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SUPPLEMENT ARTICLE

Knowledge and Attitudes of Doctor of Pharmacy Students Regarding the Appropriate Use of Antimicrobials

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Pharmacists are key partners in antimicrobial stewardship efforts, yet their degree of education on and attitudes toward this topic during training are not well documented. An electronic survey measuring knowledge and attitudes regarding antimicrobial use and resistance was administered to graduating pharmacy students at 12 US schools of pharmacy. Of 1445 pharmacy students, 579 (40%) completed the survey. The vast majority (94%) believed that strong knowledge of antimicrobials was important for their pharmacy careers, and 89% desired more education on appropriate antimicrobial use. Most students (84%) considered their pharmacy education regarding antimicrobials useful or very useful, but there was significant variability on perceptions of preparation for most antimicrobial stewardship activities according to the students' school. The mean number of correct answers on a section of 11 knowledge questions was 5.8 (standard deviation 2.0; *P* value for score between schools <.001). On multivariable linear regression analysis, significant predictors of a higher knowledge score were pharmacy school attended, planned postgraduate training, completion of a clinical rotation in infectious diseases, perception of pharmacy school education as useful, use of resources to answer the knowledge questions, and use of Infectious Diseases Society of America guidelines and smartphone applications as frequent resources for learning about antimicrobials. Pharmacy students perceive antimicrobial stewardship to be an important healthcare issue and desire more education on the subject. Student perceptions of antimicrobial coursework and actual antimicrobial knowledge scores significantly varied by the school of pharmacy attended. Sharing of best practices among institutions may enhance the preparation of future pharmacists to contribute to effective antimicrobial stewardship.

Keywords. antimicrobial stewardship; pharmacist; pharmacy student; education; survey.

The threat of increasing antimicrobial resistance is well recognized [1]. It is important to reduce unnecessary and inappropriate antibiotic use in order to reduce the development of resistance. The Centers for Disease Control and Prevention recommend that all hospitals implement antimicrobial stewardship programs that include several core elements including the drug expertise of a pharmacist responsible for improving antimicrobial use [2]. The Infectious Diseases Society of America (IDSA), the Society for Healthcare Epidemiology of America, and the Pediatric Infectious Diseases Society also recognize pharmacists as key partners in antimicrobial stewardship [3, 4].

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Studies of US medical school undergraduates have documented students' concern regarding antimicrobial resistance and desire for further education regarding antimicrobial use [5, 6]. The perceptions of graduating pharmacy students regarding these issues also warrant evaluation. Pharmacists are well positioned to act as antimicrobial stewards in a wide array of practice settings including those outside of a formal antimicrobial stewardship program. Postgraduate training is not required for pharmacists, and less than half of all pharmacy students pursue any type of such training (eg, general clinical pharmacy residency training and/or specialty residency or fellowship training) [7]. Moreover, there are few specialty training programs available in infectious diseases (ID) pharmacy [8]. Thus, a strong foundation within the professional curriculum is critical, as many pharmacy students will not have the opportunity to obtain advanced education through postgraduate training; yet, the pervasive use of antimicrobials supports the need for stewardship activities by an entire community of healthcare professionals. Finally, as interprofessional teamwork and education continue to be emphasized in healthcare, it is important to understand the varying levels of experience and foundational knowledge that healthcare professionals and trainees bring to direct patient care [9].

This study surveyed students enrolled in their final year of selected doctor of pharmacy (PharmD) programs in the United States. Our goal was to determine the students' knowledge and attitudes regarding the appropriate use of antimicrobials. The results of the study may be useful in improving professional pharmacy curricula related to antimicrobial use, thereby enhancing the contributions of future pharmacists to antimicrobial stewardship efforts in hospitals and communities.

METHODS

Study Design and Population

This study was a cross-sectional, multicenter, electronic survey designed to evaluate pharmacy students' knowledge and attitudes regarding appropriate antimicrobial use. Survey invitations were sent to 1445 graduating pharmacy students at 12 schools of pharmacy in the United States. There were no specific exclusion criteria. The South Carolina College of Pharmacy at the University of South Carolina served as the coordinating institution. Institutional review board approval was granted or waived at each participating institution.

Survey Instrument

The 26-item survey instrument (Supplementary Appendix 1) was adapted from a 24-item survey used for graduating medical students [6]. Changes were made to ensure all questions and answer choices were pertinent to pharmacy student respondents (see Supplementary Appendix 1). Data collected from the survey included the following: age, sex, pharmacy school, anticipated pharmacy postgraduate training and/or specialty the student is considering, previous research experience or education with antimicrobials prior to pharmacy school, attitudes about antimicrobials, awareness of the problem of antimicrobial resistance, sources of antimicrobial education, self-confidence in antimicrobial recommendations, knowledge regarding antimicrobial use and resistance (ie, 8 clinical vignettes with a total of 11 scored questions), and perceptions of the quality of education regarding appropriate antimicrobial use. The survey was pilot tested before dissemination. Study investigators provided site-specific data on antimicrobial stewardship instruction in the curriculum.

Survey Administration and Data Management

Survey administration was conducted from the coordinating site via the secure online application, REDCap, version 5.8.2 (Research Electronic Data Capture, Vanderbilt University, Nashville, TN) [10]. Surveys were e-mailed directly to all graduating pharmacy students at the participating sites. A unique survey link was distributed to each student to maintain anonymity and prevent duplicative responses or sharing of links. The survey period spanned 6 weeks from March 2014 through April 2014. An e-mail reminder was sent to nonresponders at 3 weeks. Survey respondents were offered compensation in the form of a $5 electronic gift card. Respondents were instructed to abstain from using resources to complete the survey.

Statistical Analysis

The de-identified data from the survey and data collection form were exported to 3 study investigators for assessment of data completeness. To facilitate comparison with the findings of Abbo et al, the investigator performing statistical analyses was blinded to participant study site, and survey responses on a 5-point Likert scale were merged into the following 2 categories: agree/strongly agree and neutral/disagree/strongly disagree [6]. For the survey, each respondent's knowledge score was calculated as the sum total of correct answers to each of the 11 knowledge-based questions.

Nonparametric tests were used to determine the presence of any significant difference(s) in student response values between pharmacy schools via the Kruskal–Wallis or χ^2 test, as appropriate. The effect of student characteristics on the student knowledge score was evaluated using linear regression. All candidate variables from the univariable analysis were included in the multivariable linear regression model; a backward selection technique was then applied, sequentially removing variables with the weakest association with the outcome until only variables with $P < .2$ remained. All statistical analyses were performed using Stata/SE, version 13.1 (StataCorp, College Station, TX).

RESULTS

Five hundred seventy-nine graduating pharmacy students completed the survey for an overall response rate of 40% (range by school, 33%–51%). The mean respondent age was 27 years (standard deviation, 3.7), and 69% (397/579) of the students were female. Community pharmacy was the largest anticipated practice area (23%), followed by clinical pharmacy (18%), managed care/administration (15%), academia (14%), and hospital pharmacy (11%). Almost half (47%) of the respondents anticipated pursuing some type of postgraduate training (>90% planning a clinical residency), with 12% expressing an interest in specializing in ID. Twenty-nine percent of students reported completing a clinical rotation in ID during pharmacy school. A list of participating institutions, characteristics of each institution and its respondents, and results for Tables 1–4 (reported by institution) are provided in Supplementary Appendix 2. There were significant differences between institutions by respondent age, anticipated postgraduate training, anticipated practice area, and completion of an ID rotation.

Pharmacy students agreed that antimicrobials are overused and that antimicrobial resistance is a problem nationally, but fewer students perceived problems in hospitals where they have had clinical rotations (Table 1). Overwhelmingly, there was agreement that poor infection control practices and inappropriate use of antimicrobials can cause resistance and harm patients and that better use of antimicrobials will reduce resistance. Students were more divided on whether appropriate use of antimicrobials can cause resistance (46% strongly agree/agree; $P = .002$ between schools) and whether antimicrobial drug development will keep up with resistance (27% strongly agree/agree; $P = .003$ between schools).

Table 2 lists the most commonly used resources for information on antimicrobial use and resistance. Significant variability existed among schools in their students' use of their peers, ID pharmacists, the Sanford guide, textbooks or other study guides, Wikipedia, the Johns Hopkins ABX Guide, and pharmaceutical representatives. Pharmacy students had mixed impressions about how well their education had prepared them on the selection and use of antimicrobials, summarized in Table 3. Overall, 84% of students rated their pharmacy education about the appropriate use of antimicrobials as useful or very useful (range across institutions, 62%–94%; $P = .001$). The majority of students believed their training in the surveyed antimicrobial tasks was good or very good, with the exception of handling a patient who demands antimicrobial therapy that is not indicated (26% believed their education in this area was good/very good). For all items except finding reliable sources of information to treat infections, there were significant differences in perceptions of education across schools.

Results from the knowledge assessment section of the survey are presented in Table 4. The mean score across the 11 items was 5.8 (total percentage correct, 53%), with a standard deviation of 2.0. The range in mean scores between schools was 4.9–7.1, and the difference between institutions was significant ($P < .001$). When asked whether they used resources to answer the clinical questions, 12% responded they had (range across schools, 5%–24%; $P = .08$). The relationship between student characteristics

Table 1. Pharmacy Students' Attitudes and Perceptions About Antimicrobial Prescribing and Resistance: Percentage Who Agree/Strongly Agree With Comparison Across Schools

Perceptions and Attitudes	Agree/Strongly Agree, % (% Range by School) N = 579	*P* Value[a]
Antimicrobials are overused nationally in healthcare	96 (89–100)	.11
Antimicrobials are overused at the hospitals where I have rotated	69 (53–78)	.11
Antimicrobial resistance is *not* a significant problem nationally	2 (0–7)	.52
Antimicrobial resistance is *not* a significant problem at the hospitals where I have rotated	5 (0–10)	.29
Better use of antimicrobials will reduce problems with antimicrobial-resistant organisms	97 (86–100)	.48
Appropriate use of antimicrobials can cause antimicrobial resistance	47 (31–68)	.002
Strong knowledge of antimicrobials is important in my pharmacy career	94 (86–97)	.66
I would like more education on antimicrobial resistance	82 (71–87)	.92
I would like more education on the appropriate use of antimicrobials	89 (78–100)	.28
New antimicrobials will be developed in the future that will keep up with the problem of "resistance"	27 (6–54)	.003
Prescribing broad-spectrum antimicrobials when equally effective, narrower-spectrum antimicrobials are available increases antimicrobial resistance	92 (86–100)	.06
Poor infection-control practices by healthcare professionals cause spread of antimicrobial resistance	89 (71–93)	.80
Inappropriate use of antimicrobials causes antimicrobial resistance	98 (86–100)	.006
Inappropriate use of antimicrobials can harm patients	97 (89–100)	.12

[a] $P < .05$ represents a significant difference across pharmacy schools.

Table 2. Resources Used by Pharmacy Students to Learn About Antimicrobial Use and Resistance, Percentage Reporting Resource Used Sometimes/Often With Comparison Across Schools

Resource	Sometimes/Often, % (Range by School) N = 579	*P* Value[a]
Drug databases (eg, Lexi-Comp, Micromedex, Clinical Pharmacology)	94 (86–100)	.17
UpToDate	88 (81–95)	.35
Infectious Diseases Society of America guidelines	83 (71–92)	.15
Medical/pharmacy journals	82 (71–89)	.71
Peers	74 (56–88)	.008
iPhone/smartphone applications	72 (50–89)	.06
Non-ID pharmacists	70 (59–86)	.42
Other professional society guidelines	69 (58–77)	.89
ID pharmacists	68 (35–78)	.002
Sanford guide	68 (43–100)	<.001
Textbooks or study guides	64 (44–83)	.001
ID physicians	45 (29–64)	.11
Wikipedia	36 (15–50)	.001
Non-ID physicians	36 (26–57)	.18
Johns Hopkins Antibiotic Guide	34 (12–56)	<.001
Pharmaceutical representatives	6 (0–18)	.004

Abbreviation: ID, infectious diseases.

[a] $P < .05$ represents a significant difference across pharmacy schools.

and knowledge score was explored using linear regression (Table 5). Variables with a significant relationship to knowledge score in the final multivariable model were as follows: pharmacy school, anticipation of postgraduate training, completion of an ID rotation, perception of pharmacy education as useful/very useful, use of resources to answer the knowledge questions, use of IDSA guidelines, and use of smartphone applications.

DISCUSSION

We assessed the knowledge, attitudes, and perceptions of pharmacy students in regard to antimicrobial use and resistance across multiple schools of pharmacy in the United States. Given the importance of pharmacists as partners in antimicrobial stewardship and the relative lack of postgraduate training

Table 3. Pharmacy Students' Perceptions on Their Education Regarding Appropriate Antimicrobial Use and Antimicrobial Stewardship—Percentage Who Feel Their Education Has Been Good/Very Good With Comparison Across Schools

Antimicrobial Stewardship Activity	Good/Very Good, % (Range by School) N = 579	*P* Value[a]
Monitor for efficacy and safety of the chosen antimicrobial therapy	73 (56–88)	.04
Find reliable sources of information to treat infections	69 (56–75)	.23
Know when to start antimicrobial therapy	67 (38–88)	<.001
Select the best antimicrobial for a specific infection	67 (46–88)	<.001
Select an appropriate regimen (dose, route, frequency)	66 (46–88)	<.001
Understand the basic mechanisms of antimicrobial resistance	59 (43–73)	.04
Describe the correct spectrum of antimicrobial therapy for different antimicrobials (what is covered by each drug)	59 (36–73)	.001
Streamline or deescalate antimicrobial therapy	54 (33–76)	<.001
Interpret antibiograms	52 (29–71)	.003
Transition from intravenous to oral antimicrobials (intravenous to oral switch)	51 (18–68)	.02
Handle a patient who demands antimicrobial therapy that is not indicated	26 (12–57)	<.001

[a] $P < .05$ represents a significant difference across pharmacy schools.

Table 4. Summary of Knowledge Vignettes With the Corresponding Percentage of Correct Answers With Comparison Across Schools

Clinical Vignette	Percentage Correct (Range by School) N = 579	*P* Value[a]
Diagnosis of community-acquired pneumonia: selection of appropriate antimicrobial and switch intravenous to oral	86 (79–94)	.66
Recognize the possible risks associated with unnecessary use of antimicrobials	72 (56–91)	.002
Recognize *Clostridium difficile* infection secondary to the use of antimicrobials	70 (50–94)	.11
Recognize the spectrum of activity of selected antimicrobial agents	60 (41–100)	.002
Extended-spectrum beta-lactamase–positive *Escherichia coli*: antimicrobial selection	56 (43–71)	.006
Identify scenarios with potential for unnecessary use of antimicrobials	50 (21–62)	.08
Complicated urinary tract infection: appropriate antimicrobial selection and duration of treatment	42 (21–64)	.02
Match the antimicrobial/organism with most likely mechanism of resistance		
E. coli/beta-lactams	50 (29–65)	.14
Methicillin-resistant *Staphylococcus aureus*	49 (32–82)	.08
Vancomycin-intermediate *S. aureus*	30 (14–46)	.33
Enterococcus/cephalosporins	18 (7–50)	<.001
Total score (1 point per correct answer to questions above; 11 points maximum): mean ± standard deviation	5.8 ± 2.0	<.001

[a] $P < .05$ represents a significant difference across pharmacy schools.

opportunities for pharmacists in ID, many pharmacists will participate in antimicrobial stewardship practices relying on the knowledge they acquired in pharmacy school. The vast majority of respondents in this study believed that strong knowledge of antimicrobial use was important in their pharmacy careers and desired more education on antimicrobials and antimicrobial resistance. Pharmacy students showed concern with antimicrobial overuse and antimicrobial resistance, and attitudes were generally similar across institutions. As has been observed in other studies, the problems of antimicrobial overuse and resistance were perceived as being greater concerns nationally than at local institutions [6, 11–13].

Students reported using a variety of resources to learn about antimicrobial use and resistance. Those students reporting greater use of IDSA guidelines had significantly higher mean knowledge scores, a finding also reported in Abbo et al's study of medical students [6]. In the present study, pharmacy students who reported sometimes or often using pharmacists or physicians as a resource (whether ID specialists or not) did not demonstrate greater knowledge. There seems to be a disconnect between the improved performance among students completing a clinical experience in ID and the lack of improvement among students who report using ID clinicians as a reference.

More than 80% of pharmacy students believed their pharmacy school education was useful or very useful in educating them about appropriate antimicrobial use, and most believed their education on specific stewardship activities was valuable. However, significant variability was observed across schools in perceived educational value. For the knowledge assessment section, on average, students got just over half of the questions correct, with significant variability by pharmacy school. The effect of pharmacy school attended on knowledge score remained after adjustment for other explanatory factors, suggesting that some pharmacy schools may have prepared students for these specific types of knowledge questions to a greater extent. Opportunities may exist to increase standardization of knowledge across schools. After school of study, the strongest predictor of a higher knowledge score was completion of an ID rotation, which fewer than a third of students reported completing. Many of the students who provided replies to an open comment question on the survey (18% of those responding) emphasized the importance of clinical experiences in developing and retaining ID knowledge. One respondent commented, "Unless a student takes an APPE [advanced pharmacy practice experience] rotation in ID or antimicrobial stewardship, they only have basic knowledge." Given the current limited availability of ID clinical rotations, consideration should be given to increasing and/or improving the ID content in other rotations (eg, medicine, intensive care, transplant, ambulatory care) and encouraging stewardship pharmacists to engage in experiential education.

Because our study design was nearly identical to that of Abbo et al of medical students, some interesting comparisons can be made (although these comparisons do not use inferential statistics) [6]. Overall, attitudes toward antimicrobial use and resistance were remarkably similar among medical and pharmacy students. Regarding resource use, pharmacy students were more likely than medical students to rely on published

Table 5. Relationship Between Student Characteristics and Knowledge Score

Variable	Univariable Analysis		Multivariable Analysis	
	Point Change in Student Knowledge Score[a]	*P* Value	Point Change in Student Knowledge Score[a]	*P* Value
Pharmacy school	(0.13–2.20)[b]	<.001	(0.17—2.37)[b]	<.001
Postgraduate training anticipated	0.90	<.001	0.55	.01
Anticipated practice area		.02		
Community/nuclear/compounding	0 (reference)			
Hospital	0.72	.02		
Clinical	0.97	.001		
Managed care/consultant/administration	0.49	.08		
Academia	0.84	.003		
Pharmaceutical industry	0.70	.04		
ID rotation completed	0.91	<.001	0.89	<.001
Interest in ID as specialty	1.13	<.001		
Prior education regarding antimicrobials	−0.03	.89		
Pharmacy education rated as useful/very useful	0.83	<.001	0.43	.047
Used resource when answering questions	0.77	.003	0.65	.008
Resources used often/sometimes				
Drug databases (eg, Lexi-Comp, Micromedex, Clinical Pharmacology)	−0.26	.47		
UpToDate	0.04	.86		
Infectious Diseases Society of America guidelines	0.75	.001	0.56	.01
Medical/pharmacy journals	0.04	.85	−0.31	.14
Peers	−0.10	.60		
iPhone/smartphone applications	0.06	.78	0.43	.03
Non-ID pharmacists	0.36	.05	0.31	.08
Other professional society guidelines	0.08	.66		
ID pharmacists	0.16	.38		
Sanford guide	0.39	.03		
Textbooks or study guides	−0.11	.52		
ID physicians	0.12	.48		
Wikipedia	0.01	.97		
Non-ID physicians	−0.31	.08	−0.34	.06
Johns Hopkins Antibiotic Guide	0.11	.52		
Pharmaceutical representatives	−0.92	.02		

Abbreviation: ID, infectious diseases.

[a] For example, a value of 0.5 would represent an average increase of 0.5 points on the 0–11 point student knowledge scale when the characteristic is present.

[b] Reference is lowest-scoring school. Range of coefficients is displayed; coefficients reported by school are provided in Supplementary Appendix 2.

materials, including IDSA guidelines (83% vs 29%, respectively) and medical/pharmacy journals (82% vs 55%). Instructional initiatives likely account for these differences. While pharmacy students rated the usefulness of their antimicrobial education more favorably than medical students (84% vs 58% reported as useful or very useful), they demonstrated similar knowledge scores (mean 5.8 vs 5.6). The only individual knowledge items with >10% difference in the proportion answered correctly were recognition of risks associated with unnecessary antimicrobial use (72% of pharmacy students answered correctly vs 91% of medical students), recognition of *Clostridium difficile* infection (70% vs 59%), and antimicrobial selection for extended-spectrum beta-lactamase–producing bacteria (56% vs 32%). These data highlight the opportunity for increased interprofessional education in this area, especially considering the interdisciplinary nature of antimicrobial stewardship efforts in clinical practice.

Although the study was not a random sample of all graduating pharmacy students, for the important factor of interest in postgraduate training (associated with greater knowledge scores), the results appear to be representative of students at the local and national levels. The proportion of respondents

planning to pursue postgraduate year 1 (PGY1) training was 43%, similar to the proportion of graduating pharmacy students who registered for the American Society of Health-System Pharmacists (ASHP) Resident Matching Program in 2014 at the 12 participating schools (median, 38%; range, 22%–74%; personal, written communication with Janet Teeters, MS, RPh, from ASHP on 22 April 2014). This figure is also comparable to the national proportion of students who registered for the ASHP PGY1 Resident Matching Program in 2013 (4928 registered of 12 982 graduating students, 38%) [7, 14].

The primary limitation to this study was the relatively low response rate. Overall, about 40% of students who were contacted responded. Thus, there is potential for selection bias, and respondents may not be representative of the overall student population at the schools surveyed. In particular, students interested in community pharmacy may be underrepresented (only 23% of respondents). This can be compared with a survey of 9405 graduating pharmacy students in 2013 from the American Association of Colleges of Pharmacy, in which at least 61% of respondents planned to practice in a community pharmacy after graduation [7]. While we found that, after adjustment for other factors, anticipated practice area was not associated with knowledge scores, the validity of the study's results among students pursuing careers in community practice requires confirmation. Another potential limitation is the clinical vignettes necessarily covered only a sample of important knowledge about antimicrobials for pharmacists. Because the questions were initially developed for a medical student survey, they may have assumed training that pharmacy students had not acquired. However, the overall comparability in results with medical students suggests pharmacy students are similarly exposed to these concepts in their training.

CONCLUSIONS

The results of this study show that pharmacy students are aware of challenges relating to antimicrobial stewardship and desire further education regarding antimicrobial use and resistance. Pharmacy students' perceptions of the value of education they have received do not appear to match their degree of knowledge as assessed through a series of clinical vignettes, and there was significant variability between schools in knowledge. Further investigations should focus on methods for enhancing pharmacy student knowledge of appropriate antimicrobial use, particularly within the experiential curriculum.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online (http://cid.oxfordjournals.org). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyedited. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

Notes

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References

1. Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States 2013. Available at: http://www.cdc.gov/drugresistance/threat-report-2013/pdf/ar-threats-2013-508.pdf. Accessed 25 April 2014.
2. Centers for Disease Control and Prevention. Core elements of hospital antibiotic stewardship programs, 2014. Available at: http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html. Accessed 14 April 2014.
3. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis **2007**; 44:159–77.
4. Society for Healthcare Epidemiology of America, Infectious Diseases Society of America, Pediatric Infectious Diseases Society. Policy statement on antimicrobial stewardship by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), and the Pediatric Infectious Diseases Society (PIDS). Infect Control Hosp Epidemiol **2012**; 33:322–27.
5. Minen MT, Duquaine D, Marx MA, Weiss D. A survey of knowledge, attitudes, and beliefs of medical students concerning antimicrobial use and resistance. Microb Drug Resist **2010**; 16:285–89.
6. Abbo LM, Cosgrove SE, Pottinger PS, et al. Medical students' perceptions and knowledge about antimicrobial stewardship: how are we educating our future prescribers? Clin Infect Dis **2013**; 57:631–38.
7. American Association of Colleges of Pharmacy. Graduating student survey summary report—2013. Available at: http://www.aacp.org/resources/research/institutionalresearch/Documents/2013_GSS_summary%20report_all%20schools_113.pdf. Accessed 25 April 2014.
8. Ernst EJ, Klepser ME, Bosso JA, et al. Recommendations for training and certification for pharmacists practicing, mentoring, and educating in infectious diseases pharmacotherapy. Pharmacotherapy **2009**; 29:482–88.
9. Institute of Medicine. Interprofessional education for collaboration: learning how to improve health from interprofessional models across the continuum of education to practice: workshop summary. Washington, DC: The National Academies Press, **2013**.
10. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform **2009**; 42:377–81.

11. Giblin TB, Sinkowitz-Cochran RL, Harris PL, et al. Clinicians' perceptions of the problem of antimicrobial resistance in health care facilities. Arch Intern Med **2004**; 164:1662–68.
12. Wester CW, Durairaj L, Evans AT, Schwartz DN, Husain S, Martinez E. Antibiotic resistance: a survey of physician perceptions. Arch Intern Med **2002**; 162:2210–16.
13. Abbo L, Sinkowitz-Cochran R, Smith L, et al. Faculty and resident physicians' attitudes, perceptions, and knowledge about antimicrobial use and resistance. Infect Control Hosp Epidemiol **2011**; 32:714–18.
14. American Society of Health-System Pharmacists (ASHP). Summary results of the Match for positions beginning in 2013. Available at: https://www.natmatch.com/ashprmp/stats/2013applstats.html. Accessed 22 April 2014.