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Assessment of Medical Students' Knowledge, Attitude, and Practice Regarding Antibiotics and Antimicrobial Resistance: Insights from a Cross-Sectional Study

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Abstract

This research examines the knowledge, attitudes, and practices (KAP) of medical students regarding antibiotics and antimicrobial resistance (AMR), recognizing their pivotal role in addressing this escalating global health issue. Adopting a cross-sectional methodology, the study used an online survey tool to capture a wide range of perspectives related to antibiotics and AMR. Data collection spanned from January through April 2023, yielding 340 completed questionnaires, which were subjected to comprehensive statistical evaluation. The analysis revealed significant deficiencies in the KAP levels among participants, reflecting patterns observed internationally. Among the concerning findings were widespread misunderstandings—such as the erroneous notion that routine antibiotic use is harmless and the incorrect belief that adherence to prescriptions completely prevents antimicrobial resistance. Furthermore, it was found that a significant proportion of respondents sourced antibiotics through informal and unauthorized means, including friends and family members. These findings underscore the pressing need for a transformative update to current medical curricula, emphasizing both the biological principles and the responsible application of antibiotics. This study highlights the urgent responsibility of academic institutions, decision-makers, and public health authorities to jointly fortify the preparedness of future healthcare professionals in combating the AMR threat.

Keywords: Practice, Antibiotics, Medical students, Antimicrobial resistance, Knowledge, Attitude

Introduction

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Antimicrobial resistance (AMR) has emerged as one of the most pressing public health threats of the 21st century, characterized by an alarming acceleration in resistance trends across the globe [1]. The mid-20th century introduction of antibiotics marked a transformative moment in medicine, dramatically enhancing survival rates and revolutionizing treatment protocols [2]. However, the misuse and overprescription of these vital agents have fueled a crisis where many

microbial pathogens now exhibit resistance, rendering formerly effective antibiotics powerless [3].

In response, the World Health Organization is actively formulating a comprehensive Global Action Plan to combat AMR and address its rapidly expanding impact [4]. The evolution and transmission of resistant organisms have compounded treatment challenges, especially within lower-income regions, where the burden of severe infections and mortality continues to rise [5–7]. These outcomes not only strain healthcare systems but also place significant economic stress on resource-limited countries [8].

The worldwide spread of AMR continues to escalate, with resistant bacterial strains being detected in every geographic region. Compounding the issue is the increase in healthcare-associated infections, which flourish in clinical environments due to the routine necessity of antibiotic administration [9]. Such settings serve as hotspots for resistant organisms, fostering their proliferation and creating severe risks to medical progress. If left unchecked, these developments threaten to undermine decades of advancements in infection control and therapeutic innovation [10].

Recognizing the gravity of the AMR threat, research strongly advocates for systematic interventions such as antimicrobial stewardship programs. These initiatives are structured to optimize antibiotic use, enhance patient care, prevent the emergence of resistance, and curtail the transmission of multidrug-resistant pathogens. Yet, recent investigations have revealed considerable deficiencies in the knowledge, attitude, and practice among both medical and dental students concerning responsible antibiotic use [11]. As a result, academic stakeholders are encouraged to integrate focused antimicrobial stewardship training into health education curricula.

Given their central role as antibiotic prescribers, medical professionals—including both practicing clinicians and students—are at the forefront of AMR management. Their competence and decision-making in antibiotic administration are pivotal to curbing the resistance trend [12]. Understanding the knowledge, attitude, and practice levels in this group becomes even more critical in the context of the ongoing COVID-19 crisis, with emerging variants like Omicron leading to increased hospital admissions and, consequently, greater antibiotic usage [13].

Because AMR is constantly evolving, continuous efforts are needed to reassess and refine strategies that mitigate its spread. This study aims to deliver updated evidence on the current knowledge, attitude, and practice of medical students regarding antibiotics and antimicrobial resistance. As tomorrow's prescribers, their approach to antibiotic use will play a fundamental role in shaping AMR outcomes. The insights gained here are vital for informing future interventions, guiding policy formation, and equipping healthcare educators and professionals with actionable strategies to address this global concern.

Materials and Methods

Study Methodology and Context

To investigate the knowledge, attitude, and practice of medical students concerning antibiotics and antimicrobial resistance (AMR), a cross-sectional approach was adopted. The research was conducted over a four-month window, from January through April 2023, aiming to capture an accurate reflection of current student perspectives and behaviors within the target population.

Participants and Recruitment

The participant pool consisted of undergraduate medical students currently studying at Umm Al-Qura University. A total of 340 individuals responded to the survey. The respondents represented various academic levels and faculties, allowing for broad coverage of the medical student demographic. Participation was entirely voluntary, and efforts were taken to include a wide range of students to enhance the generalizability of the findings.

Survey Instrumentation

The research utilized an online questionnaire, designed and distributed via platforms supported by Google LLC. The survey instrument was specifically developed to assess medical students' knowledge, attitude, and practice concerning antibiotic usage and AMR. The structure of the questionnaire included four core domains:

1. Demographics: Basic data were gathered including participant age, gender, academic institution, and year of study.
2. Knowledge: This component featured 10 targeted questions to measure participants' understanding of antibiotics, antimicrobial resistance, and related concepts.

3. Attitude: Comprising 8 questions, this section aimed to evaluate students' perspectives, beliefs, and mindset toward antibiotic usage.
4. Practice: Through 9 questions, this final segment focused on practical behaviors related to the use and prescription of antibiotics, including decision-making patterns and adherence to medical protocols.

Data Collection Techniques

To maximize reach, the survey link was circulated through multiple channels, such as institutional email lists and student-focused social media groups. These diverse platforms were utilized to ensure inclusive access and to foster participation from a representative sample of medical students. The anonymity of all participants was maintained throughout the process to safeguard confidentiality.

Analytical Framework

The dataset was analyzed using the most recent version of SPSS software. Descriptive metrics such as means, frequencies, and standard deviations were used to summarize demographic trends and the core elements of knowledge, attitude, and practice. Moreover, inferential statistical methods—including ANOVA, correlation testing, and post-hoc comparisons—were employed to examine interrelationships and highlight any statistically significant differences between subgroups.

Ethical Compliance

The research strictly adhered to established ethical standards governing human subject research. Approval was granted by the Bioethics Committee of Umm Al-Qura University (HAPO-02-K-012-2023-05-1604). Participants were provided with a clear explanation of the study's objectives, and the voluntary nature of their involvement was emphasized. Consent was obtained digitally before any data collection.
By integrating ethical rigor with methodical planning and execution, this investigation offers critical insights into how medical students engage with the topics of antibiotics and antimicrobial resistance. The results are expected to inform future educational strategies and policy decisions aimed at strengthening antimicrobial stewardship efforts.

Results and Discussion

In this KAP investigation, data were obtained from a cohort of 340 medical students who completed a structured questionnaire aimed at assessing their awareness regarding antibiotic resistance. The assessment framework was structured around three core components—knowledge, attitude, and practice—each explored concerning the academic year of the participants.
The questionnaire was divided into three targeted sections, comprising 10 items evaluating knowledge, 8 items examining attitude, and 9 items assessing practice behaviors. Before detailed analysis, the internal consistency of the instrument was examined using reliability testing. The Cronbach's alpha coefficient yielded a value of 0.812, which exceeds the acceptable threshold of 0.70, thus confirming the reliability of the measurement tool.
Following the reliability assessment, the analysis proceeded with the computation of descriptive statistics and correlation coefficients for the three major constructs: knowledge, attitude, and practice. These computations were performed within a 95% confidence interval to ensure statistical robustness. The summary of these findings, including the central tendencies and interrelationships among the KAP dimensions, is detailed in **Tables 1** and **2**.

Table 1. Descriptive statistics and 95% confidence intervals of medical students regarding knowledge, attitude, and practice

Dimensions	Mean	Standard deviation	95% Confidence interval	
			Lower bound	Upper bound
Knowledge	3.66	0.61	3.59	3.72
Attitude	2.96	0.67	2.88	3.03
Practice	3.34	0.61	3.28	3.41

Table 2. Correlations between the three measurements

Dimensions	Knowledge	Attitude	Practice
Knowledge	1	0.169 (P < 0.05)	0.448 (P < 0.05)
Attitude	Symmetric	1	0.544 (P < 0.05)
Practice	Symmetric	Symmetric	1

The findings indicate that the average scores for knowledge and practice among medical students hover just above a value of 3, reflecting a response pattern that lies between "neutral" and "agree" on the Likert scale. This implies that while students demonstrate a moderate

grasp and application of appropriate antibiotic behaviors, there is still significant scope for enhancement in both areas. In contrast, the mean attitude score falls below 3, positioning it between "disagree" and "neutral," which reveals a more concerning gap in the students' perceptions and beliefs regarding antibiotic resistance. Consequently, improving attitudes represents a more urgent need.

Correlation analysis yielded comparable insights, showing that the associations between knowledge, attitude, and practice are minimal to weak. Nevertheless, a positive relationship was observed between higher knowledge and improved practice, suggesting that strengthening understanding may lead to better antibiotic-related behaviors. However, the link between knowledge and attitude was found to be particularly weak, indicating that greater awareness about antibiotic resistance does not necessarily translate into stronger opposition to its misuse.

Confidence intervals at the 95% level were established for each of the three variables—knowledge, attitude, and practice—suggesting that their mean values are statistically estimated to fall within a range that lies between "disagree" and "agree." This further underscores the necessity of bolstering all three aspects among medical students to effectively confront the challenges posed by AMR.

To explore how these three domains vary across different academic years, an ANOVA test was conducted at the 0.05 significance level. The results, shown in **Table 3**, were preceded by a test of homogeneity of variances. This test indicated uniform variances for knowledge and attitude, while the practice variable did not meet the homogeneity assumption. As a result, post-hoc analyses were carried out using Duncan's and Games-Howell tests to examine inter-grade differences in knowledge, attitude, and practice scores.

Table 3. The results of ANOVA

Dimensions	P-value for ANOVA	Variance homogeneity test
Knowledge	0.022	0.241
Attitude	0.000	0.328
Practice	0.002	0.008

To identify the specific academic years where medical students exhibit significant differences in knowledge and attitude, Duncan's post-hoc procedure was employed. In contrast, for the variable practice—where variance assumptions were not met—the Games-Howell test was utilized to determine distinctions among grades. A breakdown of the mean scores across different academic levels for knowledge, attitude, and practice is provided in **Table 4**.

Table 4. Post-Hoc test results of mean levels concerning knowledge, attitude, and practice

Knowledge (mean/grade) Duncan test		Attitude mean (mean/grade) Duncan test		Practice (mean/grade) Games-Howell test	
Group-1	Group-2	Group-1	Group-2	Group-1	Group-2
3.45/3	3.65/2 3.7/1 3.77/4	2.62/2	3.03/1 3.06/3 3.13/4	3.18/3 3.27/2 3.35/1	3.57/4

The distribution of mean knowledge, attitude, and practice scores across different academic years among medical students revealed a series of unexpected trends. Notably, students in the 1st, 2nd, and 4th years exhibited higher knowledge scores than those in their 3rd year. This anomaly challenges the assumption that knowledge acquisition follows a linear trajectory and suggests the potential influence of disparities in curriculum design, instructional delivery, or levels of student engagement at various stages. These discrepancies highlight the importance of exploring the educational structures and learning experiences contributing to such irregularities.

In a similar vein, students in their 1st, 3rd, and 4th academic years demonstrated more favorable attitudes than those in the 2nd year, an outcome that defies expectations of progressive improvement in attitude with academic advancement. This irregularity may stem from specific features of the second-year curriculum or learning environment that fail to promote a constructive perspective toward antimicrobial stewardship. Further inquiry into instructional content, pedagogical style, or sociocultural learning contexts is necessary to determine the cause of these differences.

Practice scores, however, followed a more anticipated pattern, with 4th-year students attaining the highest average. This likely reflects increased clinical exposure and hands-on experiences gained during the later years of medical education. Yet, the absence of a similar trend in the domains of knowledge and attitude introduces complexity to the interpretation, raising questions about how different components of antimicrobial education evolve in isolation.

Specifically, while 4th-year students showed the strongest performance in practice scores, the observed variations in knowledge and attitude remain inconsistent. For instance, 1st-year students surpass 2nd-year students in attitude scores, and both 1st and 2nd years outperform 3rd-year students in knowledge, suggesting an erratic developmental pattern that warrants further investigation.

These observations point to a critical need to closely examine how KAP elements shift over time in medical training. A thorough review of curricula, instructional methodologies, evaluation practices, and the educational atmosphere is essential to identify areas needing refinement. The average scores, which fall between "neither agree nor disagree" and "agree," serve as a clear indication that there is substantial room for advancement in all three areas—knowledge, attitude, and practice.

Taken together, the outcomes of this research, aimed at evaluating the KAP regarding AMR and stewardship among medical students, offer important implications for educational policy and curricular reform. Overall, findings suggest that while medical students exhibit moderate levels of KAP concerning antibiotic resistance and antimicrobial stewardship, the attitude component consistently lags behind knowledge and practice. This observation aligns with earlier studies, suggesting that while students are becoming more informed and adjusting their behaviors, corresponding shifts in attitude are comparatively limited.

For instance, Abbo *et al.* [14] reported that although medical students had acquired some level of understanding about AMR, their commitment to antimicrobial stewardship reflected less conviction. This disconnect underscores a gap between factual knowledge and internalized values. Similarly, research by Higuita-Gutiérrez *et al.* [15] conducted in Colombia found that a mere 18.2% of medical students were familiar with the term "antimicrobial stewardship", underscoring the lack of emphasis on this vital subject within medical education frameworks. These results collectively highlight the need for a more structured and comprehensive approach to incorporating AMR education into the medical training continuum.

Our study's findings are consistent with various other investigations that highlight gaps in medical students' knowledge, attitudes, and practices related to antibiotic resistance. For instance, a survey conducted among medical undergraduates in a tertiary care setting showed that while students exhibited moderate levels of knowledge and practice in terms of antibiotic usage, about half held positive views towards it [16]. This inconsistency between knowledge, attitudes, and practices suggests that the gap might be linked to the methods of teaching, where theoretical knowledge doesn't necessarily translate into favorable attitudes or behaviors.

Similarly, research from Charité Universitätsmedizin Berlin and Julius-Maximilians-University Würzburg identified similar issues, with medical students lacking both the necessary knowledge and clinical competence regarding appropriate antibiotic use and AMR prevention [17]. These deficiencies are not merely due to limited awareness, but also point to a lack of practical skills that are critical for clinical practice, underscoring the importance of more experiential learning in AMR education.

Taken together, these studies paint a complex picture. While there has been progress in enhancing awareness and shifting practices, students' attitudes appear to lag. This delay may arise from multiple factors, such as the teaching approach for AMR, societal perceptions of antibiotics, and insufficient real-world exposure to the impacts of antibiotic resistance.

One concerning aspect of our study was the weak correlation between knowledge and attitudes. This suggests that simply increasing awareness of AMR does not necessarily foster a more positive attitude toward antimicrobial stewardship, indicating a disconnect in applying knowledge to attitude and, consequently, to practice. This finding is in line with a survey conducted in East China between 2017 and 2022, where gaps in understanding antimicrobial mechanisms and bacterial transmission were identified, alongside inappropriate behaviors such as excessive and improper use of antibiotics due to overconfidence [18].

Similarly, a study conducted by Nisabwe *et al.* [19] in Rwanda found that although medical students had good knowledge about antibiotics and AMR, a significant percentage (83%) were unfamiliar with the concept of antimicrobial stewardship. This gap echoes our findings, reinforcing the idea that knowledge alone is insufficient without targeted interventions to improve attitudes toward AMR.

Regarding how knowledge, attitude, and practice evolve across medical school years, our study uncovered some interesting trends. While 4th-year students had the highest practice scores, likely due to more extensive clinical exposure, their knowledge and attitude scores did

not show similar improvement. For example, 1st-year students had higher attitude scores than 2nd-year students and 3rd-year students scored lower in terms of knowledge compared to both 1st and 2nd-year students. These fluctuations contradict the typical assumption that with progression through medical school, there should be a steady improvement in KAP.

The findings of our research suggest a need for a thorough re-evaluation of how AMR is taught in medical education. It is crucial to develop strategies that focus not only on increasing knowledge but also on fostering positive attitudes and promoting responsible practices. This could include integrating more hands-on learning experiences, involving students in antimicrobial stewardship initiatives, and encouraging interdisciplinary learning.

Moreover, conducting longitudinal studies that track students throughout their medical education could offer deeper insights into how KAP evolves and what factors influence this development. Exploring students' attitudes and motivations behind their practices through qualitative research could also provide more precise data for targeted interventions.

Ultimately, this study emphasizes that while medical students' knowledge and practice related to AMR and stewardship are moderately acceptable, there is a critical need for a stronger focus on improving their attitudes. The discrepancies in KAP scores across different academic years underscore the need for a comprehensive review and potential overhaul of current educational strategies to ensure more effective antimicrobial stewardship training throughout the medical education journey.

Recommendations

The insights from this study on medical students' knowledge, attitudes, and practices (KAP) towards antibiotic resistance (AMR) and antimicrobial stewardship programs reveal a complex situation that calls for a comprehensive strategy to enhance awareness and understanding of antimicrobial resistance.

An essential first step is to integrate thorough modules focused on AMR and stewardship into the medical curriculum. These modules should not only cover theoretical aspects but also emphasize real-world applications to encourage both positive attitudes and responsible practices. By using interactive methods like workshops, case studies, and practical simulations, students can engage more deeply with the material, thus narrowing the gap between classroom knowledge and its application in clinical settings.

Equally important is the inclusion of hands-on learning opportunities, such as enabling students to participate in antimicrobial stewardship committees or related activities. Direct involvement in these initiatives will allow students to develop a deeper understanding of AMR, instilling a stronger sense of commitment to antimicrobial stewardship. Additionally, fostering interprofessional education—where students from various healthcare disciplines collaborate—can further solidify this knowledge. A team-based approach to combating antibiotic resistance can yield more unified and effective strategies in clinical practice.

Given the study's finding of a weak link between knowledge and attitude, it becomes clear that targeted efforts are needed to directly address students' attitudes. This can be achieved through specific campaigns, seminars, and mentoring programs focused on cultivating positive attitudes toward antimicrobial stewardship. Such initiatives can complement broader curriculum reforms, creating a holistic educational environment that nurtures both knowledge and attitude.

Long-term studies tracking medical students throughout their education are also critical to understanding how KAP evolves. These studies can provide valuable insights into the long-term effects of interventions, helping to tailor future teaching methods to the needs of students at different stages of their training. Innovative strategies like personalized learning plans, peer-led education, and technology-driven platforms could further enhance the learning process and improve student outcomes.

Beyond the medical school setting, public awareness campaigns are also necessary to address misconceptions about antibiotic use. Widespread education efforts can foster a more informed and responsible public, ultimately contributing to the fight against antibiotic resistance. As AMR is a global challenge, international collaboration is key. Partnerships between global health organizations, research institutions, and medical schools can strengthen the collective response to AMR by promoting shared educational efforts and research.

Finally, the successful implementation of these recommendations depends on continuous monitoring and assessment. Regular evaluations, along with feedback and ongoing improvements, will ensure that these strategies remain effective and adaptable to the changing

landscape of AMR. This iterative process will not only maintain the quality of educational programs but also allow them to evolve in response to emerging challenges. In summary, the recommendations outlined here advocate for a comprehensive and interconnected approach to addressing AMR. By tackling knowledge gaps, enhancing attitudes, and refining practices through curriculum development, experiential learning, targeted interventions, and public engagement, medical schools can play a pivotal role in preparing future healthcare professionals to combat antibiotic resistance. Through these collective efforts, we can build a healthier, more resilient society capable of addressing the complex issue of antimicrobial resistance.

Conclusion

The results of this research highlight considerable deficiencies in medical students' knowledge, attitudes, and practices related to antibiotics and antimicrobial resistance (AMR). These findings underscore the necessity for comprehensive revisions to the medical curriculum, focusing on both the theoretical and practical aspects of AMR and antibiotics. As future healthcare professionals will play a crucial role in combating the growing problem of antibiotic resistance, educational reforms are vital to prepare them adequately. Additionally, the study points to the need for broader public awareness campaigns to correct misconceptions about antibiotic usage among the general public.

Limitations

While this study provides valuable insights into the KAP of medical students on AMR and antimicrobial stewardship, it is not without its limitations.

The use of a cross-sectional study design is a notable constraint, as it offers a snapshot of medical students' KAP at one point in time but fails to track changes or trends over a longer period. As such, it does not allow for establishing cause-and-effect relationships between the various variables explored.

Furthermore, the reliance on self-reported data introduces potential biases. Participants' recollections of their behavior may not always be accurate due to recall bias, and social desirability bias could lead them to provide responses they believe are more socially acceptable, skewing the findings.

The research was conducted within a specific geographic and cultural context, which limits the extent to which the results can be generalized to other populations or regions. This geographical limitation should be considered when interpreting the results.

Additionally, the study's response rate and sample size were not optimal. A lower response rate introduces the possibility of non-response bias, where individuals who did not participate may differ significantly from those who did. Furthermore, a larger and more diverse sample would increase the representativeness of the findings and the robustness of the conclusions drawn. Future studies should aim to improve the response rate and ensure a broader and more representative sample to strengthen the reliability of the results.

Despite these limitations, the study makes an important contribution to understanding the KAP of medical students regarding AMR, and its findings can serve as a foundation for future research that addresses these issues with more longitudinal designs, diverse data collection methods, and expanded geographical scopes.

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