Confidence in Antibiotic Prescribing Intentions among Senior Medical Students in India

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Abstract. Antimicrobial resistance (AMR) is a major public health problem in India. We surveyed medical students to assess their knowledge, attitudes, and factors associated with confidence in antibiotic prescribing intent. In this cross-sectional study, a convenience sample of 356 students were surveyed in July–August 2017 on AMR-related knowledge, attitudes, information sources and antimicrobial training. Antimicrobial resistance knowledge and attitude scores were calculated. Bivariate analysis using the chi-square test of independence and multivariate binary logistic regression analysis were used to investigate factors associated with confidence in antibiotic prescribing intent. A total of 347 students completed the survey; 64% agreed that strong knowledge of antibiotics is important in their medical careers; 61% stated that they would like more education regarding appropriate use of antibiotics. The mean total knowledge score was 11.5 out of 31 (SD = 3.4), and the mean attitude score was 6.0 out of 16 (SD = 4.2). Although 13% of students were “very familiar”/“familiar” with the term “antimicrobial stewardship,” only 35% of students felt “very confident” or “confident” in antimicrobial prescribing to patients in the future. On multivariate analysis, female gender, clinical vignette antimicrobial knowledge scores, positive attitude scores, awareness of Infection Control Policy, and > 3 years of antimicrobial prescribing clinical training were predictors of confidence in antimicrobial prescribing. A higher attitude score was independently associated with decreased confidence in antimicrobial prescribing intent. There is a need to improve education regarding AMR in the curriculum, and increase awareness of infection control policies and antimicrobial stewardship program in clinical settings.

INTRODUCTION

The WHO recognizes antimicrobial resistance (AMR) as one of the major threats to global health today and has developed a strategic competency framework for education on AMR.¹ Factors that contribute to the development of AMR include environmental factors and agricultural antimicrobial use; however, antimicrobial prescription practices play a significant role in the progression of resistance.² On June 6, 2017, the WHO made one of its most drastic changes to its Essential Medicines List by creating categories for antibiotics.³ These categories include “access,” “watch,” and “reserve,” and function to help guide physicians on when to use these drugs. The magnitude of this change reflects the importance of physician prescribing in combating AMR.

Combating AMR is a major public health challenge in India.⁴ The overconsumption of antimicrobials, misuse of antimicrobials for viral infections, overuse of broad-spectrum antimicrobials coupled with inadequate public health systems, high infectious disease (ID) prevalence, sale of antimicrobials over the counter, and increased usage of antibiotics in farm animals are key drivers of AMR in India.^{2,4} As of 2017, India has reported an alarming increase in percent resistant strains of *Escherichia coli* (84%), *Klebsiella* (69%), *Pseudomonas aeruginosa* (34%), and *Staphylococcus aureus* (85%).⁵

The first of the five objectives in the WHO global action plan on AMR is “to improve awareness and understanding of AMR through effective communication, education, and training.”⁶ Supporting this objective, the WHO recognizes that the education of medical students on antimicrobial stewardship plays a critical role in the efforts to combat AMR.^{7,8} Medical students must know the basics of ID diagnosis and management, the linkage between antimicrobial use and AMR, and must be

adequately prepared to prescribe antimicrobials after graduation as future clinicians.^{1,6} There have been several cross-sectional studies in high-income countries seeking to investigate medical students’ knowledge, attitudes, and practices (KAP) regarding AMR.^{7,9–11}

Although studies on medical students’ knowledge, perceptions, and attitudes regarding AMR have been conducted in low- and middle-income countries,^{12–15} antimicrobial KAP data on medical students in India are very limited.^{16,17} A study in 2013 surveyed second-year medical students at a teaching hospital in Southern India found that medical students were more likely to say that antibiotic resistance is a problem in the country and world as a whole, rather than specifically a problem in their hospital. In addition, only 74.3% of respondents knew that bacteria do not cause colds and flu.¹⁷ The study results were limited by its small sample size and limited survey questions. The study asked questions in each of the KAP categories; however, it did not include clinical vignettes that many other successful KAP surveys have used to get a better understanding of clinical practice.^{7,12} Another study from Jaipur, India, surveying dental students and second-year medical students also did not include clinical vignette to evaluate KAP regarding AMR.¹⁶

The structure of the undergraduate medical education curriculum in India consists of a 5.5-year degree course (Bachelor of Medicine and Bachelor of Surgery [MBBS]). Undergraduate medical education (4.5 years) is followed by a 1-year mandatory rotating internship before a medical license is granted to provide primary care. The first year of medical school is preclinical primarily focused on basic sciences, whereas exposure to clinical medicine typically occurs during the second year of MBBS degree course. Although previous studies from India indicated a gap in medical students’ KAP regarding AMR, this subject needs to be further explored among junior and senior MBBS students in our setting to understand undergraduate medical training in AMR. We assessed knowledge, attitudes, and factors associated with

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confidence in antibiotic prescribing intentions among undergraduate medical students in India.

METHODS

Study design and setting. This cross-sectional study used an anonymous questionnaire to survey MBBS students from June 2017 through July 2017 at K.S. Hegde Medical Academy (KSHEMA) in Mangalore, Dakshina Kannada district, state of Karnataka, India. Mangalore is a coastal city in Southern India located on the shore of Arabian Sea with a population of 0.5 million. Healthcare providers from five municipal and two government hospitals, and four private medical colleges provide care to the urban population.

This study's participants consisted of MBBS students, aged 18 years and older with sampling of second-year, third-year, fourth-year, and intern students. First-year MBBS students, aged < 18 years, and those not willing to participate were excluded from participation because their curriculum is primarily related to basic sciences, rather than clinical application. Second-year students take courses in microbiology and pharmacology, whereas third- and fourth-year students begin their clinical rotations. Of the respondents, only the students in their intern year are permitted to prescribe antimicrobials. Following the completion of the intern year, students in India may practice as independent general practitioners with a medical license. The study protocol and survey were reviewed and approved by the Institutional Review Boards at KSHEMA and Wake Forest School of Medicine, respectively. Written informed consent was obtained from all participants.

Survey instrument. A 95-item, self-administered questionnaire was designed and divided into five categories: 1) demographics, 2) knowledge, 3) attitude and perceptions, 4) source of information and training, and 5) confidence in prescribing. The demographic section included age, gender, and MBBS year. The knowledge section consisted of 33 questions comprising four matching, six multiple-choice questions, 12 true/false/I don't know, and nine clinical vignettes. Knowledge data included assessment of AMR mechanisms, correct use of antimicrobial, AMR statistics in India, and factors contributing to AMR. Antimicrobial prescribing practice knowledge was assessed using nine clinical vignettes in which students could select, "appropriate," "inappropriate," or "not sure."

The survey included 20 attitude questions that were primarily assessed on a 5-point Likert scale ranging from "strongly agree" to "strongly disagree." Source of information and training questions (38 questions) were primarily recorded using a 5- or 6-point scale with the options: "often," "sometimes," "rarely," "never," and "not familiar" or "very useful," "useful," "neutral," "not useful," "not at all useful," and "not applicable," respectively. The final question asked students to rank their confidence in prescribing antimicrobials in the future as very confident, confident, unsure, not confident, or not at all confident.

The survey instrument was adapted from previous studies.^{7,12,13} The survey items were developed in English and reviewed by a multidisciplinary team of three reviewers with expertise in IDs, microbiology, epidemiology, and public health. The accuracy of the survey items in each content domain was examined. The preliminary questionnaire was then piloted among eight students to identify areas of

improvement, clarity, and comprehension of the survey items. The Cronbach alpha score for the knowledge section of the questionnaire was 0.902. A Cronbach alpha score of 0.813 was calculated using pilot data for the 20 attitude questions.

Survey administration. Using a convenient sampling method, a paper questionnaire was distributed to students on KSHEMA campus in the library, classrooms following lecture, or student hostels and collected 20–40 minutes later. No names or personal identification information were gathered in the survey; however, completing the survey, students were asked to sign a consent form. In addition, students marked their name on their class register to ensure that no student took the survey more than once. Students were instructed to complete the questions individually using no outside resources. Participation was voluntary and confidential, and there was no incentive.

Statistical analysis. Data were analyzed using the Statistical Package for the Social Sciences ([SPSS], version 20.0; SPSS, Chicago, IL). Demographic characteristics, AMR knowledge, attitude, and perceptions data are presented as frequency and percentages of those who answered correctly. Antimicrobial resistance knowledge and attitude scores were calculated.

Knowledge score. A knowledge score was calculated from 31 questions. Each correct answer was worth 1 point, and an incorrect answer or "I don't know" was given 0 points. The 12 true/false/I don't know questions were scored to calculate a score for "knowledge of factors contributing to AMR," and the nine clinical vignettes were scored to create a score for "clinical practice knowledge."

Attitude score. Attitude question responses were dichotomized into two groups: "strongly agree/agree" and "neutral/disagree/strongly disagree." The frequency and percentages of each of these responses were presented. In addition, an attitude score was calculated. Each question was scored such that responses consistent with an attitude that AMR is an important issue were given a value of 1, and responses that did not indicate an attitude that AMR is an important issue were given a value of 5. Thus, for statements that emphasize that AMR is a problem, responses of "strongly agree" were given 1 point, "agree" were given 2 points, "neutral" were given 3 points, "disagree" were given 4 points, and "strongly disagree" were given 5 points. For statements that imply that AMR is not a problem, the point system was reversed such that "strongly disagree" responses were given 1 point and "strongly agree" responses were given 5 points. The points were summed to create the attitude score. Therefore, a lower attitude score indicates a positive attitude toward antimicrobial stewardship.

Data gathered on AMR sources of information and training were dichotomized into 1) "very useful"/"useful" and 2) "neutral"/"not useful"/"not at all useful"/"not applicable" or 1) "often"/"sometimes" and 2) "rarely"/"never"/"not familiar." These data were presented as frequency and proportions. A Mann-Whitney U test was used to determine factors that were associated with significant differences in knowledge scores and attitude scores. The primary outcome measure of this study was to determine factors associated with a medical student's confidence in antimicrobial prescribing. Bivariate analysis using the chi-square test of independence and multivariate binary logistic regression analysis were used to investigate factors (demographic, knowledge, attitude/perception, and

source of information) associated with medical student 's confidence in antibiotic prescribing intent. A P value of < 0.05 was considered statistically significant.

RESULTS

A total of 347 surveys were analyzed (response rate of approximately 98%). We excluded nine surveys because of incomplete responses. Sixty-two percent of participants were female, and 38% were male.

Knowledge. The mean total knowledge score was 11.5, with an SD of 3.4, out of a maximum possible score of 31 (37%). The mean knowledge of resistance mechanisms was 1.95 with an SD of 1.2, out of a maximum possible score of 6 (33%).

The mean knowledge of factors contributing to resistance was 6.6 with an SD of 2.4, out of a maximum possible score of 12 (55.3%). The most commonly identified factor contributing to AMR was "the patient does not finish his/her treatment" (82.4%). Only 30.8% of students thought that the excessive use of antibiotics in animals contributed to AMR. Thirty percent of participants thought that poor-quality antibiotic contributed to resistance, and 31.4% thought that people are paying too much attention to pharmaceutical representatives/advertising. Fifty-eight percent of respondents said there are too many broad-spectrum antibiotic prescriptions, 57.1% said there are too many antibiotic prescriptions, and 51.6% said that antibiotics are given at a dose that is too low.

The mean clinical knowledge was 2.9 with an SD 1.5, out of a maximum possible score of 9 (32.1%). When comparing knowledge scores among second- and third-year students with fourth-year and intern year students, there was a significant difference in knowledge of factors contributing to AMR ($P = 0.023$), clinical knowledge ($P = 0.001$), and the total knowledge score ($P < 0.001$); however, when looking at the knowledge of AMR mechanisms, the difference between these two groups of students was not significant ($P = 0.467$). Although there was a significant difference in knowledge scores based on the MBBS year, there was no significant difference in knowledge scores, given gender or the number of

courses or training in antibiotics a student reported taking. However, there was a significant difference in knowledge of factors contributing to resistance ($P < 0.001$) and clinical knowledge scores ($P = 0.001$) among students who have completed a clinical rotation in ID and those who have not.

Fifty-nine percent of respondents were "familiar" or "very familiar" with the term "Infection control," while only 13.2% of students were "familiar" or "very familiar" with the term "antimicrobial stewardship."

Attitude. Medical students' attitudes and perceptions about antibiotic prescribing are summarized in Table 1. The mean attitude score was 6.0, with an SD 4.2 out of a maximum of 16 (33.2%). When comparing the attitude scores between second- and third-year students with the scores of fourth-year and intern year students, there was a significant difference ($P = 0.018$), with fourth-year and intern year students having a higher average attitude scores (Supplemental Table 1). However, there is no significant difference in attitude scores between students who received 0–3 courses of training about antibiotics and those who received four or more courses.

Only 7.2% of students "strongly agree" that antimicrobials are overused in the hospitals where they have rotated, and 9.5% of students "strongly disagree" that AMR is not a significant problem at hospitals where they have rotated. Sixty-four percent of students "strongly agree" that strong knowledge of antimicrobials is important in their medical careers. Fifty-nine percent of students "strongly agree" that they would like more education on AMR, and 60.5% "strongly agree" that they would like more education on the appropriate use of antimicrobials.

Eighty-two percent of students believe that prescribing inappropriate or unnecessary antibiotics is professionally unethical. There was a significant difference in attitude scores ($P = 0.001$), total knowledge scores ($P = 0.002$), and knowledge of factors contributing to AMR ($P < 0.001$) between students who answered yes and those who answered unsure or no to these questions.

Sources of information. Forty-six percent of respondents rated their education regarding appropriate use of antimicrobials so far as "very useful" or "useful." The source of

TABLE 1
Perceptions and attitudes of medical students about AMR

Perceptions and attitudes	Strongly agree/agree, N (%)
Antimicrobials are overused nationally	296 (85.3)
Antimicrobials are overused at the hospitals where I have rotated	106 (30.5)
AMR is not a significant problem nationally	63 (18.2)
AMR is not a significant problem at the hospitals where I have rotated	70 (20.1)
Better use of antimicrobials will reduce problems with antimicrobial-resistant organisms	283 (81.6)
Appropriate use of antimicrobials can cause AMR	89 (25.7)
Strong knowledge of antimicrobials is important in my medical career	307 (88.5)
I would like more education on AMR	301 (86.7)
I would like more education on the appropriate use of antimicrobials	321 (92.5)
I would like more education on hospital infection control	315 (90.8)
New antimicrobials will be developed in the future to fight "resistance"	258 (74.4)
Prescribing broad-spectrum antimicrobials when equally effective narrower spectrum antimicrobials are available increases AMR	238 (68.6)
Inappropriate use of antimicrobials causes AMR	292 (84.1)
Inappropriate use of antimicrobials can harm patients	267 (76.9)
Poor infection control practices by physicians and other healthcare providers causes spread of AMR	268 (77.3)
For antibiotic guidelines local guidelines are more useful than international guidelines ¹	209 (60.2)
Patients' demand for antibiotics contributes to the overuse of antibiotics in the community ¹	258 (74.3)
I believe that the antibiotics I will prescribe as a doctor will contribute to the problem of resistance	139 (40)

AMR = antimicrobial resistance.

information that was most identified as “useful” or “very useful” was “problem-solving sessions attended by small groups of medical students and residents or faculty in a classroom” (81.3%). “Interactive patient-oriented problem-solving modules on CD-ROM” was least often identified as “useful” or “very useful” (59.9%). There was a significant difference in total knowledge scores among students who ranked the following sources of information as “very useful” or “useful” when compared with students who did not: “problem-solving sessions attended by small groups of medical students and residents or faculty in a classroom” ($P = 0.006$), “interactive patient-oriented problem-solving modules on CD-ROM” ($P = 0.013$), and “interactive patient-oriented problem-solving modules on the Internet” ($P < 0.001$). Students who ranked these sources as “useful” or “very useful” had higher total knowledge scores (Table 2). However, when looking at clinical knowledge scores independent of total knowledge scores, there was no source of information that indicated a significant difference in clinical knowledge scores. Completion of a clinical ID rotation was considered clinical experience rather than a source of information used outside of clinical settings.

Fifty-nine percent of participants are “very familiar” or “familiar” with the term “infection control,” and there was a significant difference in clinical knowledge scores ($P = 0.009$) among these students compared with students who were not familiar with the term. In addition, 35.4% of students were aware of the Infection Control Program or Policy at their institution, and there was a significant difference in clinical knowledge scores among students who were aware and those who were not aware (Supplemental Table 2). Only 13.2% of students were aware of the term “antimicrobial stewardship”; however, there was no significant difference in knowledge or attitude scores among students who were familiar and those who were not.

Need for additional training. When asked, 88.2% of students would like more education on antibiotic selection at medical school. There was a significant difference in attitude ($P < 0.001$), knowledge of factors contributing to AMR ($P = 0.014$), and total knowledge scores ($P = 0.007$) among students who wanted more education compared with those who did not or were unsure (Supplemental Table 3). Forty-one percent of participants were unsure if their current hospital has antibiotic guidelines, and only 15.9% of students have been given a copy of their hospital’s antibiotic guidelines or were shown where they are if on the Internet. Only 22.8% of respondents stated they personally used or consulted antibiotic guidelines when considering an antibiotic for a patient during

their clinical rotation or when observing their supervising physician prescribing an antibiotic. There was a significant difference in knowledge of AMR mechanisms ($P = 0.011$) and clinical knowledge ($P = 0.015$) among students who had personally consulted guidelines compared with students who answered no or unsure (Supplemental Table 4). Consulting guidelines was significantly associated with a higher clinical knowledge score; however, not consulting guidelines was associated with significantly higher knowledge of mechanisms of AMR.

When asked “when do you think your medical college should spend more time teaching about the appropriate use of antimicrobials?” the most popular answer was third year (32%); however, 26.5% thought that more time should be spent in all years, and 18.4% believed more time should be spent in intern year specifically. Fifty-two percent of participants think that their current hospital has antibiotic guidelines; however, there was no significant difference in attitude or knowledge scores among students who answered yes or no/unsure.

Confidence in intent to prescribe antimicrobials. Thirty-five percent of participants were “very confident” or “confident” in antimicrobial prescribing to patients in the future (Table 3). Factors independently associated with higher confidence in antimicrobial prescribing included female gender (OR = 2.51, 95% CI: [1.51, 4.18]), clinical knowledge (OR = 1.26, 95% CI: [1.05, 1.51]), clinical training > 3 years on antibiotic prescribing (OR = 2.48, 95% CI: [1.29, 4.75]), ranking antibiotic education as “useful” or “very useful” (OR = 2.72, 95% CI: [1.63, 4.56]), and awareness of infectious control programs (OR = 1.87, 95% CI: [1.09, 3.22]). These factors are given in Table 3. There were no significant differences in knowledge or attitude scores between males and females. Total knowledge score was not significantly associated with increased or decreased confidence in antimicrobial prescribing in the future. A higher attitude score was independently associated with decreased confidence in antimicrobial prescribing in the future (OR = 0.94, 95% CI: [0.88, 0.995]).

DISCUSSION

The findings in this study suggest that clinical experience and application are a key component in building prescribing confidence in future physicians. Clinical knowledge and knowledge of factors contributing to AMR were significantly higher in students in their fourth and intern years who spend

TABLE 2
Sources of information and total knowledge scores

	N (%)	Total knowledge score	P-value
Interactive patient-oriented problem-solving modules on the Internet			
Useful	273 (78.7)	14.34	< 0.001*
Not useful	70 (20.1)	10.09	
Interactive patient-oriented problem-solving modules on CD-ROM			
Useful	208 (59.9)	11.87	0.013†
Not useful	135 (38.9)	10.87	
Problem-solving sessions attended by small groups of medical students and residents or faculty in a classroom			
Useful	282 (81.3)	11.71	0.006*
Not useful	63 (18.3)	10.42	

* Highly significant.

† Significant.

TABLE 3
Independent predictors of confidence in future antibiotic prescribing intentions

Variable	Beta coefficient	Standard error	P-value	Odds ratio	95% CI for odds ratio
Gender	0.922	0.259	< 0.001*	2.51	(1.51, 4.18)
Clinical knowledge	0.230	0.094	0.014†	1.26	(1.05, 1.51)
Attitude score	-0.065	0.031	0.035†	0.94	(0.88, 0.995)
Clinical training > 3 years on antibiotic prescribing	0.908	0.332	0.006*	2.48	(1.29, 4.75)
Familiar with the term "infection control"	-0.510	0.283	0.071	0.601	(0.35, 1.05)
Ranking of antimicrobial education as "useful" or "very useful"	1.002	0.263	< 0.001*	2.72	(1.63, 4.56)
Awareness of Infection Control Program	0.627	0.276	0.023†	1.87	(1.09, 3.22)

* Highly significant.

† Significant.

more time in clinical settings. The significant difference in clinical knowledge and knowledge of AMR mechanism is likely because of acquisition of more knowledge on the subject near the end of training. An increased clinical knowledge score was a positive predictor of confidence in prescribing, whereas total knowledge score and the other knowledge sub-scores were not significantly associated with increased confidence. Unlike the opportunities for medical students in the United States and other high-income countries in opting for a dedicated ID elective, there is no formal clinical training in IDs as part of the undergraduate medical school curriculum in India.

Increased clinical experience may be the most effective way to increase clinical knowledge, which can affect confidence in future prescribing more than knowledge of AMR mechanisms and contributing factors taught in a classroom. Although several sources of information were associated with increased total knowledge score, none of the sources we listed were significantly associated with a higher clinical knowledge score. Other studies have also found that medical students are more confident in antimicrobial prescribing when educated during clinical placements or informal teaching by supervisors during rounds and other clinical practice settings.^{10,18–21} In other studies, students have identified many factors contributing to AMR.^{9,10,22} In our study, the most commonly identified factor contributing to AMR was premature discontinuation of prescribed antibiotic treatment.

Similar to other studies, participants of this study acknowledged the importance of appropriate antimicrobial prescribing. Haque et al.¹⁴ surveyed clinical year medical students and found that 87% of students felt that prescribing inappropriate or unnecessary antibiotics is professionally unethical, similar to our study (82%). Haque et al.¹⁴ also found that 83% of students thought that antibiotic resistance was a national problem and 63% thought that it was a problem in their teaching hospital.

Although it is important to educate on the importance of AMR, education may also need to empower students on their ability to prevent further resistance. In this study, we found that a more positive attitude score about the importance of AMR was independently and significantly associated with a decreased confidence in future antimicrobial prescribing. It is possible that students who recognize the severity and importance of AMR may also be intimidated by the magnitude of the problem and doubt their preparedness to tackle this global health concern. Therefore, while educating on what contributes to AMR and the importance of it, it is also important to educate on how students can take a positive role in combating

resistance by being good stewards. This lack of empowerment could be reflected in the finding that only 13% of participants in this survey were familiar with the term "antimicrobial stewardship." It is possible that training students to be stewards may instill confidence in their ability to prevent further AMR in the future.

The finding that students who ranked their antimicrobial education as "useful" or "very useful" were more confident in their antimicrobial prescribing in the future is consistent with other studies.¹⁰ A study of final-year medical students in Australia found that students' confidence in their knowledge of IDs was significantly related to them ranking that their ID education is "sufficient."¹⁰ Thus, in future educational interventions, it may be useful to gain as much student input as possible. Whether the education is effective or not, students may gain more confidence if they perceive it as useful.

In addition to student input, incorporating more instruction on the use of antimicrobial guidelines and infection control may also be another educational intervention to improve confidence. Awareness of the infection control policy was a positive predictor of confidence among the participants of this study; however, there appears to be a gap in this awareness among students at this university. In our study, only 35% of students were aware of an Infection Control Program at their hospital and only 238% of students have consulted antimicrobial prescribing guidelines. Students who consulted antimicrobial guidelines had significantly higher clinical knowledge scores, which was an independent predictor of confidence in future prescribing. Thus, access to antimicrobial prescribing guidelines must be routinely available to all clinicians including medical students and residents.^{23–25}

Current antimicrobial education is not adequately empowering students in their future prescribing practices. Only 35% of participants felt confident in their antimicrobial prescribing in the future. Inadequate antimicrobial knowledge and low confidence level were also found among final-year medical students in Australia.¹⁰ Studies have also found that medical students and trainees receive adequate training in diagnostics but remain less confident in accurately prescribing antimicrobials.^{9,26–29} This study identified several possible high-yield interventions for improving confidence such as increased clinical knowledge through clinical experience, increased awareness of infection control policies and antimicrobial guidelines, and empowering students to be antimicrobial stewards to combat AMR. A finding from this study that may warrant further investigation is that female gender

was an independent positive predictor of confidence in prescribing in the future.

Our study had several limitations. The study was conducted at a single private medical school site located in a semi-urban setting, limiting generalizability to other settings including public medical schools. A convenience sampling method was used, resulting in potential bias in the student population. Because the survey was voluntary, the collected data from students reflect the opinions of those who likely had an interest in AMR. The survey instrument had more than 90 questions and took more than 30 minutes to complete. Consequently, some questions were not answered or not seen when the students returned the surveys, and some data were missing. However, in the final analytic sample, we excluded the nine surveys with missing data (> 5% for any variable). There were fewer interns at this institution than other MBBS years, and given clinical responsibilities, they had a busy schedule compared with other students, resulting in underrepresentation of this key group to survey in understanding the role of clinical experience. We did not survey postgraduate medical trainees. Other studies have found that AMR-related learning style preference of doctors in training is different from that of medical students, warranting a customized education approach to varied groups of learners. In our study, we did not investigate why interactive patient-oriented problem-solving modules on CD-ROM are less effective than on the Internet. Despite these limitations, our study shed light on redesigning the curriculum for medical students to incorporate concepts of antimicrobial stewardship and infection control and potential educational interventions for judicious antimicrobial prescribing.

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REFERENCES

- World Health Organization, 2018. *Competency Framework for Health Workers' Education and Training on Antimicrobial Resistance*. Available at: <https://www.who.int/hrh/resources/WHO-HIS-HWF-AMR-2018.1/en/>. Accessed March 13, 2020.
- Laxminarayan R, Chaundhury RR, 2016. Antibiotic resistance in India: drivers and opportunities for action. *PLoS Med* 13: e1001974.
- World Health Organization, 2017. *Essential Medicines List*. Available at: https://www.who.int/medicines/news/2017/20th_essential_med-list/en/. Accessed March 13, 2020.
- Kumar SG, Adithan C, Harish BN, Sujatha S, Roy G, Malini A, 2014. Antimicrobial resistance in India: a review. *J Nat Sci Biol Med* 4: 286–291.
- The Center for Disease Dynamics, Economics & Policy, 2019. *Antibiotic Resistance. Resistance Map CDDEP*. Available at: <https://resistancemap.cddep.org/CountryPage.php?countryId=17&country=India>. Accessed March 1, 2020.
- World Health Organization, 2015. *WHO Global Action Plan on Antimicrobial Resistance*. Available at: http://www.wpro.who.int/entity/drug_resistance/resources/global_action_plan_eng.pdf. Accessed March 13, 2020.
- Abbo LM, Cosgrove SE, Pottinger PS, Pereyra M, Sinkowitz-Cochran R, Srinivasan A, Webb DJ, Hooton TM, 2013. Medical students' perceptions and knowledge about antimicrobial stewardship: how are we educating our future prescribers? *Clin Infect Dis* 57: 631–638.
- World Health Organization, 2012. *The Evolving Threat of Antimicrobial Resistance: Options for Action*. Available at: https://apps.who.int/iris/bitstream/handle/10665/44812/9789241503181_eng.pdf?sequence=1. Accessed March 13, 2020.
- Dyar OJ, Pulcini C, Howard P, Nathwani D; ESCMID Study Group for Antibiotic Policies, 2104. European medical students: a first multicenter study of knowledge, attitudes and perceptions of antibiotics prescribing and antibiotic resistance. *J Antimicrob Chemother* 69: 842–846.
- Weier M, Thursky K, Zaidi STR, 2017. Antimicrobial knowledge and confidence amongst final year medical students in Australia. *PLoS One* 12: e0182460.
- Minen MT, Duquaine D, Marx MA, Weiss D, 2010. A survey of knowledge, attitudes, and beliefs of medical students concerning antimicrobial use and resistance. *Microb Drug Resist* 16: 285–289.
- Yang K, Wu D, Tan F, Shi S, Guo X, Min Q, Zhang X, Cheng H, 2016. Attitudes and perceptions regarding antimicrobial use and resistance among medical students in central China. *SpringerPlus* 5: 1779.
- Thriemer K, Katuala Y, Batoko B, Alworonga J, Devlieger H, Van Geet C, Ngbonda D, Jacobs J, 2013. Antibiotic prescribing in DR Congo: a knowledge, attitude and practice survey among medical doctors and students. *PLoS One* 8: e55495.
- Haque M, Rhaman NIA, Zulkifli Z, Ismail S, 2016. Antibiotic prescribing and resistance: knowledge level of medical students of clinical years of University Sultan Zainal Abidin, Malaysia. *Ther Clin Risk Manag* 12: 413–426.
- Wasserman S, Potgieter S, Shoul E, Constant D, Stewart A, Boyles TH, 2017. South African medical students' perception and knowledge about antibiotic resistance and appropriate prescribing: are we providing adequate training and appropriate prescribing? *S Afr Med J* 107: 405–410.
- Sharma K, Jain P, Sharma A, 2015. Knowledge, attitude and perception of medical and dental undergraduates about antimicrobial stewardship. *Indian J Pharmacol* 47: 676–679.
- Khan AKA, Banu G, Reshma KK, 2013. Antibiotic resistance and usage—a survey on the knowledge, attitude, perceptions and practices among the medical students of a southern Indian teaching hospital. *J Clin Diagn Res* 7: 1613–1616.
- Illing JC et al., 2013. Perceptions of UK medical graduates' preparedness for practice: a multi-centre qualitative study reflecting the importance of learning on the job. *BMC Med Educ* 13: 34.
- Maxwell S, Walley T, 2003. Teaching safe and effective prescribing in UK medical schools: a core curriculum for tomorrow's doctors. *Br J Clin Pharmacol* 55: 496–503.
- Martin AA, Laurence CO, Black LE, Mugford BV, 2007. General practice placements for pre-registration junior doctors: adding value to intern education and training. *Med J Aust* 186: 346–349.
- Akat PB, Karande VB, Murthy MB, Burute SR, 2012. Interns opinion on 'bedside pharmacology clinics' and its incorporation in undergraduate curriculum. *J Pharmacol Pharmacother* 3: 56–58.
- Pulcini C, Williams F, Molinari N, Davey P, Nathwani D, 2011. Junior doctors' knowledge and perceptions of antibiotic resistance and prescribing: a survey in France and Scotland. *Clin Microbiol Infect* 17: 80–87.
- Dartnell J, 2001. Activities to improve hospital prescribing. *Aus Prescr* 24: 29–31.
- Starmer K, Sinnott M, Shaban R, Donegan E, Kapitke D, 2013. Blind prescribing: a study of junior doctors' prescribing

- preparedness in an Australian emergency department. *Emerg Med Australas* 25: 147–153.
25. Slight SP, Howard R, Ghaleb M, Barber N, Franklin BD, Avery AJ, 2013. The causes of prescribing errors in English general practices: a qualitative study. *Br J Gen Pract* 63: e713–e720.
 26. de Vries TP, Henning RH, Hogerzeil HV, Fresle DA, 2009. Guide to good prescribing: a practical manual. *Action Program on Essential Drugs*. Geneva, Switzerland: World Health Organization. Available at: <http://apps.who.int/medicinedocs/en/d/Jwhozip23e/>. Accessed March 15, 2020.
 27. Dorman T, Ashcroft D, Heathfield H, Lewis P, Miles J, Taylor D, Tully M, Wass V, 2009 *An in Depth Investigation into Causes of Prescribing Errors by Foundation Trainees in Relation to Their Medical Education. EQUIP Study*. Manchester, England: University of Manchester. Available at: https://www.gmc-uk.org/-/media/documents/FINAL_Report_prevalence_and_causes_of_prescribing_errors.pdf_28935150.pdf. Accessed December 5, 2019.
 28. Ajemigbitse AA, Omole MK, Osi-Ogbu OF, Erhun WO, 2013. A qualitative study of causes of prescribing errors among junior medical doctors in a Nigeria in-patient setting. *Ann Afr Med* 12: 223–231.
 29. Rattanaumpawan P, Cheunchom N, Thamlikikul V, 2019. Perception, attitude, knowledge and learning style preference on challenges of antimicrobial resistance and antimicrobial over-use among first year doctors in training and final year medical students. *Antimicrob Resist Infect Control* 8: 142.