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INSTRUCTIONAL DESIGN AND ASSESSMENT

Development of an Antimicrobial Stewardship-based Infectious Diseases Elective that Incorporates Human Patient Simulation Technology

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Objective. To design an elective for pharmacy students that facilitates antimicrobial stewardship awareness, knowledge, and skill development by solving clinical cases, using human patient simulation technology.

Design. The elective was designed for PharmD students to describe principles and functions of stewardship programs, select, evaluate, refine, or redesign patient-specific plans for infectious diseases in the context of antimicrobial stewardship, and propose criteria and stewardship management strategies for an antimicrobial class at a health care institution. Teaching methods included active learning and lectures. Cases of bacterial endocarditis and cryptococcal meningitis were developed that incorporated human patient simulation technology.

Assessment. Forty-five pharmacy students completed an antimicrobial stewardship elective between 2010 and 2013. Outcomes were assessed using student perceptions of and performance on rubric-graded assignments.

Conclusion. A PharmD elective using active learning, including novel cases conducted with human patient simulation technology, enabled outcomes consistent with those desired of pharmacists assisting in antimicrobial stewardship programs.

Keywords: active learning, simulation, technology, antimicrobial stewardship, infectious diseases

INTRODUCTION

The alarming growth of antimicrobial resistance and its associated morbidity and mortality has been publicized on national and global platforms, commanding awareness of antimicrobial stewardship (AMS) as a mechanism to preserve the deteriorating antimicrobial armamentarium.[1-3] Pharmacists with infectious disease (ID) training have been recognized for their requisite role in antimicrobial stewardship programs (ASPs).[4] However, demand exceeds the supply of ID-trained pharmacists and, as a result, generalist pharmacists are being trained to participate in ASPs.[5,6] Antimicrobial stewardship principles aim to optimize patient clinical outcomes while minimizing unintended antimicrobial consequences including toxicity, the selection of pathogenic organisms, and the emergence of resistance.[4] Pharmacist roles in antimicrobial stewardship programs impact individual patients, as well as the budget and microbiological ecology of an institution, conceivably influencing how that institution provides care in the future.[3,7] Antimicrobial stewardship activities require pharmacists not only to integrate ID therapeutics, microbiology, pharmacology, pharmacokinetics, and pharmacodynamics, but also to think critically, problem solve, and develop and execute patient and institution-specific plans in collaboration with interprofessional teams. These abilities span all domains of the Center for the Advancement of Pharmacy Education (CAPE) educational outcomes.[8]

Recently, it has been suggested that pharmacy schools provide AMS education to prepare graduates for anticipated AMS-related activities in practice.[9] In 2010, we recognized that our PharmD curriculum did not provide AMS education to students beyond scant introductory and advanced pharmacy practice experiential offerings. We proposed, designed, and implemented an elective to fill that gap. While curricula for AMS education have been developed and are widely available to practicing pharmacists, they have only recently been described in PharmD programs, but have yet to be described utilizing human patient simulation (HPS).[5,10]

The Accreditation Council for Pharmacy Education (ACPE) curriculum standards advocate for active learning strategies including human patient simulation (HPS). This technology provides learners with a safe environment to practice skills, refine knowledge, and engage with

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other health care professionals in an interprofessional team environment.[11] Using HPS as a teaching and learning strategy has been incorporated at the University of Pittsburgh School of Pharmacy since 2006.[12-14] Use of HPS for ID content has been limited in the literature to antimicrobial administration as a precipitant for anaphylaxis management.[15] While ACPE endorses the availability of a variety of electives within PharmD programs, an elective on parasitology was previously the only ID-based elective in the program.[16] Thus, we designed an elective course to introduce pharmacy students to AMS principles using HPS and other active learning strategies to elicit learning outcomes in line with those expected of pharmacists who participate in institutional ASP activities. We aimed for the elective to provide students with a basis for AMS awareness, knowledge, and skills in the context of solving clinical cases, and developing AMS strategies. We expected that HPS would be an effective tool to help students solve clinical cases encountered by pharmacists. In this paper, we describe the design, assessment, and evaluation of the elective.

DESIGN

The elective course was designed for third-year pharmacy students who had successfully earned 8 credits in the second year from Pharmacotherapy of Infectious Diseases 1 and 2 (2 required 4-credit courses that integrate pharmacology, pharmacognosy, medicinal chemistry, microbiology, and therapeutics and that use didactic teaching and cased-based active learning and capstone activities).

Student ability outcomes and learning objectives were chosen to reflect expected roles of pharmacists participating in ASPs outlined by national ID and pharmacy organizations, and at our practice partner, UPMC Presbyterian Hospital which operates a comprehensive ASP.[4,7]Ability outcomes were also aligned with curricular outcomes of our PharmD program. Students were expected to be able to (1) describe the principles and functions of AMS programs and the roles of various professionals who contribute to AMS efforts; (2) select, evaluate, and refine or redesign patient-specific treatment plans for complex ID scenarios in the context of AMS (application of science and practice); and (3) apply AMS knowledge, skills, and resources (interpretation of cumulative antimicrobial susceptibility data and evaluation of published pharmacological and safety data) to compare and contrast similar antimicrobial agents in order to define and propose criteria and applicable AMS strategies in a health care institution's drug formulary. The ability outcomes were intended to be introductory level and were not envisioned to supplant specialist training for ID.[17]

Capped at a maximum enrollment of 12 students, this 1-credit elective was conducted in 10 class sessions over 5 weeks during the fall term. Such electives have been coordinated in the PharmD program to provide increased elective opportunities while reducing class schedule conflicts. Most class sessions for the elective were held in a small conference room or a simulation lab. One session was held at the clinical microbiology laboratory (CML) at the hospital. In each of the last 3 course offerings (2011, 2012, and 2013), 7 sessions were held in the classroom, 2 were conducted as HPS sessions, and 1 was devoted to the laboratory tour. All course faculty members participated in the ASP at the hospital. One pharmacy faculty member (the ASP associate director) developed and provided an overview of the hospital's ASP and contributed to the design of 2 major activities (clinical cases and the formulary project). A microbiologist and director of the hospital's laboratory conducted the 1-hour observation tour. The course coordinator, another pharmacy faculty member and AMS pharmacist, conducted the remaining class sessions, with support from a staff member in 2011 and 2012 and also an HPS technology expert in 2013. Both pharmacy faculty members were ID residency-trained, board-certified pharmacotherapy specialists. HPS sessions were supervised by the course coordinator and facilitated by 2 to 4 pharmacy residents and 2 to 3 ID medicine fellows, depending on the course offering. The coordinator was responsible for planning, scheduling, developing materials and activities, training the HPS session facilitators on case content, and conducting the evaluation and assessment. The HPS technology expert programmed course-specific cases (previously operated manually) and trained the facilitators to use the HPS mannequins (SimMan and SimMan 3G, Laerdal Corporation, Stavanger, Norway). The staff member coordinated room scheduling, organized HPS props, and managed drop-off of student assignments.

Pedagogy/Andragogy

Predominant teaching methods used in the course were lectures and a variety of active learning strategies. The lectures introduced AMS principles and reviewed infectious disease and microbiology fundamentals essential for AMS learning activities, such as antimicrobials, common pathogens, infections, and microbiology lab techniques.[18] Other lectures provided new knowledge about ASP functions and ASP members role delineation.

Active learning activities were chosen to facilitate student development and practice of AMS skills and were integrated into class sessions and homework assignments with active and reflective elements. Originally, the class activities were limited to 5: a baseline knowledge assessment questionnaire, mini-cases, an antimicrobial

streamlining exercise, evaluation of an institution-specific treatment protocol activity, and 2 HPS clinical cases.[19] Homework assignments included readings, online CML video tutorials, precase worksheets, written Subjective-Objective-Assessment-Plan (SOAP) notes and evidence-based justifications of the plan (SOAP/J), and the formulary project.[4, 20-27] Three required textbooks were introduced in 2012 to provide concise and clinically relevant reference materials.[28-30] The laboratory tour was intended for students to gain appreciation of the role of another AMS team member.

The baseline knowledge assessment questionnaire included 5 categories (AMS awareness, antimicrobials, pathogens, infections, and drugs of choice) and was administered on the first day of the course. Mini-cases were embedded within didactic review material (short clinical vignettes that queried likely site and type of infection, common pathogens, possible treatments, and further information needed to create a plan) and designed to interrupt the lecture to engage students in thinking. The streamlining exercise was conducted after its companion lecture on AMS strategies. Groups of 3 to 4 students received the same case scenario, medication profile, microbiological culture, and susceptibility results. The groups were instructed to discuss, propose, and then defend the most appropriate regimen for treatment completion. The clinical data allowed for more than one answer to encourage discussion. For the protocol evaluation, groups were presented with a published abstract and were asked to develop questions for the authors pertaining to implementation.[30] Each exercise complemented lecture material and aimed to engage the students in active thinking, problem solving, reasoning, and questioning. They also allowed the instructor to correct and explain inaccuracies in knowledge or logic and to confirm valid conclusions to build student confidence and preparation for formulary project and the HPS clinical cases.[31]

The formulary review project was developed to provide students with the opportunity to integrate antimicrobial and ID knowledge with AMS principles in a program-based AMS activity that pharmacists commonly perform for ASPs. Student pairs randomly selected a unique antimicrobial "class" and hospital formulary and received the same hospital antibiogram. These materials were modified annually to discourage plagiarism. Provision of wikis allowed ongoing formative feedback for students who utilized them. Originally, 1 class session was devoted to project questions. Office hours with the course coordinator were offered in the last 3 years. In 2012 a verbal proposal was added to the written assignment and students worked in pairs, rather than as individuals, to complete it. The written formulary reviews were turned in 1 day before the verbal proposals. These modifications were based on student feedback that suggested they could learn from their peers' projects. The assignment, while valuable for learning, was time intensive.

Four active learning activities were added after the second year: pet pathogens, ID headline, process or outcome literature review in 2012, and microbiology lab results in 2013. Elements of companion lectures were reduced or omitted. The pet pathogens activity required students to "adopt" and research pathogen trading cards to determine relevant facts across 8 categories.[32] At the start of the next 2 class sessions, students were required to recall these facts and fill in a game card. If correct, the card would be used for a board game competition developed for the course based on Trivial Pursuit and Pictionary. Game cards were posted on a course wiki for competition preparation. This activity was designed to replace most of the pathogen review lecture. Low-stakes game competition was used to motivate studying. For the ID headline activity, each student identified a current ID topic and attempted to convince the group that it warranted investigation for impact on AMS efforts. Each of the 2 groups (newspaper teams) selected 1 topic. The entire class then researched potential impact from the perspective of the hospital, the ASP member (ID pharmacist or physician or infection control practitioners), and the patient. Finally, newspaper teams were subdivided during class to prepare a question-guided report. This activity aligned with a companion lecture and assigned readings.[4] It aimed to demonstrate how current events (eg, drug shortages) direct AMS efforts in dynamic and unpredictable ways.[33,34] The process or outcome homework activity required reading an AMS review article on supporting evidence and then determining the type of evidence in 2 example articles (discussion sections were not provided).[25] In class, students voted on conclusions. Opposed voters compared rationales. This activity required students to determine their own conclusions while permitting instructor evaluation, student self-evaluation/ correction, and peer assessment, and instructor evaluation of peer assessment.[35] The microbiology laboratory results in-class group activities (preceded by assigned readings, video tutorials, and lecture) included 4 hands-on stations with corresponding worksheets designed to elicit recognition of limitations and nuances of common clinical microbiology assays (variation in automated identification and antimicrobial susceptibility, E-test interpretation). Worksheet answers were reviewed prior to the laboratory tour. This activity aimed to give students the opportunity to formulate questions at the tour.

Clinical Cases Using Human Patient Simulation

The clinical cases were designed to expose students to patient scenarios that pharmacists who participate in

ASPs encounter, based largely on the experience of faculty members participating in the AMS course. Incorporation of HPS technology in the clinical cases began in 2011. HPS has been embedded in the required Pharmacotherapy of Cardiovascular Disease course for second-year students since 2006 and, more recently, has been used in the epilepsy module within the required Neurology/Psychiatry course and an elective course in advanced acute care pharmacotherapy (both occur in the third year during the spring term).[36,37] While the required 2-course ID therapeutics sequence does not utilize HPS, it systematically incorporates active learning with scaffold-based paper cases for practicum and capstone exercises with SOAP/J and examinations. In the first offering of the elective, 2 paper scaffold-based clinical cases, bacterial endocarditis (BE) and cryptococcal meningitis (CM), were designed as homework assignments and debriefed in class with discussion questions. These complex infections were not covered in the required ID courses. The cases were modified to incorporate HPS technology the next year to increase case authenticity (shown to increase knowledge retention and practice confidence) and because the technology (SimMan and SimMan 3G) was available locally in the school.

The original paper-based clinical cases did not provide students with sufficient authenticity to detect, prevent, and manage *evolving* antimicrobial effects in the setting of severe infections or highly resistant pathogens, which are common complex ID scenarios that often warrant application of AMS principles to justify or avoid the use of broad spectrum agents. HPS was selected for its ability to immerse students in interactive learning without patient safety risks. HPS provided the desired clinical context where students and session facilitators could assess student performance, including interactions with other health care professionals, who were either simulated (pharmacy residents acting as nurses and ID physicians in 2011-2012) or real (ID physicians in 2013). HPS sessions were conducted in 2 parts over 2 weeks. Rubrics for the preHPS assignment and both SOAP/Js were used to evaluate correctness and completeness. Nine student activities were required (Table 1).

Learning objectives for these cases, which focused on skills and knowledge application for patients with these infections, were as follows: to correlate physical examination and test data with BE and CM diseases, to implement empiric treatment and monitoring plans, to mitigate evolving drug administration related intolerances (Red man syndrome, amphotericin induced rigors, and flucytosine-induced vomiting); to recognize inaccurate height and weight data and implications on weight and renal function-based dosing strategies; to correlate physical examination and test data with worsening or improving clinical status; to detect and mitigate drug-induced nephrotoxicity (aminoglycosides and amphotericin) and its consequences (dose-dependent flucytosine toxicity); to interpret the significance of measured drug concentrations; to clarify allergy history and identify the role for antimicrobial desensitization; and to revise treatment plans in response to drug intolerance and in accordance with AMS principles. The HPS technology was strategically used to provide authenticity of evolving drug intolerances and worsening or improving clinical status in real time so students could have the opportunity to prevent or mitigate negative outcomes and realize the consequences at the simulated patient bedside.

Table 1. Student Activities for Human Patient Simulation Sessions

1) Precase readings
2) Precase individual written assignment (5 short-answer questions)
3) PreHPS[a] session in-class group meeting
4) Two 45-minute HPS group sessions for each case[b]
5) Individual written SOAP[c] note with evidence based justification for each case after each HPS session
6) In-class lecture to debrief both cases at completion of HPS sessions
7) In-class debriefing worksheet and guided reflection
8) Peer evaluation of self and group members' HPS session participation
9) Pre- and postHPS readiness and expectation assessment

[a] Human patient simulation
[b] Designed to mimic hospital patient care rounds
[c] Subjective, objective, assessment and plan

Assessment Methods

Summative assessments were used for the clinical cases and formulary review project. All in-class active learning activities generated formative feedback for students and evaluation of class participation. All out-of-class active learning exercises were graded for correctness. The baseline knowledge questionnaire was intended to annually assess course content appropriateness. In 2013, it was repeated at the end of the course for students to self-assess and for extra credit (a suggestion from previous classes). The first short-answer question asked students to describe what they thought AMS programs do. Responses were evaluated using thematic analysis and Pearson correlation was used to test inter-rater reliability. All statistical tests were performed with SPSS version 21 (IBM Corp., Armonk, NY).

Rubrics were developed to evaluate performance on the clinical cases (the preHPS clinical case assignments and postHPS SOAP/J) and the formulary project. Observations during the clinical case HPS sessions were tabulated using

a modified HPS assessment checklist and used to provide immediate feedback to the student groups in 2011 and 2012.[14] In 2013, a revised assessment tool was introduced to guide facilitator feedback and evaluate student performance. Formative assessments aimed to provide feedback to improve performance on the graded assignments. Student perception of their learning was assessed at course completion with an anonymous online student course evaluation survey that generated aggregate data. Student time outside class needed to prepare for the course was estimated to be 1 to 3 hours per week for each of the 5 weeks. The University of Pittsburgh Institutional Review Board deemed this work to be exempt.

Continuous quality improvement was embedded throughout to meet ACPE curriculum standards and to enable expected course evaluation for the PharmD program.[16] This was accomplished with annual anonymous student course evaluations, the coordinator's annual assessment of course materials, and stakeholder feedback. Student performance was assessed based on class participation (40%), clinical case activities (30%), and the formulary project (30%). This breakdown was selected to motivate participation in the active learning activities and small group discussions, which emphasized independent learning. This structure also promoted successful completion of the entire course.

EVALUATION AND ASSESSMENT

Evaluation was conducted by examining student performance, perception of learning, and course satisfaction (Table 2). Evidence of HPS technology impact stemmed from the same sources. Curricular evaluation resulted in incorporation of HPS in 2011 and modification of the preHPS assignment to better prepare students for the HPS sessions. The added active learning activities reduced related didactic content in 2012.

Course assessment included annual review of student outcomes, course content and resources, and feedback from course stakeholders (faculty members, facilitators). Course faculty expressed consistent commitment. HPS facilitators indicated case authenticity was sufficient. The addition of ID fellows was positive and their fellowship program directors remain enthusiastic and supportive based on verbal feedback from both.

Between 2010 and 2013, 45 students completed the course (10 in 2010, 11 in 2011, 12 in 2012, and 12 in 2013). Of these, 49% were male and 51% were female. Aggregated across the 4 years, 55.6%, 31.1%, 3%, and 3% of students earned an A+, A, B+ and B, respectively. Extra credit in 2012 and 2013 may have contributed to more students receiving an A+ than in previous years. Class participation was evaluated by the faculty member's subjective observation (a 1-time peer evaluation of class participation was performed at course end in 2012 and 2013). Change in baseline AMS knowledge was qualitatively assessed in 2013. Rubric-based summative assessments were used to evaluate the clinical case assignments and the formulary review project.

Thematic analysis of responses to the open-ended question "What do you think AMS programs do?" on the baseline questionnaire resulted in 10 identified themes from 20 responses. Ten students completed this question during the first attempt (resulting in 27 themes) and the second attempt (resulting in 30 themes). Identified themes included: assure appropriate antibiotic use, limit resistance, prevent toxicity, optimize outcomes, evaluate resistance, educate, and decrease costs. Inter-rater reliability for identified themes was highly correlated (Pearson correlation, 0.779; $p<0.01$ and Spearman's rho, 0.808; $p<0.01$). Spearman's rho was performed due to apparent non-normal distribution of data. While there was more variety in themes identified in the first attempt, 50% identified "decrease costs" at course end (vs none on first attempt). This suggests students with baseline AMS awareness still gained new AMS knowledge (first course outcome). These students were the first to receive a single

Table 2. Assessment of Student Course Performance

Year	2010	2011	2012	2013
	Score (%) Mean, Median (Range), as %			
PreClinical Case[a]	-	-	95.8, 96.7 (90-100)	91.4, 90 (83.3-100)
Clinical Cases Part 1 SOAP/Justification[a]	86, 90 (50-100)	74.5, 75 (65-90)	70.6, 71.7 (53.3-93.3)	83.1, 83.3 (73.3-90)
Clinical Cases Part 2 SOAP/Justification[a]	90, 90 (90)	77.7, 80 (70-85)	94.4, 98.3 (83.3-100)	83.9, 85 (73.3-90)
Formulary Review and Antimicrobial Stewardship Proposal Project[b]	89, 86.7 (76.7-100)	83.9, 90 (56.7-100)	96.7, 96 (94-100)	93.1, 96.9 (72.5-100)

[a] Assignment completed by individual students.
[b] Assignment completed by individual students in 2010-2011, by student groups in 2012-2013.

assignment in the required ID course (in the prior year) about AMS.

The clinical case assignments were evaluated with a rubric. The mean scores across all 4 years were 78.55% (50-100%) and 86.5% (70-100%) for the SOAP/J in parts 1 and 2, respectively, showing a numerical improvement between HPS session part 1 and part 2. This occurred consistently each year. In 2011, performance on the first SOAP/J below 80% prompted improvement efforts. Review of student postcourse survey comments and verbal feedback indicated student lack of preparedness despite a presession assignment. However, this only entailed the readings and provision of additional questions the student would ask. Review of these questions revealed a deficiency in patient-specific considerations. In 2012, the preclinical case assignment was revised, session expectations for all group members (data collector, scribe, or communicator) were specified, and the preHPS group session was extended to allow more discussion of patient data. A rubric was developed to evaluate the first preHPS assignment (previously not evaluated) and students were provided with a readiness assessment survey immediately prior to the first HPS session and after the final HPS session so that an intervention could be made if needed.[36] HPS facilitators provided formative feedback at immediate end of each HPS session. Because students attended the HPS sessions in groups of 6, they were asked to complete peer evaluations during the debriefing class session.

Aggregated results over 4 years, measured as a mean score of 90.7% (83.9%-96.7%), indicated successful student achievement of the third course outcome (apply AMS knowledge, skills, and resources to compare and contrast similar antimicrobial agents in order to define and propose use criteria and applicable AMS strategies within a health care institution's drug formulary). Interestingly, mean scores appeared higher when the verbal component was required. This may have been due to score inflation or changes (ie, group work) to project design. Students performed well on both the verbal and written components. The lowest average verbal item score (4/5, 80%) occurred in 2012 when the verbal component was first added. Attention to this revealed a lack of differentiation for 2 rubric items. Explicit distinction in 2013 appeared to resolve the issue (4.83/5, 96.6%).

On the first class day, students were asked to indicate why they enrolled in the course. Responses were evenly split between "expand/gain new knowledge and/or skills" and "reinforce old knowledge/practice existing skills," except in 2011, when the split was 60% and 40%, respectively. Postcourse student surveys (5-point Likert-type items and 4 open-ended questions) evaluated student perceptions of course learning, satisfaction, and teaching methods. Questions were added periodically to reflect course changes. Survey instruments were distributed after final grades and returned sealed to a drop-off point in 2010. An anonymous online survey tool (Survey Monkey, Survey Monkey, Inc., Palo Alto, CA) replaced the paper method in subsequent years.

Aggregate results for 6 survey items (3 items in 2010, n=40 responses for each item; 3 items in 2011, 2012, and 2013, n=40, 39, and 39 responses, respectively) indicated that students perceived expected course outcomes had been achieved. Students agreed (to a high or very high degree) that the course met expectations (77.7%, 72.8%, 66.6% and 100%) and that students achieved the second course outcome to select, evaluate, and refine or redesign patient-specific treatment plans for complex ID scenarios within the context of AMS (88.8%, 81.9%, 88.8%, and 91%) in 2010, 2011, 2012 and 2013, respectively). Also, 100% of students agreed (to a high or very high degree) that the course improved understanding of AMS (in 2010 to 2013) and improved understanding and appreciation of the role of the pharmacist and other health care practitioners in the provision of AMS (in 2011 to 2013). Results from 2011, 2012 and 2013 showed students agreed (to a high or very high degree) that the course improved knowledge of BE management (81.8%, 77.8%, and 90.9%), and CM management (72.8%, 77.7%, and 93.3%), and the procedure for conducting an antimicrobial formulary review (100%, 88.9%, and 90%). These survey results indicated students perceived that the course met its stated objectives.

Impact of HPS on student achievement of clinical case learning objectives was assessed with a questionnaire containing eight 5-point Likert-type items following the last HPS session in 2013 (preHPS session surveys would reflect self-selection bias). Fifty percent of students indicated the simulation cases increased their confidence in the ability to develop a plan for a patient with either BE or CM. All students responded that they strongly agreed or agreed that the simulations helped them develop their ability to solve problems in BE or CM settings and increase their knowledge of antimicrobial pharmacology and pharmacodynamics for antimicrobial management of BE (91.7%) or CM (83.3%). Students reported they were somewhat confident in their ability to interpret Gram stain results (75%) and cerebrospinal fluid results (83.3%). Taken together, these results appear consistent with the student postcourse survey results for the previous two years, in which 88.9% of students in 2012 (n=9) and 90% of students in 2013 (n=10) indicated that the use of mannequin simulations added to their learning about management of a patients with BE or CM to a high or very high degree.

At least 90% of students indicated improvement in the following skills: clinical application, self-learning, critical thinking communication, knowledge, clinical implications, and preparedness. The results appeared to show consistency in student perception of course learning methods impact on critical thinking and self-learning, which were expected course outcomes.

DISCUSSION

The intention of providing pharmacy students with a basis for AMS awareness, knowledge, and skill development in the context of clinical case solving and AMS strategy development was accomplished with this elective and incorporation of HPS at an institution with an established history of HPS use. Evidence of student achievement of course outcomes included student performance on rubric-graded assignments and by student perceptions provided in survey tools. Assessment of use of HPS for the clinical cases indicated incorporation of this technology resulted in improved knowledge and skills, including problem solving. Performance measures for the HPS cases improved during each course offering. The course evolved over the 4 years it was offered and was refined to a point where its structure and content might be transferable. Full implementation elsewhere would depend on local faculty expertise and available technology (eg, HPS).

The design of the teaching and learning methods was modified in response to assessment of student performance and to student feedback. Ongoing course assessment was a strength of this course.

Use of surveys for assessment has inherent limitations.[39] We overcame some of these with consistently high response rates (lowest was 75% in 2012) and use of the same method for course survey distribution. However, the survey tools have not been validated and some of the survey items were not discreet. Use of performance rubrics for evaluation are well established and more reliable, however our course rubric has not yet been validated or tested for reliability.

Further improvements to optimize formative and summative feedback tools for HPS sessions customized for AMS, in addition to new case development for ID and AMS content, are needed and would increase transferability of the course. Reducing HPS student group size to increase participation opportunities would be suggested for new implementations and is being considered. However, additional classroom and technology expert resources would be needed.

Institutions that integrate AMS in their core ID curriculum may not benefit from providing a separate elective for pharmacy students. However, because the stewardship gap is likely to widen as the antimicrobial pipeline narrows, the need to develop AMS curricula for pharmacy students will increase. Interprofessional audiences that interface with AMS pharmacists should be invited to participate and collaborate on the development of future AMS educational programs that incorporate HPS technology.

SUMMARY

An antimicrobial stewardship infectious disease elective was developed and conducted with active learning, including human patient simulation, that demonstrated the ability to provide PharmD students with antimicrobial stewardship awareness, knowledge, and skills in the context of clinical case solving and development of antimicrobial stewardship program strategies.

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