The Open Microbiology Journal
DOI: 10.2174/0118742858445561260318065800, 2026, 20, e18742858445561
ISSN: 1874-2858
1

RESEARCH ARTICLE **OPEN ACCESS**

Perspectives of Medical Students at Lorestan University of Medical Sciences on Antibiotic Resistance: Its Causes, Consequences, and Proposed Solutions

Mohammad Javad Yari Firoozabadi[1], Faranak Rezaei[1], Ali Pajouhi[2,3], Parastoo Baharvand[4], Morovvat Taheri Kalani[1], Pegah Shakib[5,*] and Setareh Soroush[1,*]

[1]*Department of Microbiology, School of Medicine, Lorestan University of Medical Sciences, Khorramabad, Iran*
[2]*Student Research Committee, Lorestan University of Medical Sciences, Khorramabad, Iran*
[3]*USERN Office, Lorestan University of Medical Sciences, Khorramabad, Iran*
[4]*School of Medicine, Social Determinants of Health Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran*
[5]*Razi Herbal Medicines Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran*

Abstract:

Introduction: Today, antibiotic resistance has emerged as one of the major public health challenges worldwide. Antibiotic resistance occurs mainly due to the misuse and overuse of antibiotics. This phenomenon reduces the effectiveness of common treatments, increases the duration of illness and the risk of mortality, and imposes high costs on the health system. Since medical students, as future prescribers, play a key role in the rational management of antibiotic use, their awareness and attitudes are of particular importance. Accordingly, the present study examines the views of medical students at Lorestan University of Medical Sciences on the status of antibiotic resistance, its causes, and possible strategies to combat it.

Methods: A cross-sectional survey was conducted in 2020 among 319 medical students at Lorestan University of Medical Sciences. Data were collected using the ReAct–Action on Antibiotic Resistance International Questionnaire, a validated instrument designed to assess perceptions of antibiotic resistance. The questionnaire, consisting of 20 items, was administered online, and the responses were analyzed using SPSS version 22.0.

Results: Students identified three major contributors to antibiotic resistance: the unrestricted use of antibiotics by patients (79%), inappropriate prescribing by physicians (61%), and inadequate diagnostic tools for detecting bacterial infections (59%). To address AMR, the strategies most frequently recommended by students included stricter regulations on antibiotic sales, strengthening public healthcare services, and improving diagnostic technologies. Responsibility for combating antimicrobial resistance (AMR) was primarily attributed to physicians, pharmacists, and international organizations such as the World Health Organization (WHO). Additionally, 36% of students believed that AMR would affect their future medical careers, while 71% expressed concern about the lack of sufficient research efforts to develop new antibiotics. Moreover, 46% reported a willingness to engage with an online platform dedicated to AMR education.

Discussion: The findings suggest that although medical students recognize the seriousness of antibiotic resistance, notable gaps remain in their formal education and practical training. Factors such as self-medication, inappropriate prescribing practices, and limited access to effective diagnostic tools were identified as key contributors. These observations underscore the need for curriculum reform, focused workshops, and research-oriented learning to enhance students' roles in antibiotic stewardship and to promote the rational use of antibiotics.

Conclusion: The results highlight an urgent need for policy reforms aimed at regulating antibiotic use, improving diagnostic capacity, and fostering a culture of responsible antibiotic consumption in society. These measures, supported by ongoing educational initiatives, are essential for mitigating the growing threat of antibiotic resistance, as reflected in the perspectives of the student cohort.

Keywords: Medical students, Perceptions, Antimicrobial resistance, Lorestan university of medical sciences, Potential solutions, Knowledge.

*Address correspondence to these author at the Department of Microbiology, School of Medicine, Lorestan University of Medical Sciences, Khorramabad, Iran and Razi Herbal Medicines Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran; E-mails: soroush_setareh@yahoo.com and Shakib.pegah@yahoo.com

Cite as: Firoozabadi M, Rezaei F, Pajouhi A, Baharvand P, Kalani M, Shakib P, Soroush S. Perspectives of Medical Students at Lorestan University of Medical Sciences on Antibiotic Resistance: Its Causes, Consequences, and Proposed Solutions. Open Microbiol J, 2026; 20: e18742858445561. http://dx.doi.org/10.2174/0118742858445561260318065800

Received: September 07, 2025
Revised: November 25, 2025
Accepted: December 09, 2025
Published: March 26, 2026

1. INTRODUCTION

The discovery and introduction of antibiotics in the 1940s revolutionized the treatment of infectious diseases, transforming previously fatal conditions into manageable infections and fundamentally altering the landscape of modern medicine [1, 2]. Antibiotics not only remain essential for treating bacterial infections but also serve as critical adjuncts in a wide range of medical interventions, particularly for immunocompromised populations such as cancer patients undergoing chemotherapy, premature infants, and individuals with HIV/AIDS [3, 4]. However, the misuse and overuse of antibiotics in recent decades have accelerated the rapid emergence of antibiotic-resistant bacteria, threatening the efficacy of once-reliable treatments. This growing resistance has resulted in increased treatment failure rates, prolonged hospital stays, secondary infections, higher mortality, and substantial economic burdens on healthcare systems worldwide [5, 6].

Antibiotic resistance (AR) is now recognized as a global health crisis, undermining the very foundation of modern medical care. The persistence of untreatable infections due to antibiotic resistance poses an urgent threat that transcends geographical and economic boundaries [7, 8]. In light of this, addressing AR has become a priority for healthcare providers, policymakers, and global health organizations. While the development of new antibiotic classes is crucial, it is equally important to implement strategies aimed at preserving the efficacy of existing antibiotics. Research has consistently demonstrated a direct correlation between antibiotic use and resistance levels, indicating that reducing unnecessary antibiotic prescriptions can slow the development of resistance [9, 10].

Medical professionals, particularly physicians, are on the frontline of this battle. However, ingrained prescribing habits can be difficult to change, highlighting the need for a proactive approach to educating future doctors about antibiotic stewardship. Medical students, as future healthcare providers, are vital stakeholders in combating AR. Their understanding of the causes and consequences of antibiotic misuse, along with their commitment to responsible prescribing, will play a pivotal role in shaping the trajectory of this global issue [11]. Studies from the UK and other regions have shown that targeted educational interventions for medical students can significantly improve prescribing behaviors and reduce unnecessary antibiotic use [12].

Despite formal training, evidence suggests that many medical students and early-career physicians still lack sufficient knowledge about appropriate antibiotic use and the mechanisms underlying antibiotic resistance [13]. Compounding this issue, some students rely heavily on outdated information from senior colleagues, emphasizing the need for an updated and comprehensive medical curriculum [14]. To better understand these educational gaps and develop effective solutions, this study aims to evaluate the knowledge and perceptions of medical students at Lorestan University of Medical Sciences regarding antibiotic resistance, its causes, and potential strategies for mitigating this growing public health threat.

2. MATERIALS AND METHODS

2.1. Type of Study and Sample Size

This study employed a descriptive, cross-sectional design aimed at exploring the perceptions of medical students regarding antibiotic resistance at Lorestan University of Medical Sciences during the 2020 academic year.

The target population consisted of all enrolled medical students during the study period. First, the students were given an explanation about the purpose of the research, and those who were willing to participate received a link to the questionnaire.

A stratified sampling technique proportional to class size was used to ensure adequate representation of different academic levels. Each academic year was treated as a distinct stratum, with further subdivision by gender. Systematic sampling was then conducted within each subclass based on student identification numbers.

The sample size was calculated using Cochran's formula: $n = (Z^2\ pq) / e^2$, where $Z = 1.96$, $p = 0.50$, and $e = 0.08$. This yielded an initial sample size of approximately 151 participants. To account for the design effect, the sample size was doubled, resulting in a final target of 302 students. Ultimately, a total of 319 students participated in the study.

2.2. Data Collection

Data were collected using the ReAct-Action International Questionnaire, a validated instrument designed to assess perceptions of antibiotic resistance. The

questionnaire, which was administered online, consisted of four sections comprising a total of 20 questions [15]:

[1] Section I: Collected demographic and background information about the participants.
[2] Section II: Assessed students' perceptions of the current state of antibiotic resistance in Iran.
[3] Section III: Focused on students' views regarding the future of antibiotic resistance and potential solutions.
[4] Section IV: Explored students' engagement and participation in antibiotic stewardship efforts, including their willingness to engage with educational programs and the preferred methods for reaching this cohort.

2.3. Data Analysis

The collected data were analyzed using descriptive statistical methods, with frequency distributions calculated for categorical variables. Statistical differences between groups were assessed at a 95% confidence level, using the normal approximation method for binomial proportions where applicable. Only responses from current medical students were included in the analysis, whereas those from graduate and pre-medical students were excluded.

3. RESULTS

According to the results obtained from the total number of students participating in this study, 51.4% were women and 48.6% were men. Among the 319 participants, 50 students (15.6%) were in the Basic Sciences phase, 67 (21.0%) in the Physiopathology phase, 71 (22.2%) in the Stajer phase, 95 (29.7%) in the Internship phase, and 36 (11.2%) in the Residency phase. Overall, 21.0% of the students had participated in a meeting or workshop related to antibiotic resistance, while 79% had not. The opinions of medical students regarding the status of antibiotic resistance are presented in Tables **1**-**4**.

Table 1. Demographics and background.

Classification	Question	Option	N (%)
I	Please write your age	-	-
I	What is your gender?	Man	155(48.50%)
		Woman	164(51.40%)
I	What medical step are you studying?	Basic science	50(15.60%)
		Physiopathology	67(21%)
		Intern	95(29.70%)
		Stagiaire	71(22.20%)
		Resident	36(11.20%)
I	Apart from taking the microbiology class, have you attended a course or workshop on antibiotic resistance?	Yes	67(21%)
		No	252(78.90%)

Table 2. Perceptions of the current state of antibiotic resistance in Iran.

Classification	Question	Option	N (%)
II	Do you think Iran is facing the antibiotic resistance problem right now?	Not at all	20(6.20%)
		It is a minor problem	43(13.40%)
		It is a moderate problem	161(50.40%)
		It is a big problem	95(29.70%)
II	If you believe that Iran is facing the problem of antibiotic resistance (minor/moderate/large), where do you think is the main source of the spread of antibiotic resistance?	Hospitals	58(18.10%)
		Patients' samples	64(20%)
		Both are important	140(43.80%)
		I don't know	44(13.70%)
		I thought there was no problem	13(4%)
II	Do you think antibiotic resistance is currently of interest in Iran? Which group is interested? (check all the items you want)	Not at all	18(5.60%)
		Universities	220(68.90%)
		Hospitals	205(64.20%)
		Public media	126(39.40%)
		Healthcare policymakers	113(35.40%)
		the people	110(34.40%)
		I don't know	18(5.60%)

(Table 2) contd.....

Classification	Question	Option	N (%)
II	In your opinion, what are the 3 main reasons for the growth of antibiotic resistance in Iran? (choose 3 options)	Improper prescription of antibiotics by doctors (use of antibiotics for non-bacterial reasons; use of broad-spectrum antibiotics, *etc.*)	195(61.10%)
		Lack of effective diagnostic tools to diagnose bacterial infections	187(58.60%)
		Increased international spread of bacteria due to increased global travel	121(37.90%)
		Patients who treat themselves with antibiotics without consulting or being prescribed by a doctor	253(79.30%)
		Use of antibiotics in food production	114(35.70%)
		Due to improper hygiene practices and the spread of bacteria in sanitary environments	82(25.70%)
		I don't know	5(1.50%)
II	Do you think the economic status of the people affects the spread of antibiotic resistance in Iran?	No	23(7.20%)
		It doesn't matter	52(16.30%)
		Yes, the most serious consequences of antibiotic resistance occur in underprivileged populations	94(29.40%)
		Yes, the most serious consequences of antibiotic resistance are seen in more affluent populations	123(38.50%)
		I don't know	27(8.40%)
II	Is it possible to buy antibiotics without a prescription in Iran?	Yes	189(59.20%)
		No	90(28.20%)
		I don't know	40(12.50%)

Table 3. Future of antibiotic resistance and potential solutions.

Classification	Question	Option	N (%)
III	Do you think that in the next 10 years, the consequences of antibiotic resistance in the treatment of patients with bacterial infections will affect your career as a doctor?	Not at all	19(5.90%)
		Rarely (because less than 5% of patients have bacterial diseases)	50(15.60%)
		Sometimes (because 5-10% of patients have bacterial diseases)	77(24.10%)
		Often (because 11-40% of patients have bacterial diseases)	116(36.30%)
		High (because more than 41% of patients have bacterial diseases)	57(17.80%)
III	If you think antibiotic resistance will affect your work, what do you expect to be the biggest problem?	More expensive treatment for patients	31(9.70%)
		Fewer treatment options	66(20.60%)
		Increased complications due to incurable bacterial infections	75(23.50%)
		The spread of infectious diseases due to incurable infections	99(31%)
		I don't know	36(11.20%)
		I thought it had no effect	12(3.70%)
III	In your opinion, what are the 3 important factors to reduce the growth of antibiotic resistance in Iran? (choose 3 options)	Creating new antibiotics	50(15.60%)
		Improvement of bacteria detection techniques	172(53.90%)
		Improved laws restricting the sale and purchase of antibiotics without a prescription	235(73.60%)
		Increasing the level of community health and treatment	174(54.50%)
		Preventing the spread of bacterial diseases (*e.g.*, vaccines, sanitation, *etc.*)	140(43.80%)
		Reducing the excessive use of antibiotics by changing the attitude of doctors and patients	178(55.70%)
		I don't know	8(2.50%)
III	Do you believe today's research will be sufficient to meet future needs for new antibiotics?	Yes	56(17.50%)
		No	228(71.40%)
		I don't know	35(10.90%)

(Table 3) contd.....

Classification	Question	Option	N (%)
III	In your opinion, who should be responsible for reducing the growth of antibiotic resistance? (choose 3 of the most important options)	the government	41(12.80%)
		The media	89(27.80%)
		World Health Organization	120(37.60%)
		Doctors	230(72.10%)
		Pharmacists	156(48.90%)
		Pharmaceutical industry	91(28.50%)
		Medical students	133(41.60%)
		People/patients	97(30.40%)
III	Where do you think you, as a new doctor, will get most of your knowledge about the correct use of antibiotics?	The medical education you received at the university	138(43.20%)
		Standard instructions available	45(14.10%)
		senior colleagues	60(18.80%)
		Laboratory reports on current bacterial resistance patterns	56(17.50%)
		Pharmaceutical companies	20(6.20%)

Table 4. Engagement and participation in antibiotic stewardship efforts.

Classification	Question	Option	N (%)
IV	Do you think students can play a role in what is being done to control antibiotic resistance?	Not at all	18(5.60%)
		Marginally	78(24.40%)
		Maybe if we are better trained	158(49.50%)
		Yes, we can help	65(20.30%)
IV	How would you like to get information/learn about antibiotic resistance and the rational use of antibiotics? (Please tick your top 3 options)	through the medical education system	204(63.90%)
		Information available on the Internet	109(34.10%)
		Online courses on the appropriate use of antibiotics	232(72.70%)
		Training for hospital staff in each hospital	221(69.20%)
		National guidelines	167(52.30%)
		Senior colleagues	24(7.50%)
IV	If you had access to an Internet-based educational program on antibiotic resistance, would you be interested in using it?	I am not interested	33(10.30%)
		Somewhat	109(34.10%)
		Yes	146(45.70%)
		I am very interested	31(9.70%)
IV	What programs would you like to see in web tutorials (please indicate your top 3 choices)	Access to information and articles on antibiotic resistance	154(48.20%)
		Access to a web-based self-test course on antibiotic resistance	139(43.50%)
		Information on worldwide meetings on antibiotic resistance and their outcome	179(56.10%)
		Ability to upload information about personal antibiotic resistance projects	157(49.20%)
		A newsletter on common antibiotic resistance	167(52.30%)
		Information about international projects that students can work on	121(37.90%)
		Information about doctors and other researchers in this field, so that they can be contacted	40(12.50%)

4. DISCUSSION

This study provides a comprehensive insight into the perspectives of medical students at Lorestan University of Medical Sciences on antibiotic resistance-a growing global health threat. The findings indicate that although students are largely aware of the importance of this issue, significant gaps remain in formal education and practical experience. Only 21% had attended relevant workshops or courses, and many expressed concerns about the easy availability of antibiotics without a prescription. Participants identified several factors contributing to the spread of drug resistance, including self-medication, inappropriate prescribing by physicians, and the lack of adequate diagnostic tools, underscoring the need for educational, structural, and policy interventions. Notably, students recognized their role in combating drug resistance, demonstrating a readiness for active participation. These findings highlight a critical opportunity to leverage students' awareness and motivation to strengthen antibiotic stewardship programs in Iran.

While our study findings indicated that physicians (72.1%) and pharmacists (48.9%) were identified as the primary agents responsible for controlling antibiotic resistance, it is also important to consider students' perspectives on their own roles as future physicians. Interestingly, 41.6% of participants acknowledged their personal responsibility in controlling drug resistance, reflecting an emerging sense of professional awareness. This finding suggests that students recognize that their future prescribing practices will directly influence drug resistance patterns. Incorporating targeted educational interventions-such as clinical case-based learning, medication management workshops, and clinical simulations-can enhance students' understanding of their professional responsibilities and better prepare them to play an active role in combating antibiotic resistance.

The findings of the study showed that 71% of students expressed concern about the inadequacy of research on antibiotic resistance, reflecting their growing awareness of global health challenges. This concern aligns with global trends; international research indicates that the development of new antibiotics has slowed over the past two decades due to high production costs, limited financial incentives, and regulatory challenges, while the threat of drug resistance continues to increase. Students' awareness of this gap demonstrates a strong understanding of the importance of the issue and the need for scientific and educational action.

This concern can serve as a valuable incentive for student-led research and educational activities. Universities can encourage students to participate in small research projects, community awareness campaigns, and specialized scientific associations in the field of antibiotic stewardship. Additionally, incorporating research-based learning components into educational programs-such as optional research units or scientific mentoring programs-can enhance students' scientific literacy, critical thinking, and professional responsibility in addressing antibiotic resistance at both national and global levels. Thus, these findings not only reflect students' attitudes but also provide a basis for strengthening their active role in research, education, and community awareness in tackling the global challenge of antibiotic resistance.

Only about 54% of participants believed that antibiotic resistance would have a direct impact on their future careers, while the majority (46%) did not feel that it would. This difference likely reflects a limited understanding of drug resistance in everyday clinical challenges. Many students are still in the preclinical or early clinical stages of training and have not experienced treatment failure, prolonged patient stays, or limited drug options. Also, the current curriculum may not sufficiently emphasize the professional and economic dimensions of drug resistance in the healthcare system. Comparable international evidence supports this: for example, a Nigerian study found only about 40% of medical students had a positive perception of antibiotic resistance despite high self-rated knowledge [16]. Similarly, in a multi-country East African survey, only around one-third of final-year medical and pharmacy students achieved 'good' knowledge scores on antibiotic use and resistance [17]. Another Africa-wide study comparing South Africa and Nigeria also revealed substantial variation in knowledge and pointed to curriculum gaps [18]. This finding highlights the need for more context-based and clinical training (such as discussions of real patient cases and concrete examples of drug resistance complications) to help students better understand the connection between drug resistance and their future careers.

Currently, training related to antibiotic resistance at Lorestan University of Medical Sciences is provided in a scattered and limited manner, mainly through microbiology and pharmacology courses in the basic sciences curriculum and during parts of internships in internal medicine and infectious diseases. However, there is no dedicated unit or curriculum to systematically familiarize students with the concepts of antimicrobial stewardship and the public health aspects of drug resistance. The findings of the present study, especially the low rate of student participation in related workshops (21%) and their limited understanding of national policies to combat antibiotic resistance, indicate a serious need to review the educational content.

It seems that adding a dedicated unit or module on antimicrobial resistance and the rational use of antibiotics, holding interdisciplinary workshops involving medical, pharmacy, and nursing students, as well as using modern blended learning methods (online and clinical), which were also favoured by most participants in this study, could help improve the knowledge, attitudes, and behaviour of future physicians in this field. Such reforms could pave the way for training more informed and responsible physicians in the face of the global challenge of antibiotic resistance.

The results of this study were somewhat consistent with those of Sannathimmappa *et al*. in South Africa [13]. In the 2017 study by Sannathimmappa *et al*., the mean age of the students was 24 years, and 63% were female. Ninety-two percent of the students agreed that antibiotics are overused in South Africa, and 87% agreed that antibiotic resistance is a significant problem [13].

In the study by Alex IO *et al*. [19], conducted in Nigeria, respondents were predominantly male (62.5%) and in the age range of 20–29 years (68.9%), of whom 60.9% were in their final year. One hundred nineteen (64.7%) of the respondents had good knowledge about antibiotic use and antibiotic resistance; however, 39% incorrectly answered that bacteria cause colds. One hundred three (56%) of them had a history of antibiotic use, while 8.2% of respondents always consulted a doctor before starting antibiotics.

In this study, 51.4% of the 319 participating students were female and 48.5% were male. Of the 319 participating students, 50 (15.6%) were undergraduates, 67 (21%) were pathophysiology students, 71 (22.2%) were interns, 95 (29.7%) were clinical interns, and 36 (11.2%) were in residency.

In the study by Sannathimmappa *et al*., 38% were neutral or disagreed with the statement that poor hand hygiene by healthcare workers contributes to the spread of resistant bacteria [13]. In this study, 20% believed that the problem of antibiotic resistance was caused by the initial sample of patients, 18% believed that the problem was caused by hospitals, 44% believed that both were important, 14% indicated that they "did not know" the origin of antibiotic resistance, and 4% said that there was no problem.

In the study by Sannathimmappa *et al*., almost all students believed that good knowledge about antibiotics was important for physicians (287/289) and that inappropriate use of antibiotics contributed to resistance (283/289) [13].

In the Sannathimmappa*et al*. study, 63% of students rated their overall education on antibiotic use as helpful or very helpful. Most students reported wanting more education on appropriate antibiotic use (95%) and ABR in general (90%). In terms of curriculum, 91% of students attended a formal lecture on how to diagnose an infection, 79% on when to start antibiotics, 82% on when to take antibiotics, and 70% on when to use intrauterine antibiotics. They remembered intravenous injections as well as 89% of the basic principles of infection prevention and control. The most common sources for learning about antibiotic prescribing and antibiotic resistance were consultants (83%), registrars (85%), medical textbooks (87%), and using a tablet or smartphone (77%). Forty-seven percent of students reported learning from infectious disease physicians, and 30% from microbiologists. Less than one-third (32%) of students used medical journals as a source of learning. There was no statistically significant relationship between knowledge scores and sources used for learning [13]. In our study, 21% had attended a meeting or workshop related to antibiotic resistance, and 79% had not. Also, in this study, 138 medical students cited 45 existing standard guidelines, 60 from senior colleagues, 56 from laboratory reports on current bacterial resistance patterns, and 20 from pharmaceutical companies as the most important sources of knowledge for the appropriate use of antibiotics. Furthermore, according to the findings of this study, 204 cases were obtained through the medical education system, 109 cases through information available on the Internet, 232 cases through online courses on the correct use of antibiotics, and 221 cases through training for hospital staff in each hospital, 167 cases preferred to obtain information/training through national guidelines, and 24 cases through senior colleagues.

In a 2018 study by Dyar *et al*., it was shown that 37.3% of students wanted more education on the prudent use of antibiotics, and 26.8% wanted more education on both the prudent use of antibiotics and the general use of antibiotics. Thirty-one point two percent felt that they did not need more education, and 4.5% were unsure [20]. According to other reports, there is wide variation in students' views on additional education regarding antibiotic resistance awareness around the world; for example, the proportion of students who wanted more education ranged from 20.3% in Sweden to 94.3% in Slovakia, with an average of 66% across countries [21].

In the present study, 204 students preferred to receive information or training through the medical education system, 109 through information available on the Internet, 232 through online courses on appropriate antibiotic use, 221 through hospital staff training in each hospital, 167 through national guidelines, and 24 through senior colleagues.

In the study by Sikkens *et al*., 71 students were in the intervention group and 285 in the control group. The participation rate in e-learning in the intervention group was 81%. The pass rate on the OSCE test was 86% in the control group, while this figure was 97% in the intervention group. The overall OSCE, knowledge, and Darwin selection scores were significantly higher in the intervention group [22].

In a study by Alshehri *et al*., examining the knowledge, awareness, and perceptions of antibiotic use, antibiotic resistance, and antibiotic stewardship among final-year medical and pharmacy students in Saudi Arabia, it was found that 44.7%, 47.7%, and 52.8%, respectively, had good knowledge about antibiotic use, antibiotic resistance, and antibiotic stewardship. Pharmacy students, however, showed higher knowledge about antibiotic stewardship and the proper use of antibiotics compared to medical students. In addition, the need for targeted educational strategies, standardized curricula, and advanced training was highlighted to further prepare future healthcare professionals to effectively combat antibiotic resistance [23].

This study aims to investigate the attitudes and knowledge of medical students at Lorestan University of Medical Sciences regarding antibiotic resistance, providing a comprehensive picture of their awareness, behaviour, and the educational resources available in this field. Findings indicate that although the general understanding of the risks of resistance is relatively high, gaps remain in formal education, learning resources, and enforcement of relevant laws, which affect students' attitudes and performance. The high proportion of students in clinical settings, along with their willingness to learn through online courses, hospital training, and formal university education, indicates readiness to engage with structured educational programs. Furthermore, students have correctly identified the factors contributing to the spread of resistance, but the low involvement of policy-makers and the general public in controlling this crisis points to systematic weaknesses that need to be addressed through educational, cultural, and legal interventions. Comparisons with other studies also suggest that the challenge of awareness and education regarding antibiotic resistance is a global phenomenon, requiring the alignment of educational strategies, particularly within medical curricula.

Although a cross-sectional design is suitable for examining student attitudes, it has inherent limitations.

First, it is not possible to infer causal relationships from the data collected. Second, the study relies on self-reported data, which may be affected by recall bias or the tendency to provide socially desirable responses, potentially reducing the accuracy of the results. Finally, conducting the study at a single centre further limits generalizability. Future research could employ longitudinal or multi-centre designs to better examine changes in students' knowledge, attitudes, and behaviours over time and provide stronger evidence to support targeted interventions.

5. STUDY LIMITATIONS

This study was conducted at a single university (Lorestan University of Medical Sciences); therefore, the generalizability of the results to other universities and regions of the country is limited. The findings reflect the attitudes and knowledge of students in a specific educational and cultural context and may not fully represent the views of students at other medical universities in Iran or abroad. However, this limitation could provide an opportunity for conducting multicentred comparative studies across different universities and regions to determine whether similar patterns of awareness, attitudes, and educational needs regarding antibiotic resistance exist among other students. Such studies could offer a more comprehensive understanding of the status of antibiotic resistance education at the national level.

CONCLUSION

The findings of this study indicate that medical students are generally aware of the growing challenge of antibiotic resistance and have identified several areas requiring further attention. However, these results should be interpreted within the context of a study based on students' perspectives and cannot, by themselves, serve as the sole basis for broad policy reforms. From the participants' perspective, key areas for improvement include strengthening education, enhancing diagnostic capabilities, increasing public awareness, and reviewing regulations governing the sale of antibiotics. Nonetheless, more extensive research involving physicians, pharmacists, and policymakers is necessary to validate and prioritize these actions. The results also underscore the importance of promoting antibiotic resistance education within medical curricula. Implementing structured educational programs-such as workshops, online courses, and the provision of up-to-date clinical guidelines-can enhance students' preparedness for the rational use of antibiotics. Furthermore, multicentre studies across multiple universities would provide a more comprehensive understanding of educational gaps and support evidence-based strategies to address antimicrobial resistance effectively.

AUTHORS' CONTRIBUTIONS

The authors confirm their contribution to the paper as follows: S.S.: Study conception and design; M.J.Y.F., F.R.: Data collection; A.P., P.B.: Analysis and interpretation of results; M.T.K.: Methodology; P.S.: Writing - reviewing and editing. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

AMR	=	Antimicrobial Resistance
WHO	=	World Health Organization
AR	=	Antibiotic Resistance

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Research Ethics Committee of Lorestan University of Medical Sciences (ethics approval code: IR.LUMS.REC.1399.343).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Written informed consent was obtained from the participants.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article.

FUNDING

None.

CONFLICT OF INTEREST

Morovvat Taheri Kalani is a member of the Editorial Advisory Board of TOMICROJ.

ACKNOWLEDGEMENTS

The authors express their gratitude to the Research Vice-Chancellor of Lorestan University of Medical Sciences.

REFERENCES

[1] Muteeb G, Rehman MT, Shahwan M, Aatif M. Origin of antibiotics and antibiotic resistance, and their impacts on drug development: A narrative review. Pharmaceuticals 2023; 16(11): 1615. http://dx.doi.org/10.3390/ph16111615 PMID: 38004480

[2] Landecker H. Antimicrobials before antibiotics: War, peace, and disinfectants. Palgrave Commun 2019; 5(1): 45. http://dx.doi.org/10.1057/s41599-019-0251-8

[3] Chen CH, Chen YM, Chang YJ, Wang SH, Chang CY, Yen HC. Continuous *versus* intermittent infusions of antibiotics for the treatment of infectious diseases. Medicine 2019; 98(10): e14632. http://dx.doi.org/10.1097/MD.0000000000014632 PMID: 30855448

[4] Sadeghi F, Rajabi E, Ghanbari Z, *et al*. Antimicrobial resistance in immunocompromised outpatients: A narrative review of current

evidence and challenges. Pharmacoepidemiology 2025; 4(4): 21. http://dx.doi.org/10.3390/pharma4040021

[5] Rudrapal M, Estrada-Garcia T. Editorial: Perspectives in clinical microbiology for combating multi-drug resistant bacterial infections: 2024/2025. Front Cell Infect Microbiol 2026; 16: 1783280. http://dx.doi.org/10.3389/fcimb.2026.1783280 PMID: 41660431

[6] Pipitò L, Bono E, Mazzola CV, *et al*. Outcome of bloodstream infections caused by antibiotic-resistant bacteria: A 7-year retrospective study at the University Hospital of Palermo, Italy. Antibiotics 2025; 14(5): 464. http://dx.doi.org/10.3390/antibiotics14050464 PMID: 40426531

[7] Bengtsson B, Greko C. Antibiotic resistance - Consequences for animal health, welfare, and food production. Ups J Med Sci 2014; 119(2): 96-102. http://dx.doi.org/10.3109/03009734.2014.901445 PMID: 24678738

[8] Chandy SJ, Naik GS, Balaji V, Jeyaseelan V, Thomas K, Lundborg CS. High cost burden and health consequences of antibiotic resistance: The price to pay. J Infect Dev Ctries 2014; 8(9): 1096-102. http://dx.doi.org/10.3855/jidc.4745 PMID: 25212073

[9] Naghavi M, Vollset SE, Ikuta KS, *et al*. Global burden of bacterial antimicrobial resistance 1990–2021: A systematic analysis with forecasts to 2050. Lancet 2024; 404(10459): 1199-226. http://dx.doi.org/10.1016/S0140-6736(24)01867-1 PMID: 39299261

[10] Zay Ya K, Win PTN, Bielicki J, Lambiris M, Fink G. Association between antimicrobial stewardship programs and antibiotic use globally: A systematic review and meta-analysis. JAMA Netw Open 2023; 6(2): e2253806. http://dx.doi.org/10.1001/jamanetworkopen.2022.53806 PMID: 36757700

[11] Golding SE, Higgins HM, Ogden J. Assessing knowledge, beliefs, and behaviors around antibiotic usage and antibiotic resistance among UK veterinary students: A multi-site, cross-sectional survey. Antibiotics 2022; 11(2): 256. http://dx.doi.org/10.3390/antibiotics11020256 PMID: 35203857

[12] Haque M, Rahman NIA, Zulkifli Z, Ismail S. Antibiotic prescribing and resistance: Knowledge level of medical students of clinical years of University Sultan Zainal Abidin, Malaysia. Ther Clin Risk Manag 2016; 12: 413-26. http://dx.doi.org/10.2147/TCRM.S102013 PMID: 27042083

[13] Sannathimmappa MB, Nambiar V, Aravindakshan R. A cross-sectional study to evaluate the knowledge and attitude of medical students concerning antibiotic usage and antimicrobial resistance. Int J Acad Med 2021; 7(2): 113-9. http://dx.doi.org/10.4103/IJAM.IJAM_57_20

[14] Wilson BA, Ho BT. Revenge of the Microbes: How Bacterial Resistance is Undermining the Antibiotic Miracle. John Wiley & Sons 2023.

[15] Irwin J, Knight J. Developing an understanding of why students do not engage. J Educ Innov Partnersh Change 2017; 3(1): 198-203.

[16] Okedo-Alex I, Madubueze U, Umeokonkwo C, Akamike I. Medical students' perceptions regarding antibiotics use and antimicrobial resistance in Ebonyi State, Nigeria. Niger J Med 2019; 28(1): 73-9. http://dx.doi.org/10.4103/1115-2613.278619

[17] Archer A, Blom M, de Lange R, *et al*. The knowledge and perceptions regarding antibiotic stewardship of the interns rotating at the Bloemfontein Academic Complex. S Afr Fam Pract 2021; 63(1): e1-6. http://dx.doi.org/10.4102/safp.v63i1.5336 PMID: 34797090

[18] Lubwama M, Onyuka J, Ayazika KT, *et al*. Knowledge, attitudes, and perceptions about antibiotic use and antimicrobial resistance among final year undergraduate medical and pharmacy students at three universities in East Africa. PLoS One 2021; 16(5): e0251301. http://dx.doi.org/10.1371/journal.pone.0251301 PMID: 33961678

[19] Okedo-Alex I, Madubueze UC, Umeokonkwo CD, Oka OU, Adeke AS, Okeke KC. Knowledge of antibiotic use and resistance among students of a medical school in Nigeria. Malawi Med J 2019; 31(2): 133-7. http://dx.doi.org/10.4314/mmj.v31i2.5 PMID: 31452846

[20] Dyar OJ, Nathwani D, Monnet DL, *et al*. Do medical students feel prepared to prescribe antibiotics responsibly? Results from a cross-sectional survey in 29 European countries. J Antimicrob Chemother 2018; 73(8): 2236-42. http://dx.doi.org/10.1093/jac/dky150 PMID: 29746647

[21] Machowska A, Stålsby Lundborg C. Drivers of irrational use of antibiotics in Europe. Int J Environ Res Public Health 2018; 16(1): 27. http://dx.doi.org/10.3390/ijerph16010027 PMID: 30583571

[22] Sikkens JJ, Caris MG, Schutte T, Kramer MHH, Tichelaar J, van Agtmael MA. Improving antibiotic prescribing skills in medical students: The effect of e-learning after 6 months. J Antimicrob Chemother 2018; 73(8): 2243-6. http://dx.doi.org/10.1093/jac/dky163 PMID: 29746682

[23] Alshehri AA, Khawagi WY. Knowledge, awareness, and perceptions towards antibiotic use, resistance, and antimicrobial stewardship among final-year medical and pharmacy students in Saudi Arabia. Antibiotics 2025; 14(2): 116. http://dx.doi.org/10.3390/antibiotics14020116 PMID: 40001360