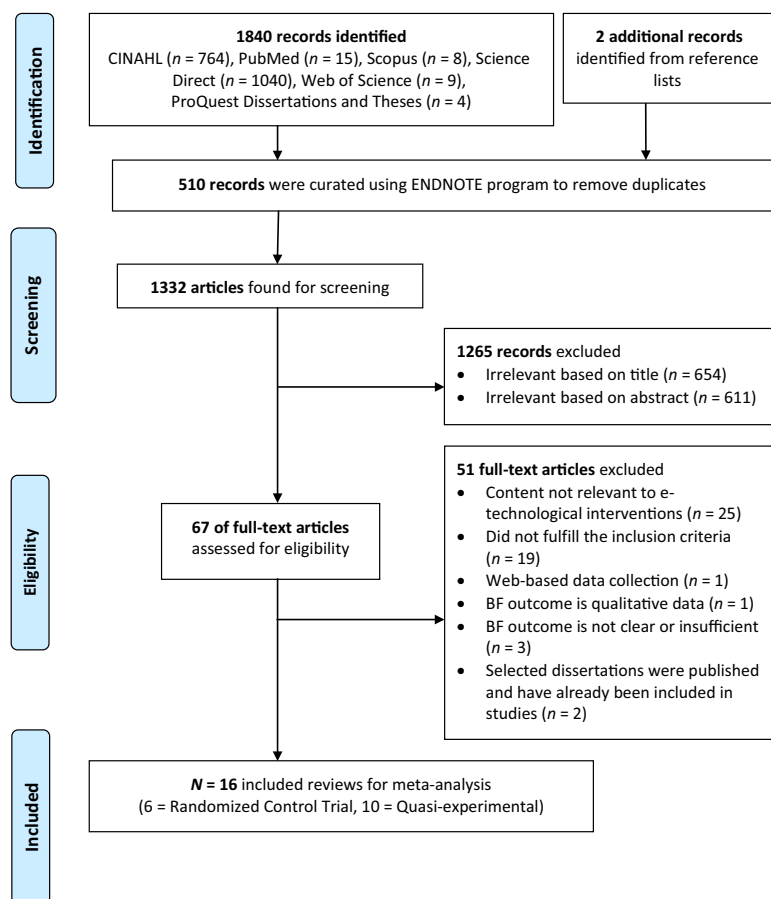
The selection process (PRISMA flow-diagram) is showed in Fig. 1. A total of 1842 records were identified from the initial database search and reference lists. Out of these studies, 510 articles were curated using EndNote to remove duplicates. Following this, 1332 were included for screening and 1265 articles were excluded based on an analysis of the text words contained in the titles and abstracts. Full text of 67 articles were retrieved, reviewed and selected based on relevance and quality for eligibility. A further 51 articles were excluded because of irrelevant content, unmet inclusion criteria, qualitative outcome, unclear or insufficient outcomes and two entire dissertations were published in peer review journals that have already been included in this review. Finally, 16 articles were selected for inclusion in this meta-analysis.

### Risk of bias in included studies

Details of the risk of bias of each study in the characteristics of included studies are presented in tables in Fig. 2 and graphically in Fig. 3. Eight out of 15 studies had adequate sequences generation for randomisation. Four of them had adequate allocation concealment. Four had implemented blinding; however, this blinding was only for outcome assessors. Four had implemented blinding of self-reported outcome assessment, and three had implemented blinding of objective outcome assessment. Thirteen of the studies addressed low risk bias concerning incomplete short-term (2–6 weeks) outcome data. Eleven of the studies addressed low risk bias concerning incomplete long-term (>6 weeks) outcome data. Fifteen of them had low risk bias for selective reporting.

### Description of studies under investigation

This meta-analysis included 16 articles with a total of 5505 participants conducted across six countries (Table 1) including America (Clark *et al.* 2009; Pate



**Fig. 1.** PRISMA flow chart of selection procedure.

2009a; Edwards *et al.* 2013; Scott 2013; Bonuck *et al.* 2014; Zhang *et al.* 2014; n = 6), Iran (Fahami *et al.* 2014; Mohamadirizi *et al.* 2014; n = 2), Finland (Salonen *et al.* 2008, 2014; Hannula *et al.* 2014; n = 3), China (Huang *et al.* 2007; Jiang *et al.* 2014; n = 2), France (Laborde *et al.* 2007; Labarère *et al.* 2011; n = 2) and Spain (Seguranyes *et al.* 2014; n = 1). Fourteen of them were published papers and two of them were unpublished theses. All the studies were conducted between 2007 and 2014, with year 2014 having the highest number of publications (n = 8). Six of the articles used RCT designs and 10 of them used quasi-experimental designs. The majority of the target populations (n = 15) were perinatal (antenatal and post-natal) women and only one study had child care providers as its target population (Clark *et al.* 2009). Majority (n = 12) of the articles was supported by research grants. The sample sizes were varied among

the 16 articles, ranging from 15 (Edwards *et al.* 2013) to 863 (Salonen *et al.* 2008), and 10 of them assessed more than one BF outcomes.

### Breastfeeding outcomes

Seven studies (Huang *et al.* 2007; Laborde *et al.* 2007; Salonen *et al.* 2008, 2014; Bonuck *et al.* 2014; Hannula *et al.* 2014; Seguranyes *et al.* 2014) assessed exclusive BF initiation. Five of them (Huang *et al.* 2007; Clark *et al.* 2009; Bonuck *et al.* 2014; Jiang *et al.* 2014; Seguranyes *et al.* 2014) assessed exclusive BF duration at 4 weeks, 6 weeks and 6 months. Five articles assessed BF attitudes; 3 of these 5 articles (Edwards *et al.* 2013; Scott 2013; Hannula *et al.* 2014) used the 17-item IOWA Infant Feeding Attitude Scale (IIFAS; de la Mora *et al.* 1999), one study (Huang *et al.* 2007) used the 26-item 5-point BF attitude scale (BAS; Teng



	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias) (Self-reported outcomes)	Blinding of outcome assessment (detection bias) (Objective outcomes)	Incomplete outcome data (attrition bias) (short-term [2-6 weeks])	Incomplete outcome data (attrition bias) (long term [≥6 weeks])	Selective reporting (reporting bias)
Bonuck et al 2014	+	+	+	+	+	+	+	+
Clark et al 2009	+	+	+	+	+	+	+	+
Edwards et al 2013	+	+	+	+	+	+	+	+
Fahami et al 2014	+	?	?	?	?	+	+	+
Hannula et al 2014	+	+	+	+	+	+	+	+
Huang et al 2007	+	+	+	+	+	+	+	+
Jiang et al 2014	+	+	+	+	+	+	+	+
Labarere et al 2011	+	+	+	+	+	+	?	+
Laborde et al 2007	+	+	+	+	+	+	+	+
Mohamadirizi et al 2014	+	?	+	+	+	+	+	+
Pate 2009	+	+	+	+	+	?	?	+
Salonen et al 2008	+	+	+	+	+	?	?	+
Salonen et al 2014	+	+	+	+	+	+	+	+
Scott 2013	+	+	+	+	+	+	+	+
Seguranyes et al 2014	+	+	+	+	+	+	+	+
Zhang et al 2014	+	+	?	?	?	+	+	+

Fig. 2. Risk of bias summary.

*et al.* 1997) and one study used a self-developed 13-item 5-point scale (Clark *et al.* 2009).

Four studies (Pate 2009a; Edwards *et al.* 2013; Hannula *et al.* 2014; Zhang *et al.* 2014) assessed BF confidence using the 14-item Breastfeeding Self-

Efficacy Scale Short-Form (BFSE-SF; Dennis & Faux 1999). Two studies assessed BF awareness using a self-developed 15-item 3-point scale (Fahami *et al.* 2014) and 50-item 3-point scale (Mohamadirizi *et al.* 2014). Two of them assessed BF knowledge using a 26-item, 3-point scale BF knowledge tool (BKT; Huang *et al.* 2007) and 1-item 7-point scale (Zhang *et al.* 2014). One study (Scott 2013) assessed BF intention using the 5-item, 5-point Infant Intention Scale (IFI; Nommsen-Rivers & Dewey 2009). One study (Hannula *et al.* 2014) assessed coping with BF using a self-developed 8-item 5-point scale. One study (Laborde *et al.* 2007) assessed BF assessment using a 5-item 3-point BF assessment score (BAS) with a BAS < 8 indicating a women was at risk of early weaning (Hall *et al.* 2002). One study (Labarère *et al.* 2011) assessed BF satisfaction and difficulty using a self-developed 1-item 2-point scale. One study (Bonuck *et al.* 2014) assessed BF intensity using a percentage of all feeding events in the past 7 days at 1, 3 and 4 months. Seven of 14 articles reported reliability and validity of BF measures.

### E-technological interventions

All the e-technological interventions found in this review are presented in Table 2. The e-technologies included seven web-based (Huang *et al.* 2007; Salonen *et al.* 2008, 2014; Clark *et al.* 2009; Pate 2009a; Scott 2013; Hannula *et al.* 2014), 2 CD-ROM-based (Laborde *et al.* 2007; Labarère *et al.* 2011), 2 e-education/learning (Fahami *et al.* 2014; Mohamadirizi *et al.* 2014), 3 virtual interactive approach (Edwards *et al.* 2013; Seguranyes *et al.* 2014; Zhang *et al.* 2014), one SMS (Jiang *et al.* 2014) and one e-prompt (Bonuck *et al.* 2014). The aims of interventions in all the studies were promoting ( $n = 6$ ), teaching ( $n = 4$ ), supporting ( $n = 8$ ) and consulting on ( $n = 6$ ) BF using an interactive approach occurring multiple times during the perinatal period. Providers of the intervention were midwives/nurses ( $n = 10$ ), dietitians ( $n = 2$ ), paediatricians ( $n = 2$ ), university staff ( $n = 3$ ) and peer counselors ( $n = 1$ ). The main target population were perinatal women ( $n = 15$ ) and only one study had child care providers as its target population (Clark *et al.* 2009). Content descriptions for the intervention about the

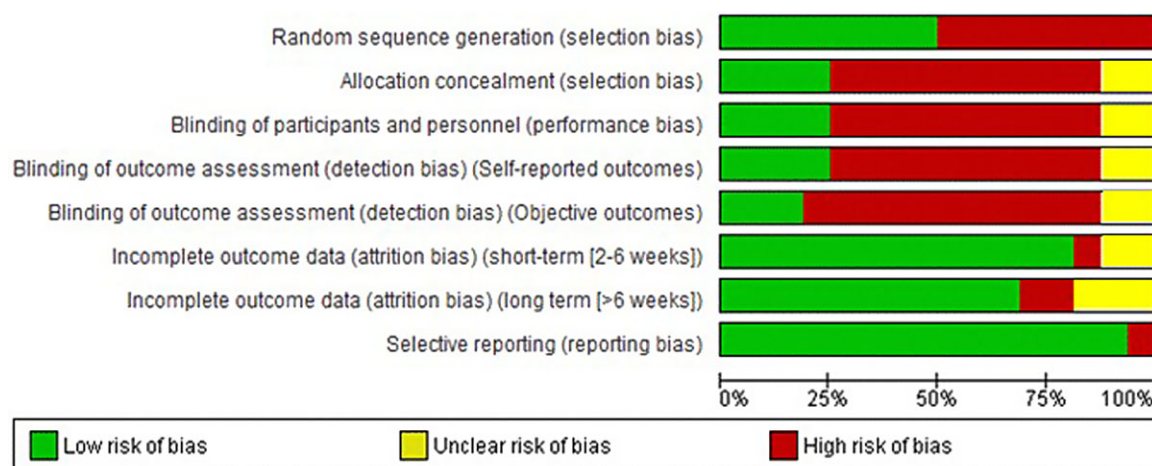


Fig. 3. Risk of bias graph.

multidimensional topics comprised benefits of BF ( $n = 7$ ), mechanism of BF ( $n = 1$ ), physiology of BF ( $n = 1$ ), BF preparation ( $n = 2$ ), BF techniques ( $n = 2$ ), BF problems management ( $n = 5$ ), BF consultation ( $n = 4$ ), BF empowerment ( $n = 3$ ) and BF peer support ( $n = 1$ ).

#### Efficacy of e-technologies on exclusive breastfeeding initiation

Seven studies assessed the efficacy of e-technological interventions among 4651 women using exclusive BF initiation as an outcome (Huang *et al.* 2007; Laborde *et al.* 2007; Salonen *et al.* 2008, 2014; Bonuck *et al.* 2014; Hannula *et al.* 2014; Seguranyes *et al.* 2014). Meta-analyses of these seven studies showed substantial heterogeneity ( $P < 0.00001$ ,  $I^2 = 97\%$ ). Sensitivity analysis detected three studies (Bonuck *et al.* 2014; Salonen *et al.* 2014; Seguranyes *et al.* 2014) that were mainly responsible for the heterogeneity. Thus, three subgroup analyses were performed because of the different nature of e-technologies used in these seven studies. Three subgroups analyses show the results of the meta-analysis of these seven articles using the M-H method and fixed-effects (Fig. 4). Two subgroup analyses of two studies (Salonen *et al.* 2008, 2014) and four studies (Huang *et al.* 2007; Laborde *et al.* 2007; Bonuck *et al.* 2014; Hannula *et al.* 2014) revealed that web-based, e-prompt and CD-ROM based inter-

ventions were significantly improved exclusive BF initiation (RR = 1.11–1.76,  $z = 2.81$ – $8.40$ ,  $P < 0.01$ ). However, visual consultation showed no impact on exclusive BF initiation among 683 women ( $z = 0.74$ ,  $P = 0.46$ ) in one study (Seguranyes *et al.* 2014). The heterogeneity for two studies ( $P = 0.39$ ,  $I^2 = 0\%$ ) and four studies ( $P = 0.42$ ,  $I^2 = 0\%$ ) were acceptable. A non-significant  $P$ -value for Cochrane Q statistic indicates that the included studies were homogeneous. The overall effect of e-technologies on exclusive BF initiation was significant ( $z = 6.90$ ,  $P < 0.00001$ ).

#### Efficacy of e-technology on exclusive breastfeeding duration

Five studies assessed exclusive BF duration at 4 weeks, 6 weeks and 6 months as outcomes of e-technological interventions among 2388 women (Huang *et al.* 2007; Clark *et al.* 2009; Bonuck *et al.* 2014; Jiang *et al.* 2014; Seguranyes *et al.* 2014). Three separated meta-analyses were performed because of three different BF duration in these five studies. Figure 5 show a pooled meta-analysis of two of the studies (Huang *et al.* 2007; Bonuck *et al.* 2014) and three of the studies (Clark *et al.* 2009; Bonuck *et al.* 2014; Jiang *et al.* 2014) that assessed exclusive BF duration at 4 weeks and 6 months as outcomes. Figure 5 shows that e-prompt and web-based interventions were significantly improving exclusive BF at



**Table 1.** Characteristics of included experimental studies

Authors (year)	Types of e-technologies	Country/setting	Research design	Participants	<i>n</i> <sub>exp</sub>	<i>n</i> <sub>con</sub>	BF Outcomes (Measures)	GS
Bonuck <i>et al.</i> (2014)	E-prompt	USA/prenatal care sites	Randomised control trial (RCT)	Pregnant women	236	77	Exclusive BF initiation Exclusive BF duration at 6 months BF intensity at 1, 3 and 6 months (% of all feedings in the past 7 days)	Yes
Clark <i>et al.</i> (2009)	Web-based	USA/child care centres	Quasi-experimental	Child care provider	23	15	Exclusive BF duration at 6 months attitude on infant feeding (self-developed 13-item 5-point scale)	Yes
Edwards <i>et al.</i> (2013)	Interactive computer agent	USA/hospital	RCT	Pregnant women in third trimester	7	8	BF attitudes (IIFAS: 17-item 5-point scale) Intent to exclusively BF for 6 months (self-developed 1-item 7-point scale)	Yes
Fahami <i>et al.</i> (2014)	E-education	Iran/hospital	Quasi-experimental	Post-partum women	36	36	BF confidence (BSES-SF 14-item 5-point scale) BF awareness (self-developed 15-item 3-point scale)	No
Hannula <i>et al.</i> (2014)	Web-based	Finland/hospital	Quasi-experimental	Pregnant women	431	274	Exclusive BF initiation Breastfeeding attitudes (IIFAS 17-item 5-point scale) Coping with BF (self-developed 8-item 5-point scale) BF confidence (BSES-SF 14-item 5-point scale)	Yes
Huang <i>et al.</i> (2007)	Web-based	Taiwan/hospital	Quasi-experimental	Pregnant women in third trimester	60	60	Exclusive BF initiation Exclusive BF duration at 6 weeks BF attitudes (BA: 26-item 5-point scale) BF knowledge (BKT: 27-item 3-point scale) Exclusive BF duration at 6 months	No
Jiang <i>et al.</i> (2014)	SMS	China/community health centres	Quasi-experimental	Pregnant women in third trimester	265	284	BF difficulties (self-developed 1-item 2-point scale) BF satisfaction (self-developed 1-item 2-point scale) Exclusive BF initiation	Yes
Labarère <i>et al.</i> (2011)	CD-ROM based	France/maternity units	Quasi-experimental	Post-partum women	240	259	BF difficulties (self-developed 1-item 2-point scale) BF satisfaction (self-developed 1-item 2-point scale) Exclusive BF initiation	Yes
Laborde <i>et al.</i> (2007)	CD-ROM based	France/hospital	Quasi-experimental	Post-partum women	435	115	BF duration (week) BF assessment (BAS: 5-item 3-point scale) BF awareness (self-developed 50-item 3-point scale) Breastfeeding confidence (BSES-SF 14-item 5-point scale)	Yes
Mohamadirizi <i>et al.</i> (2014)	E-learning	Iran/health care centre	Quasi-experimental	Pregnant women in first trimester	50	50	BF awareness (self-developed 50-item 3-point scale) Breastfeeding confidence (BSES-SF 14-item 5-point scale)	Yes
Pate (2009a)	Web-based	USA/health department	RCT	Pregnant women	23	23	Exclusive BF initiation	No
Salonen <i>et al.</i> (2008)	Web-based	Finland/hospital	Quasi-experimental	Mothers	469	394	Exclusive BF initiation	Yes
Salonen <i>et al.</i> (2014)	Web-based	Finland/hospital	Quasi-experimental	Pregnant women	433	327	Exclusive BF initiation	Yes
Scott (2013)	Web-based	USA/maternity clinics	RCT	Pregnant women	49 (web only)	50	BF attitudes (IIFAS: 17-item 5-point scale) BF intention (IFI: 5-item 5-point scale) Exclusive BF initiation	No
Seguranyes <i>et al.</i> (2014)	Virtual consultation	Spain/health care centres	RCT	Post-partum women	121	638	Exclusive BF initiation Exclusive BF duration at 6 weeks	Yes
Zhang <i>et al.</i> (2014)	Virtual agent	USA/hospital	RCT	Pregnant women in third trimester	7	10	BF confidence (BSES-SF 14-item 5-point scale) BF knowledge (self-developed 1-item 7-point scale)	Yes

E, electronic; SMS, short message service; CD-ROM, compact disc read-only memory; BF, breastfeeding; IIFAS, Iowa Infant Feeding Attitude Scale Short Form; BA, breastfeeding attitude; BAS, breastfeeding assessment score; BKT, breastfeeding knowledge tool; GS, grant support.

**Table 2.** Description of different e-technological interventions

Author (year)	Types of e-technologies	Aims	Providers	Frequency	Duration	Content description
Bonuck <i>et al.</i> (2014)	E-prompt	To promote and support BF through e-prompt using Internet technology	University staff	Multiple	Antenatal to post-partum 6 months	Topics: BF intention, BF knowledge clarification in order to increase BF duration. Mode: social network support.
Clark <i>et al.</i> (2009)	Web-based	To provide educational materials and practice information about infant feeding using website	Dietitians	Multiple	3 months	Topics: different types of infant feeding and child care-specific information. Mode: assigned website.
Edwards <i>et al.</i> (2013)	Interactive computer agent	To motivate antenatal women to consider BF during hospitalisation using a computer agent	University staff	Multiple	Prenatal visit and during the hospital stay at birth	Topics: BF information, benefits of BF and problem solving. Mode: motivational interviewing (MI) techniques by computer animated female (computer agent).
Fahami <i>et al.</i> (2014)	E-education	To educate breastfeeding through multimedia software packages	Midwives	Multiple	Post-natal period (2 weeks duration)	Topics: BF benefits, composition of breast milk, skills, and handling BF. Mode: combined text, graphics, animation, sound, images, animation, and digital video (camcorder, VCR player, video or TV).
Hannula <i>et al.</i> (2014)	Web-based	To support breastfeeding using web-based service	Midwives	Multiple	Antenatal to first week post-partum	Topics: six themes for mother, fathers, infants, life, support and problem solving. Mode: articles, pictures, videos, and educational game.
Huang <i>et al.</i> (2007)	Web-based	To teach BF knowledge, enhance skills and increase breastfeeding behaviour using a web-based education program	Midwives	Multiple	Antenatal to 6 weeks post-partum	Topics: composition of breast milk, benefit, mechanism, techniques, problem and solutions. Mode: text, static graphics, animations, interactive flash animations, audio, videos, etc.
Jiang <i>et al.</i> (2014)	SMS	To promote BF feeding practices through SMS messages	Maternal and child health care staff	Multiple	Antenatal to post-partum 12 months	Topics: BF preparation, response to problems of BF initiation, encouragement for exclusively BF, adaptation to work environment and continuing BF, adopting appropriate infant feeding practices. Mode: weekly SMS messages.
Labarère <i>et al.</i> (2011)	CD-ROM based	To provide information on how to initiate and maintain breastfeeding using CD-ROM program	Paediatrician, Midwives	Multiple	Hospital discharge to post-partum 24 weeks	Topics: 12 modules include evidence, physiology, recommendations problem management, special circumstances, working mothers and resources. Mode: animation and video sequences.
Laboree <i>et al.</i> (2007)	CD-ROM based	To deliver support to overcome barriers to BF using multimedia	Paediatrician, Midwives	Multiple	Hospital discharge to post-partum 24 weeks	Topics: breastfeeding supportive information. Mode: CD-ROM player and Internet technologies.
Mohamadirizi <i>et al.</i> (2014)	E-learning	To increase BF awareness with the use software	Health care Providers, Midwives	Multiple	Antenatal period (4 to 6 weeks duration)	Topics: health, nutrition, medication, benefits, family planning and neonatal care. Mode: online (web pages) or offline (FLV, WMV and MP4).
Pate (2009b)	Web-based	To promote and support optimal breastfeeding practices using websites	Peer counselor	Multiple	Antenatal period (6 weeks duration)	Topics: benefits of BF, myths and facts of BF, peripartum information, tips for successful BF, expectation after first week post-partum, tips for mom: vitamins and fluoride. Mode: via email weekly or by directing mothers to websites.
Salonen <i>et al.</i> (2008)	Web-based	To offer online information and support BF, parenting, and infant care	Nurses	Multiple	Antenatal to hospital discharge	Topics: six themes for mother, fathers, infants, life, support and problem solving. Mode: using web service and trained nurses and midwives, and online answering services.
Salonen <i>et al.</i> (2014)	Web-based	To offer online information and support BF, parenting and infant care	Nurses	Multiple	Antenatal to post-partum 12 months	Topics: parenting, BF and infant care. Mode: information database, online peer discussion forum and question/answer service.
Scott (2013)	Web-based	To increase BF through the use of web-based educational support program	Dietitian	Multiple	Antenatal period (6 weeks duration)	Topics: BF benefits, BF attitude, BF early weeks, BF and work or school, BF challenges. Mode: via accessing BF education websites for both web and text group and receiving two text messages per week for text group
Seguranyes <i>et al.</i> (2014)	Virtual consultation	To assess and support BF using videoconference	Midwives	Multiple	Hospital discharge to post-partum 6 weeks	Topics were fed according to individual needs. Mode: the women could consult midwives by videoconference or telephone hot line from their home.
Zhang <i>et al.</i> (2014)	Virtual agent	To promote and support BF among new mothers using a virtual agent	University staff	Multiple	Antenatal to post-partum 6 months	Topics: three modules include health benefits for the baby and the mothers, initial BF attempts. Mode: lactation consultant referral and time-based information using agent dialogue, discussion, video, homework assignment, etc.

BF, breastfeeding; E, electronic; SMS, short message service; CD-ROM, compact disc read-only memory.

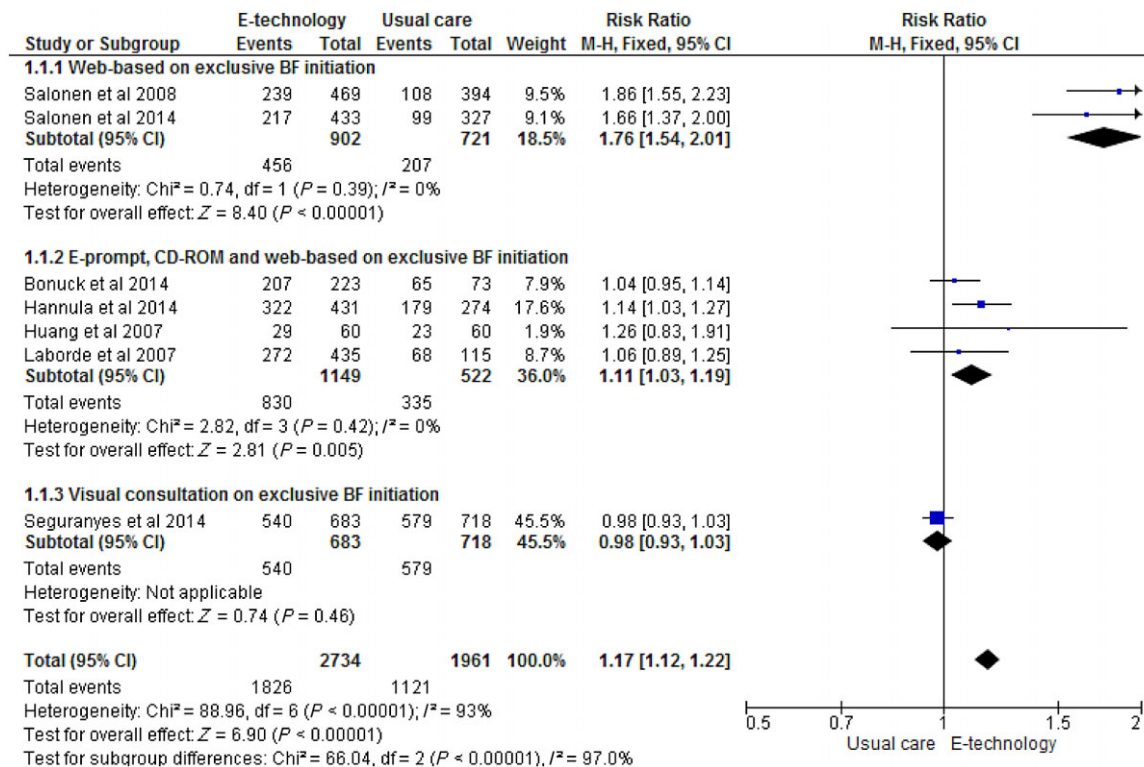


Fig. 4. Efficacy of e-technologies on exclusive BF initiation.

4 weeks ( $RR = 1.72$ , 95% CI 1.04 to 2.84,  $z = 2.12$ ,  $P = 0.03$ ). Similarly, e-prompt, web-based interventions and SMS were significantly improving exclusive BF at 6 months ( $RR = 2.23$ , 95% CI 1.36–3.65,  $z = 3.2$ ,  $P = 0.001$ ) as shown in Fig. 5. However, web-based and visual consultation interventions demonstrated no significant difference in exclusive BF events at 6 weeks compared with usual care ( $RR = 1.01$ , 95% CI 0.88–1.17,  $z = 0.20$ ,  $P = 0.84$ ) in two studies (Huang *et al.* 2007; Seguranyes *et al.* 2014). The pooled meta-analysis of three separated meta-analyses were homogeneous ( $I^2 = 0$ ,  $P > 0.10$ ).

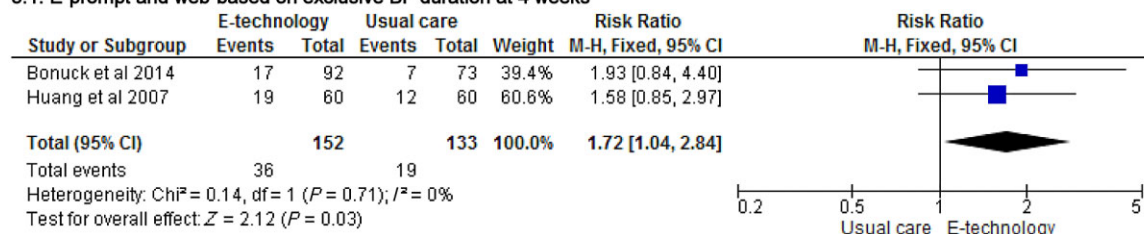
#### Efficacy of e-technology on breastfeeding awareness, knowledge, attitude and confidence

Five articles assessed the efficacy of e-technological interventions among 952 women on BF attitudes (Huang *et al.* 2007; Clark *et al.* 2009; Edwards *et al.* 2013; Scott 2013; Hannula *et al.* 2014) but no SD score of the IIFAS was reported in one study (Clark *et al.*

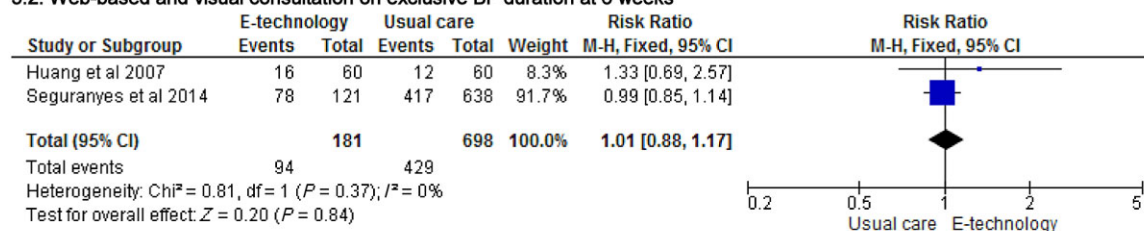
2009) so there was insufficient data for meta-analysis. The authors of the study were contacted but no feedback on the additional data was received. In this study's meta-analysis of the remaining four studies (Huang *et al.* 2007; Edwards *et al.* 2013; Scott 2013; Hannula *et al.* 2014), interactive computer agent and web-based interventions were found to have a significant effect on improving BF attitude scores among 937 women ( $SMD = 0.20$ , 95% CI 0.07–0.33,  $z = 3.01$ ,  $P = 0.003$ ) using the IV method and fixed-effects model ( $I^2 = 36\%$ ,  $P = 0.20$ ) as shown in Fig. 6.

Two studies assessed the efficacy of e-technological interventions among 172 women using BF awareness as outcome (Fahami *et al.* 2014; Mohamadirizi *et al.* 2014; Fig. 6). Two studies assessed the efficacy of e-technological interventions among 111 women using BF knowledge as outcome (Huang *et al.* 2007; Zhang *et al.* 2014). Web-based and virtual agent had a significant effect on BF knowledge scores ( $SMD = 0.94$ , 95% CI 0.53–1.34,  $Z = 4.54$ ,  $P < 0.00001$ ) as shown in Fig. 6. Four articles (Pate 2009a; Edwards

### 5.1. E-prompt and web-based on exclusive BF duration at 4 weeks



### 5.2. Web-based and visual consultation on exclusive BF duration at 6 weeks



### 5.3. E-prompt and web-based and SMS on exclusive BF duration at 6 months

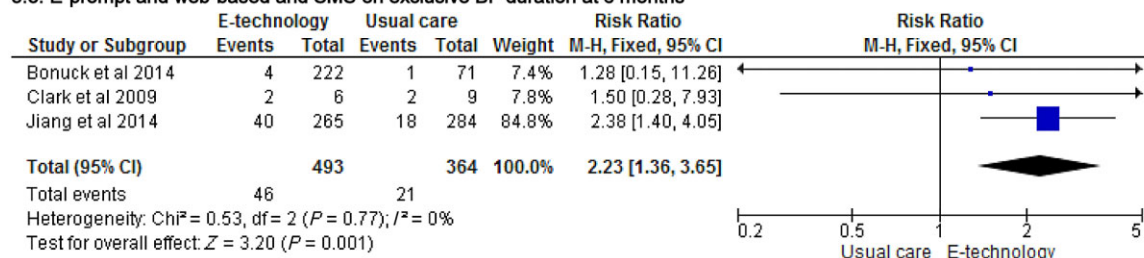


Fig. 5. Efficacy of e-technologies on exclusive BF duration.

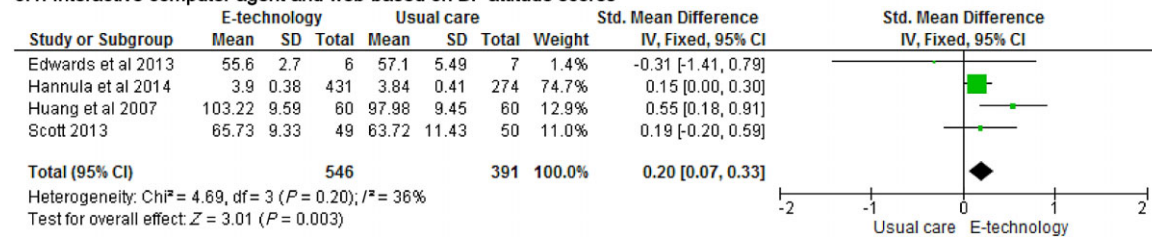
*et al.* 2013; Hannula *et al.* 2014; Zhang *et al.* 2014) assessed the efficacy of e-technological interventions using BF confidence as outcomes, but one of them could not provide sufficient data because the SD of the Self-Efficacy Scale Short-Form scores had been omitted in the reporting (Edwards *et al.* 2013). The pooled meta-analysis of two studies (Fahami *et al.* 2014; Mohamadirizi *et al.* 2014) on BF awareness scores and another three studies (Pate 2009a; Hannula *et al.* 2014; Zhang *et al.* 2014) on BF confidence showed high heterogeneity ( $I^2 = 67\%$  to  $98\%$ ,  $P < 0.05$ ). Random-effects models with weighting of these studies were chosen instead of the fixed-effect models (Fig. 6). Non-significant differences in BF awareness scores ( $\text{SMD} = 2.51$ ,  $95\% \text{ CI } -0.93$  to  $5.94$ ,  $z = 1.43$ ,  $P = 0.15$ ) was found between e-education/e-learning intervention and usual care (Fahami *et al.* 2014; Mohamadirizi *et al.* 2014). Likewise, there was no significantly improvement on BF confidence

scores ( $\text{SMD} = 0.31$ ,  $95\% \text{ CI } -0.23$  to  $0.85$ ,  $z = 0.12$ ,  $P = 0.26$ ) among web-based and usual groups (Pate 2009a; Hannula *et al.* 2014; Zhang *et al.* 2014).

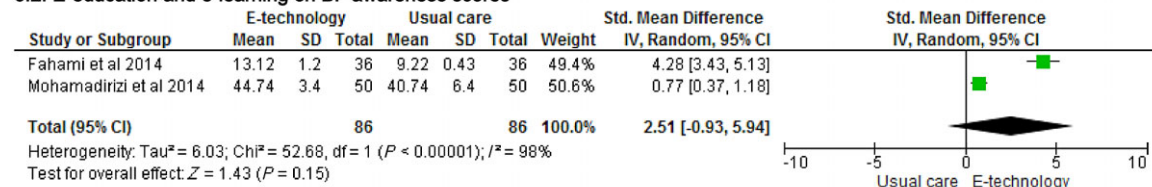
### Efficacy of e-technologies on other breastfeeding outcomes

Five selected studies (Laborde *et al.* 2007; Labarère *et al.* 2011; Scott 2013; Bonuck *et al.* 2014; Hannula *et al.* 2014) assessed eight different individual BF outcomes as shown in Table 3. Women who had  $\text{BAS} < 8$  were at significant risk of early weaning ( $P < 0.05$ ; Hall *et al.* 2002), with more women in the usual care group than the e-technology group having a  $\text{BAS} < 8$  (Laborde *et al.* 2007). However, there was no significant difference between the e-technology and usual groups in BF intention scores ( $P > 0.05$ ) (Scott 2013), coping with BF scores (Hannula *et al.* 2014), BF satisfaction or difficulty events (Labarère *et al.* 2011), and

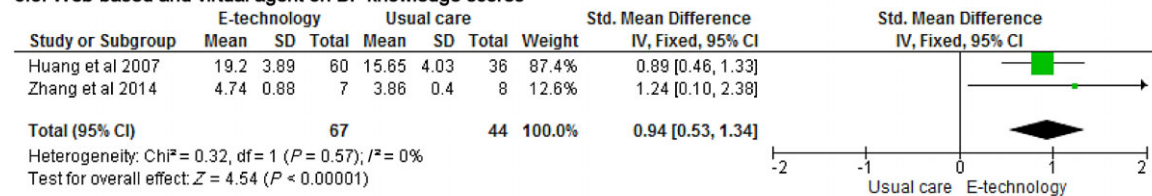
## 6.1. Interactive computer agent and web-based on BF attitude scores



## 6.2. E-education and e-learning on BF awareness scores



## 6.3. Web-based and virtual agent on BF knowledge scores



## 6.4. Web-based on BF confidence scores

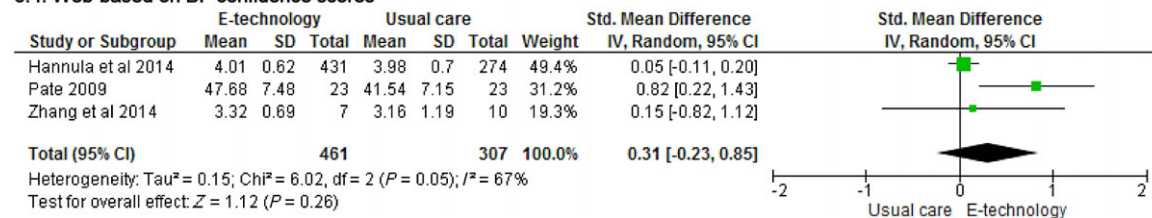


Fig. 6. Efficacy of e-technologies on BF attitude, BF awareness, BF knowledge and BF confidence scores.

Table 3. Efficacy of e-technologies on nine unique BF outcomes in included five studies

Authors (year)	BF outcomes	E-technology		Usual Care		RR/MD	95% CI	z	P-value
		Events/M	Total	Events/M	Total				
Laborde <i>et al.</i> (2007)	BF assessment	151	435	60	115	0.67	0.54, 0.83	3.67	0.0002***
Labarère <i>et al.</i> (2011)	BF satisfaction	216	240	236	259	0.99	0.93, 1.05	0.43	0.67
	BF difficulty	141	240	142	259	1.07	0.92, 1.25	0.88	0.38
Bonuck <i>et al.</i> (2014)	BF intensity at 1 month	17	73	42	223	1.24	0.75, 2.03	0.84	0.40
	BF intensity at 3 months	6	74	27	229	0.69	0.30, 1.60	0.87	0.39
	BF intensity at 4 months	3	73	10	227	0.93	0.26, 3.30	0.11	0.91
Scott (2013)	BF intention	10.71 (4.77)	49	10.38 (4.92)	50	0.33	-1.58, 2.24	0.34	0.73
Hannula <i>et al.</i> (2014)	Cope with BF	3.79 (0.67)	431	3.86 (0.7)	274	-0.07	-0.17, 0.03	1.32	0.19

M (SD), mean (standard deviation); RR, risk ratio; MD, mean difference; z, z-statistics. \*\*\* $P < 0.001$ .



BF intensity at 1, 3 and 4 months (Bonuck *et al.* 2014). Despite the identified outcomes, only one study for each BF outcome had limited generalisability. Thus, more studies are needed before firm conclusions can be made regarding the efficacy of e-technologies in improving targeted breastfeeding outcomes.

## Discussion

### Summary of main results

In the meta-analysis, data from 16 experimental studies totalling 5505 women in six countries was included. All 16 studies examined e-technological intervention versus usual care. All the interventions in these studies were designed to promote, teach and support BF during perinatal period. The intervention topics were multidimensional, comprising topics such as benefit, mechanism, physiology, preparation, techniques, problem management, consultation, empowerment and peer support related to BF. Exclusive BF initiation, exclusive BF duration, BF attitudes and BF knowledge were the four main BF outcomes among the pooled studies. The meta-analysis revealed that web-based technologies significantly improved exclusive BF initiation, exclusive BF duration, BF attitudes and BF knowledge (Huang *et al.* 2007; Salonen *et al.* 2008, 2014; Clark *et al.* 2009; Scott 2013; Hannula *et al.* 2014). Studies that assessed the efficacy of e-prompts showed a significant positive effect of e-prompts on exclusive BF initiation and duration (Bonuck *et al.* 2014). One-way text-messages (Jiang *et al.* 2014), CD-ROM based (Laborde *et al.* 2007) and interactive computer agents (Edwards *et al.* 2013; Zhang *et al.* 2014) were found in these studies to significantly improve exclusive BF duration, exclusive BF initiation, BF attitudes and BF knowledge, respectively. As most of other BF outcomes (BF awareness, BF intention, BF satisfaction, BF difficulty, BF assessment, BF intensity or coping with BF) had been studied in only one study, the findings of this single study could not contribute meaningful data in our meta-analysis.

### Quality of the evidence and potential biases

Although 16 studies were included in this study, only 15 studies with a combined sample size of 5006

women provided data for meta-analysis. Out of these 15 studies, one study had a unique BF outcome (Labarère *et al.* 2011). Moreover, there were wide variations in the nature of e-technologies, as well as in the reported BF outcomes, among the studies. Therefore, the internal validity of the results of this review is limited. The review process recommended by PRISMA statement (Moher *et al.* 2009) and Cochrane Handbook for Systematic Reviews of Interventions (Higgins & Green 2011) were followed strictly. All relevant studies were obtained and identified from the search results. All potential relevant studies were independently reviewed and resolved disagreement by discussion. If the methods or results of the studies were unclear, the authors were contacted, but only half of them provided additional data or clarified their study methods.

The overall methodological quality of the studies included in the review was mixed; 50% of the studies used methods to randomly assign women to either the intervention or usual group using methods were at low risk bias. This result was due to the selection criteria for either RCTs or quasi-RCTs. Thus, half of them prevented selection bias and insured against accidental bias. Only 25% of the studies achieved adequate allocation concealment. Therefore, participants or providers could possibly foresee assignments to introduce selection bias. A potentially important source of bias in this meta-analysis was 25% of the studies that achieved blinding of participants and personnel. For support interventions, studies would face considerable difficulties in blinding providers and women to an e-technology group. Thus, majority of women would have information bias. Only 25% and 18.75% of the studies achieved effective blinding of self-reported and objective outcomes respectively, perhaps owing mainly to the nature of the interventions. Even where there was an attempt made to blind outcome assessment would be still be a high risk of response bias for outcomes relying on self-report and objective outcomes. Hence, majority of women might harbour favorable expectation or increased apprehension in e-technology group, or they might feel deprived or relieved in usual group. The overall impact of sample attrition had a low risk bias in the majority of the studies that could improve

generalisability of findings and reduce systematic bias. More than 90% of the studies reported primary and secondary outcomes that have been reported in the pre-specific way. Consequently, the selected studies were not getting misleading results.

### **Web-based on exclusive breastfeeding initiation, duration, attitude and knowledge**

Web-based technologies found significantly improved exclusive BF initiation (Salonen *et al.* 2008, 2014), exclusive BF duration (Huang *et al.* 2007), BF attitudes (Huang *et al.* 2007; Scott 2013; Hannula *et al.* 2014) and BF knowledge (Huang *et al.* 2007). The pattern of result in this review appears to be consistent with a previous review paper that e-technology had positive effect on breastfeeding (Pate 2009b). The advantages of Internet connectivity for perinatal women include portability, timeliness, efficiency, scalability and having few limitations due to geography or mobility (Wade *et al.* 2010). The Internet increases access to the health benefits of BF (Huang *et al.* 2007), BF knowledge clarification (Bonuck *et al.* 2014), improves women's BF confidence (Hannula *et al.* 2014), strengthens women's satisfactions (Laborde *et al.* 2007; Salonen *et al.* 2008) and provides better social support (Salonen *et al.* 2008). Successful long-term BF depends on positive attitudes and a successful start (Jessri *et al.* 2013). Having a positive maternal attitude towards breastfeeding is essential for increasing the likelihood of women initiating and continuing to exclusively breastfeed (Ho & McGrath 2010; Dai *et al.* 2013). Therefore, web-based interventions have been effective in improving BF outcomes because of the significant relationships among BF attitude, BF knowledge, exclusive BF initiation and BF duration.

### **E-prompt on exclusive breastfeeding initiation and breastfeeding duration**

This review showed a significant positive effect of e-prompts on exclusive BF initiation and duration in one selected study (Bonuck *et al.* 2014). E-prompt is based on literature showing that providing support and information to prenatal women affects their plans on feeding infants, which in turn affects their behav-

iours on feeding (Dusdieker *et al.* 1985). E-prompts are structured electronic reminders with brief, open-ended questions that prompt busy prenatal care providers to promote BF among perinatal women (Bonuck *et al.* 2009). E-prompt offers scheduled, ongoing visits integrated into routine care rather than providing support only when women actively seek help (Bonuck *et al.* 2014). The study by Bonuck and colleagues (2014) found that women who received e-prompts from health care providers portraying BF as the norm, and ascertaining and clarifying women's understanding of current BF knowledge between five antenatal visits reported e-prompts to be effective in supporting and sustaining their endeavours to BF (Bonuck *et al.* 2014). However, only one study on e-prompt intervention had been in this review and further studies are thus necessary before such findings can be generalised.

### **Short message services on exclusive BF duration**

One-way text-messages were found significantly improved exclusive BF duration (Jiang *et al.* 2014) in our review. Mobile technologies complement health coaching by enabling individuals and coaches to maintain multiple channels of contact via remote monitoring, and voice and text message communications (Cormick *et al.* 2012). Text messages have become a routine and inexpensive method of communication around the world (International Telecommunication Union 2014). The use of SMS potentially provides unprecedented precision in supporting health-related behaviours as it facilitates responses to immediate needs and serves to maintain communication consistency (Song *et al.* 2013). A recent systematic review also showed that text message interventions are effective in promoting smoking cessation, diabetes control, adherence to medical consultation appointments and medication, weight loss, and vaccine uptake among perinatal women (Poorman *et al.* 2014). Text messages should link women with existing infrastructure to support and sustain BF behaviour. Further exploration on the efficacy of one-way or two-way messaging interventions on BF outcomes through large-scale RCT in different regions is warranted.

### **Compact disc read-only memory based on breastfeeding initiation**

Analyses showed CD-ROM-based intervention significantly improves exclusive BF initiation (Laborde *et al.* 2007). CD-ROM is a widely available and affordable media that can help to overcome some of the barriers to delivering effective support to BF mothers (Laborde *et al.* 2007). CD-ROMs can simulate self-study using multimedia with the presence or remote support of health care providers (Labarère *et al.* 2011). Multimedia technologies constitute a widely available resource that provides women with information on BF-related topics tailored to suit a broad range of informational needs (Laborde *et al.* 2007). The main advantages of CR-ROM-based intervention is that such interventions engage the learner in an interactive manner using animation and video sequences to illustrate BF initiation, positioning, and latch-on (Labarère *et al.* 2011). Thus, women who use CD-ROM training packages are more likely to initiate BF.

### **Interactive computer agent on breastfeeding attitude and breastfeeding knowledge**

The outcomes of present meta-analysis showed interactive computer agents had positive effects on BF attitudes (Edwards *et al.* 2013) and BF knowledge (Zhang *et al.* 2014). Interactive computer agents play the role of instructor, cheerleader and confidant using a wide range of pedagogical and motivational techniques, and media in its counselling sessions with perinatal women (Zhang *et al.* 2014). Computer agents provide an interpersonal continuity of care by maintaining the women-and-agent dialogue and relationship as an anchor during the months-long intervention (Edwards *et al.* 2013). Antenatal women who were satisfied and confident with the use of the computer agent BF support system were found to improve their BF attitude scores (Edwards *et al.* 2013) and BF knowledge scores (Zhang *et al.* 2014) after intervention.

### **Limitations**

There are several limitations to this review. Firstly, this review included only studies published in English, all

of which were conducted in developed regions with high access to the Internet or mobile. Therefore, the results may not be applicable to marginalised groups in developing regions. Secondly, because of the heterogeneity of the included studies, the subgroup analyses performed prevented drawing definitive conclusions about the efficacy of e-technologies. Subgroup analyses may pose significant interpretation problems such as false-positive or false-negative results (Rothwell 2005; Wang *et al.* 2007) and these may have over- and/or under-represented the effects of e-technologies on BF outcomes. Thirdly, majority of the research in this review were quasi-experimental designs with insufficient control of extraneous variables that might diminish the internal validity of the findings. Although WHO recommends that a successful standardised BF indicator to be preferably at 6 months after birth (World Health Organization 2014), only three studies (Clark *et al.* 2009; Bonuck *et al.* 2014; Jiang *et al.* 2014) included in this review had used BF duration at 6 months as the BF outcome. Furthermore, the absence of a specific marker for the measurement of BF outcomes was also problematic and the literature is fraught with studies that have used a variety of indicators for BF success. As a result, it was very difficult to pool studies for stronger evidence.

### **Implications for future research**

Our review highlights the limitations of data in existing studies that prevent definitive conclusions about the efficacy of e-technological intervention. It is clear that there is a need to continue research in this area to develop effective e-technological interventions that promote exclusive BF. Future studies should focus on RCT with standardised indicators for BF success, which is defined by WHO as exclusive BF duration for 6 months (World Health Organization 2014). The design of e-technological interventions needs to be guided by theory to improve the success of interventions. Meta-analysis also found that video-conferencing, e-learning and e-teaching did not improve BF outcomes; further investigations are needed to quantify the effects of each, and a combination of, e-technological applications in different regions. This is especially true in view of the lack

of current research exploring which elements of e-technology are most effective. The discrepancies in the indicators used to measure BF success may explain why we did not find a consistent effect of e-technologies on exclusive BF. This highlights the need for further research to be more consistent in their methodologies and measurements.

### Clinical implications

E-technology may function as important extensions of the range of services provided by health care professionals to individuals to enhance individuals' access to support with BF especially between consultation visits. It may enable more widespread dissemination of evidence-based care to a broader audience in a wide array of settings and models of care than is currently possible with traditional models alone (Pate 2009b). Based on the findings of this study, web-based interventions, text messaging, CD-ROM, e-prompts and interactive computer agents should be considered high-priority e-technologies in designing interventions to improve BF outcomes. BF interventions should capitalise on the use of these e-technologies in the most beneficial way. The cost of implementation of e-technological intervention is relatively minimal once it has been developed (O'Brien *et al.* 2014). Interventions delivered over the e-technology are likely to cost less than face-to-face, which requires frequent contact with health care personnel (Frances *et al.* 2006) and their relatively low delivery cost could result in e-technology being more cost effective (Tate *et al.* 2009). Although e-technology reduce cost, are convenient for users and overcome geography, the balance between the use of e-technology and face-to-face contact should be carefully considered in circumstances where women require extra face-to-face breastfeeding support (Frances *et al.* 2006). The ubiquity of technologies facilitates dissemination of information and support to a broader audience and at the same time allows for information and support to be tailored according individual characteristics and experiences (Poorman *et al.* 2014). Users can access and review content at any time and at their own pace. Multimedia features and interactivity can accommodate different learning styles (Bert *et al.* 2013). Data

visualisation capabilities and cloud computing offer accessible display of outcome information, flexible dissemination channels within and between service settings, and ready access to collaborative communication and shared resources for consumers and providers (Davidesko *et al.* 2014). E-technology will continue to become increasing popular as the cost of transportation increases and the cost of technology decreases, and more technologically literate women will use these feasible and promising methods to increase access to BF service everywhere (Macnab *et al.* 2012). Furthermore, Facebook presence (Bensley *et al.* 2014), utility of blogs (West *et al.* 2011) and Global Positioning System (Ismaeel & Hamead 2014) are another advancing wave of technological development that might potentially help map out new avenues to promote and support exclusive BF for at least 6 months among perinatal women.

### Conclusion

The rising popularity of e-technology may indicate a shift from the traditional model of care towards an e-technology-based health model. Web-based interventions, text messaging, CD-ROM, e-prompts and interactive computer agents may introduce entirely new approaches of promoting BF to perinatal women both within and outside formal systems of care. Despite limitations to the current review and analysis, this study's findings have identified a need for future research to employ RCT designs to examine the efficacy of e-technology on the outcomes of exclusive BF. The findings of this review also suggest that web-based interventions, text messaging, CD-ROM, e-prompts and interactive computer agents may improve exclusive BF initiation, exclusive BF duration, BF attitudes and BF knowledge. Given the benefits of exclusive BF for both infants and mothers, research into interventions that extend exclusive BF to 6 months is urgently needed.

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## Conflicts of interests

The authors declare that they have no conflicts of interest.

## Contributions

LY, TP and KY designed the research; LY and TP conducted the research; LY and TP analysed the data; TW provided significant advice on data analysis; LY wrote the paper and assumes primary responsibility for the final content of the paper. KY read and approved the final paper.

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## Appendix I. Search strategy to identify experimental studies on the efficacy of e-technologies in improving breastfeeding outcomes among perinatal women

First phase				
Intervention		Outcomes		Population
<i>Databases</i>				
PubMed, Google scholar				
<i>Text terms</i>				
'e-technology' OR 'internet-based' OR 'web-based' OR 'computer-based' OR 'electronic health (e-health)' OR 'mobile health (m-health)' OR 'telehealth'	AND	'breastfeeding' OR 'breast feeding'	AND	'antenatal women' OR 'postnatal women' OR 'perinatal women'
Second phase				
<i>Databases</i>				
CINHAL Medline, PsycINFO, Science Direct, Scopus, Web of Science, ProQuest Dissertations and Theses				
<i>Text terms</i>				
'e-education' OR 'e-learning' OR 'videoconferencing' OR 'SMS' OR 'Texting' OR 'CD-ROM based' OR 'virtual consultation'	AND	'exclusive breastfeeding initiation' OR 'exclusive breastfeeding duration' OR 'breastfeeding attitude' OR 'breastfeeding knowledge' OR 'breastfeeding awareness' OR 'breastfeeding intention' OR 'breastfeeding assessment' OR 'breastfeeding confidence' OR 'breastfeeding satisfaction' OR 'breastfeeding difficulty' OR 'breastfeeding intensity' OR 'coping with breastfeeding'	AND	'antenatal women' OR 'postnatal women' OR 'perinatal women'
Third phase				
Screening the references of retrieved articles from reference lists				