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

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

Mulugeta Russom¹, Merhawi Bahta^{1*}, Merhawi Debesai¹, Iyassu Bahta¹, Abrahalei Kessete¹, Aziza Afendi¹, Yodit Fitsum¹, Josephina Nambozi², Soliana Kidane², Eyasu H. Tesfamariam³

¹National Medicines and Food Administration, Ministry of Health, Asmara, Eritrea.

²WHO Country Office, Asmara, Eritrea.

³Biostatistics and Epidemiology Unit, Department of Statistics, College of Science, Eritrean Institute Technology, Mainefhi, Eritrea.

*Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara, Eritrea.

Authors' e-mail addresses:

AA: aziizaafendi@gmail.com

AK: abrahaleikessete20@gmail.com

EHT: eyasutesfamariam80@gmail.com

IB: bahtassy@gmail.com

JN: nambozej@who.int

MB: meramcp19@gmail.com

MD: dome.bable07@gmail.com

MR: satiswt@gmail.com

SK: kidanes@who.int

YF: YoditFitsumG@gmail.com

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ABSTRACT

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

Design: Population-based, nation-wide cross-sectional study with quantitative approach.

Setting: Urban settings of Eritrea

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

Data collection and analysis: Face-to-face interview was conducted using a structured questionnaire to collect data. Data collection was conducted from July to September 2019. Data was double entered and analyzed using CPro (Version 7.0) and SPSS (Version 23) respectively. Descriptive statistics, chi-square test, t-tests, analysis of variance and multivariate logistic regression was 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 antibiotic resistance. Secondary outcome measures were the determinants of knowledge, attitude and practice.

Results: A total of 2477 adults, dominated by females (74.7%), were interviewed. The knowledge and attitude of antibiotics and antibiotics resistance (ABR) mean score 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. The proportion of at least one risky practice in all those participants who used antibiotics was 23.8%. Young age <24 years (AOR=1.59, 95% CI: 1.06 to 2.38), male sex (AOR=1.48, 95% CI: 1.15 to 1.92), higher level of education (AOR=1.77, 95% CI: 1.05 to 2.90), and negative attitude on antibiotic use ($p < 0.001$) were found to be the significant determinants of risky practice of antibiotics.

Conclusion: The gap in knowledge and risky practice of antibiotics in the Eritrean urban population was widespread, requiring immediate attention from policymakers and healthcare professionals.

Keywords: Antibiotic; antibiotics resistance; knowledge; attitude; practice; Eritrea.

Article summary

Strengths and limitations of this study

- This was a population-based study covering nation-wide representative of all urban residents with high response rate.
- It is the first of its kind in Eritrea.
- The results were self-reported and thus, findings might be under- or over-estimated, which could introduce information bias or recall bias.

INTRODUCTION

Antibiotics, one of the subsets of antimicrobials, have the ability to cure bacterial infections. Their emergence was a breakthrough in medical care and has ended the dark ages of medicine, when simple infections were fatal and due to the risk of contamination, medical interventions like assisted delivery and surgical procedures were not safe. However, such advances are being threatened by the emergence of resistant strains rendering many of the previously novel antibiotics ineffective. With the quest to achieve universal health coverage, access to essential medicines, like antibiotics, to the general public has been highly advocated. On the other hand, the excess use of antibiotics, in addition to wastage of resources, poses a great health risks that would escalate bacterial resistance¹⁻⁴.

Resistant infections are now estimated to cost at least 50,000 lives each year in Europe and the US alone⁵. From this, one can speculate that the burden of antimicrobial resistance 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, surveillance, knowledge and higher infectious diseases^{1 6 7}. If left unimpeded, by 2050, deaths attributable to antimicrobial resistance are estimated to be 10 million per year globally¹.

Nowadays, antibiotic resistance is recognized 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 Goals⁸. Thus, antimicrobial resistance in general and antibiotic resistance in particular is transforming to be a political agenda.

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3 As estimated by the WHO, 80% of antibiotics is used in the community, of which 20-50% is used
4 inappropriately⁹. Use of antibiotics without prescription¹⁰⁻¹³, physicians' perception of patient
5 expectation for antibiotics^{14 15}, patient demand¹⁶⁻¹⁸, unrestricted use of antibiotics^{7 19} and poor
6 healthcare system²⁰ have been reported as among the main factors for the inappropriate use of
7 antibiotics. To tackle this, at the 68th World Health Assembly, a global action plan was endorsed
8 ²¹. One of the five global strategic objectives was to improve awareness and understanding about
9 antimicrobial resistance²¹, thus; all member states were recommended by the WHO to annually
10 conduct antibiotic awareness week campaigns in a one-health approach²¹.

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12 As part of this initiative, Eritrea started conducting massive antibiotic awareness week campaigns,
13 in a one health approach, since 2017. Due to lack of baseline data, the impact of the continuous
14 campaigns could not be assessed against pre-established parameters. This study is therefore
15 conducted to measure knowledge, attitude and practice of antibiotic usage and identify key
16 determinants for knowledge, attitude and practice in the Eritrean urban population.
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32 **METHODS**

33 **Study Design**

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35 A cross-sectional study design, with a quantitative approach, was used.
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39 **Study Area and Period**

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41 Eritrea is a country with an estimated population of 3.4 million²². It has six administrative zones
42 comprising 58 subzones in total. The country has five administrative levels namely: National,
43 Zonal, Sub-zonal, Local Administration (Kebabi administration) and Village/Block (village in
44 rural or block in urban settings) levels.
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49 The survey was conducted between July and September 2019 in all urban sites of the country. In
50 Eritrea, there are a total of 13 cities and/or towns. The urban sites included in this study were three
51 from Gash Barka, five from Debub, two from Semenawi Keih-Bahri (SKB) and one city or town
52 from each of the three zones, namely Anseba, Debubawi Keih-Bahri (DKB), and Maekel (Table
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3 1). A total of 25 sub-zones and 72 local administrations (Kebabi administration) located in the
4 above-mentioned towns and/or cities were involved in the survey.
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10 Table 1: Number of households in the urban places of Eritrea (July 2019).
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Zone	City/Town	HH Size
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

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42 *SKB: Semienawi Keih Barhri; DKB: Debubawi Keih Barhri; HH: Household*
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46 Target Population

47 The target population of the study includes all members of the general public aged 18 years or
48 above and living in the thirteen urban places in which the survey was conducted.
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Sample Size and Sampling Technique

Sample size

Sample size for the study was computed after considering the necessary parameters, namely: sampling techniques, expected proportion, precision, and level of significance. Calculation of the sample size for stratified random sampling was done using the following formula²³:

$$n \geq \frac{NV1.96^2}{V * 1.96^2 + (N - 1) * 0.05^2}$$

Where; 1.96 refers to the standard normal score of the 95% confidence level of the estimation, 0.05 to the precision, N=overall population size (of the urban places), and $V = \frac{SD^2}{\text{Pooled proportion}^2}$

SD was computed to be 0.5, using the household sizes of each zone (Table 1) and assuming p=0.5 since no other nation-wide studies were conducted in the past. Using the same data, the pooled proportion was 0.25. Hence, the sample size for all the six strata became 1524.5 and after adjusting for 10% non-response rate, it was increased to 1694.4. Finally, the design effect (deff=1.5) adjusted sample size was 2542 individuals.

Sampling Technique

The awareness, knowledge, attitude, and practice towards antibiotics and antibiotic resistance varies across the zones in Eritrea. For this reason, each zone was considered as a stratum having unique level of awareness, knowledge and attitude. There was homogeneity of awareness, knowledge, attitude, and practice within each zone, which allowed us to cluster urban places and take representative samples. Hence, it was presumed that the sample design that led to the selection of a legible person was a stratified three-stage cluster sample with some recognized geo-political area unit of variable size as the primary sampling unit, an approximately equal-sized area, segment, consisting of roughly 200 households as the secondary sampling unit, and individual households selected within sampled segments²⁴.

Sampling Frame

A new frame was constructed based on recognized administrative and geo-political organization of the urban places in Eritrea. All urban places eligible for the study were requested to supply the

list of households by subzones, local administration and blocks. According to the listing received, majority of the blocks had households size ranging from 200 to 1000. Hence, the frame used in this survey during the first stage of the selection comprised the blocks in each local administration of the subzone.

Determination of number of households in each cluster

Theoretically, the number of clusters to be selected depends on the design effect and the inter-cluster correlation. With decrease in inter-cluster correlation, more clusters need to be taken, keeping the design effect constant ²⁵. Considering the economic and administrative issues, a household size of 25 was used to form each cluster and thus; there was a demand of 102 clusters in total to achieve the desired sample size.

Allocation of Households/Clusters

Sampling guidelines suggest proportional allocation as the best one because it assigns equal weights to the zones/urban places. However, the sample size allocated for DKB using proportional allocation to the population was too small to bring zonal/urban level reliable estimates. On the other hand, equal allocation would generate too large sample, which would seriously affect the variance of country estimates. Hence, a proportional to square root of the population was used to bring about the overall and zonal level reliable estimates.

Data collection tools and approach

A structured questionnaire was prepared by reviewing questionnaires of similar studies ²⁶⁻²⁸. The questionnaire (see online supplementary file) was customized in such a way to reflect issues relevant to Eritrea whilst keeping certain necessary variables that are essential for international comparison. Modifications were made after a series of consultative meetings. The questionnaire 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, knowledge regarding antibiotics and antimicrobial resistance; attitude regarding antibiotics and antimicrobial resistance, and practice of the general public on antibiotics usage.

Efforts were made to recruit pharmacy professionals who had prior experience of data collection in surveys as enumerators (n=16). Very close, however, inspiring supervision was made by two principal investigators. Orientation was provided to data collectors and supervisors in order to

familiarize 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 as well as third stage sample selection of the households.

Prior to the main fieldwork, the questionnaire was pre-tested on five different clusters, which were not included in the main survey. These clusters are found in two local administrations of Asmara. Twenty-five households were interviewed from each selected cluster. The pre-test aided in assessing the accuracy of translation, the ability of the questions to elicit appropriate information, the ability of enumerators to administer the questionnaire and record the response given, and to estimate the time required to complete a questionnaire. Based on the observations, interviewers' comments and review of the findings from the pre-test, the questionnaire was revised and adjusted for the main study.

Actual data collection was conducted from July to September 2019. Two teams were formed and each team was composed of a supervisor, 8 interviewers, and a driver. Each team was allocated 51 clusters. Information on selected clusters was provided to the supervisor and communicated to the respective sub-zone administrative office before the field work. 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 offer respondents the opportunity to participate in the survey. If the selected candidate was found to be unavailable in a successive of three to four attempts, it was considered as a 'no response'.

Data quality and management

Orientation training, pre-test, close supportive supervision and daily field editing of the completed questionnaires were carried out to achieve high response and maximize data quality. Completed questionnaires were submitted from the field to the data manager on a daily to weekly basis. Data was processed by the data manager on frequent intervals to check for quality and reporting completeness. Processing the data concurrently with data collection allowed for regular monitoring of team performance and data quality. Data was also checked for consistency, completeness and feedback/corrective actions were provided to field supervisors on spot to improve data quality. Additionally, rigorous editing and cleaning of the entered data was made throughout the process of data entry.

Data Analysis

Data was double entered using Census and Survey processing system (CSPPro, Version 7.0) software package and exported to statistical package for social sciences (SPSS) Version 23. Data was summarized by using weighted percentages and counts. Cross-tabulations and further analysis were also done whenever relevant.

Kolmogorov-Smirnov test was used to check on the normality of the knowledge and attitude scores. Frequencies, percentages, mean (with standard deviation), median (with interquartile range) were used to describe the data, as appropriate. Independent samples t-test and analysis of variance (ANOVA) were also applied to find out the potential differences in mean scores of the knowledge and attitude towards antibiotic usage and resistance among the six zones. Scheffe adjustment and Duncan's test were used in pair-wise and group wise comparison of the post-hoc test, respectively. To compare the mean attitude and knowledge scores, among various categories of the demographic characteristics, an independent sample t-test and ANOVA was computed. To explore the association between the risky practice of antibiotic and the categorical demographic characteristics, chi-square test was performed and to control potential confounders, variables that were found to be significant or slightly higher than the cut point were subjected to multivariate analysis. In this study, *p*-value less than 0.05, in all the analyses, is considered as significant.

RESULTS

Demographic characteristics of the study participants

A total of 2542 individuals were selected for the survey. Among the selected individuals, 2,477 successfully interviewed; making an overall response rate of 97.44%. Demographic characteristics of the respondents are summarized in table1. The unweighted numbers reflect the actual observations at the time of survey, whereas the weighted numbers reflect figures that have been adjusted by the probability of selection of the respondents. A total of 2477 respondents, 18 years and above, were interviewed in the survey. The survey participants were mostly females (74.7%), Christians (77.4%), Tigrigna ethnic group (82.3%), and household size of four or more (73.6%) (Table 2).

Table 2: Percent distribution of respondents, 18 years and above, on the knowledge, attitude and practice survey of antibiotics and antibiotic resistance by background characteristics, 2019, Eritrea

Background Characteristics	Weighted Percent	Weighted Number	Unweighted Number
Age			
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
Maekele	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			
One	4.4	108	104
Two to three	22.0	545	533
Four or more	73.6	1824	1840
Occupation			
Governmental	22.8	566	529
Private employee	4.9	121	115
House wife	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

SKB: Semenawi KeihBahri, DKB: Debubawi Keih Bahri

Awareness and Knowledge on Antibiotics and Antibiotic Resistance

About three-fourth (73.3%) of the survey participants were aware of the term ‘antibiotics’ and 39% aware of the term ‘antibiotics resistance’. A quarter (23.8%) of respondents knew at least one commonly used antibiotic. The sources of information about antibiotics and antibiotic resistance (ABR) were mainly health facilities (39.6%), television (31.5%) and other people (10.1%).

Distinguishing antibiotics from non-antibiotics, identification of common illnesses that can require antibiotics and those that do not need antibiotics, when to stop antibiotics once started, definition of ABR, and potential impact and transmission of ABR were the main indicators used to measure the level of knowledge of the respondents on antibiotics and antibiotic resistance. Of the list of medicines provided, 59.4% of the respondents 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% to 70.6% of the respondents.

Less than half (36.6%-49.5%) of the respondents correctly reported about indication of antibiotics for common illnesses. Majority of the respondents reported that antibiotics can be used to treat viral infection (63.4%), watery diarrhea (61.8%), common cold (58.9%), dry cough (54.2%) and dengue fever (50.5%). Sixty-one per cent of the respondents also reported that antibiotics are not indicated for tuberculosis. Majority (83.3%) of the respondents know when to stop taking antibiotics once they had begun treatment.

Over three-fourth (78.2%) of the respondents 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. About 59% know that bacteria resistant to antibiotics can spread from person to person and another 59% reported that ABR is an issue in other countries but not in Eritrea.

The overall mean knowledge score on antibiotics and ABR was found to be 10.36/20 (SD= 3.51, min=0 and max=20). Males ($p<0.001$), Christians ($p<0.001$), respondents aged between 25 and 54 years ($p<0.001$), those who had higher educational level ($p<0.001$) and big family size ($p<0.001$) and government employee status ($p<0.001$) were more likely to have better knowledge score.

Besides, study participants residing in Maekel and Anseba Zones had better knowledge score ($p<0.001$) on antibiotics and ABR compared to those living in other Zones (Table 3).

Respondents' attitude on antibiotics and ABR

The overall mean attitude score was 22.34/30 (SD= 3.59, minimum=6 and maximum=30). A negative attitude towards appropriate disposal of antibiotics was documented in over 50% of the study participants (Table 4). Males ($p<0.001$), respondents aged between 25 and 54 years ($p<0.019$), those who had higher educational level ($p<0.001$), and government employees ($p<0.001$) had better attitude score compared to their counterparts (Table 5).

Table 3: Comparison of knowledge scores across the categories of demographic characteristics

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

Table 4: Respondents response on the attitude of antibiotics and Antibiotic Resistance (ABR), Eritrea, 2019 (N=2477)

Attitude questions on antibiotics and ABR	% agreed/ strongly agreed
Hand washing decreases ABR	92.7
Taking antibiotics when it is not required can facilitate ABR	89.7
You have a role to fight ABR	85.8
It is not okay to share antibiotics with others	90.1
We cannot use antibiotics without prescription	88
Farmers should not give antibiotics without consulting veterinarian	82.1
It is not okay to keep leftover antibiotics and use them later	82
Leftover antibiotics should not be disposed with regular garbage	46
Leftover antibiotics should not be disposed at toilets	35.7

Table 5: Comparison of attitude scores on antibiotics and antibiotic resistance across the categories of demographic characteristics, 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)					
Female	22.13 (3.48)	4.92	<0.0001	-	M>F	-
Religion						
Christian	22.37 (3.54)					
Muslim	22.24 (3.80)	0.7	0.488	-	-	-
Educational Level						
Illiterate	21.36 (3.64)					
Primary	22.14 (3.46)					
Middle	22.34 (3.65)	10.76	<0.0001	<0.0001 (linear)	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
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)				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	
House wife	22.30 (3.51)					
Self-employed	22.62 (3.48)					
Unemployed	21.69 (3.38)					
Student	21.82 (3.85)	4.95	<0.0001	-		Group 1: F, U, St, O, H, G, and Se
Farmer/Fisher	21.65 (3.92)					
Zone						
Anseba	23.19 (3.43)					
Debub	22.27 (3.35)					
Gash Barka	23.24 (3.73)					
Maekel	22.01 (3.62)	8.87	<0.0001	-	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
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.

Respondents practice on usage of antibiotics

Majority (84.5%) of the respondents had used antibiotics at least once in their life time. Over half (55%) of the study participants had history of intake of antibiotics in the last one year and 12.3% in the last one 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 authorized healthcare professionals while the rest 12% were rather on self-medication. The 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 a long queue existing in health facilities (14%) 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).

One fifth (18.8%) of those who had ever used antibiotics interrupted taking antibiotics before completing the full course. The main reason for interruption of antibiotics intake was improved illness condition (63.4%) followed by the experience of adverse effects (12.9%) (Figure 2). A small number (2.7%) of the respondents reported they had used antibiotics on their own at least once, though healthcare professionals advised them not to do so.

Overall, risky practice of antibiotics (use of antibiotics without prescription and/or discontinuation of prescribed antibiotics before completing the full course) was reported in 23.8% of the respondents. The chi-square 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 risky practice of antibiotics. On multivariate model, young age - 24 years or less (AOR=1.59, 95% CI: 1.06 to 2.38), males (AOR=1.48, 95% CI: 1.15 to 1.92), and higher level of education (AOR=1.77, 95% CI: 1.05 to 2.90) were more likely to be determinants of risk practice of antibiotics. Having positive attitude on antibiotics (AOR=0.95, 95% CI: 0.92 to 0.97) showed a protective effect for risky practice of antibiotics while knowledge had no association (Table 6).

Table 6: Multivariable predictors of risky practice of antibiotics across the categories of demographic characteristics and attitude score, Eritrea, 2019.

Background characteristic	Multivariable analysis		
	AOR	95% CI	p-value
Age			
24 or less	1.59	1.06 to 2.38	0.026
25 to 34	1.25	0.88 to 1.78	0.217
35 to 44	1.05	0.74 to 1.49	0.790
45 to 54	0.89	0.61 to 1.29	0.533
55 and above	<i>Ref.</i>		
Gender			
Male	1.48	1.15 to 1.92	0.003
Female	<i>Ref.</i>		
Educational Level			
Illiterate	<i>Ref.</i>		
Elementary	1.02	0.66 to 1.57	0.920
Junior	1.20	0.77 to 1.84	0.421
Secondary	1.32	0.86 to 2.02	0.207
Higher	1.77	1.05 to 2.90	0.023
Family Size			
One	0.79	0.44 to 1.43	0.436
Two to three	1.15	0.90 to 1.46	0.255
Four or more	<i>Ref.</i>		
Occupation			
Governmental	2.27	0.67 to 7.68	0.189
Private employee	2.58	0.72 to 9.25	0.146
House wife	3.01	0.89 to 10.22	0.077
Self-employed	3.43	0.99 to 11.90	0.052
Unemployed	2.59	0.75 to 8.93	0.132
Student	3.28	0.93 to 11.60	0.066
Farmer/Fisher	3.35	0.84 to 13.38	0.088
Other*	<i>Ref.</i>		
Zone			
Anseba	0.47	0.21 to 1.04	0.077
Debub	0.72	0.33 to 1.58	0.416
Gash Barka	0.70	0.31 to 1.55	0.375
Maekel	0.88	0.42 to 1.86	0.740
SKB	0.81	0.35 to 1.87	0.622
DKB	<i>Ref.</i>		
Attitude	0.95	0.92 to 0.97	<0.001

A total of 1473 of the respondents had animals and about 14% reported that they have treated their animals with antibiotics at least once. Of those who used antibiotics for their animals, 62% 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%

of antibiotics used for animals was prescribed by veterinarians (50.7%) whereas the rest were supplied by non-veterinarians, mainly from pharmacy retail outlets (20.8%) (Figure 3).

DISCUSSION

This nation-wide urban population-based survey revealed a significant risky practice of antibiotics, in Eritrea. One in five of the respondents, who had ever used antibiotics, reported that their last intake of antibiotic(s) was terminated for many reasons. Discontinuation of antibiotics when the consumer felt better was the most frequently reported reason. This reflects lack of awareness on the appropriate use of antibiotics and risk of antibiotic resistance. Majority of the antibiotics most recently consumed by the respondents were reported to have been prescribed by qualified healthcare professionals. This is encouraging and the nation-wide, massive antibiotic awareness week campaigns conducted in the last three years, prior to the study, might have had positive contributions. Yet, due to lack of a national baseline data, the authors could not infer causation.

The disease condition being non-serious, intention to get a 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 of 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 subsidized or nominal cost through public health facilities. To further improve patient's satisfaction, accessibility and engagement in visiting health facilities and health seeking behavior, the existing healthcare delivery services need to be optimized. Moreover, the one-week annual antibiotic awareness week campaign in place should be augmented by other continuous and regular similar activities throughout the year.

In this study, drug retail outlets were reported as the main sources for the sales of antibiotics without prescription. A recently conducted study to determine the sales of antibiotics without prescription in all drug retail outlets in Eritrea also revealed an alarming picture (87%)¹⁰ which requires immediate attention of regulators and policy makers. Continued refresher courses on appropriate use of antibiotics and antibiotic resistance 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 'prescription only medicine' category. To ensure implementation and adherence to 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 many European countries, where this practice is reported to occur in a proportions of 7% (ranging from 1% to 16%). It was however much lower than that reported in Italy²⁹, Jordan^{30 31}, United Arab Emirates³², Palestine³³, Lebanon³⁴, Iraq³⁵, Indonesia³⁶, Yemen³⁷, Saudi Arabia³⁸, Haiti³⁹, Kuwait⁴⁰, and Ethiopia^{41 42}, where proportions ranged between 31% and 79%. The variation in results, however, could be due to differences in study designs, study area, study population, type of questions, level of awareness of the study participants and soon.

Respondents of young age (24 years or less), male sex, high level of education and poor attitude score were identified as determinants of risk 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 risky practice of antibiotics. This might be explained as knowing more or being educated would predispose people to the tendency to take self-made decisions more casually with the assumption that they have the knowledge. But qualitative studies are required to further identify the determinants of risky practice of antibiotics.

In this study, an appreciably high mean attitude score towards antibiotics and antibiotic resistance was reported. Those who scored poor attitude were more likely to be involved in risky practice of antibiotics, whereas protective effect was noted in those with higher attitude scores. Male sex, age between 45 and 54 years, high educational level, being a government employee, and residing in Anseba and Gash Barka zones were associated with better attitude scores. It is, however, important to note that the poor attitude reported on the appropriate disposal of leftover antibiotics, requiring immediate attention from policy makers.

Unlike the relatively good attitude score, the mean knowledge score of respondents on antibiotics and antibiotic resistance was not satisfactory. This study revealed that majority of the respondents

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3 had no clear picture on what an antibiotic is and were unable to recognize, by name, the most
4 commonly used antibiotics (penicillin, cotrimoxazole and ciprofloxacin) in the country.
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6 Additionally, categorizing ibuprofen, ORS and paracetamol as antibiotics by a large number of
7 respondents was concerning. A significant proportion of the respondents also had the
8 misunderstanding that antibiotics could treat viral infections like common cold and acute watery
9 diarrhea. Hence, continued awareness raising programs should target such misconceptions and
10 familiarize the public with the commonly used antibiotics, their proper indications and potential
11 for resistance. The assumption that antibiotic resistance is a threat elsewhere, but not in Eritrea, as
12 reported in this study, reflects how oblivious people are on the issue of antibiotic resistance and
13 might limit the public from taking appropriate actions at their levels.
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17 Regarding the use of antibiotics to treat animals, oxytetracycline and two other antibiotics we use
18 for humans namely: amoxicillin and penicillin, were the most frequently reported ones in this
19 study. About half of the antibiotics used in animals were supplied by non-veterinarians including
20 drug retail outlets and open markets, indicating poor regulation of antibiotics in animal and human
21 health.
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25 The study has benefited many strengths, including: being the first of its kind in Eritrea; covering
26 nation-wide representation of all urban population; excellent data quality and management, and
27 high response rates. On the other hand, one of the main limitations of this study is that results were
28 self-reported and thus, findings might be under- or over-estimated, which could introduce
29 information bias or recall bias.
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32 33 34 35 36 37 38 39 40 **Conclusion**

41
42 The risky practice of antibiotics in Eritrea was prevalent and inversely proportional to the mean
43 attitude score of the respondents. Young respondents, males, and those who had higher level of
44 education and poor attitude score were identified as having greater tendency for risky practices
45 associated with antibiotics. The inability of many of the respondents to distinguish antibiotics from
46 other medicines and the reported misunderstanding that viral infections can be treated with
47 antibiotics, indicates limited knowledge of respondents on antibiotics and ABR. Continuous
48 awareness raising programs on the rational use of antibiotics (mainly on the risks of self-
49 medication, treatment interruption, and use of antibiotics for viral infections) and familiarizing the
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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, medicines schedule and regulatory inspections should be enforced. 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.

DECLARATIONS

Ethics approval and informed consent

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.

Patient consent for publication: Not required.

Conflict of interests

The authors declare that they have no competing interests.

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Author contributions

The idea was conceived by MR and IB and designed by MB, MD, MR, AK, AA, YF, IB, SK, JN and EHT. Data was collected by MD, AK, AA and YF and supervised by MR and MB. EHT analyzed the 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.

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Availability of data

All data related to the study are included in the manuscript. The complete dataset used for this study can be obtained from the corresponding author upon request.

Acronyms

ABR: Antibiotic Resistance; DKB: Debubawi Keih Bahri; SKB: Semenawi Keih Bahri; WHO: World Health Organization.

Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication: Not required.

Provenance and peer review: Not commissioned; externally peer reviewed.

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

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

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

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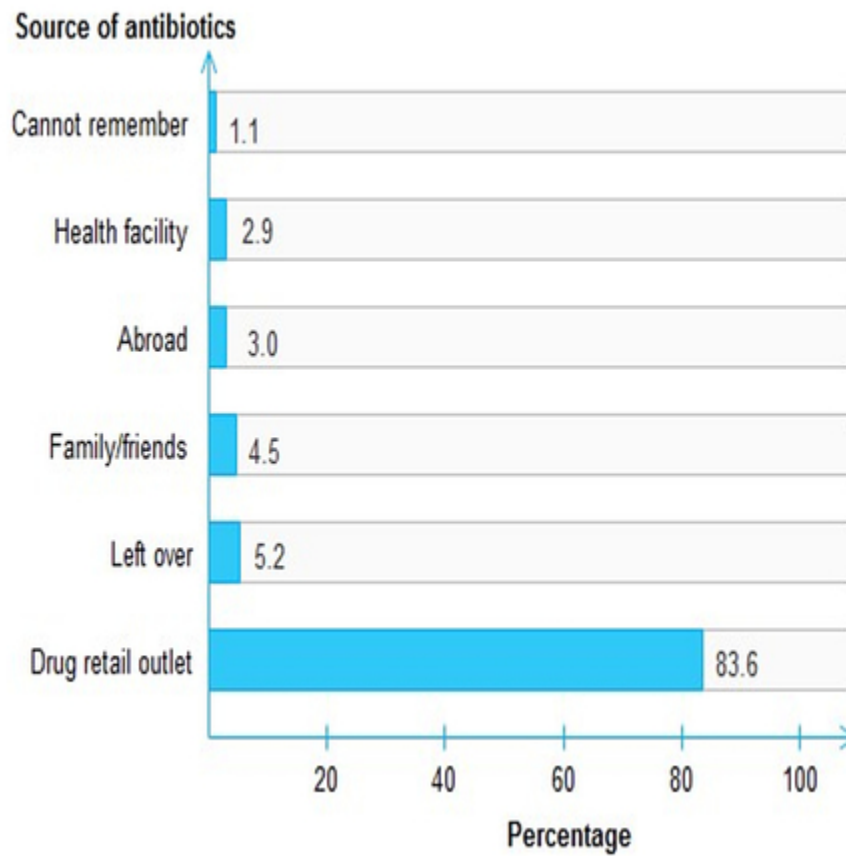


Figure 1: Source of antibiotics used without prescription among urban residents, Eritrea, 2019 (n=242)

38x38mm (300 x 300 DPI)

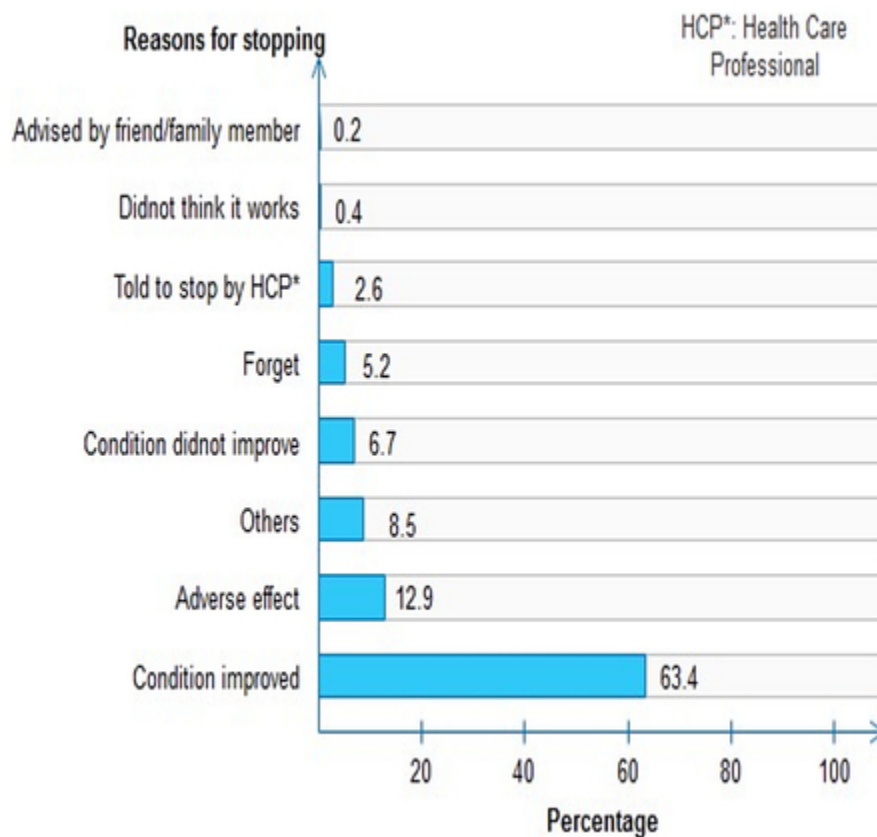


Figure 2: Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019 (n=357)

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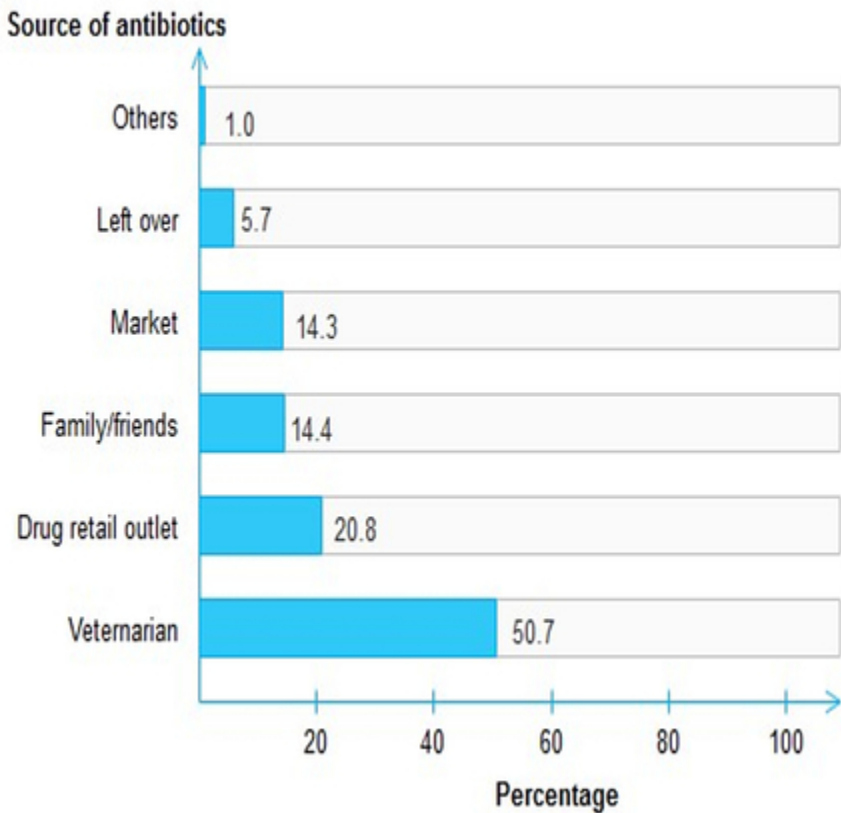


Figure 3: Source of antibiotics for animals among urban residents, Eritrea, 2019 (n=245)
38x38mm (300 x 300 DPI)

**MINISTRY OF HEALTH
National Medicines and Food Administration**

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

Household Questionnaire

Part I: Identification Particulars

Zoba				
Subzoba				
City/Town				
Kebabi				
Respondent number				

Interviewer Visits

	1	2	3	Final Visit			
Date	_____	_____	_____	Day			
				Month			
				Year	2	0	1 9
Interviewer's Name	_____	_____	_____	Int. No.			
Result*	_____	_____	_____	Result*			
Next visit: Date	_____	_____		Total number of visits			
Time	_____	_____					
*Result codes: 1 Completed 2 Not completed 3 Not willing 4 Other _____ (Specify)				Total persons In household			
				Total eligible persons (>18)			
Supervisor			Field editor			Keyed by	
Name _____			Name _____			Name _____	
Number <input type="checkbox"/>			Number <input type="checkbox"/>			Number <input type="checkbox"/>	

Part II: Demographic Information

No.	Indicators	Coding categories	Skip
101	Age (in completed years)	<input type="text"/> <input type="text"/>	
102	Sex	Male 1 Female 2	
103	Ethnicity	Tigrina 1 Afar 2 Tigre 3 Saho 4 Rashida 5 Kunama 6 Blien 7 Hidarb 8 Nara 9 Other (please specify) _____ #	
104	Religion	Christian 1 Muslim 2 Other (please specify) _____ 3	
105	Level of education (Highest level of education)	Illiterate 1 Primary school 2 Middle school 3 Secondary school 4 Higher education 5	
106	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																																				
201	Have you ever heard about antibiotics?	Yes 1 No 2	203																																				
202	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																																				
203	Which of the following do you think are antibiotics? ASK FOR EACH MEDICATION. If the response in 201 is No and heard of any one of the examples of antibiotics, explain that the term Antibiotics refers to these drugs before continuing to 204.	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Y</th> <th style="text-align: center;">N</th> <th style="text-align: center;">DK</th> </tr> </thead> <tbody> <tr> <td>Ibuprofen</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Tetracycline</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Bactrium</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>ORS</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Amoxicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Paracetamol</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Ciprofloxacin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Penicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> </tbody> </table>		Y	N	DK	Ibuprofen	1	2	3	Tetracycline	1	2	3	Bactrium	1	2	3	ORS	1	2	3	Amoxicillin	1	2	3	Paracetamol	1	2	3	Ciprofloxacin	1	2	3	Penicillin	1	2	3	
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Ciprofloxacin	1	2	3																																				
Penicillin	1	2	3																																				
204	Which of these diseases do you think are treated with antibiotics? ASK FOR EACH ILLNESS.	Common colic 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																																					
205	Do antibiotics treat viral infections?	Yes 1 No 2 Don't know 3																																					
206	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																																					
207	Have you ever heard of the term antibiotic resistance (ABR)?	Yes 1 No 2																																					
208	Antibiotic resistance occurs when your becomes resistant to antibiotics and they no work.	Yes 1 No 2 Don't know 3	216																																				
209	Where did you hear about antibiotic resistance? MULTIPLE RESPONSES ARE POSSIBLE. PROBE: Are there any other sources	Health facility A Pharmacy B Radio C TV D Newspaper E Campaign/Seminar F Other (please specify) G																																					

210	Antibiotic resistance is an issue that could affect me or my family.	Yes 1 No 2 Don't know 3	
211	Antibiotic resistance is an issue in other countries but not here.	Yes 1 No 2 Don't know 3	
212	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
213	Proper handwashing play a role in ABR.	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
214	Taking antibiotics when it is not required can facilitate ABR.	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
215	You have a role to fight ABR	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
216	We can use antibiotics without prescription	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
217	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	
218	It is okay to keep leftover antibiotics and use them later	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	

219	Farmers can give antibiotic without consulting veterinarian	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
220	Leftover antibiotics should be disposed with regular garbage	Strongly disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly agree 5	
221	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
222	Have you ever used antibiotics?	Yes 1 No 2 Don't remember 3	230
223	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	
224	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	
225	On that occasion, did you get a prescription for the antibiotics from a doctor/nurse?	Yes 1 No 2 Don't remember 3	227
226	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	

227	Did you ever stop taking antibiotics before completing the full course?	Yes 1 No 2 Don't remember 3	229
228	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	
229	Ever used antibiotics on your own, though health care professionals advice you not to take	Yes 1 No 2 Don't remember 3	
230	Have you ever given antibiotics to your animals?	Yes 1 No 2 Don't remember 3 Don't have an animal 4	301
231	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	
232	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	
233	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	

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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

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-8
Bias	9	Describe any efforts to address potential sources of bias	5-8
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-10
		(b) Describe any methods used to examine subgroups and interactions	9-10
	(c) Explain how missing data were addressed	9-10	
	(d) If applicable, describe analytical methods taking account of sampling strategy	7-8	
	(e) Describe any sensitivity analyses	NA	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6,7,10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9-10
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-19

		(b) Report category boundaries when continuous variables were categorized	10-19
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	19-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	21-22
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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

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1 1 **Knowledge, Attitude and Practice of Antibiotics and their** 2 2 **Determinants in Eritrea: Urban Population-based Survey**

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6 4 Mulugeta Russom¹, Merhawi Bahta^{1*}, Merhawi Debesai¹, Iyassu Bahta¹, Abrahalei Kessete¹,
7 5 Aziza Afendi¹, Yodit Fitsum¹, Josephina Nambozi², Soliana Kidane², Eyasu H. Tesfamariam³
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21

22 12 ¹National Medicines and Food Administration, Ministry of Health, Asmara, Eritrea.

23 13 ²WHO Country Office, Asmara, Eritrea.

24 14 ³Biostatistics and Epidemiology Unit, Department of Statistics, College of Science, Eritrean
25 15 Institute Technology, Mainefhi, Eritrea.
26
27
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29
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32 18 *Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of
33 19 Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara,
34 20 Eritrea.
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58 24 Word count: 3996
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34 ABSTRACT

35 **Objective:** To measure knowledge, attitude and practice of antibiotics and antibiotic resistance
36 and their determinants in the Eritrean urban population.

37 **Design:** Population-based, nation-wide, cross-sectional study.

38 **Setting:** Urban settings of Eritrea.

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

41 **Data collection and analysis:** Data was collected from July to September 2019 in a face-to-face
42 interview using a structured questionnaire. The collected data was double entered and analyzed
43 using CSPro (Version 7.0) and SPSS (Version 23) respectively. Descriptive statistics, chi-square
44 test, t-tests, analysis of variance, factorial analysis and multivariable logistic regression were
45 performed. All analyses were weighted and $p < 0.05$ was considered significant.

46 **Primary and secondary outcome measures:** Main outcome variables were knowledge, attitude
47 and practice of antibiotics and antibiotic resistance. Secondary outcome measure was the
48 determinants of knowledge, attitude and practice.

49 **Results:** A total of 2477 adults were interviewed. The knowledge and attitude of antibiotics and
50 antibiotic resistance (ABR) mean score was 10.36/20 (SD=3.51, minimum=0 and maximum=20)
51 and 22.34/30 (SD=3.59, minimum=6 and maximum=30) respectively. The proportion of at least
52 one risky practice (use of antibiotics without prescription and/or discontinuation of prescribed
53 antibiotics before completing the full course) in all those study population who used antibiotics
54 was 23.8%. Young age < 24 years (AOR=1.59, 95% CI: 1.06 to 2.38), male sex (AOR=1.48, 95%
55 CI: 1.15 to 1.92), higher level of education (AOR=1.77, 95% CI: 1.05 to 2.90), and negative
56 attitude on antibiotic use ($p < 0.001$) were found to be the significant determinants of risky practice
57 of antibiotics.

58 **Conclusion:** The gap in knowledge and risky practice of antibiotics in the Eritrean urban
59 population was widespread, requiring immediate attention from policymakers and healthcare
60 professionals.

61 **Keywords:** Public health, infectious diseases, epidemiology

62

63

64 ARTICLE SUMMARY

65 Strengths and limitations of this study

- 66 • This is among the few globally reported population-based surveys covering nation-wide
67 representative of all urban residents of Eritrea.
- 68 • The study employed rigorous data quality and management approaches and had high
69 percentage of response.
- 70 • Results of this study were self-reported and thus, findings might be under- or over-
71 estimated which might in-turn have introduced information or recall bias.
- 72 • During data collection, the information regarding family size and available members was
73 gathered, without verification using administrative list, from the household members who
74 were present at the time of visit and this might have introduced respondents' selection bias.
- 75 • The reliability and validity of the scales for knowledge and attitude on antibiotics usage
76 were not checked using statistical tools.

79 INTRODUCTION

80 The excess use of antibiotics, in addition to wastage of resources, poses a great health risks that
81 would escalate bacterial resistance¹⁻⁴. Resistant infections are now estimated to cost at least 50,000
82 lives each year in Europe and the US alone⁵. From this, one can speculate that the burden of
83 antimicrobial resistance (AMR) would be much higher in resource-constrained countries in which
84 the inappropriate use of antibiotics by healthcare professionals and consumers could be rampant.
85 This in part is due to poor regulation, weak health systems, surveillance, knowledge and higher
86 infectious diseases^{1 6 7}. If left unimpeded, by 2050, deaths attributable to AMR are estimated to
87 be 10 million per year globally¹.

88 Nowadays, antibiotic resistance (ABR) is recognized as one of the biggest threats to global health
89 and is becoming a medical emergency that would limit the advances of healthcare delivery
90 services. This endangers the achievements of the millennium development goals and also

1
2
3 91 sustainable development goals⁸. Thus, AMR in general and ABR in particular is transforming into
4
5 92 a political agenda.

6
7 93 As estimated by the WHO, 80% of antibiotics is used in the community, 20-50% of which is used
8
9 94 inappropriately⁹. Use of antibiotics without prescription¹⁰⁻¹³, physician perception of patients
10
11 95 expectation for antibiotics^{14 15}, patient demand¹⁶⁻¹⁸, unrestricted use of antibiotics^{7 19} and poor
12
13 96 healthcare system²⁰ have been reported among the main factors for the inappropriate use of
14
15 97 antibiotics. To tackle this, at the 68th World Health Assembly, a global action plan was endorsed
16
17 98 ²¹. One of the five global strategic objectives was to improve awareness and understanding about
18
19 99 AMR²¹, thus; all member states were recommended by the WHO to annually conduct antibiotic
20
21 100 awareness week campaigns in a one-health approach²¹.

22 101 With these recommendations, Eritrea has been in a process of establishing an antimicrobial
23
24 102 stewardship program. Through a multisectoral approach, Eritrea has developed a national action
25
26 103 plan for combating AMR that is expected to be effective in 2021. One of the four strategic
27
28 104 objectives of the national action plan is 'raise awareness through education and training'.
29
30 105 Moreover, the National Medicines and Food Administration of the State of Eritrea has published
31
32 106 a medicines schedule that is expected to contribute towards the antimicrobial stewardship. Prior to
33
34 107 implementation, knowing the current status and weakest links are important for policy decisions
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36 108 and to identify areas of intervention on tackling AMR. This study is conducted to measure
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38 109 knowledge, attitude and practice of antibiotic usage and identify key determinants for knowledge,
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40 110 attitude and practice in the Eritrean urban population. As there is no baseline data to start with and
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42 111 assess the effectiveness of the annually conducted antibiotic awareness weeks, the findings of this
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44 112 study could also be taken as a point of reference to assess relative changes in the determinants of
45
46 113 change in practice.

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49 116 **METHODS**

50 117 **Study Design and area**

51 118 A cross-sectional study design, with a quantitative approach, was used. Eritrea is a country with
52
53 119 an estimated population of 3.4 million²². It has six administrative zones comprising 58 subzones
54
55 120 in total. The country has five administrative levels namely: National, Zonal, Sub-zonal, Local
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3 121 Administration (Kebabi administration) and Village/Block (village in rural or block in urban
4 122 settings) levels.

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6
7 123 The survey was conducted between July and September 2019 in all urban sites of the country. In
8 124 Eritrea, there are a total of 13 cities and/or towns. The urban sites included in this study were three
9 125 from Gash Barka, five from Debub, two from Semenawi Keih-Bahri (SKB) and one city or town
10 126 from each of the remaining three zones, namely Anseba, Debubawi Keih-Bahri (DKB), and
11 127 Maekel (supplementary File 1). A total of 25 sub-zones and 72 local administrations (Kebabi
12 128 administration) located in the above-mentioned towns and/or cities were involved in the survey.

19 129 **Target Population**

20 130 The target population of the study includes all members of the general public aged 18 years or
21 131 above and living in the thirteen urban places in which the survey was conducted.

25 132 **Sample Size and Sampling Technique**

27 133 **Sample size**

28 134 Sample size was computed mainly for an estimation of proportion of safe practice taking 95%

29 135 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=

30 136 $\frac{SD^2}{Pooled\ proportion^2} = 0.5$ and N=size of the target population. Upon consideration of the

31 137 aforementioned parameters, the initial sample size was 1525. After an adjustment of non-
32 138 response percent (10%) and design effect (deff=1.5), the final sample size was 2542 individuals.

36 139 **Sampling Technique**

37 140 Local data, conducted by Ateshim et al. 2019 ¹¹ and other unpublished studies, implies that the
38 141 awareness, knowledge, attitude, and practice towards antibiotics and ABR varies across the zones
39 142 in Eritrea. Hence, it was presumed that the sample design that led to the selection of a legible
40 143 person was a stratified three-stage cluster sample. During the first stage of the sampling, a total of
41 144 102 primary sampling units referred to as blocks (having households ranging from 200 to 1000)
42 145 were selected from the 13 urban sites. During the second stage, 25 households were selected from
43 146 each block taking into consideration the design effect, inter-cluster correlation, economic and
44 147 administrative issues ²⁴. Finally, samples were selected from each household. To bring about
45 148 reliable zonal and overall estimates, square root allocation of households was undertaken.

149 **Data collection tools and approach**

150 A structured questionnaire (Supplementary file 2) was prepared by reviewing questionnaires of
151 similar studies²⁵⁻²⁷ and was customized in such a way to reflect issues relevant to Eritrea. It was
152 initially prepared in English and then translated into the common local language, Tigrigna. The
153 questionnaire had four sections namely: personal characteristics of the respondent; awareness,
154 knowledge regarding antibiotics and AMR; attitude regarding antibiotics and AMR, and practice
155 of the general public on antibiotic usage.

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

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

168 Households were sampled with the assistance of the administration office after listing them in
169 selected blocks. When eligible respondents were absent from their homes, at least three visits were
170 made to increase the opportunity of participation in the survey. If the selected candidate was found
171 to be unavailable in a successive of three to four attempts, it was considered as a 'no response'.

172

173 **Outcome measures:** The primary outcome measures were knowledge, attitude and practice of
174 antibiotics and ABR in the urban setting of Eritrea. The secondary outcome measure was the
175 determinants of knowledge, attitude and practice of antibiotics and ABR.

176 **Data Analysis**

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3 177 Data was double entered using Census and Survey processing system (CSPPro, Version 7.0)
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5 178 software package and exported to statistical package for social sciences (SPSS) Version 23. It was
6
7 179 summarized by using weighted percentages and counts. Cross-tabulations and further analysis
8
9 180 were also done whenever relevant.

10
11 181 Kolmogorov-Smirnov test was used to check on the normality of the knowledge and attitude
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13 182 scores. Frequencies, percentages, mean (with standard deviation), median (with interquartile
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15 183 range) were used to describe the data, as appropriate. After using independent samples t-test and
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17 184 analysis of variance (ANOVA) at bivariate level of analysis, factorial analysis was employed to
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19 185 assess the predictors of knowledge and attitude at multivariable level. To explore the association
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21 186 between the risky practice of antibiotic and the categorical demographic characteristics, chi-square
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23 187 test was performed and to control potential confounders, variables that were found to have a p-
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25 188 value less than 0.055 were subjected to multivariable analysis using logistic regression. In this
26
27 189 study, *p*-value less than 0.05, in all the analyses, is considered as significant.

28 190 **Operational definition**

29
30 191 **Risky practice:** Refers to the act of self-medication with antibiotics and/or discontinuation of a
31
32 192 regimen of antibiotics. It was determined by assessing whether the last used antibiotics were
33
34 193 prescribed by authorized health professionals and/or those who had ever used antibiotics
35
36 194 interrupted taking antibiotics before completing the full course.

37 38 195 39 196 40 41 197 **RESULTS**

42 198 **Demographic characteristics of the study participants**

43 199 A total of 2542 individuals were selected for the survey. Among the selected individuals, 2,477
44
45 200 were successfully interviewed; making an overall response of 97.44%. Demographic
46
47 201 characteristics of the respondents are summarized in table 1. The unweighted numbers reflect the
48
49 202 actual observations at the time of survey, whereas the weighted numbers reflect figures that have
50
51 203 been adjusted by the probability of selection of the respondents (Table 1).
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54 204

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

Background Characteristics	Weighted Percent	Weighted Number	Unweighted Number
Age			
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
Maekele	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			
One	4.4	108	104
Two to three	22.0	545	533
Four or more	73.6	1824	1840
Occupation			
Governmental	22.8	566	529
Private employee	4.9	121	115
House wife	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

SKB: Semenawi Keih Bahri, DKB: Debubawi Keih Bahri, * Day laborer, soldier, sheik/priest etc

205

206 Awareness and Knowledge on Antibiotics and ABR

207 Based on participants' response, 73.3% and 39% of the study population were aware of the term
208 'antibiotic' and 'antibiotic resistance' respectively. The sources of information about antibiotics
209 and ABR were mainly from health facilities (39.6%), television (31.5%) and other people (10.1%).

210 Distinguishing antibiotics from non-antibiotics, identification of common illnesses that require
211 antibiotics and those that do not need antibiotics, when to stop antibiotics once started, definition
212 of ABR, and potential impact and transmission of ABR were the main indicators used to measure
213 the level of knowledge of the study population on antibiotics and ABR. Of the list of medicines
214 provided, 59.4% of the study population correctly identified penicillin while only 44.8% and
215 11.9% correctly identified cotrimoxazole and ciprofloxacin respectively. Besides, Ibuprofen, ORS
216 and paracetamol were correctly identified as non-antibiotics by 58.5%, 60.7%, and 70.6% of the
217 population respectively.

218 Less than half (36.6 - 49.5%) of the study population correctly reported the indication of antibiotics
219 for common illnesses. Majority of them reported that antibiotics can be used to treat viral infection
220 (63.4%), watery diarrhea (61.8%), common cold (58.9%), dry cough (54.2%) and dengue fever
221 (50.5%). Sixty-one per cent of the study population also reported that antibiotics are not indicated
222 for tuberculosis. Correct knowledge on when to stop taking antibiotics once they had begun
223 treatment was in majority (83.3%) of the study population.

224 Over three-fourth (78.2%) of the study population correctly reported that ABR is an issue that
225 could affect them and their family and about two-third (63.6%) correctly answered the definition
226 of ABR. The proportion of the study population who knew that bacteria resistant to antibiotics can
227 spread from person to person and those who reported that ABR is an issue in other countries but
228 not in Eritrea was about 59% in both cases.

229 The overall mean knowledge score on antibiotics and ABR was found to be 10.36/20 (SD= 3.51,
230 min=0 and max=20). At bivariate level, males ($p<0.001$), Christians ($p<0.001$), those who were
231 aged between 25 and 54 years ($p<0.001$), those who had higher educational level ($p<0.001$), those
232 having big family size ($p<0.001$) and who were government employees ($p<0.001$) were more likely
233 to have better knowledge score. Besides, study population residing in Maekel and Anseba Zones
234 had better knowledge score ($p<0.001$) on antibiotics and ABR compared to those living in other
235 Zones (Supplementary file 3). At multivariable level, age ($p<0.001$), religion ($p=0.003$),

236 educational level ($p<0.001$), family size ($p=0.015$), occupation ($p<0.001$), and zone ($p<0.001$)
 237 maintained their association with knowledge score (Table 2). Educational level has the largest
 238 partial eta squared (6.8%), showing its prime role in prediction of the knowledge score (Table 2).
 239

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

Knowledge				
Predictor	F	p-value	Partial Eta Squared	Observed Power
Age	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 Eta Squared	Observed Power
Age	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

240
 241 **Attitude on antibiotics and ABR**
 242 A positive attitude to the majority of the attitude items (82- 92.7%) was reported (Table 3).
 243 However, a positive attitude towards appropriate disposal of antibiotics was documented in less
 244 than 50% of the study population (Table 3). The overall mean attitude score was 22.34/30 (SD=
 245 3.59, minimum=6 and maximum=30). At bivariate level, males ($p<0.001$), those aged between 25
 246 and 54 years ($p<0.019$), those who had higher educational level ($p<0.001$), and government
 247 employees ($p<0.001$) had better attitude score compared to their counterparts (Supplementary file
 248 4). At the multivariable level, age ($p=0.001$), gender ($p=0.001$), educational level ($p<0.001$),
 249 occupation ($p=0.003$) and zone ($p<0.001$) maintained their significance as predictors of attitude

250 score. Zone has largest explanatory (partial eta squared=3.8%) capability for the attitude towards
251 antibiotics (Table 2).

252

Table 3: Agree/strongly agree response on the attitude of antibiotics and antibiotic resistance (ABR), Eritrea, 2019 (N=2477)

Attitude questions on antibiotics and ABR	% (95% CI)
Hand washing decreases ABR	92.7 (91.6-94.1)
Taking antibiotics when it is not required can facilitate ABR	89.7 (88.2-91.1)
You have a role to fight ABR	85.8 (84.5-87.8)
It is not okay to share antibiotics with others	90.1 (89.4-91.6)
We cannot use antibiotics without prescription	88 (87.5-89.8)
Farmers should not give antibiotics without consulting veterinarian	82.1 (80.9-83.7)
It is not okay to keep leftover antibiotics and use them later	82 (80.7-83.5)
Leftover antibiotics should not be disposed with regular garbage	46 (45.4-49.1)
Leftover antibiotics should not be disposed at toilets	35.7 (34.3-37.9)

253

254 **Practice on usage of antibiotics**

255 Majority (84.5%) of the study population had used antibiotics at least once in their life time and
256 55% had history of intake of antibiotics in the last one year and 12.3% in the last one month prior
257 to commencement of this study. Of those who ever used antibiotics (N=2407), 88.1% reported that
258 their last intake of antibiotic(s) was prescribed by an authorized healthcare professional. Non-
259 seriousness of the disease (39.0%), need to get quick relief (33.9%), previous own successful
260 experiences (16.1%), having no time to visit a health facility (15.0%) and long queues existing in
261 health facilities (14%) were the top five reasons reported for self-medication with antibiotics. For
262 those who used antibiotics without prescription, the main sources of their last course of antibiotics
263 were drug retail outlets (83.6%) (Figure 1).

264 One fifth (18.8%) of those who had ever used antibiotics interrupted their regimen before
265 completing the full course. The main reason for interruption of antibiotics was improved illness
266 condition (63.4%) (Figure 2). About 3% of the study population reported that they had used

267 antibiotics on their own at least once, though they were advised by healthcare professionals not to
268 do so.

269 Overall, risky practice of antibiotics (use of antibiotics without prescription and/or discontinuation
270 of prescribed antibiotics before completing the full course) was reported in 23.8% of the study
271 population. The chi-square analyses found that age ($p<0.001$), gender ($p=0.01$), educational level
272 ($p<0.001$), occupation ($p<0.001$) and zonal location ($p<0.001$) were the significant associates of
273 risky practice of antibiotics. On multivariable level, those who were young - 24 years or less
274 (AOR=1.59, 95% CI: 1.06 to 2.38), males (AOR=1.48, 95% CI: 1.15 to 1.92), those who had
275 higher level of education (AOR=1.77, 95% CI: 1.05 to 2.90) and those with higher attitude score
276 (AOR=0.95, 95% CI: 0.92 to 0.97) were more likely to involve in risky practice of antibiotics
277 (Table 4).

278

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

Background characteristic	Multivariable analysis		
	AOR	95% CI	p-value
Age			0.046
24 or less	1.59	1.06 to 2.38	
25 to 34	1.25	0.88 to 1.78	
35 to 44	1.05	0.74 to 1.49	
45 to 54	0.89	0.61 to 1.29	
55 and above	<i>Ref.</i>		
Gender			0.003
Male	1.48	1.15 to 1.92	
Female	<i>Ref.</i>		
Educational Level			0.098
Illiterate	<i>Ref.</i>		
Elementary	1.02	0.66 to 1.57	
Junior	1.20	0.77 to 1.84	
Secondary	1.32	0.86 to 2.02	
Higher	1.77	1.05 to 2.90	
Family Size			0.332
One	0.79	0.44 to 1.43	
Two to three	1.15	0.90 to 1.46	
Four or more	<i>Ref.</i>		
Occupation			0.177
Governmental	<i>Ref.</i>		
Private employee	1.13	0.70 to 1.82	
House wife	1.33	0.96 to 1.83	
Self-employed	1.52	1.02 to 2.25	

Unemployed	1.14	0.79 to 1.66	
Student	1.45	0.94 to 2.22	
Farmer/Fisher	1.48	0.70 to 3.13	
Other*	0.44	0.13 to 1.50	
Zone			0.071
Anseba	0.47	0.21 to 1.04	
Debub	0.72	0.33 to 1.58	
Gash Barka	0.70	0.31 to 1.55	
Maekel	0.88	0.42 to 1.86	
SKB	0.81	0.35 to 1.87	
DKB	<i>Ref.</i>		
Attitude score	0.95	0.92 to 0.97	<0.001

*Day laborer, soldier, sheik/priest etc

A total of 1473 of the study population had animals and about 14% reported that they have treated their animals with antibiotics at least once. Of those who used antibiotics for their animals, 62% 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% 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 nation-wide urban population-based survey revealed a significant risky 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 interrupted for many reasons. Discontinuation of antibiotics when the consumer felt better was the most frequently reported reason. This reflects lack of awareness on the appropriate use of antibiotics and risk of ABR. Majority of the antibiotics most recently consumed by the study population were reported to have been prescribed by qualified healthcare professionals. This is encouraging and the nation-wide, massive antibiotic awareness week campaigns conducted in the last three years, prior to the study, might have had positive contributions. However, due to lack of a national baseline data, the authors could not come up with a definitive conclusion regarding the effectiveness of the previously conducted campaigns.

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3 299 The disease condition being non-serious, intention to get a quick relief, previous successful
4 300 experience, shortage of time to visit health facilities and long queues were the main triggering
5 301 factors reported for self-medication with antibiotics. The first three reasons mentioned above for
6 302 self-medication with antibiotics reflect lack of awareness on the risks of inappropriate use of
7 303 antibiotics. In Eritrea, guided by 'health for all policy' and 'social justice', healthcare services are
8 304 provided at a highly subsidized or nominal cost through public health facilities. To further improve
9 305 patients' satisfaction, accessibility to health services and health seeking behavior, the existing
10 306 healthcare delivery services need to be optimized. Moreover, the annual antibiotic awareness week
11 307 campaign should be augmented by additional continuous and regular health promotional activities.

12 308 In this study, drug retail outlets were reported as the main sources for the sales of antibiotics
13 309 without prescription. A recently conducted study also revealed an alarming picture of 87% of retail
14 310 outlets dispensing antibiotics without prescription in Eritrea¹⁰ and that requires immediate
15 311 attention from regulators and policy makers. Continued refresher courses on appropriate use of
16 312 antibiotics and ABR as well as further enforcement of regulations would have an impact in
17 313 bridging these gaps. Cognizant of this, the National Medicines and Food Administration of the
18 314 Ministry of Health developed medicines schedule in 2019 and all antibiotics are put under the
19 315 'prescription only medicine' category. To ensure implementation and adherence to scheduling
20 316 terms, the National Medicines and Food Administration is recommended to conduct strict and
21 317 continuous inspection on drug retail outlets.

22 318 Use of antibiotics without prescription, in this study was more or less consistent with findings of
23 319 similar studies conducted in European countries, where this practice is reported to occur in a
24 320 proportion of 7% (ranging from 0% to 20%)²⁸. It was however much lower than that reported in
25 321 Italy²⁹, Jordan^{30 31}, United Arab Emirates³², Palestine³³, Lebanon³⁴, Iraq³⁵, Indonesia³⁶, Yemen
26 322³⁷, Saudi Arabia³⁸, Haiti³⁹, Kuwait⁴⁰, and Ethiopia^{41 42}, where proportions ranged between 31%
27 323 and 79%. The variation in results, however, could be due to differences in study designs, study
28 324 area, study population, type of questions and level of awareness of the study population.
29 325 Following the WHO recommendation (2015) for all member states to start annual awareness
30 326 raising programs on AMR, Eritrea started to implement it since 2016. This study was conducted
31 327 after a few years of massive public campaigns and might have influenced the current findings. It
32 328 is also possible that in other countries that have made similar initiatives, the existing profile might
33 329 have been influenced in the same way despite no current studies are available.

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3 330 Factors such as young age (24 years or less), male sex, high level of education and poor attitude
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5 331 score were identified as determinants of risky practice of antibiotics. It is unknown why those who
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7 332 had higher level of education and those who were young (relatively with greater educational
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9 333 opportunities) were more involved in the risky practice of antibiotics. This might to some extent
10
11 334 be explained by the fact that knowing more or being educated predisposes people to the tendency
12
13 335 to take self-made decisions more casually with the assumption that they have the knowledge.
14
15 336 Qualitative studies are required to further identify the determinants of risky practice of antibiotics.
16
17 337 In this study, an appreciably high mean attitude score towards antibiotics and ABR was reported.
18
19 338 It is however important to note that the poor attitude reported on the appropriate disposal of leftover
20
21 339 antibiotics requires immediate attention from policy makers. Studies on awareness and disposal
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23 340 practices of unused and expired medicines by consumers in India and Nigeria also reported that
24
25 341 improper practices such as the disposal of medicines in domestic trash, toilets and sinks is prevalent
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27 342 ^{43 44}.

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29 343 Unlike the relatively good attitude score, the mean knowledge score of the study population on
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31 344 antibiotics and ABR was not satisfactory. This study revealed that majority of the study population
32
33 345 had no clear picture on what an antibiotic is and were unable to recognize, by name, the most
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35 346 commonly used antibiotics (penicillin, cotrimoxazole and ciprofloxacin) in the country.
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37 347 Categorizing ibuprofen, ORS and paracetamol as antibiotics by a large number of the study
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39 348 population was another concern. A significant proportion of the study population also had the
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41 349 misunderstanding that antibiotics could treat viral infections like common cold and acute watery
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43 350 diarrhea. Hence, continued awareness raising programs should target such misconceptions and
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45 351 familiarize the public with the commonly used antibiotics, their proper indications and the
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47 352 potential for resistance. The assumption that ABR is a threat elsewhere, but not in Eritrea, as
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49 353 reported in this study, reflects how oblivious people are on the issue of ABR and this may limit
50
51 354 the public from taking appropriate actions. Several of the variables (age, religion, educational
52
53 355 level, family size, occupation, and zone) identified as factors associated with knowledge and
54
55 356 attitude do not seem to be clinically meaningful as small difference in results could give
56
57 357 statistically significant difference. Thus, readers should cautiously interpret the results.

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59 358 Regarding the use of antibiotics to treat animals, in this study, oxytetracycline, amoxicillin and
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359 penicillin were the most frequently reported ones. About half of the antibiotics used in animals

360 were supplied by non-veterinarians such as drug retail outlets and open markets. This indicates
361 poor regulation of antibiotics in animal health.

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

375 This is among the few globally reported nation-wide population-based surveys that measure
376 knowledge, attitude and practice of antibiotic and ABR. The study employed a rigorous data
377 quality and management approaches and had high percentage of response. On the other hand, one
378 of the main limitations of this study is that the results were self-reported and thus, findings might
379 be under- or over-estimated. This could introduce information or recall bias. Another limitation is
380 that during data collection, the information regarding family size and available members was
381 gathered from the present household members and no verification was done using administrative
382 list. This may have in-turn introduced respondents selection bias. Moreover, the reliability and
383 validity of the scales for knowledge and attitude on antibiotics usage were not checked using
384 statistical tools.

385 **Conclusion**

386 The risky practice of antibiotics in Eritrea was prevalent and inversely proportional to the mean
387 attitude score. Being young, male, and those who had higher level of education and poor attitude
388 score were identified as having greater tendency for risky practices associated with antibiotics.
389 The inability of high proportion of the study population to distinguish antibiotics from other

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3 390 medicines and the reported misunderstanding that viral infections can be treated with antibiotics,
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5 391 indicates limited knowledge on antibiotics and ABR. Continuous awareness raising programs on
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7 392 the rational use of antibiotics (mainly on the risks of self-medication, treatment interruption, and
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9 393 use of antibiotics for viral infections) and familiarizing the public with the commonly used
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11 394 antibiotics are recommended. As drug retail outlets were identified to be the main sources for the
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13 395 supply of antibiotics without prescription, both in humans and animals, enforcement of medicines
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15 396 schedule and strengthening of regulatory inspections is vital. Besides, the huge gap in attitude
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17 397 towards appropriate disposal of antibiotics requires immediate attention from policy makers and
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19 398 establishment of an appropriate disposal system of leftover antibiotics for the community. Last but
20
21 399 not least, it is high time to expedite the implementation of the strategies stipulated under the
22
23 400 national action plan on AMR which was released in February 2021.

24 401

25 402

403 **DECLARATIONS**

404 **Ethics approval and informed consent**

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

408 **Patient consent for publication:** Not required.

409 **Conflict of interests**

410 The authors declare that they have no competing interests.

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414

415 **Author contributions**

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

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423

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11 436 Tesfamariam, Yohana Berhane and Zebib Andemeskel.

12 437 **Availability of data**

13
14 438 All data related to the study are included in the manuscript. The complete dataset used for this
15
16 439 study can be obtained from the corresponding author upon request.

17 440 **Acronyms**

18
19 441 ABR: Antibiotic Resistance; AMR: Antimicrobial resistance; DKB: Debubawi Keih Bahri; SKB:
20
21 442 Semenawi Keih Bahri; WHO: World Health Organization.

22
23 443 **Patient and public involvement:** Patients and/or the public were not involved in the design, or
24
25 444 conduct, or reporting, or dissemination plans of this research.

26
27 445 **Patient consent for publication:** Not required.

28
29 446 **Provenance and peer review:** Not commissioned; externally peer reviewed.

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5 581 Figure 1: Source of antibiotics used without prescription among urban residents, Eritrea, 2019
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7 582 (n=242)

8 583 Figure 2: Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019
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10 584 (n=357)

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12 585 Figure 3: Source of antibiotics for animals among urban residents, Eritrea, 2019 (n=245)

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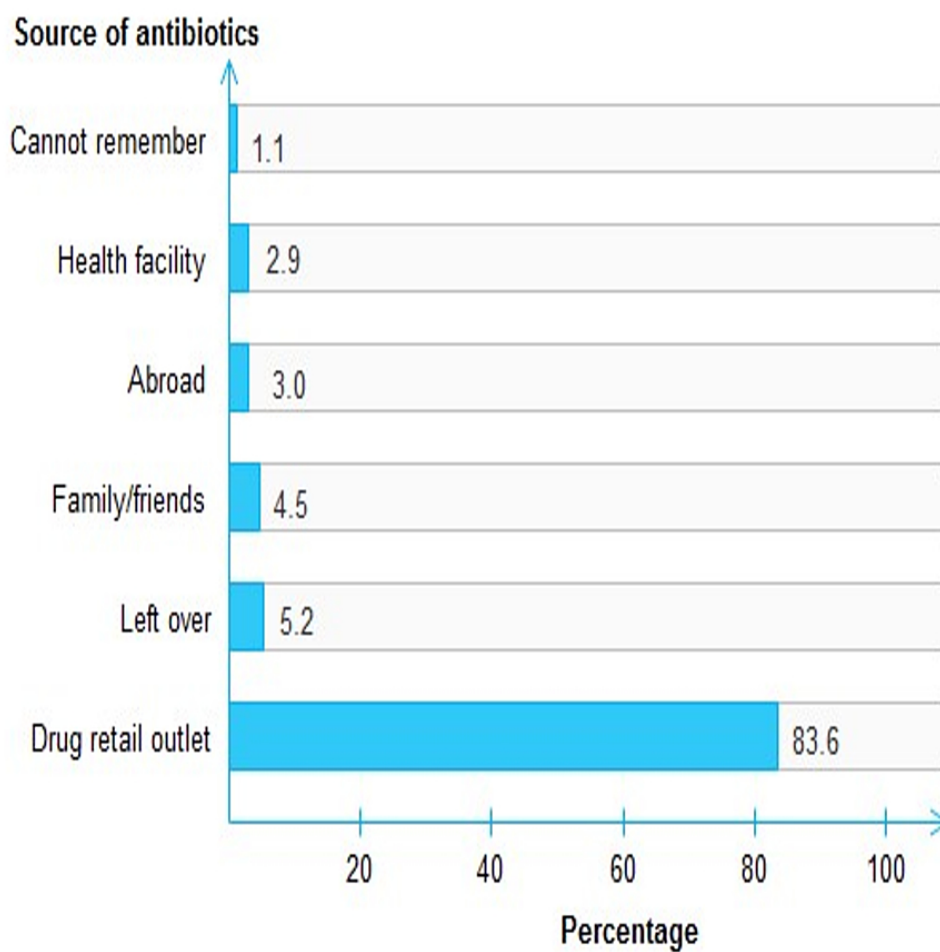


Figure 1: Source of antibiotics used without prescription among urban residents, Eritrea, 2019 (n=242)

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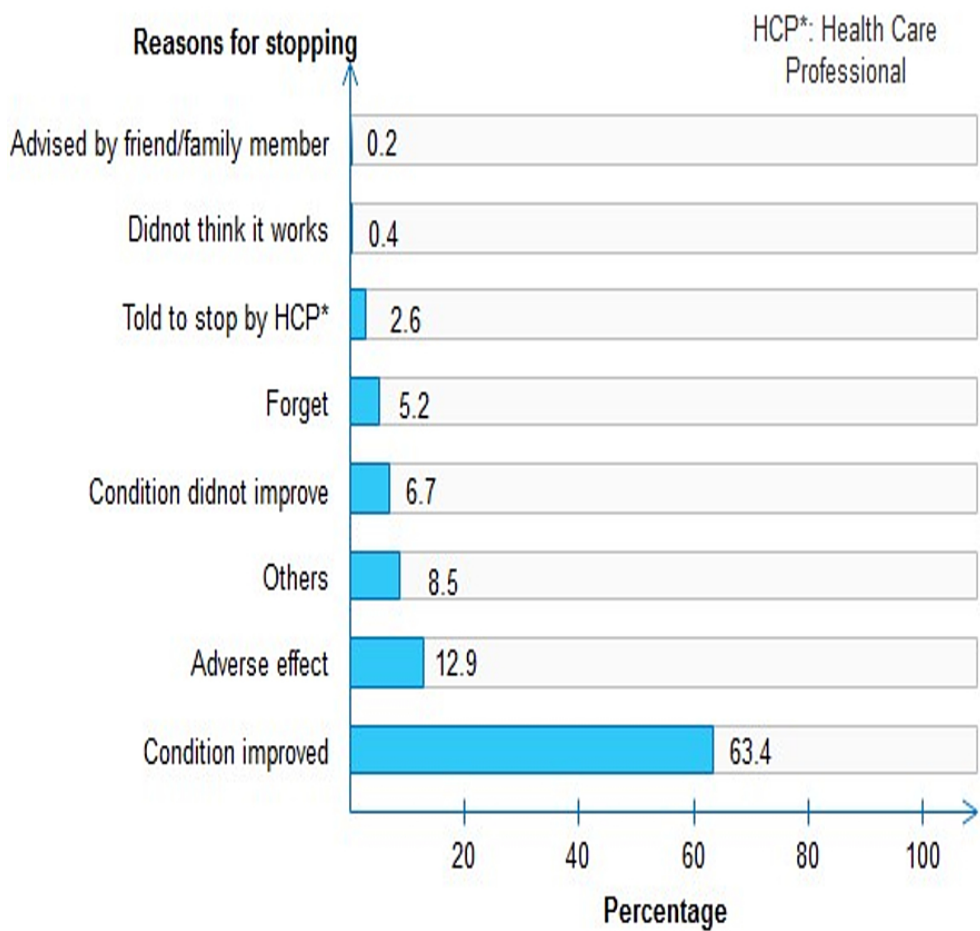


Figure 2: Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019 (n=357)

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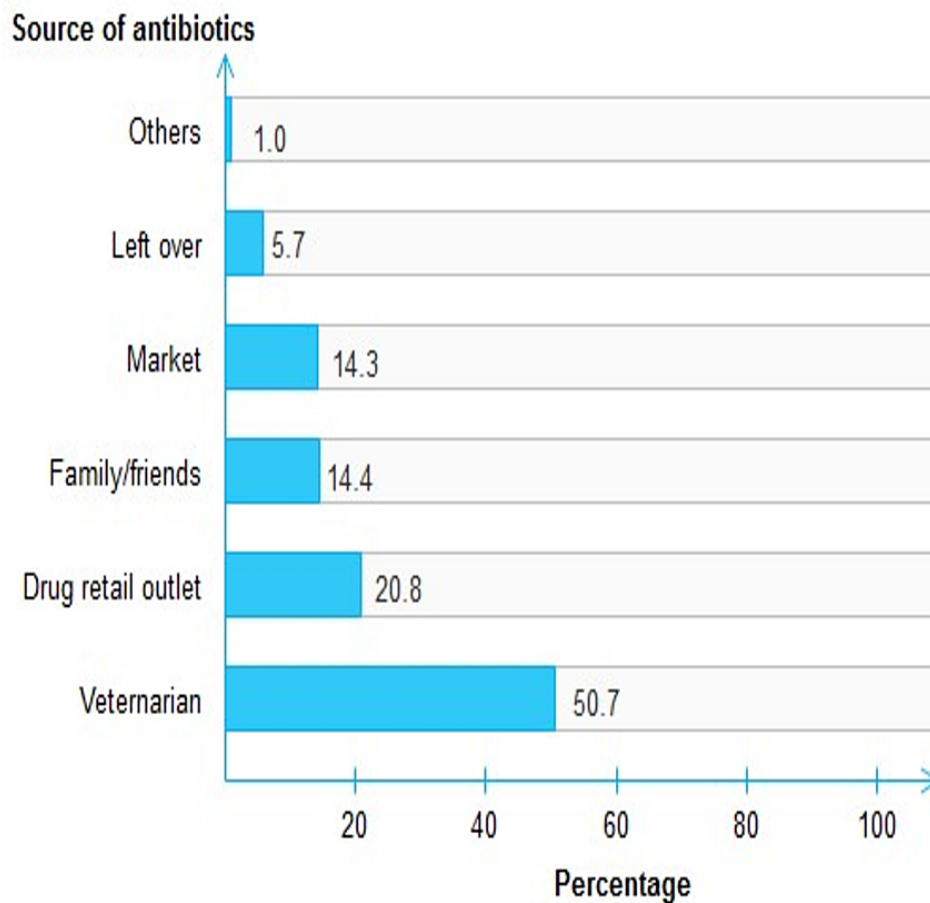


Figure 3: Source of antibiotics for animals among urban residents, Eritrea, 2019 (n=245)

38x38mm (600 x 600 DPI)

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

Mulugeta Russom¹, Merhawi Bahta^{1*}, Merhawi Debesai¹, Iyassu Bahta¹, Abrahalei Kessete¹, Aziza Afendi¹, Yodit Fitsum¹, Josephina Nambozi², Soliana Kidane², Eyasu H. Tesfamariam³

¹National Medicines and Food Administration, Ministry of Health, Asmara, Eritrea.

²WHO Country Office, Asmara, Eritrea.

³Biostatistics and Epidemiology Unit, Department of Statistics, College of Science, Eritrean Institute Technology, Mainefhi, Eritrea.

*Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara, Eritrea.

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
Debab	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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Part I: Identification Particulars

Zoba			
Subzoba			
City/Town			
Kebabi			
Respondent number			

Interviewer Visits

	1	2	3	Final Visit								
Date	_____	_____	_____	Day <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> Month <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> Year <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px; text-align: center;">2</td><td style="width: 20px; height: 20px; text-align: center;">0</td><td style="width: 20px; height: 20px; text-align: center;">1</td><td style="width: 20px; height: 20px; text-align: center;">9</td></tr></table>					2	0	1	9
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Next visit: Date	_____	_____		Total number of visits <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>								
Time	_____	_____										
*Result codes: Completed _____ Not completed _____ Not willing _____ Other _____ (Specify)				Total persons In household <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> Total eligible persons (≥18) <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>								
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Part II: Demographic Information

No.	Indicators	Coding categories	Skip
201	Age (in completed years)	<input type="text"/> <input type="text"/>	
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 No 2	303																																				
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 201 is No and heard of any one of the examples of antibiotics, explain that the term Antibiotics refers to these drugs before continuing to 204.	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Y</th> <th style="text-align: center;">N</th> <th style="text-align: center;">DK</th> </tr> </thead> <tbody> <tr> <td>Ibuprofen</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Tetracycline</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Bactrium</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>ORS</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Amoxicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Paracetamol</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Ciprofloxacin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Penicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> </tbody> </table>		Y	N	DK	Ibuprofen	1	2	3	Tetracycline	1	2	3	Bactrium	1	2	3	ORS	1	2	3	Amoxicillin	1	2	3	Paracetamol	1	2	3	Ciprofloxacin	1	2	3	Penicillin	1	2	3	
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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 resistance? MULTIPLE RESPONSES ARE POSSIBLE. 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	

END OF INTERVIEW

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INTERVIEWER'S OBSERVATIONS

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

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

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Supplementary Table 2: 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)					
35 to 44 C	11.02 (3.36)	16.03**	<0.0001	<0.0001 (Quadratic)	A<B, A<C, A<D, A=E, B=C=D, B>E, C>E, D>E	Group 1: A and E Group 2: B, C, and D
45 to 54 D	10.77 (3.70)					
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)					
Middle	10.16 (3.31)	66.78	<0.0001	<0.0001 (Linear)	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 and M Group 3: M and S Group 4: H
Secondary	10.72 (3.38)					
Higher	11.97 (3.23)					
Family Size						
One	8.84 (4.19)					
Two to three	10.08 (3.45)	12.62	<0.0001	<0.0001 (Linear)	O<T, O<F, T<F	Group 1: O Group 2: T and F
Four or more	10.52 (3.46)					
Occupation						
Governmental	11.76 (3.40)					
Private employee	10.85 (3.57)					
House wife	10.10 (3.27)					
Self-employed	10.13 (3.54)	22.05	<0.0001	-	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	Group 1: F, U, St, O, H and Se, Group 2: U, St, O, H, Se and P Group 3: H, Se, P and G
Unemployed	9.40 (3.67)					
Student	9.54 (3.40)					
Farmer/Fisher	8.71 (3.32)					
Other*	9.62 (3.30)					
Zone						
Anseba	10.53 (3.36)					
Debub	8.85 (3.65)					
Gash Barka	9.54 (3.18)	28.45	<0.0001	-	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,	Group 1: De, S, and G, Group 2: S, G, D and A Group 3: G,D,A and M
Maekel	11.00 (3.39)					
SKB	9.44 (3.51)					
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 Table 3: 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)					
Female	22.13 (3.48)	4.92	<0.0001	-	M>F	-
Religion						
Christian	22.37 (3.54)					
Muslim	22.24 (3.80)	0.7	0.488	-	-	-
Educational Level						
Illiterate	21.36 (3.64)					
Primary	22.14 (3.46)					
Middle	22.34 (3.65)	10.76	<0.0001	<0.0001 (linear)	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
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)				G=P, G=H, G=Se, G>U, G=St, G=F, G=O, P=H,	
House wife	22.30 (3.51)					
Self-employed	22.62 (3.48)					
Unemployed	21.69 (3.38)				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	Group 1: 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)				A=De, A=G, A>M, A=S, A=D, De=M,	Group 1: A, De, M, S, and D
Gash Barka	23.24 (3.73)					
Maekel	22.01 (3.62)	8.87	<0.0001	-	De<G, De=S, De=D, G>M, G=S, G=D, M=S, M=D, S=D	Group 2: A, De, M, S, and G
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.

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	5-6
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	8-9
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-14

		(b) Report category boundaries when continuous variables were categorized	10-14
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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

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1 1 **Knowledge, Attitude and Practice of Antibiotics and their** 2 2 **Determinants in Eritrea: Urban Population-based Survey**

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5 4 Mulugeta Russom¹, Merhawi Bahta^{1*}, Merhawi Debesai¹, Iyassu Bahta¹, Abrahalei Kessete¹,
6 5 Aziza Afendi¹, Yodit Fitsum¹, Josephina Nambozi², Soliana Kidane², Eyasu H. Tesfamariam³
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22 12 ¹National Medicines and Food Administration, Ministry of Health, Asmara, Eritrea.

23 13 ²WHO Country Office, Asmara, Eritrea.

24 14 ³Biostatistics and Epidemiology Unit, Department of Statistics, College of Science, Eritrean
25 15 Institute Technology, Mainefhi, Eritrea.
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32 18 *Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of
33 19 Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara,
34 20 Eritrea.
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34 ABSTRACT

35 **Objective:** To measure knowledge, attitude and practice of antibiotics and antibiotic resistance
36 and their determinants in the Eritrean urban population.

37 **Design:** Population-based, nation-wide, cross-sectional study.

38 **Setting:** Urban settings of Eritrea.

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

41 **Data collection and analysis:** Date was collected from July to September 2019 in a face-to-face
42 interview using a structured questionnaire. The collected data was double entered and analyzed
43 using CSPro (Version 7.0) and SPSS (Version 23) respectively. Descriptive statistics, chi-square
44 test, t-tests, analysis of variance, factorial analysis and multivariable logistic regression were
45 performed. All analyses were weighted and $p < 0.05$ was considered significant.

46 **Primary and secondary outcome measures:** Main outcome variables were knowledge, attitude
47 and practice of antibiotics and antibiotic resistance. Secondary outcome measure was the
48 determinants of knowledge, attitude and practice.

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

58 **Conclusion:** The gap in knowledge and inappropriate practice of antibiotics in the Eritrean urban
59 population was widespread, requiring immediate attention from policymakers and healthcare
60 professionals.

61 **Keywords:** Public health, infectious diseases, epidemiology

62

63

64 ARTICLE SUMMARY

65 Strengths and limitations of this study

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

81 INTRODUCTION

82 The excess use of antibiotics, poses great health risks that would escalate bacterial resistance¹⁻⁴.
83 Resistant infections are now estimated to cost at least 50,000 lives each year in Europe and the
84 US alone⁵. From this, one can speculate that the burden of antimicrobial resistance (AMR)
85 would be much higher in resource-constrained countries in which the inappropriate use of
86 antibiotics by healthcare professionals and consumers could be rampant. This in part is due to
87 poor regulation, weak health systems, surveillance, knowledge and higher infectious diseases^{1 6}
88 7. If left unimpeded, by 2050, deaths attributable to AMR are estimated to be 10 million per year
89 globally¹.

90 Nowadays, antibiotic resistance (ABR) is recognized as one of the biggest threats to global
91 health and is becoming a medical emergency that would limit the advances of healthcare delivery

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3 92 services. This endangers the achievements of the millennium development goals and also
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5 93 sustainable development goals⁸. Thus, AMR in general and ABR in particular is transforming
6
7 94 into a political agenda.

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9 95 As estimated by the World Health Organization (WHO), 80% of antibiotics are used in the
10
11 96 community and 20-50% of which are used inappropriately⁹. Use of antibiotics without
12
13 97 prescription¹⁰⁻¹³, physician perception of patients expectation for antibiotics^{14 15}, patient demand
14
15 98¹⁶⁻¹⁸, unrestricted use of antibiotics^{7 19} and poor healthcare system²⁰ have been reported among
16
17 99 the main factors for the inappropriate use of antibiotics. To tackle this, at the 68th World Health
18
19 100 Assembly, a global action plan was endorsed²¹. One of the five global strategic objectives was to
20
21 101 improve awareness and understanding about AMR²¹, thus all member states were recommended
22
23 102 by the WHO to annually conduct antibiotic awareness week campaigns in a one-health approach
24
25 103²¹.

26
27 104 With these recommendations, Eritrea has been in a process of establishing an antimicrobial
28
29 105 stewardship program. Through a multisectoral approach, Eritrea has developed a national action
30
31 106 plan for combating AMR that is expected to be effective in 2021. One of the four strategic
32
33 107 objectives of the national action plan is 'raise awareness through education and training'.
34
35 108 Moreover, the National Medicines and Food Administration of the State of Eritrea has published
36
37 109 a medicines schedule that is expected to contribute towards the antimicrobial stewardship. Prior
38
39 110 to implementation, knowing the current status and weakest links are important for policy
40
41 111 decisions and to identify areas of intervention on tackling AMR. Even though there is existing
42
43 112 evidence of poor knowledge and inappropriate practice of antibiotics in many countries, there is
44
45 113 paucity of nation-wide data in Eritrea and other countries with similar socio-economic profile.
46
47 114 This study was therefore conducted to measure knowledge, attitude and practice of antibiotic
48
49 115 usage and identify their key determinants in the Eritrean urban population. As there is no
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51 116 baseline data to start with and assess the effectiveness of the annually conducted antibiotic
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53 117 awareness weeks, the findings of this study could also be taken as a point of reference to assess
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55 118 relative changes in the determinants of change in practice.

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122 **METHODS**

123 **Study design and area**

124 A cross-sectional study design, with a quantitative approach, was used. Eritrea is a country with
125 an estimated population of 3.4 million ²². It has six administrative zones comprising 58 subzones
126 in total. The country has five administrative levels namely: National, Zonal, Sub-zonal, Local
127 Administration (Kebabi administration) and Village/Block (village in rural or block in urban
128 settings) levels.

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

135 **Target population**

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

138 **Sample size and sampling technique**

139 The sample size computational formula ²³ and procedures accommodating the multi-stage
140 sampling technique ²⁴ is provided as supplementary material (Supplementary file 2).

141 **Data collection tools and approach**

142 A structured questionnaire (Supplementary file 3) was prepared by reviewing questionnaires of
143 similar studies ²⁵⁻²⁷ and was customized in such a way to reflect issues relevant to Eritrea. It was
144 initially prepared in English and then translated into the common local language, Tigrigna. The
145 questionnaire had four sections namely: personal characteristics of the respondent; awareness
146 and knowledge regarding antibiotics and ABR; attitude regarding antibiotics and ABR, and
147 practice of the general public on antibiotic usage.

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3 148 Sixteen pharmacy professionals who had prior experience were recruited as data collectors.
4
5 149 Close supervision was made by two principal investigators (MR and MB). Orientation was
6
7 150 provided to data collectors in order to familiarize them with the survey objectives, questionnaire,
8
9 151 principles of conducting an interview, data collection procedures, standards of practice,
10
11 152 procedures for listing the households, and the second as well as third stage sample selection of
12
13 153 the households.

14
15 154 Prior to the main fieldwork, the questionnaire was pre-tested on five different clusters, which
16
17 155 were not included in the main survey. These blocks are found in two local administrations of
18
19 156 Asmara. Twenty-five households were interviewed from each selected block. The pre-test aided
20
21 157 in assessing accuracy of translation, ability of the questions to elicit appropriate information, and
22
23 158 ability of enumerators to administer the questionnaire. Moreover, it was helpful in estimating the
24
25 159 time required to complete the questionnaire. The questionnaire was finally modified based on the
26
27 160 results of the pre-test.

28 161 Households were sampled with the assistance of the administration office after listing them in
29
30 162 selected blocks. When eligible respondents were absent from their homes, at least three visits
31
32 163 were made to increase the opportunity of participation in the survey. If the selected candidate
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34 164 was found to be unavailable in a successive of three to four attempts, it was considered as a ‘no
35
36 165 response’.

37 166 **Outcome measures**

38
39 167 The primary outcome measures were knowledge, attitude and practice of antibiotics and ABR in
40
41 168 the urban setting of Eritrea. The secondary outcome measure was the determinants of
42
43 169 knowledge, attitude and practice of antibiotics and ABR.

44 45 170 **Data analysis**

46
47 171 Data was double entered using Census and Survey processing system (CSPRO, Version 7.0)
48
49 172 software package and exported to statistical package for social sciences (SPSS) Version 23. It
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51 173 was summarized by using weighted percentages and counts. Cross-tabulations and further
52
53 174 analysis were also computed whenever relevant.

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2
3 175 Kolmogorov-Smirnov test was used to check on the normality of the knowledge and attitude
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5 176 scores. Frequencies, percentages, mean (with standard deviation), median (with interquartile
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7 177 range) were used to describe the data, as appropriate. After using independent samples t-test and
8
9 178 analysis of variance (ANOVA) at bivariate level of analysis, factorial analysis was employed to
10
11 179 assess the predictors of knowledge and attitude at multivariable level. To explore the association
12
13 180 between the inappropriate practice of antibiotic and the categorical demographic characteristics,
14
15 181 chi-square test was performed and to control potential confounders, variables that were found to
16
17 182 have a p-value less than 0.05 were subjected to multivariable analysis using logistic regression.
18
19 183 In this study, *p*-value less than 0.05, in all the analyses, is considered as significant.

20 184 **Operational definition**

21
22 185 **Inappropriate practice:** Refers to the act of self-medication with antibiotics and/or
23
24 186 discontinuation of a regimen of antibiotics. It was determined by assessing whether the last used
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26 187 antibiotics were prescribed by an authorized health professional and/or those who used
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28 188 antibiotics interrupted their treatment regimen before completing the full course.

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205 RESULTS

206 Demographic characteristics of the study participants

207 A total of 2542 individuals were selected for the survey. Among the selected individuals, 2,477
 208 were successfully interviewed; making an overall response of 97.44%. The demographic
 209 characteristics of the respondents are summarized in table 1. The unweighted numbers reflect the
 210 actual observations at the time of the survey, whereas the weighted numbers reflect figures that
 211 have been adjusted by the probability of selection of the respondents (Table 1).

212

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

Background Characteristics	Weighted Percent	Weighted Number	Unweighted Number
Age			
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			
One	4.4	108	104
Two to three	22.0	545	533

Occupation	Four or more	73.6	1824	1840
	Governmental	22.8	566	529
	Private employee	4.9	121	115
	House wife	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

*SKB: Semenawi Keih Bahri, DKB: Debubawi Keih Bahri, * Day laborer, soldier, sheik/priest etc*

213

214 Awareness, knowledge and attitude on antibiotics and ABR

215 Based on participants' response, 73.3% and 39% of the study population were aware of the term
 216 'antibiotic' and 'antibiotic resistance' respectively. The sources of information about antibiotics
 217 and ABR were mainly from health facilities (39.6%), television (31.5%) and other people
 218 (10.1%).

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

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

230 Over three-fourth (78.2%) of the study population correctly reported that ABR is an issue that
 231 could affect them and their family and about two-third (63.6%) correctly answered the definition
 232 of ABR. The proportion of the study population who knew that bacteria resistant to antibiotics
 233 can spread from person to person and those who reported that ABR is an issue in other countries
 234 but not in Eritrea was about 59% in both cases.

235 The overall mean knowledge score on antibiotics and ABR was found to be 10.36/20 (SD= 3.51,
 236 min=0 and max=20). At bivariate level, males, Christians, those who were aged between 25 and
 237 54 years, those who had higher educational level, those having big family size and who were
 238 government employees were more likely to have better knowledge score. Besides, the study
 239 population residing in Maekel and Anseba zones had better knowledge score on antibiotics and
 240 ABR compared to those living in other Zones (Supplementary file 4). At multivariable level, age
 241 ($p<0.001$), religion ($p=0.003$), educational level ($p<0.001$), family size ($p=0.015$), occupation
 242 ($p<0.001$), and zone ($p<0.001$) maintained their association with knowledge score (Table 2).
 243 Educational level has the largest partial eta squared (6.8%), showing its prime role in prediction
 244 of the knowledge score (Table 2).

245 A positive attitude to the majority of the attitude items (82- 92.7%) was reported (Table 3).
 246 However, a positive attitude towards appropriate disposal of antibiotics was documented in less
 247 than 50% of the study population (Table 3). The overall mean attitude score was 22.34/30 (SD=
 248 3.59, minimum=6 and maximum=30). At bivariate level, males, those aged between 25 and 54
 249 years, those who had higher educational level, government employees and study population
 250 residing in Maekel and Anseba zones had better attitude score compared to their counterparts
 251 (Supplementary file 5). At the multivariable level, age ($p=0.001$), gender ($p=0.001$), educational
 252 level ($p<0.001$), occupation ($p=0.003$) and zone ($p<0.001$) maintained their significance as
 253 predictors of attitude score. Zone has the largest explanatory (partial eta squared=3.8%)
 254 capability for the attitude towards antibiotics (Table 2). Additionally, the distribution of literacy
 255 with the significant determinants of knowledge and attitude scores are summarized in a
 256 supplementary material (Supplementary file 6).

257

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

Predictor	Knowledge			
	F	p-value	Partial Eta Squared	Observed Power
Age	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 Eta Squared	Observed Power
Age	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

258

Table 3: Agree/strongly agree response on the attitude of antibiotics and antibiotic resistance (ABR), Eritrea, 2019 (N=2477)

Attitude questions on antibiotics and ABR	% (95% CI)
Hand washing decreases ABR	92.7 (91.6-94.1)
Taking antibiotics when it is not required can facilitate ABR	89.7 (88.2-91.1)
You have a role to fight ABR	85.8 (84.5-87.8)
It is not okay to share antibiotics with others	90.1 (89.4-91.6)
We cannot use antibiotics without prescription	88 (87.5-89.8)
Farmers should not give antibiotics without consulting veterinarian	82.1 (80.9-83.7)
It is not okay to keep leftover antibiotics and use them later	82 (80.7-83.5)
Leftover antibiotics should not be disposed with regular garbage	46 (45.4-49.1)
Leftover antibiotics should not be disposed at toilets	35.7 (34.3-37.9)

259

260 Practice on usage of antibiotics

261 Majority (84.5%) of the study population had used antibiotics at least once in their life time and
 262 55% had history of intake of antibiotics in the last one year and 12.3% in the last one month prior
 263 to commencement of this study. Of those who ever used antibiotics (n=2407), 88.1% reported
 264 that their last intake of antibiotic (s) was prescribed by an authorized healthcare professional.
 265 Non-seriousness of the disease (39.0%), need to get quick relief (33.9%), previous own

266 successful experiences (16.1%), having no time to visit a health facility (15.0%) and long queues
 267 existing in health facilities (14%) were the top five reasons reported for self-medication with
 268 antibiotics. For those who used antibiotics without prescription, the main sources of their last
 269 course of antibiotics were drug retail outlets (83.6%) (Figure 1).

270 One fifth (18.8%) of those who had ever used antibiotics interrupted their regimen before
 271 completing the full course. The main reason for interruption of antibiotics was improved illness
 272 condition (63.4%) (Figure 2). About 3% of the study population reported that they had used
 273 antibiotics on their own at least once, though they were advised by healthcare professionals not
 274 to do so.

275 Overall, inappropriate practice of antibiotics (use of antibiotics without prescription and/or
 276 discontinuation of prescribed antibiotics before completing the full course) was reported in
 277 23.8% of the study population. The chi-square analyses found that age ($p<0.001$), gender
 278 ($p=0.01$), educational level ($p<0.001$), occupation ($p<0.001$) and zonal location ($p<0.001$) were
 279 the significant associates of inappropriate practice of antibiotics. The independent sample t- test
 280 showed that the mean attitude score of those in inappropriate practice ($M=21.86$, $SD=3.97$) was
 281 significantly lower than those in safe practice ($M=22.51$, $SD=3.45$). On multivariable level,
 282 those who were young - 24 years or less ($AOR=1.61$, 95% CI: 1.08 - 2.41), males ($AOR=1.48$,
 283 95% CI: 1.14 - 1.91), those who had higher level of education ($AOR=1.76$, 95% CI: 1.08 - 2.88)
 284 and those with higher attitude score ($AOR=0.95$, 95% CI: 0.92 - 0.97) were more likely to
 285 involve in inappropriate practice of antibiotics (Table 4).

286

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

Background characteristic	Multivariable analysis		
	AOR	95% CI	p-value
Age			0.035
24 or less	1.61	1.08 - 2.41	
25 to 34	1.26	0.89 - 1.79	
35 to 44	1.05	0.74 - 1.48	
45 to 54	0.89	0.61 - 1.29	
55 or above	<i>Ref.</i>		
Gender			
Male	1.48	1.14 - 1.91	0.003
Female	<i>Ref.</i>		
Educational Level			0.103

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2				
3	Illiterate	<i>Ref.</i>		
4	Elementary	1.02	0.66 - 1.57	
5	Junior	1.19	0.77 - 1.83	
6	Secondary	1.33	0.86 - 2.03	
7	Higher	1.76	1.08 - 2.88	
8				
9	Occupation			0.183
10	Governmental	<i>Ref.</i>		
11	Private employee	1.14	0.71 - 1.85	
12	House wife	1.33	0.97 - 1.83	
13	Self-employed	1.53	1.03 - 2.27	
14	Unemployed	1.16	0.80 - 1.67	
15	Student	1.43	0.93 - 2.19	
16	Farmer/Fisher	1.49	0.71 - 3.15	
17	Other*	0.45	0.13 - 1.52	
18				
19	Zone			0.069
20	Anseba	0.48	0.21 - 1.09	
21	Debub	0.73	0.34 - 1.59	
22	Gash Barka	0.70	0.32 - 1.57	
23	Maekel	0.89	0.42 - 1.88	
24	SKB	0.82	0.36 - 1.89	
25	DKB	<i>Ref.</i>		
26				
27	Attitude score	0.95	0.92 - 0.97	<0.001

28 287 *Day laborer, soldier, sheik/priest etc

29
 30 288 A total of 1473 of the study population had animals and about 14% reported that they have
 31
 32 289 treated their animals with antibiotics at least once. Of those who used antibiotics for their
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 34 290 animals, 62% purchased at least once in the last year, prior to the study period. The commonly
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 36 291 used antibiotics for animals were amoxicillin (44.1%), oxytetracycline (36.2%) and penicillin
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 38 292 (16.3%). About 51% of antibiotics used for animals were obtained from veterinarians whereas
 39
 40 293 the rest were mainly from pharmacy retail outlets (20.8%), family/friends (14.4%) and open
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 42 294 markets (14.3%) (Figure 3).

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48 297 DISCUSSION

49
 50 298 This nation-wide urban population-based survey revealed a significant inappropriate practice of
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 52 299 antibiotics in Eritrea. One in five of the study population, who had ever used antibiotics, reported
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 54 300 that their last intake of antibiotic (s) was interrupted for many reasons. The discontinuation of
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 56 301 antibiotics when a consumer felt better was the most frequently reported reason. This reflects

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3 302 lack of awareness on the appropriate use of antibiotics and the risk of ABR. The majority of the
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5 303 antibiotics most recently consumed by the study population were reported to have been
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7 304 prescribed by qualified healthcare professionals. This is encouraging and the nation-wide,
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9 305 massive antibiotic awareness week campaigns conducted in the last three years, prior to the
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11 306 study, might have had positive contributions. However, due to the lack of a national baseline
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13 307 data, the authors could not come up with a definitive conclusion regarding the effectiveness of
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15 308 the previously conducted campaigns.

16 309 The disease condition being non-serious, intention to get quick relief, previous successful
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18 310 experience, shortage of time to visit health facilities and long queues were the main triggering
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20 311 factors reported for self-medication with antibiotics. The first three reasons mentioned above for
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22 312 self-medication with antibiotics reflect lack of awareness on the risks of inappropriate use of
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24 313 antibiotics. In Eritrea, guided by 'health for all policy' and 'social justice', healthcare services
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26 314 are provided at a highly subsidized or nominal cost through public health facilities. To further
27
28 315 improve patients' satisfaction, access to health services, and health seeking behavior, the existing
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30 316 healthcare delivery services need to be optimized. Moreover, the annual antibiotic awareness
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32 317 week campaign should be augmented by additional continuous and regular health promotional
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34 318 activities.

35 319 In this study, drug retail outlets were reported as the main sources for the sales of antibiotics
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37 320 without prescription. A recently conducted study also revealed an alarming picture; 87% of retail
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39 321 outlets found in Eritrea were dispensing antibiotics without prescription ¹⁰ which requires
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41 322 immediate attention from regulators and policy makers. Continued refresher courses on the
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43 323 appropriate use of antibiotics and ABR as well as further enforcement of regulations would have
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45 324 an impact in bridging these gaps. Cognizant of this, the National Medicines and Food
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47 325 Administration of the Ministry of Health developed medicines schedule in 2019 and, all
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49 326 antibiotics are put under the category of 'prescription only medicine'. To ensure implementation
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51 327 and adherence to the scheduling terms, the National Medicines and Food Administration is
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53 328 recommended to conduct strict and continuous inspection on drug retail outlets.

54 329 Use of antibiotics without prescription in this study was more or less consistent with findings of
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56 330 similar studies conducted in European countries, where it was reported to occur in an average
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58 331 proportion of 7% (ranging from 0% to 20%) ²⁸. It was, however, much lower than that reported

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3 332 in Italy ²⁹, Jordan ^{30 31}, United Arab Emirates ³², Palestine ³³, Lebanon ³⁴, Iraq ³⁵, Indonesia ³⁶,
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5 333 Yemen ³⁷, Saudi Arabia ³⁸, Haiti ³⁹, Kuwait ⁴⁰, and Ethiopia ^{41 42}, where proportions ranged
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7 334 between 31% and 79%. The variation in results, however, could be due to differences in study
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9 335 designs, study area, study population, type of questions and level of awareness of the study
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11 336 population. Following the WHO recommendation (2015) for all member states to start annual
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13 337 awareness raising programs on AMR, Eritrea has started to implement it since 2016. This study
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15 338 was conducted after a few years of massive public campaigns and might have influenced the
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17 339 current findings. It is also possible that in other countries that have made similar initiatives, the
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19 340 existing profile might have been influenced in the same way despite no current studies are
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21 341 available.

22 342 Factors such as young age (24 years or less), male sex, high level of education and poor attitude
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24 343 score were identified as determinants of inappropriate practice of antibiotics. It is unknown why
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26 344 those who had higher level of education and those who were young (relatively with greater
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28 345 educational opportunities) were more involved in the inappropriate practice of antibiotics. This
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30 346 might to some extent be explained by the fact that knowing more or being educated predisposes
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32 347 people to a tendency to take self-made decisions more casually with the assumption that they
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34 348 have knowledge. Qualitative studies are required to further identify the determinants of
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36 349 inappropriate practice of antibiotics.

37 350 In this study, an appreciably high mean attitude score towards antibiotics and ABR was reported.
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39 351 It is, however, important to note that the poor attitude reported on the appropriate disposal of
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41 352 leftover antibiotics requires immediate attention from policy makers. Studies on awareness and
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43 353 disposal practices of unused and expired medicines by consumers in India and Nigeria also
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45 354 reported that improper practices such as the disposal of medicines in domestic trash, toilets and
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47 355 sinks was prevalent ^{43 44}.

48 356 Unlike the relatively good attitude score, the mean knowledge score of the study population on
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50 357 antibiotics and ABR was not satisfactory. This study revealed that the majority of the study
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52 358 population had no clear picture on what an antibiotic is and were unable to recognize, by name,
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54 359 the most commonly used antibiotics (penicillin, cotrimoxazole and ciprofloxacin) in the country.
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56 360 Categorizing ibuprofen, ORS and paracetamol as antibiotics by a large number of the study
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58 361 population was another concern. A significant proportion of the study population also had the

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3 362 misunderstanding that antibiotics could treat viral infections like common cold and acute watery
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5 363 diarrhea. Hence, continued awareness raising programs should target such misconceptions and
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7 364 familiarize the public with the commonly used antibiotics, their proper indications and the
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9 365 potential for resistance. The assumption that ABR is a threat elsewhere but not in Eritrea, as
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11 366 reported in this study, reflects how oblivious people were to the issue of ABR and this may limit
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13 367 the public from taking appropriate actions.

14 368 In this study, those who were aged between 25 and 54 years, had higher educational level, were
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16 369 government employees, or residing in Maekel and Anseba zones were significantly associated
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18 370 with higher knowledge and attitude scores. Literacy to a larger extent might explain, among
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20 371 others, the observed good knowledge and attitude scores in relation to the above predictors as all
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22 372 these categories had better educational levels (Supplementary file 6). However, more data is
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24 373 required to make accurate deductions with regard to these predictors. It is also important to note
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26 374 that the association observed with the above-mentioned variables do not seem to be clinically
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28 375 meaningful as a small difference in results could give statistically significant difference, and
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30 376 thus, readers should cautiously interpret the results. This emphasizes the need for extensive
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32 377 awareness raising programs for those who are illiterate and having lower level of education.

33 378 Regarding the use of antibiotics to treat animals, oxytetracycline, amoxicillin and penicillin were
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35 379 the most frequently reported ones. About half of the antibiotics used in animals were supplied by
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37 380 non-veterinarians such as drug retail outlets and open markets reflecting poor regulation of
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39 381 antibiotics in animal health.

40 382 Because parasites and infections do not respect borders, combating ABR has since long ago been
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42 383 a global agenda. A problem identified in one country could have direct or indirect implication on
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44 384 the containment of ABR by other countries. The significance of this nationwide survey and the
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46 385 results it comes up with are all expected to be of a particular interest for countries with similar
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48 386 socioeconomic statuses as Eritrea. Many of these countries share the common problem of poor
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50 387 quality, inequitable, overstretched, unregulated and poorly accessible health services which
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52 388 could trigger the general public to be involved in inappropriate practice of antibiotics. Moreover,
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54 389 they lack the systems to control antibiotic consumption and the initiative to tackle the issue of
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56 390 resistance. If Eritrea's profile with regard to the prevalence of inappropriate practices such as
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58 391 self-medication with antibiotics has been relatively good while there is a long way to go to

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3 392 improve the healthcare infrastructure, it is not hard to imagine the progress the country could
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5 393 assume if the existing policies such as the national action plan on AMR and regulations such as
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7 394 medicines scheduling are enforced.

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9 395 This is among the few globally reported nation-wide population-based surveys that measure
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11 396 knowledge, attitude and practice of antibiotics and ABR. The study employed rigorous data
12
13 397 quality and management approaches and had a high percentage of response. On the other hand,
14
15 398 one of the main limitations of this study was that the results were self-reported, and thus,
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17 399 findings might be under- or over-estimated. This could introduce information or recall bias.
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19 400 Additionally, though efforts were made to provide an equal chance of selection for every
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21 401 household member, there might be selection bias as about three-fourth of the respondents were
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23 402 found to be females. The sex-imbalance might be explained by the fact that the information
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25 403 regarding family size and available members during data collection was gathered from the
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27 404 present household members and, no verification was made using an administrative list.
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29 405 Moreover, the reliability and validity of the scales for knowledge and attitude on antibiotics
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31 406 usage were not checked using statistical tools.

30 407 **Conclusion**

32 408 The inappropriate practice of antibiotics in Eritrea was prevalent and the young age, male sex,
33
34 409 higher level of education and poor attitude score were identified as the determinants of
35
36 410 inappropriate practices. The inability of a high proportion of the study population to distinguish
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38 411 antibiotics from other medicines and the reported misunderstanding that viral infections can be
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40 412 treated with antibiotics indicates limited knowledge on antibiotics and ABR. Continuous
41
42 413 awareness raising programs on the rational use of antibiotics (mainly on the risks of self-
43
44 414 medication, treatment interruption, and use of antibiotics for viral infections) and familiarizing
45
46 415 the public with the commonly used antibiotics are recommended. As drug retail outlets were
47
48 416 identified to be the main sources for the supply of antibiotics without prescription, both in
49
50 417 humans and animals, enforcement of medicines schedule and strengthening of regulatory
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52 418 inspections is vital. Besides, the huge gap in attitude towards appropriate disposal of antibiotics
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54 419 requires immediate attention from policy makers and the establishment of an appropriate
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56 420 disposal system of leftover antibiotics for the community. Last but not least, it is high time to

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3 421 expedite the implementation of the strategies stipulated under the national action plan on AMR
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5 422 which was released in February 2021.
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11 425 **DECLARATIONS**

12 426 **Ethics approval and informed consent**

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15 427 Ethical approval to conduct the study was obtained from the Ministry of Health, Eritrea and
16 428 further approval was also obtained from the Ministry of Local Government. Besides, informed
17
18 429 consent was obtained from all study participants to take part in the study.
19

20 430 **Patient consent for publication:** Not required.
21

22 431 **Conflict of interests**

23
24 432 The authors declare that they have no competing interests.
25

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30

31 436 **Author contributions**

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33
34 437 The idea was conceived by MR and IB and designed by all authors (MB, MD, MR, AK, AA, YF,
35 438 IB, SK, JN and EHT). Data was collected by MD, AK, AA and YF and supervised by MR and
36
37 439 MB. EHT edited and analyzed the collected data and all the co-authors participated in the
38
39 440 interpretation of the results. The manuscript was drafted by MB, MR and EHT and critically
40
41 441 reviewed and edited by all of the authors. Finally, all the co-authors agreed that the article be
42
43 442 published in an international journal and to take responsibility and be accountable for its content.
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14
15 455 Tesfamariam, Yohana Berhane and Zebib Andemeskel.

16 456 **Availability of data**

17 457 All data related to the study are included in the manuscript. The complete dataset used for this
18
19 458 study can be obtained from the corresponding author upon request.

20 459 **Acronyms**

21
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23 460 ABR: Antibiotic Resistance; AMR: Antimicrobial resistance; DKB: Debubawi Keih Bahri; SKB:
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25 461 Semenawi Keih Bahri; WHO: World Health Organization.

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27 462 **Patient and public involvement:** Patients and/or the public were not involved in the design, or
28
29 463 conduct, or reporting, or dissemination plans of this research.

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31 464 **Patient consent for publication:** Not required.

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33 465 **Provenance and peer review:** Not commissioned; externally peer reviewed.

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600 Figure 1: Source of antibiotics used without prescription among urban residents, Eritrea, 2019

601 (n=242)

602 Figure 2: Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019

603 (n=357)

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

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For peer review only

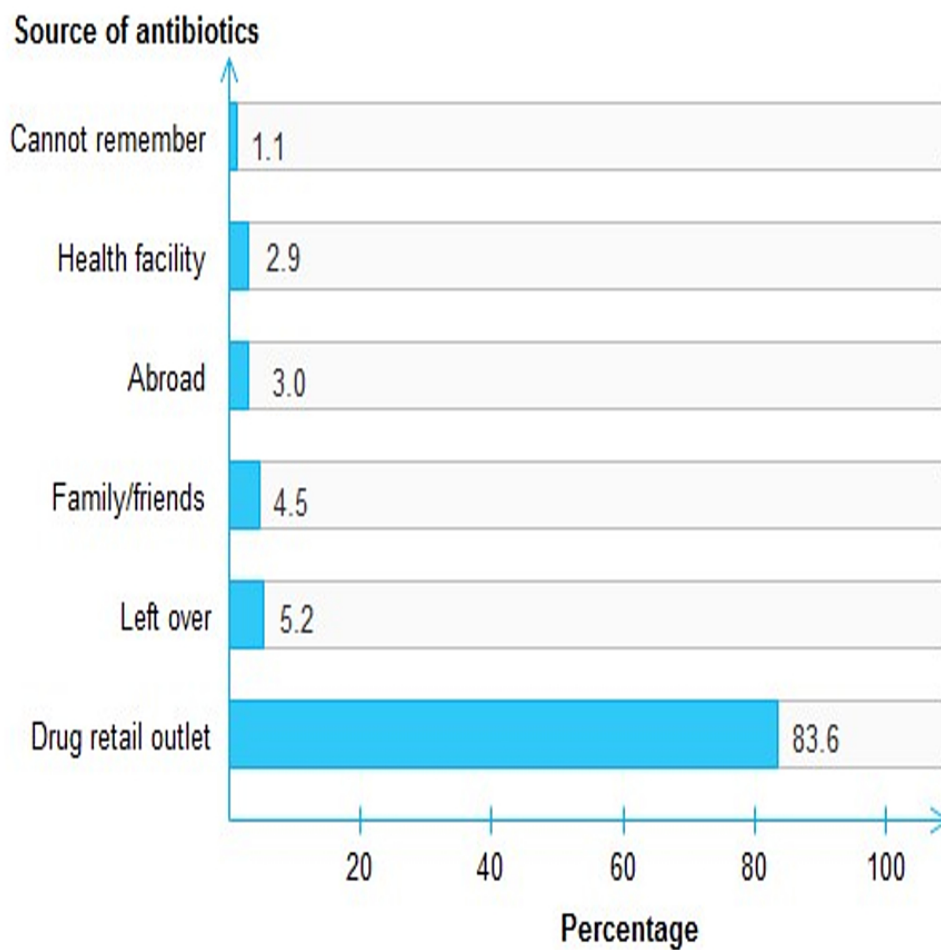


Figure 1: Source of antibiotics used without prescription among urban residents, Eritrea, 2019 (n=242)

38x38mm (600 x 600 DPI)

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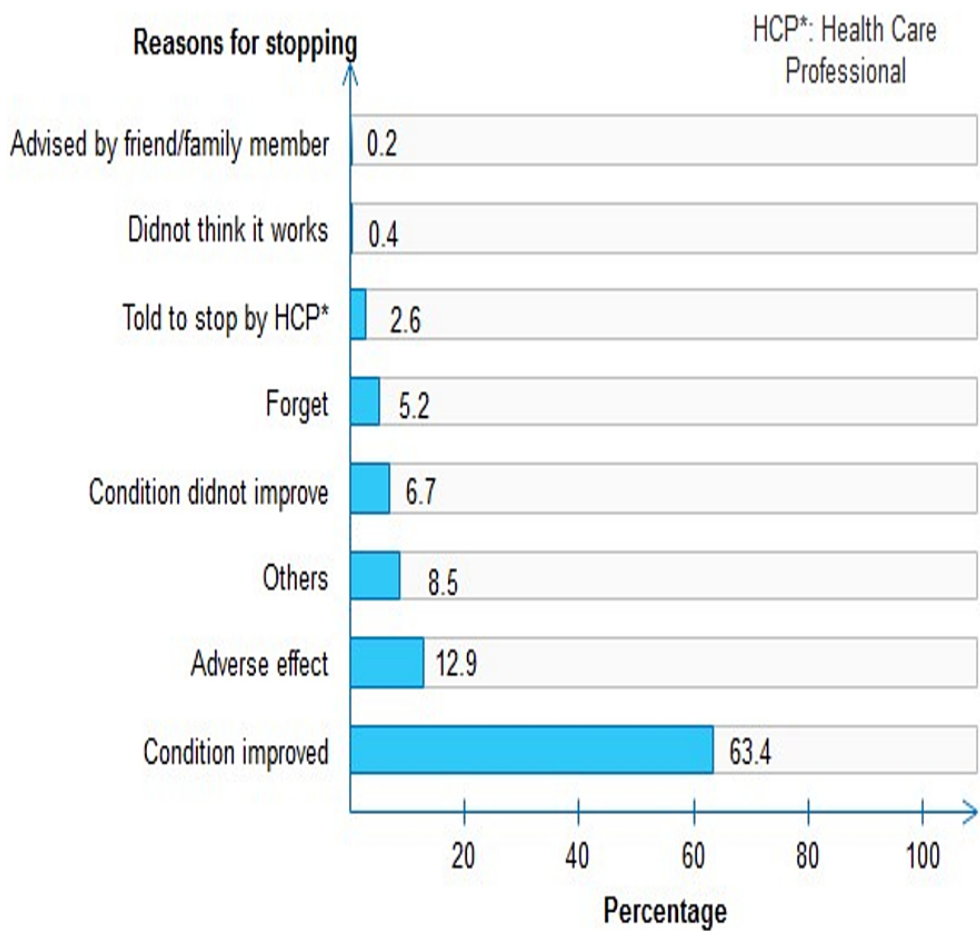


Figure 2: Reasons for stopping the intake of antibiotics among urban residents, Eritrea, 2019 (n=357)

38x38mm (600 x 600 DPI)

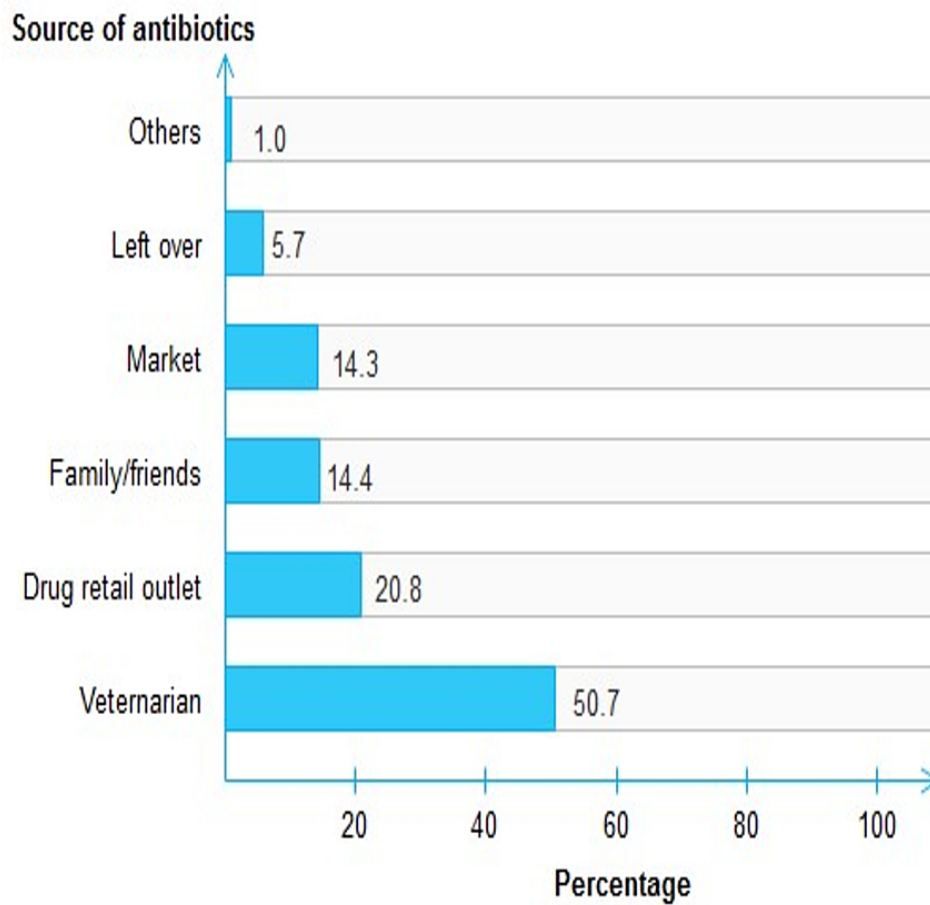


Figure 3: Source of antibiotics for animals among urban residents, Eritrea, 2019 (n=245)

38x38mm (600 x 600 DPI)

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

Mulugeta Russom¹, Merhawi Bahta^{1*}, Merhawi Debesai¹, Iyassu Bahta¹, Abrahalei Kessete¹, Aziza Afendi¹, Yodit Fitsum¹, Josephina Nambozi², Soliana Kidane², Eyasu H. Tesfamariam³

¹National Medicines and Food Administration, Ministry of Health, Asmara, Eritrea.

²WHO Country Office, Asmara, Eritrea.

³Biostatistics and Epidemiology Unit, Department of Statistics, College of Science, Eritrean Institute Technology, Mainefhi, Eritrea.

*Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara, Eritrea.

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
Debab	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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²WHO Country Office, Asmara, Eritrea.

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*Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara, Eritrea.

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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²WHO Country Office, Asmara, Eritrea.

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*Correspondence: Merhawi Bahta, National Medicines and Food Administration, Ministry of Health, e-mail: meramcp19@gmail.com, Tel: +291-7294279, Postal address:212, Asmara Eritrea.

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 number.....			

Interviewer Visits

	1	2	3	Final Visit			
Date	_____	_____	_____	Day			
				Month			
				Year	2	0	1 9
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 Name _____ Number <input type="checkbox"/>		Field editor Name _____ Number <input type="checkbox"/>		Keyed by Name _____ Number <input type="checkbox"/>			

Part II: Demographic Information

No.	Indicators	Coding categories	Skip
201	Age (in completed years)	<input type="text"/> <input type="text"/>	
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 No 2	303																																				
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 201 is No and heard of any one of the examples of antibiotics, explain that the term Antibiotics refers to these drugs before continuing to 204.	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Y</th> <th style="text-align: center;">N</th> <th style="text-align: center;">DK</th> </tr> </thead> <tbody> <tr> <td>Ibuprofen</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Tetracycline</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Bactrium</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>ORS</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Amoxicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Paracetamol</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Ciprofloxacin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td>Penicillin</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> </tbody> </table>		Y	N	DK	Ibuprofen	1	2	3	Tetracycline	1	2	3	Bactrium	1	2	3	ORS	1	2	3	Amoxicillin	1	2	3	Paracetamol	1	2	3	Ciprofloxacin	1	2	3	Penicillin	1	2	3	
	Y	N	DK																																				
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Paracetamol	1	2	3																																				
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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 resistance? MULTIPLE RESPONSES ARE POSSIBLE. 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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Knowledge, Attitude and Practice of Antibiotics and their Determinants in Eritrea: Urban Population-based Survey

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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)					
35 to 44 C	11.02 (3.36)	16.03**	<0.0001	<0.0001 (Quadratic)	A<B, A<C, A<D, A=E, B=C=D, B>E, C>E, D>E	Group 1: A and E Group 2: B, C, and D
45 to 54 D	10.77 (3.70)					
55 and above E	9.73 (3.91)					
Gender						
Male	10.98 (3.61)					
Female	10.15 (3.44)	5.08	<0.0001	-	M>F	-
Religion						
Christian	10.57 (3.53)					
Muslim	9.60 (3.30)	5.93	<0.0001	-	C>M	-
Educational Level						
Illiterate	7.99 (3.28)					
Primary	9.49 (3.38)					
Middle	10.16 (3.31)	66.78	<0.0001	<0.0001 (Linear)	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 and M Group 3: M and S Group 4: H
Secondary	10.72 (3.38)					
Higher	11.97 (3.23)					
Family Size						
One	8.84 (4.19)					
Two to three	10.08 (3.45)	12.62	<0.0001	<0.0001 (Linear)	O<T, O<F, T<F	Group 1: O Group 2: T and F
Four or more	10.52 (3.46)					
Occupation						
Governmental	11.76 (3.40)					
Private employee	10.85 (3.57)					
House wife	10.10 (3.27)					
Self-employed	10.13 (3.54)	22.05	<0.0001	-	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	Group 1: F, U, St, O, H and Se, Group 2: U, St, O, H, Se and P Group 3: H, Se, P and G
Unemployed	9.40 (3.67)					
Student	9.54 (3.40)					
Farmer/Fisher	8.71 (3.32)					
Other*	9.62 (3.30)					
Zone						
Anseba	10.53 (3.36)					
Debub	8.85 (3.65)					
Gash Barka	9.54 (3.18)	28.45	<0.0001	-	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,	Group 1: De, S, and G, Group 2: S, G, D and A Group 3: G,D,A and M
Maekel	11.00 (3.39)					
SKB	9.44 (3.51)					
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)					
Female	22.13 (3.48)	4.92	<0.0001	-	M>F	-
Religion						
Christian	22.37 (3.54)					
Muslim	22.24 (3.80)	0.7	0.488	-	-	-
Educational Level						
Illiterate	21.36 (3.64)					
Primary	22.14 (3.46)					
Middle	22.34 (3.65)	10.76	<0.0001	<0.0001 (linear)	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
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)					
Student	21.82 (3.85)	4.95	<0.0001	-	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	Group 1: F, U, St, O, H, G, and Se
Farmer/Fisher	21.65 (3.92)					
Zone						
Anseba	23.19 (3.43)					
Debub	22.27 (3.35)					
Gash Barka	23.24 (3.73)					
Maekel	22.01 (3.62)	8.87	<0.0001	-	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
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: Dehub, Gash Barka, Semenawi Keih Bahri, Debubawi Keih Bahri

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6-7
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	5-6
		(d) If applicable, describe analytical methods taking account of sampling strategy	6-7
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	8-9
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13

		(b) Report category boundaries when continuous variables were categorized	10-13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.