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Assessment of an Elective in Antibacterial Pharmacotherapy

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Abstract

The objective of this assessment was to compare antibacterial pharmacotherapy test performance for students who have and have not taken an antibacterial pharmacotherapy elective. Students took a pre-exam covering topics that would be subsequently taught in the anti-infectives module of Pharmacotherapeutics. Scores for the pre-exam and the two actual Pharmacotherapeutics exams covering this material were compared between students who had (intervention, n=56) and had not (control, n=65) taken a previously offered elective class on antibacterial pharmacotherapy. Mean scores on the pre-exam (50.7% versus 30.6%, $p< 0.05$) and the first Pharmacotherapeutics exam (80.2% versus 76.3%, $p < 0.05$) were significantly higher for the intervention students. Mean scores on the second Pharmacotherapeutics exam were not statistically different (84.4% versus 81.9%, $p = 0.05$). Students who take an antibacterial pharmacotherapy elective have greater antibacterial knowledge upon entering Pharmacotherapeutics and perform better on infectious diseases Pharmacotherapeutics exams containing information related to antibacterial pharmacotherapy.

Keywords: *Antibacterials, Antibiotics, Assessment, Education, Infectious Diseases*

Introduction

Assessment of instructional effectiveness and student learning occurs at many levels within an educational institution. As outlined by Miller and Leskes, student learning can be assessed within courses (assignments and exams) and across courses as they progress through a programme (capstone exams, grade point average) (Miller & Leskes, 2005). Assessment may focus on the outcomes of an individual course, programme, and ultimately, an institution; they may be global in nature or focus on how well components contribute to the objectives of the whole (ie, is a course fulfilling its intended role in the programme's curriculum?). While assessment of student learning outcomes is not a new concept in pharmacy education, the awareness for formal assessments at all levels has become heightened at our institution with the publication of the 2007 Accreditation Council for Pharmacy Education Standards and Guidelines (Accreditation Council for Pharmacy Education, 2006). In particular, the detail of the Self-Study Template and Evaluation Form to be used by evaluation team members during site visits suggests that future accreditation visits may require a more detailed accounting of assessment activities (Accreditation Council for Pharmacy Education Self-Study Template for Standards 2007, Accreditation Council for Pharmacy Education Evaluation Form for Standards 2007).

While it might be intuitive to include core courses in an institution's assessment plan, the assessment of elective course offerings may receive less attention by nature of the fact that they are not core courses; our review of the pharmacy education literature did not reveal any publications describing assessment of this sort. At the Massachusetts College of Pharmacy and Health Sciences - Worcester/ Manchester (MCPHS-W/M), all courses, including electives, offered through the School of Pharmacy are professional pharmacy courses. Hence, all electives are designed to have a direct impact on student professional knowledge and behavior by building upon prior knowledge, expanding into areas not addressed fully in core courses, and enhancing students' understanding for future core courses and practice experiences. Since these electives are likely to have potentially measurable effects on the outcomes for our core courses, they should be included in assessment plans. The current article describes the initial assessment activities for one of these electives, entitled "Basic Concepts in Antibacterial Pharmacotherapy".

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Methods

Programme and elective description

The MCPHS-W/M Doctor of Pharmacy programme is a year-round accelerated programme that is completed in 2 years and 10 months. It is designed for students who have completed prerequisite pre-professional course work. During the Spring term of their second year, students have the opportunity to take one of their three required elective courses. One such elective, "Basic Concepts in Antibacterial Pharmacotherapy", introduces students to concepts that are elementary to designing antibacterial pharmacotherapeutic plans. This is a 2 credit course that meets once weekly for 2 hours per week. It is taught by three instructors who teach primarily in a lecture-based format. However, the instructor who is responsible for approximately one-half of the course content regularly incorporates active learning strategies and activities (eg, handouts that are completed by students, student-driven discussions, content review activities) into the class sessions. The topics covered in this course include antibacterial decision considerations, assessment of infectious diseases-related laboratory data, culture specimen collection techniques and result interpretation, antibacterial susceptibility profiles, susceptibility testing methods and breakpoint determinations, bacterial resistance mechanisms, indications for combination antibacterial therapy, pharmacodynamics, safety during pregnancy, drug interactions, and antibiotic management initiatives.

The "Basic Concepts in Antibacterial Pharmacotherapy" elective was designed to address infectious diseases content that is only superficially discussed during the infectious diseases sessions of Pharmacotherapeutics III. We anticipated that the information delivered in this elective would be useful for students trying to understand a pharmacotherapeutic specialty area that is as complicated as infectious diseases. The type of supplemental instruction provided by our elective was considered to be of particular importance for students of our programme, since our Pharmacotherapeutics course offerings are not lecture based. Rather, instructors facilitate student-driven discussions of patient cases and accompanying guidance questions that have been provided to students. Although instructors may assist with the discussions and clarify student confusion with brief lecturing on specific issues, the class is driven by the students' discussions of the pharmaceutical care plans that they have developed prior to class based on the recommended readings and handout materials provided to them.

Assessment Methods

It was our hypothesis that students taking "Basic Concepts in Antibacterial Pharmacotherapy" would have a measurably greater baseline antibacterial knowledge base prior to entering Pharmacotherapeutics III (offered during the Summer term starting 1 week after the end of the Spring term), and would be better prepared to succeed (and thus, achieve higher test scores) in the infectious diseases module of Pharmacotherapeutics III. The objective of this study was to test these hypotheses.

All students enrolled in Pharmacotherapeutics III during the Summer 2005 term were asked to voluntarily participate in this assessment study which was reviewed and approved by our Institutional Review Board. Each participating student signed an informed consent form to indicate their voluntary participation. The students enrolled in this course included a group that had taken the "Basic Concepts in Antibacterial Pharmacotherapy" elective (intervention, n = 56) and those who had not taken this elective (control, n = 65).

On the first day of Pharmacotherapeutics III, students were asked to complete a 30 minute antibacterial pre-exam (see Appendix for question stems) which was not to count towards their course grade. The scores from this exam and those from the first two Pharmacotherapeutics III exams containing infectious diseases-related content were collected for analysis. The pre-exam administered on day one consisted of 25 questions. Each of the twelve bacterial infectious diseases sessions in Pharmacotherapeutics III were represented by two questions on the exam. The exam was prepared by one of the course coordinators of the "Basic Concepts in Antibacterial Pharmacotherapy" elective after consultation with the faculty members who were assigned to teach the antibacterial pharmacotherapy sessions in Pharmacotherapeutics III. Questions were designed to address factual information that each faculty member considered particularly important components for their respective topics. The topics represented included: an introduction to antibacterials, antibacterial resistance, pneumonia, skin and soft tissue/ intravenous catheter infections, urinary tract infections, intraabdominal infections, meningitis, sexually transmitted diseases, upper respiratory tract infections, and gastroenteritis. In Pharmacotherapeutics III, each of these topics was covered in one session (each represented by two questions on the exam) with the exception of the introduction to antibacterials, which was covered in three sessions (represented by six questions on the exam). The 25th question on the exam asked students if they had taken the "Basic Concepts in Antibacterial Pharmacotherapy" elective. The two Pharmacotherapeutics III exams were not prepared with a particular intent to assess differences between the intervention and control groups. They were prepared by the respective topic presenters, two of whom were investigators in this study. All three exams consisted of multiple choice questions with one correct answer and 3-4 distractors. All of the questions in the pre-exam and most of the questions in the two Pharmacotherapeutics III exams tested factual knowledge at a level consistent with the revised Bloom's taxonomy categories of remembering and understanding (Krathwohl, 2002).

As an additional method of assessment for the "Basic Concepts in Antibacterial Pharmacotherapy" elective, the results of the Spring 2005 student course evaluations were reviewed in order to obtain the students' perspective on this course. Specifically, we tabulated the response to the item "Overall rating of course", to which students could choose one of five responses ranging from strongly negative to strongly positive. The report generated by the tabulation software (PulseSurvey II, Scantron) categorized responses as

favorable, neutral, or unfavorable, and provided a mode response.

Data Analysis

Scores on the pre-exam and those from the first two Pharmacotherapeutics III exams were entered into an Excel spreadsheet and exported to NCSS (Number Cruncher Statistical Software, copyright© 2000, Jerry Hintze). Unpaired t-tests were used to compare the mean scores (±sd) between intervention and control students. For all analyses, statistical significance was established if the observed level of significance was $p<0.05$.

Results

There was a statistically significant difference favouring the intervention students for the mean score of the pre-exam (50.7% ± 14.1 versus 30.6% ± 12.4, 95% CI for difference 14.8-25.3%, $p < 0.05$) and the first Pharmacotherapeutics III exam (80.2% versus 76.3%, $p < 0.05$). Although the difference in the mean score for the second Pharmacotherapeutics III exam approached statistical significance (84.4% versus 81.9%, $p = 0.05$), the 95% confidence interval for the difference did include a value inclusive of no difference. Table I displays the mean exam scores and the results of the statistical analysis of the score differences between the intervention and control students for the Pharmacotherapeutics III exams.

Fifty-eight percent of students in the "Basic Concepts in Antibacterial Pharmacotherapy" elective submitted a course evaluation at end of the Spring 2005 semester. When asked to provide an overall rating for the course, 81.8% of students responded favorably, 15.2% provided a neutral response, and 3% (one student) responded unfavorably. Although a detailed breakdown indicating the responses for each point along the five point response scale is not available, the report did provide a mode. The mode response was "favorable" for this course offering.

Table I. Pharmacotherapeutics III exam score and exam score differences for intervention and control groups

	Pharmacotherapeutics Exam 1 score (%)	Pharmacotherapeutics Exam 2 score (%)
Intervention n = 56	80.2 ± 8.8	84.4 ± 7.1
Control n = 65	76.3 ± 8.5*	81.9 ± 6.5†
Score difference (95% CI)	3.9 (0.7, 7.0)	2.5 (0.0, 4.9)

*$p < 0.05$ for between group comparisons
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Discussion

The intent of offering the "Basic Concepts in Antibacterial Pharmacotherapy" elective was to help prepare students for the infectious diseases pharmacotherapeutics discussions to occur during the first half of Pharmacotherapeutics III. This elective allows for formal, methodical discussions of clinically-relevant information regarding antibacterial therapies. Although students receive some of this information in Pharmacotherapeutics III and Pharmacology/Medicinal Chemistry III during the Summer term, time does not allow for incorporation of the detailed and systematic discussions provided in this elective. The positioning of this elective in the Spring term may preclude students from being required to learn (or relearn) and concomitantly apply a large volume of infectious diseases, microbiology, and antibacterial information. Additionally, although some of the infectious diseases and microbiology information may be covered in pre-requisite courses (eg, Biology or Microbiology), application would require students to recall information that may have been learned years prior in their academic careers.

The results of our assessment study do suggest that students who take the "Basic Concepts in Antibacterial Pharmacotherapy" elective have a measurably greater baseline antibacterial knowledge base prior to entering Pharmacotherapeutics III and are better prepared to succeed in the infectious diseases portion of Pharmacotherapeutics III. Yet, despite the higher average score of the intervention group on the pre-exam, the absolute score (50.7 ± 14.1%) for this group of students was notably less than we anticipated. There are several factors which may explain this finding. This exam did not simulate typical exam-testing conditions. This was not a pre-announced exam for which students could prepare, and its "surprise" nature likely reduced performance. Also, the knowledge that the results would not affect the course grade may have caused students to place less consideration into responses. Since we are working under the hypothesis that intervention students are entering Pharmacotherapeutics III with a greater knowledge base, it is likely the effect of such factors would have a substantially greater impact on the intervention students relative to the control students.

Consistent with our hypothesis, intervention students also performed better on the first Pharmacotherapeutics III exam. The 3.9% difference in mean score for this exam is consistent with an increase in performance of one-half of a letter grade. This difference was less than anticipated, but it is still meaningful. Although there was not a measurable difference in scores of the second exam, this was also anticipated. While the information in the elective was relevant to all of the topics included in the first Pharmacotherapeutics III exam, the second exam contained topics that were either not addressed in the elective (HIV and tuberculosis pharmacotherapy) or were only partially addressed (sexually transmitted diseases). Although one could argue that it might be more relevant to evaluate performance only for questions containing information that was well covered in the elective, this would only have reinforced what we found to be true with administration of the pre-exam. Instead, by including

performance on both Pharmacotherapeutics III exams in their entirety, we were able to evaluate whether the elective produced an observable difference on overall performance on Infectious Diseases Pharmacotherapeutics III exams.

One limitation of our assessment plan is that we know little about the student groups beyond their exam performance and whether they took our elective. With the pre-exam results, we have established that the two student groups are different. While one could argue that the two groups may have other characteristics that help explain the differences in their test performance, there is not reason to assume that intervention students had higher grade point averages or a greater interest in infectious diseases compared to the control students. Our elective is very popular and is not prohibitively difficult. One of the reasons students take this elective is that it gives them a head start on the information that is to be discussed in their Summer term courses. This is likely to serve as motivation for both the exceptional and the borderline student, whether or not they have a particular interest in infectious diseases. Of note, in the Spring of 2005, we accepted the limit of 60 students into the elective (four dropped the course before the add/drop date) and refused 20 requests to add the course. Hence, approximately two-thirds of the class showed interest in the elective. It is unlikely that so many sought the course because of their interest in infectious diseases. One might also wonder whether the registrar's selection process was weighted in favor of the more successful students. However, the registrar used student identification numbers to determine who has preference within a given academic term, with "even" and "odd" identification numbers getting preference in alternating terms.

Intuitively, it would be logical to think that students successfully completing the "Basic Concepts in Antibacterial Pharmacotherapy" elective would score better on an exam containing information related to the content of that course. However, there are also other likely, possibly more relevant, benefits of this course that are not captured with use of multiple-choice exams that evaluate the most basic level of knowledge. Students who took our elective may have needed less assimilation and studying time when preparing for Pharmacotherapeutics III. The elective may also provide students with a more relevant context within which to view and apply infectious diseases pharmacotherapy. For students who took this elective, connections between symptoms, diseases states, organisms, and antibiotics are likely stronger, better understood, more readily elaborated upon, and, when it comes to application, more readily applied to real patient situations on clinical rotations (ie, the context mentioned above). Additionally, students taking this elective may also possess a greater degree of confidence in their infectious diseases knowledge base and may have better resources that they can utilize during clinical rotations as well as in their future practices. This latter point is particularly relevant since many of the handouts for this elective draw from resources such as authoritative guidelines, texts, and the primary medical and scientific literature. Some (but not all) of these resources are included as required or suggested readings during Pharmacotherapeutics III. However, it is primarily the students' responsibility to read and summarize these materials in order to utilize them to develop treatment plans for discussions in Pharmacotherapeutics III. Although this process may prompt students to develop concise and useful summaries of these materials, they may not be as useful as those utilized during our elective, since they have not been developed from the perspective of experienced practicing clinicians (ie, students may not know what is most important to focus upon). While it might be of more relevance to assess whether our elective has an impact on long-term retention of infectious diseases information or the future performance of students in their clinical rotations and practices, measurement of these and the other potential benefits mentioned herein would require assessment tools that are different and more sophisticated that those that we have employed.

Students who take "Basic Concepts in Antibacterial Pharmacotherapy" have a greater antibacterial knowledge base upon entering Pharmacotherapeutics III than those who have not taken this elective. This advantage translates into better performance on infectious diseases Pharmacotherapeutics exams. Findings from this study suggest that it would be of benefit to require that all students take such a course to facilitate their understanding of this important area of pharmacotherapy.

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Appendix: Antibacterial pre-exam questions

1. Of the antibiotics listed below, which is most likely to have activity against the organism *Enterococcus faecalis*?

2. Of the antibiotics listed below, which is most likely to have activity against VRE?

3. Which one of the following bacteria is a Gram-negative, non-lactose fermenting rod?

4. Which of the following bacteria is a coagulase-positive, Gram-positive coccus?

5. Which of the following statements about the antibacterial spectrum of cephalosporin antibiotics is false?

6. Of the antibiotics listed below, which is most likely to have activity against *Pseudomonas aeruginosa*?

7. Which of the following statements best characterizes the mechanism(s) by which MRSA expresses resistance towards beta-lactam drugs?

8. Of the antibiotics listed below, which is most likely to have activity against an ESBL-producing organism?

9. The organisms most commonly implicated as the cause of community-acquired pneumonia are *Legionella pneumophilia*, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, and *Streptococcus pneumoniae*. Of the antibiotics listed below, which is most likely to have activity against all of these organisms?

10. The organisms often implicated as a cause of hospital-acquired pneumonia include *Klebsiella pneumoniae*, *Enterobacter aerogenes*, and *Serratia marcescens*. Of the antibiotics listed below, which is most likely to have activity against all of these organisms?

11. The organisms most commonly implicated as a cause of skin infections are streptococci and *Staphylococcus aureus.* Of the antibiotics listed below, which is most likely to have activity against both of these organisms?

12. Which of the following organisms is most commonly implicated as being a contaminant of blood and central line catheter cultures?

13. The organism most commonly implicated as a cause of urinary tract infections is *E. coli.* Which of the following antibiotics would not be an option in the treatment of a urinary tract infection in a pregnant woman?

14. If a patient is receiving a fluoroquinolone antibiotic for treatment of a urinary tract infection, which of the following would least likely affect the absorption of the fluoroquinolone antibiotic?

15. The organisms most commonly implicated as a cause of intra-abdominal infections include Gram-positive cocci, Gram -negative rods, and anaerobic organisms. Of the antibiotics listed below, which is most likely to have activity against these organisms?

16. Of the antibiotics listed below, which is most likely to have activity against *Bacteroides fragilis?*

17. One of the etiologic organisms of acute bacterial meningitis is *Neisseria meningitidis.* Of the antibiotics listed below, which is most likely to have activity against this organism?

18. One of the etiologic organisms of acute bacterial meningitis is *Streptococcus pneumoniae*. Of the antibiotics listed below, which is most likely to have activity against this organism?

19. The etiologic organisms of infectious urethritis are typically *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. Of the antibiotics listed below, which is most likely to have activity against fluoroquinolone-resistant *Neisseria gonorrhoeae?*

20. Of the antibiotics listed below, which is most likely to have activity against *Chlamydia trachomatis?*

21. Penicillin-resistant *Streptococcus pneumoniae* is one of the etiologic organisms of middle ear infections in children. Of the antibiotics listed below, which is most likely to have activity against this organism?

22. *Haemophilus influenzae* and *Moraxella catarrhalis* are implicated as etiologic organisms in middle ear infections and other upper respiratory tract infections such as bronchitis and sinusitis. Of the antibiotics listed below, which is most likely to have activity against both of these organisms?

23. *Clostridium difficile* diarrhea is an adverse consequence of antibiotic therapy. This condition can be severe enough to require antibiotic therapy. Of the antibiotics listed below, which is most likely to have activity against this organism?

24. The most common bacterial causes of traveler's diarrhea include *E.coli*, *Salmonella*, *Shigella*, and *Campylobacter.* Of the antibiotics listed below, which is most likely to have activity against all of these organisms?