Medical Students' Knowledge, Attitudes, and Behaviors on Antimicrobial Resistance in Tbilisi

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SUMMARY*: Antimicrobial resistance (AMR) is a global challenge requiring improved medical education to prepare future prescribers for rational antimicrobial use. This study assessed foreign medical students' knowledge, attitudes, and behaviors regarding antibiotic use and AMR in Tbilisi, Georgia. A cross-sectional study was conducted in 2024 with 302 students from Tbilisi State University and The University of Georgia. Most participants were first-year students, primarily women aged 17–30. While 81.1% knew antibiotics are ineffective against viruses, women demonstrated superior knowledge. Discussions on AMR occurred during lectures, and awareness before medical school was also common. Self-medication persisted in some students despite AMR education. Although students showed strong foundational knowledge, misconceptions and gaps in confidence remain. Curriculum improvements and ongoing AMR education are vital for future healthcare professionals.*

Keywords: Antimicrobial resistance (AMR); Medical education; Knowledge, Attitudes and Behaviors (KAB); Tbilisi, Georgia; Antibiotic use.

INTRODUCTION:

AMR has become a persistent public health issue globally, projected to cause 10 million deaths annually by 2050 (de Kraker et al., 2016).

AMR happens when bacteria, viruses and also parasites and fungi no longer respond to the antimicrobial treatments in animals and people, enabling these microorganisms to survive within the host. The main factor driving this crisis is the excessive and less use of antimicrobial medications, especially the improper use of antibiotics, which heightens the global challenge of antimicrobial resistance (Tang et al., 2023).

Consequently, the rational use of antibiotics is crucial in addressing antimicrobial resistance (AMR), a global health threat. Medical students play an important role in healthcare delivery as

future prescribers. Therefore, they should have proper knowledge, positive attitudes, and appropriate behaviors regarding antibiotic use to prevent AMR (Lin et al., 2020).

Antibiotics and Antimicrobial resistance

Antibiotics are often referred to as magic bullets for combating bacteria and are regarded as one of the most extraordinary discoveries of the 20th century in medicine. The advent of antibiotics transformed the landscape of medical treatment and continues to save millions of lives from bacterial infections (Salam et al., 2023).

"The discovery of the antibiotic penicillin, by Sir Alexander Fleming was one of the greatest medical advancements which initiated the "golden era" of antibiotics" (Hutchings et al., 2019).
Antibiotics are also known as antibacterial medications, which inhibit the bacteria's grow or destroy it. So, they are the pharmaceuticals that treat only bacterial diseases, but cannot be used for viral infections, for example: such as: cough, flu and cold (Sa'adatu Sunusi et al., 2019).

Antibiotic resistance is an evolutionary adaptation of bacteria in response to the use of therapeutic antibiotics. Clinically, pathogens are initially susceptible to a newly introduced antibiotic, but over time, sustained use leads to the development of resistance. From an evolutionary standpoint, bacteria counteract the effects of antibiotics through chromosomal gene mutations or by acquiring foreign deoxyribonucleic acid (DNA) via horizontal gene transfer (HGT), which carries resistance genes (Salam et al., 2023).

The objective of the study

The main aim of this study is to assess the existing knowledge of Antimicrobial resistance (AMR) and the attitude and behavior of antibiotic usage among medical students in Tbilisi, Georgia.

Methods

Study design

This study employed a cross-sectional design to assess the knowledge, attitude and behavior regarding the rational use of antibiotics and antimicrobial resistance among medical students in two universities of Tbilisi, Georgia.

Study participants, Sampling and Recruitment

This study included 302 participants, who were foreign medical students at Tbilisi State University and The University of Georgia.

The inclusion criteria consisted of the students from first to sixth year, who were studying at the faculty of Medicine.

This study excluded Georgian students, graduates, also the students not studying in Tbilisi and those students studying on other faculties than Medicine.

We used convenience sampling methods to ensure maximum reach and participation of the students.

The recruitment process involved a combination of online and offline approaches. We developed an online questionnaire consisted of total 23 questions and used the survey administration software Google Forms. In order to distribute it to the medical students on the one hand, we sent academic emails to them and on the other hand arranged in-person presentations in the medical classes. Both recruitment methods included a brief introduction to the study, the potential benefits of this study to future medical curriculum, the significance of their opinions and participation, a link to the online questionnaire and assurance of confidentiality and the voluntary nature of participation in this study.

Statistical analyses

We performed statistical analyses using IBM SPSS Statistics version 23. The first step involved identifying sociodemographic data, including gender, age, and level of study, which were treated as categorical variables. To explore the relationships between different variables, we calculated Pearson's chi-square (χ^2) test for categorical variables to assess associations between these sociodemographic factors and key outcomes.

For correlating variables, we used a 95% confidence interval (CI) and a p-value threshold of 0.05 to determine statistical significance. Differences were considered significant if the p-value was less than 0.05. For example, we used the chi-square test to examine the association between year of study and students' ability to correctly explain antibiotic resistance. When the p-value was greater than 0.05, we reported non-significant results, acknowledging the absence of strong evidence for an association.

Additionally, we employed a one-sample t-test to assess how participants' responses deviated from a neutral or baseline response (e.g., a score of 3 on a Likert scale). This test was used to examine how medical students perceived the significance and seriousness of antimicrobial resistance (AMR) as a global health problem. A p-value less than 0.05 was considered statistically significant, indicating that participants' perceptions deviated significantly from the neutral response. Significant findings were interpreted in the context of the study, with results suggesting a clear difference in how students perceived AMR as a global health issue.

Results

In total, this study included 302 foreign medical students from Tbilisi State University and The University of Georgia. The results have shown that a small majority were women: 181 (59.9%) and men were:121 (40.1%).

The students participating in our study were also divided according to the level of education at the Faculty of Medicine, from the first to the sixth year. The research revealed that the significant majority was in their first year: 63.2% (191 students); 17.2% (52 students) – in the second year; 12.9% (39 students) – in the third year; 4.6% (14 students) – in the fourth year; 1.3% (4 students) – in the fifth year and the lowest number 0.7% (2 students) – in the sixth year. For the statistical analysis, we divided the students into 2 groups according to the level of education, in particular, we assigned first and second year students to the first group and the students from the third to the sixth year to the second group and analyzed the research results according to it (Table 1).

Table 1. Demographic and Academic Distribution of Medical Students

Demographic Category	Total students	Percentage
Gender		
Female	181	59.9%
Male	121	40.1%
Level of Education		
First year	191	63.2%
Second year	52	17.2%
Third year	39	12.9%
Fourth year	14	4.6%
Fifth year	4	1.3%
Sixth year	2	0.7%

In the questionnaire, we included an open-ended question: “explain what is meant by antibiotic resistance in your own words” to which medical students from different courses responded with varying levels of understanding.

The first figure shows the distribution of students based on their year of study and their ability to correctly explain antibiotic resistance. The bar chart indicates that 147 from the 1st-2nd year group and 37 from the 3rd-6th year group provided accurate explanations of antibiotic resistance. Some students: 35 from the 1st-2nd year group and 14 from the 3rd-6th year group gave partially correct explanations, while 61 from the 1st-2nd year group and 8 from the 3rd-6th year group were unable to explain it.

Statistical analysis revealed no significant difference in the level of knowledge about antibiotic resistance between students in different years of study ($\chi^2 = 5.352$, $df = 2$, $P = 0.069$). This result indicates that the year of study does not significantly affect students' understanding of antibiotic resistance. Although the P-value is slightly above the conventional threshold for

significance ($P < 0.05$), it suggests that factors other than the year of study may contribute to students' knowledge. (Figure 1).

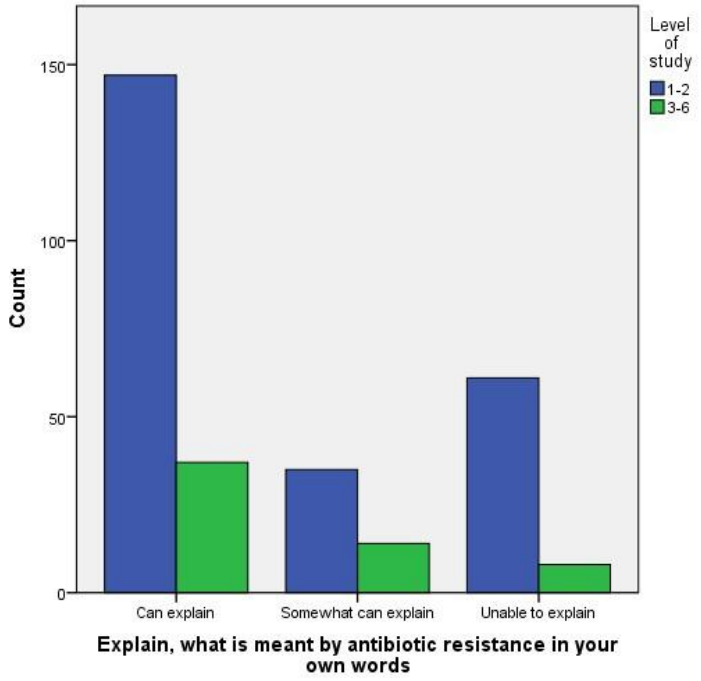

Figure 1: The distribution of students by level of study and knowledge of antibiotic resistance

Assessment of Knowledge regarding antibiotics and antimicrobial resistance in medical students

The second table shows us the level of knowledge of medical students regarding antibiotics and antimicrobial resistance and the distribution of answers according to whether they thought the statement given in the form of a question was true or false or if they did not know the answer at all. Most of the participants of this study identified correctly whether statements were true or false, besides the one about using of antibiotics for shortening the recovery period from coughs and colds, where medical students marked true and false options equally (Table 2).

Table 2: The Knowledge of respondents regarding Antibiotics and Antimicrobial Resistance

Statement	True	False	Don't know
Antibiotics are effective only for viral infections	42 (13.9%)	245 (81.1%)	15 (5%)
Antibiotics are effective only for bacterial infections	213 (70.5%)	80 (26.5%)	9 (3%)
The use of antibiotics shortens the recovery period from coughs and colds	144 (47.7%)	144 (47.7%)	14 (4.6%)
It is advisable to stop taking antibiotics after the symptoms have resolved	125 (41.4%)	160 (53%)	17 (5.6%)
Self-medication with broad-spectrum antibiotics is safe for any disease	32 (10.6%)	250 (82.8%)	20 (6.6%)

Establishing control over the sale of antibiotics in pharmacies contributes to the development of antibiotic resistance	117 (38.7%)	142 (47%)	43 (14.2%)
If antimicrobials are taken for a long time, then it is more likely that their effects will be maintained in the future	86 (28.5%)	173 (57.3%)	43 (14.2%)

To assess how medical students perceived the significance and seriousness of antimicrobial resistance (AMR) as a global health problem, we used a Likert scale-based question where participants rated their agreement with the statement, "Antimicrobial resistance does not represent a significant and serious challenge for global public health," ranging from "Strongly Disagree" to "Strongly Agree." The data was then analyzed to determine how students' responses deviated from a neutral position (i.e., neither agree nor disagree).

The mean score of participants' responses was calculated, with descriptive statistics including the standard deviation (SD) to assess the variability in responses. A one-sample t-test was employed to evaluate if there was a statistically significant difference between the mean response and the neutral value (which is 3, corresponding to "Neutral" on the Likert scale).

The results of the one-sample t-test revealed a significant deviation from the neutral response. The mean score of participants was 3.75 (SD = 1.253), and the statistical analysis indicated a highly significant difference from the neutral value, with a P-value of <0.0001. This suggests that the participants did not perceive antimicrobial resistance as a neutral issue, with a clear trend towards stronger disagreement with the notion that AMR is not a serious global problem.

Figure 2 illustrates the distribution of responses, with the majority of students expressing strong disagreement with the statement. Specifically, 112 participants (37.1%) strongly disagreed, 78 (25.8%) disagreed, 56 (18.5%) were neutral, 36 (11.9%) agreed, and 20 (6.6%) strongly agreed. These findings highlight that the majority of medical students perceive antimicrobial resistance to be a serious and significant challenge for global public health. (Figure 2).

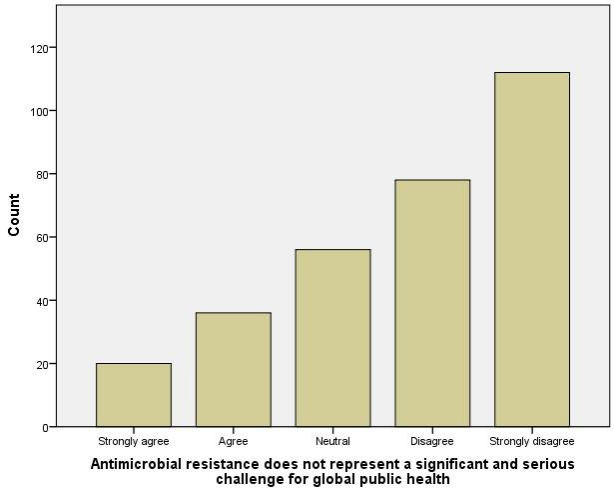

Figure 2: Distribution of answers received to question: “antimicrobial resistance does not represent a significant and serious challenge for global public health”

Assessment of attitudes towards antimicrobial resistance in medical students

In addition, we were also interested in assessing the individual attitudes of medical students regarding this issue, for which we asked them various questions, such as: first of all, what did they think, if it was necessary for medical students in general to know about the existence of antimicrobial resistance, to which a large majority of the participants answered that yes it was necessary, namely 294 students (97.4%) and only 8 students (2.6%) answered no.

The next question was as follows: "Do you think that the university provides enough knowledge to determine when it is appropriate to start antibiotic therapy?", to which 140 participants agreed (46.4%), 80 students (26.5%) disagreed, and 82 students (27.2%) did not know about it.

Also, a similar attitude-exploring question we included was about whether they thought their university provided enough knowledge to be able to choose the appropriate antibiotic for a specific bacterial infection, to which half of the participated students in our study gave only positive answers, specifically 151 of them indicated yes (50%), 73 of them disagreed (24.2%) and 78 participants did not know about it (25.8%).

And also at the end, we asked them about their opinions whether the representatives of the non-medical professions should know about antimicrobial resistance or not, to which most of them: 264 students (87.4%) agreed and the rest 38 students (12.6%) did not agree that.

Assessment of behaviors regarding antimicrobial resistance of medical students

We also assessed the behaviors and the own experiences of medical students regarding this issue.

On table 3, there is shown the questions associated with the behaviors about antimicrobial resistance and their answers to those questions. As it is clear from this table, more students have experienced talking about antimicrobial resistance during studying at the university on lectures (198, 65.6%), also most of them knew the existence of AMR before starting to study on medicine faculty (213, 70.5%), then, next question which was about the experience of students regarding taking antibiotics on their own before and after learning this topic, we can notice a difference in the quantity of students who initially answered: they took antibiotics on their own before learning about antimicrobial resistance and after learning this topic. So, we can conclude that the number of students with self-medication decreased from 54.3% to 43.4% as they started to study antimicrobial resistance in the university.

And lastly, we assessed their actions, by asking if they were discussing about antimicrobial resistance in non-medical population too, which shown us positive results that 175 of them out

of 302 were talking about this issue, but other students did not have this kind of experience (Table 3).

Table 3: The behaviors of participants regarding Antimicrobial Resistance

Questions	Yes	No
Did you talk about antimicrobial resistance during your studies at your university, during the lectures?	198 (65.6%)	104 (34.4%)
Have you heard about antimicrobial resistance before starting university?	213 (70.5%)	89 (29.5%)
Have you taken an antibiotic on your own before learning about antibiotic resistance?	164 (54.3%)	138 (45.7%)
Have you taken an antibiotic on your own after learning about antibiotic resistance?	131 (43.4%)	171 (56.6%)
Do you discuss about antimicrobial resistance with the population of non-medical professions?	175 (57.9%)	127 (42.1%)

To assess the relationship between students' correct responses to the question about the effectiveness of antibiotics during colds and coughs and their perception of the sufficiency of the university's knowledge provision on choosing appropriate antibiotics, we employed the Chi-square (χ^2) test of independence. This test was used to determine if there was a statistically significant association between these two categorical variables.

The Chi-square test revealed a statistically significant association between students' correct answers regarding the effectiveness of antibiotics during colds and their belief that the university provides sufficient knowledge about the appropriate choice of antibiotics. The Chi-square statistic was $\chi^2 = 13.196$ with 4 degrees of freedom ($df = 4$), and the p-value was 0.010, which is less than the 0.05 threshold, indicating that the difference is statistically significant.

Table 4 provides the detailed breakdown of the frequencies and percentages of responses for the two variables. This result suggests that students who correctly answered the question about antibiotics' effectiveness during colds and coughs are more likely to agree that the university provides sufficient knowledge about antibiotic use, reinforcing the association between knowledge and the perception of educational quality (Table 4).

Table 4: "Association Between Correct Knowledge of Antibiotic Use During Colds and Perceived Adequacy of University Education on Antibiotic Selection"

In your opinion, does the university provide sufficient knowledge about the principle of selecting the appropriate antibiotic for a particular bacterial infection? * The use of antibiotics shortens the recovery period from coughs and colds Crosstabulation

			The use of antibiotics shortens the recovery period from coughs and colds			
			True	False	Don't know	Total
In your opinion, does the university provide sufficient knowledge about the principle of selecting the appropriate antibiotic for a particular bacterial infection?	Yes	Count	78	71	2	151
		% of Total	25.8%	23.5%	0.7%	50.0%
	No	Count	35	35	3	73
		% of Total	11.6%	11.6%	1.0%	24.2%
	Don't know	Count	31	38	9	78
		% of Total	10.3%	12.6%	3.0%	25.8%
Total		Count	144	144	14	302
		% of Total	47.7%	47.7%	4.6%	100.0%

To explore the relationship between students' self-medication behavior with broad-spectrum antibiotics and their perception of the safety of self-medication after learning about antimicrobial resistance (AMR), we performed a Chi-square test of independence. The two variables assessed were:

1. whether students had taken an antibiotic on their own after learning about AMR (Yes or No).

2.Whether students agreed, disagreed, or were unsure about the safety of self-medication with broad-spectrum antibiotics.

The responses were organized into the following crosstabulation (Table 5), which outlines the frequency of each combination of responses.

A Chi-square test of independence was conducted to assess whether there was a statistically significant relationship between students' self-medication behavior and their perception of the safety of self-medication with broad-spectrum antibiotics. The results revealed that the Chi-square value ($x^2 = 5.462$, $df = 2$, $P = 0.065$) indicates that there is no statistically significant association between these two variables, as the p-value exceeds the conventional threshold of 0.05 for statistical significance.

Thus, we can conclude that although there is a difference in the proportions of students who agree, disagree, or are unsure about the safety of self-medication with broad-spectrum antibiotics, this difference is not statistically significant in relation to whether students have engaged in self-medication after learning about AMR (Table 5).

Table 5: Association Between Self-Medication Practices After AMR Education and Beliefs About the Safety of Broad-Spectrum Antibiotics

Have you taken an antibiotic on your own after learning about antibiotic resistance? * Self-medication with broad-spectrum antibiotics is safe for any disease Crosstabulation

			Self-medication with broad-spectrum antibiotics is safe for any disease			
			True	False	Don't know	Total
Have you taken an antibiotic on your own after learning about antibiotic resistance?	Yes	Count	20	102	9	131
		% of Total	6.6%	33.8%	3.0%	43.4%
	No	Count	12	148	11	171
		% of Total	4.0%	49.0%	3.6%	56.6%
Total		Count	32	250	20	302
		% of Total	10.6%	82.8%	6.6%	100.0%

In order to investigate the relationship between medical students' responses regarding the necessity of both bacteriological studies and antibiotic sensitivity tests prior to prescribing antibiotics, and their reported discussions of antimicrobial resistance (AMR) during their academic training, we conducted a Chi-square (χ^2) test of independence. This test was employed to determine whether there was a statistically significant association between these two categorical variables.

As illustrated in Figure 4, a majority of the students correctly acknowledged that both bacteriological studies and antibiotic sensitivity tests are essential components in the process of antibiotic prescription. Furthermore, a substantial proportion of students (47%, n = 142) indicated that they had engaged in discussions concerning AMR during their academic coursework.

The Chi-square test results ($\chi^2 = 12.106$, df = 3) revealed a P-value of 0.07, suggesting that there is no statistically significant relationship between students' awareness of the need for bacteriological and antibiotic sensitivity testing and their participation in AMR-related discussions within their university curriculum. This P-value exceeds the conventional threshold of 0.05, thus indicating that the observed association is not significant at the 5% level. (Figure 3).

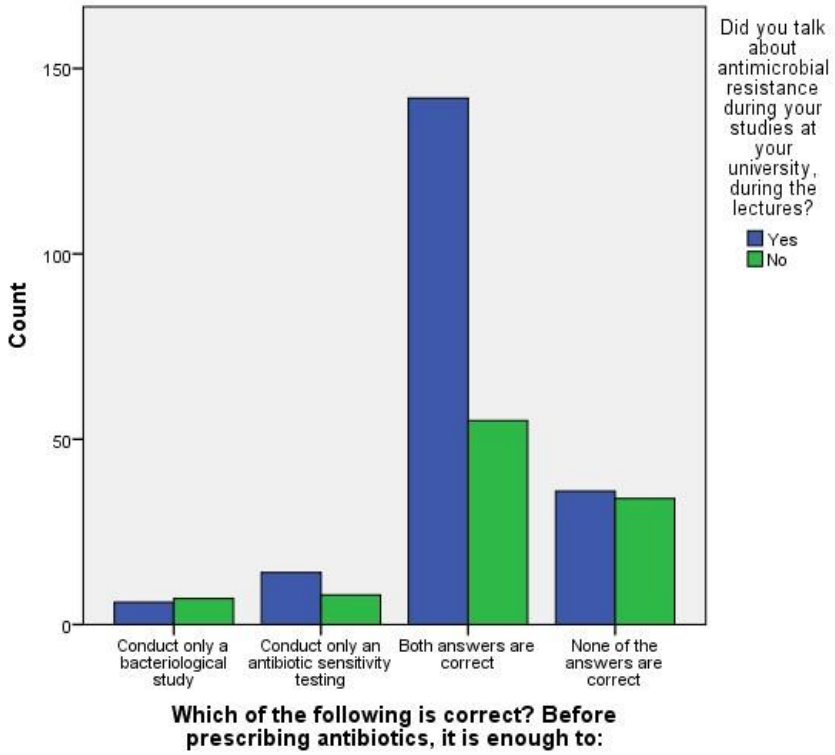

Figure 3: Relationship between good antibiotic prescribing practice and discussion of AMR during university lectures

Discussions:

This study provides valuable insights into the knowledge, attitudes, and behaviors of medical students regarding antimicrobial resistance (AMR). However, the overrepresentation of first-year students and underrepresentation of higher-year students limits the generalizability of the findings, particularly regarding the progression of AMR knowledge. This distribution resulted from voluntary participation and logistical factors rather than a pre-determined stratified sampling approach. To account for this imbalance, students were grouped into two categories based on their level of education: preclinical (first and second years) and clinical (third to sixth years).

While most students demonstrated a strong understanding of AMR, variations in gender differences and misconceptions about antibiotics highlight the need for curriculum improvements. Similar gender-related trends have been observed in other studies.

For instance, a study conducted in Colombia found that women (64.4%) comprised the majority of participants, suggesting that gender-related differences in AMR perceptions and behaviors may warrant further investigation (Salcedo et al., 2022).

Additionally, research from Croatia highlighted disparities in AMR knowledge across medical disciplines, with pharmacy students exhibiting the highest awareness levels, while a notable

percentage of dental and medical students held misconceptions about antibiotics. These findings suggest that tailored educational interventions may be necessary to address discipline-specific and gender-related differences in AMR knowledge (Cikes et al., 2020).

Misconceptions about AMR remain prevalent among medical students in different regions. Our findings align with prior research conducted in Georgia (Phagava et al., 2019), the United Arab Emirates (Jairoun et al., 2019), and Saudi Arabia (Akbar et al., 2021) where a significant proportion of students incorrectly believed that antibiotics could treat viral infections.

Similarly, a study in China (2017-2022) showed that while AMR knowledge improved over time, misunderstandings persisted, particularly regarding transmission pathways and causal agents (Min et al., 2022).

These persistent misconceptions highlight the need for a more comprehensive AMR curriculum with an emphasis on clear differentiation between bacterial and viral infections and the appropriate use of antibiotics.

To improve knowledge retention and address misconceptions, it is essential to integrate interactive learning strategies, case-based discussions, and real-world clinical scenarios into medical education.

We suggest future studies use stratified sampling to ensure better representation across all year groups.

Overall, the study emphasizes the importance of education in shaping AMR-related behaviors, though comprehensive interventions are necessary to drive sustained behavioral change.

Conclusions:

Our study identifies both the strengths and the areas needing improvement in the current medical education on AMR. Although students have a solid knowledge base, some misconceptions remain, and not all students feel sufficiently prepared for clinical decision-making. It is crucial to enhance the medical curriculum to fill these gaps and promote ongoing education about AMR to equip future healthcare professionals with the necessary skills and knowledge to tackle this global health challenge effectively. Further research could investigate the root causes of gender differences in knowledge and determine the most effective educational interventions to correct misconceptions and encourage responsible antibiotic use.

Recommendations:

Based on the findings of our study, we offer the following recommendations to improve medical education on AMR and ensure that future healthcare professionals are well-prepared to combat this global health threat effectively:

Integrate comprehensive modules on AMR into the medical curriculum, emphasizing both theoretical knowledge and practical applications, to address existing misconceptions and ensure that students understand key concepts, such as the ineffectiveness of antibiotics against viral infections, to implement training programs, especially for senior-year students, focused on improving their clinical decision-making skills regarding antibiotic therapy, provide case-based learning opportunities, promote continuous education on AMR beyond the classroom, including workshops, seminars, and online courses to keep students updated on the latest developments in the field, educate students about the dangers of self-medication and the significance of adhering to prescribed antibiotic regimens, incorporate public health perspectives into the medical curriculum to highlight the broader implications of AMR on global health.

Abbreviations:

AMR-Antimicrobial Resistance, DNA-Deoxyribonucleic Acid, HGT-Horizontal Gene Transfer, KAB-Knowledge, Attitudes and Behavior.

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