EFFECT OF INTERNET-BASED LEARNING IN PUBLIC HEALTH TRAINING: AN EXPLORATORY META-ANALYSIS

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ABSTRACT

Internet-based learning is increasingly applied in medical education, but its effect in the field of public health training is still unclear. This meta-analysis was undertaken to explore the impact of Internet-based learning on students/professionals' knowledge of public health compared with no intervention and with traditional face-to-face (FTF) formats. Two reviewers independently searched Medline, Web of Science, ProQuest, Google scholar, ERIC and Elsevier databases for relevant studies between 1st January, 1990 and 30th December, 2016. Studies in English language providing information on educational outcomes after Internet-based training in public health courses compared with no-intervention or a pre-intervention assessment, or with FTF control group were retrieved, reviewed, and assessed according to the established inclusion/exclusion criteria in the current study. There were 16 eligible studies with 1183 participants in total. Heterogeneity in results was detected across studies. A random effects model was used to pool effect sizes for knowledge outcomes. The pooled effect size (standardized mean difference, SMD) in comparison to no intervention was 1.92 (95% CI: 1.05 to 2.78; P<0.0001), favoring Internet-based interventions. Compared with FTF formats, the pooled effect size was 0.39 (95% CI: -0.06 to 0.83; P=0.09). The study suggested that Internet-based learning was superior to no-intervention in improving students/professionals' public health knowledge. Compared with traditional FTF formats, Internet-based learning showed a similar effect.

KEYWORDS

Internet-based learning; Public health training; Meta analysis

1. INTRODUCTION

Internet-based learning, which has been defined as using the Internet to deliver and access learning materials, to interact with peers and instructors and to enhance knowledge and performance (Wutoh et al. 2004), is increasingly applied in medical education over the past few decades. Compared to traditional learning approach, Internet-based learning has advantages in satisfying an extensive range of learning needs and permitting flexible learning transcending time and space (Cook et al. 2010; Greenhalgh 2001). Its growing spread has led to discussion, research, and debate over the effect of Internet-based learning compared with traditional face-to-face (FTF) instruction and no-intervention (Choules 2007; Greenhalgh 2001; Hemans-Henry et al. 2012).

Quantitatively summarizing these evidences could increase statistical power and is more convincible to inform educators and learners about the extent to which the Internet-based learning is effective. Currently, the reviews concerning the effect of Internet-based learning in medical education have mostly focused in the field of clinical medicine or basic medicine (Cook et al. 2008; Lahti et al. 2013; Lewis 2003). Cook DA and his colleagues reported positive results in their meta-analysis comparing Internet-based intervention to no-intervention in clinical medicine (Cook et al. 2008). Lahti M et al. reported that Internet-based learning is as good as traditional learning methods in nursing courses in a review (Lahti et al. 2013).

However, so far there is no quantitative pooling to estimate the effect of Internet-based learning in the field of public health. As Internet-based learning is a new field, interventions are not yet clear. According to the previous meta-analysis (Cook et al. 2008; Lahti et al. 2013), we expect large heterogeneity of studies, especially of intervention. Two meta-analyses were conducted in the present study, the first exploring Internet-based compared with no intervention or pre-intervention assessment, and the second summarizing the studies comparing Internet-based and traditional FTF instructional methods.

2. MAIN RESULTS

2.1 Data Sources

To identify the relevant studies, Medline, Web of Science, ProQuest, Google scholar, ERIC and Elsevier databases were searched. Key search terms included delivery concepts (such as "Internet, OR Web OR computer OR distance OR online" AND "learning OR instruction OR education OR training"), study design concepts (such as "evaluat* OR compar* OR pretest OR effect*"< * is a truncation symbol for searching. For instance, evaluat* would retrieve entries containing the words: evaluate, evaluation, or evaluative, etc>), and educational topics "public health/education [mesh]". To complement the search strategies, keyword searching of Google scholar was also conducted. The reference lists of retrieved articles were reviewed to identify any additional publication. More details on the search strategies were available upon request from the authors.

2.2 Search Results

The search strategy identified 709 studies from the databases. A review of the reference lists of the retrieved studies identified additional 13 potentially relevant articles. Out of the 722 publications, 109 potentially eligible articles were read in full text for further assessment. From these, 22 were considered appropriate for inclusion. After that, six studies were excluded due to insufficient data for coding quantitative outcomes. Thus a total of 16 studies were included in the quantitative analyses, among which four studies compared the Internet-based learning with both no intervention and traditional FTF instruction (Abdelhai et al. 2012; Hugenholtz et al. 2008; McGready and Brookmeyer 2013; Smits et al. 2012). Therefore 12 studies were contributed to meta-analysis of no-intervention comparison (Abdelhai et al. 2012; Aggarwal et al. 2011; Chung et al. 2004; Curioso et al. 2008; Farel et al. 2001; Hugenholtz et al. 2008; McGready and Brookmeyer 2013; Ried 2010; Sears et al. 2008; Smits et al. 2012; Steckler et al. 2001; Zahner 2006), and 8 contributed to meta-analysis of traditional FTF instruction comparison (Abdelhai et al. 2012; Campbell et al. 2008; Evans et al. 2007; Fayram and Anderko 2009; Hugenholtz et al. 2008; McGready and Brookmeyer 2013; Rose et al. 2000; Smits et al. 2012). The search flow was shown in figure 1.

2.3 Study Characteristics

The included 16 studies were published between 2000 and 2016. Table 1 summarizes key characteristics of the included studies. The sample size of the included studies varied from 13 to 138 participants, and the total number was 1183. Besides one study conducted in Egypt (Abdelhai et al. 2012), one in India (Aggarwal et al. 2011), the remaining 14 studies were in Europe and North America, including two in Netherlands (Hugenholtz et al. 2008; Smits et al. 2012), one in the United Kingdom (Campbell et al. 2008), one in Canada (Sears et al. 2008), and ten in the United States (Chung et al. 2004; Curioso et al. 2008; Evans et al. 2007; Farel et al. 2001; Fayram and Anderko 2009; McGready and Brookmeyer 2013; Ried 2010; Rose et al.

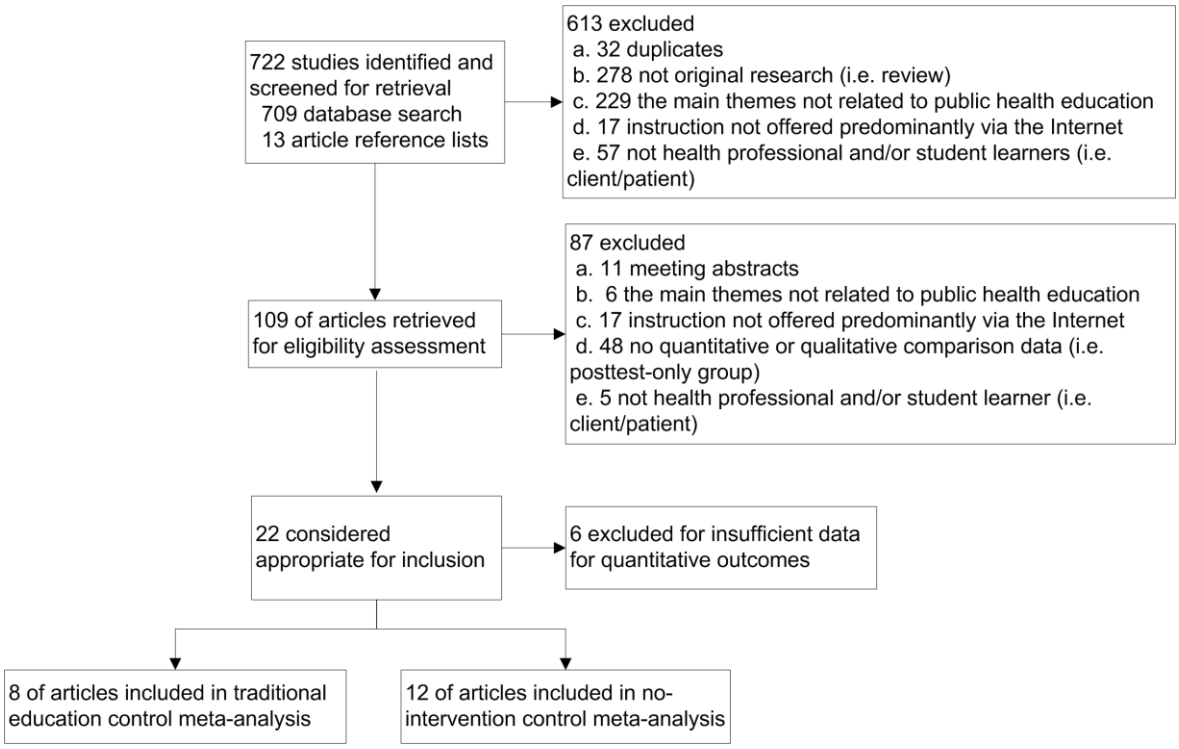

Figure 1. Flow diagram

2000; Steckler et al. 2001; Zahner 2006). Besides biostatistics and epidemiology courses (6/16), topics such as occupational health, community health, reproductive health, tobacco and public health, and quantitative and qualitative research methods were also addressed. In addition, review of the selected articles revealed big variations in the Internet-based education modalities, including tutorial, videoconference, case study and online discussion with peers and/or instructors, et al.

2.4 Quantitative Data Synthesis of No-Intervention Comparison

Twelve studies were included in the analysis (Fig 2). The pooled effect size of 1.92 (95% CI: 1.05 to 2.78, P<0.0001) significantly reflected a large effect according to Cohen's criteria (Cohen 1992), which suggested that Internet-based learning has a substantial benefit on learners' knowledge compared with no-intervention. However, there were large inconsistency across studies (I^2=97%), and individual effect sizes ranged from 0.10 to 5.41. The test of funnel plot asymmetry indicated publication bias among studies (Egger's test P=0.003). We executed sensitivity analyses by sequential omission of individual studies to reflect the influence of the individual data on the pooled effect size and evaluate the stability of the findings. The results demonstrated that the sensitivity analyses would not considerably affect the conclusion.

Subgroup analyses were further performed and categorized by study design, methodological quality scale, and instructional design aspects to explore the sources of inconsistency. The effect sizes showed consistently positive number (favoring Internet-based learning) when conducting each subgroup analysis respectively, although some of the results became statistically insignificant (undergraduate degree courses, duration less than 1 week, absence of exercise, and with single access to course materials)(Table 2).

Table 1. Characteristics of the included study

Study characteristic	No-intervention control		Traditional instruction control	
	No. of studies	No. of participants	No. of studies	No. of participants
All studies	12	951	8	865
Design				
pre-posttest, 2 group	4	633	4	633
posttest, 2 group	0	0	4	232
pre-post, 1 group	8	318	0	0
Quality Newcastle scale				
≧4 points	9	558	5	493
≦3 points	3	393	3	372
Country				
USA	7	368	4	266
Netherlands	2	200	2	200
Egypt	1	295	1	295
Canada	1	59	0	0
UK	0	0	1	104
India	1	29	0	0
Degree				
undergraduate	3	527	3	474
graduate	3	225	5	391
not mentioned	6	199	0	0
Object				
student	4	665	4	612
professionals	8	286	4	253
Duration				
≧1 week	7	625	5	620
< 1 week	3	259	2	200
not mentioned	2	67	1	45
Exercise				
present	9	766	5	582
absent	3	185	3	283
Discussion				
present	5	536	4	569
absent	7	415	4	296

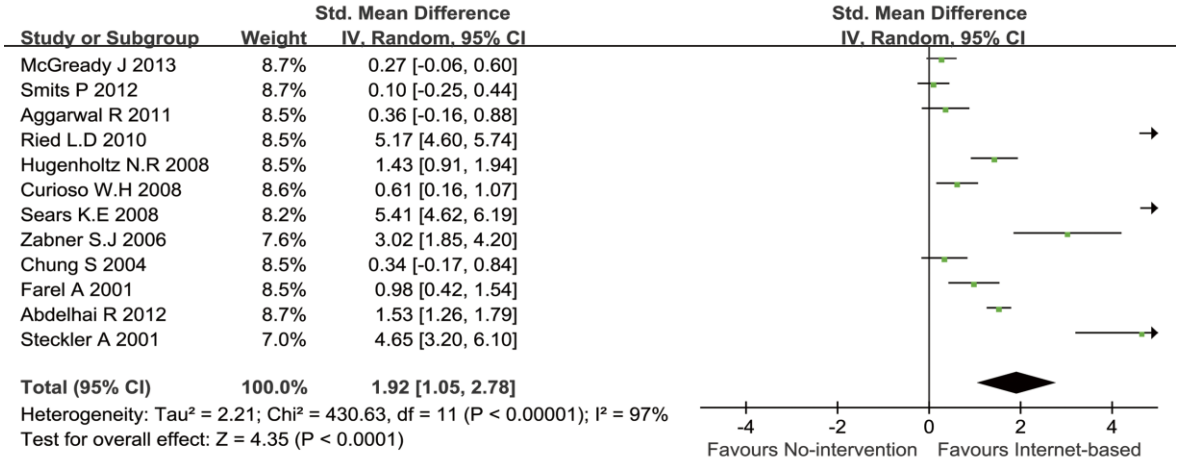

Figure 2. Forest plot for no-intervention control meta-analysis

Table 2. Pooled effect sizes (standard mean difference, SMD) for subgroup meta-analyses of Internet-based learning vs. no-intervention

Subgroup	No. of studies	No. of participants	SMD (95%CI)	I2	p-value
All studies	12	951	1.92(1.05, 2.78)	97%	<.0001
Design					
Pre-posttest, 2 group	4	633	0.82(0.05, 1.60)	95%	.05
Pre-posttest,1 group	8	318	2.53 (1.01, 4.05)	98%	
Quality Newcastle-scale					
≧4 points	9	558	1.74 (0.68, 2.80)	97%	.51
≦3 points	3	393	2.48 (0.53, 4.42)	97%	
Degree					
undergraduate	3	527	2.25 (-0.01, 4.51)	99%	.93
graduate	3	225	1.91 (0.35, 3.48)	95%	
not mentioned	6	199	1.74 (0.43, 3.05)	97%	
Participant					
student	4	665	1.75 (0.11, 3.39)	98.9%	.79
professionals	8	286	2.01 (0.93, 3.09)	96%	
Duration					
≧1 week	7	625	2.12 (0.87, 3.36)	98%	.07
< 1 week	3	259	2.29 (-0.29, 4.87)	99%	
not mentioned	2	67	0.76 (0.41, 1.11)	0%	
Exercise					
present	9	766	2.43 (1.31, 3.55)	98%	.002
absent	3	185	0.44 (-0.06, 0.95)	71%	
Discussion					
present	5	536	2.33 (0.94, 3.73)	98%	.47
absent	7	415	1.64 (0.37, 2.90)	98%	
Repetition					
persistent access	8	663	1.99 (0.93, 3.05)	97%	.86
single instance	4	288	1.79 (-0.02, 3.61)	98%	

2.5 Quantitative Data Synthesis of Traditional FTF Instruction Comparison

Eight traditional FTF instruction controlled studies were included in the present analysis (Figure 3). Although the random effect size showed some improvement associated with Internet-based learning compared to traditional FTF format, it was not statistically significant (SMD: 0.39; 95% CI: -0.06 to 0.83; P=0.09). Individual effect sizes ranged from-0.32 to 1.30. The heterogeneity amongst studies was large (I^2=88%), but the test of funnel plot asymmetry indicated no evidence of publication bias (Egger's test P=0.665).

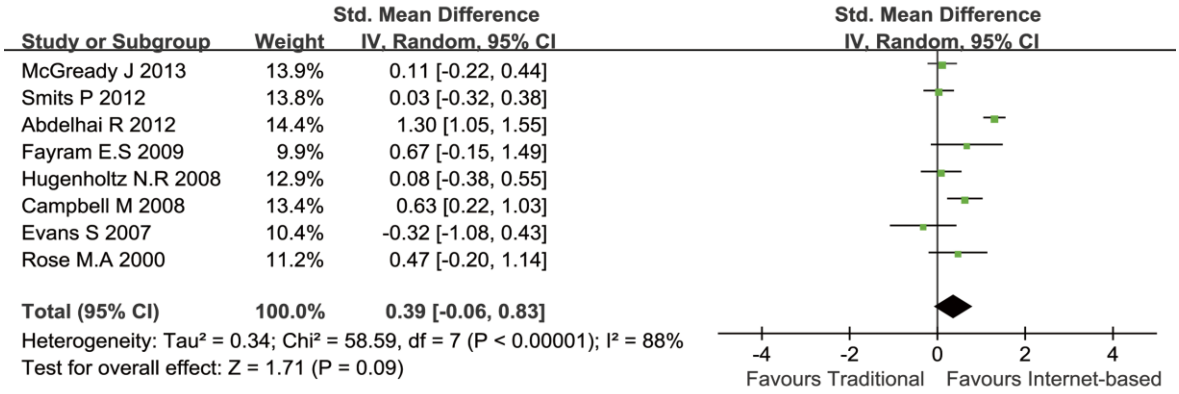

Figure 3. Forest plot for traditional F2F instruction control meta-analysis

Table 3. Pooled effect sizes for subgroup meta-analyses of Internet-based learning vs. F2F-intervention

Subgroup	No. of studies	No. of participants	SMD (95%CI)	I2	p-value
All studies	8	865	0.36 (-0.10,0.83)	89%	.12
Design					
Pre-posttest, 2 group	4	633	0.35 (-0.39, 1.10)	94%	.97
posttest,2 group	4	232	0.41 (-0.00, 0.82)	40%	
Quality Newcastle-scale					
≧4 points	5	493	0.16 (-0.10,0.42)	46%	.03
≦3 points	3	372	0.89 (0.29, 1.49)	70%	
Degree					
undergraduate	3	474	0.37 (-0.67, 1.41)	95%	.94
graduate	5	391	0.33 (0.07,0.58)	28%	
Participant					
student	4	612	0.31 (-0.46, 1.08)	94%	.77
professionals	4	253	0.43 (0.15, 0.72)	11%	
Duration					
≧1 week	5	620	0.51 (-0.10, 1.12)	90%	.26
< 1 week	2	200	0.05 (-0.23, 0.33)	0%	
not mentioned	1	45	0.47 (-0.20, 1.14)	-	
Exercise					
present	5	582	0.53 (-0.09, 1.15)	90%	.38
absent	3	283	0.17 (-0.34, 0.68)	72%	
Discussion					
present	4	569	0.68 (0.05, 1.32)	91%	.08
absent	4	296	0.07 (-0.18, 0.31)	0%	
Repetition					
persistent access	4	582	0.64 (0.02, 1.26)	91%	.10
single instance	4	283	0.07 (-0.19, 0.33)	5%	

In subgroup analyses, the effect sizes showed significantly positive number (favoring Internet-based learning) in studies of low quality score, delivering graduate degree courses, with public health professionals, the presence of discussion and ongoing access to learning materials (Table 3).

3. CONCLUSION

To our knowledge, this is the first meta-analysis to explore the effect of Internet-based public health training on participants' knowledge improvement compared to no-intervention and traditional FTF format. The results of the present study revealed that Internet-based learning in public health training has a large positive effect compared with no-intervention. In contrast, the pooled effect sizes of Internet-based learning in comparison with traditional FTF instructional formats were small and of no statistical significance. The findings indicated that Internet-based learning is educationally beneficial and can achieve similar effects as that of traditional FTF instructional approach in public health training context, which concurred with previous reviews regarding Internet-based learning in other health branches such as clinical context (Cook et al. 2008), basic medicine (Lewis 2003), and nursing courses (Lahti et al. 2013).

However, results suggested heterogeneity existed across studies. With reference to the preliminary evidence (Cook et al. 2010; Lahti et al. 2013), we hypothesized that the inconsistency might arise from the variations in study design, the involved education topics, participant type, and instructional design aspects of the retained studies. Yet the results of the subgroup analyses seemed only partially explaining such inconsistency.

The present exploratory meta-analyses have several limitations. Firstly, we chose to collect only published articles in English, which could bring publication bias, despite there being no significant evidence of publication bias detected in meta-analysis of traditional FTF control group; Secondly, the sample size of 1183 participants was relatively small, and the educational outcomes were restricted to knowledge level due

to limited quantitative data in other outcome levels such as skills and practice. Thirdly, unexplained inconsistencies would allow us to make tenuous inferences.

In summary, despite conclusions could be weakened by the methodological limitations, heterogeneity across reviewed studies and the possibility of publication bias, meta-analyses of individual studies increased statistical power by reducing the standard error of the weighted average effect size. The synthesized evidence demonstrated that Internet-based learning appears to have a consistent positive effect as compared to no-intervention and have a similar effect to traditional FTF instruction methods in public health training context. Even the Internet-based learning is not superior to traditional FTF formats, it can, however, offer an alternative method of learning in public health training areas. In general, this review offers important information to increase knowledge about the effectiveness of the state-of-the-art education methods.

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