

Antibiotic resistance: a hospital-based multicenter study in Tabuk city, Kingdom of Saudi Arabia

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Umar Yagoub¹
Bandar Al Qahtani²
Ibrahim AL Hariri³
Attiya Al Zahrani⁴
Kashif Siddique¹

¹Research Department, Academic Affairs, King Salman Armed Forces Hospital Northwestern Region, Tabuk 71411, Saudi Arabia; ²Department of Academic Affairs, King Salman Armed Forces Hospital Northwestern Region, Tabuk 71411, Saudi Arabia; ³Department of Family Medicine, King Salman Armed Forces Hospital Northwestern Region, Tabuk 71411, Saudi Arabia; ⁴Department of Surgery, King Salman Armed Forces Hospital Northwestern Region, Tabuk 71411, Saudi Arabia

Background: During the 21st century, antimicrobial resistance (AMR) has emerged as one of the greatest public health challenges worldwide. In the coming 20 years, health care systems may be unable to treat bacterial diseases efficiently due to this phenomenon.

Objective: To determine the level of knowledge regarding AMR among patients attending two hospitals in Tabuk city in northeast Kingdom of Saudi Arabia (KSA).

Materials and Methods: This cross-sectional study was conducted at King Salman Armed Forces Hospital and King Khalid Armed Forces Hospital in Tabuk city. The study participants were selected from different outpatient departments using a simple random sampling technique. Data collection was performed using a self-reported questionnaire. All of the questions were closed-ended to facilitate study participation and were translated into Arabic. The data were entered into SPSS version 22 for Windows, cleaned and managed before analysis.

Results: Our results showed that 26.85% of the respondents had knowledge regarding antibiotic resistance. Knowledge regarding the use of antibiotics for treating bacterial infection was good among participants (60%), but responses related to viral infection indicated confusion (23.06%), and misconceptions were observed. Several factors were significantly associated with knowledge regarding AMR among participants: 1) the use of antibiotics in the last year (OR: 2.102, CI: 0.654–6.754); 2) the discontinued use of antibiotics when feeling better (OR: 8.285, CI: 3.918–17.523); 3) giving antibiotics to friends or family members to treat the same illness ([False]: OR: 108.96, CI: 29.98–395.93) and 4) asking doctors to prescribe antibiotics that had been previously administered for the same symptoms (OR: 9.314, CI: 3.684–23.550).

Conclusion: Our results revealed a very high unawareness of AMR and its contributing factors among the study participants. Thus, health education and awareness are highly and urgently recommended to address AMR in the Tabuk area.

Keywords: antibiotic, resistance, knowledge, self-medication

Introduction

Antimicrobial resistance (AMR) has emerged as one of the most important challenges of public health care during the last 10 years and is considered to be one of the primary risks to human health.^{1,2} AMR is defined as the ability of a microorganism to survive or grow in the presence of a concentration of antibiotics that should be enough to restrain or kill that organism.³ In the coming 20 years, health care systems may be unable to treat bacterial diseases efficiently.⁴ Infections caused by multidrug-resistant microorganisms result in increased mortality, morbidity, and higher hospitalization rates as well as increased complications and health care costs.⁵

Correspondence: Umar Yagoub
Research Department, Academic Affairs,
King Salman Armed Forces Hospital
Northwestern Region, Tabuk 71411,
Saudi Arabia
Tel +9 661 444 1088 Ext 85818
Email mohammedumar2001@yahoo.com

Exacerbating factors responsible for the development of AMR include poor knowledge, misconceptions, views on infectious diseases, inappropriate prescription and medication use and patient demand.^{6–10}

Misconceptions regarding the therapeutic effects of antibiotics have shown that people consider antibiotics to be extraordinary medications that can be used to treat any infection caused by viruses, bacteria or fungi.¹¹ Thus, the problem of AMR can be minimized if the general population possesses good knowledge of the appropriate use of antibiotics.¹²

In the Middle East region, the Kingdom of Saudi Arabia is among the richest developing countries, and its population is multiethnic.¹³ In most of the government hospitals in Saudi Arabia, medication provision and doctor consultation are free, and self-medication with antibiotics and nondoctor prescriptions are very common in the community. There are many reasons for self-medication with antibiotics: if patients use particular antibiotics for specific signs and symptoms in the past, he may use the same antibiotics if he feels his current illness is similar to the one the past. Other reasons such as friend advice based on similar experience or if the pharmacy is near to the patients' residence and the hospital is far from patients may encourage self-prescription with antibiotics. A bad doctor–patient relationship may also discourage doctor consultations and encourage self-medication with antibiotics, such as the distance to the hospital being too far or advice from friends with regards to self-medication with antibiotics leading to no other information being obtained.¹³

Internationally, the KSA has been recognized as a country with escalating AMR, which is a concern for the Kingdom health authorities.¹⁴ According to the results of a previous study, the use of antibiotics without any prescriptions is quite frequent in the community, and antibiotics are used to treat inappropriate conditions.¹⁵

The public has easy access to antibiotics, and the availability of antibiotics is uncontrolled in the KSA. This frequent and easy access to antibiotics changes the perspective of interventions initiated by the health authorities to control the irrational use of antibiotics that leads to AMR.^{16,17} To date, very few studies have been reported on AMR in the KSA. However, the results of available studies have shown that there is very poor knowledge regarding antibiotic use and AMR among the general population.^{13,17}

To tackle the urgent issues surrounding AMR in Saudi Arabia, it is of vital importance to raise public awareness regarding this issue. A better understanding regarding the spread of AMR can encourage the general population to avoid practices and behaviors that spread antibiotic resistance.¹⁸

In the KSA, there is no national surveillance system of AMR and health care-acquired infections. To date, no study has been conducted in Tabuk (North Western region) to assess the knowledge and awareness of people regarding antibiotic resistance. Therefore, the results of this study will provide data concerning the knowledge regarding AMR in Tabuk. In addition, this study will help the medical service division in planning and formulating new educational strategies and interventions to promote the appropriate use of antibiotics among the general population to minimize the escalating rate of AMR in this region. Therefore, we designed this study to determine the level of knowledge regarding AMR in the general population in Tabuk city. The locality of the study is shown in [Figure 1](#).

Materials and methods

Study design, sample size calculation and sampling

This was a hospital-based cross-sectional study that was conducted in King Salman Armed Forces Hospital and King Khalid Armed Forces Hospital in Tabuk City between November 2016 and October 2017. The inclusion criteria for the study participants were that they be adults (either sex, male or female) and Saudi nationals who willingly agreed to participate in the study. Those who refused to participate, could not read the study questionnaire, were below 18 years of age or refused to participate were excluded from the study. Verbal consent to participate in the study was obtained prior to the start of the study, and parents or legal guardian of any participant under the age of 18 years provided this consent. The sample size was collected from the two hospitals mentioned above which are the main hospitals in the city of Tabuk. The outpatient departments in the two hospitals are the main areas where most of the patients are seen for treatment and follow-up. The sample size was based on a single proportion using the following formula adopted from Cochran (1977).

$$n = \frac{Z^2 p(1-p)}{d^2}$$

n: the sample size=1,066



Figure 1 Study area location.

p: the probability of success (ie, AMR knowledge) =47.9%

Z: the standardized variable that corresponds to a 95% level of confidence=95%

d: the desired marginal error=3%

According to this formula, knowledge regarding AMR in Saudi Arabia was reported as 47.9%.¹⁷ Using this percentage and other parameters in the formula, the calculated sample size was 1,066. Additionally, it is important to consider the nonresponse rate, which we suggest was 20% of the total recruitment number (1,066), yielding a value of 213. The total sample size was 1,279 participants.

The study participants were selected from a range of different outpatient departments from King Salman Armed Forces Hospital and King Khaled Armed Forces Hospital which are now one hospital under the same administration using a simple random sampling technique by a trained research assistant. This is done through a computer-generated process in which each of the patients is assigned a number, after which the requested sample would be chosen at random. The dependent variable (AMR knowledge among study participants) and independent variables (sociodemographic characteristics, factors leading to antibiotic resistance, different diseases that can be treated with

antibiotics and problems of antibiotic resistance) were recorded.

Study instrument and data collection

The self-reported study questionnaire was developed following an extensive literature review of similar studies, and the AMR report published by the WHO was also used. The questionnaire consisted of two parts. The first part included sociodemographic characteristics and the second part consisted of three sections: the use of antibiotics, participants' general knowledge about antibiotics and participants' knowledge about antibiotic resistance. All of the questions were close-ended. The study questionnaire was forward and backward translated from English into Arabic with the help of a bilingual translator. The pretested and validated study instrument was first pilot-tested on 20 participants and then administered to the study participants who fulfilled the inclusion criteria by research assistants. Before analysis, the data were entered into SPSS IBM version 22 for Windows, cleaned and preprocessed, which involved accuracy checking, treatment of missing values and categorization of study variables.

Data analysis and modeling

Data analysis was performed using SPSS version 22. Quantitative variables are presented as means \pm SDs.

Qualitative variables are presented using frequency tables and percentages. Multiple logistic regression was used to identify the factors associated with antibiotic resistance. All of the statistical values were considered significant at $P \leq 0.05$. Only the results of multivariate logistic analyses are reported, showing ORs and 95% CI.

Ethical approval

Ethical approval was obtained from the Research Ethical Committee of King Salam Armed Forces Hospital under project number RREC2016-145. The Research Ethical Committee also covers King Khalid Armed Forces Hospital. Verbal informed consent was acceptable and approved by the approving research ethics committee.

Results

Of the 1,279 participants, 1,188 completed questionnaires without any missing values after data cleaning and management. The response rate was 93%.

Table 1 shows the sociodemographic characteristics of the study participants, while Figure 2 shows the responses of participants regarding the use of antibiotics for treating certain conditions. The top 5 common conditions for which antibiotics were used were urinary tract infection (UTI), diarrhea, sore throat, gonorrhea and skin or wound infection, whereas the least common conditions were headache, HIV/AIDS, cold and flu and measles. Figure 3 shows the knowledge of participants regarding AMR terminology, while Table 2 shows the knowledge of participants regarding antibiotic resistance. Only 10.2% of participants knew that AMR develops when bacteria become resistant to antibiotics, 17.6% of participants knew that it is difficult to cure an infection in the presence of antibiotic resistant bacteria and 25% of respondents knew that surgical procedures are dangerous during an AMR infection. Furthermore, 32.4% of respondents told us that they used antibiotics for the duration prescribed by the doctor, while 24.1% of respondents reported that they stopped taking antibiotics before the end of the treatment.

The results of the multiple logistic regression analysis (Table 4) revealed that several factors showed a significant association with the knowledge of the participants regarding antibiotic resistance (Table 3): age; region; education; monthly income; nationality; job status; use of antibiotics (in the last 6 months and more than a year ago); time of prescription; time during the antibiotic course when participants stopped taking antibiotics; giving antibiotics to a friend or family member as long as the antibiotics were

Table 1 Demographic characteristics of the study participants (n=1,188)

Characteristics	n	Percentage (%)
Age (years)		
16–24	297	25.0
25–33	389	32.7
34–42	385	32.4
43–51	59	5.0
52–60	58	4.9
Total	1,188	100
Sex		
Male	913	76.9
Female	275	23.1
Total	1,188	100
Residence		
Tabuk city	935	78.7
Rural side of Tabuk city	253	21.3
Total	1,188	100
Education		
No formal schooling	78	6.6
12th grade or less	166	14.0
High school graduate with diploma	366	30.8
Technical/vocational training or associate degree	198	16.7
University graduate with bachelor's degree	253	21.3
Postgraduate degree	126	10.7
Total	1,188	100
Monthly income (SR)		
≤5,000	143	12.0
5,001–1,000	242	20.4
10,001–15,000	330	27.8
≥15,000	473	39.8
Total	1,188	100%
Nationality		
Saudi	1,078	90.7
Non-Saudi	110	9.3
Total	1,188	100
Job status		
Not employed	924	77.8
Employed	99	8.3
Retired	165	13.9
Total	1,188	100

used to treat the same illness; and buying the same antibiotics from a doctor if the participant was sick and the

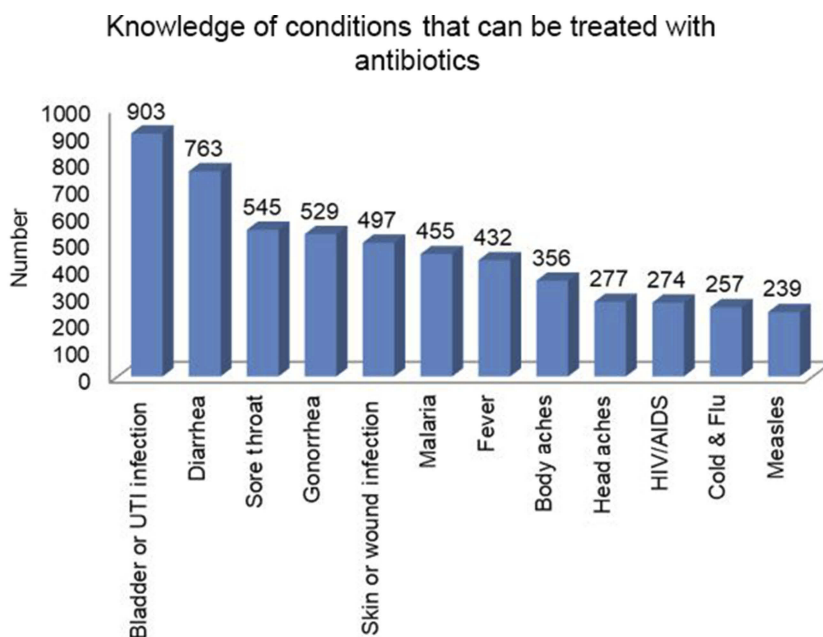


Figure 2 Participants' knowledge of conditions that can be treated with antibiotics.

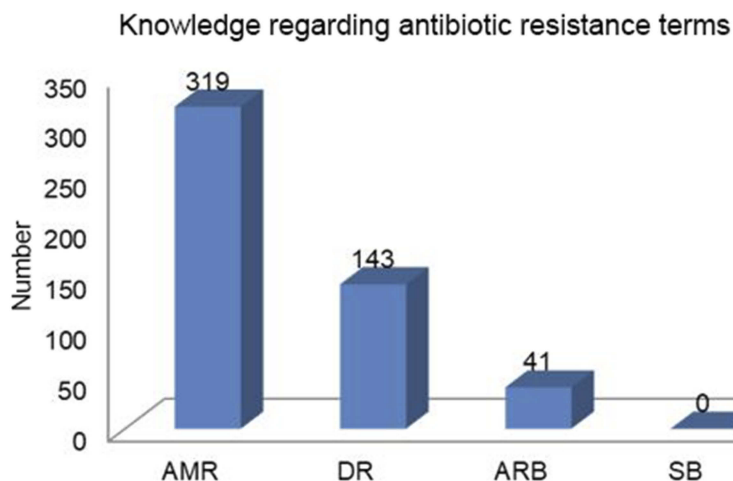


Figure 3 Participants' knowledge regarding antimicrobial resistance.

Abbreviations: AMR, antimicrobial resistance; DR, drug resistance; ARB, antibiotic resistant bacteria; SB, superbugs (multidrug resistance bacteria).

same antibiotics had helped the participant recover from the same symptoms. Before multiple logistic regression analysis, all possible confounding variables were considered.

Discussion

The primary objective of this study was to determine the level of knowledge regarding AMR among study participants in two major hospitals in Tabuk city. One of the most important steps in combating AMR is augmenting the knowledge of the general public.

In this study, only 26.85% of the respondents had knowledge regarding antibiotic resistance, which is very low compared to the results of a similar study conducted in other parts of the kingdom. In contrast to this study, a higher percentage of knowledge regarding AMR was reported from South Korea,¹⁹ Kuwait (45.4%),²⁰ and Saudi Arabia and Jordan (60.7%).²¹ Compared to these studies, studies from Hong Kong (91%) and Indonesia (85%) showed a greater knowledge of respondents for the term antibiotic resistance.^{11,22} In contrast, an Italian

Table 2 Factors related to antibiotic use by study participants (n=1,188)

When did you last use antibiotics?		
In the last month	869	73.1%
In the last 6 months	110	9.3%
In the last year	99	8.3%
More than a year ago	77	6.5%
Never	33	2.8%
Total	1,188	100%
From where did you get the antibiotics?		
Medical store or pharmacy	891	75.0%
Stall or hawker	154	13.0%
From the internet	99	8.3%
Friend or family member	44	3.7%
Total	1,188	100%
When did you stop taking these antibiotic?		
When I felt better	254	21.4%
When I had taken all of the antibiotics as directed	378	31.8%
I don't know	556	46.8%
Total	1,188	100%
"Using antibiotics that were given to a friend or family member, as long as they were used to treat the same illness, is a correct practice."		
True	480	40.4%
False	299	25.2%
Don't know	409	34.4%
Total	1,188	100%
It's okay to use the same antibiotics which were used to treat the same symptoms in the past		
True	649	54.6%
False	539	45.4%
Total	1,188	100%

study showed a lower level of knowledge among study participants (ie, 9.8% knew the definition of antibiotic resistance).²³ The above-discussed studies showed inconsistencies in the knowledge of populations regarding the AMR in different regions.

In this study, the knowledge of the study participants was good regarding the use of antibiotics for treating bacterial infection, but when queried regarding viral infection, the study population exhibited confusion and misconception. Over 60% of the respondents knew that antibiotics can be effectively used to treat bacterial infections. However, only one-fourth of the study population reported that antibiotics cannot be used to treat viral infections, showing that the respondents were not well aware that antibiotics have no therapeutic effect toward viral

diseases. The same findings were reported in studies from Kuwait and Malaysia.^{20,24,25} In contrast to the findings of this study, a higher level of awareness regarding the appropriate use of antibiotics was reported in studies from the UK, Sweden, Jordan and European countries.^{7,21,26} The results of studies from Sweden and Kuwait confirm the confusion among the public regarding whether antibiotics are effective against bacteria or viruses.^{7,20}

In this study, 22–46% of the study participants used antibiotics to treat cold/flu (22%), fever (36%) and sore throats (46%). These findings are comparable with those reported in studies from the USA²⁷ and Poland.²⁸ In contrast, a higher proportion of participants used antibiotics to treat a cold, flu, fever and sore throat in studies from Namibia, Nigeria and Jordan.^{21,29,30}

As discussed above, it is evident that the general population lacks proper knowledge regarding the appropriate use of antibiotics and the meaning of antibiotic resistance.

Females were 0.74 times (95% CI 0.42–1.30) more likely to be aware of AMR than were the male participants. Participants in the 16- to 18- and 25- to 34-year-old age groups had the highest awareness regarding antibiotic resistance. Literature reported that knowledge of AMR increased with age,³¹ a trend that was observed in this study.

Various studies around the world have concluded that a lack of knowledge regarding AMR is associated with lower education.^{7,9,24,32}

In his study, Francesco Napolitano identified a lower educational level and unemployment as being significantly associated with not knowing the definition of antibiotic resistance.²³ In contrast to this study, participants with a lower education and an unemployed status were more likely to be aware of antibiotic resistance. The finding of Tatyana Belkina regarding education and knowledge concerning AMR is consistent with the findings of this study, as he has shown that more educated respondents were less knowledgeable regarding bacterial resistance in Yemen.³¹

Various studies across the globe have reported that age, gender and educational level are recognized as potential factors that influence attitudes toward antibiotics.^{9,18,23,33}

The following factors were significantly associated with AMR knowledge among participants: participants who used antibiotics in the last year (OR: 2.102, CI: 0.654–6.754), discontinued antibiotics upon feeling better (OR: 8.285, CI: 3.918–17.523), gave antibiotics to friends or family members to treat the same illness ([False]: OR: 108.96, CI: 29.98–395.93) and participants who asked their doctors to prescribe

Table 3 Knowledge regarding AMR (n=1,188)

No.	Questions	Yes	No	I don't know	Total
1	It occurs when antibiotic treatments do not work in the body	121 (10.2%)	792 (66.7%)	275 (23.1%)	1,188
2	When antibiotics do not treat infection	209 (17.6%)	880 (74.1%)	99 (8.3%)	1,188
3	Bacteria resistant to antibiotics are difficult to treat	99 (8.3%)	1,056 (88.9%)	33 (2.8%)	1,188
4	AMR can affect me and my family	44 (3.7%)	1,023 (86.1%)	121 (10.2%)	1,188
5	AMR is an issue in other countries but not here	704 (59.3%)	451 (38%)	33 (2.8%)	1,188
6	A problem for people who take antibiotics regularly	385 (32.4%)	770 (64.8%)	33 (2.8%)	1,188
7	Bacteria resistant to antibiotics can spread person to person	198 (16.7%)	924 (77.8%)	66 (5.6%)	1,188
8	AMR infections could make medical procedures more dangerous	297 (25%)	803 (67.6%)	88 (7.4%)	1,188
9	People should use antibiotics only when prescribed by doctors	319 (26.9%)	638 (53.7%)	231 (19.4%)	1,188
10.	People should not keep antibiotics and use them later for other illnesses	946 (79.6%)	66 (5.6%)	176 (14.8%)	1,188
11	AMR is one of the biggest problems the world faces	671 (56.5%)	418 (35.2%)	99 (8.3%)	1,188
12	There is not much people like me can do to stop AMR	0 (0%)	924 (77.8%)	264 (22.2%)	1,188
13	Governments should reward the development of new antibiotics	1,078 (90.7%)	99 (8.3%)	11 (0.9%)	1,188
14	Pharmaceutical companies should develop new antibiotics	231 (19.4%)	913 (76.9%)	44 (3.7%)	1,188
15	Patients should use antibiotics for the entire period described by the doctor	198 (16.7%)	913 (76.9%)	77 (6.5%)	1,188
16	Do you stop the antibiotic before the prescribed period?	385 (32.4%)	748 (63%)	55 (4.6%)	1,188
17	Failure to comply with the prescribed duration of treatment (antibiotics) can result in AMR	286 (24.1%)	825 (69.4%)	77 (6.5%)	1,188
18	Do you think that you should tell your doctor all the antibiotics that have already been taken previously?	429 (36.1%)	704 (59.3%)	55 (4.6%)	1,188
19	Have you ever used a particular antibiotic and then the use of the same antibiotic in a subsequent period did not improve symptoms?	374 (31.5%)	759 (63.9%)	55 (4.6%)	1,188

Abbreviation: AMR, antimicrobial resistance.

previously administered antibiotics for the same symptoms (OR:9.314, CI: 3.684–23.550).

Social factors, such as misconceptions regarding antibiotics, poor knowledge regarding infectious diseases, improper prescribing and use of antibiotics, overprescription of antibiotics at patient demand, nonadherence and self-medication, escalate the development of antibiotic resistance. Therefore, it is of vital importance that public health specialists and health care providers offer instruction to the community regarding the understanding and appropriate use of antibiotics.

Our study had several limitations such as recall bias which was minimized by adapting a well-formatted, simple and easy-to-understand questionnaire and selection bias which was minimized by using appropriate sampling technique. One of the limitations is the study population is limited to the two major hospitals and not all the populations of the city. Using multicenter for data collection is strength of this study.

It is important for the benefit of society that the general public and individuals can understand the AMR phenomenon and minimize/control activities that result in the

spread of antibiotic resistance. Behavioral interventions are of core importance to minimize the phenomenon of antibiotic resistance.

To correct the extensive misconceptions regarding antibiotic use, reliable and multifaceted interventions are needed to promote the appropriate use of antibiotics and deal with problems regarding antibiotic resistance. To effectively control and prevent antibiotic resistance, public health interventions are considered to be one of the most successful strategies that can promote the appropriate use of antibiotics.

Conclusions

The results of this study demonstrated that the people of Tabuk are not well informed regarding AMR and its contributing factors. Furthermore, the study participants had many misconceptions regarding the use of antibiotics. Thus, this situation requires urgent educational intervention campaigns that can provide assistance to promote an awareness of the appropriate use of antibiotics in both King Salman and King Khalid Hospital in Tabuk. The Ministry of Health in Tabuk city should take

Table 4 Demographic characteristics, knowledge and practice of participants regarding antibiotics in relation to antimicrobial resistance (AMR) knowledge

Predictors	DV: Knowledge of AMR			OR	95% CI		p-value
	Yes	No	Total				
Sex							
Male	253	660	913	0.742	0.42	1.30	0.302
Female	66	209	275	1	-	-	-
Total	319	869	1188				
Age group (years)							
16-18	77	220	297	6.405	2.33	17.55	0.000
19-24	82	307	389	2.730	1.03	7.23	0.043
25-34	143	242	385	9.299	3.34	25.86	0.000
35-44	10	49	59	2.785	0.83	9.34	0.097
45-54	7	51	58	1	-	-	-
Total	319	869	1188				
Region							
Tabuk city	253	682	935	0.456	0.26	0.78	0.004
Rural side of Tabuk city	66	187	253	1	-	-	-
Total	319	869	1188				
Education							
Not educated	22	56	78	31.045	8.24	116.91	0.000
Primary	77	89	166	14.025	4.42	44.45	0.000
Middle	108	258	366	6.198	2.06	18.59	0.001
Secondary	55	143	198	3.162	1.01	9.88	0.048
Diploma	22	231	253	0.265	0.07	0.91	0.035
Bachelor's degree	29	52	81	5.048	1.72	14.79	0.003
Master's degree	6	40	46	1	-	-	-
Total	319	869	1188				
Monthly Income (Saudi riyals)							
< 5000	44	99	143	0.085	0.023	0.306	0.000
5001-1000	66	176	242	0.028	0.007	0.109	0.000
10001-15000	88	242	330	0.327	0.177	0.605	0.000
>15000	121	352	473	1	-	-	-
Total	319	869	1188				
Nationality							
Saudi	264	814	1078	0.105	0.046	0.236	0.000
NonSaudi	55	55	110	1	-	-	-
Total	319	869	1188				
Job Status							
Not employed	242	682	924	5.693	2.997	10.816	0.000
Employed	33	66	99	3.290	1.388	7.797	0.007
Retired	44	121	165	1	-	-	-
Total	319	869	1188				
When did you use antibiotics the last time?							

(Continued)

Table 4 (Continued).

Predictors	DV: Knowledge of AMR			OR	95% CI		p-value
	Yes	No	Total				
In the last month	231	638	869	0.314	0.116	0.846	0.022
In the last 6 months	33	77	100	0.438	0.136	1.407	0.165
In the last year	33	66	99	2.102	0.654	6.754	0.212
More than a year ago	11	66	77	0.128	0.030	0.541	0.005
Never	11	22	33	1	-	-	-
Total	319	869	1188				
Where did you get the antibiotics from?							
Medical store/ Pharmacy	253	638	891	0.218	0.070	0.676	0.008
Stall or hawker	33	121	154	0.023	0.006	0.083	0.000
The internet	22	77	99	0.014	0.003	0.067	0.000
Friend or family member	11	33	44	1	-	-	-
Total	319	869	1188				
Stop taking antibiotics once you've begun treatment							
When I feel better	94	160	254	8.285	3.918	17.523	0.000
When taken all antibiotics as directed	83	295	378	2.648	1.226	5.721	0.013
Don't know	142	414	556	1	-	-	-
Total	319	869	1188				
"Use antibiotics that were given to a friend or family member, as long as they were used to treat the same illness"							
True	119	361	480	0.40	0.16	0.96	0.042
False	108	191	299	108.96	29.98	395.93	0.000
Don't Know	92	317	409	1	-	-	-
Total	319	869	1188				
It's okay to buy the same antibiotics from a doctor, if you're sick and they helped you get better when you had the same symptoms before							
True	163	486	649	9.314	3.684	23.550	0.000
False	156	383	539	1	-	-	-
Total	319	869	1188				

Note: A p-value ≤ 0.05 was considered significant.

strong action and enforce strict policies regarding dispensation of medications without prescription. In addition, physicians in both hospitals must also play a role in providing information to their patients so that they can adopt positive behaviors regarding the cautious use of antibiotics.

Informed consent

Informed consent was obtained from all the participants included in the study.

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Disclosure

The authors have no conflicts of interests to declare in this work.

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