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Research Article:

The Knowledge and Usage of Antibiotics and Medicinal Plants Among Undergraduate Students: Their Awareness of Resistance in Sulaymaniyah, Iraq

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Abstract

Background: Antimicrobial resistance (AMR) is a critical global health concern affecting millions worldwide. Misuse of antibiotics and increased reliance on traditional remedies such as medicinal plants contribute to the complexity of AMR, especially in developing regions. **Objectives:** This study aimed to assess the knowledge and utilization of antimicrobial drugs and medicinal plants among undergraduate students in Sulaimani City, Iraq. **Methods:** A quantitative cross-sectional study was conducted between February and March 2023 using convenience sampling among 301 students from four institutions: Kurdistan Technical Institute (KTI), Sulaimani Polytechnic University (SPU), University of Human Development (UHD), and University of Sulaimani (UOS). Data were analyzed using Chi-square and Kruskal-Wallis tests. **Results:** The correct knowledge rate was 61.3% for antibiotics and 73.5% for medicinal plants. Antibiotics were primarily used to treat nasal and pharyngeal infections (n = 161; 53.5%), while medicinal plants were commonly used for the same conditions (n = 104; 34.6%). A majority of students (n = 222; 73.7%) expressed dissatisfaction with medications used for recurrent bacterial infections. **Conclusions:** The findings emphasize the need to promote rational antibiotic use and safe application of medicinal plants. Educational initiatives targeting prescribers and students may help curb AMR and support public health. Limitations include sampling bias due to the predominance of female and medical students, which may limit generalizability. Future studies should aim for more representative populations.

1. Introduction

Antibiotics are an indispensable part of modern medicine, which is regularly used in the treatment of infectious diseases. However, there is an inclination in developing immunity and resistance to modern medicines through mutation and gene transfer by bacteria [1], [2]. Low- and middle-income countries will experience the greatest concerns related to public health, primarily due to the prevalence of infections, availability of antibiotics, lack of prescribing guidelines, and restricted access to low-cost diagnostic tests [3]. Many infections once easily treated with antibiotics have become difficult to cure, leading to longer hospital stays, higher risk of hospital-acquired infections, and increased mortality. Many infections once easily treated with antibiotics have become difficult to cure, leading to longer hospital stays, higher risk of hospital-acquired infections, and increased mortality [4]. It has been estimated that more than 700,000 people pass away each year because of these multidrug-resistant bacteria, or superbugs [5]. Due to problems with toxicity and resistance, interest in alternative antibiotic sources has increased. These co-therapeutics comprised of mushrooms, lichens, and specifically medicinal plants, which contain plant secondary metabolites that are produced for defense

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mechanisms [6]. They are comprised of tannins, terpenoids, alkaloids, and flavonoids, which are effective antimicrobial agents [7].

WHO highlighted that traditional medicine is among the primary sources of healthcare for the majority of people across the world. Plant materials have been used for centuries to promote human health and treat common infectious diseases. These autochthonic remedies, such as bear berries (Arctostaphylos uvaursi), cranberry juice (Vaccinium macrocarpon), Hydrastis canadensis and Echinacea sp. are still in use worldwide [8]. Medicinal plants have been researched for the creation of novel antibiotics for a long time [9]. Current rise in awareness of the issues with antibiotic resistance provides the excessive use of plant-based products in the treatment of bacterial infections [10]. Addressing the novelty of this study, it is crucial to focus on the knowledge gaps in antimicrobial resistance (AMR) research specific to Iraqi students, particularly undergraduates, who represent future prescribers and healthcare providers. Their education and awareness are essential in combating AMR, as they will influence future prescribing practices.

Teaching students about antibiotic resistance, raising their awareness from an academic standpoint, and informing them about co-therapeutics, specifically medicinal plants, might contribute the struggle against antibiotic resistance [10].

Currently, the widespread availability of over the counter (OTC) antibiotics in Iraq, along with patient's careless usage of these antibiotics, has prompted concerns. Furthermore, due to the lack of data regarding knowledge about AMR, antibiotic usage, and the utilization of plants as sources of new co-therapeutics among patients in Iraq, there is a need to create awareness in AMR. Thus, this study aims to determine the level of knowledge and utilization of both antimicrobial drugs and medicinal plants as co-therapeutics among undergraduate students in Sulaymaniyah city, Iraq. By assessing the understanding and application of these topics among 301 undergraduate students, we hope to enhance awareness about antibiotic resistance and formulate control initiatives to effectively address this issue in Iraq, particularly among undergraduates in the city of Sulaymaniyah within the Kurdistan region.

2. Materials and Methods

This research has emerged due to the misuse and overuse of antibiotic drugs, as well as the lack of priority and significance given to medicinal plants in the Kurdistan region of Iraq. A quantitative cross-sectional study was carried out among the undergraduate students at Kurdistan Technical Institute (KTI), the largest institute in Kurdistan, Sulaimani Polytechnic University (SPU), University of Human Development (UHD); and University of Sulaimani (UOS), between the periods of February and March 2023.

Ethical approval was obtained from the institutional review boards of the participating institutions (reference number 4, dated 1 February 2023). All participants provided informed consent prior to participation. The questionnaire was anonymous and self-administered online, ensuring confidentiality and voluntary participation. All procedures were conducted in accordance with ethical standards protecting participants' rights and welfare.

A total of 301 students were selected using convenience sampling based on their availability and willingness to participate. The participants were classified as medical (medical laboratory, nursing, and pharmacy) and non-medical (information technology, computer science, petroleum engineering, interior design engineering, digital media, accounting, and business administration) departments. A closed-ended, anonymous, and self-administered Google online questionnaire was prepared in English and then translated into Kurdish by bilingual academic experts. The Kurdish version was reviewed for clarity and cultural appropriateness to ensure consistency in meaning across both languages. All participants were native Kurdish. The sample consisted predominantly of female participants (69.1%) and students from medical-related fields (64.8%), which may introduce sampling bias. This limitation is discussed further below.

The questionnaire was divided into two categories: antibiotics and medicinal plants. The antibiotics category was further divided into two parts. The first part consisted of questions related to knowledge about antibiotics and antimicrobial resistance. The second part focused on questions regarding the usage of antibiotics. Similarly, the medicinal plant category included questions regarding knowledge and usage of medicinal plants and plant resistance. Additionally, demographic questions were included to gather information about the participants' background and characteristics.

Knowledge scores were calculated based on the percentage of correct responses to a total of seven structured questions, four related to antibiotics and three related to medicinal plants. Each correct answer was awarded one point, while incorrect or 'don't know' responses received zero. The total score was converted into a percentage for each participant. Based on standard classification in previous studies [11,12], knowledge was categorized as acceptable (≥80%), moderate (60–79%), and low (<60%). The questionnaire was developed based on existing literature and previously validated tools used in similar studies. The questionnaire was internally reviewed by academic experts from participating institutions for face and content validity. However, we acknowledge that the absence of formal reliability testing, such as a pilot study or Cronbach's alpha calculation, is a limitation. We recommend future studies include these steps to strengthen psychometric reliability. The questionnaire was internally reviewed for content relevance, clarity, and linguistic accuracy by scientific staff and academic experts

from each participating institution (KTI, SPU, UHD, and UOS). Future studies should consider conducting formal reliability and validity testing, including pilot implementation and statistical consistency measures, to further strengthen the tool's quality.

The sample size (n = 301) was determined pragmatically, based on available time and resources. Although a formal power calculation was not performed, this sample size aligns with previous cross-sectional studies conducted in the Middle East region, making it reasonably adequate for exploratory analysis, making it reasonably adequate for exploratory analysis. A series of meticulous steps was undertaken in our data analysis to ensure the robustness of the findings. Data was presented using percentages and frequencies. If significance was observed, it implied that at least one of the sample groups was distinct from the others. In such instances, the differences were further investigated using the Mann-Whitney U test. Additionally, the relationships between categorical groups were explored through the Chi-square test. The threshold for statistical significance was set at $p < 0.05$ It is important to provide thorough technical explanations in this section to help others reproduce the experiments. Be sure to fully disclose where all materials came from. If any new formulations are used in the research, make sure to list all the ingredients and where they were sourced. Sharing this information promotes transparency and allows for proper replication of the study's methods and results.

3. Results

The parameters of knowledge and usage were measured using multiple-choice and yes/no questions; the overall correct rate for knowledge was 61.3% for antibiotics and 73.5% for medicinal plants. Previous studies have classified knowledge in terms of the correct rate of responses as acceptable (≥80%), moderate (60–80%), and low (60%) [11], [12]. According to this classification, the knowledge rate of antibiotics in this study was moderate. Regarding the usage, the correct rate was 78.1% for antibiotics and 81.93% for medicinal plants.

3.1. Demographic information of the respondents:

A total of 301 participants responded to the questionnaire. The vast majority of participants were female (n = 208), 69.1%, while males comprised the lowest proportion (n = 93), 30.9%. Among the participants, the highest percentage of the age range was 17-24 (n= 269; 89.3%), while the lowest contributors were between 25 and 32 (n= 32; 10.7%). The distribution of respondents according to their residential areas was as follows: urban areas 77.1% (n = 232), suburban areas 18.6% (n = 56), and rural areas 4.3% (n = 13).

Regarding education level, the majority of participants (71.4%; n = 215) have a diploma, while a lower percentage (28.6%; n = 86) had only a bachelor's degree. Additionally, it was found that 64.8% of the participants (n=195) were medical students, whereas the rate of non-medical students was relatively lower (35.2%; n=106). Considering the economic status, the distribution was as follows: good (47.8%; n = 144), moderate (40.9%; n = 123), very good (9%; n = 27), and bad (2.3%; n = 7).

3.2. Usage of antibiotics and medicinal plants by respondents:

The description of the usage of participants regarding medicinal plants and antibiotics is presented in **Table 1**. Regarding the antibiotics, A total of 70.1% (n=211) of students reported past usage of antibiotics (either less than or more than 6 months), while 19.9% (n=60) had never used antibiotics, and 10% (n=30) were current users. The breakdown of antibiotic usage by the students is as follows: 58.8% (n=177) under the permission of doctors, 25.6% (n=77) under the permission of pharmacists, 7.3% (n=22) under the permission of nurses, 4.3% (n=13) through self-medication, and 4% (n=12) through their family and friends. Almost all the students (96.7%; n=291) obtained necessary antibiotics from a pharmacy. However, only a small number (2.3%; n=7) of students acquired antibiotics through their home medication, and other individuals (1%, n=3). Notably, no students reported buying medications through the internet. The prevalent illnesses and disorders for which students used antibiotics were nasal and pharyngeal infections (53.5%; n=161). In contrast, antibiotics were used least frequently for skin infections (12%; n=36). As shown in **Figure 1**, nasal and pharyngeal infections were the most commonly reported conditions treated with antibiotics.

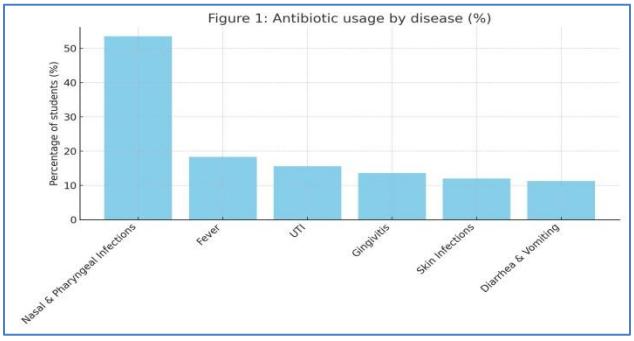

Figure 1. Percentage of students who used antibiotics to treat specific diseases. Nasal and pharyngeal infections were the most frequently reported, followed by fever, diarrhoea, urinary tract infections, and skin conditions.

On the other hand, 36.2% of the participants (n=109) reported never using medicinal plants in their life. A total of 49.5% (n=149) reported past usage of medicinal plants (either less than or more than 6 months), 36.2% (n=109) had never used them, and 14.3% (n=43) were current users.

The consumption of medicinal plants by the students is as follows: (n=122) 40.5% under the permission of non-academic expert persons (n=97) 32.2% under the permission of academic experts (n=61) 20.3% through family and friends (n=21), and 7% through self-medication. Approximately, most of the students (n=202; 67.1%) obtained necessary medicinal plants from herbal shops, followed by a lower number from pharmacies (n=58; 19.3%), other individuals (n=32; 10.6%), and the internet (n=9; 3%). As participants could select multiple answers for different usage scenarios, cumulative percentages may exceed 100%."

Different types of medicinal plants are used for treating various diseases, such as for nasal and pharyngeal infections: mint, spearmint, rose flower, chamomile flower, lemon fruit, ginger, pepper, quince fruit, cinnamon, and cloves; for fever: onion and garlic; for skin infections: black tea, coffee, lemon fruit, and anise; for diarrhea and vomiting: mastic, dry lemon fruit, mint, and onion; for gaining weight: fenugreek seeds, nuts, seeds, legumes, and whole grains; for losing weight: green tea, lemon, ginger, and cumin; for gingivitis: only cloves; and for urinary tract infections: parsley and rosehip **Figure 2**.

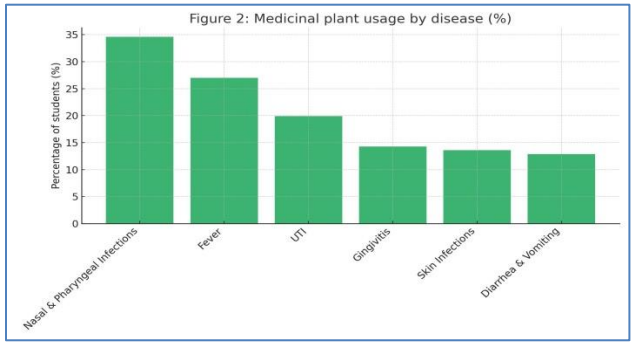

Figure 2. Percentage of students who used medicinal plants for various illnesses. Common uses included nasal and pharyngeal infections, digestive disorders, fever, skin conditions, and weight management.

In total, 47.8% of the students reported using antibiotics, while 54.8% reported using medicinal plants. Reading instructions before use was reported by 71.1% for antibiotics and 76.7% for medicinal plants. Around 61.8% used antibiotics during colds or flu, and 46.8% used medicinal plants for the same. Mixed injected use of antibiotics was reported by 14.6%, while 22.9% of students reported using mixed or injected medicinal plants. Additionally, 47.2% had found antibiotics ineffective at some point, and 39.2% had the same experience with medicinal plants. When comparing medical and non-medical students, statistically significant differences were observed in several aspects of usage behavior. Medical students were significantly more likely to report using antibiotics ($p = 0.010$), reading instructions before use ($p = 0.006$), and using antibiotics during the common cold or flu ($p = 0.009$). Similarly, medicinal plant use and their use during colds/flu were also significantly higher among medical students ($p = 0.041$ and $p = 0.024$, respectively). In contrast, there were no significant group differences in whether students found antibiotics ($p = 0.467$) or medicinal plants ($p = 0.380$) ineffective. Likewise, the use of mixed injected antibiotics ($p = 0.060$) and medicinal plants ($p = 0.177$) did not differ significantly between medical and non-medical students.

3.3. Knowledge of respondents about antibiotics and medicinal plants with their resistance

The description of the knowledge of contributors about antibiotics and medicinal plants is presented in **Table 2**. Regarding antibiotics, the majority of the students agreed that people should adhere to the prescribed time and duration of antibiotic usage (n=186) 61.8%. However, a significant number of students stopped the usage upon their recovery, (n=101) 33.6%. Fortunately, most participants (n=259; 86%) do not agree to use antibiotics prescribed for treating other patients, while a smaller proportion (n=20; 6.6%) agreed to do so. On the other hand, a large portion of students (n=222; 73.8%) were dissatisfied with using the same medication that was previously utilized for their bacterial infections; at the same time, about n=53 (17.6%) of them were satisfied. The majority of the students acquired their knowledge about antibiotics through their education (n=116; 38.5%), while only a few (n=3; 1%) heard about it from family and friends.

The students are aware that antimicrobial resistance can cause barriers and difficulties in surgical procedures (n=111; 36.9%). Additionally, most of them are aware that antibiotics cannot treat all infections (n=125; 41.5%), and they consider it a challenge that affects themselves and their families (n=107; 35.5%). Unfortunately, only a small number of students (n=33; 11%) consider that antimicrobial resistance can be transmitted from person to person. Regrettably, students think that antibiotic resistance only emerges with the misuse of antibiotics (n=104; 34.6%). Further, a few students (n=16; 5.3%) stated that this issue related to other counties, not only in the Kurdistan region/ Iraq.

On the other hand, a significant part of the students (n=138; 45.8%) stop using medicinal plants upon recovery, and approximately one-third of them (n=93; 30.9%) continue for a determined period. Thankfully, a lower percentage of the participants (n= 80; 26.8%) accepted using medicinal plants indicated for treating other patients, although the majority (n=171; 58.6%) did not agree with this statement. While the overwhelming number of participants (n= 166; 55.1%) were dissatisfied, a limited number (n= 83; 27.6%) expressed satisfaction with the medication they had previously used for their infections. It is worth to be mentioned that the greater part of the students got the knowledge of herbal antimicrobial drug resistance through TV and social media (n = 25; 8.3%) and herbal shops and their education (n = 10; 3.3%). Most of the students believe that medicinal plants have weaker

effects compared to antibiotics (n = 231; 76.7%). Besides, a significant number of the participants (n= 244; 81.1%) disagreed with using both antibiotics and medicinal plants together in their treatment process.

Statistical Comparison Between Medical and Non-Medical Students: When comparing medical and non-medical students, statistically significant differences were observed in several areas of knowledge. For instance, a significantly higher proportion of medical students reported having heard about antibiotic resistance (p = 0.022) and herbal antimicrobial drug resistance (p = 0.024), compared to their non-medical peers. Similarly, a larger percentage of medical students believed that antibiotics are widely used in agriculture (p = 0.026), that antibiotic resistance is caused by bacteria (p = 0.042), and that improper hospital hygiene contributes to its spread (p = 0.041).

In contrast, no significant difference was observed between the two groups regarding the belief that medicinal plants are widely used in agriculture (p = 0.808) or that irregular use of medicinal plants may reduce their effectiveness (p = 0.345). These findings suggest that while medical students tend to demonstrate greater knowledge about the mechanisms and contributing factors of antibiotic resistance, the awareness related to medicinal plants is more evenly distributed between both groups.

Table 1. Usage Patterns of Antibiotics and Medicinal Plants Among Students. Percentages represent independent responses and may exceed 100% due to multiple responses per participant.

Questions regarding usage	Antibiotics Yes (%)	p-value	Medicinal Plants Yes (%)	p-value
Q1: Do you use antibiotics/medicinal plants?	144 (47.8%)	0.010	165 (54.8%)	0.041
Q2: Do you read the instruction before using antibiotics/medicinal plants?	214 (71.1%)	0.006	231 (76.7%)	0.297
Q3: Have you ever used antibiotics/medicinal plants and found them ineffective?	142 (47.2%)	0.467	118 (39.2%)	0.380
Q4: Do you use antibiotics/medicinal plants during the common cold and flu?	186 (61.8%)	0.009	141 (46.8%)	0.024
Q5: Have you used mixed injected antibiotics/medicinal plants?	44 (14.6%)	0.060	69 (22.9%)	0.177

Table 2. The description of knowledge of contributors about antibiotics and medicinal plants among students.

Questions Regarding Knowledge	Antibiotics Yes (%)	p-value	Medicinal Plants Yes (%)	p-value
Q6: Have you heard about antibiotic resistance / herbal antimicrobial drug resistance?	204 (67.8%)	0.022	217 (72.1%)	**0.024**
Q7: Do you think antibiotics / medicinal plants are widely used in agriculture in your country?	131 (43.5%)	0.026	142 (47.2%)	0.808
Q8: Is it correct that antibiotic resistance is induced by bacteria?	233 (77.4%)	0.042	—	—
Q9: Is improper hygiene in hospitals a factor for spreading antibiotic resistance?	239 (79.4%)	0.041	—	—
Q10: Is irregular usage of medicinal plants a factor for not getting benefit from them?	—	—	239 (79.4%)	0.345

Note: *'Co-therapeutics' refers to the combined use of antibiotics and medicinal plants in managing infections."*

4. Discussion

The increasing problem of antibiotic resistance poses a significant threat to public health, particularly in developing regions, where regulation and awareness are often lacking [13]. In the Kurdistan Region of Iraq, where our study was conducted, there is an urgent need to enhance public understanding and promote responsible usage of both antibiotics and medicinal plants. In response to the growing threat of antimicrobial resistance (AMR), the 2023 World Health Assembly adopted the WHO Global

Action Plan, which outlines five key goals: raising awareness, strengthening research, preventing infections, optimizing antimicrobial use, and promoting sustainable investment in new treatments and interventions [14]. While

AMR is a global concern, our findings emphasize the importance of region-specific interventions tailored to local cultural and healthcare contexts. The results highlight the need to educate young adults, especially university students, about antibiotic resistance and the safe use of medicinal plants. Instead of claiming global implications, this study aims to provide foundational data for local public health strategies in Kurdistan and potentially similar neighboring regions. The primary manner for preventing antibiotic resistance is the prudent use of antibiotics, which can be accomplished by altering prescribers' behavior and level of understanding [15]. This aligns with previous findings that educational interventions significantly improve antibiotic prescribing and usage behavior [14], [16]. These findings directly align with the third objective of the WHO Global Action Plan on AMR: optimizing the use of antimicrobial medicines in human health. By assessing the current knowledge and practices among undergraduate students —future healthcare providers —our study identifies specific behavioral patterns, such as premature cessation of antibiotics and high reliance on non-prescribed medicinal plants. These insights highlight the urgent need for educational interventions and stewardship programs targeting young adults. Strengthening rational drug use through academic curricula and community awareness can contribute to better antimicrobial use, as encouraged by WHO. Moreover, the students' dissatisfaction with repeated antibiotic use (73.8%) reflects the need to diversify treatment approaches, including evidence-based herbal therapies under proper guidance, further supporting WHO's emphasis on integrating traditional medicine within regulated frameworks. Therefore, the present survey sought to examine the awareness and utilization of antibiotics and medicinal plants among undergraduate students in Sulaimani City, Iraq. Our discoveries carry significant implications for combating AMR by promoting the prudent use of antibiotics and enhancing them to use medicinal plants as a source of drugs instead of antimicrobial chemotherapy. The results may impact AMR prevention by educating and informing prescribers to enhance their understanding and behavior, ultimately improving public health.

In this study, most participants were from medical departments, which likely enhanced the reliability of responses regarding antibiotic use and AMR knowledge. However, the overrepresentation of medical students (64.8%) and females (69.1%) may have skewed the results toward greater awareness of antibiotics and antimicrobial resistance (AMR). Medical students typically receive more education on pharmacology and infectious disease control, which could artificially elevate the knowledge scores in our sample. Similarly, previous studies have found that female students tend to show more responsible health behaviors and better awareness in survey-based research. Therefore, the generalizability of our results to the wider student population—particularly non-medical and male students-may be limited. Our finding of 61.3% correct knowledge on antibiotics represents a moderate level of awareness. This is higher than results from Ethiopia, where knowledge levels were around 53% [27], and similar to studies in Lebanon (~60%) [21]. However, it remains lower than studies in Jordan, where awareness among medical students exceeded 70% [17]. This suggests that while students in our sample have some awareness of AMR, there is room for targeted education, especially among non-medical students.

Similar findings were reported in Jordan, where over half of participants showed good awareness of antibiotic resistance, influenced by age, education, and health literacy [17]. In Egypt, while some medical students demonstrated awareness, notable misconceptions and knowledge gaps were observed, especially among nursing students [18]. However, this concentration of medical students (64.8%) and female participants (69.1%) introduces potential sampling bias. This overrepresentation may have influenced the findings, particularly in areas related to health knowledge and attitudes toward antibiotics and medicinal plants. Medical students are more likely to be informed about antibiotic use and resistance due to their academic exposure. Similarly, gender-related factors may impact health behaviors and perceptions. As a result, the findings may not be fully generalizable to the broader student population in Kurdistan. This limitation should be addressed in future studies through more representative sampling. The sampling bias toward females and medical students may have led to overestimation of AMR knowledge, limiting the applicability of results to the broader undergraduate population.

Additionally, the relatively lower AMR awareness in our population compared to studies from Palestine and Ethiopia may be due to differences in participant education levels, sampling methods, or the reach of national AMR campaigns. Of course, plants have been used for centuries to treat infections and other illnesses in humans in aboriginal groups, but controlled clinical studies are scarce. In some cases, traditional healers working together with trained scientists have begun keeping records of the safety and effectiveness of phytochemical treatments. Recently, investigating plants as antimicrobial agents has been one of the common studies; day by day, scientists discover a good point about medicinal plants as antimicrobial agents [19]. Thus, regarding medicinal plants and their huge impact, a part of this study focused on using them as antimicrobial agent treatments and to reduce the AMR phenomenon. Although, it is possible that there could be mechanisms of herbal antimicrobial drug resistance just like AMR in microbes. Fortunately, according to the data in this study, most of the contributors (63.8%) used medicinal plants for less than or more than six months or even continuously. In contrast, most of the contributors (62.1%) used the antibiotic for less than six months or never. These figures are slightly more favorable compared to similar studies among students in Jordan and Lebanon [20], [21], suggesting an emerging trend of preference for herbal solutions in Iraq. However,

79.4% of respondents believed that irregular use of medicinal plants could reduce their effectiveness, indicating awareness of the risks associated with inconsistent use and the need for proper guidance and education in this area. Inappropriately, in this study, some of the contributors used antibiotics as a treatment without a known cause of infection for fever, headache, urinary tract infection, gingivitis, skin infection, and nasal and pharyngeal infection, as well as diarrhea and vomiting. These findings are in agreement with other research that revealed numerous misunderstandings about practices [22, 23]. On the other hand, [24] argues our finding that a lot of contributors use medicinal plants as co-therapeutics during most of the infection, especially 34.6% for nasal and pharyngeal infections.

Most of the respondents (96.7%) obtained the antibiotic drug primarily from a clinic, medical store, or pharmacy. This result is generally consistent with the findings of the previous studies, such as a survey conducted in Morocco [25]. On the other hand, due to the few academic staff in the field of medicinal plants and low quality of medical stores in this region, unfortunately, 67.2% of respondents mentioned that they gained medicinal plants only from herbal shops instead of clinics or pharmacies. A significant finding in this study is that 67.1% of students obtained medicinal plants from herbal shops, highlighting a strong cultural preference and reliance on traditional sources for health care. This pattern underscores the importance of cultural beliefs and accessibility in shaping treatment choices, especially in settings where formal healthcare access may be limited or where traditional knowledge remains influential. However, the unregulated nature of many herbal shops raises concerns regarding the quality, safety, and efficacy of the medicinal plants being used. These findings suggest the urgent need for health policies that ensure standardized training for herbal shop staff, quality control measures for plant-based products, and public education campaigns that bridge traditional and modern medical knowledge. This highlights the need for policy interventions to regulate over-the-counter (OTC) antibiotic sales and to improve the safety and quality of medicinal plant distribution.

Our survey showed that some of the contributors used a combination of antibiotics at the same time for a specific disease, which is one of the factors for increasing AMR problems. Furthermore, the data revealed that 61.8% of the respondents interrupted the antibiotics under the permission of doctors, pharmacists, and nurses; however, only a small number of them did not receive instructions on how to use and complete the entire course for antibiotics. In contrast, they are more likely to quit taking their antibiotics when feeling better. This situation eventually fuels the spread of resistance in the population, which is similar to that noted in Brunei Darussalam [19]. However, most of the medicinal plant users (45.8%) mentioned that they stopped the treatment without a doctor's or medicinal plant professional's recommendation when their symptoms disappeared and they felt better. To address this, integrating medicinal plant safety and efficacy education into healthcare and pharmacy curricula could help improve treatment outcomes and reduce misuse. The preference for herbal shops as the primary source of medicinal plants (67.1%) highlights an urgent policy consideration: regulating the distribution and quality of plant-based treatments. Authorities should consider developing certification programs for herbal vendors and incorporating traditional medicine frameworks into formal health systems to align cultural practices with safety and efficacy standards.

The current study parallels the study conducted in Saudi Arabia [26], suggesting that a large number of participants have heard about antibiotic resistance, while they have a high knowledge rate regarding herbal antimicrobial drug resistance. Moreover, we found that the majority of the students learned about antibiotics from their academic coursework. We did not observe the same patterns as those documented in the Ethiopian study, where participants learned from healthcare professionals [27] instead of TV, social media, herbal stores, and their education.

According to our research, the majority of the students (61.8%) think that people should take antibiotics for the recommended amount of time and length. Nonetheless, a considerable proportion of students (33.6%) ceased using the service when they recovered, which is consistent with earlier studies such as a study conducted in Palestine [28]. Further, in terms of medicinal plants, most of the students (45.8%) quit taking them after they get better; they also think that it should be used in a safe manner as agreed with a study conducted in Ethiopia [16]. Our results indicate most of the participants (86%) oppose using antibiotics prescribed for treating other patients; this is aligned with the research conducted in Singapore [29]. On the other hand, a comparatively smaller percentage of participants (26.8%) agreed to use medicinal plants recommended for treating other patients.

In agreement with prior research conducted by Alima, F., et al. [30], our results indicate that a significant percentage of students (73.8%) were unhappy about using the same antibiotics that they had previously used to treat their bacterial infections. Conversely, a significant proportion of participants (55.1%) expressed discontent with the same medicinal plants that they had previously used to treat their infections. In harmony with existing literature in a survey across 30 EU/EEA countries [31], students in Iraq believe that antibiotics are commonly utilized in agriculture. In the meantime, our research supports the widely held belief that farmers utilize a variety of medicinal plants in their agricultural practices [32]. There is a strong correlation between our study and an earlier review study carried out by Aghababa, A. A., et al., which suggests that antibiotic resistance is induced by bacteria [33]. Likewise, our findings reinforce the idea that improper hygiene in hospitals is among the important factors for spreading antibiotic resistance [34].

These students are aware that obstacles and challenges in surgical procedures can result from antibiotic resistance; furthermore, most of them understand that not all infections can be treated with antibiotics, and they view this as a challenge that impacts both themselves and their families, as this is collaborated with a conclusion reached by studies conducted in Cyprus [35] and Italy [36]. Consistent with previous research in the UK [31], our data indicates only 11% of students think that the spread of antibiotic resistance occurs between individuals; we differ from the finding of a previous study in Italy [37]. Unfortunately, 34.6% of students believe that antibiotic misuse is the only way antibiotic resistance develops, which is in concordance with the literature in Zambia and Gambia [38, 39]. In the same vein, 5.3% of students recognize that this is a problem that affects other countries rather than the Kurdistan region of Iraq; our research falls in line with the prevailing misunderstanding in Italy [36]. We concurred with the findings in the United Arab Emirates, where it was also observed that one reason why people do not experience the full benefits of medicinal plants is their irregular use [40]. Our findings clarify that students think that medicinal plants work more slowly than antibiotics, which was reported previously in India and Nepal [32]. Furthermore, a significant portion of them disagreed with the idea of treating their illness concurrently with both antibiotics and medicinal plants, which is consistent with Jordan's current body of knowledge [41]. This study used convenience sampling, which may introduce selection bias and limits the generalizability of the findings. Additionally, although the questionnaire was internally reviewed, the lack of pilot testing and formal reliability statistics such as Cronbach's alpha may affect the robustness of the results.

5. Conclusions

This study investigated the knowledge and utilization of antimicrobial drugs and medicinal plants among 301 undergraduate students in Sulaimani City, Iraq. Our findings revealed a high rate of correct knowledge regarding antibiotics (61.3%) and medicinal plants (73.5%), with both being predominantly used for respiratory tract infections and diseases. To enhance the impact of these findings, we propose actionable recommendations, such as targeted workshops for nonmedical students to improve their understanding of antimicrobial resistance (AMR) and the appropriate use of these substances. Collaborating with herbal shops could also promote safe practices regarding medicinal plants. Furthermore, we emphasize the need for longitudinal studies to track changes in knowledge and behavior post-education. These efforts are vital for combating AMR and promoting public health globally. Actionable recommendations based on this study include the integration of antimicrobial resistance education into undergraduate curricula, especially for non-medical students, to build foundational awareness. Additionally, public health campaigns—through universities, herbal shops, and digital platforms-should be launched to encourage safe, evidence-based use of antibiotics and medicinal plants. Collaborations between academic institutions and healthcare providers can further support behavior change and policy development. By addressing the knowledge and behavior of future prescribers, this study contributes directly to WHO's AMR action plan objective of optimizing antimicrobial use. Educational and policy reforms guided by these findings can support more responsible antimicrobial practices in Iraq and similar regions. These findings have the potential to inform targeted AMR awareness campaigns in Iraqi universities, particularly by highlighting current knowledge gaps and promoting responsible antibiotic and medicinal plant usage among future healthcare providers."

6. Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships.

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معرفة واستخدام المضادات الحيوية والنباتات الطبية بين طلاب البكالوريوس: وعيهم بمقاومتها في السليمانية، العراق

الخلفية: تُعدّ مقاومة مضادات الميكروبات مشكلة صحية عالمية حرجة تؤثر على ملايين البشر حول العالم. يُسهم سوء استخدام المضادات الحيوية والاعتماد المتزايد على العلاجات التقليدية، مثل النباتات الطبية، في تعقيد مقاومة مضادات الميكروبات، لا سيما في المناطق النامية. **الأهداف:** هدفت هذه الدراسة إلى تقييم معرفة واستخدام الأدوية المضادة للميكروبات والنباتات الطبية بين طلاب البكالوريوس في مدينة السليمانية، العراق. **المنهجية:** أُجريت دراسة كمية مقطعية بين فبراير ومارس 2023 باستخدام عينة عشوائية من 301 طالب من أربع مؤسسات: معهد كردستان التقني، وجامعة السليمانية التقنية، وجامعة التنمية البشرية، وجامعة السليمانية. حُلّلت البيانات باستخدام اختباري مربع كاي وكروسكال واليس. النتائج: بلغ معدل المعرفة الصحيحة 61.3% للمضادات الحيوية و73.5% للنباتات الطبية. استُخدمت المضادات الحيوية في المقام الأول لعلاج التهابات الأنف والبلعوم (ن = 161؛ 53.5%)، بينما استُخدمت النباتات الطبية بشكل شائع لنفس الحالات (ن = 104؛ 34.6%). أعربت غالبية الطلاب (ن = 222؛ 73.7%) عن عدم رضاهم عن الأدوية المستخدمة لعلاج الالتهابات البكتيرية المتكررة. **الاستنتاجات:** تؤكد النتائج على ضرورة تعزيز الاستخدام الرشيد للمضادات الحيوية والتطبيق الآمن للنباتات الطبية. قد تساعد المبادرات التعليمية التي تستهدف الأطباء والطلاب في الحد من مقاومة مضادات الميكروبات ودعم الصحة العامة. تشمل القيود تحيز العينة بسبب غلبة الإناث وطلاب الطب، مما قد يحد من إمكانية التعميم. ينبغي أن تهدف الدراسات المستقبلية إلى فئات سكانية أكثر تمثيلاً.

الكلمات المفتاحية: مقاومة المضادات الحيوية، النباتات الطبية، طلاب البكالوريوس، العلاج المشترك، المعرفة والاستخدام، الأمراض، العراق

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