INSTRUCTIONAL DESIGN AND ASSESSMENT

An Elective Course on Antimicrobial Stewardship

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Objective. To implement an antimicrobial stewardship (AS) elective course for second-year and third-year pharmacy students and to assess its impact on students' perceptions regarding the application of AS principles.

Design. A 2-credit elective course focusing on principles of AS incorporated prelecture didactic recordings with primary literature and guideline-based reading assignments, in-class active-learning group work and student-led presentations, and student-generated examination items.

Assessment. Perceptions were assessed by precourse and postcourse survey items. Graded course assessments included completion of preclass assignments (readings, prerecorded lecture and writing assessment items), in-class active participation and group presentations, a midpoint examination, and a final examination.

Conclusion. An AS-themed elective course in a doctor of pharmacy curriculum incorporating preclass, self-directed learning and in-class group-based active-learning strategies positively impacted students' perceived understanding of AS strategies.

Keywords: pharmacy education, infectious diseases, antimicrobial stewardship, elective course

INTRODUCTION

Microbial resistance to antimicrobial agents is a public health threat with direct impact on patient care. To mitigate the progression of antimicrobial resistance, antimicrobial stewardship (AS) initiatives and infection control measures are employed. The purpose of AS is to optimize clinical outcomes while minimizing unintended consequences of antimicrobial use including emergence of drug resistance, selection of pathogenic organisms, and drug toxicity.¹ The importance of AS to the future of health care is reflected in documents released by the US and Canadian governments, calling for widespread implementation of institutional AS programs at thousands of patient-care centers.²⁻⁴ In developing an institutional AS program, a pharmacist and a physician with advanced training in infectious diseases (ID) are identified as core personnel.^{1,5} There is a substantial shortage of clinical ID

pharmacists to serve as AS program champions, and opportunities to acquire advanced ID training are limited.^{6,7} As barriers to implementing robust AS programs persist, incorporation of AS-specific educational opportunities into pharmacy school curricula requires consideration.

Fundamentals of general ID pharmacotherapy are required content in pharmacy education curricula. Documents provided by the Accreditation Council for Pharmacy Education, Center for Advancement of Pharmacy Education, and American College of Clinical Pharmacy provide recommendations on general ID-related educational outcomes, but do not specifically include the term "antimicrobial stewardship."⁸⁻¹⁰ The principles of AS extend beyond general ID and include particular attention to system-based variables that may affect an intended intervention's outcome (eg, information technology capabilities, interprofessional relationships or supply chain management practices). Although AS is not synonymous with general ID, AS has emerged as an essential component of ID patient care.

The role of AS in pharmacy education is ill-defined, and literature on the topic remains scarce. In a survey of 579 final-year doctor of pharmacy students representing 12 US schools of pharmacy, Justo et al attempted to

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characterize pharmacy student knowledge and perceptions of antimicrobial use.¹⁰ Respondents perceived AS as an important health care issue and desired to learn more about the topic, but achieved low knowledge scores. Such data support the need for greater AS education in pharmacy curricula, and the authors suggested opportunities to improve professional pharmacy curricula related to antimicrobial use. Hidayat et al described the implementation of a general ID elective for pharmacy students.¹¹ This 4-week course was offered at one school of pharmacy, used active learning strategies (ie, mini-lecture, journal club and debate with follow-up discussion) and was found to increase knowledge and awareness of infectious diseases.

To our knowledge, only one publication exists detailing the impact of an AS elective course on pharmacy education. Falcione and Meyer provided an assessment of an AS-based ID elective incorporating human patient simulation technology.¹² The course was successful in impacting student awareness, knowledge, and skills related to AS program strategies. While novel in design and content, the course had a limited number of participating students (45 students over 4 years and 4 course offerings) and relied heavily on the availability of human patient simulation mannequins. Reproducing such a course may be limited at institutions lacking such technology or with more student interest. The purpose of our AS elective course was to enhance pharmacy student preparedness for participating in AS activities. Prior to this elective course, the Nova Southeastern University College of Pharmacy did not offer any ID-oriented elective courses.

DESIGN

A 15-week, 2-credit hour elective course focused on AS was offered to second-year and third-year pharmacy students at the college during the winter semester of 2014. The college has one main campus and 2 synchronous distance campuses. Students from all campuses were eligible to enroll in the elective course. Prerequisites included the core curricular courses of microbiology and pharmacotherapy. Students receive the majority of ID pharmacotherapy content during Pharmacotherapy IV (taken during the winter semester of the final didactic year).

The goal of this elective course was to familiarize students with core principles and activities related to AS, specifically those endorsed in the Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA) guidelines.¹ Students were expected to achieve the course objectives presented in Table 1. These objectives were met through employment of pedagogical methods and student-learning assessment strategies, including didactic teaching and active learning. To evaluate the effectiveness of the course, precourse and postcourse surveys were administered to enrolled students. This study was approved by the NSU Institutional Review Board.

The AS elective course became available for enrollment late (approximately one month after open enrollment had begun, at the time of the institution's curricular approval). Twenty-eight students enrolled in the course, and after the add-drop period (week 2), 22 students remained enrolled. The course was taught by 3 ID pharmacy specialists within the pharmacy practice department (2 general ID and one HIV/AIDS). Each course faculty member was responsible for developing, facilitating, and grading 3 to 4 of the weekly course topics. Two faculty members from the main campus designed and coordinated the course.

The course outline and weekly topics are shown in Table 2. The topics were chosen by reviewing the IDSA/SHEA guidelines and supporting primary literature.¹ The consensus of the course coordinators was that these topics would provide students with comprehensive instruction and an understanding of the most common activities expected of pharmacists performing AS activities. Initially, the 15 sections of the IDSA/SHEA guidelines on AS were intended to be divided into one section weekly during the semester, but as shown in the completed schedule in Table 2, adjustments were made to allow time for in-class mid-term and final examinations, spring break, and also for our university's biennial research day event.

During the first session of the course, the faculty members described course expectations, grading policies and in-class/out-of-class expectations. This was followed by a live 50-minute didactic lecture describing the basics of antimicrobial resistance, the scope of the antimicrobial

Table 1. Antimicrobial Stewardship Elective Course Objectives

Define antimicrobial stewardship
Recognize key concepts discussed in the Infectious Diseases Society of America and Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship
List the core and supplemental strategies of antimicrobial stewardship programs and initiatives
Appraise published literature investigating antimicrobial stewardship practices and principles
Identify challenges in the global health care community as a result of the spread of antimicrobial resistance
Create assessment questions incorporating concepts learned from in-class and out-of-class activities

Table 2. Antimicrobial Stewardship Elective Course Schedule

Week	Topic(s)
1	Course introduction and description; scope of antimicrobial resistance problems; ASP elements, members, and administrative support
2	Prospective audit with intervention and feedback; formulary restriction and preauthorization requirements for specific agents
3	Comprehensive multidisciplinary antimicrobial and antiretroviral management programs; ASP education
4	Antimicrobial cycling; Scheduled antimicrobial switch; Antimicrobial order forms
5	Guidelines and clinical pathways
6	Health Professions Division Research Day (no class)
7	Combination therapy: prevention of resistance vs redundant antimicrobial coverage
8	Midterm examination (in-class)
9	Dose optimization; Conversion from parenteral to oral therapy
10	Streamlining and de-escalation of therapy
11	Computer surveillance and decision support
12	Spring break, no class
13	Microbiology laboratory
14	Monitoring of process and outcome measures
15	Final examination (in-class)

ASP=antimicrobial stewardship program

resistance problem, and the state of the antimicrobial drug development pipeline. In the subsequent classes, at least one new AS strategy was introduced each week such that self-study was required prior to class, and active-learning activities occurred in class.

Self-study consisted of the following preclass requirements: viewing a prerecorded, 30- to 45-minute didactic lecture; reading select peer-reviewed publications along with the relevant section of the IDSA/SHEA guideline; and writing and submitting 2 multiple-choice assessment questions and answers. Faculty members utilized Tegrity Lecture Capture (Tegrity, Burr Ridge, IL) to record lectures, which were posted with relevant handouts and readings on Blackboard (Blackboard Inc., Washington, DC) at least one week in advance of the in-class session. Students submitted 2 multiple-choice assessment items by 9 p.m. the day before the class. These questions and answers were used to verify student completion of the preclass learning activities. Rubrics and training for multiple-choice item writing were reviewed with students in the first class session, and each item was to be based upon the AS content for that particular week. This exercise was designed to complement lecture material and readings and to engage students in active thinking, problem solving, and reasoning. This activity also allowed the instructors to perceive any inaccuracies in student knowledge or perceptions for the topic content. Each 30-item midterm and final examination included up to 5 student-submitted assessment items covered in class, which were modified by the course faculty members to enhance readability and accuracy.

In-class time was structured around active-learning techniques aimed at stimulating critical thinking and

illumination of ideas. The instructor reviewed the week's AS strategy and answered students' questions. Students then were divided at their campuses into small randomly assigned groups of 3 to 4 students. The groups were given 10 to 20 minutes to develop a clinical case scenario in which the AS topic for that week was integrated into a practice setting of their choice. During this time, students designed clinical scenarios to mimic situations in which pharmacists would be expected to implement an AS measure in an institutional setting (eg, how a pharmacist with 8 hours per week to devote to AS activities in a small community hospital may use information technology to develop an educational program for nurses).

After the scenario creation, faculty members called on one group to present to the class. A single member of the group presented their scenario, after which, the other group members could provide additional reasoning. Ensuing discussion was based on procedure, preference, and judgment, as described by the Socratic method.¹³ Students from other groups were encouraged to identify potential pitfalls of the presented scenario, and course faculty members promoted discussion by posing open-ended and analytical questions to the group and to the class as a whole (eg, "How would you address infection control if you allow handheld electronic devices in patient care areas?"). Participation was documented by course faculty members. To facilitate student self-assessment, during the last 15 minutes of each class, approximately 5 to 10 of the student-submitted assessment items were chosen at random by the instructor and reviewed in class anonymously, which allowed for an

open critique and identification of opportunities for improvement.

Clinical scenarios developed by student groups were an integral part of the active-learning design of the course and allowed students to reinforce and apply their clinical knowledge. For topics for which clinical scenario development may have been vague (eg, microbiology), faculty members provided prompts (eg, "What is the role of rapid diagnostic tests in influencing patient care?") and facilitated debate among the students regarding the validity of the statement based on current literature. Information covered in these presentations and discussions was treated the same as material taught in didactic lectures and was eligible for inclusion in midterm and final examinations.

Class attendance and participation were monitored closely throughout the semester because the value of the course directly depended on it. Students received points for participation based on classroom discussions and homework assignments. Grades were determined with a 100-point scale, with a maximum of 30 points for the midterm examination, 30 points for the final examination, 25 points for in-class assignments (ie, participation in group discussions and presentations), 10 points for pre-class assignments (ie, item writing), and 5 points for attendance. This breakdown was selected to motivate participation in active-learning activities and small-group discussions to develop independent learners. This structure also promoted successful completion across all aspects of the course.

Statistical analysis of precourse and postcourse survey responses was performed using SAS Enterprise Guide 6.1 (SAS Institute Inc., Cary, NC). The nonparametric Wilcoxon rank-sum test was used to analyze survey results, reported as median (25%-75% interquartile range) and considered significant at $p < 0.05$. Demographic information and postcourse survey results not used for pre/post comparison are reported as frequencies.

To assess the influence of the course on student perceptions and satisfaction, a survey was done on the first (23 items) and last day of class (37 items). The postcourse survey expanded on precourse data to incorporate items directed toward student satisfaction with the course and opportunities for course improvement. The purpose of the surveys was to collect demographic data, document changes in student perceptions, assess student satisfaction, and identify opportunities for course improvements. A 5-point Likert scale ranging from strongly disagree to strongly agree was employed to assess perceptions and satisfaction. Open-answer questions were incorporated into both tools and subsequently were assessed by course faculty members for recurring themes.

EVALUATION AND ASSESSMENT

Participation was voluntary and not incentivized. Twenty-seven students completed the precourse survey, and 22 completed the postcourse survey (96% and 100% response rates, respectively). The average student respondent age was 27.6 and 27.7 years, respectively. Two second-year students took both surveys. Twenty-five third-year students took the presurvey, and 20 took the postsurvey.

In the precourse survey, using an open answer format, students described their motivation for enrolling in the course. The most common themes identified included enhancing preparedness for future responsibilities ($n=11$), interest in learning more about infectious diseases ($n=9$), and desire to complement other related coursework ($n=5$).

Student perceptions before and after the course are presented and compared in Table 3. Interest in infectious diseases as a specialty was high before and after the course. Students' perceived ability to define, identify, participate in, and appraise literature of AS was enhanced after completing the course ($p < 0.001$ for all). Additionally, students perceived an enhanced understanding of AS initiatives and confidence in their ability to engage in AS activities. Overall, students reported feeling that antimicrobial resistance was both a US and global health issue, but increased concern was noted on the national level in postsurvey ($p=0.03$) responses. In both surveys, students agreed that pharmacists should be familiar with AS concepts and supported incorporation of interprofessional education within the course.

Student satisfaction measured by the postsurvey is summarized in Table 4. All students agreed the course objectives were met, and 95% of students were satisfied with the course format. Ninety-five percent of students believed the material taught in the course would assist them during their advanced pharmacy practice experiences (APPEs) and during their careers as pharmacists and, additionally, would recommend the course to a friend or colleague. Students were least satisfied with the pre-class item-writing component, and 2 students (one second-year and one third-year) indicated they did not feel prepared to take the course.

Additional data were collected in open-answer format in the postcourse survey. When asked which other health professions students should be invited to enroll in the class, all students identified allopathic or osteopathic medicine, and 8 students (36%) identified nursing. Physician's assistant, microbiology, and public health students were mentioned, as well. The in-class active-learning discussions and exposure to a variety of

Table 3. Comparison of Pre/Postcourse Survey Results^{a,b,c}

Survey Item	Precourse (n=27)	Postcourse (n=22)
Infectious disease is the specialty I am most interested in.	4 (3-4)	4 (3-4)
I can provide an accurate definition of “antimicrobial stewardship.”	3 (2-4)	5 (5-5)
I am aware of the existence of the “Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship.”	3 (2-4)	5 (5-5)
I am familiar with key concepts discussed by the “Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship.”	2 (2-3)	5 (5-5)
I am aware that antimicrobial stewardship aims to limit inappropriate antimicrobial use, optimize antimicrobial selection/dose/duration of therapy, maximize clinical cure or prevention of infection, and limit unintended consequences such as emergence of resistance, adverse drug events, and cost.	4 (4-5)	5 (5-5)
I am aware that the two core strategies for antimicrobial stewardship are (1) prospective audit with intervention and feedback and (2) formulary restriction.	3 (2-4)	5 (5-5)
I can accurately identify core and supplemental strategies of antimicrobial stewardship programs and initiatives.	2 (2-3)	5 (5-5)
I am confident in my ability to accurately and appropriately appraise published literature investigating antimicrobial stewardship practices and principles.	3 (2-3)	4 (4-5)
I am confident in my ability to participate in antimicrobial stewardship activities.	4 (2.5-4)	5 (4-5)
Antimicrobial resistance is a major global health issue.	5 (4-5)	5 (5-5)
Antimicrobial resistance is a major US health issue.	5 (4-5)	5 (5-5)
Pharmacists should be familiar with concepts related to antimicrobial stewardship.	5 (5-5)	5 (5-5)
Antimicrobial stewardship should be permanently incorporated into pharmacy school curricula.	5 (4-5)	5 (4-5)
Participation of nonpharmacy students (eg, medical students) would enhance the value of this course.	5 (4-5)	5 (5-5)
Participation of nonpharmacy faculty members would enhance the value of this course.	4 (3.5-5)	5 (4-5)
I am confident in my ability to write assessment questions.	3 (2-3)	4 (4-4)

^aSurvey questions were reported using a Likert scale (1=strongly disagree and 5=strongly agree)

^bResults reported as median (25%-75% interquartile range)

^cTwenty-two students remained enrolled and completed the course following the allotted course drop period

resources (eg, literature, web-based tools), were identified as being the most helpful aspect of the course (n=8 and n=6, respectively). Students stated the least helpful aspect of the course was the lack of consistent student-specific feedback regarding weekly submitted assessment items (n=5).

The item most often recommended for addition to the course was interprofessional involvement (n=8). No other theme was found in the open-answer comments, and no course issues of major concern were identified. Sixteen students (73%) reflected on how the course positively impacted their perceptions. All indicated increased

knowledge about AS programs and/or preparedness for future responsibilities. One student commented, “I see the whole health care world as more of a team now,” and another stated, “I now feel confident that I can make a difference through various AS strategies once I become a pharmacist. I have also learned to appreciate the difficulty faculty members go [through] when creating examination questions.”

Quantitative course assessment data included a median course grade of 94% (range 85.5% to 99%), including the midterm examination grade median of 93% (range 80% to 100%) and the final examination grade median of

Table 4. Course Satisfaction Among Postcourse Survey Respondents (n=22)^{a,b}

Statement	Strongly Agree/ Agree, % (n)	Strongly Disagree/ Disagree, % (n)	Median Response (IQR)
I was prepared to take this course.	77 (17)	9 (2)	4 (4-4)
I was satisfied with the format of this course.	86 (19)	5 (1)	4 (4-5)
The stated course objectives were successfully met by this course.	100 (22)	0 (0)	5 (5-5)
I am satisfied with the online preclass videos used in this course.	100 (22)	0 (0)	4 (4-5)
I am satisfied with the quality of the preclass readings of this course.	90 (20)	0 (0)	5 (4-5)
I am satisfied with the question-writing of this course.	59 (13)	5 (1)	4 (3-4)
I am satisfied with the in-class discussion of this course.	90 (20)	5 (1)	4.5 (4-5)
I believe the information I learned in this course will assist me in advanced pharmacy practice experiences.	95 (21)	5 (1)	5 (5-5)
I believe the information I learned in this course will assist me as a pharmacist.	95 (21)	0 (0)	5 (5-5)
I would recommend this course to a friend or colleague.	95 (21)	5 (1)	5 (4-5)

^aSurvey questions were reported using a Likert scale (1=strongly disagree and 5=strongly agree). Neutral responses are not listed

^bResults reported at median (25%-75% interquartile range [IQR])

90% (range 63% to 100%). All students received full credit for the in-class active participation grade, 18 of 22 students (82%) received full credit for the preclass assignments, and 20 of 22 students (91%) received full credit for attendance. Both second-year students achieved final grades above 90%.

DISCUSSION

This AS elective course sought to provide pharmacy students with education on methods to ensure safe and appropriate antimicrobial drug use. Results from examinations, group presentations, and active-learning activities illustrated that students understood the material. There was significant improvement in students' perceived knowledge of all areas covered by the course objectives, as well as an increase in students' perceived knowledge of and confidence regarding AS. Thus, the course aided in bridging the curricular gaps in the area of AS.

Students demonstrated the capacity to appraise AS literature, identify AS fundamentals, and apply new concepts individually (preclass) as well as in a group (in-class). Students showed improved awareness and familiarity with AS guidelines, aims, key concepts, supplemental strategies, and core strategies. Students reported feeling significantly more confident in their ability to appraise literature regarding AS. Nearly every student (95%) reported feeling this course was beneficial to preparation for APPEs. In addition, students reported a significant improvement in their confidence participating in AS activities. Moreover, students' personal reflection of achievement paralleled objective success as measured by examination performance. Because of the nonidentifiable

nature of the survey tools, we were unable to pair self-reported success with course grades to further validate this finding.

We believe the success of the course was related to the structure, which incorporated the use of preclass assignments that prepared students for in-class active learning and discussions. All students agreed that the course objectives were met, and 86% were satisfied with the format. The students enjoyed application of preclass material to classroom discussions, which was reported as one of the most helpful aspects of the course. Course faculty members concurred with students that this "flipped" classroom technique was beneficial to reinforce lecture material. All course faculty members also were cognizant of engaging students from all campuses in discussions by calling on specific students and/or groups to share their thoughts, ensuring students at all campuses had an opportunity to speak prior to advancing the discussion or changing the topic.

As this was the initial offering of the course, there were several opportunities for improvement. First, the student sample may have been biased by the high level of interest in ID noted at baseline. The capacity for the elective course to impact those with less baseline interest remains unmeasured. The second offering of the course had filled 43 of 50 available seats a month prior to its commencement in January 2015, reflecting increased student interest compared with the initial year. Second, a natural progression for the course is to incorporate inter-professional education, taking advantage of NSU's Health Professions Division, which houses colleges of osteopathic medicine, dental medicine, optometry, nursing, and health

care sciences (ie, physician assistant and respiratory therapy). Future incorporation of students from these programs is planned; furthermore, faculty members from those colleges will be invited to participate and lead discussions in the classroom. Third, opportunities for improvement identified in the postclass survey were to provide greater individualized, formal feedback on preclass assignments. We plan to increase student-specific feedback in the next offering of the course. Finally, the potential exists to expand the course to an online offering that can be completed by students at the college, students enrolled in other pharmacy schools, students in other health professions, and even practicing pharmacists or other health care professionals.

Whether trained in infectious diseases or not, pharmacists are well-positioned to impact antimicrobial therapy. Thus, exposure to the fundamentals of AS within pharmacy curricula can better prepare students for the pharmacist's expanding role in the health care team. This course was specifically designed to provide such exposure and to prepare students with necessary tools to participate in and contribute to an AS program using evidence-based practices. The study provides the framework for an AS course that can easily be adapted and integrated at schools of pharmacy nationally and internationally, including those with distance campuses; even before they are exposed to ID pharmacotherapy in the curriculum.

There are several limitations to the study. First, a larger sample size and data from multiple course offerings would strengthen study results. Second, a follow-up survey administered after completion of the PharmD degree could provide an enhanced perspective regarding course strengths and weaknesses. Finally, external validity may be limited by the class format and varying capacities of other schools of pharmacy to administer such a course with the described methodology.

SUMMARY

An AS-themed elective course within a doctor of pharmacy curriculum incorporating preclass, self-directed learning and in-class, group-based active-learning strategies positively affected students' perceived understanding of AS strategies. The elective course was effective in achieving the intended objectives and will continue to be offered to students at the college with plans to expand the offering to students within other professions.

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