Evidence-Based Medicine Curriculum Improves Pediatric Emergency Fellows' Scores on In-Training Examinations

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Introduction

The practice of modern medicine requires that physicians understand and skillfully apply evidence-based medicine (EBM) to provide high-quality patient care. The Accreditation Council for Graduate Medical Education (ACGME) requires that pediatric emergency medicine (PEM) fellows demonstrate competency in practice-based learning through “appraisal and assimilation of scientific evidence related to their patients’ health problems[1].” Additionally, the American Board of Pediatrics (ABP) requires that PEM fellows demonstrate proficiency in “Core Knowledge in Scholarly Activities” including application of principles of biostatistics, epidemiology, and research design for clinical practice[2].”

Despite similar requirements, many post-graduate programs report a lack of structured educational curricula for teaching EBM[3-5]. In post-graduate programs that have implemented an EBM curriculum, learner satisfaction and comfort are often the only outcomes measured, which, while valuable, are not objective [6-9]. Several questionnaires aimed at assessing EBM knowledge and skills have also been developed but lack rigorous external validation that limits their generalizability[10]. Additionally, these questionnaires have been primarily used to assess educational gains immediately after implementation of a curriculum. Recently, Trickey et al. described the use of In-Training Examination (ITE) scores as a method to assess surgical residents’ gains in knowledge of research and statistics content[11]. Given that the currently available literature is limited regarding the best method(s) to assess learning outcomes, our primary objective was to compare PEM fellows’ ABP ITE scores prior to and after implementation of a curriculum designed to develop knowledge and skills in EBM.

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Materials and Methods

We implemented our EBM curriculum in an ACGME-accredited PEM fellowship program. The fellows primarily train in a free-standing, tertiary-care, university-affiliated pediatric hospital with an annual emergency department census of ~80,000 visits per year; all extramural rotations (e.g. Trauma, Adult Emergency) are performed at tertiary-care adult facilities within the hospital network. The three-year fellowship program at our institution consists of three trainees per post-graduate year (PGY) for a total of 9 fellows each academic year. During the four academic years prior to implementation of the EBM curriculum, each fellow led a monthly journal club session once per academic year in which they presented an article from the literature. While journal club was likely not the only source of EBM instruction (i.e. bedside teaching, didactic lectures during the academic year, etc.), it was the programmatic component most focused on teaching EBM. All fellows were expected to attend all journal club sessions offered during the academic year with the exception of those who were on rotations that logistically did not allow for attendance (e.g. Trauma, Adult Emergency). Fellows also had access to an online repository of resources including electronic articles related to EBM and critical appraisal.

We identified the need for more formalized and structured training in EBM (prompted by fellows' self-identified discomfort with EBM), and, thus created and implemented an EBM curriculum to replace the existing journal club. Under the new EBM curriculum, fellows were instructed to follow a timeline for the preparation of the session they were to lead (Figure 1). We created two online, self-directed modules (using PowerPoint® 2010 presentation graphics program) for fellows to access and review 3-4 weeks prior to their assigned session: the first is a presentation that provides a step-by-step framework for asking a clinically-relevant question, performing an effective literature search (in which they identify a target article for discussion), and utilizing widely-available critical appraisal tools (e.g. Critical Appraisal Skills Programme, <http://www.casp-uk.net/casp-tools-checklists>); the second is a sample EBM session presentation that provides a model for how fellows can structure their own sessions. Approximately 2-3 weeks prior to the fellows' scheduled session, he or she meets with the Teaching Attending (M.M.T.) for a 1-hour session in which the fellow receives coaching and feedback on the learning objectives developed, materials created (including relevant handouts and PowerPoint® presentations), and important discussion points identified. The teaching attending models important probing questions and small group teaching techniques during these preparatory sessions.

During each monthly EBM session, the assigned fellow leads a critical appraisal and discussion of the selected target article in a small-group format that emphasize small-group teaching techniques to encourage articulation of ideas and review of key concepts. After each session, an EBM worksheet is distributed to all fellows to be completed on their own time to provide further reflection and exploration of the topics discussed; the Teaching Attending provided formative feedback on completed worksheets. The worksheets consist of 3-5 questions created by the Teaching Attending utilizing data from the target article and designed to review core content from the "Core Knowledge in Scholarly Activities" section of ABP Content Outline for PEM [2]. Table 1 lists the key concepts and topics that have been covered prior to and after the EBM curriculum was implemented.

Two academic years prior to the EBM curriculum, the PEM fellowship program directors implemented a longitudinal research methods curriculum aimed at increasing fellows' knowledge and skills in research methods and application specifically for fellows' scholarly projects. This research methods curriculum contains some educational content that overlaps with the new EBM curriculum. Thus, we divided the study period into three instruction periods: 2-year baseline period during which journal club alone was in place, 2-year transition period during which journal club and the research methods curriculum were in place, and the 2-year EBM period during which the EBM and research methods curriculums were in place. During the overall study period, no other structured curricular interventions or changes aimed specifically at increasing EBM knowledge and skills were undertaken. Two fellows completed MPH degrees prior to fellowship; the scores for these fellows were all in the baseline instruction period. Also, none of the fellows included pursued advanced degrees during fellowship. Our study was reviewed and approved by our local Institutional Review Board.

We obtained de-identified, raw sub-scores from fellows enrolled in our program on the "Core Knowledge in Scholarly Activities" (SA) section of the ITE (which accounts for approximately 5-7% of the ITE questions). Additionally, we obtained the raw sub-scores for the "Emergencies Treated Medically" (EM) section, which accounts for approximately 17%, the largest proportion, of the ITE questions. We decided a priori to use the EM sub-score as a balancing measure since performance on the EM section of the ITE should not be affected by an EBM curriculum. PEM fellows are expected to take the ITE during each year of training. We created a database in which we recorded data on the following variables: unique fellow identification number (ID), post-graduate year at the time of the score (PGY), instruction period ("baseline" corresponding to the two academic years during which there was no structured EBM curriculum, "transition" corresponding to the subsequent two academic years during which the research methods curriculum with some overlapping EBM content was implemented, and "EBM" corresponding to the two academic years with our current EBM curriculum implemented), SA sub-score, and EM sub-score.

We calculated median and interquartile ranges for non-parametric continuous variables; we analyzed differences among instruction periods using the independent sample Kruskal-Wallis test, and, between instruction periods using the independent sample Mann-Whitney U test. We utilized multivariate mixed effects linear models with robust standard error wherein the individual fellow variable was treated as a random effects term to account for multiple exam results per fellow in the database. The "EBM" instruction period was set as the reference category, and the "baseline" and "transition" instruction periods were compared to the reference category to assess the effect of instruction period on the SA sub-score and EM sub-score, while controlling for the PEM fellows' PGY in training at the time the exam was taken. Software used included SPSS® (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.) and SAS® (SAS Institute Inc., Version 9.3, Cary, NC: SAS Institute Inc., 2002-2004).

Results

Forty-nine SA and EM sub-scores from 22 PEM fellows over 6 academic years were available and included in our analysis. Ten of 22 fellows had scores available for all three training years. The SA sub-score was significantly higher during the EBM instruction period (median 0.70, range 0.50-1.00) in comparison to the baseline (median 0.50, range 0.30-0.73) and transition (median 0.55, range 0.36-0.78) instruction periods (Figure 2). In contrast, the EM sub-score (balance measure) was similar across instruction periods (median [range]: baseline 0.75 [0.58-0.88], transition 0.79 [0.54-1.00], and EBM 0.83 [0.57-0.92]). The results of our multivariate mixed effects linear modelling demonstrated our EBM curriculum had an independent and statistically significant effect on fellows' SA sub-score (Table 2). In comparison to the baseline instruction period (with not structured curriculum), fellows' SA sub-score was 28 percentage points higher during the EBM curriculum instruction period. In comparison to the transition instruction period (no structured EBM curriculum, but research lecture series in place some overlapping content), fellows' SA sub-score was 21 percentage points higher.

Discussion

Acquisition of knowledge and skills in EBM is now a required component of postgraduate medical education training programs. For educators and program directors, determining the success of curricula aimed at addressing this educational need remains a challenge. Most studies at both the undergraduate [12-18] and post-graduate medical education levels have utilized primarily subjective outcomes, such as satisfaction and comfort, to evaluate EBM curricula.

However, some authors have reported the use of objective outcomes. In 2001, Taylor et. al. reported the development of an 11-item questionnaire to assess the effectiveness of EBM teaching among healthcare professionals[19]. Performance on this instrument has been described as an outcome by Sanchez-Mendola et. al. [20], but it has not been externally validated. In 2002, Fritsche et. al. described the development and internal validation of the Berlin Questionnaire which consists of 2 sets of 15 multiple-choice questions[21]; it has primarily been used to assess the impact of EBM curricula among medical students[17, 22]. The Fresno test, developed by Ramos et. al., measures EBM skills and consists of open-ended questions which are scored with grading rubrics [23]. While use of the Fresno test to assess EBM curricular interventions has been widely published in both students and residents[24-28], its psychometric properties have only been validated in 2 small cohorts of family medicine residents [23, 29]. Given the recent findings by Trickey et. al. [11], we considered that assessing performance on EBM-related questions from the ITE (which undergo rigorous and lengthy review undertaken by the respective certification body) could provide a training program-specific, pre-integrated educational outcome[30].

In our study, we sought to determine if a new, formalized EBM curriculum had an impact on PEM fellows' aggregate sub-scores on the "Core Knowledge in Scholarly Activities" section of the ABP ITE. Our results demonstrate scores on the "Core Knowledge in Scholarly Activities" section of the ABP ITE were 28 percentage points higher after the

implementation of our EBM curriculum when compared to the “baseline” period when no structured curriculum was in place. When compared to the “transition” period during which a research methods curriculum was implemented, fellows’ score were 21 percentage points higher during the EBM curriculum period. These results are not only statistically significant, but also could potentially contribute to an individual fellows’ improved performance on the examination as a whole. Further, our statistical methods allowed us to determine that the EBM curriculum’s positive effect was independent of fellows’ PGY level or maturation over time. Additionally, the ITE is administered annually in the middle of the academic year. In contrast to other investigators, our outcome was not assessed immediately after the educational intervention.

Our study had several limitations which should be acknowledged. Twelve of 22 fellows had incomplete score data. Generalizability of our study is likely limited given it was performed at a single training center. While we only had one dedicated teaching attending, the curriculum materials developed could be disseminated to faculty at other institutions and theoretically implemented. Our sample size was small; ideally, a large, randomized study would address important fellow-level confounders such as other EBM-related educational experiences. However, in our multivariate analysis we addressed fellows’ maturation over time, a primary weakness of quasi-experimental studies such as ours, by controlling for PGY level and accounting for multiple exams per fellow. While our study had no pre-determined control group, we analyzed fellows’ scores on the “Emergencies Treated Medically” section (the largest, accounting for 17% of ITE questions) as a balance measure; the lack of change in “Emergencies Treated Medically” scores makes an argument that fellow composition (i.e. higher academic achievement in one class versus another other the study period) was not a major factor in the increased scores noted on the “Core Knowledge in Scholarly Activities” section after implementation of the EBM curriculum. Additionally, specific educational interventions are known to result in greater learning gains than others (formative feedback vs. computer-assisted instruction) [31]. While we were could not determine which components of our educational intervention were most contributory to fellows’ improvement, our curriculum employed evidence-based educational techniques.

In summary, our EBM curriculum was associated with significantly higher scores on the “Core Knowledge in Scholarly Activities” section of the ITE. There is evidence to suggest better performance on licensing examinations is associated with improved care of patients after graduation [32]. PEM post-graduate educators could consider using fellows’ scores on the “Core Knowledge in Scholarly Activities” section of the ABP ITE to assess the impact of their EBM curricula. Future investigations should consider exploring whether trainees’ EBM knowledge and skills (self-reported versus observed) impact clinical practice, patient care and patient-level outcomes.

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EBM Session Checklist for Fellows**3-4 weeks prior:**

- Select ONE article for discussion
- Review it with Teaching Attending
- NO non-systematic reviews, case series, and case reports
- Preferably select article published in past 2 years

2-3 weeks prior:

- Use resources on internal intranet to create appraisal worksheet (Note: Decide which questions most relevant)

1 week prior:

- Meet with Teaching Attending (Tavarez)
- Review key learning concepts & issues to emphasize
- Review format and materials

2-3 days prior:

- Ask program coordinator to email article and critical appraisal worksheet

Day of the presentation:

- Discussion will be led by the fellow with interactive discussion from audience
- The fellow will ask the audience to comment on different aspects of the article:

Figure 1. Timeline for Preparation of Yearly EBM Session Undertaken by Each Fellow

Figure 2. Comparison of median raw sub-scores between “Scholarly Activities” and “Emergencies Treated Medically” sections across instruction periods
(Left panel) The difference in median raw sub-score on the “Scholarly Activities” section was significantly higher in the EBM instruction period than in the baseline ($p = 0.007$) and the transition ($p = 0.002$) instruction periods. (Right panel) In contrast, there was no statistically significant difference in raw median sub-score on the “Emergencies Treated Medically” section ($p = 0.06$), indicating that fellows had similar overall performance across the study on the largest section of the ITE. (Abbreviations: EBM = Evidence-Based Medicine curriculum)

Table 1
List of Topics Covered Prior To and After EBM Curriculum Implementation

Biostatistics & Research Design Topics	Prior to EBM Curriculum	After EBM Curriculum
P-value interpretation	X	X
Confidence interval interpretation	X	X
Type I and II error	X	X
Relative risk reduction		X
Absolute risk reduction		X
Number-needed-to-treat (harm)		X
Odds ratio	X	X
Survival analysis (eg, Kaplan-Meier)		X
Sensitivity and specificity	X	X
Predictive values		X
Likelihood ratios		X
Receiver operator curve		X
Systematic review		X
Meta-analysis		X
Retrospective study	X	X
Case-control study	X	X
Cohort study	X	X
Randomized-controlled study	X	X
Bias and confounding	X	X
Cost-effectiveness analysis		X
Intent-to-treat analysis	X	X
Sample size calculation	X	X
Power	X	X

Table 2
Effect of EBM curriculum on sub-scores in the “Scholarly Activities” & “Emergencies Treated Medically” sections of ITE

The EBM curriculum had a large and statistically significant effect on the sub-scores on the “Scholarly Activities” section of the ITE; sub-scores were 28 and 21 percentage points lower in the baseline and transition instruction periods, respectively, when compared to the EBM curriculum instruction period.

Variable	SA score			EM score	
	Parameter Estimate	CI	p-value	Parameter Estimate	CI
Baseline vs. EBM	-0.28	[-0.41, -0.14]	0.0004	-0.08	[-0.17, 0.01]
Transition vs. EBM	-0.21	[-0.35, -0.08]	0.005	-0.01	[-0.10, 0.08]
PGY	0.06	[0.02, 0.11]	0.01	0.002	[-0.03, 0.04]

Abbreviations: EBM = Evidence-Based Medicine, ITE = In-Training Examination, SA = “Scholarly Activities”, EM = “Emergencies Treated Medically”, CI = confidence interval, PGY = post-graduate year