Improving Antimicrobial Resistance Awareness Among Medical Students in India: The Sensitization of Medical Students on Antimicrobial Resistance (SOS-AMR) Study

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ABSTRACT

OBJECTIVES: To evaluate the impact of an online educational intervention on improving knowledge of antimicrobial resistance (AMR) and stewardship among final-year medical students in Chennai, India.

METHODS: This was a prospective 'before-after' study conducted across 5 medical colleges in Chennai, India. Participants who were final-year (fourth year) undergraduate medical students were administered a pretest to evaluate baseline knowledge. Students were then provided access to online educational material comprising 20 short lectures. Lectures were delivered by content experts and covered a range of topics which included basics of microbiology, fundamental concepts in AMR and stewardship, diagnosis and management of common infections, basics of antimicrobial pharmacokinetics and pharmacodynamics, and vaccination. Students were required to take a posttest at the end of these modules. Primary outcome was improvement in test scores from pretest baseline which was analyzed using a *t* test. A 30% improvement in the mean scores from baseline was predefined as a measure of success.

RESULTS: A total of 599 students participated from 5 medical colleges among whom 339 (56.6%) were female participants; 542 (90.4%) students completed the posttest. Mean pretest score was 11.6 (maximum possible score of 25) (SD: 4.3) and the mean posttest score was 14.0 (SD: 4.6). Comparing pre and posttest scores, there was an improvement of 2.4 marks (20%) from the baseline (95% confidence interval: 1.9, 2.9) ($P < .001$). Improvement in scores was similar for male and female participants.

CONCLUSIONS: In this before-after study evaluating the impact of an educational intervention on AMR among final-year medical students, there was an improvement in knowledge; however, the extent of improvement did not meet the predefined metric of success.

KEYWORDS: Antimicrobial resistance, medical students, educational intervention

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Introduction

Antimicrobial resistance (AMR) contributes to nearly 5 million deaths annually with over half of that burden distributed in South and South-East Asia.[1] In addition to mortality, AMR accounts for substantial morbidity with an estimated 189 000 Years of Life Lost.[1] As with other major health challenges, low and lower-middle-income countries face a disproportionate share of this burden.[2–4]

There are several drivers of AMR including the abuse and overuse of antimicrobials in humans, crops, and animals,[5] the easy over-the-counter availability of these medicines in several countries,[6] the absence or poor enforcement of antimicrobial stewardship,[7,8] and the fear of poor outcomes secondary to infectious etiologies and delayed antibiotic delivery among healthcare workers.[9,10]

One of the key contributors to antimicrobial abuse is inadequate awareness among physicians and inappropriate prescription practices.[11–13] The Global Antibiotic Resistance Partnership – India Working Group has identified that education and awareness is one of the key links in any strategy directed at taking on the threat of AM. The World Health Organization in its Global Action Plan also identified education and awareness as a key component of strategies that can address the threat of AM.[4] In a survey of medical practitioners from Tamil Nadu, India, 12% of respondents emphasized the need for continued medical education (CME) on AMR and

antibiotic use guidelines.[15] While CME programs are indeed essential, we posit that the problem may perhaps be more upstream. Medical students (doctors-in-training) represent the future of the health care system and are critical stakeholders in the problem of AMR. Surveys from high-income countries have shown large gaps in knowledge among medical students on the appropriate use of antibiotics.[16,17] Results of similar surveys from India corroborate these findings.[18,19]

In addition, the coverage of AMR and topics on stewardship in the Indian medical school curriculum is grossly inadequate.[20] In this context, we evaluated the impact of an online educational intervention on improving knowledge of AMR and stewardship among final-year medical students in Chennai, India.

Methods

Study Design, Setting, and Participants

This was a prospective multicenter 'before-after' study which was conducted across 5 medical colleges in Chennai, India, between March 2021 and December 2022. Participants were final-year (fourth year) undergraduate medical students training in these institutions. All final-year medical students at these institutions were eligible and encouraged to participate. There were no exclusion criteria. Undergraduate medical education in India is typically 5.5 years long which includes a one-year compulsory rotating internship. By final-year, medical students are expected to have completed a range of competencies related to AMR, stewardship, and prescription.

Study Procedures

All final-year medical students at participating medical colleges were administered a pretest comprising 25 questions to evaluate baseline knowledge (electronic supplemental material) which was hosted on a learning management system (LMS) platform developed exclusively for the purposes of this study (https://sosam.n/course-category/sos-amr/). Each student was required to register on the LMS and create a unique 'username' and 'password' for exclusive access to the educational material. The questions tested knowledge on common concepts across the domains of microbiology (5 questions), antimicrobial stewardship (5 questions), AMR (3 questions), diagnosis (2 questions), and antimicrobial prescription (10 questions). The questions were developed by the study investigators and pilot tested on 47 participants for clarity and content. One mark was awarded for each correct response for a total of 25 marks.

Following the pretest, the students were provided access to online educational material comprising 20 short lectures hosted on the same LMS. Lectures were developed and delivered by content experts (from the disciplines of microbiology, infection control, infectious diseases, and critical care medicine) and covered a range of topics which included basics of microbiology, fundamental concepts in AMR and stewardship, diagnosis and management of common infections, basics of antimicrobial pharmacokinetics and pharmacodynamics, and vaccination. The content of the lectures was based on gaps identified in the medical school curriculum[20] and the consensus of the study team. The duration of each online lecture was approximately 15 to 20 min, and the course was structured in a way that students could only proceed to the next lecture after completion of the preceding one. The lectures followed in an order of increasing complexity such that concepts were introduced in a sequential manner.

Once a student completed the 20 lectures, they were provided access to the posttest which included the same 25 questions as the pretest. On completion of the posttest, students were provided access to their scores and a certificate of completion was also autogenerated by the LMS. Each student was provided access to the LMS for a period of 4 weeks from the time of registration on the LMS to complete the pretest, online lectures and the posttest. Figure 1 summarizes the study flow.

Data Collection

Using the LMS platform, data were collected on basic demographics of the participating students and the medical colleges they represented. Pretest and posttest scores were extracted for each candidate from the LMS platform.

Sample Size

We originally proposed to enroll 1500 medical students across 10 medical colleges in Chennai. The project was conceived in late 2019 and enrollment was to start in 2020. However, the outbreak of the pandemic meant that the study could not be initiated until early 2021. As India was one of the worst affected countries during the first and second waves of the pandemic, we were forced to restrict our enrollment to 5 medical colleges and stop after the first 599 students. Medical students were co-opted into the pandemic response across medical colleges in India and as such, we were unable to continue the study. We also had originally proposed a second posttest 3 months after the first posttest to test retention. This could not be accomplished either.

Statistical Analysis

Categorical variables are represented as counts and percentages and continuous variables as mean and standard deviation. Our primary outcome was the improvement in test scores from the pretest to the posttest. This is reported as a mean improvement in the test scores from baseline. Our apriori specified metric of success was a 30% improvement in the mean scores from baseline.

Ethics and Consent

The study was approved by the Institutional Ethics Committee (AMH-C-S-001/01-21) at the central coordinating site and

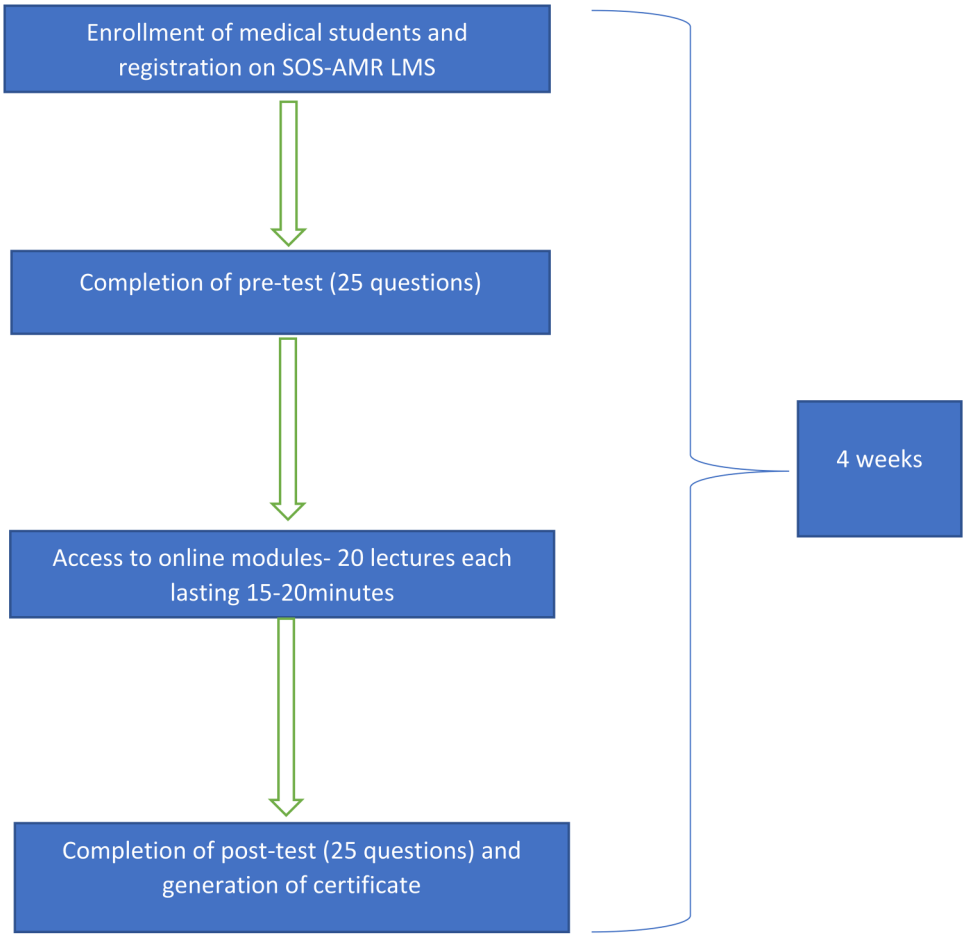

Figure 1. Study structure and flow.

additional approvals were obtained at the participating medical colleges as necessary. At each medical college, the Dean (or equivalent) approved the study and appointed a faculty member as study liaison. The project was conceived and delivered as an educational intervention aimed at improving awareness and students were encouraged to participate; however, the program was not mandatory and students could choose not to participate. Students that signed up for the program were presumed to have provided consent.

Results

A total of 599 students participated from 5 medical colleges in Chennai with 339 female participants (56.6%). Mean age of the participants was 22.0 years.

Of the 599 medical students that registered and completed the pretest, 542 students went on to complete the posttest (90.4%). The maximum possible test score was 25. The mean pretest score was 11.6 (SD: 4.3) (range: 0-24). The mean posttest score was 14.0 (SD: 4.6) (range: 0-23).

Comparing the pre and posttest scores for the cohort of participants that completed both tests, there was an improvement of 2.4 marks from the baseline (95% confidence interval [CI]: 1.9, 2.9) ($P < .001$) (Table 1). In addition, the Cohen's d or the effect size in improvement seen is 0.55 standard deviation units. For context, a Cohen's d of 0.20 is considered small, 0.50 as medium and 0.80 large.[21]

Table 1. Before-and-After Comparison.

	Pretest mean (SD)	Posttest mean (SD)	Difference; 95%CI	*P* value
Overall (n = 542)	11.6(4.3)	14.0(4.6)	2.4(1.9-2.9)	<.001
Male (n = 233)	11.3(4.6)	13.6(4.7)	2.3(14-3.1)	<.001
Female (n = 309)	12.0(4.0)	14.2(4.5)	2.2(1.5-2.9)	<.001

Of the 542 students that completed the posttest, 309 were female (57.0%). The improvement in scores was similar for male and female students 2.3 marks (95% CI: 1.4, 3.1) ($P < .001$) versus 2.2 marks (95% CI: 1.5-2.9) ($P < .001$) respectively.

Discussion

Our before-after educational study conducted across 5 medical colleges in Chennai demonstrated an improvement in

knowledge on AMR and stewardship among final-year medical students. However, this improvement was less than the 30% apriori specified threshold for declaring success.

There are no clear recommendations on what is an acceptable metric of success for interventions such as ours. As a consensus, we chose a 30% improvement. The team also felt that the resources and effort needed to roll out such interventions on a larger scale across medical colleges would only be justified if a certain minimum improvement was demonstrable. As a team, we felt that this threshold should be at least 30%. In addition, from the Cohen's *d*, we can see that the improvements seen are "medium" or modest.

There are several possible reasons for being unable to demonstrate this prespecified improvement. We were unable to reach our target sample size of 1500 medical students and had to stop the study after enrolling 40% of the sample size due to the pandemic, and this could have impacted the results. The study was conducted in the interwave periods of the pandemic and it is possible that students were unable to engage with the material and content given the stressors of COVID-19. In addition to medical students being deployed in the pandemic response,[22] it is likely that they had to support or care for family members or friends or other loved ones who may have been infected. In addition, medical education across the world faced significant disruption.[23] For all of these reasons, medical students may not have had the bandwidth to engage with additional educational content. Given the scale of the pandemic in India, AMR may not have been perceived by students as an immediate threat or priority although data clearly suggest that the pandemic has only worsened the problem of AMR.[4,25] While our original study proposal included a combination of in-person and online learning modules, the pandemic meant that we had to change to an online-only model. There is hence the possibility of fatigue associated with online learning given that regular medical education had also switched to virtual learning platforms.[26,27] Finally, it is possible that although the educational content we provided was comprehensive and covered a variety of relevant domains, it was unable to meet the desired objectives.

While there have been a number of interventions[28,29] targeted at improving community-level awareness of the consequences of AMR and several studies demonstrating the problem of lack of knowledge and awareness among medical students,[15–17] none have exclusively targeted medical students or doctors-in-training in improving the situation. Our study is unique in attempting to improve knowledge among final-year medical students who are on the cusp of independent medical practice in India.

In a systematic review[29] focused on medical students' knowledge, attitude, and beliefs regarding antibiotic use and resistance, authors found that while medical students perceived resistance as posting a major public health problem, there were substantial gaps in knowledge about treatment of common infections. Reassuringly, in this study as well as in other studies,[30,31] medical students felt that they could contribute positively to work being done to mitigate AM. A third of participants in the study felt they could contribute more, if better trained.

While our study did not achieve the prespecified goal, the improvements seen overall (average improvement of 20%), indicate that further modifications to the training program (in-person teaching, addition of interactive components, seeking feedback on engagement, testing retention, etc) may bring about the desired changes. In the intermediate to long term, changes to the medical curriculum that emphasize the importance of stewardship and expand competencies to include those related to AMR are urgently needed. In addition, impressionable medical students are likely to be influenced by the behaviors that their teachers and senior physicians' role model, thus necessitating a multipronged approach.

Strengths and Limitations

Our study is novel and innovative in evaluating the impact of an educational intervention on improving knowledge on AMR for medical students. Our educational modules were comprehensive and covered a range of essential topics in the areas of microbiology, infection control, diagnosis and treatment of common infections, core concepts in AMR, and stewardship and were developed and delivered in collaboration with domain experts. Our study is aligned with the Government of India's national action plan on AMR where "improving awareness and understanding of AMR through effective communication, education and training" is one of the 6 key strategic priorities.[32] Additionally, and in the spirit of maximizing the reach and benefits, we have made the educational content open access and shared it with the Departments of Medical Education and Public Health, Govt. of Tamil Nadu, India.[33]

There are important limitations to this work. We did not achieve the target sample size and as noted, this may have impacted our final results and 10% of the enrolled students did not complete the posttest. We were unable to test retention of knowledge at a later time point (eg, 3 months) or obtain feedback on the educational modules. It is also important to note that that lectures address only the knowledge component of the cognitive domain and may have little impact on higher domains such as application, synthesis, and evaluation.[34] Case-based or problem-based interactive learning may be a more effective method to impact the higher levels of cognitive domain. Finally, to remain pragmatic and be able to implement the program across medical colleges, we kept data collection to the minimum. This limited our ability to perform additional detailed analyses.

Conclusions

In this before-after study evaluating the impact of an educational intervention on AMR among final-year medical students, there was an improvement in knowledge; however, the

extent of improvement noted did not meet our predefined metric of success. Further modifications to the training program such as the inclusion of in-person and interactive training sessions, seeking feedback on engagement, and testing knowledge retention may bring about the desired response. In addition, changes to the medical school curriculum that emphasize the importance of antimicrobial stewardship and role-modeling by senior colleagues and teachers is essential as part of a multipronged approach at driving behavioral change.

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Author Contributions

BKTV: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, writing-original draft, writing-review, and editing. LR: Formal analysis, investigation, writing-review, and editing. RV, VRS, YR, and NR: Conceptualization, funding acquisition, investigation, writing-review, and editing. AD, PK, MA, RSR, and SM: investigation, project administration, writing-review, and editing.

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Supplemental Material

Supplemental material for this article is available online.

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