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Research article

Educational strategies for teaching evidence-based practice to undergraduate health students: systematic review

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Abstract

Purpose: The aim of this systematic review was to find best teaching strategies for teaching evidence-based practice (EBP) to undergraduate health students that have been adopted over the last years in healthcare institutions worldwide. **Methods:** The authors carried out a systematic, comprehensive bibliographic search using Medline database for the years 2005 to March 2015 (updated in March 2016). Search terms used were chosen from the USNLM Institutes of Health list of MeSH (Medical Subject Headings) and free text key terms were used as well. Selected articles were measured based on the inclusion criteria of this study and initially compared in terms of titles or abstracts. Finally, articles relevant to the subject of this review were retrieved in full text. Critical appraisal was done to determine the effects of strategy of teaching evidence-based medicine (EBM). **Results:** Twenty articles were included in the review. The majority of the studies sampled medical students (n = 13) and only few conducted among nursing (n = 2), pharmacy (n = 2), physiotherapy/therapy (n = 1), dentistry (n = 1), or mixed disciplines (n = 1) students. Studies evaluated a variety of educational interventions of varying duration, frequency and format (lectures, tutorials, workshops, conferences, journal clubs, and online sessions), or combination of these to teach EBP. We categorized interventions into single interventions covering a workshop, conference, lecture, journal club, or e-learning and multifaceted interventions where a combination of strategies had been assessed. Seven studies reported an overall increase to all EBP domains indicating a higher EBP competence and two studies focused on the searching databases skill. **Conclusion:** Followings were deduced from above analysis: multifaceted approach may be best suited when teaching EBM to health students; the use of technology to promote EBP through mobile devices, simulation, and the web is on the rise; and the duration of the interventions varying form some hours to even months was not related to the students' EBP competence.

Keywords: Educational measurement; Evidence-based practice; Health occupations; Medical students; Teaching

Introduction

Evidence-based practice (EBP) has been defined as the 'interpretation of the best research evidence with clinical expertise and the patient's unique values and circumstances' [1]. It is an approach to clinical decision-making that has gained considerable interest over recent years within the healthcare field [2]. It is important that higher institutions always strive for the most effective approach to teaching students the knowledge and skills required for EBP, so that upon commencing clinical practice they can confidently incorporate research evidence into their clinical decision-making. This systematic review brought together the existing teaching strategies for EBP

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that have been adopted over the last years in healthcare institutions worldwide. The specific objective of this review was to identify best teaching strategy for teaching EBP to undergraduate health students. Also, recent trends of EBP were deduced.

Methods

Literature search strategy

A systematic review of the existing literature on the existing strategies to teach EBP to undergraduate health students was carried out. We posed the following review question: "What are the existing strategies appropriate for teaching EBP to undergraduate health students?" We drew up a review protocol in advance following standards outlined in the MOOSE (Meta-analysis of Observational Studies in Epidemiology) guidelines for meta-analyses and systematic reviews of observational studies [3]. Next we carried out a systematic, comprehensive bibliographic search using Medline database for the years 2005 to March 2015 (updated in March 2016). Search terms used were chosen from the list of MeSH (Medical Subject Headings) and free text key terms were used as well. The search algorithm used was: ("Students, Nursing" OR "Students Medical" OR "Students, Dental" OR "Health students") AND ("Models, Educational" OR "Education" OR "Health education" OR "Education, Nursing, Graduate" OR "Teaching"; "Curriculum" OR "Training" OR "Critical appraisal" OR "Workshops" OR "Journal clubs" OR "Evidence- Based Practice" OR "Evidence-Based Nursing" OR "Evidence-Based Dentistry" OR "Evidence-Based Emergency Medicine"). Full details of the search strategy and the keywords' combination are provided in Table 1. The same search method was then repeated using the EMBASE database. Bibliographies of each retrieved study and reviews were also checked by hand for additional studies that met broad eligibility criteria.

Selection criteria

From the identified papers, studies meeting the following eligibility criteria were selected: (1) Papers published in peer-reviewed journal as high quality literature was of interest; (2) Papers published in English language as authors had not advanced skills of other languages; (3) Papers published during the last 10 years as up-to-date knowledge was considered necessary; (4) Study designs including randomized controlled trials, controlled trials or cohort studies (pre-post longitudinal studies); (5) Studies that focused on educational interventions (no restrictions placed upon the mode of delivery or the type) to increase EBP competence among undergraduate health students; (6) Studies that evaluated EBP outcomes pre- and post- the educational intervention irrespective of the presence of comparator groups; (7) Studies that performed quantitative estimates of the effectiveness of EBP educational approaches on the outcome of interest (EBP related competence, knowledge, attitudes, skills).

Studies not meeting these criteria were excluded and studies meeting the criteria were shortlisted for inclusion in the review.

Table 1. Search terms used to identify relevant studies for the review on teaching strategies for evidence- based practice among health students

Teaching strategies for EBP among health students	Search terms
Health students	1. * Students, Nursing/
	2. * Students Medical /
	3. * Students, Dental /
	4. * Health students /
	5. 1 or 2 or 3 or 4
Teaching strategies	6. * Models, Educational /
	7. * Education /
	8. * Health education /
	9. * Education, Nursing, Graduate /
	10. * Teaching/
	11. * Curriculum/
	12. * Training/
	13. * Critical appraisal/
	14.* Workshops/
	15. * Journal clubs/
	17. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
EBP	16. * Evidence- Based Practice/
	17. * Evidence- Based Nursing /
	18. * Evidence- Based Dentistry/
	19. *Evidence- Based Emergency Medicine/
	20. 16 OR 17 OR 18 OR 19
Combined terms	34. 5 AND 17 AND 20

EBP, evidence-based practice.

Literature screening and data extraction

Studies were evaluated for inclusion by two independent reviewers for relevance to the subject. Study selection was accomplished through three levels of study screening. At level 1 screening, studies were excluded by reviewing the title of the article. At level 2 screening, abstracts of all studies accepted at level 1 were reviewed for relevance. For level 3 screening, the full text was obtained for relevant papers and any citations for which a decision could not be made from the abstract. Where there was uncertainty, discussion was held with the research team to reach consensus. Information on study design, methods and outcomes were obtained by using a previously piloted data extraction form. The following information was extracted verbatim from each included study: research design, health student discipline, sample size, EBP intervention, instrument used, effect sizes, and key message.

Results

Bibliographic search

Our combined search to MEDLINE and EMBASE retrieved 973 records. The initial screening of manuscript titles and abstracts excluded 799 records. We excluded another 155 articles after examination of the full text. Additionally, two articles were retrieved by searching the reference lists of the retrieved reviews and articles. Fig. 1 shows the numbers of studies identified and selected/excluded in each phase of the search. Ultimately, 20 articles were deemed suitable for inclusion in the review.

Studies' characteristics

One study was conducted in a European country, Spain [4], and nineteen studies in non-European countries including US [5-12], Mexico [13,14], Australia [2,15], Korea [16], Japan [17], Malaysia [18], Thailand [19], Taiwan [20], Jordan [21], and Nigeria [22]. Seventeen studies have been published since 2010 [2,4,6-18,20,21]. Of the 20 studies, 16 were pre-post (uncontrolled) studies and four were controlled trials [4,5,12,15]. Controlled studies compared the intervention group to a control group with no intervention. The sample size for the included studies ranged from 14 to 319 students. The majority of studies sampled medical students (n = 13) [5,6,9-11,13-15, 18-22] and the remaining studies nursing (n = 2) [4,16], pharmacy (n = 2) [7,17], physiotherapy/therapy (n = 1) [2], dentistry (n = 1) [8] students, or students from mixed disciplines (n = 1) [12]. Studies evaluated many different educational interventions of varying duration, frequency and format (lectures, tutorials, workshops, conferences, journal clubs, and online sessions), or combination of these to teach EBP. We categorized interventions into single interventions (SI) covering a workshop, conference, lecture, journal club, or e-learning [2,4,5,7,8,10,12,14-17,19,20,22] and multifaceted interventions (MI) where a combination of strategies had been assessed [6,9,11,13,18,21]. Similarly, the duration of training ranged widely, from 2 hours to 1 year. Interventions covered different steps of the EBP domains (research question, sources of evidence, evidence appraisal, and implementation into practice). All but seven studies reported using valid and reliable instruments [4,6,9,14,16,21]. Two studies used the Fresno test [6,21], one the Fresno test and Berlin questionnaire [9], one the Taylor questionnaire [14], one the Scale of efficacy toward EBP [16], one the EBP competence questionnaire [4], and one a validated instrument for assessment of EBP related knowledge [20]. Knowledge, attitudes, and EBP skills were the outcomes most commonly explored among the included studies. The majority of the studies assessed the effect of the intervention soon after the delivery of the intervention and only 2 studies examined the longer term effect, one 2 months [4] and one 6 months [15] following the intervention. A detailed presentation of the characteristics of the studies and included interventions is provided in Table 2 and Table 3.

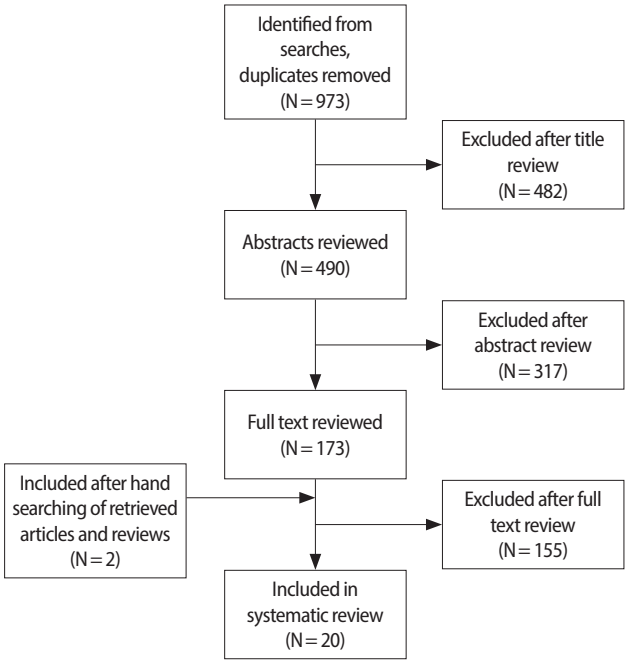

Fig. 1. Flowchart for selection of studies of systemtic review on teaching strategies for EBP among health students.

Synthesis of results

Due to the heterogeneity of interventions used and outcomes measured across studies a meta-analysis was not performed. A narrative synthesis of the key-findings of the studies included in the review will be presented below.

Seven studies reported an overall increase to all EBP domains indicating a higher EBP competence and 2 studies focused on the searching databases skill. Liabsuetrakul et al. [19] in 2009 offered a SI (small group sessions) to medical students. In this study 3 assessments were performed, before, in the middle and after the EBM course and findings showed that the students' skills in the middle and after the course were improved significantly compared to ratings before the delivery of the course [19]. The second study offered a SI (two sessions, one provided in the middle and the other at the end of the semester) to nursing students [16]. Before the intervention, the overall and individual subscale scores for EBP efficacy had an overall mean score of 2.30, indicating that the students were 'a little confident.' After the intervention, the scores increased to a mean of 3.05, indicating that students felt 'confident' regarding the EBP process.

Table 2. Summary of studies conducted among medical students on teaching strategies for evidence-based practice among health students

Author et al. (year) [reference]	Main study characteristics	Aim of the study	Intervention & instrument	Main findings
Gruppen et al. (2005) [5]	US, Michigan, University of Michigan Medical School, 2001-2003 4th year medical students (n = 92)	To examine the influence of teaching the EBM skill of efficiently searching the research literature and describe criteria for documenting and quantifying search quality	SI: 90'-session on EBP Study questionnaire	Average number of search errors for each student: intervention vs. control group (4.4 vs. 6.2) Search performance: intervention (60% vs.72.5%); control (60% vs. 59.3%) Average improvement in search quality: intervention vs. control group (12.7% vs. -0.7%)
Okoromah et al. (2006) [22]	Nigeria, Lagos, University of Lagos, 2006 5th year medical students (n = 54)	To explore the feasibility of introducing a course aiming to improve students' competencies in EBM and their learning	SI: 3-month course Study questionnaire	**Pre- vs. post- course mean scores:** mean (SD) Mean scores for their understanding of the EBM concepts: 2.20 (0.85) vs. 3.17 (0.80), P < 0.001 Mean scores for student knowledge about the need for effective literature search processes in EBM practice: 3.24 (0.71) vs. 3.33 (0.89), P > 0.05
Liabsuetrakul et al. (2009) [19]	Thailand, Hat Yai, Prince of Songkla University, 2005-2007 4th year medical students (n = 259)	To determine changes in attitudes and skills after integration of EBM into a medical school curriculum	SI: 5 steps taught in small-group sessions, the first 3 during the 4th year of studies and the other 2 during the 5th year (total time 15 months) Study questionnaire	**Comparison of scores at T0, T1, & T2:** median (interquartile range) Overall attitudes: 2.4 (1.7, 3.0) vs. 3.6 (3.0, 4.0) vs. 4.0 (3.4, 4.2) Overall skills: 2.2 (1.8, 2.8) vs. 3.4 (3.0, 4.0) vs. 3.8 (3.2, 4.0)
Aronoff et al. (2010) [6]	US, Philadelphia, Temple University, 2005-2006 3rd year medical students (n = 139)	To determine the impact of the online course in EBM that runs concurrently with the undergraduate clinical clerkships of a medical school	MI: online EBM instruction, 6 online didactic modules and sessions Fresno questionnaire	**Pre- vs. post- course comparisons:** mean (SD) Question development: 3.73 (1.27) vs. 4.13 (1.39), P < 0.001 Sources of evidence: 3.96 (1.54) vs. 4.53 (1.45), P < 0.001 Search strategies: 5.07 (1.88) vs. 5.86 (1.52), P < 0.001
Lai et al. (2010) [18]	Malaysia,Kuala Lumpur, International Medical University, Clinical School Batu Pahat, 2005-2006 Final year medical students (n = 65)	To evaluate the information-seeking behaviors of medical undergraduate students and understand how they are influenced by the final 6 months of the EBM training	SI: six two-hour clinical sessions Study questionnaire	**Pre- vs. post- training scores** Search activities: 9.7% vs. 31.7%, P < 0.001 Search speed pre- vs. post- training: 48.4% vs. 49.2%, P = 0.979
West et al. (2011) [9]	USA, Mayo Clinic, Rochester, 2006-2008 2nd year medical students (n = 99)	To evaluate a longitudinal medical school EBM curriculum using validated instruments	MI: short course, didactic, small- group sessions, EBM assignments Berlin questionnaire Fresno questionnaire	**Pre- vs. post- course scores** Self-rated EBM knowledge: year 2 (2.1 vs. 3.1, P < 0.001); year 3 (2.1 vs. 3.5, P < 0.001) Berlin questionnaire score: year 2 (6.3 vs. 9.3, P < 0.001); year 3 (6.3 vs. 9.7, P < 0.001) Fresno test: year 2 (97.8 vs. 137.5, P < 0.001); year 3 (97.8 vs. 152.4, P < 0.001)
Cheng et al. (2012) [20]	Taiwan, Taipei, Taipei Medical School, 2008-2009 Final (7th) year medical students (n = 94)	To compare the effects of 2 clinically integrated educational strategies on final year medical students' EBP competencies	SI: EBP-structured case conference for group A & didactic lectures for group B EBP questionnaire divided into 4 domains: EBP-K (knowledge), EBP-P (application), EBP-A (attitude) and EBP-F (future use)	Mean (SD) Group A higher scores in EBP-K: 21.2 (3.5) vs. 19.0 (4.6), P < 0.01 EBP-P: 18.7 (4.3) vs. 15.3 (3.9), P = 0.001
Gagliardi et al. (2012) [10]	US, Durham, Duke University School of Medicine, 2008-2009 3rd and 4th year medical students (n = 30)	To describe how an interactive forum for students contributed in developing EBM skills and competences	SI: interactive forum organized in 6 120-minutes sessions Study questionnaire	Median difference between overall scores from pre- to post-course administrations was 13% (min 13% and max 73%) (P < 0.001)

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Table 2. Continued

Author et al. (year) [reference]	Main study characteristics	Aim of the study	Intervention & instrument	Main findings
Ilic et al. (2012) [15]	Australia, Melbourne, Monash University 3rd year medical students (n = 121)	To identify the effectiveness of delivering a single workshop in EBM literature searching skills to medical students entering their first clinical years of study	SI: 2 hours workshop Fresno questionnaire Clinical effectiveness and EBP	**1-Week post-intervention:** mean (SD) Overall EBM literature searching skills: 10.51 (5.10) vs. 10.50 (4.53), P = 0.99 Writing a focused clinical question: 1.73 (0.66) vs. 1.76 (0.76), P = 0.82 Identifying information sources: 2.31 (1.84) vs. 2.78 (1.77), P = 0.15 Identifying an appropriate study type: 4.33 (2.85) vs. 3.80 (2.77), P = 0.30 Performing a literature search: 2.12 (2.39) vs. 2.14 (2.51), P = 0.96
Morley et al. (2012) [13]	US, Rio Rancho, New Mexico University medical school, 2006 2nd and 3rd year medical students (n = 51)	To assist students in understanding the changing nature of scholarly communications and online publishing, identifying resources and strategies for researching best EBM and demonstrating effective communication of information	MI: course, exercises, small group discussion and didactic lecture Study questionnaire	**Pre- vs. post- course comparisons:** mean scores Defining the topic: 3.06 vs. 3.87 Identifying keywords or subject headings: 3.09 vs. 3.90 Finding evidence-based information: 3.03 vs. 3.87 Using a database to identify articles: 3.12 vs. 3.93 Using bibliographic management software: 1.71 vs. 3.23 Assessing the reliability/validity of information on the web: 2.59 vs. 3.77
Sanchez-Mendiola et al. (2012) [14]	Mexico, Mexico City, UNAM Faculty of Medicine 4th,5th,6th year medical students (n = 289) M5 EBM = 5th year exposed to intervention M5 non-EBM = 5th year not exposed M4 = 4th year not yet exposed M6 = 6th year exposed a year before	To assess EBM learning (knowledge, attitudes and self-reported skills) in undergraduate medical students	SI: 14 two-hour weekly sessions Taylor's questionnaire 100-item multiple-choice question test	**Confidence in critical appraisal skills:** mean (SD) M4 = 11.7 (6.3) vs. M5 non-EBM = 8.4 (5.7) vs. M5 EBM = 17.1 (3.6) vs. M6 = 16.8 (4), P < 0.001 **Knowledge scores with EBM summative multiple-choice questionnaire test:** mean (SD) M5 EBM group had a test score of 58.5 (7.9) higher than M4 and M5 non-EBM. M6 had a knowledge score of 41.0 (10.9), higher than the control groups, P < 0.001 M6 had a knowledge score lower than M5 EBM, P < 0.001
Barghouti et al. (2013) [21]	Jordan, Amman, Jordan University Hospital, 2011 5th year medical students (n = 54)	To assess the effectiveness of a short course in EBM to change the knowledge and skills of undergraduate medical students and point to possible incorporation of EBM in their curriculum	MI: lectures, seminars, online search, and answering worksheets Fresno questionnaire	**Pre- vs. post- intervention:** mean (SD) scores All domains: 26.7 (16.1) vs. 119.5 (28.5), P < 0.001 Sources of evidence: 7.4 (5.8) vs. 13.5 (5.1), P < 0.001 Formulation of clinical question: 4.4 (3.5) vs. 10.0 (2.0), P < 0.001 Searching strategies: 2.4 (3.1) vs. 10.6 (6.4), P < 0.001
Cyrus et al. (2013) [11]	US, Shreveport, Louisiana State University School of Medicine, 2007-2010 4th year medical students (n = 319)	To assess whether the level of knowledge and understanding of evidence-based medicine and critical appraisal of medical literature increases as a result of the course	SI: 3-sessions course Study questionnaire	Overall difference between pre- and post-tests scores was highly statistically significant (Z-score = -3.398, P = 0.001) Number of students with all correct answers: pre- vs. post-course: 10.0% vs. 17.7%

EBM, evidence-based medicine; EBP, evidence-based practice; SI, single interventions; MI, multiple interventions.

Table 3. Summary of studies conducted among non-medical students on teaching strategies for evidence-based practice among health students

Author et al. (year) [reference]	Main study characteristics	Aim of the study	Course & Assessment	Main findings
Oh et al. (2010) [16]	Korea, Seoul, 29 clinical sites at 5 tertiary hospitals, 2009 Nursing students in the 2nd semester of their 1st year divided into 8 groups (n = 81)	To enhance students' competencies for EBP knowledge, skills and attitudes and expose them to opportunities that would encourage them to use best evidence	MI: lectures, individual mentoring on EBP practicum, small group and wrap-up conferences The scale of efficacy toward EBP The scale of barriers of the research utilization	**Pre- vs. post- course scores:** mean (SD) EBP efficacy scores: 2.30 (0.35) vs. 3.05 (0.38), P < 0.001 Explain of EBP definition/goal/process: 2.54 (0.55) vs. 3.31 (0.50), P < 0.001 Formulation EBP questions: 2.09 (0.41) vs. 3.06 (0.53), P < 0.001 Evidence search: articles and clinical guidelines: 2.30 (0.47) vs. 2.88 (0.54), P < 0.001 Appraisal of evidence: 2.16 (0.51) vs. 2.82 (0.63), P < 0.001 Integrating evidence into practice: 2.42 (0.45) vs. 2.98 (0.56), P < 0.001 Facilitation of EBP: 2.26 (0.49) vs. 3.00 (0.55), P < 0.001
Bennett et al. (2011) [2]	Australia,Queensland, University of Queensland Therapy and physiotherapy students (n = 91)	To evaluate the effectiveness of a semester-long multi-professional university course teaching EBP principles to allied health students	MI: 13-week period course including: didactic lectures, tutorial and workshop formats, and a hands-on database searching session Study questionnaire	**Pre- vs. post- course mean scores:** mean (SD) Attitude towards EBP: 19.8 (2.01) vs. 20.02 (1.99), P = 0.56 Confidence in using EBP skills: 12.51 (3.25) vs. 21.53 (2.74), P < 0.001 Perceived knowledge about EBP concepts: 16.56 (5.52) vs. 30.71 (4.07), P < 0.001 Actual knowledge about EBP concepts: 4.14 (2.37) vs. 7.69 (2.31), P < 0.001
Bookstaver et al. (2011) [7]	USA, South Carolina, South Carolina College of Pharmacy 3rd pharmacy students who were also evaluated by 38 advanced pharmacy practice experiences preceptors (n = 14)	To evaluate the impact of an elective EBM course on student performance during advanced pharmacy practice experiences	MI: 2-hour elective course each week, case studies, problem-based learning, journal club simulations, and student-driven wiki pages Study questionnaire	Pre- vs. post- course: 8.6/15 vs. 13.7/15 Preceptor survey: 79% agreed that students who completed the course are more efficient in critiquing and evaluating the medical literature Student survey: 100% agreed that after the course they are confident to accurately interpret the medical literature
Hinton et al. (2011) [8]	USA, Texas, Baylor College of Dentistry, 2008-2009 1st year dental students	To describe the impact of an R25 grant awarded to the Texas A&M Health Science Center's Baylor College of Dentistry on its curriculum and faculty development efforts	MI: lectures, interactive sessions, small group discussions and seminars Study questionnaire	**Pre- vs. post- course comparisons** More likely to read dental and medical journals: 53/104 vs. 19/90, P < 0.001 More confident in evaluating research reports: 95% vs.71%, P < 0.001 More experienced using evidence: 84% vs. 67%, P < 0.05
Nakagawa et al. (2015) [17]	Japan, Sendai, Miyagi, Tokohu University Hospital, Department of Pharmaceutical Sciences, May-November 2013 Pharmacy students (n = 37)	To create an EBM workshop that would enhance Japanese pharmacy students' awareness regarding the importance of reading up-to-date clinical literature	SI: one-day workshop Study questionnaire	**Pre- vs. post- workshop comparisons:** mean (SD) Pharmacists should read clinical literature regularly: pre 5.70 (0.17) vs. post 6.51 (0.13), P < 0.0001 Confident to read clinical literature: pre 1.81 (0.15) vs. post 3.92 (0.18), P < 0.0001 Scores on the EBM tests: pre 11.4 (0.29) vs. post 12.6 (0.22), P < 0.0001

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Table 3. Continued

Author et al. (year) [reference]	Main study characteristics	Aim of the study	Course & Assessment	Main findings
Long et al. (2016) [12]	Study 1: USA and Middle East, Fall 2013-Spring 2014, quasi-experimental study, nursing students (n = 158) Study 2: USA, RCT, nutrition students (n = 80) Study 3: USA, RCT, pharmacy students (n = 79)	To report the results of the effectiveness of the evidence-based radiology tool to improve the overall online research and critical appraisal skills of learners engaged in EBP	SI: web-based, evidence-based research tool that is usable from a computer, smartphone, or iPad Study questionnaire	**Pre- vs. post- intervention mean difference in scores** Improvement in research skills: study 1: T1-T2 (3.50-2.88), P < 0.05; study 2 (intervention vs. control): T1-T2 (2.85-2.44) vs. (2.60-2.21), P = 0.002; study 3 (intervention vs. control): T1-T2 (3.17-2.83) vs. (3.00-2.47), P = 0.001
Ruzafa-Martinez et al. (2016) [4]	Spain, Public University, during spring term in 2010 2nd and 3rd nursing students (n = 148) IG = 75, CG = 73	To evaluate the effectiveness of an EBP course on the EBP competence undergraduate nursing students	MI: theoretical classes, practical classes with access to computers, peer group discussions in small groups, individual work, teamwork, and oral presentation of a final project EBP competence questionnaire	**Pre- vs. post- intervention comparisons:** mean (95% CI) EBP competence: CG: 3.37 (3.25-3.5) vs. 3.62 (3.51-3.73); IG: 3.06 (2.93-3.19) vs. 4.11 (4.01-4.22) EBP attitude: CG: 3.84 (3.65-4.03) vs. 3.92 (3.8-4.05); IG: 3.33 (3.14-3.52) vs. 4.28 (4.16-4.41) EBP knowledge: CG: 2.51 (2.32-2.71) vs. 3.01 (2.87-3.15); IG: 2.82 (2.62-3.02) vs. 3.92 (3.77-4.06) EBP skills: CG: 3.2 (3.01-3.38) vs. 3.49 (3.32-3.65); IG: 2.75 (2.56-2.94) vs. 4.01 (3.85-4.18)

EBP, evidence-based practice; EBM, evidence-based medicine; SI, single interventions; MI, multifaceted interventions; RCT, randomized controlled trial; CG, control group; IG, intervention group.

West et al. [9] organized a MI, which included didactic, small-group sessions and EBP assignments, for 2nd year medical students. EBM knowledge scores on the 15-point Berlin questionnaire increased from baseline by 3.0 points at the end of the second year of the course and by 3.4 points at the end of the third year (P < 0.001). EBM knowledge scores on the 212-point Fresno test increased from baseline by 39.7 points at the end of the course and by 54.6 points at the end of the third year (P < 0.001). Barghouti et al. [21] assessed the effectiveness of MI (lectures, seminars, online search, and answering worksheets) offered to medical students. The students were asked to complete the Fresno test pre- and posttest and findings showed that the mean difference between the pre- and posttests was 92.8 (P < 0.001).

A quasi-experimental study conducted in Spain among nursing students included MI i (lectures, practicals, group discussions, teamwork, and students' presentations) designed to teach EBP competence [4]. The EBP competence questionnaire was administered before and at two months after the 15-week intervention period and results showed that the mean scores of the intervention group were significantly improved versus baseline in skills (4.01 vs. 2.75) dimensions. Another study conducted in Japan among pharmacy students was designed as one-day MI (students' presentations, lectures, and small group discussions) and findings showed a significant improvement in the overall scores on the EBM test: 11.4 (0.29) vs. 12.6 (0.22), P < 0.0001) [17].

The latest study was conducted by Long et al. [12] and tested a web-based EBP tool that is usable from a computer, smartphone, or iPad. Findings showed that a significant improvement in overall research skills among the nursing and nutrition student group.

Two interventions offered to medical students were found to increase the ability of students in performing effective literature searches [5,18]. The first study designed by Gruppen et al. [5] aimed to quantify the impact of a SI (two-hour) intervention on techniques for searching Medline for evidence related to a clinical problem. Findings showed that the intervention students had fewer search errors and correspondingly higher quality searches than did the control students. The second study involved final-year medical students who received MI (lectures and small-group clinical sessions) and findings showed that students who searched PubMed or Medline for more than three times per week increased from 9.7% to 31.7% (P < 0.001) [18].

Six studies examined the effect of an intervention on students' EBP knowledge and attitude. Two of them have been previously described [4,19]. Ruzafa-Martinez et al. [4] showed that attitudes and knowledge scores were significantly improved versus baseline after the EBP course (4.28 vs. 3.33 and 3.92

vs. 2.82, respectively) [9]. Similarly, Liabsuetrakul et al. [19] showed significantly higher scores for attitude over time following the intervention (P < 0.001). Okoromah et al. [22] delivered a SI (3 month course) offered to medical students from Nigeria. A statistically significant increase in students' self-reported knowledge and attitudes regarding EBM was found. Mean scores for their understanding of the EBM concepts increased from 2.20 (0.85) to 3.17 (0.80) on a 4-point rating scale (P < 0.001). Another study included occupational therapy and physiotherapy students who completed MI (lectures, tutorial and workshop formats, and database searching session) over a 13-week period (2 hours per week). Following the MI students' perceived knowledge improved with a statistically significant mean increase of 14.15 (score range, 5 to 25; 95% confidence interval [CI], 12.55 to 15.75) and there was a statistically significant mean increase in actual knowledge of 3.56 (score range, 0 to 10; 95% CI, 2.83 to 4.29) [2]. West et al. [9] offered MI ('short course' with didactic, small-group sessions and EBP assignments) to medical students. On a 5-point scale, self-rated EBP knowledge increased from baseline by 1.0 and 1.4 points, respectively (both P < 0.001). A year later another study was published by Cheng et al. [20] in 2012. Authors offered either a weekly EBP-structured case conference or a weekly didactic lecture about EBP to final year medical students. The teaching effects of these 2 interventions were evaluated by a validated instrument for assessment of EBP related knowledge. When compared to students in the didactic lecture group, students in the EBP conference group had significantly higher post-intervention scores of EBP knowledge: 21.2 (3.5) vs. 19.0 (4.6), P < 0.01.

Discussion

On the whole, EBP teaching to future healthcare professionals has mainly been documented in medical students. Many different educational interventions of varying duration, frequency, and forma to teach EBP in a variety of settings exist. It showed that educational strategies adopted were found to improve students' overall EBP competence and their EBP knowledge and skills. Students felt more confident to accurately interpret the literature, could better assess the reliability/validity of information on the web and felt more comfortable with the concepts of EBP.

It indicated that EBP is a learnable skill and the question is not whether EBP can or should be taught, but how to best teach [23]. The challenge for nursing academics is to find innovative ways to engage students in a way that facilitates the development of positive attitudes to research so that knowledge utilization and translation are skills all future nurses and health professionals actively use. However, there is little robust evidence to guide the most effective way to build EBP knowledge and skills in undergraduate health students. Towards this direction, the first question to be answered is when EBP teaching should be first introduced into the curriculum. Our findings provide us with inconclusive evidence regarding the best possible time for EBP introduction to the health curriculum. Burns and Foley [24] in 2005 supported EBP inclusion in the first year aiming to foster an EBP approach to clinical practice, but others supported its introduction at a later stage after training in research methods [25]. This is in line with other researchers who support the need for students to learn basic epidemiology and statistics before taking a specific EBP course, which is facilitated by statistical knowledge and contextualizes it in a critical framework, investing it with greater meaning and relevance for the students [26].

The second critical question is how EBP should be taught in order to increase students' engagement and foster students' learning experience. Our review showed that existing studies have used different approaches including didactic lectures, computer sessions, group discussions, class activities, or a combination of these. Existing evidence supports, however, the idea that MI have been demonstrated more likely to improve knowledge, skills, and attitudes compared to SI offered over a short duration or to no interventions [4,27]. MI, with combinations of methods including lectures, computer sessions, small group discussions, journal clubs, and assignments were more likely to improve knowledge, skills, and attitude compared to SI or no interventions. As a result, a multifaceted approach may be best suited when teaching EBM to health students.

Furthermore, the use of technology to promote EBP through mobile devices, simulation, and the web is on the rise and web-based educational platforms have been demonstrated as an effective and desirable mechanism to deliver educational content to health professionals [28,29]. Our review showed that the use of online material and tools to teaching EBP is in its infancy as only 2 studies adopted an online approach to teach EBP and concluded that the use of technology to teach research skills can facilitate EBP teaching [6,12]. Future studies should take advantage of the technology improvements and achievements and incorporate the use of internet and widely used smartphone applications with the aim to foster online interactive learning and engagement [30].

In addition, the duration of the interventions varying form some hours to even months was not related to the students' EBP competence. An important aspect that should be considered in future research is the frequency of the delivery of the intervention as continuous or repeated interventions may help more so that not only do students become more comfortable with EBP, but also they remain comfortable for a longer period of time. As in the majority of the studies the pre- and post-

test duration was too short that may lead to recall bias, meaning that we need further evaluation of the course to determine its effect on the students after a longer period. Better methodologies for identifying EBP competencies retention in the long term should be undertaken.

Finally, validated tools to assess knowledge and skill acquisition exist and have been widely used but similar, validated tools to determine the extent to which attitudes change after an educational intervention are lacking [31]. Most studies reporting change in attitude or behaviour rely on student self-reports as measurements tools, but this is not reliable method for measuring long- term changes in attitude [31]. In addition, increase in EBP competency is dependent on a variety of factors including prior training and exposure to epidemiology, research design, biostatistics, and organizational culture and support toward EBP. None of the studies identified in this review adjusted for these potential confounding factors. Therefore, it is difficult to estimate what effect, if any, these factors contribute to participants' EBP competency across undergraduate and post- graduate settings.

A limitation of this systematic review is the fact that due to the heterogeneity of interventions used and outcomes measured across studies a meta- analysis was not performed. More comprehensive studies are needed to resolve many important issues concerning the effective methods to teach EBP among health students. Specifically, further studies are required to clarify issues as to when, how and by whom EBP should be taught. In addition, future research should examine the effectiveness of use of technology improvements and online communication tools on fostering online interactive learning and engagement. In addition, future studies need to adopt better methodologies and validated tools for identifying EBP competencies retention in the long term and for determining the extent to which attitudes change following the implementation of an educational intervention.

In conclusion, above results told us that multifaceted approach may be best suited when teaching EBM to health students. The use of technology to promote EBP through mobile devices, simulation, and the web is on the rise. Also, the duration of the interventions varying form some hours to even months was not related to the students' EBP competence.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Supplementary materials

Audio recording of the abstract.

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