Knowledge and Habits Towards Antibiotic Use and Resistance of Public University Students in Nisava Region – Southern Serbia

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Abstract

Antibiotic resistance has become a serious threat to global health. This study aimed to assess knowledge and habits surrounding the use of antibiotics and antibiotic resistance of university students residing in urban areas compared to those in rural areas of Nisava region, Serbia. Data was gathered using an online survey and tested for statistical differences using the Chi-squared test. A total of 380 students participated with a response rate of 94.7 per cent. Of this, 84.4 per cent of students correctly identified antibiotics as being effective against bacteria and distinguished well between antibiotics and other types of medicines. However, 31.4 per cent believe that antibiotics help with most diseases, not just bacteria-related illnesses. While only 12.5 per cent said they believed that therapy can be interrupted when the symptoms fade, a total of 45.8% admitted to premature treatment interruption. As many as 59.7 per cent reported having bought antibiotics without a prescription, and a significant portion of 62.5 per cent reported having taken antibiotics for travel emergencies. There was no statistically significant difference related to the domicile of the students (p>0.05). Students demonstrated relatively acceptable knowledge on antibiotics use and antibacterial resistance – which is not reflected in their practice of using antibiotics. Campaigns are needed to promote awareness on antibiotic resistance as students' habits are not satisfactory.

Keywords: Antibiotics usage habits, antibiotic resistance awareness, Serbia, students, public health

Introduction

Paul Ehrlich, Nobel prize laureate in medicine in 1908, famously called antibiotics *magic bullets*: a completely safe medicine directly specific for the target (Valent *et al.,* 2016: 118). Throughout the Second World War, antibiotics were advertised as able to cure any disease, and the *British Medical Journal* stated that 'penicillin is to other antiseptics what radium is to other metals' (Shama, 2015: 132). Such beliefs have led to inappropriate usage of antibiotics in recent decades. Inappropriate use practices include self-medication, missed purpose, short duration of treatment, inadequate dose, or stopping prematurely upon improvement of disease symptoms (Ocan *et al.,* 2015). The percentage of self-medicating patients in Europe has grown in the past years from 5 per cent in 2009 to 7 per cent in 2016 (Lescure *et al.,* 2018), ranging from 3 per cent in Northern Europe (Horvat *et al.,* 2018) to the largest rates in countries of South-Eastern Europe. This includes 28 per cent in Slovenia and 20.5 per cent in Croatia, neighbouring countries to Serbia where this study was conducted (Grigoryan *et al.,* 2010).

Literature data cites that the public unawareness level regarding the ineffectiveness of antibiotics in viral diseases was as high as 57 per cent (Machowska and Lundborg, 2018: 27). Extensive use of antibiotics has been reported in cases of upper respiratory tract infections, despite that these infections are mostly viral in origin (Ochoa *et al.,* 2000). In general, antibiotics cannot be used to treat viral infections as viruses feature no molecular targets attacked by antibiotics (Dworkin, 2003). Non-adherence to dosing regimens is also common, either prolonging the course or ending it prematurely as soon as the symptoms fade. The latter is especially dangerous as it may leave some more resistant pathogens behind that reintroduce the illness.

Antibacterial resistance: a global danger

Antibacterial resistance (ABR) is an ability of bacteria to develop resistance towards the drug employed (Aslam *et al.,* 2018: 1645–46). It occurs when bacteria change in response to usage of antibiotics. While it does occur naturally, the highly increasing rate of ABR is linked to inappropriate usage of antibiotics (World Health Organization, 2020).

The bacterial population, and not the organism in which they reside, develops resistance over generations, with the fittest bacteria surviving. (Brookes-Howell *et al.,* 2012). First

cases were reported soon after the discovery of **penicillin** (Lee Ventola, 2015). Antibiotic resistance leads to higher medical costs, prolonged hospital stays and increased mortality (World Health Organization, 2020). An estimated 25,000 deaths in Europe and 23,000 in USA per year are linked to antibiotic-resistant bacteria (Laxminarayan *et al.,* 2013: 1060).

One typically identifies four mechanisms that bacteria employ to protect themselves from antibiotics (Hawkey, 1998): (i) The resistant bacteria may prevent the antibiotic from reaching the sensitive target on the bacterium, or (ii) the sensitive target may be altered, preventing the antibiotic from inhibiting bacterial activity due to structural changes in the molecule. (iii) Bacteria may also produce an alternative target that is resistant to inhibition by the antibiotic, therefore protecting the initial sensitive site. Finally, (iv) the antibiotic may be prevented from entering the cell or pumped out of the cell at a rate faster than the one at which it enters the cell. Lowering the effect of antibiotics means that the disease becomes more dangerous and more difficult to cure, representing great danger to public health (Pechère *et al.,* 2007, Fair and Tor, 2014).

Need for a new study

Inappropriate use of antibiotics, ultimately leading to ABR, is a problem in the broader region of the Balkans and South-Eastern Europe, including very high consumption rates reported in Romania, Greece, Montenegro and Turkey (World Health Organization, 2018: 28). Antibiotic consumption in Serbia was among the highest in Europe in 2015 (World Health Organization, 2018). A nationwide campaign in 2016 managed to reduce it, but still keeping it much higher than the European average (World Bank, 2018). Also, past studies have reported erroneous practices in Serbia. Serbian households often keep antibiotics in home pharmacies (Paut Kusturica *et al.,* 2015: 115) and over-prescription by physicians has occurred even after the completion of the campaign, notably in cases of acute bronchitis (Petrovic *et al.,* 2019: 687). In addition, Serbia is among few European countries not participating in ESAC-Net (European Surveillance of Antimicrobial Consumption Network) (Horvat *et al.,* 2018). This indicates a link between high antibiotic consumption and erroneous attitudes of the public, showing that further investigation of attitudes of the public is needed.

Aforementioned dangers of inappropriate use and the unfavourable situation in Serbia have motivated this study, whose primary goal was to investigate students' knowledge and habits regarding antibiotic usage and ABR in a public university in the Nisava region of Southern Serbia and compare them to available data from the immediate region and from other developing countries. A secondary goal was to inspect differences between answers of students coming from rural areas and those from urban regions, as different socio-economic statuses and different beliefs of communities more inclined to traditional medicine and curing methods have shown to influence the attitudes of patients towards drug use (Akici *et al.,* 2017; Peng *et al.,* 2018).

Based on previous studies, healthcare and socio-economic differences (Primary Healthcare Centre Nis, 2020)**,** we expected that our sample would demonstrate doubts regarding knowledge, as well as erroneous usage and self-medication, with less appropriate attitudes present in the rural region.

It is important to assess the knowledge on the subject among the population of university students, whose opinion will become that of the most educated population of the country. This way, gaps in their knowledge can be identified, and antibiotic stewardship campaigns can be planned to contribute to the action of stopping antibiotic resistance. Such campaigns were successfully conducted in many countries, such as France, where knowledge improved from 2002 to 2007 (Sabuncu *et al.,* 2009).

Past studies in Serbia mostly concentrated on habits of antibiotics usage in hospitals in other regions of the country and were written from a clinician's point of view. There is currently a paucity of data addressing public's attitudes. Therefore, this study on the knowledge and habits towards antibiotic use and resistance of public university students in Southern Serbia provides novel information and contributes to the global knowledge on the subject.

Materials and methods

This study concentrated on students at Nis University, the only university centre in the region. It has 20,455 undergraduate students (Janković, 2017). The sample size of 378 was calculated using *Raosoft* calculator, with a confidence interval of 95 per cent and a margin of error of 5 per cent.

We used a stratified sample, aiming to roughly equalise the number of students coming from urban and rural areas for direct comparison. The students included were undergraduates – excluding students of medicine and pharmacology from the Faculty of Medicine – as well as students of biology and chemistry from the Faculty of Natural Sciences. This was to avoid potential response bias as the above-mentioned courses were linked to the current topic.

This research was exempt from ethical committee evaluation as it only acquired opinions of the surveyed parties. Prior to completing the survey, all participants gave personal informed consent about processing of personal information and data use for the purpose of the research. There was no compensation nor reward offered to the participants.

Questions were designed in compliance with previous successful studies from Saudi Arabia (Zaidi *et al.,* 2020), Italy (Napolitano *et al.,*2013), China (Zhu *et al.,* 2016) and South Sudan (Sa'adatu Sunusi *et al.,* 2019). The questions were altered to include commercial names of the drugs used in Serbia (such as paracetamol). The questionnaire had 16 questions in Serbian language and was available online and in paper format. The questions are given in Table 1.

Subsequently, the results have been quantified and represented in percentile. The data was analysed on the level of whole group, as well as on the two groups of students coming from the surrounding rural area belonging to the Nisava region (Group A) and from the urban territory of city of Nis where university is located (Group B). For statistical difference, the common χ^2-test for independence (Chi-squared test) was used, where value $p<0.05$ was considered significant.

	Question	Answers
KNOWLEDGE		
1.	Antibiotics are effectively used against (more responses possible):	***bacteria**, viruses, fungus*
2.	Mark the drugs that are antibiotics (more responses possible):	*Paracetamol* (acetaminophen) Brufen* (ibuprofen) Probiotic Sinacillin* (Amoxicillin) Bromazepam **Penicillin***
KNOWLEDGE		

3.	Antibiotics need not be taken in regular intervals, if the daily dosage is respected.	Yes/**No**
4.	Antibiotics help with all types of cough, throat pain and common cold.	Yes/**No**
5.	Antibiotics can be kept for further usage, if the illness reappears.	Yes/**No**
6.	Antibiotics can help with most diseases.	Yes/**No**
7.	Taking antibiotics preventively can immunise us against the common flu.	Yes/**No**
8.	Therapy may be interrupted when the symptoms fade out.	Yes/**No**

HABITS

1.	Have you ever acquired antibiotics with no prescription?	Yes/**No**
2.	Have you ever acquired antibiotics preventively?	Yes/**No**
3.	Would you consume alcohol during your therapy with antibiotics?	Yes/**No**
4.	Do you carry an antibiotic when you travel, if someone falls ill?	Yes/**No**
5.	Have you ever interrupted your regime before the time prescribed?	Yes/**No**
6.	Do you always inspect the instruction manual and check the expiry date prior to taking an antibiotic?	**Yes**/No

Question		**Answers**

KNOWLEDGE

7.	Have you ever skipped a dose	Yes/**No**

that you went on to make up for?

8.	If you take antibiotics on your own, the main reasons you do it for are: (multiple responses allowed)	I keep some at home I have studied about antibiotics, so I am informed Someone from my household works in healthcare It is hard to reach a doctor I had a good experience with that antibiotic

Table 1: List of questions and correct (rational) answers. An asterisk (*) denotes a commercial name used in Serbia. Correct (rational) answers are given in **bold**.

Results and discussion

From a total of 380 questionnaires in compilation, 360 were fully answered, giving a response rate of 94.7 per cent. Out of these, 194 (53.9 per cent) were sorted into Group A, rural (students from the surrounding region), and 166 (46.1 per cent) into Group B, urban (students from the university centre). The mean age of the students was 20.3 years, ranging from 18 to 29 years. No statistically significant difference related to the domicile of students was found (p>0.05).

Results have been compared against studies that assessed literacy on antibiotics in Serbia, in the immediate region and in other developing countries. Another criterion for comparison was Defined Daily Dose (DDD) per thousand inhabitants, defined by the WHO as the assumed average maintenance dose per day for a drug used for its main indication in adults (World Health Organization, 2017). DDD for Europe ranges between 7.66 in Azerbaijan to 38.18 in Turkey. In Serbia, DDD was 31.57, indicating a very high rate of antibiotics usage. DDD was similarly high in Romania, Greece, Italy, Turkey, Sudan and Montenegro (World Health Organization, 2018: 26–28), and, by some reports, China (Qu *et al.,* 2018). Such comparisons show possible differences in habits regarding consumption of antibiotics in these countries.

Knowledge

We aimed to evaluate whether the students are familiar with basic purposes of treatment with antibiotics, such as their ineffectiveness against viruses, as well as the importance of adherence to dosing regimen. We also wanted to examine whether they are capable of

distinguishing antibiotics from other medicines, as several studies conducted on students have shown that antibiotics are commonly substituted for Non-Steroid Anti-Inflammatory Drugs (NSAIDs), which can be obtained without a prescription. Students' responses to questions on knowledge are summarised in Table 2.

	Question		Answers	
	KNOWLEDGE		Yes	No
1	Antibiotics are effectively used against (more responses possible):	Bacteria	304 (84.4%)	56 (15.6%)
		Viruses	86 (23.9%)	274 (76.1%)
		Fungi	40 (11.1%)	320 (88.9%)
2	Mark the drugs that are antibiotics (more responses possible):	Ibuprofen	39 (10.8%)	321 (89.2%)
		Paracetamol	84 (23.3%)	276 (76.7%)
		Probiotic	27 (7.5%)	333 (92.5%)
		Amoxicillin	296 (82.2%)	64 (17.8%)
		Bromazepam	10 (2.8%)	350 (97.2%)
		Penicillin	299 (83.1%)	61 (16.9%)
3	Antibiotics need not be taken in regular intervals, if the daily dosage is respected.		49 (13.6%)	311 (86.4%)
4	Antibiotics help with all types of flu, cough, throat pain, and common cold.		63 (17.5%)	297 (82.5%)
	Question		Answers	
	KNOWLEDGE		Yes	No
5	Antibiotics can be kept for further usage, if the illness reappears.		119 (33.1%)	241 (66.9%)

6	Antibiotics can help with most diseases.	113 (31.4%)	247 (68.6%)
7	Taking antibiotics preventively can immunise us against the common flu.	28 (7.8%)	332 (92.2%)
8	Therapy may be interrupted when the symptoms fade out.	45 (12.5%)	315 (87.5%)

Table 2: Answers to questions on knowledge

The study has shown that students are aware of key points about antibiotics, such as that antibiotics are primarily effective against bacteria. The largest percentage has correctly identified bacteria as the main pathogen treated with antibiotics (84.4 per cent), although with a smaller per cent than students in Nepal (98.2 per cent) (Shrestha, 2019: 76), but larger than in South Jordan (67.2 per cent) (Nawafleh *et al.,* 2017). Nevertheless, as 23.9 per cent identified that antibiotics could kill viruses too, there is room for improvement.

Based on studies conducted in other developing countries, we expected that students would have major doubts when identifying drugs as antibiotics or NSAIDs. However, the result has proven to be largely satisfactory, with largest percentages correctly identifying *Amoxicillin* (82.2 per cent) and *Penicillin* (83.1 per cent) as being antibiotics. This can be explained with available data, as a study conducted in a Serbian hospital catering for approximately 70,000 inhabitants reports penicillin drugs as the most prescribed group of antibiotics. Amoxicillin was the most frequently prescribed individual antibiotic in Serbia in 2017 (Tomic Smiljanic *et al.,* 2017: 245), as well as in Montenegro and Greece (Sahman-Zaimovic *et al.,* 2017: 46; Maltezou *et al.,* 2017: 109).

Significantly lower numbers identified NSAIDs as antibiotics, showing that the students are largely acquainted with the most pertinent examples. Students from Serbia identified *Paracetamol* correctly in 76.7 per cent of cases, whereas studies from Saudi Arabia (Zaidi *et al.,* 2020: 5) have reported large percentages of students mistaking paracetamol for an antibiotic. Therefore, the surveyed students from Serbia can be considered to be aware of the most common examples of antibiotics and can distinguish them well from other commonly used drugs.

A third of surveyed students (33.1 per cent) stated antibiotics may be kept for future use; similarly, a study in neighbouring Croatia conducted on students of health sciences reported that as many as 46 per cent of students and their families kept antibiotics for future use (Aljinovic-Vucic *et al.,* 2005: 76). Only a small percentage (17.5 per cent) believed that antibiotics are effective against all types of flu, common cold and cough, indicating that most students are aware that viral flu cannot be treated with antibiotics. This number is much better than the ones reported by studies from China (at 40.5 per cent) (Zhu *et al.,* 2016: 81) and Turkey (83.1 per cent) (Buke *et al.,* 2005: 135) – a country with a similarly high DDD (38.18 vs. 31.57 in 2015) (World Health Organization, 2018: 45). Most importantly, this number is significantly lower than 58.4 per cent reported by a Serbian study conducted in 2017 on general population (Horvat *et al.,* 2017), showing that the surveyed students have a better idea of what antibiotics should be used for.

Most students studied understand that antibiotics cannot be taken preventively (92.2 per cent) and that it is essential to complete the treatment in its entirety (87.5 per cent). Such numbers have been common in many studies on university students (Kanneppady *et al.,* 2019) and on the general population in Europe, like in Italy (Napolitano *et al.,* 2013). Based on these answers only, it would seem that the students are aware of antibiotic resistance and that they consider that treatment should not be interrupted as soon as signs of relief are shown, as more resistant pathogens may survive and reintroduce the illness. This is, however, not reflected in other answers. Almost a third stated that antibiotics help with most diseases (31.4 per cent). This is quite the opposite of what we wanted to see, as many studies on causes of antibiotic resistance have stated overuse and misconceptions on healing power of antibiotics to be one of the principal causes of resistance development (Machowska and Lundborg, 2018).

The impression is that students from the Serbian sample have a slightly better level of knowledge on antibiotics compared to similar studies from the immediate region, as well as from other developing countries throughout the world. Such results can be partially attributed to the high-school biology curriculum, elaborated in *Rural vs. urban* section below. Still, some questions have yielded conflicting results, indicating possible confusion.

Habits

This section aimed to assess if the students adhere to the principles of rational usage and whether they put the knowledge they have into practice. The questions also aimed to discover whether self-medication was common as in past studies (Horvat *et al.,* 2017; Grigoryan *et al.,* 2010). The answers are summarised in Table 3.

	HABITS	Yes	No
1.	Have you ever acquired antibiotics with no prescription?	215 (59.7%)	145 (40.3%)
2.	Have you ever acquired antibiotics preventively?	17 (4.7%)	343 (95.3%)
3.	Would you consume alcohol during your therapy with antibiotics?	69 (19.2%)	291 (80.8%)
4.	Do you carry an antibiotic when you travel, in case someone falls ill?	225 (62.5%)	135 (37.5%)
5.	Have you ever interrupted your regime before the time prescribed?	165 (45.8%)	195 (54.2%)
6.	Do you always inspect the instruction manual and check the expiry date prior to taking an antibiotic?	261 (72.5%)	99 (27.5%)
7.	Have you ever skipped a dose that you went on to make up for?	120 (33.3%)	240 (66.7%)
			Agree
8.	If you take antibiotics on your own, the main reasons you do it for are: (multiple responses allowed)	I keep some at home	92 (25.6%)
		I have studied about antibiotics, so I am informed	59 (16.4%)
		Someone from my household works in healthcare	88 (24.4%)
		It is hard to reach a doctor	25 (6.9%)
		I had a good experience with that antibiotic	67 (18.6%)

Table 3: Answers to questions on habits

We expected that the section on students' habits would show erroneous usage and self-medication, with less appropriate attitudes present in the rural region. As expected, this section yielded less acceptable results. Ironically, it seems that students' knowledge is not well reflected in practice.

As many as 59.7 per cent of students admitted to acquiring antibiotics without a prescription, which is higher than reported by comparable studies in both Serbia and abroad. The only Serbian study on general public stated that 47.2 per cent of interviewees has admitted to self-medication (Horvat *et al.,* 2017), and in neighbouring Croatia, this number was even lower (37 per cent in 2001, and 41 per cent in 1977) (Aljinovic-Vucic *et al.,* 2005: 76). This shows that, as expected, self-medication with antibiotics is common among surveyed students. Even after introducing stricter regulations in 2011, which forbid selling antibiotics over the counter, antibiotics have been available for purchase without prescription (Tomas *et al.,* 2018). Poor management of private pharmacies and their great autonomy from the Ministry of Health has made it difficult to assess what the most prescribed antibiotics in Serbia truly are and what the rate of purchasing them with no prescription is (Horvat *et al.,* 2018). Our results support the general public opinion that antibiotics may be obtained over the counter easily in Serbia due to inadequate management of pharmacies. One somewhat plausible result regarding acquisition of antibiotics by surveyed students from Serbia is that seldom have they done so preventively (4.7 per cent).

Despite their sound thinking on length of the treatment demonstrated in the *Knowledge* section (Q. 3), 45.8 per cent of students admitted to having prematurely finished their course of antibiotics. This directly contradicts with the rational belief demonstrated in answers to other questions about premature treatment interruption, where 87.5 per cent disagreed that treatment may be interrupted early. Therefore, there is no clear picture on how well the students are acquainted with the severity of antibiotic resistance, illness progression and infection management. While they might be aware of it in theory, their practices do not reflect the knowledge.

Some studies in countries with a similar DDD have reported common premature interruption of treatment (Ghana, Sudan) (Donkor *et al.,* 2012; Sa'adatu Sunusi *et al.,* 2019). In Serbia, 33.3 per cent of surveyed students have reported making up for missed doses, and as many as 62.5 per cent carry antibiotics with them for any emergencies when travelling. According to media reports, these are common practices in Serbia

(Radivojevic, 2019). It is therefore evident that students frequently alter their dosages and do not adhere to their regimens. However, these numbers are better than ones reported in a large study in China, where 70.8 per cent reported interruption of the treatment after first signs of relief (Zhu *et al.,* 2016: 81). In another Chinese study, 55.6 per cent reported taking doses irregularly (Pan *et al.,* 2012).

On the positive side, a large portion of surveyed students would not use alcohol during antibiotic treatment (80.8 per cent). Past studies on Serbian students' attitudes towards alcohol demonstrated that drinking alcohol was a common practice (Kilibarda *et al.,* 2013). In any case, in order to avoid errors that could occur when students who do not drink would answer 'No' as an answer to this question, the statement was given in a hypothetical form. The large percentage of students not taking alcohol during therapy could demonstrate their awareness of reactions of alcohol with some antibiotics and the overall effect of fatigue that alcohol has, as discussed in many official online guides regarding alcohol usage during treatments (Steckelberg, 2018). In our study, we reported a better percentage than the one reported in Tamil Nadu, India (61.4 per cent) (Arul Prakasam *et al.,* 2011). Another satisfactory result is that 72.5 per cent of students stated they always read the instructions and checked the expiry date before usage, which is an important habit in handling any medicine. A similar number (70.8 per cent) was reported in China (Zhu *et al.,* 2016: 81).

The most frequently chosen motive for taking antibiotics without a prescription was keeping leftovers at home (25.6 per cent), in line with the answer that they end their treatments prematurely. Our result is lower than those reported by some older studies in Serbia (46.5 per cent) (Paut Kusturica *et al.,* 2015), possibly indicating a positive outcome of the 2015–16 campaign. Also, this number is significantly lower than the one reported in a similar Chinese study, where 63 per cent of those studied kept antibiotics at home (Peng *et al.,* 2018), but very similar to a study on the general public from neighbouring Romania, a country with a similarly high DDD (31.57 vs. 28.5 in 2015) (World Health Organization, 2018: 28). This study reported 22.9 per cent of respondents using their leftovers from last treatments (Voidazan *et al.,* 2019: 3385), indicating similar habits across the Balkans.

The second most chosen reason is having a medical professional in the household (24.4 per cent). Similar percentages of students trust their experience (18.6 per cent) and knowledge (16.4 per cent). The answers to this question confirm that students tend to

trust their acquaintances, experience and knowledge acquired through high-school education, and indicate that they might consider that some diseases are not worth visiting their doctor about. This reinforces the statement that the opinions of close acquaintances have a high impact on consumer's attitude towards the drug (Akici *et al.,* 2017).

Rural vs. urban: no statistically significant difference

A secondary objective of this study was to inspect differences in answers between students who live in an urban area and those who come from less developed (rural) regions. The *urban area* was defined as the immediate area of the City of Nis, which is the largest urban centre in the studied region and the third-largest city in the country, featuring a large clinical centre, a large primary healthcare centre and 13 municipality-specific primary healthcare centres (Primary Healthcare Centre Nis, 2020). The *less developed – rural area* included the surrounding villages and settlements in Nisava region, which includes a significantly lower number of pharmacies, 12 primary healthcare centres and 27 ambulances with highly irregular working hours dispersed over 163,244 people, according to the 2011 census (Vukmirovic, 2015a: 464; Primary Healthcare Centre Nis, 2020)**.** Students from the urban area benefit from a larger mean parental salary (Statistical Office of the Republic of Serbia, 2020), higher rate of employment in tertiary sector of economy and a higher number of inhabitants with high school or higher education (Vukmirovic, 2015b: 88–89). As such, we expected that urban-area students would score better than their counterparts from the rural region.

However, there was no statistical difference found between the two groups from Nisava region. This shows that awareness of the surveyed students is the same across the region where the university is located, which can be partially attributed to a high-school education system that equally covers antibiotics in most study courses. The official textbooks for biology that were being used at the time when the survey was conducted address the topic equally in the two main study courses available in Serbia. These include the language-humanities study course and the mathematics-natural sciences study course. The chapter on bacteria and viruses describes different types of bacteria, along with most common illnesses they provoke. It outlines the main guidelines of usage of antibiotics and briefly describes antibiotic resistance. While the part on rational usage of the drugs is not very extensive nor puts much emphasis on the global threats of ABR, it

could provide students with some basic knowledge, regardless of places where their high schools were located. This also explains the relatively acceptable results obtained in the section on knowledge.

Additionally, a national campaign conducted in Serbia in 2015–16 managed to bring down the DDD per thousand inhabitants from 36.5 to 30.03 (World Bank, 2018). Despite the age of these students, the campaign could have altered the perception of usage of antibiotics and affected students' attitudes as well. These were the only sources of knowledge we identified that could have influenced these results, as there were no records of newer campaigns addressing antibiotic resistance and consumption.

Limitations and further research

One of the main limitations we encountered was the lack of data on current public health attitudes and practices in Serbia, including data on usage of antibiotics, incidence of infections, as well as availability of antibiotics and any public health strategies or campaigns being implemented. This is due to the scarce treatment of this subject in Serbia and poor pharmaceutical management. The country requires national guidelines on antibiotic use in the outpatient primary care (Horvat *et al.,* 2018). Some information regarding the subject is available in the Serbian language only and as such is inaccessible to the international audience.

This study on its own does not address knowledge on the topic of all young people in the region of similar age, rather it focuses on university students. Our other work refers to the knowledge of students of biomedical sciences and comparison to their colleagues from other fields. This is in line with many similar studies conducted around the world. However, further studies are required to assess the situation in the entire age group, including young people not attending universities. Also, one needs to take into account that students' habits could have easily been influenced by their parents or other members of the family (Akici *et al.,* 2017). Due to the young age of the surveyed sample, their opinions can be easily formed on practices of their elders. As such, further investigations on the general public are needed to assess this link and to design campaigns appropriately.

Conclusions and the future

Despite demonstrating a satisfactory level of knowledge, habits of students regarding usage of antibiotics are not as appropriate. Comparable studies conducted in the developing world and in Serbia have given similar results regarding habits. Students are aware of the antibiotics' mechanism of functioning and can distinguish them well from other types of commonly used NSAIDs. However, many have reported changing their regimens, interrupting them prematurely or taking doses irregularly, as well as buying antibiotics without a prescription. Such behaviour will aggravate the already unfavourable situation in Serbia. Rate of students who acquired antibiotics with no prescription is higher than those in countries with a similar DDD per thousand inhabitants rating.

Students' answers did not demonstrate awareness of the potential dangers and consequences of such actions. No difference was found in relation to the domicile of students, most probably due to common high-school education.

After the 2015–16 campaign, there has been no evidence of new campaigns being implemented, besides occasional closed-circle lectures organised by the Ministry of Health (Ministry of Health of the Republic of Serbia, 2020). International programmes, such as Antibiotic Awareness Week, or European Day of Rational Antibiotic Usage, are not well-promoted in Serbia. For example, the Medical faculty of Nis University has organised a small-scale campaign on ABR only once in the past five years (*Campaign for rational antibiotics usage in Nis,* 2018), despite engaging regularly in public health-related activities such as the World Diabetes Day.

Therefore, new campaigns are necessary across the region to improve students' awareness on the risks of self-medication and ABR. Such campaigns should follow the internationally successful programmes and include greater media coverage, as well as internationally accredited organisations, such as the World Health Organization office in Belgrade. The campaigns should feature informative material distributed over the internet and lectures for youth in collaboration with their centres of education.

Acknowledgements

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Glossary

Antibiotics: drug class belonging to group of antimicrobials, effective primarily against bacteria.

Antibiotic resistance: capacity of bacteria to develop mechanisms over generations to fight the detrimental effect of antibiotics

Amoxicillin: common antibiotic belonging to the class of β-lactams, used for many bacterial infections such as pneumonia, middle ear infection, skin infections, urinary tract infections

Bromazepam: non-antimicrobial medicine used as an anti-anxiety agent, or as a pre-medicant for minor surgeries

Defined Daily Dose (DDD): assumed average maintenance dose per day for a drug used for its main indication in adults

Global Health: study of health and health issues on a global scale, aiming to improve health and achieve global equity regarding healthcare

Ibuprofen: non-antimicrobial medicine used to treat pain, fever and inflammation

Non-Steroid Anti-Inflammatory Drugs (NSAIDs): drug class used to reduce pain, fever and inflammation, as well as for prevention of blood clots formation. Commonly obtained without a prescription in most countries.

Paracetamol: also known as acetaminophen, a non-antimicrobial drug used to treat mild to severe pain, commonly in children.

Penicillin: wide group of antibiotics derived from Penicillium moulds, discovered by Fleming in 1928. First antibiotic to be discovered. The group also includes amoxicillin.

Probiotics: live microorganism-based medicine or food promoted as improving or restoring the gut flora

Self-medication: usage of medicine without directives from a medical professional, most dangerously of those whose issuing requires prescription. Commonly done with antibiotics

Sensitive target (site): in context of antibiotics, molecular complex on the bacterium attacked by an antibiotic

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