

Original Research

Antibiotic resistance awareness in the UAE: Nationwide insights on knowledge, attitudes, and perceptions in the post-outbreak era

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Abstract

Objectives: To provide insights into public knowledge and practices toward antibiotic resistance as well as common behaviours related to antibiotic use and resistance in the UAE. **Methods:** This study is a cross-sectional, observational investigation into the knowledge, and attitudes, of UAE residents toward antibiotic resistance, using a convenience sampling approach. From May to June 2022, the survey was distributed throughout the seven emirates of the UAE. The methodology was adapted from the WHO's "Antibiotic Resistance: Multi-Country Public Awareness Survey". The study followed the Strengthening Reporting of Observational Studies in Epidemiology reporting (STROBE) guideline for cross-sectional studies. **Results:** A total of 1074 individuals completed the survey. Approximately two thirds of the respondents (66.0%) were familiar with the term "Antibiotic resistance". The percentage of respondents who believed that antibiotics could be effective against viral infections decreased from 57.8% to 45.4% after the COVID-19 pandemic period. Additionally, 79.1% of respondents incorrectly believed that antibiotic resistance occurs when their bodies become resistant to antibiotics. Studying in the medical field and having a postgraduate degree were significant predictors of adequate knowledge (Odds ratios were 2.15 and 1.77, respectively). **Conclusion:** The participants in this study were generally aware of antibiotic resistance; however, incorrect descriptions of antibiotic resistance were frequently encountered. Respondents involved in the medical sector during their studies and those with higher educational degree were more likely to possess adequate knowledge about antibiotic resistance. This evidence can be used to contextualize and enhance the efficiency, effectiveness and success of antimicrobial resistance interventions.

Keywords: Antibiotics, Antibiotic resistance, Awareness, Attitudes, Public knowledge

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INTRODUCTION

Antibiotics are experiencing progressively declining effectiveness over time, distinguishing them from most other medications¹. It is a widely established fact that the inappropriate utilization of a diverse range of antibiotics contributes to the emergence of antimicrobial resistance (AMR)²⁻⁴, where an antibiotic loses its capacity to effectively inhibit the growth of bacteria at its therapeutic level⁵. Antibiotic resistance may lead to prolonged sickness, increased use of medical facilities, longer hospital stays, more expensive treatments, and even death⁶. According to the World Health Organization (WHO), approximately 80% of antibiotics are used within the community setting, with approximately 20-50% of these usages being deemed inappropriate⁷. In 2019, approximately 4.95 million deaths were estimated to be linked to bacteria that had developed resistance to antibiotics.

Within the Gulf Cooperation Council (GCC) region, including the United Arab Emirates (UAE), multiple reports have presented evidence of diminishing susceptibility to essential antibiotics among prevalent bacterial pathogens, alongside the development of previously unknown distinct patterns of resistance⁸⁻¹⁰. Moreover, the most recent surveillance data on AMR in the UAE reveals a prevalent and escalating trend of antibiotic resistance across the nation¹¹.

Self-medication is a prevalent phenomenon worldwide, particularly in developing nations, and is often considered an alternative for individuals who cannot afford the expenses associated with healthcare facilities and services¹². The improper consumption of antibiotics serves as the main source for the emergence and development of antibiotic resistance in microorganisms¹³. In a retrospective cohort study involving participants from the UAE, self-medication with antibiotics was reported in 31.7% of the population¹⁴. In addition, self-treatment with antibiotics has been reported to have been higher during the COVID-19 pandemic compared to previous periods in the UAE and in the region^{15,16}.

Antibiotic resistance is recognized as one of the most concerning public health challenges of the twenty-first century. Educating current and future healthcare practitioners, patients, and the public about infection control measures, antibiotic usage, and the environmental impact of antibiotic use is crucial for managing this issue¹⁷. Previous studies have highlighted a broad

awareness of antibiotic resistance across different populations. For example, Muflih et al. reported that approximately three-quarters of Jordanian participants were aware of the term 'antibiotic resistance'¹⁸, and similarly high levels of awareness were observed among UAE residents, with more than 70% recognizing it as a major health concern¹⁹. However, despite high awareness, there is often significant misinterpretation of antibiotic resistance mechanisms. Michaelidou et al. reported that a majority of participants incorrectly believed that the human body, rather than bacteria, develops resistance to antibiotics²⁰. This misconception was also evident in Italy and Germany, where only a small proportion correctly identified the bacterial basis of antibiotic resistance^{21,22}. Additionally, studies have shown that misconceptions about antibiotic resistance being an issue only in other countries persist, with higher rates of this belief in the UAE compared to Canada, Ecuador, Cyprus, and Jordan^{20,23-25}. These findings underscore the need for targeted educational initiatives to improve public understanding of antibiotic resistance mechanisms, modes of transmission, and the role individuals play in combating resistance.

Understanding the knowledge and patterns of antibiotic use among the general population may help relevant authorities in developing optimal interventions to combat AMR effectively. Across various studies, there was a common trend where many individuals, despite being aware of AMR, often misunderstand its mechanism^{2,18,26}. This pattern of misunderstanding highlights a significant gap in public knowledge about the true nature of antibiotic resistance. Therefore, promoting rational use of antibiotics and proper understanding of AMR mechanisms should be regarded as the principal component of strategies aimed at reducing the emergence and dissemination of AMR. Limited attempts have been made to evaluate the level of antibiotic knowledge within the population of the UAE^{27,28}. Mohammad et al., reported that approximately half of participants from Dubai and Abu Dhabi believed that common colds could be treated with antibiotics²⁸. Similarly, Jairoun et al reported that 58% and 68.5% of students believed that antibiotics are effective in treating common colds and sore throats, respectively²⁷. Similar findings were observed in other populations. For instance, a survey conducted in Jordan reported that a significant proportion of Jordanian individuals (67.1%) hold the belief that antibiotics can be effective in treating common colds and coughs²⁹. In another study, only 15% of parents in the UAE demonstrated accurate knowledge regarding the appropriate use of antibiotics for treating bacterial infections³⁰.

Educational programs, workshops, and training sessions offer healthcare practitioners as well as the public a valuable platform to emphasize the importance of appropriate antibiotic usage and to raise awareness about the complications associated with antibiotic resistance³¹. Multiple educational interventions have been implemented globally with the aim of enhancing awareness, knowledge, and good practice concerning antibiotic use^{1,32,33}. However, the outcomes of these interventions have been inconsistent and varied across different study settings, making their overall impact unclear. Therefore, additional



evidence regarding public awareness of AMR within specific settings should be sought. This evidence can then be used to contextualize and enhance the efficiency, efficacy, and success of AMR-directed interventions.

The current study aims to shed light on public awareness and practices regarding antibiotic resistance in the UAE. It seeks to explore the population's understanding, knowledge, and common behaviours related to antibiotic use and resistance through a nationally representative study. This finding will help guide future efforts to enhance awareness campaigns, plan educational and regulatory interventions and improve measures to promote optimal antibiotic use within the community.

MATERIALS AND METHODS

Study design, questionnaire development and validation

This study is a cross-sectional, observational investigation into the knowledge, and attitudes, of UAE residents toward antibiotic resistance, using a convenience sampling approach. From May to June 2022, the survey was distributed throughout the seven emirates of the UAE. The methodology was adapted from the WHO's "Antibiotic Resistance: Multi-Country Public Awareness Survey"⁵³. The study followed the Strengthening Reporting of Observational Studies in Epidemiology reporting (STROBE) guideline for cross-sectional studies.

The original survey was written in English, translated into Arabic and tested by two bilingual linguistics using a forward and backward translation technique⁵⁴. Adjustments were made accordingly.

Study tool

The final data-collection form consisted of four sections, each prefaced with a statement outlining the type of questions for the respondent's benefit. Section-1 contained six multiple-choice questions assessing demographics, including age, sex, education level, field of employment, city of residence, and marital status. Sections 2 and 3 were designed to gather data on knowledge and perceptions of antibiotic resistance, featuring eleven questions in total. Of these, four questions evaluated participants' perception of antibiotic resistance. The level of knowledge regarding antibiotic resistance was assessed by the number of correct answers to seven true/false statements. A participant was deemed to have adequate knowledge if he/she answered more than 4 knowledge questions correctly (out of 7). The final section (Section 4) included eight Likert scale questions designed to gather information on participant's attitudes toward antibiotic resistance. The participants' attitude toward antibiotic resistance was assessed using 5-likert scale questions. Agreement levels with attitudes that implicate awareness about the importance of antibiotic resistance issue were estimated based on subjects' responses for seven items that indicate positive attitudes (all attitudes except "There isn't much that individuals can do to fight antibiotic resistance."). The total agreement score was calculated for each subject by adding up the score for each item with a maximum score of

35 (according to Likert scale response ranged from 1 assigned to strongly disagree response to 5 assigned to strongly agree response). The survey used in this study is provided in the supplementary material (Appendix A).

Data collection

The questionnaire was administered using an online Google Form document, which was distributed via various social media platforms, including Facebook, Twitter, Instagram, and WhatsApp. The Google Form settings were configured to restrict respondents to submitting only one response per person to ensure data integrity.

To maximize response rates, reminders were sent out periodically. Three reminders were sent over the data collection period, with each reminder spaced one week apart

Participation in the survey was voluntary, and anonymous. An information page outlining the study's aims was included at the beginning of the questionnaire, and each participant was asked to complete the survey independently. The survey began with an informed consent statement detailing the study's purpose, the voluntary nature of participation, confidentiality measures, and participants' rights.

Inclusion and exclusion criteria

The inclusion criteria for the study were as follows: participants had to be above the age of 18, residents of the UAE, have internet access, and be free from any mental disabilities. This ensured that the study's sample was representative and that participants could fully understand and engage with the survey content.

Sampling technique and size

A simple random sampling technique was employed to determine sample prevalence within the study population. Based on data from the UAE government portal, the study population was estimated at approximately nine million people. Using this number, the necessary sample size was calculated with a 95% confidence level, a 5% predetermined margin of error and a response distribution of 50%. employing the Raosoft sample size calculator (<http://www.raosoft.com/samplesize.html>). The minimum sample size was 385 participants. The survey was not directed towards any specific population or platform, ensuring a random selection process. Additionally, the voluntary nature of participation was maintained by providing individuals with the choice to opt in or out of the survey at the beginning.

Validity

The final version of the questionnaire underwent discussion and validity evaluation by a panel of professionals who are experts in several areas of pharmacy practice and antimicrobial resistance. The panel consisted of a total of six experts who were university professors with not less than 10 years of experience in the academic field. Four of these experts were professors in clinical pharmacy and pharmacy practice. Additionally, we invited two experts specializing in the field of antimicrobial stewardship to provide their expertise. A virtual



meeting, convened by the principal investigator, served as a platform for these esteemed experts to assess the content of the questionnaire. During the meeting, the panel members were asked to grade each item in the questionnaire on a scale of 1-10 for clarity, relevance, and appropriateness. Clarity refers to the comprehensibility and transparency of each item in the questionnaire, ensuring that it can be easily understood by respondents. Relevance relates to the significance and relevance of each item to the overall objectives of the study, ensuring that the questionnaire captures relevant information. Appropriateness involves assessing whether each item is suitable and fitting for the study's aims and population. A score of 1 represents the lowest level of clarity, relevance, or appropriateness, while a score of 10 expresses the highest level. The panel's collective insights and recommendations were instrumental in refining the questionnaire, ensuring its robustness and validity. Question content validity indices (CVI) were calculated and adjusted as necessary. The overall means ($\pm$ SD) of clarity, relevance, and appropriateness were 8.51 ± 1.67 , 9.34 ± 2.07 , and 8.27 ± 1.14 , respectively (Supplementary Table 1). Additional amendments and comments recommended by the panel members were also considered (detailed in the supplementary information, Appendix B).

Reliability

To ascertain if the core questionnaire is calculating the same domain or not, inter-item correlations were reported using Cronbach's statistics. Internal consistency reliability tests and test-retest reliability analyses were performed to assess the reliability of the questions. The final version of the survey was completed and created. The calculated Cronbach's alpha was 0.95 which indicates excellent internal consistency.

Pilot study

It was crucial to make sure the right information was gathered for the pilot test while creating the final questionnaire. Pilot testing was intended to find any elements that respondents reported unclear. Thirty-five respondents (5-from each Emirate) who met the inclusion criteria were invited to complete the questionnaire as part of the tool's pilot phase. The data collected was examined, and the subjects' feedback about potential challenges encountered was obtained. No challenges were encountered by either the subjects or the researchers. Yet, the research sample and outcome did not include the data from these 35 participants. The responses were imported into t SPSS version 26 (IBM Corp, Armonk, NY). In order to assess reliability Cronbach alpha (α) was calculated for positive attitude items measuring internal consistency of these items. The calculated Cronbach's alpha was 0.91 which indicates excellent internal consistency.

Statistical analysis

Descriptive statistics such as frequencies with percentages and arithmetic means with standard deviations were calculated to describe subjects' demographics, experiences, knowledge, and attitudes regarding antibiotic resistance. Participant knowledge was evaluated using 7 true/false questions. The total level of knowledge was calculated using the number of

correct answers for each question with a maximum score of 7. Considering that the average number of correct answers for the study participants was 4.2, adequate level of knowledge was deemed to be larger than the average. A multivariable logistic regression model was conducted to assess predictors of adequate knowledge regarding antibiotic and antibiotic resistance. A multivariable linear regression model was conducted to assess predictors of attitude agreement scores. Variables assessed in the mentioned regression models were age group, gender, education level, marital status, and studying in the medical field. A Hosmer-Lemeshow test was conducted to evaluate the goodness of fit in our logistic regression model. All data analyses were conducted using Stata version 17 software (StataCorp, 2021, "Stata: Release 17. Statistical Software," College Station, TX: StataCorp LLC). Statistical significance was set at a 2-sided $P < 0.05$.

RESULTS

Demographics and general characteristic

A total of 1074 individuals completed the survey (Table 1). Most of the respondents (43.67%) were aged between 18-29 years old. The number of respondents who were involved in the medical field was lower than those who were in a non-medical field (23.28% vs. 76.72%). Furthermore, more than half of the participants were married (58.29%) and had a Bachelor's degree (50.37%).

Perception and Knowledge regarding antibiotic resistance

Approximately two-thirds of the study population (66.01%) had previous knowledge regarding the term "Antibiotic resistance" (Table 2). Most of the respondents stated that they obtained knowledge regarding antibiotic resistance from the media (26.35%), doctors and/or nurses (25.7%), and family members and/or friends (21.51%). Furthermore, more than half of the participants (57.82%) believed that antibiotics could be effective against viral infections such as cold and flu before the COVID-19 period. Of those, less than half (45.44%) still believed that antibiotics can be effective against viral infections such as cold and flu since COVID-19.

To assess the level of knowledge regarding antibiotic resistance, seven true/false statements were asked (Table 3). Most of the respondents (79.14%) incorrectly believed that antibiotic resistance occurs when their bodies become resistant to antibiotics, so they do not work properly. Furthermore, approximately one-third of respondents (34.54%) wrongly believed that resistance to antibiotics is an issue in other countries but not in the UAE.

A majority of the respondents correctly identified the following statements: 80.91% for "Antibiotic resistance is a situation where antibiotics become ineffective in controlling or killing bacteria", 78.03% for "Many infections are becoming increasingly resistant to treatment with antibiotics", and 77.28% for "Antibiotic-resistant infections make medical procedures such as surgery, organ transplants, and cancer treatment, more dangerous". However, more than half of



Table 1. Sociodemographic characteristics of the study population (n=1074)	
Variable	Frequency (%)
Gender	
Female	809 (75.33%)
Male	265 (24.67%)
Age group (years)	
18-29	469 (43.67%)
30-39	309 (28.77%)
40-49	207 (19.27%)
50-59	77 (7.17%)
60-69	12 (1.12%)
Study field	
Medical sector	250 (23.28%)
Non-medical sector	824 (76.72%)
City of residence	
Al Fujairah	19 (1.77%)
Abu Dhabi	483 (44.97%)
Ras Al Khaimah	37 (3.45%)
Um Quwain	14 (1.30%)
Sharjah	224 (20.86%)
Dubai	167 (15.55%)
Ajman	130 (12.10%)
Marital status	
Widowed	6 (0.56%)
Single	427 (39.76%)
Married	626 (58.29%)
Divorced	15 (1.40%)
Educational level	
Primary school degree	83 (7.73%)
High school degree	353 (32.87%)
Bachelor's degree	541 (50.37%)
Master's degree	86 (8.01%)
PhD degree	11 (1.02%)

the participants (53.07%) reported the correct answer to the statement “antibiotic-resistant bacteria can spread from person to person”, and fewer than half of respondents (40.69%) correctly believed that antibiotic resistance is an issue that can affect them or their families. On average, participants answered 4.16 knowledge questions correctly (SD = 1.3). with more than one third of participants (41.7%) considered to have adequate knowledge regarding antibiotic and antibiotic resistance (average knowledge score > 4).

Attitude toward the antibiotic resistance problem

Figure 1 illustrates the participants’ attitudes toward the antibiotic resistance problem. More than 70% of the participants agreed or strongly agreed about the attitude statements

“people should wash their hands regularly”, “physicians should prescribe antibiotics when only needed”, “everyone has to take on the responsibility to use antibiotic responsibly”, “parents must make sure to vaccinate their children”, and “people should only use antibiotics when prescribed by a doctor”. However, fewer than a quarter of the participants (27.3%) agreed or strongly agreed with the attitude statement “There is not much that individuals (like me) can do to fight antibiotic resistance”. More than half of the participants (51.7%) agreed or strongly agreed that people should not keep antibiotics and use them later for other diseases, and approximately half of the participants (49.8%) agreed that antibiotic resistance is one of the greatest problems in the world. The average agreement level with attitudes that implicate awareness about the importance of antibiotic resistance issue was 26.7 (±7.7).

Predictors of adequate knowledge of antibiotics and antibiotic resistance

The percentage of participants who studied in medical fields was significantly higher among those with adequate knowledge regarding antibiotic resistance compared to participants with inadequate knowledge (32.4% vs 16.8%, p value <0.001). Having a PhD degree or Master’s degree was also more prevalent among participants with adequate knowledge compared to those with inadequate knowledge (12.05% vs 6.87%; p value = 0.008). The percentage of married participants was lower among those with adequate knowledge compared to those with inadequate knowledge (54.5% vs 61.02%, p value = 0.032). After adjusting for potential confounders, studying in the medical field and having a PhD, or master’s degree remained significant predictors of adequate knowledge (Odds ratios (OR) were 2.15 and 1.77, respectively) (Table 4).

Predictors of agreement about the importance of the AMR problem

Participants with a PhD, or Master’s degree had significantly higher agreement scores regarding the importance of antibiotic resistance (positive attitudes) compared to those with a primary school degree (Coefficient: 2.361, p value = 0.014) (Table 5).

DISCUSSION

Antibiotic resistance is one of the most difficult clinical and public health challenges of the twenty-first century¹⁷. Educating the current and future generations of healthcare practitioners, patients, and the public about proper infection control measures, antibiotic usage, and the environmental impact of antibiotic use is a critical requirement to assure a more cautious approach to antimicrobial usage thus lightening the burden of antimicrobial resistance³⁴. In understanding the dynamics of antibiotic resistance, it is essential to explore the interconnectedness of knowledge, perspective, attitude, and predictors among the population. Knowledge refers to the factual information and understanding that individuals have regarding antibiotic resistance, including its mechanisms and implications. Perspective encompasses the ways individuals perceive antibiotic resistance as a health issue, influenced by



Table 2. Participants' perception about antibiotic resistance (n=1074)	
Question	Frequency (%)
Have you heard of the term "Antibiotic Resistance"?	
No	365 (33.99%)
Yes	709 (66.01%)
Where did you hear about antibiotic resistance?	
Doctor and/or nurse	276 (25.70%)
Pharmacist	159 (14.80%)
Family member and/or friend	231 (21.51%)
Media (newspaper, TV, and radio)	283 (26.35%)
Specific campaign	108 (10.06%)
Other	61 (5.68%)
Before the COVID-19 pandemic, did you believe that antibiotics could be effective against viral infections such as cold and flu?	
Yes	621 (57.82%)
No	453 (42.18%)
If the answer for the above question is yes, after COVID-19 pandemic, do you still believe that antibiotics can be effective against viral infections such as cold and flu?	
Yes	488 (45.44%)
No	586 (54.56%)

Table 3. Knowledge about antibiotic resistance among study subjects (n=1074)		
Question	The correct answer	Number of correct answers (%)
Antibiotic resistance occurs when your body becomes resistant to antibiotics, so they do not work properly.	FALSE	224 (20.86%)
Antibiotic resistance is a situation where antibiotics become ineffective in controlling or killing bacteria.	TRUE	869 (80.91%)
Many infections are becoming increasingly resistant to treatment with antibiotics.	TRUE	838 (78.03%)
Antibiotic-resistant bacteria can spread from person to person.	TRUE	570 (53.07%)
Antibiotic-resistant infections make medical procedures such as surgery, organ transplants and cancer treatment, more dangerous.	TRUE	830 (77.28%)
Antibiotic resistance is an issue that can affect me or my family.	TRUE	437 (40.69%)
Resistance to antibiotics is an issue in other countries but not here.	FALSE	703 (65.46%)

Table 4. Predictors of participants' adequate knowledge of antibiotics and antibiotic resistance (N=1074)							
	Inadequate knowledge n (%)	Adequate knowledge n (%)	P-value*	Adjusted OR (Adequate vs. Inadequate)	P-value**	95% Confidence interval	
Medical field study/work	105 (16.8)	145(32.4)	<0.001	2.15	<0.001	1.6	2.92
Male gender	146 (32.2)	119 (26.6)	0.225	1.2	0.213	0.9	1.61
Marital status (Married vs single)	382 (61.02)	244 (54.5)	0.032	0.79	0.168	0.57	1.1
Education			0.008				
Primary school degree¥	129 (20.61)	88(19.64)		Ref			
High school degree¥¥	142 (22.68)	77(17.19)		0.88	0.515	0.59	1.31
Bachelor's degree	312 (49.84)	229(51.12)		1.15	0.411	0.82	1.61
Master's or PhD degree	43(6.87)	54 (12.05)		1.77	0.026	1.07	2.95
Age (years)			0.85				
18-29	267(42.65)	202 (45.09)		Ref			
30-39	181(28.91)	128 (28.57)		1.07	0.701	0.75	1.53
40-49	125(19.97)	82 (18.3)		1.08	0.713	0.71	1.63

50-69	53(8.47)	36 (8.04)		1.05	0.845	0.62	1.78
¥ Grade 1-9 in the UAE							
¥¥ Grade 12 completion degree							
*Unadjusted analysis (Chi2)							
**Adjusted analysis (multivariable logistic regression). Hosmer-Lemeshow test showed reasonable goodness of fit (P value was 0.156). OR: Odds Ratio							

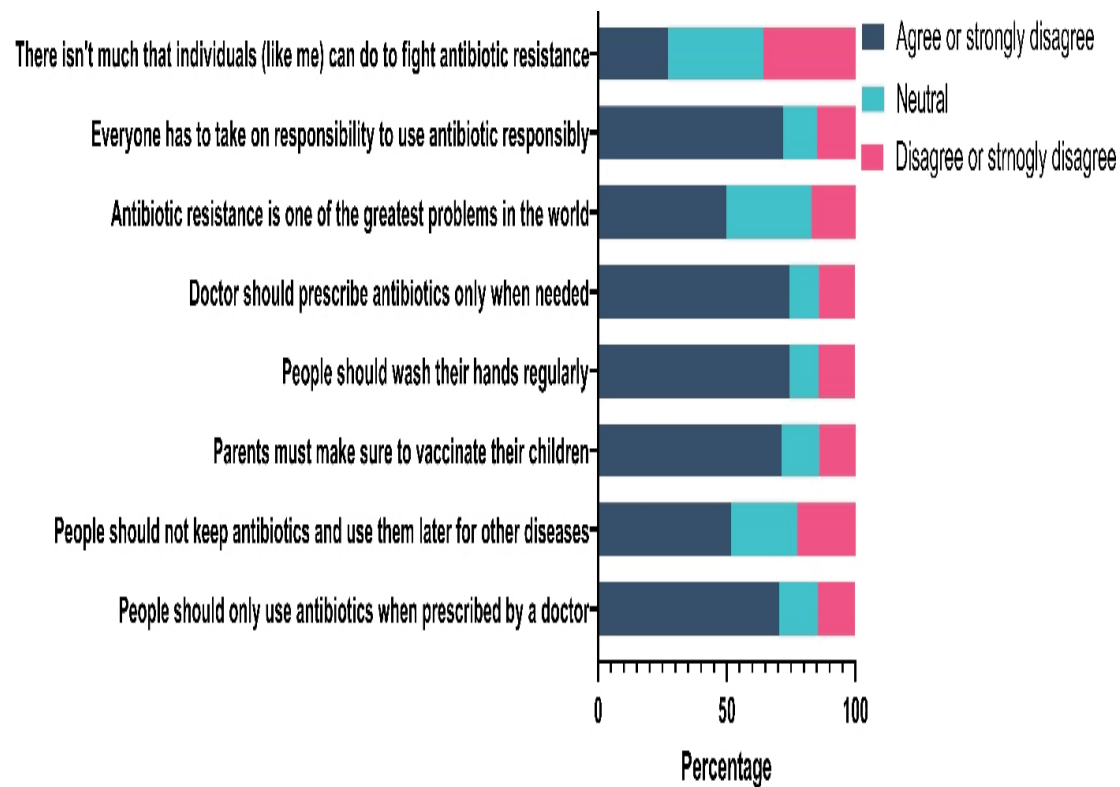


Figure 1. The participants attitude towards antibiotic resistance (n=1074)

Table 5. Predictors of participants' agreement about the importance of antibiotic resistance problem (n=1074)			
	Coefficient	95% Confidence interval	P-value*
Medical field study/ work	0.326	-0.8 to 1.45	0.569
Gender	-0.464	-1.55 to 0.62	0.399
Marital status	0.616	-0.6 to 1.83	0.321
Education			
Primary school degree	Ref		
High school degree	-0.457	-1.92 to 1.01	0.541
Bachelor's degree	0.866	-0.38 to 2.11	0.172
Master's or PhD degree	2.361	0.48 to 4.25	0.014
Age group (years)			
18-29	Ref	-1.24 to 1.37	0.919
30-39	0.067	-1.56 to 1.47	0.952
40-49	-0.046	-2.75 to 1.11	0.403
50-69	-0.82		
*Adjusted analysis (Linear regression) Ref...			



their awareness and beliefs. Attitude reflects the disposition and readiness of individuals to engage in behaviors that mitigate antibiotic resistance, such as adhering to prescribed antibiotic regimens. Predictors are the factors that influence the level of knowledge, perspective, and attitude among individuals, such as education level, field of study, and previous exposure to health education. For instance, the study reported that respondents involved in the medical sector and those with higher educational degrees (e.g., PhD or Master's degree) demonstrated significantly higher levels of knowledge and more positive attitudes towards antibiotic resistance^{23,24,25}.

Perception and knowledge regarding antibiotic resistance

The survey's findings revealed that a significant number of participants were knowledgeable about the term 'antibiotic resistance,' suggesting that there is a broad awareness of the issue among the population in the UAE. Similar results were observed in numerous studies in other countries^{2,18}. For instance, Muflih and colleagues reported that approximately three-quarters of Jordanian participants were previously aware of the term "antibiotic resistance"¹⁸. When the UAE residents were questioned about the matter of "antibiotic resistance", an overwhelming majority, comprising more than 70 % of the participants, were aware of it and expressed their belief that it was indeed a "major health concern"¹⁹. This high level of acknowledgment underscores the importance placed on this issue within the field of public health. The term 'major health concern' reflects the participants' recognition of the significance of the issue, not necessarily an emotional response to it.

The present study reported that misconceptions regarding the effectiveness of antibiotics against viral infections improved after the COVID-19 pandemic as the proportion of respondents who believed that antibiotics are effective against such infections was reduced. A similar reduction was observed previously in Jordan from 60.8% before the COVID-19 pandemic to 51.6% after the pandemic²⁵.

Despite the fact that most participants in this study were previously aware of antibiotic resistance, antibiotic resistance was frequently incorrectly described. Similar findings were observed in previous studies [2,25,26,36]. For instance in a cross-sectional study by Michaelidou et al., more than two thirds of the participants (70.7%) believed that it is the human body that develops resistance to antibiotics, rather than the bacteria themselves which is slightly lower than what was observed in the present study²⁰. In this study, only (21%) of respondents correctly identified the statement "Antibiotic resistance occurs when your body becomes resistant to antibiotics, so they do not work properly" as false. Similar results (correctly identifying that antibiotic resistance is due to bacteria rather than the human body) were reported in two studies in Italy (22%) and Germany (28.7%)^{21,22}. In this study, a more than one-third of participants (34.5%) wrongly indicated that antibiotic resistance is an issue in other countries but not in the UAE. This ratio is much higher than previously observed in other countries like Canada (1.9%), Ecuador (5.1%), Cyprus (10.9%), and Jordan (20.6%)^{18,20,23,24}.

The results of the present study indicated that there was a significant degree of misinterpretation regarding particular elements of antibiotic resistance. Future initiatives should place emphasis on disseminating knowledge regarding the mechanism of resistance development, the modes of transmission for resistant bacteria, and the individual contributions in fighting resistance²⁰.

Attitude toward the antibiotic resistance problem

The findings of this study suggested that respondents were extremely conscious and well aware of antibiotic resistance and possible antibiotic-resistance solutions. Results from previous research in Jordan were consistent with this finding¹⁸. Most of the participants in this study agreed or strongly agreed that physicians should prescribe antibiotics only when needed and people should only use antibiotics when prescribed by a doctor. These findings were previously observed in similar studies investigating antibiotic inappropriate use, underuse, and overuse in different countries^{2,26,35}. Similar to our findings, Prigitano et al. reported that most study participants had positive attitudes toward strategies to fight antibiotic resistance such as proper handwashing as well as only using antibiotics when recommended and necessary²¹. Our results suggested that respondents had good knowledge regarding the proper use of antibiotics and antibiotic resistance. However, enhancing the public understanding of antibiotic resistance along with implementing various techniques and strategies may exert a beneficial effect in reducing resistance to antibiotics and may enhance antibiotic stewardship in a variety of sectors.

Predictors of adequate knowledge of antibiotics and antibiotic resistance

The findings of the present study suggested that respondents involved in the medical sector during study were understandably more knowledgeable about antibiotic resistance. Similar findings have been reported in previous research^{18,37,38}. Baddal et al. reported that medical students were much better educated about antibiotic and antibiotic resistance when compared to other students³⁹. In the study conducted by Zgliczyński et al. it was revealed that a significant majority of physicians demonstrated awareness regarding the link between the unwarranted use of antibiotics and the development of AMR⁴⁰. In a previous study, approximately 75% of the 18,635 participants from 30 countries exhibited a commendable level of knowledge concerning the mechanisms driving the development and dissemination of antibiotic resistance⁴¹. These findings may be explained by the fact that healthcare workers have access to educational courses about antibiotics in their facilities. Moreover, some medical doctors learn during their education about the proper use of antibiotics thus increasing their knowledge regarding this matter.

Similar to previous studies, this study reported that higher education levels such as a PhD or Master's degree were significantly associated with improved levels of knowledge regarding antibiotic resistance⁴²⁻⁴⁷. In a study by Pogurschi et al. respondents with higher educational levels (post-graduate education) were less likely to have inadequate and inaccurate



antibiotic resistance-related knowledge (OR=0.092, 95% CI: 0.02-0.305, p value <0.001)⁴⁸.

Predictors agreement about the importance of antibiotics resistance

This study reported that respondents with high levels of education such as a PhD degree have a proper attitude toward antibiotic resistance and were more likely to agree on the importance of that. Results from several studies are consistent with our findings as they have reported that a high degree of education is significantly associated with a positive attitude toward antibiotic resistance^{43,45,49}.

Limitations

The gender distribution observed in our study does not fully reflect the national population demographics. Although we aimed to reach a diverse participant pool representative of the population, the final sample's gender distribution was influenced by factors such as varying survey participation rates among different demographic groups. Despite efforts to promote inclusivity, we acknowledge that the sample may not be entirely representative of the national population. On the other hand, using social media for participant recruitment introduced potential biases due to unequal access to internet resources and varying social media usage patterns^{50,51}. To mitigate non-response bias, the survey was repeatedly posted and shared on different social media platforms (Facebook, WhatsApp and others) thus maximizing the response rate. However, individuals with greater interest in the topic of antibiotics may have been more likely to participate, potentially leading to self-selection bias⁵².

Additionally, the surveys included numerous statements asking respondents to agree or disagree, which may have generated acquiescence bias. This bias happens when respondents are

tending to agree with statements regardless of the content being evaluated.

CONCLUSION

This study offered initial evidence regarding public knowledge and awareness regarding antibiotic resistance within the population of the UAE. Improved antibiotic knowledge was attributed to educational campaigns during the COVID-19 pandemic, potentially reducing antibiotic resistance rates. While participants in this study were generally aware of antibiotic resistance, incorrect descriptions of antibiotic resistance were frequently encountered. Enhancing the public understanding of antibiotic resistance along with implementing various techniques and strategies may exert a beneficial effect in reducing resistance to antibiotics and may enhance antibiotic stewardship in a variety of sectors.

AUTHOR CONTRIBUTIONS

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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