The comparison of teaching efficiency between massive open online courses and traditional courses in medicine education: a systematic review and meta-analysis

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Background: This systematic review and meta-analysis aimed to investigate and compare the passing rates of Massive Open Online Courses (MOOCs) with Traditional Courses to indicate how to improve the teaching efficiency in Medicine Education.

Methods: A systematic search of relevant published literature was conducted to collect relevant retrospective cohort studies that compared the teaching efficiency of MOOCs and Traditional Courses.

Results: There are three retrospective cohort studies included in the final meta-analysis. There were no significant differences in the passing rates of MOOCs and Traditional Courses.

Conclusions: it is necessary for universities to invest in online education to promote the development of MOOCs, which will probably have an advantage over Traditional Courses for postgraduate medical education in the near future.

Keywords: Massive Open Online Course (MOOC); Traditional Course; Medicine Education; meta-analysis

Introduction

Although higher education today faces many challenges, including concerns about its role in society, fragmented functions within universities, and growing diversity of the student population, Massive Open Online Courses (MOOCs) probably could probably provide free Internet-based learning opportunities to improve the current situation (1). They can be regarded as part of the Open Educational Resources (OER) movement because they can provide free educational assistance to anyone in any location (2).

Medicine is traditionally slower in the adaptation of new trends, but it is inspired by these new educational patterns as well (3). For example, some systematic reviews demonstrated that many health related MOOCs were conducted (4). The wide appeal of MOOCs in medical education is attributed to their ability to break barriers to education and provide high quality teaching resources to all learners around the globe without a financial cost (5). MOOCs are also seen as a tool in curriculum reform, which requires students to engage in self-directed online preparations prior to face-to-face learning activities (3). Since the start of the implementation of MOOCs in medical education, many benefits can be enjoyed by medical

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students and continuing medical education (CME) or continuing professional development (CPD) for graduate or postgraduate learners, considered as the main areas of progress in education (6-8).

However, some educators are concerned that the massive number of enrolled students on MOOCs causes difficulty for instructors to implement effective teaching and learning strategies and the emphasis on technology and logistics may broadly overwhelm teaching and learning (9). It is still controversial if MOOCs are the best pattern in medical education for the diverse populations and countries with different economic development levels of the world. Many educators also want to know whether MOOCs can replace traditional medical education or only act as a complementary tool.

Therefore, a systematic review and meta-analyses are required to resolve these questions with definitive analysis providing stronger evidence for choosing a specific educational pattern to teach different medical students from diverse backgrounds. For this reason, we performed a meta-analysis of pooled data from existing retrospective cohort studies to evaluate the passing rates of MOOCs and Traditional Courses.

Methods

Literature search strategy

We carried out and reported this systematic review and meta-analyses according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (10). The published reports were identified and selected by searching the following databases: Science Direct, PubMed, Springer Link and Wiley Online Library, from their date of inception to December 2016 with no lower date limit applied. The search used combinations of the following text strings (MOOC* OR 'Massive Open Online Course*') and 'Medicine Education'. The searches were restricted to English although there was no restriction on origin. We also reviewed the reference lists of all retrieved studies to identify any potentially related articles. All retrieved studies and many potentially relevant articles were carefully read, including the names of authors and the time of publishing, to avoid duplication of data.

Selection criteria

Studies were selected for inclusion in the meta-analyses

based on the following criteria: (I) studies using retrospective cohort methods to conduct research on Massive Open Online Courses and Traditional Courses; (II) the MOOCs disciplines were based on the medical profession; (III) the passing rates regarding the effectiveness of Massive Open Online Courses and Traditional Courses were available; (IV) the studies were documented in English. Exclusion criteria for these meta-analyses were as follows: (I) students who participated in the studies and who only enrolled in either MOOCs or Traditional Courses; (II) review articles or case reports; (III) letters, editorials, and expert opinions without original data; (IV) the passing rates of students of MOOCs and Traditional Courses that were not analysed separately in the reports; (V) studies that lacked control groups and did not clearly report the outcomes of interest.

Data extraction and quality assessment

Two reviewers, QJ Zhang and Y Zhou, independently selected the eligible studies and performed data extraction according to a standard protocol. All the data were extracted from four eligible studies (11-14). When the reviewers initially disagreed, it was resolved by discussion whereby a consensus was eventually reached. According to a standard protocol, data comprising several necessary characteristics were extracted: the first author(s) or the name of the study group, the journal the article had been published in, the year of the publication, the country of the study, the number of the students enrolled and the passing rates of students from MOOCs and Traditional Courses. When data were missing or unclear in a paper, the corresponding authors were contacted through mail or email to obtain the necessary information. An article was excluded if there was no response after two contact attempts.

Statistical analysis

The Review Manager 5.3 and STAT 12.0 software was used for the statistical analysis of studies. The OR and 95% CI were used to present the statistical values derived from the efficacy analysis for dichotomous variables. All statistical assessments were 2-sided and the significance level was defined as $P<0.05$. The fixed effects model was adopted for the pooled analysis if a statistical homogeneity existed among the studies ($P>0.05$, $I^2<50\%$) and the random effects model was utilised for the analysis if a statistical heterogeneity existed among the studies ($P<0.05$, $I^2>50\%$).
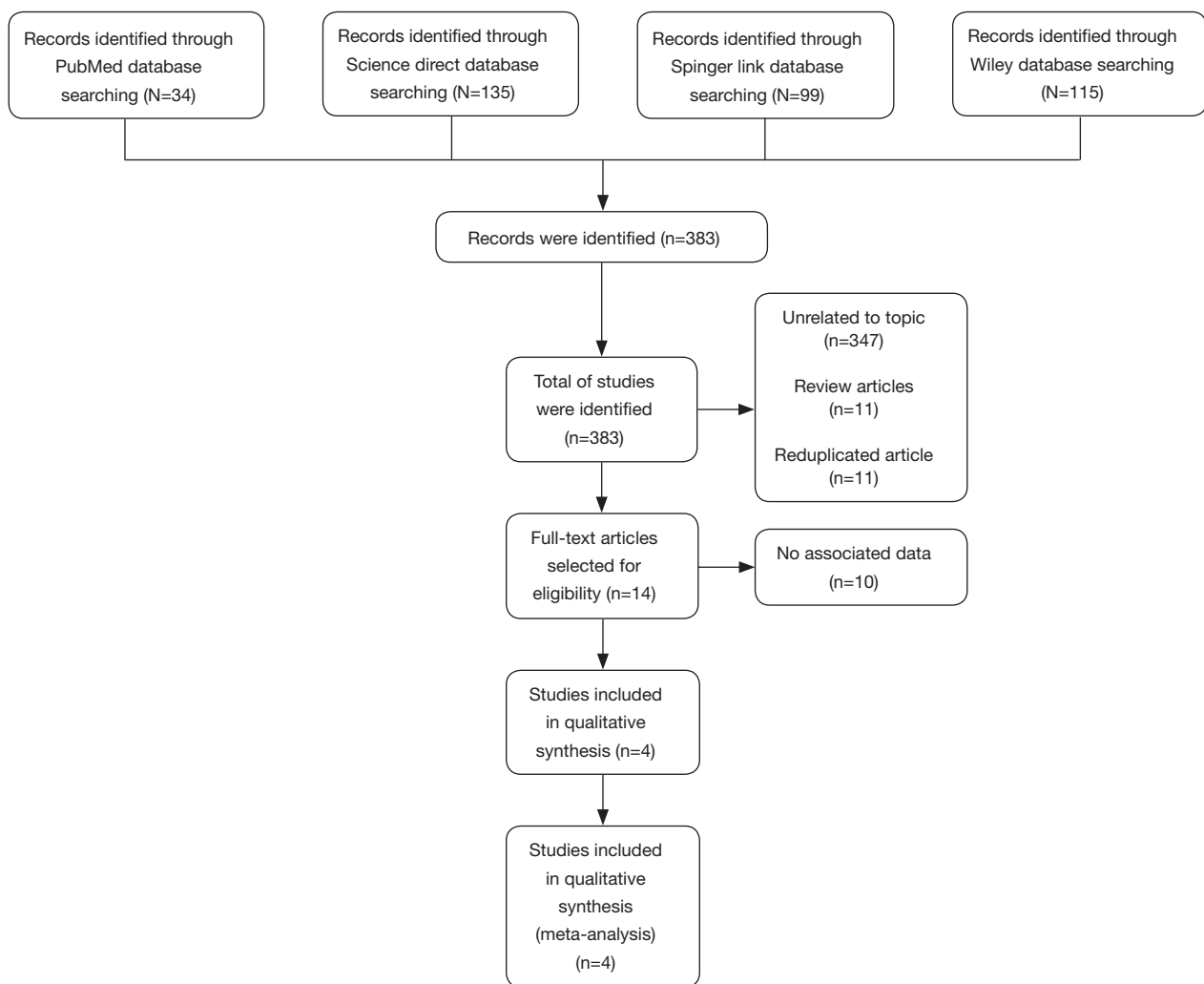
Records identified through PubMed database searching (N=34)

Records identified through Science direct database searching (N=135)

Records identified through Spinger link database searching (N=99)

Records identified through Wiley database searching (N=115)

Records were identified (n=383)

Total of studies were identified (n=383)

Unrelated to topic (n=347)

Review articles (n=11)

Reduplicated article (n=11)

Full-text articles selected for eligibility (n=14)

No associated data (n=10)

Studies included in qualitative synthesis (n=4)

Studies included in qualitative synthesis (meta-analysis) (n=4)

Figure 1 Flow diagram showing the process used for selecting articles.

Results

Search results and trial characteristics

A total of 383 studies were identified by searching database. Out of all the studies, 34 were identified by searching the PubMed database, 135 by searching the Science Direct database, 99 by searching the Springer database and 115 by searching the Wiley database. We identified 372 studies after 11 duplicates were removed. By scanning titles and abstracts, we excluded 358 studies including 11 reviews and 347 studies with no apparent relevance to the present study. In total, 14 studies were therefore included in the next round of review. After reading the full text of these articles, we removed 10 studies not containing enough data to be analysed. The diagram in *Figure 1* represents the flow

of identification and inclusion of trials, as recommended by the PRISMA statement. As a result, four studies (11-14) that included a total of 17,339 students were selected for meta-analyses (*Table 1*). The quality of eligible studies were assessed using Newcastle-Ottawa Quality Assessments Scale (*Table 2*).

Comparison of passing rates between MOOCs and traditional courses

A total of four papers reported results that were simultaneously divided into two groups (MOOCs group and Traditional Courses group). We analysed the passing rates of all students with MOOCs and Traditional Courses. The homogeneity test on these 4 studies resulted in $P < 0.00001$

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Table 1 Main characteristics of individual studies included in the meta-analysis

Author	Year	Country	No.	MOOC		Traditional		OR	LCI	UCI
				Event	Total	Event	Total			
Frank (11)	2016	British	330	134	167	132	163	0.95	0.55	1.65
Magana-Valladares (12)	2018	Mexico	16,111	10,191	11,569	4,542	4,542	0.00	0.00	0.01
Schneider (13)	2016	America	293	71	148	61	145	1.27	0.80	2.01
Bowen (14)	2012	America	605	249	313	223	292	1.20	0.82	1.77

Table 2 Newcastle-Ottawa Quality Assessments Scale

Author	Year	Selection				Comparability	Exposure			Scores
		1	2	3	4	5	6	7	8	
Frank (11)	2016								–	8
Magana-Valladares (12)	2018	–	–							7
Schneider (13)	2016			–						8
Bowen (14)	2012	–	–				–			6

1, representativeness of the exposed cohort; 2, selection of the non-exposed cohort; 3, ascertainment of exposure; 4, outcome of interest not present at start of study; 5, control for important factor or additional factor; 6, assessment of outcome; 7, follow-up long enough for outcomes to occur; 8, adequacy of follow up of cohorts.

and I^2=99% (*Figure 2*). There was significant heterogeneity in the analysis of these 4 studies; so, we performed subgroup analysis according to sample size and found that homogeneity test on three studies resulted in P=0.71 and I^2=0% if we excluded the study with a big sample size by author Magana-Valladares (*Figure 3*). An analysis of these 3 studies using the fixed effects model showed an OR of 1.16 (95% CI: 0.90–1.51), although this was not statistically significant (P=0.26), indicating that there are no significant differences in the passing rates of all students of MOOCs and Traditional Courses (*Figure 4*).

Comparison of passing rates of MOOCs and Traditional Courses within different countries

Regarding the subgroup analysis of three papers according to different professions, we found that the homogeneity test of subgroup analysis on these 3 studies resulted in P=0.42 and I^2=0%. An analysis using the fixed effects model showed an OR of 1.23 (95% CI: 0.92–1.65) in American learners and 0.95 (95% CI: 0.55–1.65) in British learners, although, again, this was statistically significant neither in the American (P=0.17) nor in the British case (P=0.86), indicating that there are no significant differences in

the passing rates of students from different countries of MOOCs and Traditional Courses. However, we found that the OR of 1.23 in American learners is more than that of British at 0.95, especially in the study from author Schneider *et al.* in 2016, which showed an OR of 1.27 (95% CI: 0.80–2.01) indicating that the passing rates of all students of MOOCs in America are probably greater than those of Traditional Courses (*Figure 5*).

Comparison of passing rates of MOOCs and Traditional Courses for different professions

The subgroup analysis of three papers according to different professions, revealed that the homogeneity test of subgroup analysis on these 3 studies resulted in P=0.65 and I^2=0%. An analysis using the fixed effects model showed an OR of 1.27 (95% CI: 0.80–2.01) in the physician group and 1.11 (95% CI: 0.81–1.53) in the student group, although, again, this was statistically significant neither in the physician group (P=0.31) nor in the student group (P=0.50), indicating that there are no significant differences in the passing rates of students of different professions of MOOCs and Traditional Courses. However, we found that OR of 1.27 in the physician group and 1.11 in the student group
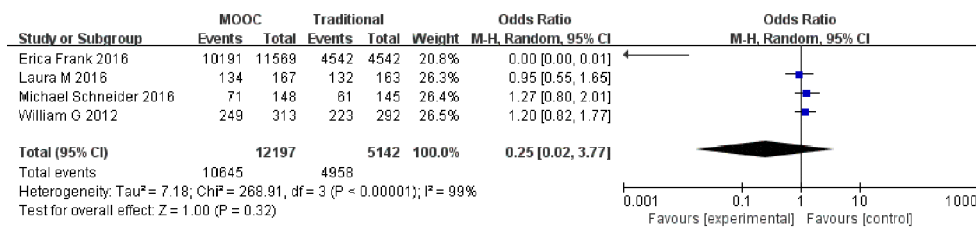
Figure 2 Forest plot of passing rates of MOOCs *vs.* traditional courses in four studies. MOOCs, Massive Open Online Courses; OR, odds ratio; CI, confidence interval.
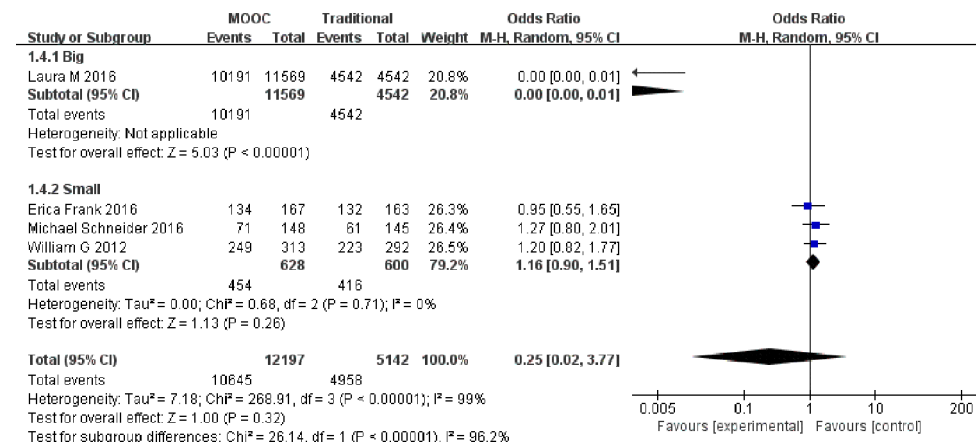

Figure 3 Subgroup analysis of passing rates of MOOCs *vs.* traditional courses according to sample size. MOOCs, Massive Open Online Courses; OR, odds ratio; CI, confidence interval
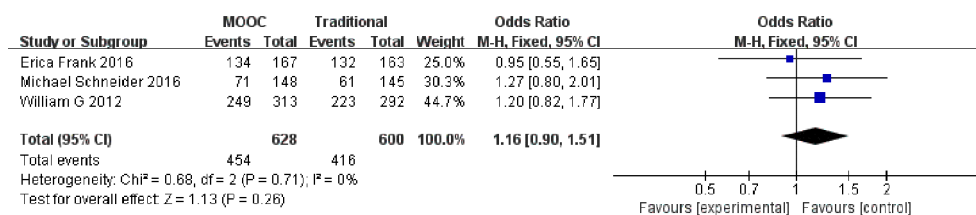

Figure 4 Forest plot of passing rates of MOOCs *vs.* traditional courses in three studies. MOOCs, Massive Open Online Courses; OR, odds ratio; CI, confidence interval.

are both more than one and the OR of 1.27 in the physician group is more than that of 1.11 in the student group (*Figure 6*).

Discussion

'Connectivism and Connective Knowledge' in 2008 at the University of Manitoba is considered the first MOOC (15). Unlike traditional online courses that rely mainly on resources posted by the facilitators through a learning management system, this course was accessible on the Internet and open to registration generally without limits on numbers (16). The advantages of MOOCs are that they can offer free educational opportunities to anyone in any location.

The potential value of the growing online phenomenon of MOOCs offers new possibilities to support educational activity (17). In medicine, MOOCs is used to support
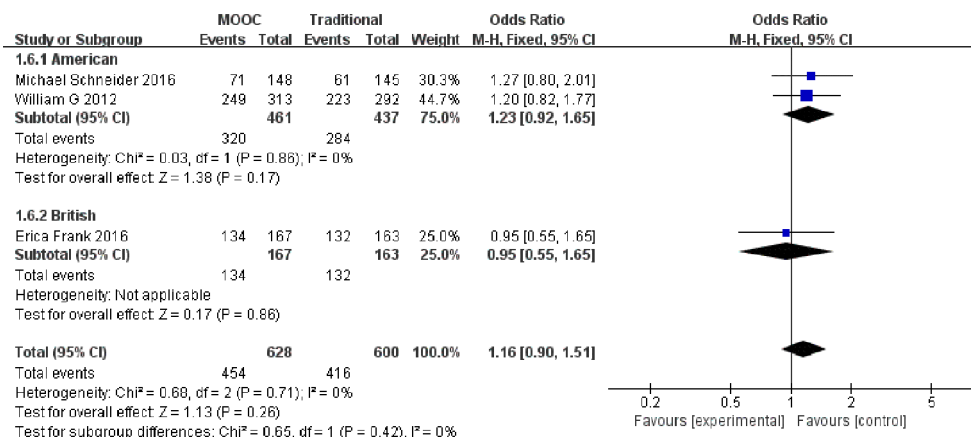
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Figure 5 Subgroup analysis of passing rates of MOOCs *vs.* traditional courses according to different countries. MOOCs, Massive Open Online Courses; OR, odds ratio; CI, confidence interval.
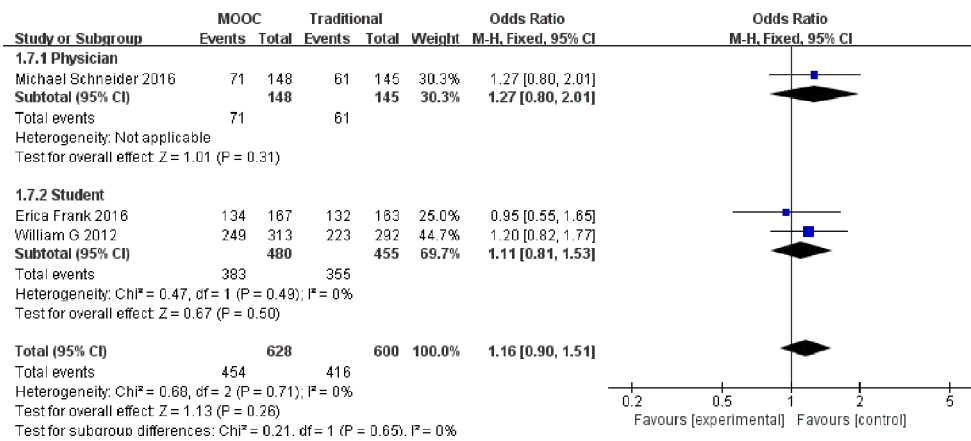

Figure 6 Subgroup analysis of passing rates of MOOCs *vs.* traditional courses according to different profession. MOOCs, Massive Open Online Courses; OR, odds ratio; CI, confidence interval.

postgraduate medical training and CPD is being recognised (4,18,19) and there is evidence to demonstrate that doctors and undergraduate students are participating in this educational trend (20).

Some investigators have argued that the size of the electronic online learning MOOCs forum can inhibit some students' potential involvement (21,22). Others showed that a lengthy course and a static online one-way instructional approach are other disadvantageous factors (23-26). Therefore, it is apparent that controversies still existed about whether MOOCs can replace traditional medical education or only complement it.

Our meta-analysis included four retrospective cohort studies, according to the inclusion criteria. After the

analysis of these studies, only three studies are included in the final analysis because one has a big sample size, which produces the significant heterogeneity. Our results showed that there are no significant differences in the passing rates of MOOCs and Traditional Courses (OR =1.16, 95% CI: 0.90–1.51 P=0.26). From these results, we concluded that generally, MOOCs have no advantages over Traditional Courses regarding teaching efficiency, although, we found that the OR is 1.16. However, if a detailed analysis had not been performed, some evidence would have been neglected. For this reason, we used subgroup analysis to find out the passing rates of MOOCs and Traditional Courses within different countries and professions. Our results showed that there are no significant differences in American (P=0.17) and

in British (P=0.86). However, we found that the OR of 1.23 in American courses is more than 0.95 in British, indicating that an advantage of MOOCs will gradually appear in America when universities there start investing more money in online education and construct a more extensive network platform. Our results also showed that there are no significant differences in the physician group (P=0.31) and the student group (P=0.50). However, we found that an OR of 1.27 in the physician group is more than that of 1.11 in the student group, indicating that MOOCs are probably more suitable for people with sufficient medical knowledge, such as qualified physicians than students who were still accumulating medical knowledge. With the development of a network platform and online education, we can conclude that MOOCs will probably play an important role in postgraduate medical training in the near future.

It is worth noting that this meta-analysis suffers from several limitations. First, evidence comparing the passing rates of MOOCs with Traditional Courses is still insufficient: only 4 studies were enrolled which makes the results less convincing. Second, high heterogeneity was detected limiting the value of this meta-analysis in some way. Third, other factors, such as economy level and educational level, is likely to affect the passing rate. Owing to lack of data, subgroup analysis can't be conducted to further explore the association between those factors. Despite above limitations, the value of this meta-analysis comparing the passing rates of MOOCs with Traditional Courses can't be denied.

Conclusions

The results of our meta-analysis indicated that there was no statistically significant difference in the passing rates of MOOCs and Traditional Courses. However, it is still necessary for universities to invest in online education to promote the development of MOOCs, which will probably have advantages over Traditional Courses for postgraduate medical education in the near future.

Acknowledgements

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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