**Knowledge, Attitude, and Practices Towards** **Antibiotic Use and Resistance: A Cross-Sectional Study among College Students in Israel**

## 1. Introduction

Antibiotics have been one of modern medicine's most significant medical breakthroughs (Terreni et al., 2021). Antibiotics enabled the treatment of complex medical conditions and saved the lives of millions of people (Duan et al., 2022). Antibiotic resistance is one of the most disturbing problems in health systems and food security and development today (Choudhury et al., 2022). It constitutes one of the greatest threats to human health and is a major public health problem (WHO, 2020). About 700,000 people die every year because of bacteria that antibiotics cannot kill, and the numbers may increase in the coming years (Tagliabue & Rappuoli, 2018; Mancuso et al., 2021). Without new and better treatments, the World Health Organization (WHO) predicts that this number could rise to 10 million by 2050 (Abdelaziz et al., 2021; WHO, 2018).

Antibiotic resistance occurs everywhere worldwide (van Hecke et al., 2017). Antibiotic overuse and misuse have resulted in bacteria developing antibiotic resistance (CDC, 2019; Li & Webster, 2018). The more bacteria become antibiotic-resistant, the harder it is to treat bacterial diseases. Already today, some bacteria are resistant to almost all antibiotics (Hutchings et al., 2019). As these bacteria multiply and more bacteria become resistant to antibiotics, the probability of contracting a disease that cannot be treated increases (Hutchings et al., 2019). Infections caused by resistant bacteria are characterized by a longer illness time and usually more aggressive treatment measures, so the complication and mortality rates may be higher. Another aspect of harm is the resources consumed when dealing with pathogens resistant to antibiotic preparations, such as loss of working days and decreased occupational productivity due to prolonged hospitalizations, diverting more resources to patient care and significantly higher treatment costs (Madhav et al., 2017). According to the Israeli Ministry of Health, in 2015, more than 4,100 patients were hospitalized due to infections caused by resistant bacteria. The average length of hospitalization was over two weeks. The total number of hospitalization days during 2015 for these patients exceeded 64,000, and the total cost was more than 128 million NIS (Haklai, 2015). In addition, in the era of globalization, the transfer of resistant bacteria from continent to continent is easy. Thus, the resistant bacteria spread rapidly worldwide (Singh et al., 2019).

Studies show public misconceptions about antibiotic use and resistance (Halls et al., 2017). Many do not see a connection between resistant bacteria and the use of antibiotics (Huttner et al., 2019). For example, people with good knowledge about when to use antibiotics still report being able to take them on their own without a prescription (McNulty et al., 2007). A systematic review article included 54 studies on the public's knowledge and beliefs about antibiotic resistance (McCullough et al., 2016) and found that some participants had heard of antibiotic resistance. Still, most believed it referred to changes in the human body. Participants believed they were at low risk of antibiotic resistance and argued that strategies to minimize resistance should be aimed primarily at physicians. The researchers concluded that the public does not have a complete understanding of antibiotic resistance, has misconceptions about it and its causes, and does not believe that they contribute to the development of the phenomenon.

Studies among students have found improper use of antibiotics and a lack of knowledge about antibacterial substances (Sunusi et al., 2019). A survey conducted among 1,200 undergraduate students in the United Arab Emirates (Jairounet al., 2019) showed that 38% of the students took antibiotics on their own in the six months preceding the study. More than half of the students took antibiotics when they had a cold or sore throat. The researchers assumed that the sick students thought the antibiotics would speed up their recovery to return to university. In a study conducted among 733 students in Ecuador (Ortega-Paredes et al., 2022), differences between disciplines were identified when students from the basic sciences received a higher grade than their peers from the social sciences. Most interviewees were knowledgeable about the use but mistakenly associated antibiotic resistance with the patient and not with the bacteria. Similarly, a study that examined knowledge and attitudes among 750 Lebanese students found that approximately 78% of respondents from health-related majors achieved high knowledge compared to only 41% from non-health-related majors (Sakr et al., 2020).

Although the issue of antimicrobial resistance is not new, it has long been assumed that this problem will be solved by continuously developing new drugs. However, antibiotic development has been an alarming decline over time (Gottlieb & Nimmo, 2011). Returning to the "pre-antibiotic era" will render many routine infections untreatable and will seriously affect the current practice of surgery, intensive care, organ transplantation, and cancer treatment through a significant increase in morbidity and mortality. Assessing awareness of the phenomenon is critical in dealing with the spread of antibiotic resistance.

This study aims to examine the level of knowledge, awareness, attitudes, and behavior of students in Israel towards antibiotic resistance, as well as the relationships between these variables, and to compare students from health sciences with students from other disciplines in terms of knowledge and awareness. The research findings will help recommend an outreach program to policymakers in public health and infectious diseases to raise the knowledge and understanding of antibiotic resistance and how humans can influence and mitigate this threatening phenomenon. A similar study has not yet been conducted in academic institutions in Israel.

2. Materials and Methods

2.3. Research Procedure

This study was cross-sectional among students enrolled at Ashkelon Academic College in 2023. After approval from the Ashkelon Academic College Ethics Committee (approval #40-2023), the questionnaires were programmed using Qualtrics and distributed to the students on 12 January 2023. A reminder to complete the questionnaire was sent the same way after two weeks. On 11 February 2023, the questionnaire was closed in the program. The time to answer the questionnaire was estimated at 6.1±2.13 minutes on average. The introductory page of the questionnaire contained an explanation of the essence and aim of the questionnaire. Completion of the questionnaire indicated informed consent to participate in the survey. The students could stop responding to it at any stage or choose not to answer some questions. No questions were defined as compulsory. The sample comprised 371 students who answered at least 90% of the questionnaire.

2.2. Tools

We translated the anonymous, closed, self-completion questionnaire of the World Health Organization "Antibiotic Resistance, Multi-country public awareness survey" (WHO, 2015) from English into Hebrew by a professional translator. This questionnaire is used among a variety of populations, including student populations, and it has been translated into different languages (e.g., WHO, 2015; Sakeena et al., 2018; Okedo-Alex et al., 2019; Sakr et al., 2020; Shahpawee et al., 2020; Ortega-Paredes et al., 2022). After the questionnaire was translated into Hebrew, it was given to five students who did not attend the college to ensure that the questions were understood; The questionnaire was revised according to the comments. In addition, the questionnaire was validated using the content validity method using two experts in public health and infectious diseases. Description of questionnaire sections:

1. Demographic information- gender, age, marital status, religion, department, year of study.
2. Practice- three questions: when did you take antibiotics? Did you get the prescription from a doctor? Did a doctor/nurse/pharmacist explain how to take the antibiotics?
3. Knowledge about the use of antibiotics- three questions in which respondents were asked to indicate whether, in their opinion, the statement is correct or incorrect or whether they do not know. For example, "You should stop taking antibiotics when you feel well." The correct responses to questions in each statement were added to give the knowledge score.
4. Knowledge about the necessity of antibiotics in 12 medical conditions. Only three situations out of the 12 must be treated with antibiotics (gonorrhea, bladder or urinary tract infection, and skin or wound infection). The correct responses to questions in each statement were added to give the knowledge score.
5. Familiarity with four terms related to antibiotic resistance (antibiotic resistance, superbugs, antimicrobial resistance, antibiotic-resistant bacteria) in which respondents were asked to indicate whether they were familiar with the term or not.
6. General knowledge about antibiotic resistance- eight questions in which respondents were asked to indicate whether, in their opinion, the statement is correct or incorrect or whether they do not know. For example, "Antibiotic resistance is an issue in other countries but not in Israel."
7. The level of awareness and understanding regarding the ways to treat antibiotic resistance- seven questions in which respondents were asked to indicate to what extent they agree with the statement on a Likert scale of 1–5 (not at all to a very large extent). For example, "People should use antibiotics only when prescribed by a doctor." The average of the answers was calculated for each participant. The reliability was Cronbach's α = 0.73.
8. Awareness of the severity of antibiotic resistance- five questions in which respondents were asked to indicate to what extent they agree with the statement on a Likert scale of 1–5 (not at all to a very large extent). For example, "Antibiotic resistance is one of the biggest problems the world faces." The average of the answers was calculated for each participant. The reliability was Cronbach's α = 0.75.

2.3. Data Analysis

The data were analyzed using SPSS V. 29 (IBM, Armonk, NY, USA). The relationships between the variables were examined using Pearson correlations. The differences between the groups of students were analyzed using χ2 tests and one-way Analysis of Variance (ANOVA) according to the variables' measurement scale. A linear regression model was used to test the prediction of the level of awareness and understanding regarding the ways to treat antibiotic resistance. All reported *p-values* were based on two-sided tests and were considered significant when the values were below 0.05.

3. Results

3.1. Sample Characteristics

In total, 371 individuals participated in the study, of whom 74% were women, 57% were in relationships, and 27% had children. Most participants were Jewish (92%) and Israeli-born (86%). The mean age of the respondents was 28 ± 8.58 years. Sample characteristics are shown in Table 1.

**Table 1.** Sample Characteristics.

**Sample Health Sciences Social Sciences Computers & Management**

**Character (*n* = 371) (*n* = 110, 30%) (*n* = 201, 54%) (*n* = 60, 16%)** χ**2/F**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **n** | **%** | **n** | **%** | **n** | | **%** | **n** | | **%** |  |
| Men  Women | 96  275 | 26  74 | 15  95 | 14  86 | 47  154 | | 23  77 | 34  26 | | 57  43 | χ2 = 38.90 \*\*\* |
| In relationship | 210 | 57 | 60 | 55 | 118 | | 59 | 32 | | 53 | N.S. |
| Having children | 102 | 27 | 21 | 19 | 71 | | 35 | 8 | | 13 | χ2 = 16.26 \*\*\* |
| Jewish | 341 | 92 | 90 | 82 | 193 | | 96 | 58 | | 97 | χ2 = 21.27 \*\*\* |
| Born in Israel | 319 | 86 | 87 | 79 | 178 | | 89 | 54 | | 90 | χ2 = 6.24 \* |
| Year of studies: |  |  |  |  |  | |  |  | |  |  |
| 1st  2nd  3rd + 4th | 110  201  60 | 30  54  16 | 41  85  22 | 37  42  37 | 34  74  20 | | 31  37  33 | 35  42  18 | | 32  21  30 | N.S. |
| Age (M ± SD) | 28 ± 8.58 | | 26 ± 6.22 | | | 30 ± 9.41 | | | 27 ± 8.55 | | F = 7.08 \*\*\* |

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

3.2. Antibiotic Usage Pattern

The pattern of antibiotic usage is presented in Table 2. All participants had ever taken antibiotics, half of them in the past year. 14% of respondents were not explained how to take antibiotics from a doctor, nurse, or pharmacist. A tenth took antibiotics they had at home on their own. Although the differences are insignificant, the phenomenon is more common among health sciences students.

**Table 2.** Antibiotics Usage Pattern.

**Sample Health Sciences Social Sciences Computers & Management**

**Character (*n* = 371) (*n* = 110, 30%) (*n* = 201, 54%) (*n* = 60, 16%)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **n** | **%** | **n** | **%** | **n** | **%** | **n** | **%** | χ**2** |
| Last antibiotic use: |  |  |  |  |  |  |  |  |  |
| In the last month  Last six months  Last year  More than a year | 60  72  55  184 | 16  19  15  50 | 22  26  14  48 | 20  33  13  44 | 29  35  32  105 | 14  17  16  52 | 9  11  9  31 | 15  18  15  52 | N.S. |
| Getting a prescription from a doctor: |  |  |  |  |  |  |  |  |  |
| Yes  Had at home | 333  38 | 90  10 | 94  16 | 85  15 | 185  16 | 92  8 | 54  6 | 90  10 | N.S. |
| Getting an explanation from a doctor, nurse, or pharmacist | 320 | 86 | 93 | 84 | 175 | 87 | 53 | 87 | N.S. |

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

3.3 Levels of Knowledge and Attitudes

Table 3 presents the level of knowledge and attitudes towards antibiotic resistance.

**Table 3.** Levels of knowledge and attitudes towards antibiotic resistance (*n* = 371).

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Maximum**  **Obtainable Score** | **Range Obtained by Respondents** | **Mean** ± **SD** |
| Knowledge about the use of antibiotics | 3 | 0-3 | 2.19 ± 0.79 |
| Knowledge about the necessity of antibiotics in medical conditions | 12 | 0-11 | 5.75 ± 2.75 |
| Familiarity with four terms related to antibiotic resistance | 4 | 0-4 | 2.52 ± 1.24 |
| Knowledge about antibiotic resistance | 8 | 0-8 | 4.91 ± 2.39 |
| General knowledge (adding up the scores on all knowledge questions) | 27 | 1-27 | 15.49 ± 5.35 |
| The level of awareness and understanding regarding the ways to treat antibiotic resistance | 5 | 2.29-5.00 | 4.28 ± 0.52 |
| Awareness of the severity of antibiotic resistance | 5 | 1.67-5.00 | 3.81 ± 0.68 |

3.4 The Relationships between Knowledge and Attitudes

We found positive and significant relationships between the levels of knowledge and attitudes, as shown in Table 4. In other words, the higher the level of knowledge and awareness of the severity of antibiotic resistance, the more awareness and understanding regarding the ways to treat antibiotic resistance.

**Table 4.** Relationships between knowledge and attitudes.

|  |  |  |
| --- | --- | --- |
| **Variables** | The level of awareness and understanding regarding the ways to treat antibiotic resistance | |
| *rp* | *p* |
| Knowledge about the use of antibiotics | 0.16\*\* | 0.003 |
| Knowledge about the necessity of antibiotics in medical conditions | 0.13\* | 0.015 |
| Familiarity with four concepts related to antibiotic resistance | 0.14\*\* | 0.009 |
| Knowledge about antibiotic resistance | 0.14\*\* | 0.010 |
| General knowledge | 0.19\*\*\* | <0.001 |
| Awareness of the severity of antibiotic resistance | 0.31\*\*\* | <0.001 |

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

3.5 The differences between disciplines

Table 5 highlights the differences between the disciplines regarding the levels of knowledge and attitudes. The data demonstrate that Health Sciences students expressed more knowledge of antibiotic resistance and more awareness and understanding regarding how to treat antibiotic resistance, followed by social sciences students and Computers & Management students. A follow-up Scheffe test showed that Health Sciences students have significantly more knowledge in relation to other disciplines. No differences were found between the disciplines regarding the level of awareness of the severity of antibiotic resistance.

**Table 5.** Differences between disciplines.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Disciplines** | **n** | **Mean ± SD** | **F** | **p** |
| **General** **knowledge** | Health Sciences  Social Sciences  Computers & Management | 103  191  56 | 18.33 ± 4.29  14.54 ± 5.05  13.48 ± 6.11 | 24.22\*\*\* | <0.001 |
| **Awareness of the severity of antibiotic resistance** | Health Sciences  Social Sciences  Computers & Management | 110  201  60 | 3.88 ± 0.60  3.76 ± 0.71  3.82 ± 0.73 | 1.12 | 0.326 |
| **The level of awareness and understanding regarding the ways to treat antibiotic resistance** | Health Sciences  Social Sciences  Computers & Management | 103  191  56 | 4.39 ± 0.45  4.25 ± 0.54  4.19 ± 0.57 | 3.60\* | 0.028 |

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

3.6 Linear Regression Model to Predict the Level of Awareness and Understanding Regarding the Ways to Treat Antibiotic Resistance

The results of the multiple linear regression model to predict the level of awareness and understanding regarding the ways to treat antibiotic resistance are presented in Table 6. The models included variables that were significantly related to the attitudes in the univariate analyses. The regression is significant (F(349) = 25.43, *p* < 0.001), with an explained variance of 13%. Awareness of the severity of antibiotic resistance is the best predictor of the level of awareness and understanding regarding the ways to treat antibiotic resistance (β = 0.30, p < 0.001), followed by general knowledge (β = 0.20, p < 0.001).

**Table 6.** Linear Regression Model for Attitudes toward the level of awareness and understanding regarding the ways to treat antibiotic resistance.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **β** | **B** | ***p*** |
| General knowledge  Awareness of the severity of antibiotic resistance | 0.20  0.30 | 0.02  0.24 | <0.001  <0.001 |
| R2  Adj. R2  N  F(df) | 0.12  0.13  350  25.43(349) | | |

4. Discussion

The current study aimed to explore the knowledge, attitude, and practice among college students toward antibiotic use and resistance. To the extent of the authors' knowledge, this is the first study carried out among Israeli college students. We found that half of the participants reported the use of antibiotics in the year prior to the study (Sakr et al., 2020; Jifar & Ayele, 2018). However, In the UK, a third have used antibiotics in the previous year (Dyar et al., 2018). Similar to our findings, some students in the UK started treatment from leftover antibiotics without getting a prescription (Dyar et al., 2018). Although the differences are insignificant, the phenomenon is more common among health sciences students compared to students from other disciplines. It is possible that health sciences students have higher rates of family members from health professions, thus better access to drugs without prescription. Researchers suggest that knowledge among health sciences students influences the disposition to antibiotic usage (Odetokun et al., 2019; Al-Taani et al., 2022).

We also found that overall, the level of knowledge and attitude was not satisfactory. The knowledge about the necessity of antibiotics in different medical conditions was rather low (average 5.75 out of 12), similarly the level of knowledge about antibiotic resistance (average 4.91 out of 8). Comparably, in previous studies, low knowledge about antibiotic resistance was documented among students in different countries (Mo et al., 2019; Sakr et al., 2020; Odetokun et al., 2019; Jairoun et al., 2019; McClelland et al., 2021; Marzan et al., 2021). Moreover, health sciences students had significantly better knowledge and were more aware of the problem of antibiotic resistance compared to social sciences or computers & management students. When comparing these findings to other studies conducted among university students, our results are in line with previous surveys conducted among students (Shahpawee et al., 2020; Jairoun et al., 2019; Sunusi et al., 2019; Huang et al., 2013; Chamoun et al., 2016). As for the knowledge about the necessity of antibiotics in different medical conditions, the same pattern was observed by Sakr et al. (2020), which found that a high percentage of university students agreed that antibiotics could be used to cure colds, fever, sore throat, and viral infections. These results are consistent with more findings that demonstrated misunderstandings regarding antibiotic use (Sakeena et al., 2018; Scaioli et al., 2015; Zaidi et al., 2020). A lack of understanding of the difference between bacterial and viral infections can cause inappropriate use of antibiotics and increase antibiotic resistance.

As for Familiarity with four terms related to antibiotic resistance, the average knowledge was pretty low (2.52 out of 4). This is confirmed by previous research (Anyanwu et al., 2018; Ortega-Paredes et al., 2022). Students from developed countries like Australia, France, Italy, and other European countries have also expressed the necessity for additional learning on antibiotic resistance (McClelland et al., 2022; Dyar et al., 2013; Scaioli et al., 2015; Dyar et al., 2014).

All three groups of students perceived the severity of the phenomenon at a similar level without significant differences. They all agreed that antibiotic resistance is a serious problem. These findings were similar to previous studies (Jifar & Ayele, 2018; Jairoun et al., 2019). It seems that despite the differences in the level of knowledge and awareness, all students intuitively understand the severity of the phenomenon of antibiotic resistance.

Moreover, the results of the multiple linear regression model showed that awareness of the severity of antibiotic resistance is the best predictor of the level of awareness and understanding regarding the ways to treat antibiotic resistance, followed by general knowledge. Previous studies in the field of health behavior suggested that knowledge is not necessarily a strong predictor of behavior but attitudes (Ajzen & Fishbein, 2000).

4.1 Limitations

The current study has some limitations. Firstly, it was conducted only at Ashkelon Academic College and may not be a representative sample. Secondly, no causal inferences could be drawn due to its cross-sectional design. Another limitation of the study may be the social desirability bias of the participants.

5. Conclusions

This study shed light on the level of knowledge, awareness, and practice among students in Israel from various disciplines regarding antibiotic resistance. The overall knowledge was moderate, and the level of awareness was unsatisfactory, while students from health sciences scored higher than students from social science and management. These findings provide important insights into the level of understanding of antibiotic resistance among students, which will be helpful when designing interventions to raise the knowledge and awareness of antibiotic resistance, its implications, and the ways to mitigate it. The curriculum of non-health disciplines needs lessons related to antibiotic resistance and other public health issues. For this purpose, effective actions are required with the cooperation of all stakeholders: clinicians, universities, governments, drug industries, and the public. Health authorities must improve oversight on access to antibiotics, and all should plan interventions to change the conception of how people contribute to antibiotic resistance. A new plan in Israel to fight antimicrobial resistance is being considered, based on "one health" approach with a strong emphasis on antimicrobial resistance in food-producing animals (Berman et al., 2023). The national plan should also include the component of educating the public, with an emphasis on students from all disciplines, as agents of change. A future study can evaluate this program.