Original Article

# Two Strategies to Intensify Evidence-based Medicine Education of Undergraduate Students: A Randomised Controlled Trial

Hao Min Cheng,[1,2]MD, Fei Ran Guo,[3]MD, Teh Fu Hsu,[4]MD, Shao Yuan Chuang,[5] PhD, Hung Tsang Yen,[4] MD, PhD, Fa Yauh Lee,[6] MD, Ying Ying Yang,[6]MD, PhD, Te Li Chen,[6]MD, PhD, Wen Shin Lee,[6]MD, Chiao Lin Chuang,[6]MD, Chen Huan Chen, [1,2,7]MD, Low Tone Ho,[1] MD

## Abstract

**Introduction: Undergraduate evidence-based practice (EBP) is usually taught through standalone courses and workshops away from clinical practice. This study compared the effects of 2 clinically integrated educational strategies on final year medical students. Materials and Methods: Final year medical students rotating to the general medicine service for a 2-week internship were randomly assigned to participate in a weekly EBP-structured case conference focusing on students' primary care patients (Group A, n = 47), or to receive a weekly didactic lecture about EBP (Group B, n = 47). The teaching effects of these 2 interventions were evaluated by a validated instrument for assessment of EBP related knowledge (EBP-K), attitude (EBP-A), personal application (EBP-P), and anticipated future use (EBP-F) on the first and last days of rotation. Results: All scores improved significantly after the 2-week EBM-teaching for both groups. When compared to Group B, students in Group A had significantly higher post-intervention scores of EBP-K (21.2 ± 3.5 vs 19.0 ± 4.6; ie. 57.8 ± 72.9% vs 29.1 ± 39.1%; *P* <0.01) and EBP-P (18.7 ± 4.3 vs 15.3 ± 3.9; ie. 28.5 ± 25.5 % vs 14.1 ± 18.7 %; *P* <0.001). In contrast, the scores of EBP-A and EBP-F were similar between the 2 groups. Conclusion: Structured case conference, when compared to the didactic lectures, significantly improved EBP-K and EBP-P for final year medical students.**

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**Key words: Evidence-based medicine, Medical education, Preclinical medical student**

## Introduction

Knowledge and skills of evidence-based medicine (EBM) can be taught by many methods, such as role modeling evidence-based care, using evidence for clinical medicine instruction, and teaching specific EBM skills.[1] Standalone courses and workshops away from the clinical environment are usually the traditional educational designs for teachers to convey knowledge or skills of evidence-based practice (EBP).[2] Previous systematic reviews have demonstrated the efficacy of integrated courses in teaching EBM and that these integrated strategies are superior to standalone teaching for postgraduates.[1,2] Emphasis on incorporating EBM principles in undergraduate medical education has been stressed by many associations.[3]

Most medical students usually have limited knowledge and skills in patient management. For medical students in the commencement of clinical training, principles of EBP can serve as the bridge between learning medical knowledge and clinical decision-making strategies.[4,5] However, there is insufficient evidence supporting the efficacy of an undergraduate EBM curriculum.[5-7] Although there is a growing body of literature exploring EBM teaching and learning in undergraduate learning environments, this evidence is often limited by their study designs, such as a lack of control groups, validated assessment instruments, or

[1]Department of Research and Education, Taipei Veterans General Hospital, Taipei, Taiwan
[2]Cardiovascular Research Center, National Yang-Ming University, Taipei, Taiwan
[3]Department of Family Medicine, National Taiwan University Hospital
[4]Emergency Department, Taipei Veterans General Hospital, Taipei, Taiwan
[5]Division of Preventive Medicine and Health Service, Research Institute of Population Health Sciences, National Health Research Institutes, Miaoli, Taiwan
[6]Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan
[7]Department of Public Health, National Yang-Ming University, Taipei, Taiwan
Address for Correspondence: Dr Chen Huan Chen, No. 201, Sec. 2, Shih-Pai Road, Department of Medical Research and Education, Taipei Veterans General Hospital, Taipei, Taiwan.
Email: chench@vghtpe.gov.tw

integrated strategies for undergraduate.[6-8] We hypothesised that different intensity of clinical integration could have different efficacy of EBP-training courses for the undergraduates. We therefore conducted a randomised controlled trial with before and after assessments to examine the effects for final year medical students rotating to the general medicine service of 2 clinical integration strategies: (i) EBP-structured case conference for students to reflect on their own clinical practice cases and (ii) didactic EBP lectures arranged during clinical rotation. All participants were evaluated at the baseline and again 2 week later (post-intervention) on knowledge (EBP-K), attitude (EBP-A), personal application (EBP-P), and future anticipated use (EBP-F) of EBP. These 2 strategies were aimed at intensifying effects of EBP-teaching curriculum through clarifying EBP principles by didactic lectures or reflecting on problems from patient care experiences with an EBP approach by case conference.

## Materials and Methods

*Study Population*

Medical students in our medical school receive a 7-year curriculum including 2 years premedical education, 2 years problem-based integrated basic and clinical medicine, and 3-years of clinical training (9 months' core clerkship and 20 months' internship). The targeted population of the present study was the final year medical students rotating to the general medicine service from January 2008 to February 2009, who were randomly assigned to participate in a weekly 1-hour EBP-structured case conference that involved the EBP on the students' primary care patients (Group A, N = 47), or to receive a weekly 1-hour lecture about the essentials of EBM (Group B, N = 47). Blinding and allocation concealment were not possible in the present study because teachers and students were all aware of the courses they were going to attend. However, study hypothesis had not been disclosed to all participants. After rotating schedules were finalised, students were randomly allocated to the above 2 groups using a table of random numbers with even and odd in Group A and B, respectively. A research assistant who was blinded to outcome analysis performed the randomisation as well as allocation of participants. Our Institutional Review Board decided that informed consent was not required from the participating students.

## Two Educational Intervention Strategies

Two researchers (HMC and FRG) designed the content of the educational interventions, which focused on teaching EBM via "User Mode".[9] The 2-week EBM-teaching for the final year students during clinical rotation to the general medicine service was incorporated into the daily ward round and patient care. Students in both groups were aware from the first day of the course that they had to receive the assessment for their EBP concepts at the end of the course and were requested to learn from our prepared on-line and e-learning material (http://fdc.vghtpe.gov.tw/web2/index.asp). The learning objectives of both groups, which were set out the same since the commencement of the courses, had been familiarisation with the skills in the "3E-4Q-5A" process as well as determination of "level of evidence" of their acquired literature. During the ward round, students were encouraged by attending physicians to formulate clinical questions in "PICO" format and finish the steps of acquiring and appraising evidence. A companion in-depth reference book about core concepts of EBM and on-line web learning resources (http://fdc.vghtpe.gov.tw/web2/index.asp) were provided for every student in the present study. In addition, Group A students attended a weekly 1-hour EBP-structured case conference held by EBM teachers for 2 consecutive weeks. In the first week conference, principles of EBP were summarised in addition to the introduction of rules and the format of case presentation as well as an example case demonstration. In the second week conference, Group A students (usually less than four) attended the conference to present the EBP application process on their own patient care, including case description, question formulation, evidence searching process, examination of internal and external validity of the selected literature and/or evidence, and self reflection. Group B students, however, received a weekly 1-hour didactic lecture for 2 weeks. In the lectures, EBM teachers instructed the core components of EBP, i.e., 3E (evidence, expertise, patients expectation), 4Q (therapy, diagnosis, harm, prognosis), and 5A (ask, acquire, appraise, apply, audit) using simulated or real teaching case examples. Group B students did not attend the EBP-structured conference, and vice versa. The former intervention in Group A was designed to have stronger degree of clinical integration because students in this group were asking to demonstrate the "3E-4Q-5A" process on their real clinical cases and whether the acquired evidence can be used for clinical decision process in the 2 week care. The didactic lectures and EBP-structured conferences were carried out in the format of small group activities with less than 10 participants by 3 experienced teachers with more than 4 years' EBM teaching experience and 10 years' clinical experiences. In addition, each student was assigned to 1 of the 4 service teams. The 4 attending physicians on general medicine service incorporated EBP during daily ward rounds. They had received a 12-hours faculty development programme focusing on teaching EBM before the commencement of this study. Skills and attitudes toward how to meet the learning objectives of the EBP courses for students had been demonstrated.

Aside from the randomly allocated 2-hour didactic lectures or EBP-structured conferences, all students in both groups were treated equally including the learning references, the teaching faculty, online education material, and core contents aimed at tutoring for problems formulation, evidence search, and critical appraisal. The teacher for didactic lecture in Group B was the same as the one who facilitate the EBP-structured conference in Group A. All students were also exposed to the same ward round hours (2 hours per day), assignments, and evaluation. The students received descriptive feedback by documents for their formulated PICO before the end of programme. The teaching effects of the interventions were evaluated by validated instruments for the assessment of EBP (see appendix) in terms of knowledge (EBP-K), personal application (EBP-P), attitudes (EBP-A), and anticipated future use (EBP-F) which were employed on the first and last days of the 2-week clinical rotation incorporating the EBM-teaching.[10]

Table 1. Study Subject Characteristics

| Characteristics | Structured conferences (Group A) (n = 47) | Didactic lectures (Group B) (n = 47) | *P* value |
|---|---|---|---|
| Men, (%) | 27 (57) | 26 (55) | 0.84 |
| Age, years | 24.8 ± 1.6 | 24.9 ± 2.4 | 0.81 |
| Prior EBM course, % | 63.8 | 76.0 | 0.16 |
| Number of trainees in the small group activities | 8.8 ± 1.2 | 8.6 ± 0.8 | 0.95 |
| Baseline scores of EBM questionnaire | | | |
| EBP-K* | 14.9 ± 4.1 (4~24) | 15.3 ± 4.4 (8~26) | 0.71 |
| EBP-P* | 13.9 ± 3.8 (6~25) | 13.6 ± 3.5 (6~23) | 0.69 |
| EBP-A* | 24.2 ± 2.7 (19~31) | 24.3 ± 3.2 (17~32) | 0.78 |
| EBP-F* | 31.6 ± 4.1 (16~40) | 31.9 ± 3.6 (22~46) | 0.77 |

*: ranges of the score are included in parenthesis.
EBM = evidence-based medicine, EBP-A = attitudes toward evidence-based practice; EBP-F = future use of evidence-based practice; EBP-K = knowledge of evidence-based practice; EBP-P = personal application of evidence-based practice; NS= not significant.

## Results

### *Assessment of Outcomes*

The assessment questionnaires consisted of 26 questions modified from a reliable assessment tool using 6 points Likert scale. The development process of the questionnaire, assessment content, and question format have been described by Johnston et al[10] (Appendix). The 26 items yielded 4 principle components that reflected EBP-K (5 items), EBP-P (6 items), EBP-A (6 items), and EBP-F (9 items). The questionnaire has been developed and validated for the assessment of EBP education in the undergraduate learning environment based on year 5 students in University of Hong Kong with similar ages as our participants. The scores in each category were summed up for comparisons in the controlled trial and before and after study, of which the increase of scores was associated with better knowledge, attitudes, and behaviours. The instruction, administration, collection, and analyses of the questionnaire followed standard procedures by a research assistant who was blinded to the allocation. All participants were encouraged to respond to the questions faithfully. Students were welcome to feedback on the courses at the end of the questionnaires.

### *Sample Size*

The sample size was calculated based on the pretest results of 45 subjects, and following the hypothesis: Group A could gain 15% difference in EBP-K (pretest score of 15.2 ± 4.2) and EBP-P (pretest score 15.0 ± 3.5) as compared with Group B. As to EBP-A (pretest score 24.3 ± 3.2) and EBP-F (pretest score 31.8 ± 3.6), it was anticipated that there would be an increase by 10% for Group A compared to Group B. We used the information from the above pilot study to estimate the sample size with 0.7 for correlation coefficients between baseline and follow-up measures. The effective sample size with 80% power at the 5% significance level and 2-sided test in each group was 42 for EBP-K, 30 for EBP-P, 32 for EBP-A, and 35 for EBP-F. Anticipating a drop-out rate of 10%, we aimed to recruit 48 subjects in each group.

### *Statistical Analyses*

In the before and after comparison, the questionnaire scores were compared via paired t-test. Percentage change was the relative change between the baseline score and follow-up score. In the controlled trial, ascertainment of success of randomisation was carried out using the independent t-test for continuous variables and chi-square test for categorical variables. Comparisons of outcomes between Group A and Group B were conducted using Analysis of Covariance (ANCOVA) accounting for baseline age, gender, and prior exposure to EBP courses. Statistical

significance was declared at the two-tailed $P$ <0.05 level.

## Programme Evaluation

A total of 99 undergraduate students rotating to the wards of general medicine were recruited into the EBM teaching courses. Two students were excluded because they didn't finish the full intervention and complete the post-test. Forty-nine students were randomly allocated to Group A and 48 to Group B. As shown in Figure 1, 47 subjects in each group completed the post-test questionnaires. Baseline characteristics of the 2 groups are shown in Table 1. The 2 groups had similar age, gender, and baseline EBM scores. The distributions of age and gender of the recruited students were not significantly different from the rest of final year students who did not rotate to the general medicine service (n = 68, age 25.0 ± 1.7 years , 60.5% male).

### *Before and After Comparisons*

For the whole study population (N = 94), significant increases were observed in the before and after comparisons for all four domains of assessment in each group (all $P$ <0.01) (Fig. 2). The increase was most pronounced for EBP-K and EBP-P, followed by EBP-F and EBP-A.

### *Between Groups Comparisons*

Differences in teaching outcomes between participants receiving structured conferences and didactic lectures are shown in Table 2 and Figure 2 at the post-intervention follow-up assessment. Students participating in the integrated EBP-structured case conference had significantly higher scores of EBP-K (21.2 ± 3.5 vs. 19.0 ± 4.6, $P$ <0.01) and EBP-P (18.7 ± 4.3 vs. 15.3 ± 3.9, $P$ <0.001) as compared with students attending the EBP lectures. On the other hand, the scores of EBP-A and EBP-F were similar between the 2 groups with a trend in favor of Group A for EBP-F.

Students in the EBP-structured conference (Group A) gave the feedback at the end of the course that the course helped them get familiar with the useful skills of EBP to care for their real-patients and gave them confidence on clinical decisions and patient communication through the preparation for case presentation. In contrast, some students in the didactic lecture group (Group B) suggested that some of the concepts of EBP, despite being very logical, were not easy to apply on practice.

## Discussion

This study demonstrated that significant improvement in terms of EBP knowledge, attitudes, and behavior can be achieved by 2-weeks of clinically integrated EBP teaching for final year medical students during their rotation to general medicine service. Furthermore, the study also provided evidence that EBP-structured conference involving the students' primary care patients may be better than EBP lectures in improving the knowledge and application of EBP among undergraduate students.

Previous methodologically sound research has also demonstrated that improved cognitive and technical EBP skills can be achieved by implementing educational interventions in resident training programmes[2,11-16] and with clinicians.[17-20] As to the training for undergraduate medical students, studies have shown that standalone EBM workshops can increase their ability to form clinical questions and carry out appropriate literature searches.[5,6] It also improved their attitudes towards learning and applying EBM.[5-8] However, research deficits have been recognised in these studies, mainly due to inappropriate study designs.[21] In our pre- and post-test randomised trial, the efficacy of clinically integrated EBP-teaching to undergraduate students in terms of the scores of the knowledge, behaviors, attitudes, and anticipated future uses of EBM has been

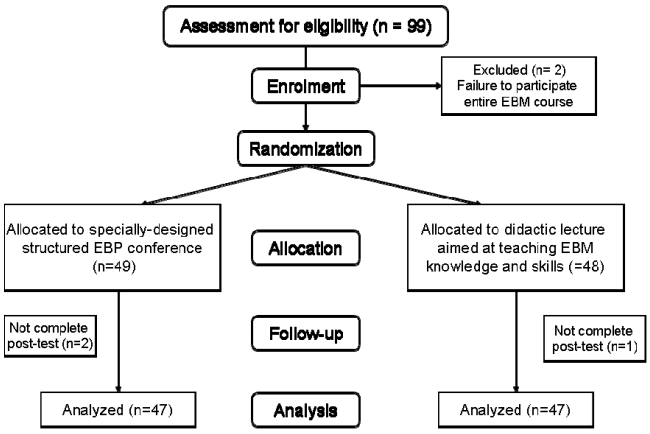


Fig. 1. Profile of Student Recruitment and Enrollment into the Study

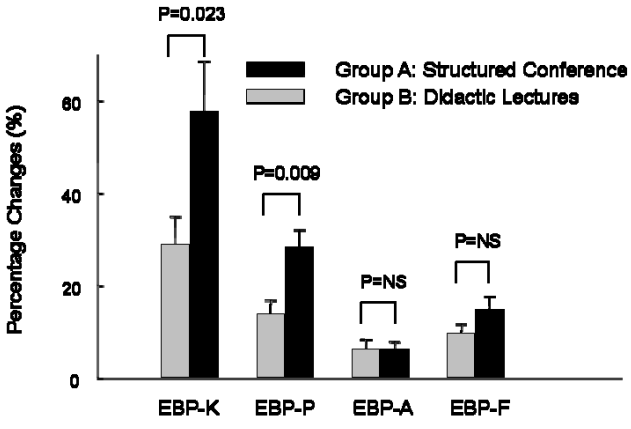


Fig. 2. Percentage Changes of Scores by EBM Education Course

Table 2. Comparison of Scores (Presented with Means and Standard Deviation) at Follow-up Assessment and Percent Change of EBP Knowledge, Attitude, and Behaviour Measured by the Validated Questionnaire after the Educational Interventions

| | | Structured Conferences (Group A) (n = 47) | Didactic Lectures (Group B) (n = 47) | *P* value between Group A and B |
|---|---|---|---|---|
| EBP-K | Follow-up score (confidence interval) | 21.2 ± 3.5 (14.3~28.1) | 19.0 ± 4.6 (10.0~28.0) | 0.009 |
| | Percent change | 57.8 ± 72.9% | 29.1 ± 39.1% | |
| EBP-P | Follow-up score (confidence interval) | 18.7 ± 4.3 (10.3~27.1) | 15.3 ± 3.9 (7.7~22.3) | 0.001 |
| | Percent change | 28.5 ± 25.5% | 14.1 ± 18.7% | |
| EBP-A | Follow-up score (confidence interval) | 25.6 ± 3.8 (18.2~33.0) | 25.7 ± 3.9 (18.1~33.3) | 0.89 |
| | Percent change | 6.2 ± 14.9% | 6.2 ± 11.6% | |
| EBP-F | Follow-up score (confidence interval) | 35.9 ± 5.4 (25.3~46.5) | 34.8 ± 5.1 (24.8~44.8) | 0.12 |
| | Percent change | 15.0 ± 19.0 % | 9.7 ± 12.8 % | |

EBP-K = knowledge of evidence-based practice; EBP-P = personal application of evidence-based practice; EBP-A = attitudes toward evidence-based practice; EBP-F = future use of evidence-based practice
**P* values was calculated by Analysis of Covariance (ANCOVA) accounting for baseline age, gender, and prior exposure to EBP courses

confirmed.

*Adult Learning Theory*

Of the educational effectiveness for postgraduate curriculum, a hierarchy of teaching and learning activities has been proposed based on empirical and theoretical research,[2] which indicated that didactic or standalone teaching can provide only knowledge improvement.[22] In contrast, clinically integrated interactive teaching activities can give rise to changes in skill, attitude, and behaviour.[23,24] Our study extends this viewpoint to the training for undergraduates. Based on adult learning theory, clinically integrated EBM-teaching is superior in bringing about sustained desirable change than traditional standalone lectures.[23,24] The intensity of the clinical integration was stronger in the EBP-structured seminar group because students had to prepare for presentation of the "3E-4Q-5A" process focusing on the question in the "PICO" format arising from the students' primary care patients. However, to a lesser extent, the students in the didactic lecture group could also participate in clinically integrating EBP teaching activities, such as joining the EBM oriented ward rounds, application of basic EBM skills on clinical visits, role modeling from teachers, and other non-EBM format seminar reviewing latest literatures. Our before and after comparisons (Fig. 2) demonstrated significant changes in knowledge, attitude, and behaviour of both groups confirming the usefulness of integrating EBM-teaching activities to daily clinical work. Moreover, the increased intensity of clinical integration can lead to more pronounced desirable changes as shown in the comparisons between the randomly allocated groups.

There were no significant differences between both groups in terms of "attitude" and "anticipated future use" of EBP. Further improvement in behavioural change is much more difficult and there are several possible factors relating to this finding. First, both groups improved in the scores of these 2 factors after intervention with reference to the baseline scores which might mitigate the differences between groups. Second, the 2-week training course might be too short to produce further advantageous changes. Third, the medical students were short of clinical experiences and were not independent enough to make clinical decisions as well as application of EBP strategies. Stronger supports from clinical environment, e.g., more supervised decision-making by the students in patient care, can facilitate the better adaptation to these 2 learning goals.

Although feasible adult learning theory can be applied to undergraduate as well as postgraduate students, training of undergraduate students has several different features.[3,5,6] In addition to the lack of clinical experiences, the diversity of basic medical knowledge and skills of undergraduates is less pronounced as compared to residents and clinicians. Moreover, they are required to fulfill the qualification examination of medical knowledge and skills, which can direct their learning demands as well. These features can also help facilitate the better learning outcomes with regard

to the EBP teaching. However, concerns regarding the appropriate timing to teach EBM have emerged, especially when the teaching activities seem to be irrelevant to their "real world" tasks.[23,24] In contrast, there were also supporters proposing that earlier exposure to evidence-based curricula is feasible and practical with excellent satisfaction of students and facilitators,[7] which might create more sustainable behavioural changes. With respect to relevance, to teach EBM during the clinical years of undergraduate students is presumably the better timing of educational intervention.[4,5,7,16]

There are numerous methods aimed at evaluating teaching effects of evidence-based practice such as questionnaires, case based discussion, and objective structured clinical examination.[25,26] These methods mainly focus on assessing effects of curriculum on knowledge and skills. The present study adopted a validated questionnaire for undergraduate EBP teaching and learning in terms of knowledge, attitudes and behaviour change.[10] From the point of view of adult learning theory, motivation toward learning objectives might be the utmost key of success in teaching, which traditional skill-evaluating tools might overlook, especially for undergraduates.

### *Limitations of the Present Study*

This pilot study adopted a short duration educational intervention based on the curricular design of our university and teaching hospital. Furthermore, the assessment was performed immediately after the course and long-term durable outcomes were not assessed. Smaller than anticipated change in scores of "attitude" and "future application" of EBP suggested that increased intensity of the integrated EBM teaching course, stronger supports from the clinical environment, or longer educational interventions might be next steps to achieve these desirable long-term outcomes. Similar to other cognitive skills, to increase the retention of teaching outcomes, continuous application and integrated repetition is mandatory, which was not attainable merely by the short duration interventions in the current study. Moreover, although the outcome was evaluated by a validated questionnaire, it was self-reported results rather than actual performance. Further studies using rigorous study designs as well as reliable, valid, and objective evaluation instruments, such as objective structured clinical examination, Fresno test,[26] and an improvement project[27] in real EBP practice should be considered to evaluate the effects of EBP teaching programmes. It is probable that questionnaire scores can be biased by the emphasis on the value of EBP. However, the observed different effects of the two clinically integrated educational strategies on last-year medical students were probably not affected by the effects of social desirability or "Hawthorne effect"[28] because of the randomised study design, similar exposure time to teaching programmes, and the same frequency of evaluation.

## Conclusion

In conclusion, we have demonstrated that EBP knowledge, attitudes, and behaviour of final year medical students can be improved by 2 weeks of clinically integrated EBP teaching programme. Furthermore, the improvements in EBP knowledge and personal application are even more pronounced by the EBP-structured conference involving the students' primary care patients than the didactic EBP lectures.

### *Practice Points*

1. The teaching of clinically integrated EBP for last-year medical students involving didactic lectures or EBP-structured case conference could significantly improve EBP related knowledge, attitudes, and behaviors.

2. Compared with the didactic lectures, the structured case conferences integrated into the clinical practice could result in significantly greater increases in students' knowledge and personal application of EBP.

3. Further refinement of the integrated EBP-teaching curriculum for undergraduate medical students is required to intensify the teaching effects on their EBP attitudes and future use.

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**Appendix**

Questionnaires of EBM skills

*Evidence-based practice – knowledge*

Content: asking clinical questions, acquiring evidence, appraising evidence, applying evidence to a clinical situation, and assessing treatment effectiveness in terms of patient outcomes Question format: statements rated on a Likert scale (1 strongly disagree, 6 strongly agree)

1. Evidence-based medicine requires the use of critical appraisal skills to ensure the quality of all the research papers retrieved
2. Effective searching skills /easy access to bibliographic databases and evidence sources are essential to practicing evidence-based medicine
3. Critically appraised evidence should be appropriately applied to the patient using clinical judgment and experience
4. The evidence-based medicine process requires the appropriate identification and formulation of clinical questions
5. Practicing evidence-based medicine increases the certainty that the proposed treatment is effective

*Attitudes toward evidence-based practice*

Content: perceived need for information, willingness to practice EBP, perceived role of EBP in clinical practice, attitude about EBP's threat to clinical practice Question format: statements rated on a Likert scale (1 strongly disagree, 6 strongly agree)

1. If evidence-based medicine is valid, then anyone can see patients and do what doctors do
2. There is no reason for me personally to adopt evidence-based medicine because it is just a fad (or fashion ) that will pass with time
3. Evidence-based medicine is cook-book medicine that disregards clinical experience
4. Doctors, in general, should not practice evidence-based medicine because medicine is about people and patients, not statistics
5. Evidence-based medicine ignores the art of medicine
6. Previous work experience is more important than research findings in choosing the best treatment available for a patient

*Personal application and use of evidence-based practice*

Content: access and acquisition of evidence, application to patient care, influence of positive role models on EBP adoption, barriers to adopting EBP, contribution of EBP to clinical reasoning and learning, current proportion of clinical activity based on EBP principles, frequency of actual use of EBP, perceived need for EBP each day or week and for each patient encounter, overall use of EBP in the past year (1 never, 5 every day; 1 not at all, 6 completely)

1. How frequently do you access medical evidence from a textbook?
2. How frequently to you access medical evidence in general?
3. How frequently do you access medical evidence on the Internet (excluding Medline and Cochrane Reviews)?
4. How frequently do you access medical evidence from original research papers?
5. How frequently do you access medical evidence from the Cochrane database?
6. How frequently do you access medical evidence from secondary sources such as the ACP Journal Club, the Journal of Evidence-Based Medicine, POEMs (Patient Oriented Evidence that Matters) or CATs (Critically Appraised Topics)?

*Future use of evidence-based practice*

Content: perceived future importance of EBP to medical practice, willingness to practice EBP in the future, usefulness of EBP in the future, potential barriers to the adoption of EBP currently and in the future. Question format: statements rated on a Likert scale (1 very unwilling, 6 very willing; 1 completely useless, 6 very useful; 1 not at all, 6 completely)

1. Compared to 1 year ago, how useful do you believe evidence-based medicine will be in your future practice as a doctor?
2. Compared to 1 year ago, how willing are you to practice evidence-based medicine as a doctor in the future?
3. You personally appreciate the advantages of practicing evidence-based medicine
4. Evidence-based medicine should be an integral part of the undergraduate medical curriculum
5. Compared to 1 year ago, how much do you support lifelong learning using evidence-based medicine techniques?

6. Compared to 1 year ago, how much do you support the principles of evidence-based medicine?

7. How much do you consider the practice of evidence-based medicine a routine part of your learning?

8. How much has the practice of evidence-based medicine changed the way you learn?

9. How easy or difficult has it been for you to practice evidence-based medicine as a medical student in the last month?

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