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

## 1. Introduction

Antibiotics have been one of the most significant medical breakthroughs in modern medicine (Terreni et al., 2021), enabling the treatment of complex medical conditions and saving millions of lives to date (Duan et al., 2022). Antibiotic resistance is one of the most prominent threats to health systems and food security in the world (Choudhury et al., 2022), posing a major risk to human life and public health (WHO, 2020). An estimated 700,000 people die every year of infections caused by antibiotic-resistant bacteria (Tagliabue & Rappuoli, 2018; Mancuso et al., 2021), and 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 has been reported throughout the world (van Hecke et al., 2017). Antibiotic overuse and misuse have contributed to bacterial development of antibiotic resistance (CDC, 2019; Li & Webster, 2018). As such resistance becomes more common among bacteria, treating bacterial diseases becomes increasingly difficult. At present, some bacteria are already resistant to almost all antibiotics (Hutchings et al., 2019). As these bacteria multiply and more bacteria become acquire similar resistance, 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 duration and usually more aggressive treatment measures, with corresponding complication and mortality rates that tend to be higher. Another aspect of the harm associated with these pathogens is the resources consumed when treating affected patients, such as loss of working days and decreased occupational productivity due to prolonged hospitalizations diverting more resources to patient care and contributing to significantly higher treatment costs (Madhav et al., 2017). According to the Israeli Ministry of Health, more than 4,100 patients were hospitalized due to infections caused by resistant bacteria in 2015 alone, with an average hospitalization duration of 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 can occur rapidly, leading to the global dissemination of these resistant bacteria (Singh et al., 2019).

Studies have identified several public misconceptions regarding antibiotic use and resistance (Halls et al., 2017). Many individuals are not aware of the connection between resistant bacteria and the use of antibiotics (Huttner et al., 2019). For example, some people who are well informed as to when to use antibiotics still report being able to take them on their own without a prescription (McNulty et al., 2007). A systematic review of 54 studies focused on the public's knowledge and beliefs about antibiotic resistance found that some participants had heard of antibiotic resistance (McCullough et al., 2016), but that most individuals 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, harboring misconceptions regarding such resistance and its causes while believing that they do not contribute to the development of this phenomenon.

Analyses of students have reported improper antibiotic use and a lack of knowledge about antibacterial substances (Sunusi et al., 2019). A survey of 1,200 undergraduate students in the United Arab Emirates found that 38% of the students took antibiotics on their own in the six months preceding the study (Jairounet al., 2019). More than half of these students took antibiotics when they had a cold or sore throat. The researchers assumed that the sick students thought the antibiotics would expedite their recovery such that they could return to university. In a separate study of 733 students in Ecuador (Ortega-Paredes et al., 2022), differences between disciplines were identified such that students from the basic sciences received a higher grade than their peers from the social sciences. Most interviewees were knowledgeable about the use of antibiotics 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 exhibited a high level of knowledge as compared to only 41% of students 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 the continuous development of novel drugs. However, antibiotic development has declined alarmingly 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 public awareness of the phenomenon is critical for efforts aimed at dealing with the spread of antibiotic resistance.

This study was developed with the goal of examining the levels of knowledge, awareness, attitudes, and behaviors of students in Israel related to antibiotic resistance and the relationships among these variables, while also comparing the knowledge and awareness of students in the health sciences to those of students from other disciplines. These research findings will aid policymakers in public health and infectious diseases in the formulation of an outreach program aimed at improving public knowledge and understanding of antibiotic resistance and how humans can influence and mitigate this threat to global public health. No similar studies have been conducted to date in any academic institutions in Israel.

2. Materials and Methods

2.1. Research Procedure

This study was a cross-sectional analysis of students enrolled at Ashkelon Academic College in 2023. After receiving 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 via the same approach after two weeks. On 11 February 2023, the questionnaire was closed in the program. The average time taken to answer the questionnaire was 6.1±2.13 minutes. The introductory page of the questionnaire contained an explanation of the essence and aims of the questionnaire. Completion of the questionnaire indicated informed consent to participate in the survey. The students could stop responding to the questionnaire at any stage and had the option to elect not to answer certain questions. No questions were defined as compulsory. The sample comprised 371 students who answered at least 90% of the questionnaire.

2.2. Tools

We hired a professional translator who translated the anonymous, closed, self-completed WHO questionnaire entitled "Antibiotic Resistance, Multi-country public awareness survey" (WHO, 2015) from English into Hebrew. 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 then revised according to their feedback 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 was correct or incorrect or whether they do not know. For example, "You should stop taking antibiotics when you feel well." The number of correct responses to each statement was summed to calculate the knowledge score.
4. Knowledge about the necessity of antibiotics for 12 medical conditions - Only 3 of the 12 indicated conditions require antibiotic treatment (gonorrhea, bladder or urinary tract infection, and skin or wound infection). The number of correct responses to each statement was summed to calculate the knowledge score.
5. Familiarity with four terms related to antibiotic resistance - Respondents were asked to indicate whether or not they were familiar with the following terms: antibiotic resistance, superbugs, antimicrobial resistance, antibiotic-resistant bacteria.
6. General knowledge about antibiotic resistance - eight questions in which respondents were asked to indicate whether, in their opinion, the statement was 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 approaches to treating antibiotic resistance - seven questions in which respondents were asked to indicate to what extent they agree with the statement on a Likert scale from 1 (not at all) to 5 (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 Cronbach's α for reliability was 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 from 1 (not at all) to 5 (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 Cronbach's α for reliability was 0.75.

2.3. Data Analysis

The data were analyzed using SPSS 29.0 (IBM, Armonk, NY, USA). Relationships between the were examined using Pearson correlation analyses. Differences between groups of students were analyzed using χ2 tests and one-way analyses of variance (ANOVAs) as appropriate. 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. Participant characteristics are summarized in Table 1.

**Table 1.** Participants 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

The pattern of antibiotic usage among study participants is presented in Table 2. All participants had taken antibiotics, with half of them having done so in the past year. Of these respondents, 14% did not receive an explanation of how to take antibiotics from a doctor, nurse, or pharmacist, and 10% took antibiotics they had at home on their own. While the differences among these groups were not significant, the phenomenon was more common among health sciences students.

**Table 2.** Antibiotic Usage Among Study Participants.

**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 levels of knowledge and attitudes towards antibiotic resistance among study participants.

**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 Relationships between Knowledge and Attitudes

We found positive and significant relationships between the levels of knowledge and attitudes, as shown in Table 4. This indicates that a higher level of knowledge and awareness regarding the severity of antibiotic resistance is associated with greater awareness and understanding of the ways available 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 Differences between Participant Disciplines

Table 5 highlights the differences between the disciplines with respect to the levels of knowledge and attitudes observed among study respondents. Students in the Health Sciences students expressed the most 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 indicated that Health Sciences students exhibited significantly more knowledge as compared to students in these other disciplines. No differences were found among these disciplines with respect to the level of awareness regarding 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 Development of a Linear Regression Model to Predict the Level of Awareness and Understanding Regarding Approaches to Treating Antibiotic Resistance

The results of the multiple linear regression model developed to predict the level of awareness and understanding regarding approaches to treating antibiotic resistance are presented in Table 6. The model included variables that were significantly related to participant attitudes in univariate analyses. The regression was 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 approaches to treating 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 knowledge, attitudes, and practices among college students related to antibiotic use and resistance. To the best of our knowledge, this is the first such study conducted among Israeli college students. We found that half of the participants reported having used antibiotics in the year prior to the study (Sakr et al., 2020; Jifar & Ayele, 2018). However, in the UK, one-third of respondents indicated that they had used antibiotics in the previous year (Dyar et al., 2018). In line with our findings, some students in the UK began treatment using leftover antibiotics without getting a new prescription (Dyar et al., 2018). Although differences among groups were not significant, this phenomenon was nonetheless more common among students in the Health Sciences relative to other disciplines. It is possible that these Health Sciences students are more likely to have family members from health professions, thus providing better access to drugs without a prescription. Researchers suggest that knowledge among Health Sciences students influences their disposition to antibiotic usage (Odetokun et al., 2019; Al-Taani et al., 2022).

We also found that, overall, the level of knowledge and attitudes regarding antibiotic resistance were unsatisfactory. Participant knowledge about the necessity of antibiotic use for the treatment of different medical conditions was rather low (average: 5.75/12), as was the level of knowledge about antibiotic resistance (average: 4.91/8). 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 exhibited significantly better knowledge and were more aware of the problem of antibiotic resistance as 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 (Shahpawee et al., 2020; Jairoun et al., 2019; Sunusi et al., 2019; Huang et al., 2013; Chamoun et al., 2016). With respect to student knowledge of the necessity of antibiotics for the treatment of different medical conditions, the same pattern was observed by Sakr et al. (2020), who found that a high percentage of university students agreed that antibiotics could be used to cure colds, fevers, sore throats, and viral infections. These results are consistent with other research highlighting misunderstandings pertaining to antibiotic use (Sakeena et al., 2018; Scaioli et al., 2015; Zaidi et al., 2020). A lack of understanding of the differences between bacterial and viral infections can contribute to the inappropriate use of antibiotics and to increased antibiotic resistance.

With respect to familiarity with four terms related to antibiotic resistance, the average knowledge was relatively low (2.52/4). This is consistent with previous research (Anyanwu et al., 2018; Ortega-Paredes et al., 2022). Students from developed countries including Australia, France, Italy, and other European countries have also expressed the necessity for additional learning related to 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 among disciplines. They all agreed that antibiotic resistance is a serious problem. These findings were similar to previous reports (Jifar & Ayele, 2018; Jairoun et al., 2019). It thus 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 developed multiple linear regression model indicated that awareness of the severity of antibiotic resistance is the best predictor of the level of awareness and understanding regarding approaches to treating antibiotic resistance, followed by general knowledge. Previous studies in the field of health behavior have suggested that knowledge is not necessarily a strong predictor of behavior but instead of 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 among participants.

5. Conclusions

This study shed light on the knowledge, awareness, and practices of Israeli students from various disciplines regarding antibiotic resistance. The overall knowledge level among these students was moderate, and the level of awareness was unsatisfactory, with students from Health Sciences disciplines scoring higher than students from Social Sciences and Management disciplines. These findings provide important insights into the level of understanding of antibiotic resistance among students, which will be helpful when designing interventions aimed at raising knowledge and awareness of antibiotic resistance, its implications, and the ways to mitigate it. The curriculum of non-health disciplines should incorporate lessons related to antibiotic resistance and other public health issues. To achieve this goal, effective actions are required with the cooperation of all stakeholders: clinicians, universities, governments, drug industries, and the public. Health authorities must improve the oversight of access to antibiotics, and these groups should formulate interventions to address misconceptions regarding how people contribute to antibiotic resistance. A new plan in Israel to fight antimicrobial resistance is being considered, based on a "one health" approach with a strong emphasis on antimicrobial resistance in food-producing animals (Berman et al., 2023). This national plan should also include the component of public education, with an emphasis on students from all disciplines as agents of change. A future study can evaluate this program.