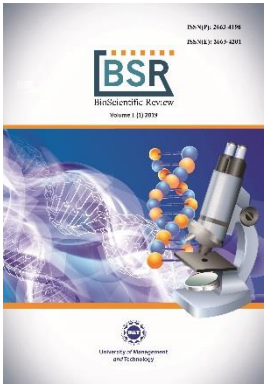

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Knowledge, Attitude and Practices (KAP) of University Students of Pakistan towards Antibiotic Use and Resistance: A Questionnaire-based Assessment

Muhammad Abrar Yousaf[1,2], Hafsa Zahid[3], Zumama Khalid[3], Abeedha Tu-Allah Khan[3], Misbah Noreen[1,2], Tayyaba Saleem[4], Sibgha Farooq[1], Iram Yousaf[5], Samer Sakr[6]*

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antibiotics, cross-sectional study, knowledge, attitudes and practices (KAP), Pakistan, university students

Abstract

Antibiotic resistance is a serious health concern all over the world. The incorrect prescription, inappropriate consumption and excess use of antibiotics, are possibly the main factors contributing to the widespread of antibiotic-resistant bacteria. This study aims to assess the knowledge, attitudes and practices (KAP) towards antibiotic use and resistance among Pakistan's university students of biological sciences. A descriptive cross-sectional study was conducted amongst 826 students of biological sciences studying in eight major Pakistani universities from September 2020-November 2020. A four dimensional self-administered online questionnaire was developed covering students' sociodemographic characteristics (3 questions) and assessed their knowledge, attitude and practices with 13, 6 and 11 questions, respectively. The association of KAP scores with sociodemographic characteristics was analyzed using a non-parametric analysis, that is, Mann-Whitney U and Kruskal-Wallis H test (p-value < 0.05). The sample comprised more female subjects (82.9%) than male subjects. Most of the respondents were in the age group 21-23 years and were enrolled in the master's degree program. The overall knowledge score (correct answer) was 74.7% and it was significantly associated with gender, age and degree. The positive attitude score (87.9%) was significantly higher in the age group of >23 years. Around 75% of the surveyed students performed positive practices. The scores of female subjects of the age group 21-23 years and doctoral

students were significantly higher than the rest. The current study provides baseline evidence about knowledge, attitude and practices regarding antibiotic use and resistance among biology students. Overall, the participants showed a good positive attitude (score higher than 80%). However, the level of knowledge and positive practices was lower and declared moderate (scores in the range of 60-80%). Academic interventions such as lectures, courses, seminars and workshops on antibiotic use, establishment of open-access antibiotic-resistance learning sites, and the use of mainstream and social media platforms are measures needed to improve the awareness and practices of university students of biological sciences with regard to the rational use of antibiotics.

1. Introduction

Antibiotics have been at the forefront in the prevention and cure of various pathogenic infections for the last few decades [1]. However, emerging resistance in microorganisms towards antibiotics has become a serious concern [2]. Antibiotic or antimicrobial resistance emerges when pathogens develop the ability to conquer the antibiotics used to kill them. Antibiotic resistance is a serious concern for public health care across the globe [3, 4], usually rooted in the improper use of antibiotics [5] via self-medication or via improper antibiotic consumption due to the lack of knowledge, easy access to antibiotics due to the lack of restrictions on their sale without prescription and because of the lack of public awareness about their use [6–11]. These practices are responsible for the gradual decline in antibiotic efficacy and increase the chances of failure of disease treatment, leading to severe health outcomes and eventually mortality [6]. Approximately 700,000 deaths occur each year due to antibiotic resistance and 10 million deaths/year are estimated to occur after 2050, equal to the number of deaths/year due to cancer, at present [12]. Therefore, appropriate means of intervention are required to control the improper use of antibiotics. For this purpose, several approaches have been proposed, such as formulary replacement or restriction, education of health care providers, feedback activities, strict requirement of drug prescription from a specialist physician or other disease specialists for purchasing antibiotics, and their enhanced rational use [13, 14].

The assessment of knowledge, attitudes and practices (KAP) on a large scale at university level can be an effective way to bring improvement in the use of antibiotics [15]. Therefore, several such investigations were carried out in the past. These studies showed that university students lack in appropriate KAP towards antibiotic use despite being students of higher education. Excessive use of antibiotics for self-treatment without prescription has been observed in students [11, 16–18]. In developing countries such as Pakistan, antibiotic resistance has become a serious issue for healthcare, mainly due to self-medication, and the problem is only

expected to worsen with time. To the best of our knowledge, very few studies [19–22] have been carried out in Pakistani universities related to antibiotic use and resistance, especially focusing on KAP assessment among university students. Hence, there is a dire need to design a comprehensive study to report the KAP data of students from various major universities of Pakistan. With a background in biology, students of biological sciences are expected to have adequate knowledge regarding the use of antibiotics and they can perform a more positive practice towards antibiotic use that would help to deal with this issue. So, the current cross-sectional study aims to assess the level of KAP among students enrolled in different degree programs in the field of biological sciences in eight major universities of Pakistan.

2. Methodology

The overall flowchart of the current cross-sectional study is depicted in Figure 1.

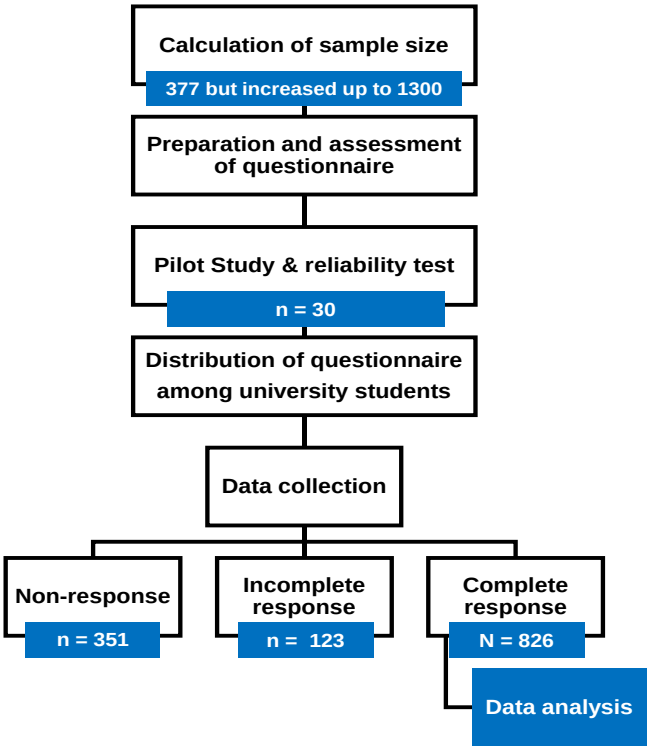

Figure 1. The flowchart of the pipeline of this cross-sectional study related to antibiotics use and resistance among biological sciences students. Starting with the selection of the required sample size for the current study, the preliminary steps included the preparation of the questionnaire and its assessment via reliability tests before its distribution among students for data collection. Further sorting of data was performed based on responses obtained and the inclusion criteria included data from questionnaires having complete responses

2.1. Survey Design

The current study was designed as a descriptive questionnaire-based cross-sectional survey conducted with a random sample of students from eight major universities of Pakistan (Quaid-i-Azam University, Islamabad; University of the Punjab, Lahore; Government College University, Lahore; University of Education, Lahore; Lahore College for Women University, Lahore; University of Peshawar, Peshawar; Bahauddin Zakariya University, Multan; The Islamia University of Bahawalpur, Bahawalpur). The target population comprised the students of various biological sciences, such as agriculture, biochemistry, biology, biotechnology, botany, environmental biology, microbiology, molecular biology, psychology and zoology.

2.2. Data Collection

The survey was conducted from September 2020 to November 2020. A questionnaire was developed and designed by the research team after doing a thorough review of available literature related to antibiotic use and resistance. After its formulation, the questionnaire was further reviewed by two experts before the survey. Three irrelevant questions were removed, while five questions were modified to increase their validity and relevancy. After modifications, the questionnaire was subjected to a pilot study conducted among 30 students, followed by the reliability test. Cronbach's alpha coefficient (0.72) was found satisfactory and within an acceptable range, indicating the reliability and validity of the data. The pilot study data was not included in the final analysis. The present investigation followed the ethical principles for research involving human subjects outlined in the Declaration of Helsinki. The Bioethics Committee of the University of the Punjab, Quaid-i-Azam Campus, Lahore approved the study under reference no. 1580-42. All participants completed the anonymous survey voluntarily and gave their informed consent before completing the survey questionnaire. The procedure was explained very clearly and the respondents could quit or interrupt the survey at any point without mentioning the reason.

The online questionnaire was generated using Google Forms (https://docs.google.com/forms/) in English. The electronic link to the questionnaire was shared with approximately thirteen hundred (1300) students of eight universities through email and other frequently used social media platforms, such as WhatsApp and Facebook. A brief message including introduction, objectives, information of confidentiality and anonymity, procedure description and the statement of the voluntary nature of survey was also mentioned along with the electronic link.

2.3. Measures

The questionnaire consisted of four sets. The first set covered sociodemographic characteristics, that is, gender, age and degree/course of enrollment in the university. The second comprised 13 questions and assessed the students' knowledge, while the third set (6 questions) dealt with the attitude of the students. The fourth and final set (11 questions) was related to the practices regarding antibiotic use and resistance. The KAP-related questions were answered by choosing among 'yes/no/maybe' responses. Along with these sections, the information related to the health facilities from where the

respondents received medical care was also obtained.

2.4. Statistical Analysis

Descriptive statistical analysis was used to calculate the frequency (n) and percentage (%) of sociodemographic characteristics and KAP data. In the knowledge section, each correct response obtained '1' score, while each incorrect or 'maybe' response got '0'. Similarly, a score of '1' was allotted to each positive attitude and practice, while any negative or 'maybe' answer was given '0' score [23]. In descriptive analysis, a score higher than 80% was regarded as 'good', between 60-80% as 'moderate' and less than 60% as 'poor' [24].

Shapiro–Wilk test on KAP scores displayed the non-normal distribution of data. Therefore, non-parametric analysis *i.e*, Mann–Whitney U and Kruskal–Wallis H tests with $p < 0.05$ were performed to analyze the association of KAP data with sociodemographic characteristics. The results were presented through mean and standard deviation (SD), as well as through median and interquartile range (IQR). All statistical tests were applied using IBM SPSS Statistics (SPSS Inc, version 20.0, IBM, Chicago, IL, USA) software.

2.5. Strengths and Limitations

This study had a large sample size and covered eight major universities of Pakistan. To evaluate the KAP data, it is more feasible to generalize from the results computed for biology students in all Pakistani universities. However, the current study has a few limitations. It only covered the students of biological sciences, so the results cannot be generalized for all students. Further studies are required with university students of non-biology related programs, as well as with non-university students, to better understand and improve the level of KAP among young adults and adolescents towards antibiotic use and resistance in Pakistan.

3. Results

Online questionnaire was circulated among approximately 1300 university students enrolled in different degree programs in biological sciences. However, 351 participants did not respond to the questionnaire, whereas 123 forms were returned incomplete and these were not included in the final analysis. A total of eight hundred and twenty-six (826) participants (63.5% of total) responded by filling the complete questionnaire forms and the data were subjected to further statistical analyses.

3.1. Sociodemographic Characteristics of Study Population

The results in Table 1 demonstrate the sociodemographic characteristics of the participants (N = 826). Most of the participants (n = 685, 82.9%) were female, while 141 (17.1%) participants were male. The majority (n = 635, 76.9%) belonged to the age group 21-23 years; however, 135 (16.3%) participants were aged > 23 years, while 56 (6.8%) were aged 18-20 years. About three-quarters of the participants (n = 626, 75.8%) were enrolled in the master's degree program; whereas, 125 (15.1%) and 75 (9.1%) participants were enrolled in bachelor and doctoral degree programs, respectively.

Most of the participants (n = 491, 59.4%) reported that they mostly received medical care from hospitals. Whereas 285 (34.5%) received medical care from clinics, 30 (3.6%) from pharmacies and 20 (2.4%) from other sources (Figure 2).

Table 1. Sociodemographic Characteristics of the Participants (N = 826)

No.	Sociodemographic characteristics		N	%
	Gender	Male	141	17.1
		Female	685	82.9
	Age (years)	18-20	56	6.8
		21-23	635	76.9
		> 23	135	16.3
	Degree	Bachelors	125	15.1
		Masters	626	75.8
		Doctoral	75	9.1

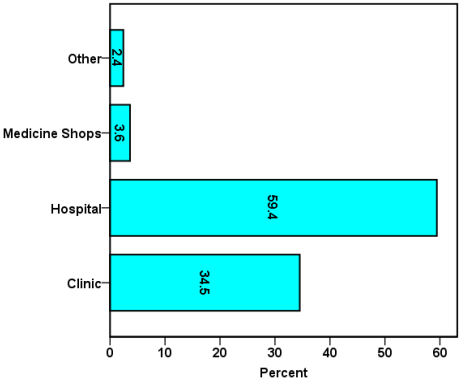

Figure 2. Bar chart representing the variations in health care facilities approached by the participants in the case of illness. Four hundred and ninety-one (59.4%) participants visited the hospital during illness, followed by clinic (34.5%), medicine shops (3.6%) and other sources (2.4%).

3.2. Knowledge of Antibiotic Use and Resistance among Participants

Table 2 depicts the frequency (n) and percentage (%) of participants answering 'yes/no/may' for KAP questions regarding antibiotic use and resistance. The overall knowledge score (correct answers) of participants was found to be 74.7%, indicating a 'moderate' level of knowledge with a mean of 9.7 ± 1.9 and a score range of 2-13. Out of 826 participants, 711 (86.1%) had knowledge about the presence of useful bacteria in human body and 776 (92.7%) knew the difference between antibiotics and antivirals. Almost all respondents (n = 801, 97.0%) reported that antibiotics were useful against harmful bacteria but could not be used to cure antiviral infections (n = 616, 74.6%). However, few students knew about the ineffectiveness of antibiotics for a speedy recovery from coughs, colds and other diseases (n = 140, 16.9%), as well as the requirement of doctor's prescription to obtain antibiotics from pharmacies (n = 121, 14.6%). Most of the students (n = 706, 85.5%) had an idea of antibiotic resistance and 756 (91.5%) students were aware of the fact that antibiotic resistance lowers antibiotic efficacy. Moreover, many students also knew that frequent use of antibiotics would not lower the chances of contracting an infection (n = 515, 62.3%). Most of the students (n = 706, 85.5%) reported that antibiotics can have side effects and the majority knew that tetracycline (n = 751, 90.9%), penicillin (n = 750, 90.8%) and amoxicillin (n = 686, 83.1%) are antibiotics. The overall knowledge scores are displayed in Figure 3.

3.3. Attitude towards Antibiotic Use and Resistance among Participants

Based on six questions, the overall positive attitude score (positive answers) was calculated as 87.9%, depicting a good level of attitude among university students of biological sciences. The mean score was found to be 5.3 ± 1.1 and the range was 1-6. Table 2 demonstrates that most of the

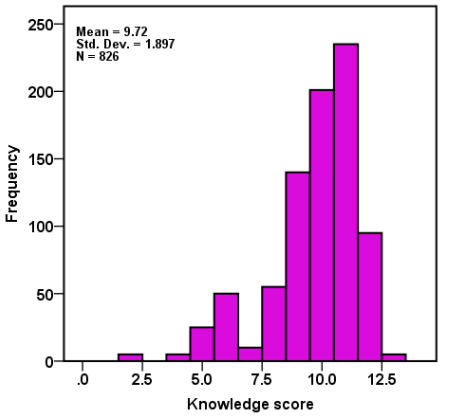

Figure 3. Histogram depicting the knowledge score of the participants. The knowledge scores ranged from 2 to 13 with the mean of 9.7 ± 1.9, while the most repetitive number (mode) was 11 which was scored by 235 participants (28.4%)

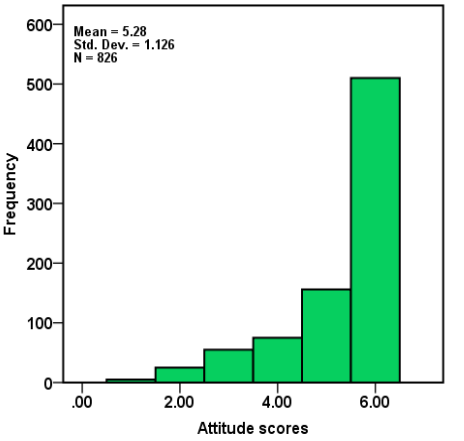

Figure 4. Histogram depicting the attitude score of the participants. The scores ranged from 0-6 with the mean of 5.3 ± 1.1, whereas the most participants (n = 510, 61.7%) obtained the score of 6

participants reported the existence of antibiotic misuse (n = 725, 87.8%) and resistance (n = 676, 81.8%) in Pakistan. Most of them (n = 701, 84.9%) reported the negative effect of antibiotic resistance on health and almost all (n = 816, 98.8%) agreed to the importance of its awareness for everyone. According to most students (n = 736, 89.1%), there should be a proper course related to the rational use of antibiotics in the degree program. Overall, positive attitude scores are depicted in Figure 4.

3.4. Practices towards Antibiotic Use and Resistance among Participants

The overall score of the practices of participants was found to be 75.5% (moderate level), with a mean of 8.3 ± 2.1 and a range of 3 to 11. As described in Table 2, most participants (n = 615, 74.5%) always consulted the doctor before using antibiotics and 591 (71.5%) never used these medicines on the suggestion of any neighbor or friend. About half of the participants (n = 411, 49.8%) reported that they did not have a stock of different antibiotics at their home. However, 320 (38.7%) had a stock of common antibiotics at their home, while the rest 95 (11.5%) were not sure about this. Two hundred and thirty-five participants (28.5%) practiced either self-administration of antibiotics or giving them to their sick family members. However, 65.5% did not practice this. More than three-quarters of the participants (n = 630, 76.3%) always read the antibiotics instructions label. About half of the participants (49.6%) always completed the course duration of antibiotics as recommended by the doctor. However, 37.0% did not follow the doctor's instructions related to it, while 13.3% did not give a clear response related to this matter. The majority (n = 781, 94.6%)

Table 2. Frequency (N) and Percentage (%) of Participants Answering the KAP Questions on Antibiotic use and Resistance (N = 826)

No.	Questions	Yes		No		Maybe	
		n	%	n	%	n	%
	Knowledge	([a] Correct answer)					
1.	There are bacteria found in the human body which are useful for us	711[a]	86.1	20	2.4	95	11.5
2.	Antibiotics and Antivirals are the same things	40	4.8	776[a]	92.7	20	2.4
3.	Antibiotics are used to cure bacterial infections	801[a]	97.0	15	1.8	10	1.2
4.	Antibiotics are also used to cure viral infections	140	16.9	616[a]	74.6	70	8.5
5.	Antibiotics can be used for the speedy recovery from coughs, colds, and other diseases	570	69.0	140[a]	16.9	116	14.0
6.	Antibiotics are obtainable at pharmacies without prescription of a doctor	595	72.0	121[a]	14.6	110	13.3
7.	I have an idea of 'antibiotic resistance'?	706[a]	85.5	105	12.7	15	1.8
8.	Frequent use of antibiotics could reduce their efficacy	756[a]	91.5	35	4.2	35	4.2
9.	Frequent use of antibiotics lowers the chances of infection	175	21.2	515[a]	62.3	136	16.5
10.	Antibiotics can have side effects	706[a]	85.5	15	1.8	105	12.7
11.	Tetracycline is an antibiotic	751[a]	90.9	20	2.4	55	6.7
12.	Penicillin is an antibiotic	750 [a]	90.8	35	4.2	41	5.0
13.	Amoxicillin is an antibiotic	686 [a]	83.1	35	4.2	105	12.7
	Attitude	([a] Positive attitude)					
1.	Misuse of antibiotics exists in the society	725[a]	87.8	15	1.8	86	10.4
2.	Antibiotic resistance is an issue in Pakistan	676[a]	81.8	40	4.8	110	13.3
3.	Frequent use of antibiotics results in resistance in harmful bacteria	706[a]	85.5	50	6.1	70	8.5
4.	Antibiotic resistance affects the health	701[a]	84.9	40	4.8	85	10.3
5.	Information related to antibiotic resistance is necessary for everyone	816[a]	98.8	10	1.2	0	0.0
6.	There should be a subject related to the rational use of antibiotics in the university course	736[a]	89.1	25	3.0	65	7.9

	Practices	([a] Positive practices)					
1.	I always consult a doctor before using an antibiotic	615[a]	74.5	180	21.8	31	3.8
2.	I sometimes use antibiotics on the suggestion of any neighbor or friend	150	18.2	591[a]	71.5	85	10.3
3.	I always keep a stock of different antibiotics at my home	320	38.7	411[a]	49.8	95	11.5
4.	I myself give antibiotics to other family members if someone gets sick	235	28.5	541[a]	65.5	50	6.1
5.	I always read the antibiotics instructions label	630[a]	76.3	96	11.6	100	12.1
6.	I stop taking antibiotics before completing the full course recommended by doctor?	306	37.0	410[a]	49.6	110	13.3
7.	I always check the expiry date of an antibiotic before using it	781[a]	94.6	30	3.6	15	1.8
8.	I sometimes use leftovers antibiotics without consulting the doctor	185	22.4	550[a]	66.6	91	11.0
9.	I demand antibiotics from a doctor while he says you don't need it	25	3.0	781[a]	94.6	20	2.4
10.	I trust the doctor's decision if he/she doesn't prescribe me antibiotics	779[a]	94.3	45	5.4	2	0.2
11.	I trust the doctor's decision if he/she prescribes me antibiotics	766[a]	92.7	25	3.0	35	4.2

always checked the expiry date of an antibiotic before using it. Five hundred and fifty (66.6%) students did not practice using leftover antibiotics without consulting the doctor. However, 185 (22.4%) practiced this activity, while 91 (11.0%) were not sure about this. A majority of participants, that is, 781 (94.6%) did not demand antibiotics themselves from a doctor. Similarly, 779 (94.3%) participants would believe the doctor if he did not prescribe antibiotics, while 766 (92.7%) would trust the doctor if he prescribed them. Overall, positive practices score related to antibiotic use and resistance are shown in Figure 5.

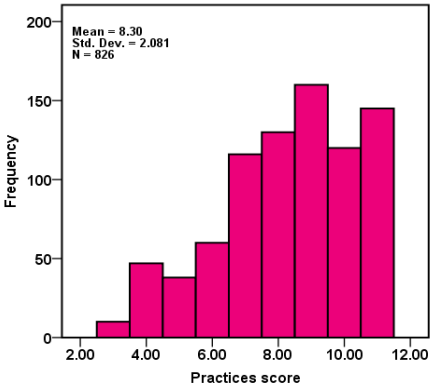

Figure 5. Histogram depicting the practice scores of the participants. The scores varied from 3 to 11 with 8.3 ± 2.1 mean. The most achieved score was 9 which was obtained by 160 students

3.5. Association of Sociodemographic Characteristics with KAP Scores

Table 3, 4 and 5 explain the association of sociodemographic characteristics with KAP scores. Knowledge scores were associated significantly with gender, age and degree ($P < 0.05$), as displayed in Table 3. Female students scored significantly higher (75.4%) than male students. The lowest score was achieved by the age group 18-20 years (75.4%), while the other two age groups (21-23 years; > 23-year) fared slightly better (76.9%). Similarly, a higher score (76.2%) was achieved by master's and doctoral students, while bachelor's students obtained the lowest score (67.7%).

A significant association ($p < 0.05$) was observed between positive attitude and age groups, where the highest score was achieved by the age group of more than 23 years (90.0%). A non-significant association ($p > 0.05$) was obtained for gender and degree, with a higher score by male participants (91.7%) and doctoral degree participants (86.7%). The details are explained in Table 4.

Table 5 demonstrates that positive practices were associated significantly ($p < 0.05$) with all sociodemographic characteristics, that is, gender, age and degree. Maximal scores were earned by the female participants (76.4%), age group 21-23 years (76.4%) and doctoral degree holders (80.0%).

Table 3. Association of Sociodemographic Characteristics with Knowledge Score Related to Antibiotic use and Resistance (N = 826)

No.	Sociodemographic characteristics		Positive knowledge score			Z/χ^2	*p*-value
			%	Mean ± SD	Median (IQR)		
1.	Gender[a]	Male	73.1	9.5±1.7	10(2)	−2.481	0.013
		Female	75.4	9.8±1.9	10(2)		
2.	Age (years)[b]	18-20	75.4	9.8±1.8	9(4)	32.382	< 0.001
		21-23	76.9	10.0±1.4	10(2)		
		> 23	76.9	10.0±1.6	10(2)		
3.	Degree[b]	Bachelors	67.7	8.8±2.6	10(4)	16.807	< 0.001
		Masters	76.2	9.9±1.7	10(2)		
		Doctoral	76.2	9.9±1.1	10(2)		

[a]Mann–Whitney U test, [b]Kruskal–Wallis H test

Table 4. Association of Sociodemographic Characteristics with Attitude Score Related to Antibiotic use and Resistance (N = 826)

No.	Sociodemographic characteristics		Positive attitude score			Z/χ^2	*p*-value
			%	Mean ± SD	Median (IQR)		
1.	Gender[a]	Male	91.7	5.5±0.9	6(1)	−1.838	0.066
		Female	86.7	5.2±1.2	6(1)		
2.	Age	18-20	71.7	4.3±1.2	5(2)	53.639	< 0.001

No.	Sociodemographic characteristics		Positive attitude score			Z/χ^2	*p*-value
			%	Mean ± SD	Median (IQR)		
	(years)[b]	21-23	88.3	5.3±1.1	6(1)		
		> 23	90.0	5.4±0.9	6(1)		
3.		Bachelors	85.0	5.1±1.3	6(1)	1.666	0.435
	Degree[b]	Masters	88.3	5.3±1.1	6(1)		
		Doctoral	86.7	5.2±1.2	6(2)		

[a]Mann–Whitney U test, [b]Kruskal–Wallis H test

Table 5. Association of Sociodemographic Characteristics with Practices Score Related to Antibiotic use and Resistance (N = 826)

No.	Sociodemographic characters		Positive practices score			Z/χ^2	*p*-value
			%	Mean ± SD	Median (IQR)		
1.		Male	70.9	7.8±2.3	8(4)	−2.601	0.009
	Gender[a]	Female	76.4	8.4±2.0	9(3)		
2.		18-20	64.5	7.1±2.3	7(5)	16.872	< 0.001
	Age (years)[b]	21-23	76.4	8.4±2.0	9(3)		
		> 23	75.5	8.3±1.9	9(3)		
3.		Bachelors	70.9	7.8±2.3	8(3)	11.014	0.004
	Degree[b]	Masters	75.5	8.3±1.9	8(3)		
		Doctoral	80.0	8.8±2.2	9(2)		

[a]Mann–Whitney U test, [b]Kruskal–Wallis H test

4. Discussion

Antibiotic resistance is among the gravest issues facing the public health sector. The evaluation of KAP among university students with reference to the said problem can be of great importance in tackling the antibiotics related threats [25, 26] and for the guided development of optimal training related to antibiotic practices [11].

Given the worldwide importance of antibiotic resistance and irrational antibiotic use, the current study assessed self-medication and KAP among university students for the development of antibiotics related optimal training programs. In the current study, the overall observed veracious knowledge score was found to be 74.7%, indicating its moderate level in university students enrolled in different degree programs of biological sciences. In comparison, about 78% of university students of biology/health-related majors showed high knowledge scores in Lebanon [5]. While health-related students of UAE made comparatively lower knowledge scores (65%), as reported by Jairoun et al. [3]. Concerning the efficacy of antibiotics against antiviral infections, most of the current study respondents knew that antibiotics are effective only against bacterial infections. However, only few of them (16.9%) knew that antibiotics are not effective against cold, cough and other common seasonal viral diseases. This could be due to the lack of knowledge that the

above mentioned diseases are viral infections. The misuse of antibiotics for the treatment of viral infections is a common practice and the prevalence of self-medication is highly alarming in developing countries [27, 28]. In a study conducted on antibiotic use in the Ethiopian population, 83% of the participants believed that antibiotics are useful against common cough and flu symptoms [29]. In another study conducted on the Lebanese population, only 26.5% participants knew that antibiotics are not anti-viral [30]. Similarly, a study conducted by Arshad et al. [21] involving the students of Bahauddin Zakariya University Multan, Pakistan revealed that 59% of the participants believed that the symptoms of cold and flu can be managed through the use of antibiotics. In the general Pakistani population, 47.5% believed that antibiotics could be used to treat cold and flu [31]. Poor awareness about the difference between viral and bacterial infections is consistent with multiple studies carried out in developing countries. It is alarming to know that only 14.6% participants knew that antibiotics are not obtainable from pharmacies without doctor's prescription, which indicated that getting antibiotics without prescription from pharmacies is a common practice in Pakistan. This fact is also indicated by other researches. In a study conducted on antibiotic use in Swat, Khyber Pakhtunkhwa (KPK), Pakistan, the majority of the respondents (57.6%) contacted pharmacies directly without getting any prescription for antibiotics [32]. In a study on less educated communities of Punjab, Pakistan, 60% of the participants gave an affirmative answer to self-medication using antibiotics [31]. Most of the participants (85.5%) knew about antibiotic resistance, their side effects and the lowering of antibiotic efficacy up to 91.5% on their frequent usage. In comparison with this study, an investigation of antibiotic self-medication in non-medical university students of Pakistan showed that only 43% of students knew about antibiotic resistance. Furthermore, only 30% knew that misuse will eventually result in causing/enhancing antibiotic resistance [33]. This massive difference in numbers further strengthens the conclusion that medical and biosciences students have a greater degree of awareness as compared to non-medical students about health related issues. In the current survey, 85.5% of students were aware of the side effects of antibiotics. In a similar study on non-medical university students, 73% of students were aware of the misuse of antibiotics and their side effects [33]. Moreover, Gillaniet al. [31] reported that only 53.5% of the general population of Punjab was aware of the side effects of antibiotic use. Overall, the comparison of these different data sets from multiple studies revealed how education, especially in health related fields, can greatly enhance the student's awareness of antibiotic use and misuse. In a questionnaire-based survey, Sakr et al. [5] found that students' the knowledge scores with health-related majors (biology, biochemistry, nutrition, food sciences, biomedical sciences and pharmacy) was significantly higher as compared to the students with non-health related majors. A similar pattern was also observed by several other studies [3, 11, 18, 19]. Moreover, most biosciences students were aware of some famous antibiotics such as tetracycline, penicillin and amoxicillin. In another cross-sectional survey conducted by Shah et al. [22], most

of the students recognized penicillin and amoxicillin as antibiotics.

A considerable increase in antibiotic resistance, disease severity, duration of disease, complication risk, health care cost and mortality has been observed because of the unorthodox use of antibiotics [33]. Several mutated and antibiotic resistant pathogens are creating threats throughout the world and developing countries are contributing towards enhancing the strength of resistance [34, 35]. In Pakistan, there is an emergency of a bacterial strain "super-bug" which is resistant to all available antibiotics. This is definitely the result of the unregulated use of antibiotics [36]. There is a dire need of strong law enforcement and public education to eradicate self-medication practices. This practice was adopted in several developed countries and found to be very effective [37, 38]. Antibiotics are prescription-only drugs and should be sold on prescription, only.

The current study revealed a good positive attitude score (88%) towards antibiotic use and showed consensus among students regarding the importance of the awareness about antibiotic use and misuse. In similar studies, Sakr et al. [5] reported 93.4% attitude scores while Jairoun et al. [3] reported 80% attitude score of university students studying biology and health related majors in Lebanon and UAE, respectively. Most of the participants agreed that the existence of antibiotic abuse in the Pakistani society is causing the emergence of resistance in harmful bacteria, affecting the human health adversely. Similarly, it was found that most of the university students in Lebanon studying health related majors believed that high antibiotic use caused resistance, as reported by Sakr et al. [5]. Supporting the present study, three- fourths of Chinese students identified misuse of antibiotics as a health problem in their country [17]. According to almost all respondents, information about antibiotic resistance is necessary for everyone. Moreover, 89.1% agreed about the inclusion of the subject related to the rational use of antibiotics in university curriculum to boost their level of knowledge. In a report by Huang et al. [17], 74% of Chinese medical students favored the introduction of an antibiotic related course in the university, while 88.4% of UAE university students agreed with the establishment of a course regarding the rational use of antibiotics. Similarly, Minen et al. [39], reported that more than 75% of medical students support education about the use of antibiotics in America.

A moderate level of positive practice (75.5%) was observed in antibiotic use among the participants of the current study. In similar study, Biology and health related university students of Lebanon showed the practices score of 84.4% [5]. However, health related students in UAE showed 47% practice scores [3]. Lower scores in UAE indicated that the students there did not practice what they knew. In this report, 74.5% of respondents reported to consult a doctor before antibiotic use, while 21.8% took them without doctor's instructions, indicating self-medication. During another investigation [40] targeting university students of Pakistan, it was found that 65.7% of students reportedly took antibiotics when prescribed by a doctor, whereas a high percentage of students (54%) also took them without prescription. On the other hand, 55.6% of UAE students took antibiotics without consulting the

doctor [3]. Most of the participants (71.5%) did not use antibiotics suggested by their neighbors or friends. However, 28.5% had a habit of prescribing antibiotics to their family members without consulting any health care professional. A significant part of the participants (38.7%) kept a stock of antibiotics at their homes. Moreover, 66.6% also used leftover antibiotics without consulting the doctor. This indicated that the students of biological sciences from Pakistani universities are not well aware of the irrational use of antibiotics, although they demonstrated a better attitude and practices. The contrasting facts that 74.5% of them consulted the doctor before using antibiotics, 38.7% had their stock at home, while 66.6% used leftover antibiotics depict that most of the students took antibiotics on their doctor's prescription but stored them at home and used leftovers, afterwards. Comparable with the current results, a study on self-medication by university students of Islamabad, Pakistan depicted that nearly 77% of students self-medicated using antibiotics [40]. Another report on self-medication using antibiotics by non-medical university students of Karachi, Pakistan showed that 50.1% of students used antibiotics without proper prescription [20]. In the case of their stock, a study reported that 17% of respondents kept antibiotics at home for future use [41]. Pavydė et al. [42] reported that 28.5% of participants stored antibiotics for future use. In India, it was found that 76% of users obtained antibiotics without prescription [43], The same was reported for 32.7% of patients in Italy [44], 28.8% in Saudi Arabia [45] and 9% in Hong Kong [46]. Such differences could be due to country to country variation in regulations and their application besides the differences of sociodemographic conditions.

Three-fourths of the total participants (76.3%) always read the instructions label of antibiotics, while 94.6% checked the expiry date before their use. In an investigation carried out by Mouhieddine et al. [30],it was mentioned that 69.7% of participants read the instructions label and 83.2% read the date of expiration. In line with the current study, during a survey carried out by Nepal et al. [47], 94.5% of participants checked the expiry date before use. About half of the respondents completed the full course of antibiotics as recommended by the doctor in the case of any disease, while 37% stopped taking them before the completion of the course and the rest were not sure about this. Similar results were obtained from the general population of Kuwait, where more than one-third (36%) didn't complete the prescribed antibiotics course [25]. Almost all the participants (more than 90%) did not demand antibiotics and trusted the doctor's decision regarding their use.

Statistical analysis showed interesting findings in terms of identifying the sociodemographic characteristics influencing the knowledge, attitude and practices of students. Antibiotics related knowledge was significantly different among different gender, age and degree groups of students, while positive attitude was depicted as significantly different for different age groups. Students of different gender, age and degree programs used significantly different practices. These findings clearly indicated that sociodemographic features of students strongly determine the KAP regarding antibiotic use and resistance. A report of

Jairoun et al. [11] showed that jointly major subject, study level, sex and age were highly associated with KAP regarding antibiotic use among university students of UAE. Jairoun et al. [11] determined the association of demographics with the joint data of KAP. In the current study, the association was found separately with each parameter of KAP.

The current findings clearly indicate that there is an urgent need to limit the open access for antibiotics in developing countries such as Pakistan. World Health Organization (WHO) is actively taking stance on the increasing levels of antibiotic resistance. WHO has issued "Global Strategy for Containment of Antimicrobial Resistance" for governments and policymakers to implement and take actions on this subject. In this regard, South Korea launched numerous educational campaigns to regulate antibiotic use in several ways targeting the general population [48]. Current study for the assessment of KAP towards antibiotic use and resistance among Pakistani university students depicted that although the students of biological sciences and health related subjects showed a good level of positive attitude (87.9%) towards antibiotic use and resistance, yet the results of knowledge (74.7%) and positive practices (75.5%) were not very satisfactory (moderate level). So, the findings call for tailored interventions to improve the students' knowledge and positive practices. For this purpose, antibiotics related educational programs such as workshops, seminars and symposiums are required at university level. In the university, a multidisciplinary group consisting of expert microbiologists, infectious-disease specialists and pharmacists should be involved in developing the curriculum of educational programs about antibiotics. University teachers delivering sessions or lectures on the irrational use of antibiotics must be trained also. Public Health England introduced the "train the trainer" workshop for teachers to train them on how to educate students about the spread of infection, hygiene, and antibiotic use [49].

Interactive learning in the form of problem-based learning with case vignettes can be the right approach in this regard. For example, a program-based module was offered to undergraduate students at the University of Nijmegen, Netherlands on antibiotic policy based on the infectious diseases' history, principles of prophylaxis and antibiotic guidelines [50]. Additionally, establishing the standardized electronic tools providing easy access to the correct information can be very beneficial for the improvement of knowledge related to antibiotics. In US, an open-access antimicrobial resistance learning site was developed by CDC, University of Minnesota and Michigan State University for veterinary medical students [51]. Mainstream and social media platforms can also play a vital role in this regard.

To cope with antibiotic resistance, substantial efforts should be made to create awareness among people, especially the layperson, about the prudent use of antibiotics. In the current study, the targeted group belonged to the field of biological sciences. Hence, it was expected to be well aware of the judicious use of antibiotics. However, the gap found in KAP perturbs about the gravity of the situation. Several problems that need to be addressed urgently include restricting the widespread availability of antibiotics from unofficial

distributors, irrational prescription of antibiotics by healthcare personnel, misconceptions regarding the excessive use of antibiotics, self-medication, and deleterious effects of the irrational use of antibiotics. Educating the 'educated' health workers along with the general population is indispensable to limit the extravagant prescription of antibiotics. Campaigns at the grassroots level should be initiated to inform and educate the people about the correct use of drugs. Moreover, educating the university and college students, irrespective of their field, can yield promising results. A person being instructed at the university/college/school level about the pros and cons of antibiotic use can disseminate the information very effectively to their family members. This systematic and structured approach regarding antibiotic resistance and their overuse can have a remarkable effect on the community in the future. Besides, a bold note should be added to the leaflet of every drug being distributed / administered for any disease condition. Although new drugs are being developed, without changing the existing attitudes and behavior towards the use and prescription of antibiotics, no amelioration can be expected.

5. Conclusion

The evaluation of knowledge, attitudes and practices towards antibiotic use and resistance among university students is a helpful tool to help improve the use of antibiotics. The current investigation addressed the KAP of students enrolled in the biological sciences programs of eight major universities of Pakistan about the use of antibiotics. The findings revealed that students showed a moderate level of knowledge (74.4%), good attitude scores (87.9%) and moderate practices (75.5%). With the relevant background, biology students depicted satisfactory KAP scores. However, there is still a need to improve their knowledge about antibiotic use and resistance which would remediate and rationalize their attitude and practices regarding the issue. This can be achieved by educating the students through nationwide awareness programs, academic interventions including seminars, workshops and courses related to public health concerns, and through interactive learning. Awareness campaigns through media propagating public health is also recommended. Involving civil society organizations and media intervention would greatly serve this aim.

Conflict of Interest

The authors declare no conflict of interest.

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