BMJ Open

Knowledge, attitude and practice of antibiotics and their determinants in Eritrea: an urban population-based survey

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To cite: Russom M, Bahta M, Debesai M, *et al*. Knowledge, attitude and practice of antibiotics and their determinants in Eritrea: an urban population-based survey. *BMJ Open* 2021;**11**:e046432. doi:10.1136/bmjopen-2020-046432

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-046432).

Received 06 November 2020
Accepted 13 September 2021

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ABSTRACT

Objective To measure knowledge, attitude and practice of antibiotics and antibiotic resistance (ABR) and their determinants in the Eritrean urban population.

Design A population-based, nation-wide, cross-sectional study.

Setting Urban settings of Eritrea.

Participants Members of the general public aged ≥18 years and living in 13 urban places of Eritrea. Three-stage stratified cluster sampling was used to select the study participants.

Data collection and analysis Date were collected from July 2019 to September 2019 in a face-to-face interview using a structured questionnaire. The collected data were double entered and analysed using Census and Survey Processing system (V.7.0) and SPSS (V.23), respectively. Descriptive statistics, χ^2 test, t-tests, analysis of variance, factorial analysis and multivariable logistic regression were performed. All analyses were weighted and $p<0.05$ was considered significant.

Primary and secondary outcome measures Main outcome variables were knowledge, attitude and practice of antibiotics and ABR. Secondary outcome measure was the determinants of knowledge, attitude and practice.

Results A total of 2477 adults were interviewed. The mean score of knowledge and attitude of antibiotics and ABR was 10.36/20 (SD=3.51, minimum=0 and maximum=20) and 22.34/30 (SD=3.59, minimum=6 and maximum=30), respectively. Of those who used antibiotics, the proportion of at least one inappropriate practice (use of antibiotics without prescription and/or discontinuation of prescribed antibiotics before completing the full course) was 23.8%. Young age <24 years (adjusted odds ratio (AOR)=1.61, 95% CI: 1.08 to 2.41), male sex (AOR=1.48, 95% CI: 1.14 to 1.91), higher level of education (AOR=1.76, 95% CI: 1.08 to 2.88), and negative attitude towards appropriate use of antibiotics (AOR=0.95, 95% CI: 0.92 to 0.97) were found to be the significant determinants of inappropriate practice of antibiotics.

Conclusion The gap in knowledge and inappropriate practice of antibiotics in the Eritrean urban population was widespread; requiring immediate attention from policy-makers and healthcare professionals.

Strengths and limitations of this study

- This is among the few globally reported population-based surveys covering nationwide representative of all urban residents of Eritrea.
- The study employed rigorous data quality and management approaches and had a high percentage of response.
- Results of this study were self-reported and thus, findings might be underestimated or overestimated, which might in turn have introduced information or recall bias.
- During data collection, though efforts were made to provide an equal chance of selection for every household member, there might be a selection bias as about three-fourth of the respondents were found to be females. This sex imbalance might be explained by the fact that the information regarding family size and available members during data collection was gathered without verification with an administrative list.
- The reliability and validity of the scales for knowledge and attitude on antibiotics were not checked using statistical tools.

INTRODUCTION

The excess use of antibiotics poses great health risks that would escalate bacterial resistance.[1–4] Resistant infections are now estimated to cost at least 50 000 lives each year in Europe and the USA alone.[5] From this, one can speculate that the burden of antimicrobial resistance (AMR) would be much higher in resource-constrained countries in which the inappropriate use of antibiotics by healthcare professionals and consumers could be rampant. This in part is due to poor regulation, weak health systems, poor surveillance and knowledge, and higher infectious diseases.[1 6 7] If left unimpeded, by 2050, deaths attributable to AMR are estimated to be 10 million per year globally.[1]

Nowadays, antibiotic resistance (ABR) is recognised as one of the biggest threats to global health and is becoming a medical emergency that would limit the advances of healthcare delivery services. This endangers the achievements of the millennium development goals and also sustainable development goals.[8] Thus, AMR in general and ABR in particular is transforming into a political agenda.

As estimated by the WHO, 80.0% of antibiotics are used in the community and 20.0%–50.0% of which are used inappropriately.[9] Use of antibiotics without prescription,[10–13] physician perception of patients expectation for antibiotics,[14 15] patient demand,[16–18] unrestricted use of antibiotics[7 19] and poor healthcare system[20] have been reported among the main factors for the inappropriate use of antibiotics. To tackle this, at the 68th World Health Assembly, a global action plan was endorsed.[21] One of the five global strategic objectives was to improve awareness and understanding about AMR;[21] thus, all member states were recommended by the WHO to annually conduct antibiotic awareness week campaigns in a one-health approach.[21]

With these recommendations, Eritrea has been in a process of establishing an antimicrobial stewardship programme. Through a multisectoral approach, Eritrea has developed a national action plan for combating AMR that is expected to be effective in 2021. One of the four strategic objectives of the national action plan is 'raise awareness through education and training'. Moreover, the National Medicines and Food Administration of the State of Eritrea has published a medicines schedule that is expected to contribute towards the antimicrobial stewardship. Prior to implementation, knowing the current status and weakest links are important for policy decisions and to identify areas of intervention on tackling AMR. Even though there is existing evidence of poor knowledge and inappropriate practice of antibiotics in many countries, there is a paucity of nationwide data in Eritrea and other countries with similar socioeconomic profile. This study was, therefore, conducted to measure knowledge, attitude and practice of antibiotics and identify their key determinants in the Eritrean urban population. As there is no baseline data to start with and assess the effectiveness of the annually conducted antibiotic awareness week, the findings of this study could also be taken as a point of reference to assess relative changes in the determinants of change in practice.

METHODS

Study design and area

A cross-sectional study design, with a quantitative approach, was used. Eritrea is a country with an estimated population of 3.4 million.[22] It has 6 administrative zones comprising 58 subzones in total. The country has five administrative levels namely: national, zonal, sub-zonal, local administration (Kebabi administration) and village/block (village in rural or block in urban settings) levels.

The survey was conducted between July 2019 and September 2019 in all urban sites of the country. In Eritrea, there are a total of 13 cities and/or towns. The urban sites included in this study were three from Gash Barka, five from Debub, two from Semenawi Keih-Bahri and one city or town from each of the remaining three zones, namely, Anseba, Debubawi Keih-Bahri and Maekel (online supplemental file 1). A total of 25 sub-zones and 72 local administrations (Kebabi administration) located in the above-mentioned towns and/or cities were involved in the survey.

Target population

The target population of the study includes all members of the general public aged 18 years or above and living in the 13 urban places in which the survey was conducted.

Sample size and sampling technique

The sample size computational formula[23] and procedures accommodating the multistage sampling technique[24] is provided as supplemental material (online supplemental file 2).

Data collection tools and approach

A structured questionnaire (online supplemental file 3) was prepared by reviewing questionnaires of similar studies[25–27] and was customised in such a way to reflect issues relevant to Eritrea. It was initially prepared in English and then translated into the common local language, Tigrigna. The questionnaire had four sections, namely: personal characteristics of the respondent; awareness and knowledge regarding antibiotics and ABR; attitude regarding the use of antibiotics and ABR; and practice of the general public on antibiotic usage.

Sixteen pharmacy professionals who had prior experience were recruited as data collectors. Close supervision was made by two principal investigators (MR and MB). Orientation was provided to data collectors in order to familiarise them with the survey objectives, questionnaire, principles of conducting an interview, data collection procedures, standards of practice, procedures for listing the households and the second-stage as well as third-stage sample selection of the households.

Prior to the main fieldwork, the questionnaire was pretested on five different clusters, which were not included in the main survey. These blocks are found in two local administrations of Asmara. Twenty-five households were interviewed from each selected block. The pretest aided in assessing accuracy of translation, ability of the questions to elicit appropriate information and ability of enumerators to administer the questionnaire. Moreover, it was helpful in estimating the time required to complete the questionnaire. The questionnaire was finally modified based on the results of the pretest.

Households were sampled with the assistance of the administration office after listing them in selected blocks. When eligible respondents were absent from their homes, at least three visits were made to increase the opportunity

of participation in the survey. If the selected candidate was found to be unavailable in a successive of three–four attempts, it was considered as a 'no response'.

Outcome measures

The primary outcome measures were knowledge, attitude and practice of antibiotics and ABR in the urban setting of Eritrea. The secondary outcome measure was the determinants of knowledge, attitude and practice of antibiotics and ABR.

Data analysis

Data was double entered using Census and Survey Processing system (V.7.0) software package and exported to SPSS V.23. It was summarised by using weighted percentages and counts. Cross-tabulations and further analysis were also computed whenever relevant.

Kolmogorov-Smirnov test was used to check on the normality of the knowledge and attitude scores. Frequencies, percentages, mean (with SD) and median (with IQR) were used to describe the data, as appropriate. After using independent samples t-test and analysis of variance at bivariate level of analysis, factorial analysis was employed to assess the predictors of knowledge and attitude at multivariable level. To explore the association between the inappropriate practice of antibiotic and the categorical demographic characteristics, χ^2 test was performed. To control potential confounders, variables that were found to have a p value less than 0.05 were subjected to multivariable analysis using logistic regression. In this study, a p value less than 0.05, in all the analyses, is considered as significant.

Operational definition

Inappropriate practice

Refers to the act of self-medication with antibiotics and/or self-discontinuation of a regimen of antibiotics. It was determined by assessing whether the last used antibiotics were prescribed by an authorised health professional and/or those who used antibiotics interrupted their treatment regimen before completing the full course.

RESULTS

Demographic characteristics of the study participants

A total of 2542 individuals were selected for the survey. Among the selected individuals, 2477 were successfully interviewed, making an overall response of 97.4%. The demographic characteristics of the respondents are summarised in table 1. The unweighted numbers reflect the actual observations at the time of the survey, whereas the weighted numbers reflect figures that have been adjusted by the probability of selection of the respondents (table 1).

Awareness, knowledge and attitude on antibiotics and ABR

Based on participants' response, 73.3% and 39.0% of the study population were aware of the term 'antibiotic' and 'ABR', respectively. The sources of information about antibiotics and ABR were mainly from health facilities (39.6%), television (31.5%) and other people (10.1%).

Of the list of medicines provided to assess distinguishing antibiotics from non-antibiotics, 59.4% of the study population correctly identified penicillin, while only 44.8% and 11.9% correctly identified cotrimoxazole and ciprofloxacin, respectively. Besides, ibuprofen, ORS and paracetamol were correctly identified as non-antibiotics by 58.5%, 60.7% and 70.6% of the population, respectively.

Less than half (36.6%–49.5%) of the study population correctly reported the indication of antibiotics for common illnesses. Majority of them reported that antibiotics can be used to treat viral infection (63.4%), watery diarrhoea (61.8%), common cold (58.9%), dry cough (54.2%) and dengue fever (50.5%). Sixty one per cent of the study population also reported that antibiotics are not indicated for tuberculosis. Correct knowledge on when to stop taking antibiotics once they had begun treatment was in the majority (83.3%) of the study population.

Over three-fourth (78.2%) of the study population correctly reported that ABR is an issue that could affect them and their family and about two-third (63.6%) correctly answered the definition of ABR. The proportion of the study population who knew that bacteria resistant to antibiotics can spread from person to person and those who reported that ABR is an issue in other countries but not in Eritrea was about 59.0% in both cases.

The overall mean knowledge score on antibiotics and ABR was found to be 10.36/20 (SD=3.51, minimum=0 and maximum=20). At bivariate level, males, Christians, those who were aged between 25 years and 54 years, those who had higher educational level, those having big family size and who were government employees were more likely to have better knowledge score. Besides, the study population residing in Maekel and Anseba zones had better knowledge score on antibiotics and ABR compared with those living in other zones (online supplemental file 4). At multivariable level, age (p<0.001), religion (p=0.003), educational level (p<0.001), family size (p=0.015), occupation (p<0.001) and zone (p<0.001) maintained their association with knowledge score (table 2). Educational level has the largest partial η^2 (6.8%), showing its prime role in prediction of the knowledge score (table 2).

A positive attitude to the majority of the attitude items was reported to be 82.0% - 92.7% (table 3). However, a positive attitude towards appropriate disposal of antibiotics was documented in less than 50.0% of the study population (table 3). The overall mean attitude score was 22.34/30 (SD=3.59, minimum=6 and maximum=30). At bivariate level, males, those aged between 25 years and 54 years, those who had higher educational level, government employees and study population residing in Maekel and Anseba zones had better attitude score compared with their counterparts (online supplemental file 5). At the multivariable level, age (p=0.001), gender (p=0.001), educational level (p<0.001), occupation (p=0.003) and zone (p<0.001) maintained their significance as predictors of attitude score. Zone has the largest explanatory

Table 1 Distribution of the study population, 18 years and above, on the knowledge, attitude and practice survey of antibiotics and ABR by background characteristics, 2019, Eritrea

Background characteristics		Weighted per cent	Weighted number	Unweighted number
Age (years)				
	24 or less	18.2	451	433
	25 to 34	25.9	643	644
	35 to 44	22.3	552	567
	45 to 54	15.0	372	396
	55 and above	18.5	459	437
Sex				
	Male	24.7	611	605
	Female	74.7	1851	1857
	Missing	0.6	15	15
Religion				
	Christian	77.4	1918	1749
	Moslem	22.5	558	726
	Other	0.1	2	2
Zone				
	Anseba	8.4	209	352
	Debub	15.9	393	410
	Gash Barka	12.1	301	397
	Maekel	55.7	1380	865
	SKB	6.3	155	322
	DKB	1.6	39	131
Educational level				
	Illiterate	12.0	298	342
	Elementary	15.9	394	452
	Junior	18.6	462	510
	Secondary	35.7	884	801
	Higher	17.1	425	358
	Missing	0.6	15	14
Household size				
	1	4.4	108	104
	2–3	22.0	545	533
	4/more	73.6	1824	1840
Occupation				
	Governmental	22.8	566	529
	Private employee	4.9	121	115
	Housewife	38.3	949	980
	Self-employed	8.2	202	209
	Unemployed	14.8	366	361
	Student	7.2	179	166
	Farmer/fisher	2.2	55	77
	Other*	1.2	30	33
	Missing	0.4	10	7
Total		100	2477	2477

*Day labourer, soldier, sheik/priest, etc.
ABR, antibiotic resistance; DKB, Debubawi Keih-Bahri; SKB, Semenawi Keih-Bahri.

Table 2 Predictors of knowledge and attitude towards antibiotics and ABR at multivariable level, Eritrea, 2019

Knowledge				
Predictor	**F**	**P value**	**Partial η^2**	**Observed power**
Age (years)	28.5	<0.001	0.04	1.000
Gender	0.4	0.536	<0.001	0.095
Religion	9	0.003	0.003	0.849
Educational level	49.7	<0.001	0.068	1.000
Family size	4.2	0.015	0.003	0.738
Occupation	6.3	<0.001	0.014	0.999
Zone	18.4	<0.001	0.033	1.000
Attitude				
Predictor	**F**	**P value**	**Partial η^2**	**Observed power**
Age (years)	4.5	0.001	0.007	0.944
Gender	11.6	0.001	0.004	0.926
Educational level	22	<0.001	0.031	1.000
Occupation	3.4	0.003	0.007	0.942
Zone	21.6	<0.001	0.038	1.000

ABR, antibiotic resistance.

(partial η^2=3.8%) capability for the attitude toward antibiotics (table 2). Additionally, the distribution of literacy with the significant determinants of knowledge and attitude scores are summarised in a supplemental material (online supplemental file 6).

Practice on usage of antibiotics

Majority (84.5%) of the study population had used antibiotics at least once in their life time and 55.0% had a history of intake of antibiotics in the last 1 year and 12.3% in the last 1 month prior to commencement of this study. Of those who ever used antibiotics (n=2407), 88.1% reported that their last intake of antibiotic(s) was prescribed by an authorised healthcare professional. Non-seriousness of the disease (39.0%), need to get quick relief (33.9%), previous own successful experiences (16.1%), having no time to visit a health facility (15.0%) and long queues existing in health facilities (14.0%) were the top-five reasons reported for self-medication with antibiotics. For those who used antibiotics without prescription, the main sources of their last course of antibiotics were drug retail outlets (83.6%) (figure 1).

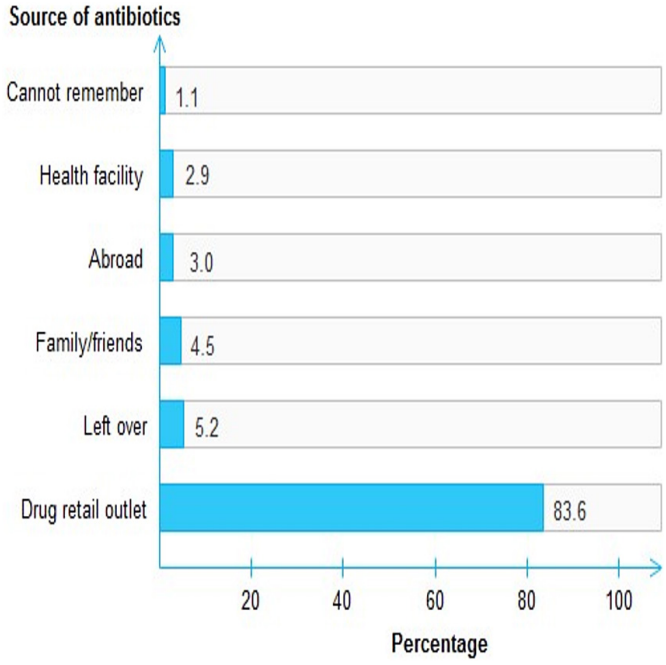

Figure 1 Source of antibiotics used without prescription among urban residents, Eritrea, 2019 (n=242).

One-fifth (18.8%) of those who had ever used antibiotics interrupted their regimen before completing the full course. The main reason for interruption of antibiotics was improved illness condition (63.4%) (figure 2). About 3.0% of the study population reported that they had used antibiotics on their own at least once, though they were advised by healthcare professionals not to do so.

Table 3 Agree/strongly agree responses on the attitude of antibiotics usage and ABR, Eritrea, 2019 (N=2477)

Attitude questions on antibiotics usage and ABR	% (95% CI)
Hand washing decreases ABR	92.7 (91.6 to 94.1)
Taking antibiotics when it is not required can facilitate ABR	89.7 (88.2 to 91.1)
You have a role to fight ABR	85.8 (84.5 to 87.8)
It is not okay to share antibiotics with others	90.1 (89.4 to 91.6)
We cannot use antibiotics without prescription	88.0 (87.5 to 89.8)
Farmers should not give antibiotics without consulting veterinarian	82.1 (80.9 to 83.7)
It is not okay to keep leftover antibiotics and use them later	82.0 (80.7 to 83.5)
Leftover antibiotics should not be disposed with regular garbage	46.0 (45.4 to 49.1)
Leftover antibiotics should not be disposed at toilets	35.7 (34.3 to 37.9)

ABR, antibiotic resistance.

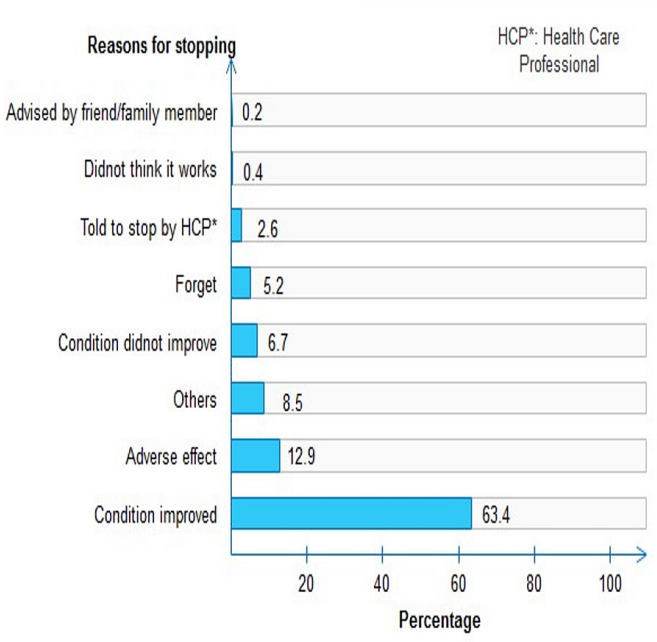

Figure 2 Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019 (n=357).

Overall, inappropriate practice of antibiotics (use of antibiotics without prescription and/or self-discontinuation of prescribed antibiotics before completing the full course) was reported in 23.8% of the study population. The χ^2 analyses found that age (p<0.001), gender (p=0.01), educational level (p<0.001), occupation (p<0.001) and zonal location (p<0.001) were the significant associates of inappropriate practice of antibiotics. The independent sample t-test showed that the mean attitude score of those in inappropriate practice (M=21.86, SD=3.97) was significantly lower than those in safe practice (M=22.51, SD=3.45). On multivariable level, those who were young, 24 years or less (adjusted odds ratio (AOR)=1.61, 95% CI: 1.08 to 2.41), males (AOR=1.48, 95% CI: 1.14 to 1.91), those who had higher level of education (AOR=1.76, 95% CI: 1.08 to 2.88) and those with higher attitude score (AOR=0.95, 95% CI: 0.92 to 0.97) were more likely to involve in inappropriate practice of antibiotics (table 4).

A total of 1473 of the study population had animals and about 14.0% reported that they have treated their animals with antibiotics at least once. Of those who used antibiotics for their animals, 62.0% purchased at least once in the last year, prior to the study period. The commonly used antibiotics for animals were amoxicillin (44.1%), oxytetracycline (36.2%) and penicillin (16.3%). About 51.0% of antibiotics used for animals were obtained from veterinarians, whereas the rest were mainly from pharmacy retail outlets (20.8%), family/friends (14.4%) and open markets (14.3%) (figure 3).

DISCUSSION

This nationwide urban population-based survey revealed a significant inappropriate practice of antibiotics in Eritrea. One in five of the study population, who had ever used antibiotics, reported that their last intake of antibiotic(s) was self-interrupted for many reasons. The discontinuation of antibiotics when a consumer felt better was the most frequently reported reason. This reflects lack of awareness on the appropriate use of antibiotics and the risk of ABR. The majority of the antibiotics most recently consumed by the study population were reported to have

Table 4 Predictors of inappropriate practice of antibiotics across the categories of demographic characteristics and attitude score at multivariable level, Eritrea, 2019

	Multivariable analysis		
Background characteristic	Adjusted odds ratio	95% CI	P value
Age (years)			0.035
24 or less	1.61	1.08 to 2.41	
25 to 34	1.26	0.89 to 1.79	
35 to 44	1.05	0.74 to 1.48	
45 to 54	0.89	0.61 to 1.29	
55 or above	Ref.		
Gender			
Male	1.48	1.14 to 1.91	0.003
Female	Ref.		
Educational level			0.103
Illiterate	Ref.		
Elementary	1.02	0.66 to 1.57	
Junior	1.19	0.77 to 1.83	
Secondary	1.33	0.86 to 2.03	
Higher	1.76	1.08 to 2.88	
Occupation			0.183
Governmental	Ref.		
Private employee	1.14	0.71 to 1.85	
House wife	1.33	0.97 to 1.83	
Self-employed	1.53	1.03 to 2.27	
Unemployed	1.16	0.80 to 1.67	
Student	1.43	0.93 to 2.19	
Farmer/fisher	1.49	0.71 to 3.15	
Other*	0.45	0.13 to 1.52	
Zone			0.069
Anseba	0.48	0.21 to 1.09	
Debub	0.73	0.34 to 1.59	
Gash Barka	0.70	0.32 to 1.57	
Maekel	0.89	0.42 to 1.88	
SKB	0.82	0.36 to 1.89	
DKB	Ref.		
Attitude score	0.95	0.92 to 0.97	<0.001

*Day labourer, soldier, sheik/priest etc.
DKB, Debubawi Keih-Bahri; SKB, Semenawi Keih-Bahri.

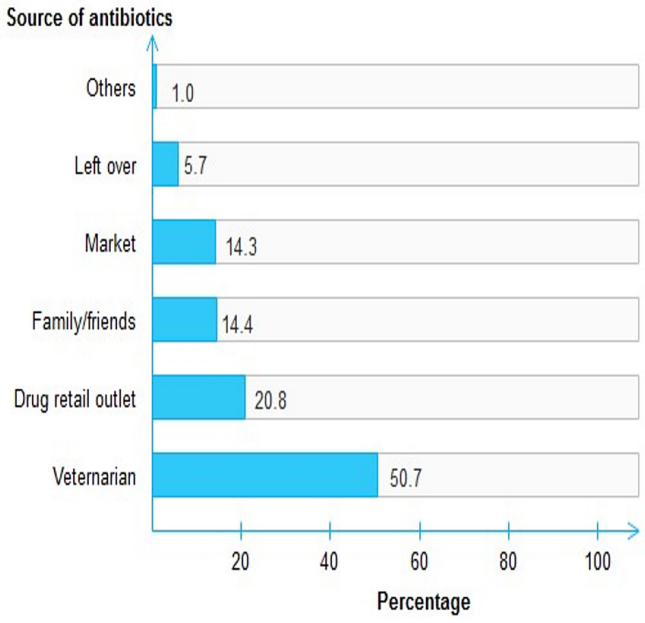

Figure 3 Source of antibiotics for animals among urban residents, Eritrea, 2019 (n=245).

been prescribed by qualified healthcare professionals. This is encouraging and the nationwide, massive antibiotic awareness week campaigns conducted in the last 3 years, prior to the study, might have had positive contributions. However, due to the lack of a national baseline data, the authors could not come up with a definitive conclusion regarding the effectiveness of the previously conducted campaigns.

The disease condition being non-serious, intention to get quick relief, previous successful experience, shortage of time to visit health facilities and long queues were the main triggering factors reported for self-medication with antibiotics. The first three reasons mentioned above for self-medication with antibiotics reflect lack of awareness on the risks of inappropriate use of antibiotics. In Eritrea, guided by 'health for all policy' and 'social justice', healthcare services are provided at a highly subsidised or nominal cost through public health facilities. To further improve patients' satisfaction, access to health services and health seeking behaviour, the existing healthcare delivery services need to be optimised. Moreover, the annual antibiotic awareness week campaign should be augmented by additional continuous and regular health promotional activities.

In this study, drug retail outlets were reported as the main sources for the sales of antibiotics without prescription. A recently conducted study also revealed an alarming picture; 87.0% of retail outlets found in Eritrea were dispensing antibiotics without prescription,[10] which requires immediate attention from regulators and policymakers. Continued refresher courses on the appropriate use of antibiotics and ABR as well as further enforcement of regulations would have an impact in bridging these gaps. Cognizant of this, the National Medicines and Food Administration of the Ministry of Health developed medicines schedule in 2019 and all antibiotics are put under the category of 'prescription-only medicine'. To ensure implementation and adherence to the scheduling terms, the National Medicines and Food Administration is recommended to conduct strict and continuous inspection on drug retail outlets.

Use of antibiotics without prescription in this study was more or less consistent with findings of similar studies conducted in European countries, where it was reported to occur in an average proportion of 7.0% (ranging from 0% to 20.0%).[28] It was, however, much lower than that reported in Italy,[29] Jordan,[30 31] United Arab Emirates,[32] Palestine,[33] Lebanon,[34] Iraq,[35] Indonesia,[36] Yemen,[37] Saudi Arabia,[38] Haiti,[39] Kuwait[40] and Ethiopia,[41 42] where proportions ranged between 31.0% and 79.0%. The variation in results, however, could be due to differences in study designs, study area, study population, type of questions and level of awareness of the study population. Following the WHO recommendation (2015) for all member states to start annual awareness raising programmes on AMR, Eritrea has started to implement it since 2016. This study was conducted after a few years of massive public campaigns and might have influenced the current findings. It is also possible that in other countries that have made similar initiatives, the existing profile might have been influenced in the same way despite no current studies are available.

Factors such as young age (24 years or less), male sex, high level of education and poor attitude score were identified as determinants of inappropriate practice of antibiotics. It is unknown why those who had higher level of education and those who were young (relatively with greater educational opportunities) were more involved in the inappropriate practice of antibiotics. This might to some extent be explained by the fact that knowing more or being educated predisposes people to a tendency to take self-made decisions more casually with the assumption that they have knowledge. Qualitative studies are required to further identify the determinants of inappropriate practice of antibiotics in the general public.

In this study, an appreciably good attitude score towards appropriate use of antibiotics and ABR was reported. It is, however, important to note that the poor attitude reported on the appropriate disposal of leftover antibiotics requires immediate attention from policy-makers. Studies on awareness and disposal practices of unused and expired medicines by consumers in India and Nigeria also reported that improper practices such as the disposal of medicines in domestic trash, toilets and sinks was prevalent.[43 44]

Unlike the relatively good attitude score, the mean knowledge score of the study population on antibiotics and ABR was not satisfactory. This study revealed that the majority of the study population had no clear picture on what an antibiotic is and were unable to recognise, by name, the most commonly used antibiotics (penicillin, cotrimoxazole and ciprofloxacin) in

the country. Categorising ibuprofen, ORS and paracetamol as antibiotics by a large number of the study population was another concern. A significant proportion of the study population also had the misunderstanding that antibiotics could treat viral infections like common cold and acute watery diarrhoea. Hence, continued awareness raising programmes should target such misconceptions and familiarise the public with the commonly used antibiotics, their proper indications and the potential for resistance. The assumption that ABR is a threat elsewhere but not in Eritrea, as reported in this study, reflects how oblivious people were to the issue of ABR and this may limit the public from taking appropriate actions.

In this study, those who were aged between 25 years and 54 years, had higher educational level, were government employees or residing in Maekel and Anseba zones were significantly associated with higher knowledge and attitude scores. Literacy to a larger extent might explain, among others, the observed good knowledge and attitude scores in relation to the above predictors as all these categories had better educational levels (online supplemental file 6). However, more data are required to make accurate deductions with regard to these predictors. It is also important to note that the association observed with the above-mentioned variables do not seem to be clinically meaningful as a small difference in results could give statistically significant difference, and thus, readers should cautiously interpret the results. This emphasises the need for extensive awareness raising programmes for those who are illiterate and having lower level of education.

Regarding the use of antibiotics to treat animals, oxytetracycline, amoxicillin and penicillin were the most frequently reported ones. About half of the antibiotics used in animals were supplied by non-veterinarians such as drug retail outlets and open markets reflecting poor regulation of antibiotics in animal health.

Because parasites and infections do not respect borders, combating ABR has since long ago been a global agenda. A problem identified in one country could have direct or indirect implication on the containment of ABR by other countries. The significance of this nationwide survey and the results it comes up with are all expected to be of a particular interest for countries with similar socioeconomic status as Eritrea. Many of these countries share the common problem of poor quality, inequitable, overstretched, unregulated and poorly accessible health services, which could trigger the general public to be involved in inappropriate practice of antibiotics. Moreover, they lack the systems to control antibiotic consumption and the initiative to tackle the issue of resistance. If Eritrea's profile with regard to the prevalence of inappropriate practices such as self-medication with antibiotics has been relatively good while there is a long way to go to improve the healthcare infrastructure, it is not hard to imagine the progress the country could assume if the existing policies such as the national action plan on AMR and regulations such as medicines scheduling are enforced.

This is among the few globally reported nationwide population-based surveys that measure knowledge, attitude and practice of antibiotics and ABR. The study employed rigorous data quality and management approaches and had a high percentage of response. On the other hand, one of the main limitations of this study was that the results were self-reported, and thus, findings might be underestimated or overestimated. This could introduce information or recall bias. Additionally, though efforts were made to provide an equal chance of selection for every household member, there might be a selection bias as about three-fourth of the respondents were found to be females. The sex imbalance might be explained by the fact that the information regarding family size and available members during data collection was gathered from the present household members, and no verification was made using an administrative list. Moreover, the reliability and validity of the scales for knowledge and attitude on antibiotics were not checked using statistical tools.

CONCLUSION

The inappropriate practice of antibiotics in Eritrea was prevalent and the young age, male sex, higher level of education and poor attitude towards appropriate use of antibiotics were identified as the determinants of inappropriate practices. The inability of a high proportion of the study population to distinguish antibiotics from other medicines and the reported misunderstanding that viral infections can be treated with antibiotics indicates limited knowledge on antibiotics and ABR. Continuous awareness raising programmes on the rational use of antibiotics (mainly on the risks of self-medication, treatment interruption and use of antibiotics for viral infections) and familiarising the public with the commonly used antibiotics are recommended. As drug retail outlets were identified to be the main sources for the supply of antibiotics without prescription, both in humans and animals, enforcement of medicines schedule and strengthening of regulatory inspections is vital. Besides, the huge gap in attitude towards appropriate disposal of antibiotics requires immediate attention from policy-makers and the establishment of an appropriate disposal system of leftover antibiotics for the community. Last but not least, it is high time to expedite the implementation of the strategies stipulated under the national action plan on AMR, which was released in February 2021.

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Acknowledgements The authors sincerely thank the Ministry of Local Government and mayors of the administrative zones and their staff for the dedication they have shown in provision of demographic data, guidance and participation in the data collection process. Besides, the authors would also like to acknowledge the heads of the Zonal Pharmaceutical Services of all administrative zones for their collaboration and contribution in the data collection. We would also like to appreciate the following pharmacists for their invaluable contribution in data collection and data entry: Abel Tesfatsion, Abel Tekle, Adiam Andemariam, Asmerom Mosazghi, Dawit Ghebrehiwet, Freminatos Misghina, Habtemariam Berhane, Hagos Zerehaimanot, Hermela Yemane, Kibrom Shimendi, Luna Kiflay, Martha Amanuel, Michael Ghirmai, Michael Habteslassie, Michael Kidane, Natnael Bereket, Neamin Ghebremedhin, Niyat Belai, Nuru Abdu, Robel Werede, Samrawit Yonas, Selam Ghebrehiwet, Sirak Saleh, Sirak Tesfamariam, Yohana Berhane and Zebib Andemeskel.

Contributors The idea was conceived by MR and IB and designed by all authors (MB, MD, MR, AK, AA, YF, IB, SNK, JN and EHT). Data was collected by MD, AK, AA and YF and supervised by MR and MB. EHT edited and analysed the collected data and all the co-authors participated in the interpretation of the results. The manuscript was drafted by MB, MR and EHT and critically reviewed and edited by all of the authors. Finally, all the co-authors agreed that the article be published in an international journal and to take responsibility and be accountable for its content.

Funding This work was funded by the WHO Country Office in Asmara, Eritrea (budget line: 1813144; 66415; 6.1).

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Ethical approval to conduct the study was obtained from the Ministry of Health, Eritrea, and further approval was also obtained from the Ministry of Local Government. Besides, informed consent was obtained from all study participants to take part in the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information. All data related to the study are included in the manuscript. The complete data-set used during the current study are available from the corresponding author and can be accessed upon reasonable request.

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Knowledge, Attitude and Practice of Antibiotics and their Determinants in Eritrea: Urban Population-based Survey

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Supplementary file 1: Number of households in the urban places of Eritrea (July 2019)

Zone	City/Town	Number of Households
Gash Barka	Akordat	3,822
	Barentu	10,935
	Tessenei	15,205
	Subtotal	**29,962**
Debub	Mendefera	8,023
	Adiquala	3,419
	Dekemhare	9,769
	AdiKeih	5,335
	Senafe	6,574
	Subtotal	**33,120**
SKB	Ghindae	5,832
	Massawa	9,512
	Subtotal	**15,344**
Anseba	Keren	19,343
	Subtotal	**19,346**
DKB	Assab	3,106
	Subtotal	**3,106**
Maekel	Asmara	116,146
	Subtotal	**116,146**
Total		**217,024**

SKB: Semienawi Keih Barhri; DKB: Debubawi Keih Barhri; HH: Household

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Supplementary file 2: Brief description of the sampling technique and sample size, Eritrea, 2019

Sample size

Sample size was computed mainly for an estimation of proportion of safe practice taking 95% confidence level, 0.05 precision; using the formula [23]: $n \geq \frac{NV1.96^2}{V*1.96^2+(N-1)*0.05^2}$, where $V=\frac{SD^2}{Pooled\ proportion^2}$=0.5 and N=size of the target population. Upon consideration of the aforementioned parameters, the initial sample size was 1525. After an adjustment of non-response percent (10%) and design effect (deff=1.5), the final sample size was 2542 individuals.

Sampling Technique

Local data, conducted by Ateshim et al. 2019 [11] and other unpublished studies, implies that the awareness, knowledge, attitude, and practice towards antibiotics and ABR varies across the zones in Eritrea. Hence, it was presumed that the sample design that led to the selection of a legible person was a stratified three-stage cluster sample. During the first stage of the sampling, a total of 102 primary sampling units referred to as blocks (having households ranging from 200 to 1000) were selected from the 13 urban sites. During the second stage, 25 households were selected from each block taking into consideration the design effect, inter-cluster correlation, economic and administrative issues [24]. Finally, samples were selected from each household. To bring about reliable zonal and overall estimates, square root allocation of households was undertaken.

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Supplementary file 3: Questionnaire on Knowledge, Attitude and Practice of Antibiotics and their Determinants in Eritrea: Urban Population-based Survey, 2019

Part I: Identification Particulars

Zoba				
Subzoba				
City/Town				
Kebabi				
Respondent numbe				

Interviewer Visits

	1	2	3	Final Visit
Date				Day / Month / Year (2019)
Interviewer's Name				Int. No.
Result*				Result*
Next visit: Date				Total number of visits
Time				

*Result codes:

Completed
Not completed
Not willing
Other _____ (Specify)

Total persons In household

Total eligible persons (≥18)

Supervisor		Field editor		Keyed by	
Name	Number	Name	Number	Name	Number

Part II: Demographic Information

No.	Indicators	Coding categories	Skip
201	Age (in completed years)	☐☐	
202	Sex	Male ..... 1 Female 2	
203	Ethnicity	Tigrina ..... 1 Afar ..... 2 Tigre ..... 3 Saho ..... 4 Rashida ..... 5 Kunama ..... 6 Blien ..... 7 Hidarb ..... 8 Nara ..... 9 Other (please specify) _____ 10	
204	Religion	Christian ..... 1 Muslim ..... 2 Other (please specify) _____ 3	
205	Level of education (Highest level of education)	Illiterate ..... 1 Primary school ..... 2 Middle school ..... 3 Secondary school ..... 4 Higher education 5	
206	Main occupation	Farmer ..... 1 Government employee ..... 2 Private employee ..... 3 Housewife ..... 4 Self-employed ..... 5 Unemployed ..... 6 Student ..... 7 Fisher man ..... 8 Other (please specify) _____ 9	

Part III: Knowledge

No.	Questions	Coding categories	Skip
301	Have you ever heard about antibiotics?	Yes . . . . . 1 → 303 No 2	
302	Have you ever heard of any one of the following medications? ASK FOR EACH MEDICATION.	Amoxicillin . . . . . A Tetracycline . . . . . B Oxytetracycline . . . . . C I haven't heard all of them . . . . . D → **END**	
303	Which of the following do you think are antibiotics? ASK FOR EACH MEDICATION. *If the response in Q301 is No and heard of any one of the examples of antibiotics, explain, after completing Q303 and before continuing to Q304, that the term 'Antibiotics' refers to such drugs.*	Y N DK Ibuprofen . . . . . 1 2 3 Tetracycline . . . . . 1 2 3 Bactrim . . . . . 1 2 3 ORS . . . . . 1 2 3 Amoxicillin . . . . . 1 2 3 Paracetamol . . . . . 1 2 3 Ciprofloxacin . . . . . 1 2 3 Penicillin 1 2 3	
304	Which of these diseases do you think are treated with antibiotics? ASK FOR EACH ILLNESS.	Common cold . . . . . 1 2 3 Watery diarrhea . . . . . 1 2 3 TB . . . . . 1 2 3 Dengue fever . . . . . 1 2 3 Pneumonia . . . . . 1 2 3 Dry cough 1 2 3	
305	Do antibiotics treat viral infections?	Yes . . . . . 1 No . . . . . 2 Don't know 3	
306	When do you think you should stop taking antibiotics once you've begun treatment? MULTIPLE RESPONSES ARE POSSIBLE. PROBE: Are there any other reasons	When I feel better . . . . . A When I do not see improvements . . . . . B When I encounter adverse drug reactions C It should not be stopped . . . . . D Don't know . . . . . E	
307	Have you ever heard of the term antibiotic resistance (ABR)?	Yes . . . . . 1 No 2	
308	Antibiotic resistance occurs when your becomes resistant to antibiotics and they no work.	Yes . . . . . 1 No . . . . . 2 Don't know 3	**404**
309	Where did you hear about antibiotic resistanc MULTIPLE RESPONSES ARE POSSIBL PROBE: Are there any other sources	Health facility . . . . . A Pharmacy . . . . . B Radio . . . . . C TV . . . . . D Newspaper . . . . . E Campaign/Seminar . . . . . F Other (please specify) _____ G	

310	Antibiotic resistance is an issue that could affect me or my family.	Yes . . . . . 1 No . . . . . 2 Don't know 3	
311	Antibiotic resistance is an issue in other countries but not here.	Yes . . . . . 1 No . . . . . 2 Don't know 3	
312	Bacteria which are resistant to antibiotics can spread from person to person.	Yes . . . . . 1 No . . . . . 2 Don't know 3	

Part IV: Attitude

No.	Questions		Skip
401	Proper handwashing play a role in ABR.	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
402	Taking antibiotics when it is not required can facilitate ABR.	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
403	You have a role to fight ABR	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
404	We can use antibiotics without prescription	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
405	It is okay to share antibiotics with family members or friends for similar illness	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
406	It is okay to keep leftover antibiotics and use them later	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	

407	Farmers can give antibiotic without consulting veterinarian	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
408	Leftover antibiotics should be disposed with regular garbage	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	
409	Leftover antibiotics should be disposed at toilets	Strongly disagree . . . . . 1 Disagree . . . . . 2 Neutral . . . . . 3 Agree . . . . . 4 Strongly agree 5	

Part V: Practice

No.	Questions	Coding categories	Skip
501	Have you ever used antibiotics?	Yes . . . . . 1 No . . . . . 2 Don't remember 3	**509**
502	When was the last time you took antibiotics?	Now . . . . . 1 Last month . . . . . 2 Last six months . . . . . 3 Last year . . . . . 4 More than a year ago . . . . . 5 Don't remember 6	
503	Source of the last course of antibiotic MULTIPLE RESPONSES ARE POSSIBLE.	Health facility . . . . . A Drug retail outlet . . . . . B Friend or family member . . . . . C Saved up from a previous time . . . . . D From abroad . . . . . E Don't remember . . . . . F	
504	On that occasion, did you get a prescription for the antibiotics from a doctor/nurse?	Yes . . . . . 1 Don't remember . . . . . 2 No 3	**506**
505	What was (were) your reason(s) of self-medication with antibiotics? MULTIPLE RESPONSES ARE POSSIBLE.	Long queue A Had no time to visit a health facility . . . B To get a quick relief . . . . . C Disease was not serious . . . . . D To save expenses . . . . . E Own previous successful experience . . . F Other (please specify) _____ G	

506	Did you ever stop taking antibiotics before completing the full course?	Yes . . . . . 1 No . . . . . 2 Don't remember 3	**508**
507	Why did you stop taking the antibiotics?	Condition didn't improve . . . . . 1 Condition improved . . . . . 2 Due to adverse effects . . . . . 3 Advised by a friend or family member 4 I didn't think it works . . . . . 5 Told to stop by a healthcare profession . 6 Other (please specify) _____ 7	
508	Ever used antibiotics on your own, though health care professionals advice you not to take	Yes . . . . . 1 No . . . . . 2 Don't remember 3	
509	Have you ever given antibiotics to your animals?	Yes . . . . . 1 No . . . . . 2 Don't remember . . . . . 3 Don't have an animal 4	**END**
510	Which antibiotic did you use for your animal? ASK FOR EACH MEDICATION.	Amoxicillin . . . . . A Erythromycin . . . . . B Oxytetracycline . . . . . C Penicillin . . . . . D Tylosin . . . . . E Didn't use all of these antibiotics . . . . . F Other (please specify) _____ G	
511	Source of the antibiotics	Bought from the market . . . . . A Bought from Drug retail outlet . . . . . B Veterenarian . . . . . C Friends/family membe . . . . . D Other (please specify) _____ E	
512	How many times did you buy antibiotics for your animal in the last one year ?	Once . . . . . 1 Twice . . . . . 2 Three times . . . . . 3 More than three times . . . . . 4 Never 5	

Y: Yes; N;No; DK: Don't Know

END OF INTERVIEW

INTERVIEWER'S OBSERVATIONS

TO BE FILLED IN AFTER COMPLETING THE INTERVIEW
COMMENTS ABOUT THE INTERVIEW
COMMENTS ON SPECIFIC QUESTIONS
ANY OTHER COMMENTS
SUPERVISOR'S OBSERVATIONS
EDITOR'S OBSERVATIONS

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Supplementary file 4: Comparison of knowledge scores across the categories of demographic characteristics at bivariate level, Eritrea, 2019

Characteristics	Mean (SD)	F/t Value	p-value	p-value trend (Type of trend)	Post Hoc Test	
					Pair wise comparison	Group wise comparison
Age						
24 or less **A**	9.57 (3.24)					
25 to 34 **B**	10.53 (3.25)			<0.0001	A<B, A<C, A<D,	Group 1: A and E
35 to 44 **C**	11.02 (3.36)	16.03**	<0.0001	(Quadrati	A=E, B=C=D,	Group 2: B, C, and
45 to 54 **D**	10.77 (3.70)			c)	B>E, C>E, D>E	D
55 and above **E**	9.73 (3.91)					
Gender						
Male	10.98 (3.61)	5.08	<0.0001	-	M>F	-
Female	10.15 (3.44)					
Religion						
Christian	10.57 (3.53)	5.93	<0.0001	-	C>M	-
Muslim	9.60 (3.30)					
Educational Level						
Illiterate	7.99 (3.28)					
Primary	9.49 ((3.38)			<0.0001	I<P, I<M, I<S, I<H, P=M,	Group 1: I
Middle	10.16 (3.31)	66.78	<0.0001	(Linear)	P<S, P<H, M=S, M<H, S<H	Group 2: P and M
Secondary	10.72 (3.38)					Group 3: M and S
Higher	11.97 (3.23)					Group 4: H
Family Size						
One	8.84 (4.19)					
Two to three	10.08 (3.45)	12.62	<0.0001	<0.0001	O<T, O<F, T<F	Group 1: O
Four or more	10.52 (3.46)			(Linear)		Group 2: T and F
Occupation						
Governmental	11.76 (3.40)					
Private employee	10.85 (3.57)				G=P, G>H, G>Se, G>U,	
House wife	10.10 (3.27)				G>St, G>F, G=O, P=H,	
Self-employed	10.13 (3.54)	22.05	<0.0001	-	P=Se, P>U, P=U, P=St,	Group 1:F, U, St, O,
Unemployed	9.40 (3.67)				P=O, H=Se, H=U, H=St,	H and Se, Group
Student	9.54 (3.40)				H=F, H=O, Se=U, Se=St,	2:U, St, O, H, Se and
Farmer/Fisher	8.71 (3.32)				Se=F, Se=O, U=St, U=F,	P Group 3: H, Se, P
Other*	9.62 (3.30)				U=O, St=F, St=O, F=O	and G
Zone						
Anseba	10.53 (3.36)					
Debub	8.85 (3.65)				A>De, A=G, A=M, A=S,	Group 1: De, S, and
Gash Barka	9.54 (3.18)	28.45	<0.0001	-	A=D, De<M, De=G, De=S,	G, Group 2: S, G, D
Maekel	11.00 (3.39)				De=D, G<M, G=S, G=D,	and A Group 3:
SKB	9.44 (3.51)				M>S, M=D,	G,D,A and M
DKB	10.27 (3.09)					

Other: Day laborer, soldier, sheik/priest etc; ** Welch test statistic was used to obtain robust result; SKB: Semenawi Keih Bahri; DKB: Debubawi Keih Bahri*

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Supplementary file 5: Comparison of attitude scores on antibiotics and antibiotic resistance across the categories of demographic characteristics at bivariate level, Eritrea, 2019.

Characteristics	Mean (SD)	F/t Value	p-value	p-value trend (Type of trend)	Post Hoc Test	
					Pair wise comparison	Group wise comparison
Age						
24 or less **A**	22.10 (3.81)					
25 to 34 **B**	22.50 (3.31)					
35 to 44 **C**	22.25 (3.66)	2.97*	0.019	0.034 (quadratic)	A=B=C=D=E,	Group 1: A, B, C, D and E
45 to 54 **D**	22.80 (3.47)					
55 and above **E**	22.07 (3.76)					
Gender						
Male	23.0 (3.86)	4.92	<0.0001	-	M>F	-
Female	22.13 (3.48)					
Religion						
Christian	22.37 (3.54)	0.7	0.488	-	-	-
Muslim	22.24 (3.80)					
Educational Level						
Illiterate	21.36 (3.64)					
Primary	22.14 (3.46)				I=P, I<M, I<S, I<H, P=M, P=S, P<H, M=S, M<H, S<H	Group 1: I Group 2: P, S and M Group 3:H
Middle	22.34 (3.65)	10.76	<0.0001	<0.0001 (linear)		
Secondary	22.32 (3.52)					
Higher	23.16 (3.62)					
Family Size						
One	21.86 (3.42)					
Two to three	22.25 (3.46)	1.2	0.300	-	-	-
Four or more	22.39 (3.64)					
Occupation						
Governmental	22.93 (3.73)					
Private employee	22.04 (3.32)					
House wife	22.30 (3.51)					
Self-employed	22.62 (3.48)					
Unemployed	21.69 (3.38)				G=P, G=H, G=Se, G>U, G=St, G=F, G=O, P=H, P=Se, P=U, P=U, P=St, P=O, H=Se, H=U, H=St, H=F, H=O, Se=U, Se=St, Se=F, Se=O, U=St, U=F, U=O, St=F, St=O, F=O	Group1:F, U, St, O, H, G, and Se
Student	21.82 (3.85)	4.95	<0.0001	-		
Farmer/Fisher	21.65 (3.92)					
Zone						
Anseba	23.19 (3.43)					
Debub	22.27 (3.35)					
Gash Barka	23.24 (3.73)				A=De, A=G, A>M, A=S, A=D, De=M, De<G, De=S, De=D, G>M, G=S, G=D, M=S, M=D, S=D	Group 1: A, De, M, S, and D Group 2: A, De, M, S, and G
Maekel	22.01 (3.62)	8.87	<0.0001	-		
SKB	22.76 (3.20)					
DKB	21.73 (4.32)					

** Welch test statistic was used to obtain robust result; SKB: Semenawi Keih Bahri; DKB: Debubawi Keih Bahri.*

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Supplementary file 6: Distribution of the significant determinants of knowledge and attitude scores by low educational level

Variables		% low level of education
Age	25 to 54 years	25.0
	> 54 years	63.0
Employment	Government employees	7.5
	Other categories of occupation*	34.2
Family size	2 or more	13.8
	One	61.1
Sex	Males	16.0
	Females	32.0
Religion	Christians	25.6
	Muslims	38.4
Zones	Maekel	10.2
	Anseba	33.8
	Other zones**	43.2

**Other categories of occupation: Private employee, house wife, self-employed, unemployed, student and farmer/fisher;*

***Other zones: Debub, Gash Barka, Semenawi Keih Bahri, Debubawi Keih Bahri*