

Promoting Antimicrobial Stewardship by Incorporating it in Undergraduate Medical Education Curricula

Aaron P. Beck; Kelsey Baubie, MPH, MS; Mary Jo Knobloch, PhD, MPH; Nasia Safdar, MD, PhD

ABSTRACT

Background: Education related to antimicrobial stewardship—the judicious use of antimicrobials—is essential to stem the rising tide of resistance.

Methods: Using a scoping review method that includes a consultation component, we explored the extent to which antimicrobial stewardship is incorporated in undergraduate medical education.

Results: We found 4 studies evaluating stewardship content in undergraduate medical school curricula along with 2 studies assessing the effectiveness of specific stewardship training programs in medical education.

Discussion: We highlight three recommendations: (1) if applicable, identify an institutional “champion” and incorporate antibiotic stewardship-related content into medical school curriculum; (2) evaluate the status and effectiveness of antibiotic stewardship curricular components in medical education; (3) conduct research evaluating the long-term outcomes of antibiotic stewardship training in medical education.

BACKGROUND

Antimicrobial resistance in bacteria causing infections is a public health crisis that requires urgent action.¹ Antibiotic overuse and misuse drives antimicrobial resistance, thus antibiotic stewardship (AS) programs, including training in judicious use of antibiotics, are crucial to stem the rising tide of resistance.

Guidelines from national societies such as the Infectious Disease Society of America, the Society of Healthcare Epidemiology of America and the Pediatric Infectious Disease Society recommend that AS education include learners such

• • •

Author Affiliations: University of Wisconsin School of Medicine and Public Health, (Beck, Baubie); Division of Infectious Disease, Department of Medicine, University of Wisconsin Madison, (Knobloch, Safdar); William S. Middleton Memorial Veterans Hospital, (Knobloch, Safdar); Madison, Wis.

Corresponding Author: Nasia Safdar, MD, PhD, University of Wisconsin Medical Foundation Centennial Building, 1685 Highland Ave, Madison, WI 53705-2281; phone 608.213.4075; fax 608.263.4464; email ns2@medicine.wisc.edu.

as fellows, postgraduate residents, and medical students.²⁻⁵ To date, most stewardship education programs have targeted health care professionals at the postgraduate level.⁶⁻¹⁰ However, the literature points out that the undergraduate medical education setting, when prescribing behavior is being developed, is an important time to engage in AS learning activities.^{9,11}

Research shows that medical students often feel inadequately prepared to judiciously prescribe antibiotics, have an insufficient comprehension of AS principles, and prefer additional education on AS-related content and

prescribing of antibiotics.^{12,13} Yet the extent to which AS features in education in medical student curricula is unclear. This review identifies gaps and summarizes findings related to AS education in medical school.

METHODS

We used a scoping review method to summarize this topic. The purpose of a scoping review is to examine the extent, range, and nature of research on a topic; identify research gaps; provide a descriptive overview; and quickly determine the potential of undertaking a full systematic review.^{14,15} This type of review is useful when the topic has not yet been extensively reviewed or studies are heterogeneous in nature.¹⁴ We reviewed published literature using PubMed and Scopus databases through August 2017. These search engines were used over others (eg, MedEd Portal) as they provided a more comprehensive list of records. MeSH terms pertaining to “antibiotic stewardship” and “medical school curriculum” were combined with a Boolean “AND” without search limitations. We excluded non-English and duplicate articles before reviewing the Title and Abstract of the remaining records, excluding articles that failed to include keywords or pertained to broad AS platforms or clinic-/hospital-related

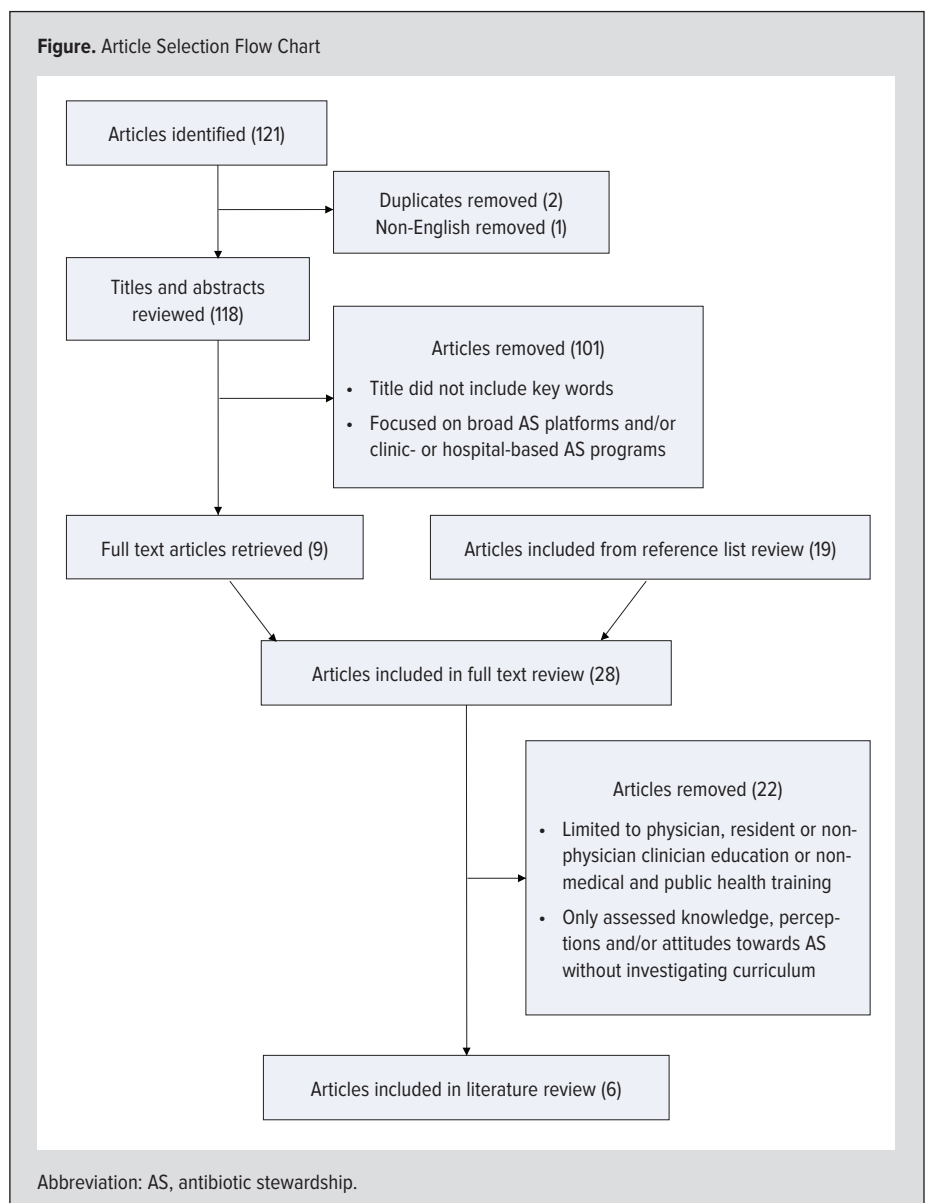
AS programs. In an effort to identify any missed articles in our literature search, we reviewed reference lists of the publications included in full-text review. Studies were excluded if content was limited to education of physicians, residents, or nonphysician clinicians and/or nonmedical, public health training. We also excluded studies that evaluated medical students' knowledge, perception, and/or attitudes of AS without significant investigation of curricula. After applying exclusion criteria, we included 6 articles that examined AS in medical school curricula (Figure).

We also conducted interviews with 2 institutional leaders overseeing medical school curriculum development and administration, which augmented our findings by providing a more indepth examination of factors relevant to integrating AS principles in medical education. These experts were chosen for their experience in medical school curriculum development and recent involvement in a medical school curriculum transformation. Furthermore, each expert actively teaches and pursues research in medical education.

RESULTS

We found 6 articles that investigated AS programs in medical school curricula. Four were cross-sectional national surveys investigating AS-related curricular components, such as prevalence of AS teaching and content, delivery, and evaluation of material. These studies show frequent, yet disparate AS content offered through undergraduate medical curricula.^{10,16-18} Each cross-sectional study is summarized in Table 1, with specifics on curricula content, delivery, and evaluation detailed in Table 2.

We also found 2 studies that evaluated the impact of AS programs through a quasi-experimental design (Table 3). They found medical students' knowledge and attitudes of AS and interprofessional collaboration were significantly increased after completing the AS-specific curriculum. Both studies also emphasized the importance of long-term outcomes research to better understand the impact of AS training in medical school on physicians' prescribing behaviors.^{19,20} In addition, the University of California San Francisco research group provided free access to their curriculum, which can be found online at <http://tiny.ucsf.edu/stewardship>.¹⁹



Our interviews with institutional experts yielded insights into incorporating AS in medical education. The observed heterogeneity of AS teaching in medical school curricula is likely linked to institutional flexibility when developing a curriculum, and meeting national accreditation standards largely depends on the institution's curriculum development strategy and mission-sensitive content prioritization. Furthermore, medical training occurs in a fast-paced content-dense setting, and the integration of additional content such as AS may be at the expense of another topic. Both experts stressed that a "champion" is necessary to spark and sustain a medical school's interest and ability to teach AS as a key curriculum component.

DISCUSSION

We found 4 studies on AS in medical school curriculum and 2 studies evaluating the effectiveness of a specific AS program. It is evident disparate learning environments and training approaches exist in medi-

Table 1. Summary of Research Investigating Medical School Curricula Related to Antimicrobial Stewardship

Article	Topic	Outcome Measures	Country	Method	Participants	Response Rate	Recommendations
Castro-Sanchez et al, 2016¹⁶	Teaching of AS principles	Prevalence of AS teaching, stewardship principles taught, time allotted to content, content delivery and teaching strategies, evaluation methodologies, multi disciplinary learning	United Kingdom	Cross-sectional survey	Medical, Dental, Nursing, Pharmacy and Veterinary Medicine Schools	70.5% ^a	Educators must adopt a comprehensive approach using standardized content relating antimicrobial stewardship; increased standardization of AS-related content
Melber et al, 2016¹⁷	Microbiology and Infectious Disease (MID)	Prevalence of MID topics, course leadership, curricular structure, course content, educator perceptions about microbiology education locally and nationally	United States	38 questions cross-sectional survey, interviews	LCME accredited US Medical Schools	73%	Multi disciplinary local and national collaboration; changing curriculum structure and content; identify best practices and support research
O'Shaughnessy et al, 2010¹⁸	Clinical pharmacology and therapeutics	Prevalence of CPT teaching, course structure, course leadership, content delivery and teaching strategies, assessment measures, interdisciplinary education, medical student transition, follow-up prescribing performance	United Kingdom	10 questions web-based cross-sectional survey	UK medical schools	94%	Increased collaboration between foundation schools, medical schools, pharmacists, and clinicians to ensure GMC's emphasis on CPT is met
Pulcini et al, 2015¹⁰	Teaching of prudent antibiotic prescribing behavior	Prevalence of prudent antibiotic use principles, content delivery and teaching strategies, qualitative background on the topic, associations between curriculum, antibiotic use and/or rates of bacterial resistance	13 European Countries ^b	57-point cross-sectional survey, interviews	Proportional sampling of 13 European countries' medical schools	94.6%	Improvement in the teaching of prudent antibiotic prescribing principles through national and European programs that establish specific learning outcomes and competencies

^a Response rate refers to medical schools only.

^b Countries include Belgium, Croatia, Denmark, France, Germany, Italy, Netherlands, Norway, Serbia, Slovenia, Spain, Switzerland, and United Kingdom.

Abbreviations: AS, antibiotic stewardship; CPT, clinical pharmacology and therapeutics; MID, microbiology and infectious disease; LCME, liaison committee on Medical Education; GMC, General Medical Council; US, United States; UK, United Kingdom.

Table 2. Summary of Medical Schools' Curricula Content, Delivery and Evaluation Related to Antimicrobial Stewardship

Article	Content	Delivery	Course Structure	Timing ^b	Evaluation
	AS Principles	Lecturers			Methodologies
Castro-Sanchez et al, 2016¹⁶	95.8%	Academician (82.6%)	Integrated (54.2%)	N/A	Essays + OSCEs + other (33.3%)
Melber et al, 2016¹⁷	66%	Microbiologist (48%) Microbiologist + Clinician (23%) Clinician (20%)	Integrated (45%)	First year (32%) Second year (53%) First + second year (12%)	Multiple-choice exams (98%) Small group and team-based learning
O'Shaughnessy et al, 2010¹⁸	60% ^a	Pharmacologist (70%)	Vertical integration (72%) Horizontal integration (17%)	Third year ^c	Written exams (90%) OSCEs (73%)
Pulcini et al, 2015¹⁰	97.1%	AS involvement (77%)	Integrated (68%)	Prior to clinical training (71%)	N/A

Percentages refer to the proportion of schools.

^a Percentage of schools teaching CPT, AS principles may be underlying theme.

^b Years denote when the majority of content was delivered.

^c No exact proportion provided.

Abbreviations: AS, antibiotic stewardship; OSCE, objective structured clinical examination; CPT, clinical pharmacology and therapeutics.

Table 3. Summary of Research Evaluating the Effectiveness of Newly Developed Antibiotic Stewardship Curricula

Article	Location and Sample	Curriculum	Design	Assessment	Results	Recommendations
McDougall et al, 2017¹⁹	UCSF 425 2nd year medical students, 320 3rd year pharmacy students	Online case vignette Online learning module 3Two-hour group workshop (Open source curriculum)	Quasi-experimental	Knowledge and attitudes, efficacy of interprofessional collaboration; attitudes towards interprofessional collaboration	48% more students were able to describe role in appropriate antibiotic use; 19% more students were able to communicate in an interprofessional team; 43% more students were able to describe collaborative approaches to antimicrobial use	More robust analyses of effectiveness of AS curricula needed; desire for their open sourced curriculum to serve as exemplar for AS-related medical education; long-term impact evaluation is needed
Nori et al, 2017²⁰	AECM 183 medical students pers year from 2014-2016; residents, ID fellows, and attending physicians also surveyed	Two 2-hour seminars on AS and IPC Integrated case-based modules, ARS, group learning, smartphone applications	Quasi-experimental	General antibiotic use, principles of microbiology and testing, prescribing using local antibiogram, understanding of IPC and HAI	Improved prescriber confidence; Improved understanding of transmission-based precautions	Smartphone technology is a convenient and effective platform for enforcing AS-related topics; long-term impact evaluation is needed

Abbreviations: UCSF, University of California San Francisco; AS, antibiotic stewardship; AECM, Albert Einstein College of Medicine; ID, infectious disease; IPC, infection prevention and control; HAI, hospital acquired infection.

cal schools incorporating AS modules, but these studies also feature the potential benefits of AS-specific curricula on medical student's knowledge and attitudes of AS, prescribing behaviors, and infection prevention and control. In addition, our interviews with institutional experts elucidate several key aspects to curriculum design and modification related to AS, including time and content constraints and the importance of an AS "champion." Our limited findings stress the need to augment current evaluations of AS training in medical education to determine evidence-based teaching approaches to AS and to understand the long-term outcomes of AS training.^{19,20} These steps are essential to better understand how AS-related curricular components in medical education impact physician prescribing behavior.

This paper has implications for medical schools seeking how to best incorporate AS-related content into undergraduate medical curricula, as recommended by national societies.^{2,3,7} One option may be to incorporate existing open source curricula, such as the University of California San Francisco's, (<http://tiny.ucsf.edu/stewardship>) as a framework.¹⁹ Institutional leaders also should evaluate current medical school curricula to assess the status and effectiveness of AS-related topics. This evaluation will identify institutional gaps in AS content and supplement the limited body of literature in this field. Research to examine novel approaches to AS training in medical education, (eg, smartphone technology) is needed.²⁰

Limitations

The goal of this scoping review was to take a broad look at the extent to which medical students are being exposed to AS education. A limitation is that we excluded non-English articles. We also acknowledge this scoping review is meant to serve as a precursor

to systematic review, and one such systematic review of this topic has been published.²¹ This paper found that while medical schools are implementing AS training, thorough evaluation of the curricula's effectiveness has not been completed.

Publication bias may be another limitation of this paper; it is possible not all AS education and training activities are reported in peer reviewed journals. In addition, our qualitative data may not represent that of other medical school administrators and curriculum developers. These limitations notwithstanding, the inclusion of a key step of consultation—our interviews with topic experts from our institution—is a strength of our scoping review.¹⁴

CONCLUSIONS

We highlight 3 recommendations: (1) if applicable, identify an institutional "champion" and incorporate AS-related content into medical school curriculum; (2) evaluate the status and effectiveness of AS curricular components in medical education; (3) conduct research evaluating the long-term outcomes of AS training in medical education.

Funding/Support: None declared.

Financial Disclosures: None declared.

REFERENCES

1. Antibiotic resistance. World Health Organization. <http://www.who.int/mediacentre/factsheets/antibiotic-resistance/en/>. Published 2016. Accessed March 21, 2017.
2. Fishman N; 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 Diseases Society (PIDS). *Infect Control Hosp Epidemiol*. 2012;33(4):322-327. doi:10.1086/665010.
3. Southwick F, Katona P, Kauffman C, et al. Commentary: IDSA guidelines for improving the teaching of preclinical medical microbiology and infectious diseases. *Acad Med*. 2010;85(1):19-22. doi:10.1097/acm.0b013e3181c485c5.
 4. Barlam TF, Cosgrove SE, Abbo LM, et al. Executive summary: implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Clin Infect Dis*. 2016;62(10):1197-1202. doi:10.1093/cid/ciw217.
 5. Shekarchian S, Schwartz BS, Teherani A, Irby D, Chin-Hong PV. Is it time for a coordinated and longitudinal approach to antibiotic stewardship education? *Clin Infect Dis*. 2016;63(6):848-849. doi:10.1093/cid/ciw419.
 6. Davey P, Brown E, Charani E, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. *Cochrane Database Syst Rev*. 2013;4:CD003543. doi:10.1002/14651858.CD003543.pub3.
 7. Dellit TH, Owens RC, Mcgowan JE, et al; Infectious Diseases Society of America. 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(2):159-177. doi:10.1086/510393.
 8. Ohl CA, Luther VP. Health care provider education as a tool to enhance antibiotic stewardship practices. *Infect Dis Clin North Am*. 2014;28(2):177-193. doi:10.1016/j.idc.2014.02.001.
 9. Pulcini C, Gyssens IC. How to educate prescribers in antimicrobial stewardship practices. *Virulence*. 2013;4(2):192-202. doi:10.4161/viru.23706.
 10. Pulcini C, Wencker F, Frimodt-Møller, et al; ESGAP Curriculum Working Group. European survey on principles of prudent antibiotic prescribing teaching in undergraduate students. *Clin Microbiol Infect*. 2015;21(4):354-361. doi:10.1016/J.CMI.2014.11.015.
 11. Schwartz BS, Armstrong WS, Ohl CA, Luther VP. Create allies, IDSA stewardship commitments should prioritize health professions learners. *Clin Infect Dis*. 2015;61(10):1626-1627. doi:10.1093/cid/civ640.
 12. 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(5):631-638. doi:10.1093/cid/cit370.
 13. 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(4):285-289. doi:10.1089/mdr.2010.0009.
 14. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8(1):19-32. doi:10.1080/1364557032000119616.
 15. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci*. 2010;5:69. doi:10.1186/1748-5908-5-69.
 16. Castro-Sánchez E, Drumright LN, Gharbi M, Farrell S, Holmes AH. Mapping antimicrobial stewardship in undergraduate medical, dental, pharmacy, nursing and veterinary education in the United Kingdom. *PLoS One*. 2016;11(2):e0150056. doi:10.1371/journal.pone.0150056.
 17. Melber DJ, Teherani A, Schwartz BS. A comprehensive survey of preclinical microbiology curricula among US medical schools. *Clin Infect Dis*. 2016;63(2):164-168. doi:10.1093/cid/ciw262.
 18. O'Shaughnessy L, Haq I, Maxwell S, Llewelyn M. Teaching of clinical pharmacology and therapeutics in UK medical schools: current status in 2009. *Br J Clin Pharmacol*. 2010;70(1):143-148. doi:10.1111/j.1365-2125.2010.03665.x.
 19. MacDougall C, Schwartz BS, Kim L, Nanamori M, Shekarchian S, Chin-Hong PV. An interprofessional curriculum on antimicrobial stewardship improves knowledge and attitudes toward appropriate antimicrobial use and collaboration. *Open Forum Infect Dis*. 2017;4(1):ofw225. doi:10.1093/ofid/ofw225.
 20. Nori P, Madaline T, Munjal I, et al. Developing interactive antimicrobial stewardship and infection prevention curricula for diverse learners: a tailored approach. *Open Forum Infect Dis*. 2017;4(3):ofx117. doi:10.1093/ofid/ofx117.
 21. Silverberg SL, Zannella VE, Countryman D, et al. A review of antimicrobial stewardship training in medical education. *Int J Med Educ*. 2017;8:353-374. doi:10.5116/ijme.59ba.2d47.

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

© 2018 Board of Regents of the University of Wisconsin System and The Medical College of Wisconsin, Inc.

Visit www.wmjonline.org to learn more.