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ANALYSIS OF PUBLIC KNOWLEDGE ON ANTIBIOTIC USE AND ANTIMICROBIAL RESISTANCE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract
Inappropriate and excessive use of antibiotics remains a major public health concern contributing to antimicrobial resistance worldwide. The aim of this study is to examine the public's knowledge of antibiotic use and antimicrobial resistance in the context of sustainable development, highlighting the importance of health literacy and the rational use of antibiotics in reducing the spread of antimicrobial resistance and ensuring the availability of effective treatments for future generations. A quantitative cross-sectional survey was conducted in January 2025 using an online questionnaire platform. The study included 433 adults aged 18 years and older. Descriptive statistics, cross-tabulation, and K-means cluster analysis were applied to evaluate respondents' knowledge and practices. The results demonstrated that although most respondents were familiar with antibiotics, misconceptions regarding their use persisted. Many participants reported storing leftover antibiotics for future use, and a considerable proportion incorrectly believed that antibiotics are effective against viral infections. The findings emphasize the importance of continuous public education and targeted health communication to promote rational antibiotic use and reduce antimicrobial resistance.

Keywords*: Antibiotics, Knowledge, Attitudes, Practices, Rational Use, Health Literacy.*
JEL Codes: *I12, I18, C38, D83.*

Introduction

Antimicrobial resistance (AMR) – when microbes develop resistance to drugs that previously worked against them – is a growing threat to public health. Although this trend is a natural part of biological evolution, it is greatly accelerated by the inappropriate and excessive use of antibiotics in human medicine, veterinary medicine, and agriculture. As a result, antibiotics, considered the most effective drugs for treating bacterial infections, are becoming less effective, and simple infections can lead to severe forms of disease or even death. According to WHO data, more than 1 in 6 bacterial infections worldwide are resistant to standard antibiotic therapy, and cases of resistance have increased by more than 40% since 2018. (World Health Organization) The problem is also serious in the European context, with around 35,000 deaths each year in the EU/EEA directly linked to antibiotic-resistant bacteria, which is equivalent to the number of deaths caused by other serious diseases such as tuberculosis, influenza, and HIV. (European Antibiotic Awareness Day) In addition, EU health policy institutions have identified AMR as one of the main threats to public health requiring coordinated prevention and control measures. (Public Health)

AMR is also a major concern in Lithuania. Statistics show that in 2019, more than 60% of hospitalized patients were treated with antibiotics, but about 30% of these treatments were considered inappropriate or unnecessary (SAM, 2020). In addition, a Eurobarometer survey (2016) revealed that more than a third of Lithuanian residents incorrectly believe that antibiotics are effective in treating cold or flu symptoms (Eurobarometer, 2016).

Insufficient awareness of AMR and inappropriate use of antibiotics are major problems contributing to the spread of resistance.

In Lithuania, as in many other countries, the level of public education on this issue remains limited. For example, a 2020 study by the Lithuanian Institute of Public Health showed that only 45% of respondents were aware of the threat of antibiotic resistance, and more than 20% were inclined to use antibiotics without consulting a doctor.

The aim of this study is to examine the public's knowledge of antibiotic use and antimicrobial resistance in the context of sustainable development, highlighting the importance of health literacy and the rational use of antibiotics in reducing the spread of antimicrobial resistance and ensuring the availability of effective treatments for future generations.

When researching this topic, it is important to recognize that antimicrobial resistance is not only a medical problem, but also a social, economic, and political threat, the management of which requires a comprehensive approach. Global efforts to combat AMR, including initiatives by the WHO and EU countries, have shown that raising awareness among the population is one of the key factors for success. Only through education and interdisciplinary cooperation can we expect to see significant changes in the fight against this global challenge.

Antimicrobial resistance (AMR) is increasingly recognized not only as a public health problem but also as a major obstacle to sustainable development, affecting healthcare systems, economic productivity, food security, and social well-being. Recent studies show that rising levels of AMR directly hinder the achievement of several United Nations Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), and also affect goals related to poverty reduction, environmental protection, and global partnerships (Aslam et al., 2024; Jasovský et al., 2016). Therefore, preserving the effectiveness of antibiotics should be viewed as a global public good that must be safeguarded for future generations by ensuring responsible antibiotic stewardship and their rational use. Furthermore, it is emphasized that sustainable AMR management requires coordinated action across the human health, animal health, agriculture, and environmental sectors (Ferdinand et al., 2023). Therefore, deepening public knowledge and promoting evidence-based antibiotic use are essential components of sustainable healthcare systems and long-term public resilience to antimicrobial resistance.

Knowledge and practice of antibiotic use in Lithuania

The study "Resistance to Antimicrobial Agents" conducted from February 21 to March 20, 2022, in all European Union member states (26,511 respondents in the EU, LT - 1,003 respondents) shows that the knowledge and behaviour of Lithuanian residents regarding the use of antibiotics is largely in line with the European Union (EU) average, although certain national characteristics have been identified. In Lithuania, 52% of respondents correctly stated that antibiotics are not effective against viral infections (EU – 50%), and 39% understood that antibiotics are ineffective in treating colds (EU – 40%). The problem of antibiotic resistance was correctly identified by 82% of Lithuanian residents (EU – 84%), while the possible side effects of frequently used antibiotics were identified by 67% of respondents (EU – 72%). Compared to 2018 data, there has been a moderate increase in knowledge in Lithuania, particularly in the area of antibiotic resistance (+2%) and awareness of possible side effects (+4%). When assessing consumption habits, 78% of Lithuanian respondents indicated that antibiotics should be taken for the entire course prescribed by the doctor (EU – 85%), but 19% of respondents said they would stop treatment once they felt better (EU – 13%). The most common reasons for taking antibiotics in Lithuania were to treat urinary tract infections (53%), throat infections (58%), and bronchitis (42%). However, only 42% of respondents indicated that diagnostic tests had been performed before taking antibiotics (EU – 46%).

Over the past 12 months, 34% of respondents in Lithuania received information on the responsible use of antibiotics, which is above the EU average (23%). The main sources of information were healthcare professionals: doctors (38%), pharmacies (35%) and hospitals (28%). The need expressed by respondents for more information on antibiotic resistance and

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proper use shows that public education in this area remains relevant.

In summary, it can be said that the knowledge of the Lithuanian population about the action, use, and resistance of antibiotics is close to the EU average, but practical usage habits, the use of diagnostic tests, and the use of information sources remain limited. This highlights the importance of targeted health education and consistent information provision.

Analysis of research results

Methodology and survey participants

According to data from the Lithuanian Population Register:

(https://www.registrucentras.lt/bylos/dokumentai/gr/20250101_Gyventoju_skaicius_savivaldybese.pdf) as of January 1, 2025, the population of Panevėžys City Municipality is distributed by age as follows: 59.6% of the city's residents are of working age and 40.4% are of retirement age. The distribution of Panevėžys residents is influenced by social and demographic trends such as emigration, declining birth rates, and an increase in the number of older people. The study reflects these changes indirectly, but focuses more on the analysis of the working-age population.

The study included 433 residents of a Lithuanian city, ranging in age from 18 to 65 and older. More than two-thirds of the study participants (72.7%) were in the 30–64 age group. This age group is naturally larger and easier to include in studies because they are more active and more likely to participate in social activities or surveys. Slightly less than a fifth belonged to the 18-29 age group (16.9%) and the 65+ age group (10.4%). As the survey was based on voluntary participation, younger and older respondents were less likely to participate for various reasons, including lack of time, lack of motivation, or health conditions, more difficult accessibility due to limited mobility, technological skills, or less involvement in surveys. Four-fifths of respondents (81.5%) were women, and one-fifth (18.5%) were men. This gender distribution of respondents reflects the fact that there are 1,234 women for every 1,000 men in Panevėžys. In Panevėžys, as in the rest of Lithuania, the number of women significantly exceeds the number of men. In addition, it is common in Lithuania for women to participate more often in various surveys and studies. This may be related to their greater interest in social, health, and other public issues, as well as their greater willingness to express their opinions. Men, on the other hand, tend to participate less in surveys, mostly due to less interest or lack of time. Since the study is based on voluntary participation, this gender imbalance is quite common. Women tend to respond more actively to invitations to participate in studies and devote their time to them, while men are more likely to ignore such invitations. As many as 50.1% of respondents have a higher education degree, and another 32.3% have a higher or vocational education, meaning that more than 80% of the study participants have a specialized education. This shows that the study involved a more educated segment of society, which may be more active in surveys.

Descriptive statistics of responses

The right answers were assigned 1 and wrong were assigned 0. This way we got the sum of right answers representing the konowledge about antibiotics and microorganisms of each respondent . From the histogram (Fig. 1) it is seen that the most often level of knowledge of the majority of respondents about antibiotics and microorganisms ranges from 20 to 30 points, while the maximum number of points equals to 44.

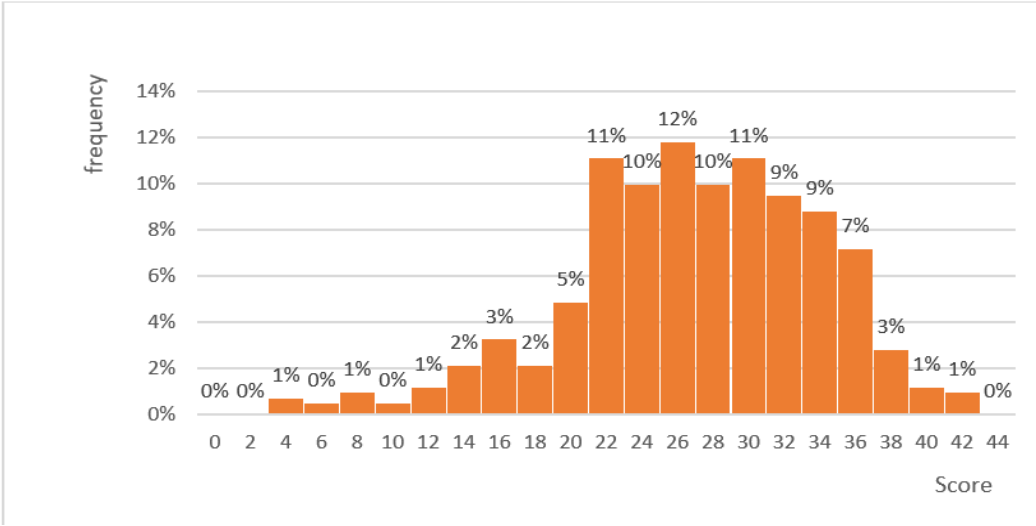

Figure 1. Distribution of respondent number by their knowledge about microorganisms

The correlations analysis revealed that there are no connections between knowledge score, age and education level. The given choises to the question *Where do you put leftover antibiotics* were I take them to the pharmacy, I keep them for next time, I offer them to a sick relative or acquaintance and Other were represented as word cloud. The word cloud revealed (Fig.2) that the most often given answers were *I take them to the pharmacy* (158 responses from total 433) which was the most correct answer, and *I keep them for the next time* (203 responses).

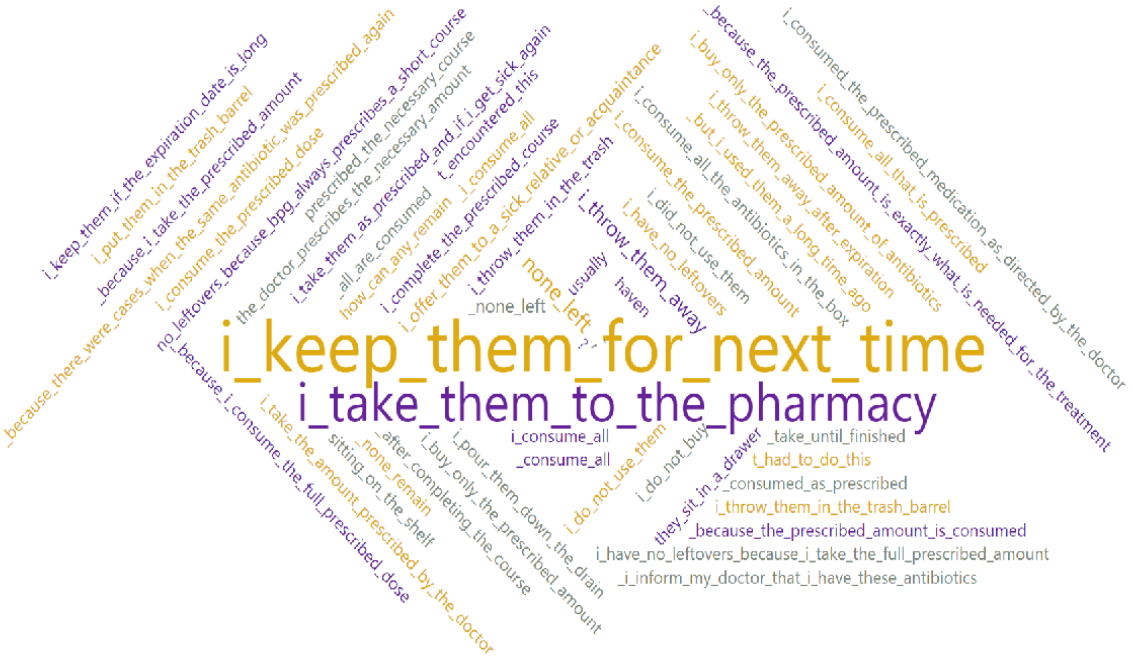

Figure 2. Word cloud of answers to the question Where do you put leftover antibiotics

This result raises question, do those who keep spare antibiotics have worse knowledge about antibiotics or they just do this for economic reasons and next time takes the reserves only then they are prescribed. To address this question the knowledge scores distributions of these two groups were compared (Fig 3a. and Fig.3b.).

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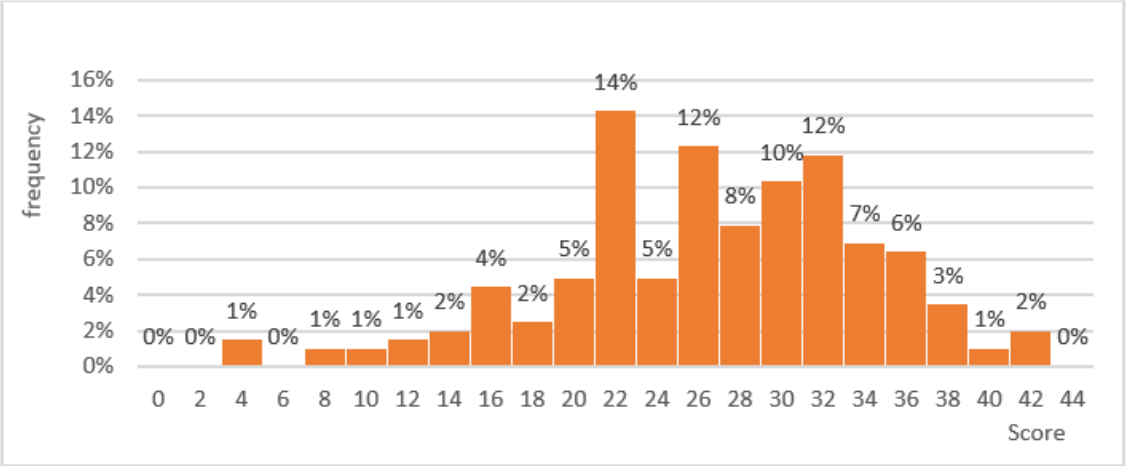

Figure 3A. The knowledge scores distribution of respondents who and keep them for the next time

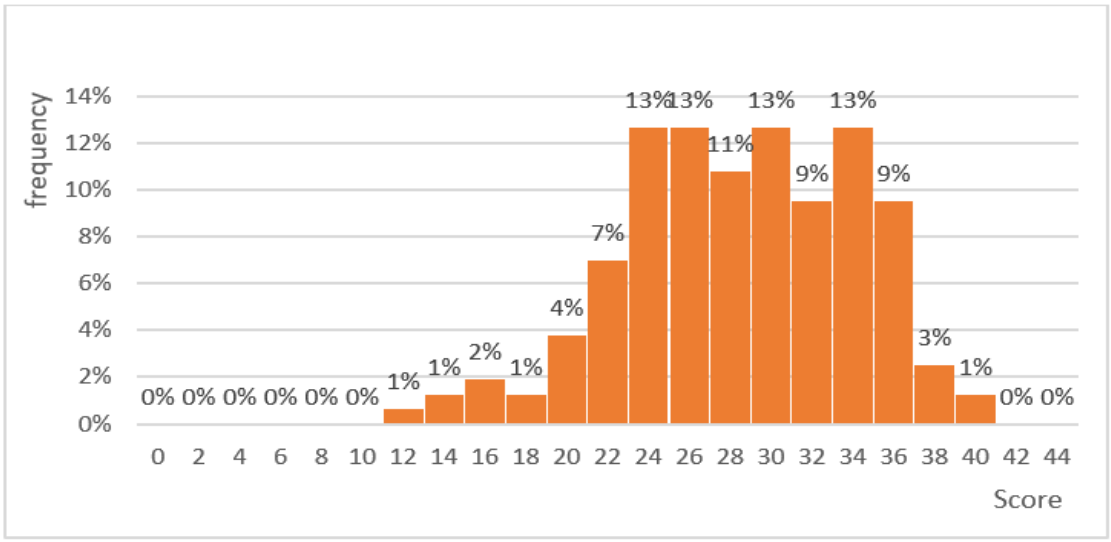

Figure 3B. The knowledge scores distribution of respondents who take leftover antibiotics to the pharmacy

It is seen that small part those who keep antibiotics for the next time have gained very low points, less than 10 points, meanwhile, those who take leftover medication to the pharmacy received at least 12 points. Furthermore, the correct response frequencies of respondents who stockpile antibiotics are more dispersed.

Also, it is important to find out, whether those who kept antibiotics for the next time later used them according to a doctor's prescription or without prescription. The cross tabulation (Table 1) revealed that 65 percent of those who had reserves used them only according to doctor recommendation, while 72 percent in the group who took drugs to pharmacy, use antibiotics according doctor prescription. Thus, the behavior of these groups differs but not significantly. Only 10% and 5% respectively of these groups used antibiotics without doctor's advice.

Table 1. Who prescribed or recommended vs Where do you put leftover

Who prescribed or recommended	Where do you put leftover	
	I keep them for next time	I take them to the pharmacy
Did not use	50 (25%)	36 (23%)
Doctor	132 (65%)	114 (72%)
Other	21 (10%)	8 (5%)
Total	203	158

Study of respondents' answers using the K-means clustering method

Despite the results presented above, descriptive statistics may not provide all the features about respondents. To have a deeper insight into the structure of the respondents' knowledge we applied cluster analysis by K-means method using Orange data mining software.

The K-means algorithm splits records containing counts of right answers into groups, called clusters. Each cluster is represented by a record which consists of average right answers of those respondents, who are assigned to this cluster (Witten, 2011). The record representing of a group is called centroid or prototype.

Then to measure the compatibility of records with the assigned cluster a Silhouette scores were used.

The silhouette value is a measure of how similar a record is to its centroid compared to other clusters. The silhouette value ranges from −1 to +1, where a high value indicates that the object is well matched to its own cluster and poorly matched to neighbouring clusters. A clustering with an average silhouette value of over 0.7 is considered to be strong, while values starting from 0.5 are reasonable.

We used Orange data mining software to find clusters. It turned out that the reasonable silhouette values are achieved when respondents are divided into two clusters – C1, consisting of 234 respondents, and C2, consisting of 199 respondents (Table 2).

All records of both clusters have silhouette values 0.5 and higher.

Table2. Cluster centroids

Questions and max points	c1	c2
4. Infectious disease agents (max=10)	6.9	5.4
5. Knowledge about microorganisms (max=1)	0.9	0.7
6. Resistance of microorganisms (max=1)	0.6	0.4
7. How can humans become infected (max=6)	3.9	2.2
8. Antimicrobial-resistant infection factors (max=10)	2.7	1.5
9.Where resistant substances are found (max=11)	3.8	1.0
10. Is it possible to contract infection (max=1)	0.5	0.3
11. Risks to get infected with drug-resistant microbes (max=7)	5.6	3.7
16. When to stop taking antibiotics (max=1)	0.9	0.9
17. Where do you put leftover antibiotics (max=1	0.4	0.3

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The Table 2 shows that the all elements of the centroid C1 is higher than corresponding elements of the centroid C2. Thus the cluster C1 consists of respondents whose average knowledge in all areas about antibiotics and microorganisms are higher than in the other cluster C2.

The largest difference of these average values between centroids is achieved on question 7. *How can humans become infected* 65 and 37 percent respectively from the maximum number of correct answers, 9. *Where resistant substances are found* 35 and 9 37 percent respectively from the maximum number of correct answers and 11. *Risks to get infected with drug-resistant microbes* 80 and 53 percent respectively from the maximum number of correct answers.

Conclusions

1. The most often level of knowledge of the majority of respondents about antibiotics and microorganisms ranges from 20 to 30 points, while the maximum number of points equals to 44. The correlations analysis revealed that there are no connections between knowledge score, age and education level.

2. The analysis of categorical answers to the question *Where do you put leftover antibiotics* revealed that the most frequent answers were *I take them to the pharmacy* (158 responses from total 433) and *I keep them for the next time* (203 responses). The majority, 72 percent, of those respondents, who kept reserves of antibiotics used them later according to doctor recommendation.

3. After dividing the respondents into two clusters, it turned out that in the first cluster, the average knowledge of respondents of the first group in all areas about antibiotics and microorganisms is higher than in the second group.

4. The knowledge of Lithuanian residents about the effects of antibiotics and antibiotic resistance is close to the European Union average and has been improving over the past few years, However, this knowledge is not sufficiently reflected in practical antibiotic use habits, especially in terms of adherence to treatment courses and the use of diagnostic tests, so it is necessary to strengthen continuous and targeted public health education.

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