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Knowledge, attitude, and practices (KAP) of University students regarding antimicrobial use (AMU) and antimicrobial resistance (AMR) in Ethiopia

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Abstract

A cross-sectional questionnaire-based study on 1252 University students was conducted in Ethiopia to assess their knowledge, attitude, and practices (KAP) towards antimicrobial usage (AMU) and antimicrobial resistance (AMR). Verbal consent was obtained from randomly selected students to participate in this study. A logistic regression analysis was used to assess the association between the socio-demographic profiles of the students against their knowledge, attitude, and practices toward antimicrobial resistance and antimicrobial usage. The Kruskal-Wallis and chi-square tests were used to examine how the median scores in each of the knowledge, attitude, and practice categories varied across study participants. A p-value of less than 0.05 was considered significant. The overall median AMR and AMU knowledge score was 13 (IQR=11, 14). The median AMR and AMU attitude score was 15 (IQR: 13, 15). The median score of AMU and AMR practice was 10 (IQR: 10, 11). Logistic regression analysis revealed that the students' birthplace was found to be a significant factor ($p < 0.01$) regarding the knowledge of students. The analysis further revealed that students' birthplace, field of studies, and good knowledge were significant factors ($p<0.01$) affecting their attitudes. Students with good knowledge had 3.9 times more positive attitudes than those with poor knowledge (OR = 3.9, CI = 3.0 -5.2, $p < 0.01$). Students from VM had 1.6 times better attitudes than students from HS and NHS (OR = 1.6, CI=1.2- 2.1, p = 0.002). Finally, students in the field of veterinary medicine and those having good knowledge had 1.4 and 0.5 times better practice than their counterparts (OR=1.4; CI=1.2, 2.1, $p<0.01$ and OR= 0.5, CI=0.4, 0.6, $p<0.01$, respectively). In conclusion, there were critical gaps in knowledge, attitudes, and practices

among University students regarding antimicrobial usage and antimicrobial resistance. Hence, students are encouraged to exhaustively utilize the digital era to advance their knowledge. Interventions to raise awareness should also target students majoring in fields other than health sciences.

Keywords*:* AMR and AMU; KAP; students; Ethiopia.

Introduction

Antimicrobial resistance (AMR) is a multifaceted global public health issue affecting both human and animal populations. Antibiotic resistance must be carefully monitored, yet in the vast majority of developing nations; it is minimal to nonexistent (WHO, 2014). Additionally, most developing countries lack the necessary quality control practices to ensure that the antibiotics given are of the highest quality (Obodozie *et al.,* 2006). Antibiotic overuse, underuse, and misuse will result in the emergence of antimicrobial resistance (Ventola, 2015) and manifest in an attempt to treat infectious diseases in humans and animals as well as when used as a growth promoter in animals (Robinson *et al*., 2016). In addition to other equally significant social and cultural factors, self-medication, erroneous prescription, inappropriate intake, and excessive use of these antimicrobial medications are the main causes of the development and spread of AMR. Antibiotic self-medication has emerged as a significant issue and a major contributor to antibiotic resistance. It can be caused by a variety of issues, including a lack of awareness regarding appropriate antibiotic usage policies, a lack of public understanding and attitude toward antibiotics, and easy access to antibiotics in many locations (Jairoun *et al*., 2019).

Sunusi *et al.* (2019) reported inappropriate antibiotic usage among college students is documented as a result of self-medication and inadequate antibacterial agent understanding; particularly, their indications, their pathogen specificity, and the adherence to dosing schedules. Taking antibiotics for a short period can lead to drug resistance development in pathogenic bacteria. Stopping a course of antibiotics early may lead to a relapse of illness for the patient and increase the risk of infected individuals passing drug-resistant pathogens to others. Some people stop taking prescribed antibiotics early due to unpleasant side effects because they are feeling better, or because they want to save the remaining antibiotics for later use or to share with others (Mallhi *et al*., 2019).

Future prescribers, such as human and animal health students, must be well prepared throughout their training to contribute to the prevention of AMR. As demonstrated previously, the information learned during training will aid in forming future prescribers' proper attitudes and views regarding the usage of antimicrobials and antimicrobial resistance (Heaton *et al*., 2008). Therefore, it is undeniable that educational interventions, particularly those at the undergraduate level are still essential and should receive special emphasis in the effort to combat antimicrobial resistance. If educational interventions are not properly managed, AMR will continue to be a significant public health issue; with microbes gaining resistance to almost all antimicrobials (Ross and Maxwell, 2012). Antibiotic misuse and the pace of resistance development are closely related, therefore, it is crucial to use antibiotics responsibly in both animal and human health systems to stop the emergence of resistance (Hockenhull *et al*., 2017).

Knowledge, attitude, and practice (KAP) surveys are representative of a specific population to collect information on what is known, believed, and done about a particular topic, and are the most frequently used study tool in health-seeking behavior research (WHO, 2008). Knowledge is usually assessed to see how far students' knowledge corresponds to biomedical concepts (Perring, 1994). Attitude has been defined as "a learned predisposition to think, feel and act in a particular way towards a given object or class of objects" (Ribeaux *et al*., 1978). As such, attitude is a product of a complex interaction of beliefs, feelings, and values. Practices in KAP surveys usually enquire about the use of antimicrobials. Finding out what the public knows, thinks, and does about using antimicrobials helps to plan effective AMR prevention initiatives. As far as we are aware, no research has been conducted in Ethiopia to highlight an in-depth KAP among wider University students. Hence, this study aims to ascertain KAPs toward antimicrobial usage and antimicrobial resistance among Ethiopian public University students.

Material and methods

Description of the study area

The study was carried out at purposely selected 10 public Universities located in different regional states of Ethiopia: University of Gondar (Northern), Metu, and Dambi Dolo Universities (Western), Jimma University (Southwest), Adama Science and Technology and Addis Ababa Universities (central Ethiopia),

Arbaminch, Wolaita Sodo, and Hawassa Universities (Southern), and Haramaya University (Eastern). The Universities were selected purposively based on their geographical location, accessibility, and willingness to participate in this study (Figure 1).

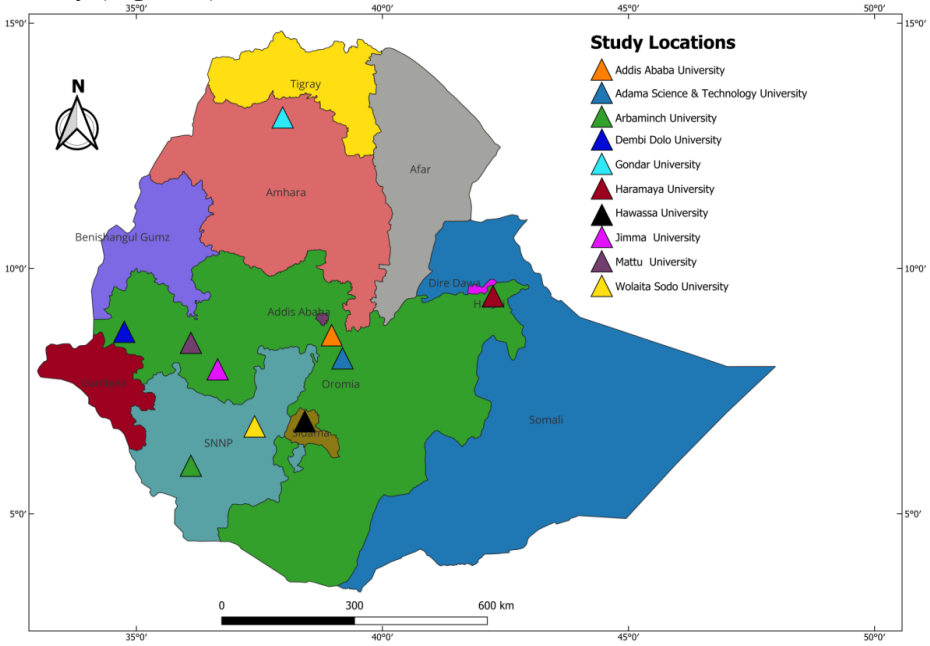

Figure 1. Map of the study area

Study design

A University-based cross-sectional survey was conducted among randomly selected students of human health-related sciences (medicine, pharmacy, nursing, public health, and midwifery), non-human health-related sciences (engineering, computational, social, and business and agriculture), and veterinary medicine students to assess their KAP towards antimicrobial usage and antimicrobial resistance.

Sample size determination

The calculation for the single population proportion was used to determine the sample size (Thrusfield, 2005) by using the following assumptions: a 95% level of confidence, a 5% margin of error, a 50% proportion of low knowledge,

and a 10% non-response rate. A 10% non-response rate was included in the minimum estimated sample size of 423*3=1269 (Bolarinwa, 2020). Of 1269 students, only 1,252 students filed the questionnaire for participation (the response rate was 98.7%).

Data collection

Based on a review of the literature, a structured questionnaire was developed and modified to address all of the major themes of the research issue of antimicrobial usage and antimicrobial resistance (Jairoun *et al*., 2019; Sylvia, 2019; WHO, 2015; Huang *et al*., 2014). The questionnaire's content, design, relevance, readability, and comprehension were then examined and evaluated by subject-matter experts. Ten students and 10 subject-matter specialists participated in pilot research to evaluate the validity and reliability of the questions. Data from the pilot study were not included in the findings but were used to make minor changes to the questions based on the review of the comments that were gathered.

Data management and analysis

Data were entered into a Microsoft Excel spreadsheet and the analysis was made using SPSS version 26.0. To summarize the data, descriptive statistics including frequency, percentages, and median (IQR) were generated. Each respondent's responses to questions on their knowledge, attitude, and practices received a score. Participants received a score of "0" for each question with a 'No' response and a score of "1" for each question with a 'Yes' response for all knowledge, attitude, and practice questions. Following the addition of all the scores, those with scores equal to and above the median were classified as having "good" knowledge, a 'positive' attitude, and 'good' practice, respectively (Kassahun and Mekonen, 2017). The Kruskal-Wallis test and chi-square tests were used to examine how the median scores in each of the knowledge, attitude, and practice categories varied across study participants. To identify the factors that are associated with good knowledge, positive attitudes, and good practices of antimicrobial usage and antimicrobial resistance, multivariate logistic regression was used in conjunction with the independent variables of socio-demographic profiles (Fetensa *et al*., 2020). In the final model, variables with a p-value of 0.05 or lower were deemed significant.

Ethics approval and consent to participate

This research was reviewed and approved by the ethical committees of Addis Ababa University, College of Health Science, IRB (Protocol No.: 031/21), and the University of Liverpool (Reference No.: 9935). A verbal consent was obtained from the students and thereafter they were requested to finish a self-administered survey during their free time.

Results

Socio-demographic profiles of participants

Based on their fields of study, students were divided into three groups: 33.0% (n = 413) from human health-related sciences (HS) (medicine, pharmacy, nursing, public health, midwifery, and biomedical sciences); 27.9% (n = 349) from non-health related sciences (NHS) (engineering, computational, social, business administration, agriculture, arts, and education); and the remaining 39.1% (490) were majoring in veterinary medicine (VM). Overall, more than half of the participants 760 (60.7%) were males, and the mean age of the respondents was 22.31 ± 1.4 years.

Knowledge of antimicrobial usage and antimicrobial resistance

The overall median antimicrobial usage and antimicrobial resistance knowledge score was 13 (IQR=11, 14). Table, 1 shows Ethiopian public University students' knowledge of antimicrobial resistance and antimicrobial usage. The percentage of students in the VM, HS, and NHS fields of studies who correctly answered antimicrobial resistance and antimicrobial usage knowledge questions was 72.0%, 70.0%, and 15.8%, respectively. When asked if they had heard of antimicrobial resistance, 83.3%, 82.9%, and 72.2% of HS, VM, and NHS students responded that they had heard and are aware of antimicrobial resistance ($p<0.01$). A large proportion of students from HS (79.9%), NHS (55.6%), and VM (62.0%) stated that treatment of sick animals should be performed by both human and animal health professionals ($p<0.01$). The interesting point is that 89.2%, 70.0%, and 66.2% of VM, HS, and NHS students correctly answered that antibiotics should be purchased from drug stores or pharmacies based on a prescription ($p<0.01$).

Table 1. Summary of some of the knowledge about antimicrobial usage and antimicrobial resistance among University students in Ethiopia (n= 1252)*

Questions regarding AMU and AMR knowledge	Study discipline	No n (%)	Yes n (%)	X^2	*P value*
Microbes can become resistant to antimicrobials	Human health sciences Non-health science Veterinary medicine	28 (6.8) 199 (57.0) 49 (10.0)	385 (93.2) 150 (43.0) 441 (90.0)	345.8	<0.01
Are there bacteria in the human body that are good for our health?	Human health sciences Non-health science Veterinary medicine	16 (3.9) 152 (43.6) 154 (31.4)	397 (96.1) 197 (56.4) 336 (68.6)	169.6	<0.01
Can antibiotics be used to cure infections caused by viruses?	Human health sciences Non-health science Veterinary medicine	132 (32.0) 213 (61.0) 95 (19.4)	281(68.0) 136 (39.0) 395 (80.6)	157.8	<0.01
Antibiotics shouldn't be obtainable without a prescription at pharmacies.	Human health sciences Non-health science Veterinary medicine	245 (59.3) 206 (59.0) 181 (36.9)	168 (40.7) 143 (41.0) 309 (63.1)	59.1	<0.01
Have you heard of antimicrobial resistance?	Human health sciences Non-health science Veterinary medicine	69 (16.7) 97(27.8) 84 (17.1)	344 (83.3) 252 (72.2) 406 (82.9)	18.6	<0.01
Frequent use of antimicrobials will lead to a decrease in the number of treatment options	Human health sciences Non-health science Veterinary medicine	88 (21.3) 94 (26.9) 66 (13.5)	325 (78.7) 255 (73.1) 424 (86.5)	24.1	<0.01
Is efficacy better if the antibiotics are newer and the price is higher?	Human health sciences Non-health science Veterinary medicine	171 (41.4) 157 (45.0) 183 (37.3)	242 (58.6) 192 (55.0) 307 (62.7)	5.0	0.08
Amoxicillin is an antibiotic?	Human health sciences Non-health science Veterinary medicine	38 (9.2) 119 (34.1) 40 (8.2)	375 (90.8) 230 (65.9) 450 (91.8)	123.2	<0.01
Penicillin is an antibiotic	Human health sciences Non-health science Veterinary medicine	19 (4.6) 67 (19.2) 33 (6.7)	394 (95.4) 282 (80.8) 457 (93.3)	54.0	<0.01
Tetracycline is an antibiotic	Human health sciences Non-health science Veterinary medicine	33 (80.0) 85 (24.4) 60 (12.2)	380 (92.0) 264 (75.6) 430 (87.8)	44.1	<0.01

Questions regarding AMU and AMR knowledge	Study discipline	No n (%)	Yes n (%)	χ^2	*P value*
Bacteria that developed resistance in animals can become resistant in humans through the consumption of food of animal origin	Human health sciences Non-health science Veterinary medicine	216 (52.3) 174 (49.9) 100 (20.4)	197 (47.7) 175 (50.1) 390 (79.6)	119.3	<0.01
Treatment of sick animals should be carried out by both human and animal health professionals	Human health sciences Non-health science Veterinary medicine	83 (20.1) 155 (44.4) 186 (38.0)	330 (79.9) 194 (55.6) 304 (62.0)	56.0	<0.01
Antibiotics should be purchased from drug stores or pharmacies based on prescription	Human health sciences Non-health science Veterinary medicine	121 (22.3) 118 (33.8) 53 (10.8)	292 (70.0) 231 (66.2) 437 (89.2)	72.6	<0.001
It is good to use antimicrobials as additives with animal feeds	Human health sciences Non-health science Veterinary medicine	103 (24.9) 197 (56.4) 235 (48.0)	310 (75.1) 152 (43.6) 255 (52.0)	85.7	<0.01
Antimicrobials used to treat animals can remain within their tissues	Human health sciences Non-health science Veterinary medicine	265 (64.2) 213 (61.0) 156 (31.8)	148 (35.8) 136 (39.0) 334 (68.2)	114.6	<0.01

**' Yes or no' is exclusively the response of the respondents*

Attitudes on antimicrobial resistance and antimicrobial usage

Students were given various statements about their attitudes toward the use of antimicrobials and antimicrobial resistance and asked how many of them they thought were correct or incorrect (Table 2). The overall median antimicrobial usage and antimicrobial resistance attitudes score was 15 (IQR: 13, 15). A higher proportion of students from veterinary medicine (95.9%), human health-related sciences (89.0%), and non-human health-related sciences (NHS) (83.1%) agreed that antimicrobial resistance affects animal health and production (χ^2=38.2, p = 0.01). When students were asked about the inappropriate use of antibiotics, human health-related science students have a positive feeling that inappropriate use of antimicrobials is one of the reasons for the occurrence of antimicrobial resistance (93.5%), followed by veterinary medicine (92.0%), and non-health-sciences (84.5%) (χ^2=31.6, p< 0.01).

Table 2. Summary of the attitude of University students towards AMU and AMR in Ethiopia (n= 1252)*

Questions regarding attitude towards AMU and AMR	Study discipline	No n (%)	Yes n (%)	X^2	*p-value*
Antimicrobial resistance will affect your and your family's health	Human health sciences Non-health science Veterinary medicine	92 (22.3) 60 (17.2) 35 (7.1)	321 (77.7) 289 (82.8) 455 (92.9)	42.3	<0.01
Antimicrobial resistance will affect animal health and production	Human health sciences Non-health science Veterinary medicine	45 (10.9) 59 (16.9) 20 (4.1)	368 (89.1) 290 (83.1) 470 (95.9)	38.2	<0.01
I have sufficient knowledge of antibiotic use	Human health sciences Non-health science Veterinary medicine	300 (76.3) 211 (60.5) 307 (62.7)	102(24.7) 138 (39.5) 183 (37.3)	22.7	<0.01
It is necessary to give more education to clinical-level students about antimicrobial resistance	Human health sciences Non-health science Veterinary medicine	39 (9.4) 54 (15.5) 39 (8.0)	374 (90.6) 295 (84.5) 451 (92.0)	13.3	<0.01
Inappropriate use of antimicrobials causes antimicrobial resistance	Human health sciences Non-health science Veterinary medicine	27 (6.5) 59 (16.9) 32 (6.5)	386 (93.5) 290 (83.1) 458 (93.5)	31.6	<0.01
Poor infection control practices by healthcare professionals will cause the spread of antimicrobial resistance	Human health sciences Non-health science Veterinary medicine	33 (8.0) 34 (9.7) 58 (11.8)	380 (92.0) 315 (90.3) 432 (88.2)	3.7	0.16
Clinical-level students should get special training on the appropriate ways of prescribing antimicrobials before graduation	Human health sciences Non-health science Veterinary medicine	99 (24.0) 63 (18.1) 63 (12.9)	314 (76.0) 286 (81.9) 427 (87.1)	19.0	<0.01
Currently, antimicrobial resistance is a major problem in the world as well as in Ethiopia	Human health sciences Non-health science Veterinary medicine	46 (11.1) 46 (13.2) 25 (5.1)	367 (88.9) 303 (86.8) 465 (84.9)	18.1	<0.01
Prescribing antibiotics should be more closely controlled	Human health sciences Non-health science Veterinary medicine	29 (7.0) 68 (19.5) 37 (7.6)	384 (93.0) 281(80.5) 453 (92.4)	39.0	<0.01
Dispensing antibiotics without prescription or over-the-counter should be more closely controlled	Human health sciences Non-health science Veterinary medicine	49 (11.9) 92 (26.4) 98 (20.0)	364 (88.1) 257 (73.6) 392 (80.0)	25.8	<0.01

**'Yes or no' is exclusively the response of the respondents*

Practice on AMU and AMR

Students were given various statement practices about AMU and AMR and asked how many of them responded as 'yes' or 'no' (Table 3). The overall median AMU and AMR practice score was 10 (IQR: 10, 11). A higher proportion of NHS (81.1%), HS (72.2%), and VM (62.0%) students stated that they terminate antibiotics as soon as their complaints subside (χ^2=32.3, p<0.01). A higher proportion of HS students (71.9%) testified that they use antibiotics without a doctor's prescription, as do (66.8%) of NHS and 48.6% of VM (χ^2=57.5, p<0.01). Overall, a large proportion of students reported using antibiotics to treat a common cold (69.4%), sore throat (76.1%), when coughing up yellow-green (71.7%), and flu (76.4%).

Table 3. Summary of practice towards AMU and AMR among University students in Ethiopia (n= 1252)*.

Questions regarding practice towards AMU and AMR	Study discipline	No, n (%)	Yes, n (%)	X^2	P value
I stop antibiotics as soon as complaints lessen	Human health sciences	115 (27.8)	298 (72.2)	36.3	<0.01
	Non-health science	66 (18.9)	283 (81.1)		
	Veterinary medicine	186 (38.0)	304 (62.0)		
I use antibiotics prescribed by doctors	Human health sciences	15 (3.6)	394 (95.4)	3.2	0.20
	Non-health science	14 (4.0)	335 (96.0)		
	Veterinary medicine	10 (2.0)	479 (98.0)		
I follow the prescription after choosing an antibiotic	Human health sciences	32 (7.7)	381(92.3)	0.6	0.74
	Non-health science	23 (6.6)	326(93.4)		
	Veterinary medicine	32 (6.5)	458(93.5)		
I use antibiotics without the doctor's instructions	Human health sciences	116 (28.1)	297 (71.9)	57.5	<0.01
	Non-health science	116 (33.2)	233 (66.8)		
	Veterinary medicine	252 (51.4)	238 (48.6)		
I ask the doctor to prescribe antibiotics for the common cold	Human health sciences	214 (51.8)	214 (51.8)	68.1	<0.01
	Non-health science	267 (76.5)	267 (76.5)		
	Veterinary medicine	362 (73.9)	362 (73.9)		
I use antibiotics for the common cold	Human health sciences	173 (41.9)	240 (58.1)	37.1	<0.01
	Non-health science	89 (25.5)	260 (74.5)		
	Veterinary medicine	121 (24.7)	369 (75.3)		
I use antibiotics for acute bronchitis	Human health sciences	130 (31.5)	283 (68.5)	22.6	<0.01
	Non-health science	114 (32.7)	235 (67.3)		
	Veterinary medicine	97 (19.8)	393 (81.0)		
I use antibiotics when coughing up yellow/ green phlegm	Human health sciences	158 (38.3)	255 (61.7)	31.1	<0.01
	Non-health science	92 (26.4)	257 (73.6)		
	Veterinary medicine	104 (21.2)	386 (78.8)		
I use antibiotics for a sore throat caused by any microbe	Human health sciences	105 (25.4)	308 (74.6)	29.0	<0.01
	Non-health science	113 (32.4)	236 (67.6)		
	Veterinary medicine	81 (16.5)	409 (83.5)		
I use antibiotics for flu with a fever	Human health sciences	259 (62.7)	154 (37.3)	64.1	<0.01
	Non-health science	288 (82.5)	61 (17.5)		
	Veterinary medicine	409 (83.5)	81 (16.5)		

' Yes or no' is exclusively the response of the respondents

Factors associated with good knowledge, positive attitude, and practice on AMR and AMU

Multivariable logistic regression analysis revealed that students' fields of study were closely related to their level of good knowledge. Students from the field of HS had 18.4 times (OR = 18.4, CI =12.1 - 28.0; p<0.01) and those from VM had 12.7 (OR = 16.8, CI = 11.2 – 25.2, p<0.01) times better knowledge of AMU and AMR compared to students from NHS field of studies. Most of the demographic variables were significantly related to attitudes toward AMU and AMR. Moreover, students having good knowledge had 3.9 times more positive attitudes than students with poor knowledge (OR = 3.9, CI = 3.0 -5.2, p<0.01) (Table 4).

Table 4. Multivariable logistic regression analysis of factors associated with AMU and AMR among University students in Ethiopia (n= 1252)*.

Variables	Good knowledge			Positive attitude			Good practices		
	n (%) aOR (95% CI)	p-value	n (%)	aOR (95% CI)	p-value	n (%)	aOR (95% CI)	p-value	
Birth place									
Town	265 (67.9)	Ref		282 (72.3)	Ref		237 (60.8)	Ref	
Rural	593 (91.0)	0.5 (0.4,0.7)	<0.01	541 (62.8)	0.5 (0.4,0.7)	<0. 01	587 (68.1)	0.5 (0.4,0.7)	<0.01
Gender									
Male	511 (67.2)	Ref		516 (67.9	Ref		532 (70.0)	Ref	
Female	347 (70.5)	1.0 (0.8,1.3)	0.20	307 (62.4))	1.8 (1.4,2.3)	<0.01	292 (59.3)	1.8 (1.4,2.3)	<0.01
Year of Study									
3rd	281 (73.6)	Ref		244 (63.9)	Ref		242 (63.4)	Ref	
4th	317 (65.9)	1.4 (1.0, 2.0)	0.05	334 (69.4)	1.0 (0.7,1.3)	0.98	313 (65.1)	1.0 (0.7,1.3)	0.98
5th	260 (90.0)	1.2 (0.9,1.6)	0.43	245 (63.0)	1.3 (1.0, 1.3)	0.60	269 (69.2)	1.3 (1.0,1.7)	0.10
Field of study									

Variables	Good knowledge			Positive attitude			Good practices		
	n (%) aOR (95% CI)	p-value	n (%)	aOR (95% CI)	p-value	n (%)	aOR (95% CI)	p-value	
NHS	101 (28.9)	Ref		186 (53.3)	Ref		230 (66.0)	Ref	
HS	417 (85.1)	18.4 (12.1,28.0)	<0.01	384 (78.4)	0.9 (0.6, 1.2)	0.34	364 (74.3)	0.9 (0.6, 1.2)	0.4
VM	340 (82.3)	16.8 (11.2,25.2)	<0.01	253 (61.3)	1.6 (1.2,2.1)	<0.01	230 (55.7)	1.4 (1.2, 2.1)	<0.01
				Knowledge					
Poor	0(0)			176 (44.7)	Ref		286 (72.6)	Ref	
Good	858(100)			647 (75.4)	3.9 (3.0, 5.2)	<0.01	538 (62.7)	0.5 (0.4, 0.6)	<0.01
				Attitude					
Negative	211 (49.2)	Ref			Ref		315 (73.4)		
Positive	647 (78.6)						509 (61.8)	0.6 (0.5,0.8)	<0.01

**P-values were obtained from regression models. AMR: antimicrobial resistance, OR: odds ratio, CI: confidence interval, aOR: adjusted odds ratio, na: not applicable, NHS: non-health science, HS: human health science, VM: veterinary medicine*

Discussion

Overall, this study showed critical gaps in knowledge and practices among University students regarding AMU and AMR. Accordingly, it is only 15.8% of non-health science students correctly answered knowledge questions about AMU and AMR. Students in the health-related fields (both human and animal health) had better knowledge (higher percentages of correct answers) in almost all knowledge-related questions, and they also had positive attitudes toward AMU and AMR (higher percentages of correct answers in all attitude-related questions). This study revealed that the field of studies has an impact on the level of knowledge among students. Our finding showed that 90.7% of students irrespective of their field of studies were aware that antibiotics are used to treat bacterial infections. This result is consistent with Jairoun *et al.* (2019). However, Chang *et al.* (2021) and Pogurschi *et al.* (2022) have reported that only 49.0% and 22.2% of the respondents claimed that antibiotics kill bacteria, respectively. Hence, our result is very encouraging that almost all students are aware that antibiotics kill bacteria. Strikingly, 80.6% of VM students reported that viral infections can be treated with antibiotics. Pogurschi *et al.* (2022) reported that antibiotics are ineffective against viruses, however, 37.5% of respondents believe that antibiotics treat viral infections. Similar confusions have been reported by previous researchers (Alqarni and Abdulbari, 2019; Yusef *et al.,* 2018). Seid and Hussen (2018) reported that approximately 28.0% of the participants believed that antibiotics could kill both viruses and bacteria. Our findings were consistent with a study conducted in Portugal, in which more than 60.0% of participants agreed that antibiotics should be prescribed for viral illnesses (Azevedo *et al.*, 2009). Encouraging results were also recorded in this study that a large proportion of students had heard about AMR, and frequent use of antibiotics reduces treatment efficacy antibiotics. Jairoun *et al.* (2019) reported that a large proportion of respondents have similar agreements. This implies that a rigorous assessment of University students' knowledge would aid in the development of an educational program.

In terms of attitude, approximately 63.4% of students have correctly responded to questions regarding antimicrobial resistance and antimicrobial usage. Similar results (66.0%) were reported from India (Sadasivam *et al.,* 2016). This result, however, was lower than the report of Seid and Hussen (2018) in which 96.0% of students had a positive attitude toward antimicrobial resistance. The majority of students (85.1%) also stated that improper antibiotic usage can harm their families. Similarly, Seid and Hussen (2018) found that 90.7% of

the students agreed that their health and the health of their families will be impacted by antibiotic resistance. The vast majority of students (80.8%) irrespective of their field of studies agreed that dispensing antibiotics without a prescription should be strictly regulated. However, only a few students (26.0%) had not received instructions on how to take antibiotics or the importance of completing the entire duration of the treatment. It is worth noting that those who did not seek advice are more likely to discontinue antibiotics when they feel better, resulting in the spread of resistance in the community. Similar studies in Ethiopia and India found that 82.4% (Seid and Hussen, 2018) and 65.0% (Sadasivam *et al*., 2016) of participants believed that antibiotics should never be purchased as over-the-counter drugs.

In terms of practice, nearly 54.6% of students have correctly answered AMR and AMU practice questions; however, the appropriate use of antibiotics was not demonstrated in their daily lives. This is demonstrated by the proportion of students (70.7%) who reportedly stopped using antibiotics after symptom improvement; of which 72.2% (HS), 81.1% (NHS), and 62.0% (VM) students feel similarly. Previous studies in the UAE (Jairoun *et al*., 2019) (44.5%), Pakistan (Limaye *et al*., 2019) (28%), and Lebanon (Mouhieddine *et al*., 2015) (51.5%) found similar results. The tendency of stopping antibiotics after symptom improvement might be related to self-medication. Self-medication could be a potential factor in the medication's discontinuance. Medical students appear to disregard proper antibiotic use, which sets a poor example for the general public (Sylvia, 2019). Antibiotics were among the top three medications used for self-medication among undergraduate healthcare students in Nigeria, who believed they had acquired the necessary medical knowledge of what to use for a specific condition treated (Akande-Sholabi and Ajamu, 2021). However, Akande-Sholabi and Ajamu (2021) reported that the majority of participants (91.0%) always completed the entire course of treatment. Saving money on expensive consultation fees and the inconvenience of making a doctor's appointment for a mild illness are two possible justifications for storing antibiotics for potential respiratory illnesses and using leftover antibiotics.

This study also showed critical gaps in AMR and AMU practice among students; a large proportion of students 69.4%, 76.1%, 71.7%, and 76.4%, respectively, claimed using antibiotics to treat the common cold, or sore throat, when coughing up yellow-green, and flu. Similar studies in Nigeria and Rwanda found that 50.0% and 20.0% of study participants had used antibiotics to treat common colds and sore throats, respectively (Akande-Sholabi and Ajamu,

2021; Nisabwe *et al*., 2020). This inappropriate use of antibiotics could be attributed to a lack of knowledge about antimicrobial use. A systematic review of antibiotic use for the common cold and acute purulent rhinitis, on the other hand, found that antibiotics have no benefit for the common cold, sore throat, and cough (Kenealy and Arroll, 2013). Moreover, a majority of students (61.3%) reported using antibiotics without a doctor's prescription. In a similar study from Nigeria, however, 86% of participants always consulted a doctor before beginning an antibiotic regimen. Nonetheless, only 65.0% agreed that antibiotics should never be purchased as over-the-counter drugs, and doctors take the time to explain the dos' and don'ts of antibiotics in detail. According to Kalungia *et al*. (2019) and Fadare *et al*. (2019), reinforcing antimicrobial stewardship in all health facilities would raise antimicrobial resistance awareness among healthcare professionals.

This study also revealed that 61.3% of the students claimed to have obtained antibiotics without a prescription from vendors or drug stores. Reynolds and Rodin (2009) supplemented our finding that due to relatively lax antibiotic regulations, it is not difficult to obtain antibiotics without a proper prescription (over-the-counter acquisition) in China. Personal observation also showed that purchasing antibiotics without a prescription is a common phenomenon in Ethiopia. This indicates a lack of stringent enforcement of laws and regulations governing how antibiotics are prescribed and dispensed in retail pharmacies. Lukovic *et al*. (2014) revealed that the prevalence of non-prescription drug use is quite high and common among medical students. Personal observation also revealed that there is an indiscriminate abuse of prescription drugs for non-prescription drugs among several pharmaceutical shops in different areas of the country. As far as someone can afford the prices, several pharmaceutical shops can sell them to their customers. Alnasser *et al*. (2021) stressed that the public should be educated on the effectiveness of these medications and how they should be used to reduce AMR. Age, educational level, family attitudes, drug manufacturer advertising, laws governing the dispensing and sale of pharmaceuticals, prior experiences with the symptoms or condition, and significance attached to the disease are factors that have been found to influence how often people self-medicate (Zhu *et al*., 2016), prescription medicines kept at home (Klemenc-Ketis and Kersnik, 2010) and financial circumstance of responders (James *et al*., 2006). It has to be noted that there is a risk of overprescribing antibiotics in retail pharmacies and among vendors if antimicrobial susceptibility tests are not performed. Hence, the findings of this study support strict enforcement of laws and regulations governing how antibiotics are

prescribed and dispensed in retail pharmacies. In conclusion, this study has demonstrated there were critical gaps regarding antimicrobial use and antimicrobial resistance among University students. Hence, students are encouraged to use additional online training platforms to advance their knowledge. Moreover, interventions to raise awareness should also target students majoring in fields other than health sciences is recommended.

Limitations of the study

As the measurements were cross-sectional, we cannot document causal relationships. Moreover, the survey was a self-administered questionnaire; thus, the use of antimicrobials was self-reported, and the frequency of antimicrobial use may be overestimated or underestimated due to recall bias. The results obtained in this study were dependent on the recall ability and honesty of the respondents and hence, underreporting or overreporting could not be ruled out.

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References

Akande-Sholabi, W. and Ajamu, A.T., 2021. Antimicrobial stewardship: Assessment of knowledge, awareness of antimicrobial resistance and appropriate antibiotic use among healthcare students in a Nigerian University. *BMC Med. Educ.*, 21(1), 1–8.

Alnasser, A.H.A., Al-Tawfi, J.A., Ahmed, H.A.A., Alqithami, S.M.H., Alhaddad, Z.M.A., Rabiah, A. S.M., *et al*., 2021. Public knowledge, attitude and practice towards antibiotics use and antimicrobial resistance in Saudi Arabia: A web-based cross-sectional survey. *J. Public Health Res.*, 10(4), 711–718.

Alqarni, S.A. and Abdulbari, M., 2019. knowledge and attitude towards antibiotic Use within consumers in Alkharj, Saudi Arabia. *Saudi Pharm. J.*, 27, 106–111.

Azevedo, M.M., Pinheiro, C., Yaphe, J. and Baltazar, F., 2009. Portuguese students' knowledge of antibiotics: A cross-sectional study of secondary school and university students in Braga. *BMC Public Health*, 9, 1–6.

Bolarinwa, O.A., 2020. Sample size estimation for health and social science researchers: the principles and considerations for different study designs. *Niger Postgrad. Med. J.*, 27(2), 67.

Chang, C.T., Lee, M., Lee, J.C.Y., Lee, N.C.T., Ng, T.Y., Shafie, A.A., *et al.,* 2021. Public KAP towards COVID-19 and antibiotics resistance: A Malaysian survey of knowledge and awareness. *Int. J. Environ. Res. Public Health*, 18(8), 3964.

Fadare, J.O., Ogunleye, O., Iliyasu, G., Adeoti, A., Schellack, N., Engler, D., *et al.,* 2019. Status of antimicrobial stewardship programs in Nigerian tertiary healthcare facilities: Findings and implications. *J. Glob. Antimicrob. Resist.*, 17, 132–136.

Fetensa, G., Wakuma, B., Tolossa, T., Fekadu, G., Bekuma, T. T., Fayisa, L., *et al.*, 2020. Knowledge and attitude towards antimicrobial resistance of graduating health science students of Wollega University. *Infect Drug Resist*, 13, 3937–3944.

Heaton, A., Webb, D. J. and Maxwell, S. R. (2008). Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. *Br. J. Clin. Pharmacol*., 66(1), 128-134.

Hockenhull, J., Turner, A. E., Reyher, K. K., Barrett, D. C., Jones, L., Hinchliffe, S., *et al.,* 2017. Antimicrobial use in food producing animals: a rapid evidence assessment of stakeholder practices and beliefs. *Vet. Rec*., 181(19), 510-510.

Huang, X., Zou, X., Zhao, J., Shi, J., Zhang, X., Li, Z., *et al.,* 2014. Sensing the quality parameters of Chinese traditional Yao-meat by using a colorimetric sensor combined with genetic algorithm partial least squares regression. *Meat Sci.*, 98(2), 203–210.

Jairoun, A., Hassan, N., Ali, A., Jairoun, O., Shahwan, M. and Hassali, M., 2019. University students' knowledge, attitudes, and practice regarding antibiotic use and associated factors: A cross-sectional study in the United Arab Emirates. *Int. J. Gen. Med.*, 12, 235–246.

James, H., Handu, S. S., Al Khaja, K. A., Otoom, S. and Sequeira, R. P., 2006. Evaluation of the knowledge, attitude, and practice of self-medication among first-year medical students. *Med. Princ. Pract.*, 15(4), 270-275.

Kalungia, A.C., Mwambula, H., Munkombwe, D., Marshall, S., Schellack, N., May, C., Jones, A.S. C. and Godman, B., 2019. Antimicrobial stewardship knowledge and perception among physicians and pharmacists at leading tertiary teaching hospitals in Zambia: implications for future policy and practice. *J. Chemother.*, 31(7–8), 378–387.

Kassahun, C. W. and Mekonen, A. G., 2017. Knowledge, attitude, practices and their associated factors towards Diabetes mellitus among non-diabetes community mem-

bers of Bale Zone administrative towns, South East Ethiopia. A cross-sectional study. *PloS one*, 12(2), e0170040.

Kenealy, T. and Arroll, B., 2013. Antibiotics for the common cold and acute purulent rhinitis. In Cochrane Database of Systematic Reviews. John Wiley and Sons Ltd.

Limaye, D., Ziesenis, P., Limaye, V., Ahmad, M., Saeed, F., Rizvi, R., *et al*., 2019. Knowledge, attitude, and practices of antibiotic usage among University students from Karachi, Pakistan. *J. Res. Med. Sci.*, 7(2), 519.

Mallhi, I. Y., Sohaib, M., Khan, A. U., Nawaz, M. and Abdullah. 2019. Evaluating food safety knowledge, practices, and microbial profile of meat in abattoirs and butchery shops in Lahore, Pakistan. *J. Food Saf.*, 39(2), 1–7.

Mouhieddine, T.H., Olleik, Z., Itani, M.M., Kawtharani, S., Nassar, H., Hassoun, R., *et al*., 2015. Assessing the Lebanese population for their knowledge, attitudes, and practices of antibiotic usage. *J. Infect. Public Health*, 8(1), 20–31.

Nisabwe, L., Brice, H., Umuhire, M.C., Gwira, O., Harelimana, J.D.D., Nzeyimana, Z., *et al*., 2020. Knowledge and attitudes towards antibiotic use and resistance among undergraduate healthcare students at University of Rwanda. *J. Pharm. Policy Pract.*, 13(1). 7. https://doi.org/10.1186/s40545-020-00207-5.

Obodozie, O. O., Mustapha, K. B., Ebeshi, B. U. and Inyang, U. S. (2006). A comparative study on the prevalence of substandard ampicillin/cloxacillin preparations in the Nigerian market: Mid-1990s and present. *JOPAT*, 11. Doi: 10.4314/jopat.v11i1.48619.

Perring, C.M., 1994. Medicine, Rationality, and Experience: An Anthropological Perspective. Sociology, 28(3), 823-825.

Pogurschi, E.N., Petcu, C.D., Mizeranschi, A.E., Zugravu, C.A., Cirnatu, D., Pet, I., *et al.,* 2022. Knowledge, attitudes, and practices regarding antibiotic use and antibiotic resistance: A latent class analysis of a Romanian population. *Int. J. Environ. Res. Public Health*, 19(12). 7263. doi 10.3390/ijerph19127263.

Reynolds, E.H., & Rodin, E., 2009. The clinical concept of epilepsy. *Epilepsia*, 50(3), 2–7.

Ribeaux, P., Poppleton, S. E., Ribeaux, P. and Poppleton, S. E., 1978. Psychology and Work: an introduction, Macmillan Education UK, 294-313.

Robinson, T.P., Bu, D.P., Carrique-Mas, J., Fèvre, E.M., Gilbert, M., Grace, D., *et al*., 2016. Antibiotic resistance is the quintessential One Health issue. *Trans. R. Soc. Trop. Med. Hyg.*, 110(7), 377–380.

Ross, S. and Maxwell, S., 2012. Prescribing and the core curriculum for tomorrow's doctors: BPS curriculum in clinical pharmacology and prescribing for medical students. *Br. J. Clin. Pharmacol.*, 74(4), 644-661.

Sadasivam, K., Chinnasami, B., Ramraj, B., Karthick, N. and Saravanan, A., 2016. Knowledge, attitude, and practice of paramedical staff towards antibiotic usage and its resistance. *Biomed. Pharmacol. J.*, 9(1), 337-343.

Seid, M.A. and Hussen, M.S., 2018. Knowledge and attitude towards antimicrobial resistance among final year undergraduate paramedical students at University of Gondar, Ethiopia. *BMC Infect. Dis.*, 18(1), 1–8.

Sunusi, L.S.A., Awad, M.M., Hassan, N.M. and Isa, C.A., 2019. Assessment of knowledge and attitude toward antibiotic use and resistance among students of the International University of Africa, medical complex, Sudan. *Glob. Drug Ther.*, 4, 1-6. doi: 10.15761/GDT.1000171.

Sylvia, S.C., 2019. Knowledge, practice, and attitude of antibiotic usage: a questionnaire-based study among medical students. *Indian J. Appl. Res.*, 9(12), 18–20.

Tegegne, H. A. and Phyo, H.W.W., 2017. Food safety knowledge, attitude, and practices of meat handlers in abattoir and retail meat shops of Jigjiga town, Ethiopia. *J. Prev. Med. Hyg.*, 58(4), E320-E327. doi 10.15167/2421-4248/jpmh2017.58.4.737.

Tesfaye, A. and Tegene, Y., 2020. Assessment of food hygiene and safety practices among street food vendors and its associated factors in urban areas of Shashemane, West Arsi Zone, Oromia, Ethiopia, 2019. *Sci. J. Immunol. Immunother.*, 4, 1-5.

Thrusfield, M., 2005. Veterinary epidemiology (2nd Edition). Blackwell Science, Oxford.

Turner, J. C. and Keller, A., 2015. College health surveillance network: epidemiology and health care utilization of college students at US 4-year Universities. *J. Am. Coll. Health*, 63(8), 530-538.

Ventola, C.L., 2015. The antibiotic resistance crisis: part 1: causes and threats. *P.T.,* 40(4), 277.

World Health Organization and Stop TB Partnership, 2008. Advocacy, communication and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys. World Health Organization. https://apps.who.int/iris/handle/10665/43790.

World Health Organization, 2015. Antibiotic resistance: multi-country public awareness survey. World Health Organization. https://apps.who.int/iris/handle/10665/194460.

World Health Organization, 2014. Antimicrobial resistance global report on surveillance: 2014 summary (No. WHO/HSE/PED/AIP/2014.2). World Health Organization.

Yoder, P. S., 1997. Negotiating relevance: belief, knowledge, and practice in international health projects. *Med. Anthropol. Q.*, 11(2), 131-146.

Yusef, D., Babaa, A.I., Bashaireh, A.Z., Al-Bawayeh, H.H., Al-Rijjal, K., Nedal, M. *et al*., 2018. Knowledge, practices and attitude toward antibiotics use and bacterial resistance in Jordan: a cross-sectional study. *Infect. Dis. Health*, 23(1), 33-40.

Zhu, X., Pan, H., Yang, Z., Cui, B., Zhang, D. and Ba-Thein, W., 2016. Self-medication practices with antibiotics among Chinese University students. *Public Health*, 130, 78-83.