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A decade of antibacterial drug consumption for systemic use in Montenegro (2014–2023): trends, patterns, and AWaRe classification insights

Decenija potrošnje antibakterijskih lekova za sistemsku primenu u Crnoj Gori (2014–2023): trendovi, obrasci i uvidi u AWaRe klasifikaciju

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Abstract

Background/Aim. Antimicrobial resistance (AMR) represents an increasing threat to global health, with serious implications for public health and the economy. Monitoring antibiotic consumption is crucial in understanding and addressing AMR. The aim of this study was to analyze trends in the use of antibacterial drugs for systemic use in Montenegro from 2014 to 2023. **Methods.** A ten-year retrospective study was conducted using data collected by the Institute for Medicines and Medical Devices of Montenegro, Podgorica, Montenegro. Antibiotics were classified according to the World Health Organization's (WHO) Anatomical Therapeutic Chemical system, expressed in defined daily doses *per* 1,000 inhabitants *per* day, and categorized by WHO's Access, Watch, Reserve (AWaRe) classification to identify trends and patterns in antibiotic use. **Results.** A gradual decline in antibiotic consumption was observed until 2019, after which a sharp increase in both use and costs occurred during the coronavirus disease 2019 pandemic (2020–2021). Although consumption stabilized after the pandemic, it remained higher compared to pre-pandemic levels. The overall consumption trend showed a tendency to decrease but without statistical significance ($p = 0.291$), while the increase in costs was also not statistically significant ($p = 0.089$). The subgroup analysis revealed no significant changes in the antibiotic consumption of J01C and J01M classes. On the other hand, a statistically significant increase was recorded in the use of antibiotics from classes J01D and P01AB ($p = 0.001$ for both). According to the AWaRe classification, significant positive trends were noted in the consumption of antibiotics from the Access ($p = 0.022$), Watch ($p = 0.006$), and Reserve ($p = 0.026$) categories. **Conclusion.** These results highlight the importance of implementing continuous antibiotic stewardship programs, as well as applying targeted interventions aimed at optimizing their use in Montenegro. Furthermore, these results contribute to global efforts in achieving a reduction in antibiotic consumption.

Key words:
anti-bacterial agents; covid-19; drug resistance, microbial; montenegro.

Apstrakt

Uvod/Cilj. Antimikrobna rezistencija (AMR) predstavlja sve veću pretnju globalnom zdravlju, sa ozbiljnim posledicama po javno zdravlje i ekonomiju. Praćenje potrošnje antibiotika je od ključne važnosti za razumevanje i rešavanje AMR. Cilj rada bio je da se analiziraju promene u upotrebi antibakterijskih lekova za sistemsku primenu u Crnoj Gori u periodu od 2014. do 2023. godine. **Metode.** Sprovedena je desetogodišnja retrospektivna studija u kojoj su korišćeni podaci Instituta za lekove i medicinska sredstva Crne Gore, Podgorica, Crna Gora. Antibiotici su klasifikovani prema Anatomsko-terapijsko-hemijskom sistemu Svetske zdravstvene organizacije (SZO), izraženi u definisanim dnevnim dozama na 1 000 stanovnika na dan i kategorizovani prema *Access, Watch, Reserve* – AWaRe klasifikaciji SZO, kako bi se identifikovali trendovi i obrasci u upotrebi antibiotika. **Rezultati.** Do 2019. godine uočen je postepeni pad u potrošnji antibiotika, nakon čega je tokom pandemije koronavirusne bolesti 2019 (2020–2021) došlo do naglog porasta i u upotrebi i u troškovima. Iako je nakon pandemije došlo do stabilizacije, potrošnja je ostala viša u

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odnosu na nivoe pre pandemije. Ukupni trend potrošnje imao je tendenciju smanjenja, ali bez statističke značajnosti (p = 0,291), dok je porast troškova takođe bio statistički neznačajan (p = 0,089). Analiza po podgrupama nije pokazala značajne promene u potrošnji antibiotika iz klasa J01C i J01M. S druge strane, zabeležen je statistički značajan porast u upotrebi antibiotika iz klasa J01D i P01AB (p = 0,001 za obe). Prema AWaRE klasifikaciji, primećeni su značajni pozitivni trendovi u potrošnji antibiotika iz *Access* (p = 0,022), *Watch* (p = 0,006) i *Reserve* (p = 0,026) kategorija.

Zaključak. Ovi rezultati ističu važnost sprovođenja kontinuiranih programa upravljanja antibioticima, kao i primene ciljanih intervencija usmerenih ka optimizaciji njihove upotrebe u Crnoj Gori. Takođe, ovi rezultati doprinose globalnim naporima u postizanju smanjenja potrošnje antibiotika.

Ključne reči:
antibiotici; covid-19; lekovi, rezistencija mikroorganizama; crna gora.

Introduction

Antimicrobial resistance (AMR) is recognized as one of the top 10 most urgent global health threats, causing approximately 33,000 deaths annually and costing the European healthcare system about €1.1 billion. In the United States of America (USA), AMR-related healthcare expenses are estimated at $4.6 billion *per* year [1]. Moreover, the World Bank estimates AMR could lead to a $1.1 trillion global economic loss by 2030, potentially rising to $2 trillion by 2050 [2]. By 2050, AMR-related infections are expected to cause 10 million deaths annually, with an additional 24 million people projected to fall into extreme poverty [3, 4].

Antibiotic overuse and misuse are major drivers of AMR [5], with strong evidence linking antibiotic consumption to the emergence of resistance [6–10]. Up to 50% of antibiotics in inpatient care and over 50% in outpatient settings are misused or overused [11]. In addition, their widespread use raises healthcare costs, accounting for 20–30% of total drug expenditures [12]. Without effective intervention, global antibiotic consumption is projected to rise by 52.3% by 2030 compared with 2023, and could be nearly 200% higher than 2015 levels, especially in low- and middle-income countries (LMICs) [13, 14]. While high-income countries still have the highest overall use, LMICs are experiencing the fastest growth [15]. If current trends continue, resistance to second-line antibiotics in the European Economic Area (EU/EEA) could increase by 72% from 2005 levels, while resistance to last-line treatments may more than double [1]. These alarming projections highlight the urgent need for global action to limit unnecessary antibiotic use and strengthen antimicrobial stewardship.

Considering that AMR is a public health threat, antimicrobial stewardship programs aim to promote the prudent use of antimicrobials and maintain their effectiveness. Monitoring consumption is central to antimicrobial stewardship programs and national resistance control strategies [16]. Furthermore, surveillance also provides insights into population health, prescribing practices, and factors driving inappropriate use [17].

Quantifying antibiotic consumption is considered a cornerstone in the fight against AMR [18]. While the European Antimicrobial Resistance Surveillance Network covers 29 countries and represents the largest regional surveillance system worldwide, Montenegro is not part of this network. Like many countries in the region, Montenegro faces challenges related to antimicrobial use; however, comprehensive data on consumption patterns are limited. Moreover, as part of the global response to the AMR crisis, the World Health Organization (WHO) developed the Global Antimicrobial Resistance and Use Surveillance System (GLASS) in 2015, within its Global Action Plan to strengthen AMR surveillance. For the first time, data on both AMR and antimicrobial consumption were reported together in the 2022 GLASS report [2].

To help evaluate and monitor the use of antibacterials, the WHO developed a classification system, which includes the Access, Watch, Reserve (AWaRe) categories. Measuring the absolute or relative use of antibiotics in each of the AWaRe categories can provide valuable insights into the overall quality of antibiotic use within a country [2]. Access antibiotics are first-choice antibiotics that are relatively safe and have the lowest potential for resistance. On the other hand, Watch antibiotics are broader-spectrum antibiotics with higher resistance potential and are, therefore, prioritized for monitoring under antimicrobial stewardship programs. Reserve antibiotics, classified as "last resort" options, should only be used when alternatives are ineffective or unsuitable [19, 20].

Despite the widespread issue of AMR, significant gaps remain in understanding antimicrobial consumption, particularly in LMICs, where usage patterns and appropriateness are poorly understood [21]. Montenegro, like many other countries, faces challenges related to antimicrobial use, and there is a need for a comprehensive assessment of its consumption trends.

The aim of this study was to analyze national trends in the consumption of systemic antibacterial drugs in Montenegro over a ten-year period (from 2014 to 2023), with a specific focus on AWaRe classification. By examining antibiotic use patterns, this research seeks to fill an important gap in the European context and provide insights for tailoring future antimicrobial stewardship strategies in Montenegro.

Methods

This study employed a retrospective analysis of antibiotic consumption data provided by the Institute for Medicines and Medical Devices of Montenegro, Podgorica, Montenegro. According to the Medicines Act, this institute is responsible for collecting, processing, and publishing reports on medicine consumption in Montenegro. Data on the overall

pharmaceutical market are based on the values of sales of all medicines, as well as the sales volume for all individual medicines (by packaging) registered by wholesalers in Montenegro. Reports are published for the previous calendar year and provide a comprehensive overview of consumption in both the private and public sectors.

The data covered a ten-year period (from 2014 to 2023) and are classified according to the Anatomical Therapeutic Chemical (ATC) classification system, allowing standardized comparisons. Trends in antibiotic consumption are examined using defined daily doses (DDD) *per* 1,000 inhabitants *per* day as the standard measurement unit. The DDD *per* 1,000 inhabitants *per* day was calculated using the WHO methodology: (total number of DDDs dispensed in a year/population of that year) × 1,000/365.

Annual population estimates were obtained from the Statistical Office of Montenegro and used to adjust for changes over time. While DDD is a standardized and internationally accepted metric, its limitations should be acknowledged. It does not account for individual patient characteristics (e.g., age, weight, comorbidities) or deviations from standard doses in clinical practice. In the Montenegrin context, differences in diagnostic practices, empirical prescribing, or the availability of certain formulations may also lead to discrepancies between DDD values and actual daily doses prescribed or used. Costs of treatment expressed in euros are also presented from the cited agency publications.

To obtain more details on antibiotic consumption, a similar approach was used by authors in a paper that also analyzed the consumption of antibacterials for systemic use [22].

For the analysis of data on medicine consumption, approval was obtained from the Institute for Medicines and Medical Devices of Montenegro (from February 26, 2025).

In addition to ATC classification, antibiotic agents were categorized using the WHO's AWaRe classification to evaluate the balance between essential, broad-spectrum, and last-resort antibiotic use. This framework was chosen because it aligns with global stewardship goals and provides actionable insight into consumption patterns that may contribute to AMR. The classification of each antibiotic into an AWaRe group was based on the most recent WHO Essential Medicines List.

Statistical analysis

To assess temporal trends in antibiotic consumption and cost, linear regression analysis was performed using time (year) as the independent variable. Trends were evaluated for total DDDs, ATC subgroups, and AWaRe categories. The statistical significance of trends was tested using the slope coefficient (β) and corresponding p-values. All analyses were conducted using IBM SPSS Statistics version 24 (IBM Corporation, Armonk, NY, USA), with $p < 0.05$ considered statistically significant.

Results

Trends in the consumption of anti-infective drugs for systemic use

Over the past decade, antibiotic consumption and associated costs in Montenegro experienced notable fluctuations. A general decline was seen until 2019, followed by a sharp increase during the coronavirus disease 2019 (COVID-19) pandemic. This rise was likely due to increased prescribing for suspected bacterial co-infections and COVID-related complications. Although the post-pandemic period brought relative stabilization, both consumption and costs remained above pre-pandemic levels.

Although a negative trend in DDD over time (y = 717.3 - 0.34*x) was observed, this trend was not statistically significant (p = 0.291), indicating that the reduction in consumption was not consistent or strong enough to be considered a meaningful, statistically reliable change over the years (Figure 1).

A positive trend in costs over time (y = -1,420,505,753.9 + 708,344.4*x) was observed, but this trend was not statistically significant (p = 0.089). This implies that while a

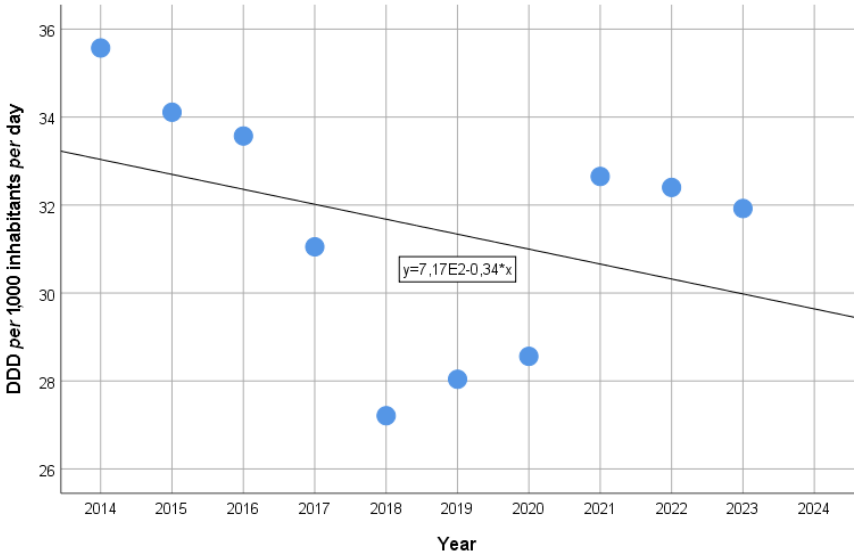

Fig. 1 - Trends in consumption of anti-infective drugs in Montenegro. DDD - defined daily doses.

temporal increase in costs is observed, the trend does not exhibit statistical significance, suggesting that it may not reflect a true underlying pattern. The observed fluctuations may be influenced by external factors, such as the COVID-19 pandemic, which could have contributed to the variability in costs (Table 1).

Consumption of antibacterial drugs for systemic use by subgroups

Table 2 presents antibiotic consumption trends in Montenegro from 2014 to 2023 by ATC code, highlighting shifts in prescribing patterns and changes in the use of various an-

Table 1

Trends in the cost of anti-infective drugs for systemic use in Montenegro over time

Year	Euro
2014	6.973.672,62
2015	6.470.769,16
2016	7.394.161,60
2017	7.599.321,53
2018	7.742.359,68
2019	8.613.069,47
2020	8.569.911,09
2021	19.557.152,93
2022	9.619.360,14
2023	10.333.589,00

Table 2

Annual consumption of antibacterial drugs for systemic use by subgroups expressed in DDD/1,000/day

ATC codes	Antibiotic class	Years									
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
J01C	Beta-lactam antibacterials	10.02	9.65	9.97	8.78	9.5	10.15	7.37	7.46	9.57	10.29
J01CA	Penicillins with extended spectrum	7.02	6.89	6.64	6.27	6.35	6.6	5.16	5.16	5.99	5.99
J01CE	Beta-lactamase-sensitive penicillins	1.13	0.64	0.9	0.86	0.91	0.82	0.38	0.09	0.1	0.07
J01CF	Beta-lactamase-resistant penicillins	/	/	0.00	/	/	0.00	0.00	0.00	0.01	0.01
J01CR	Combinations of penicillins, including beta-lactamase inhibitors	1.88	2.12	2.43	1.65	2.25	2.72	1.82	2.21	3.47	4.22
J01D	Other beta-lactam antibacterials	4.12	4.38	4.79	3.95	4.78	5.31	5.84	8.48	7.65	7.55
J01DB	First-generation cephalosporins	1.19	1.1	1.97	1.16	1.86	2.02	1.68	1.38	1.85	2.28
J01DC	Second-generation cephalosporins	0.07	0.07	0.04	0.04	0.03	0.01	0.01	0.01	0.00	0.00
J01DD	Third-generation cephalosporins	2.84	3.17	2.74	2.71	2.84	3.22	4.01	6.84	5.68	5.16
J01DE	Fourth-generation cephalosporins	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
J01DF	Monobactams	/	/	/	/	/	/	/	/	/	/
J01DI	Other cephalosporins and penems	/	/	/	/	/	/	/	/	0.00	0.00
J01DH	Carbapenems	0.03	0.03	0.04	0.04	0.05	0.06	0.14	0.24	0.1	0.10
J01M	Quinolones	3.70	3.53	3.4	3.16	3.25	1.97	2.48	3.29	2.83	2.62
P01AB	Nitroimidazole derivatives	0.47	0.48	0.46	0.53	0.44	0.45	0.67	0.79	0.83	0.85
J01F	Macrolides	5.32	5.4	5.26	4.72	4.79	5.07	7.9	7.2	7.24	6.61
J01A	Tetracyclines	1.11	1.32	1.37	1.41	1.3	1.5	1.62	2.3	1.74	1.65
J01E	Sulfonamides and trimethoprim	0.12	0.75	0.84	0.81	0.8	1.05	1.05	0.97	0.97	0.96
J01G	Aminoglycosides	0.49	0.12	0.14	0.12	0.13	0.13	0.19	0.49	0.32	0.37
J01B	Amphenicols	/	/	/	/	/	/	/	/	/	/
J01X	Other antibacterials	0.22	0.27	0.29	0.29	0.23	0.21	0.24	0.44	0.41	0.52
Total consumption		25.57	25.90	26.52	23.77	25.22	25.84	27.36	31.42	31.56	31.42

DDD – defined daily doses; ATC – Anatomical Therapeutic Chemical.

***Note*: "/" signifies that the drugs were not commercially available.**

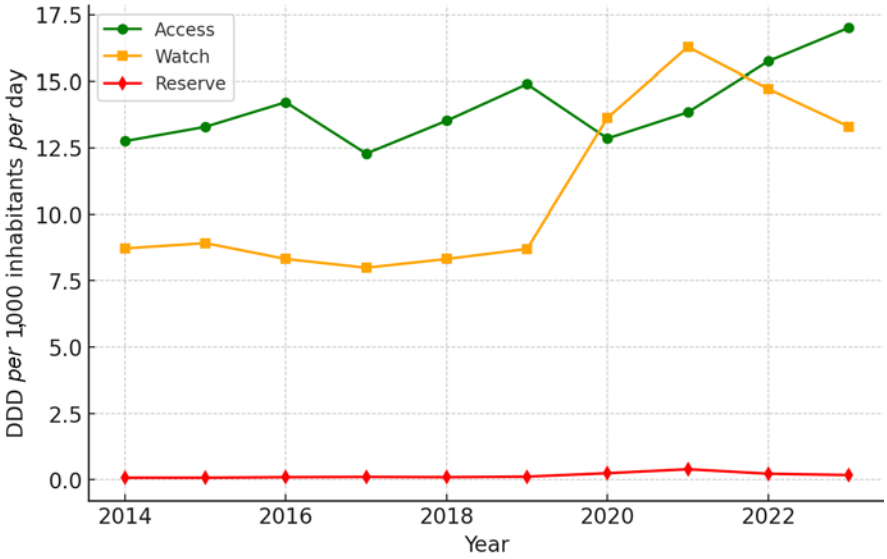

Fig. 2 – Antibiotic consumption by Access, Watch, Reserve (AWaRE) classification in Montenegro. DDD - defined daily doses

tibiotic classes. Among antibiotic subgroups, no significant changes were found in the use of J01C (y = 183.7 - 0.09*x; p = 0.495) and J01M (y = 229.2 - 0.11*x; p = 0.051) classes. These results suggest that the consumption of these classes did not exhibit a consistent or meaningful directional change over the study period. Despite fluctuations in their usage, the absence of statistical significance indicates that these changes were likely due to random variation or external factors, rather than a sustained trend. In contrast, significant positive trends were identified for J01D (y = -953.5 + 0.48*x; p = 0.001) and P01AB (y = -96.7 + 0.05*x; p = 0.001) classes, indicating a consistent increase in the consumption of these antibiotics over time.

Antibiotic consumption by Access, Watch, Reserve classification

From 2014 to 2023, the antibiotic consumption in Montenegro, categorized by the AWaRE classification, displayed distinct trends (Figure 2). A significant positive trend was observed in the consumption of the Access, Watch, and Reserve antibiotics over time (p = 0.022, p = 0.006, p = 0.026, respectively). Antibiotic use increased across all three AWaRe categories. Access and Watch antibiotics showed the most pronounced growth, suggesting their expanding role in empirical treatment. A smaller but significant rise in Reserve antibiotic use highlights a potentially concerning trend that warrants closer monitoring. These trends indicate a consistent increase in the use of antibiotics across all three categories, with the most noticeable rises in the Watch and Access groups, likely due to changes in clinical guidelines, prescribing practices, and the growing need for these antibiotics.

Discussion

This study provides the first comprehensive analysis of long-term outpatient antibiotic consumption trends in Montenegro. The results reveal a slight, non-significant decline in overall use from 2014 to 2019, followed by a sharp increase in 2021, likely influenced by the COVID-19 pandemic and stabilization at elevated levels in 2022 and 2023. A statistically significant upward trend was observed in the consumption of broad-spectrum antibiotics, particularly those from the Watch group, although Access antibiotics remained the most frequently used class.

Antibiotic use in Montenegro showed a slight, non-significant decline from 2014 to 2019, followed by a sharp increase in 2021, likely driven by the COVID-19 pandemic. Although COVID-19 is a disease caused by a viral infection, widespread antibiotic use was reported globally due to concerns about bacterial co-infections, panic, lack of treatment options, and low vaccine trust [23, 24]. This pattern reflects findings from other studies showing disproportionately high antibiotic use during the pandemic, especially in LMICs [3]. Factors such as panic, limited knowledge, lack of treatment options, and low vaccine trust contributed to excessive antibiotic use during this period [24].

In contrast to the declining or stable antibiotic consumption trends observed in many EU/EEA countries, Montenegro experienced an overall increase in outpatient antibiotic use from 2000 to 2022 [25].

This divergence highlights the need to examine factors such as regulatory oversight, prescriber behavior, and public awareness to inform targeted antimicrobial stewardship strategies.

Over a decade ago, Montenegro ranked among the highest consumers of antimicrobial drugs in Europe, with 31.5 DDD/1,000/day recorded in 2011 [26]. In the following years (2014–2019), antimicrobial consumption began to decline, aligning with reductions observed across Europe. However, despite this reduction, Montenegro's consumption levels remained higher than the population-weighted mean in the EU/EEA (19.4 DDD/1,000/day in 2019) [27]. In comparison, Montenegro's antibiotic consumption in 2019 was similar to Romania's (28.8 DDD/1,000/day), but significantly higher than that of its neighboring countries:

Bulgaria (20.7 DDD/1,000/day), Bosnia and Herzegovina, Republic of Srpska (19.4 DDD/1,000/day), Croatia (18.8 DDD/1,000/day), Hungary (14.4 DDD/1,000/day), and Slovenia (13.0 DDD/1,000/day) [24, 27].

The consumption in 2021 was 32.65 DDD/1,000/day, which is almost twice as much as the average consumption in the EU/EEA weighted population for 2021, at 16.4 DDD/1,000/day. After the pandemic-related spike (32.65 DDD/1,000/day), antibacterial consumption slightly declined to 32.40 DDD/1,000/day in 2022 and 31.92 DDD/1,000/day in 2023, indicating that while consumption surged in 2021, it did not continue rising but stabilized at a slightly lower level. For comparison, the EU population-weighted mean for systemic antibacterial drugs was 19.4 DDD/1,000/day in 2022 and 20.0 DDD/1,000/day in 2023 [28]. According to the WHO Regional Office for Europe, in 2023, the total consumption of J01 antibacterials in Montenegro was comparable to that in Serbia (31.4 DDD/1,000/day), while lower levels were reported in Bosnia and Herzegovina (24.7 DDD/1,000/day), Bulgaria (19.8 DDD/1,000/day), and Republic of North Macedonia (16.8 DDD/1,000/day) [29].

A study from Poland reported a slight increase in total antibiotic use between 2007 and 2016, with particular growth in beta-lactamase-sensitive penicillins, reflecting shifting prescribing patterns in Eastern Europe [30]. Similarly, Austria demonstrated relatively low overall antibiotic consumption compared to other European countries, although an increase in the use of fluoroquinolones and beta-lactams was noted over the study period [31]. The European Center for Disease Prevention and Control 2023 report on antimicrobial consumption across the EU/EEA highlighted significant variations between countries and emphasized the impact of the COVID-19 pandemic on antibiotic use trends, underlining the importance of sustained stewardship efforts to control antibiotic consumption and resistance at a regional level [28]. While comparing antibiotic consumption trends across countries provides valuable insights, it is essential to consider differences in data sources, methodologies, healthcare system structures, and prescribing practices. These factors may limit direct comparability and require cautious interpretation of observed similarities or differences.

Implications for policy and stewardship

Although both consumption and expenditure have stabilized, they remain elevated compared to pre-pandemic levels, suggesting a persistent shift in prescribing patterns and financial burden. In comparison, in 2023, Croatia reported €130.5 million in expenditure on systemic antibacterial drugs, reflecting broader regional concerns [32], while Serbia reported an expenditure of approximately €96.8 million for the same category of medications during the same year [33]. These figures underscore the sustained economic burden that antibiotic use continues to impose on national healthcare systems, even as public health efforts aim to promote more rational and targeted prescribing practices. Despite regulations that restrict antibiotics to prescription-only availability, control over the dispensing of antimicrobial drugs remains inadequate in Montenegro. Previous studies have identified inappropriate patient behavior as a major factor contributing to antibiotic misuse. Specifically, a study on antibiotic use in the general population of Montenegro revealed that 60.9% of respondents had used antibiotics in the past 12 months, with 33.4% obtaining them without a prescription or medical supervision [34]. The same issue was reported in Serbia, where approximately a quarter of packages were used for self-medication—purchased at a pharmacy without a prescription (20.65%) [35], and in the Republic of North Macedonia (43.3%) [36]. These findings underscore the urgent need for sustained antimicrobial stewardship efforts and informed policy-making to optimize antibiotic use, curb the rise of resistance, and ultimately protect public health in Montenegro.

The analysis of antibiotic consumption trends revealed differing patterns among the classes studied. Statistically significant increasing trends were observed for J01D and P01AB, reflecting a shift toward broader-spectrum antibiotics. This trend aligns with broader patterns observed across Europe, where countries have shown statistically significant increases in the use of broad-spectrum antibiotics such as penicillins, cephalosporins, and other beta-lactams [28]. Furthermore, the same trend was observed in the USA [37], Africa [38], and Asia [39].

The consumption of AWaRE antibiotics has significantly increased over time, highlighting a growing reliance on these classes of antibiotics. According to Freudenhammer et al. [40], to mitigate the development of AMR, at least 60% of total antibiotic consumption should consist of Access antibiotics. The WHO similarly recommends that Access antibiotics should make up no less than 60% of national consumption [41], which aligns with the prominent use of the Access group observed in this study.

When compared to the WHO's 2015 assessment, which reported 6.3 DDDs for Watch antibiotics and 10.6 DDDs for Access antibiotics [42], Montenegro's consumption levels were slightly higher. Access antibiotics in Montenegro accounted for 13.29 DDDs, while Watch antibiotics reached 8.92 DDDs. This reflects a notable increase in the use of both Access and Watch antibiotics in the country, highlighting changes in prescribing practices and underscoring the need for continuous surveillance and targeted stewardship programs. Access to antibiotic consumption in Montenegro in 2023 is comparable to neighboring countries such as Serbia (16.4 DDD/1,000/day), Bosnia and Herzegovina (15.0 DDD/1,000/day), and Bulgaria (13.7 DDD/1,000/day), while Republic of North Macedonia reports notably lower use (8.3 DDD/1,000/day) [29].

In 2019, comparable consumption levels of Watch group antibiotics were observed among several Balkan countries, including Bosnia and Herzegovina (6.6 DDD/1,000/day), Bulgaria (7.3 DDD/1,000/day), Republic of North Macedonia (7.8 DDD/1,000/day), and Serbia (11.4 DDD/1,000/day) [43]. By 2023, an upward trend was noted, with increased consumption in Bosnia and Herzegovina (9.8 DDD/1,000/day), Republic of North Macedonia (8.0

DDD/1,000/day), and Serbia (15.7 DDD/1,000/day) [29]. However, the increasing use of Watch antibiotics is a significant concern, which may be driven by factors such as economic growth, the affordability of broad-spectrum antibiotics, and market-driven prescribing practices. Weak regulatory frameworks enable over-the-counter antibiotic sales, and diagnostic uncertainty contributes to their overprescription. Physicians may also feel compelled to prescribe "Watch" antibiotics as a precaution due to the lack of resistance data and limited testing. Moreover, antibiotic resistance is often given lower priority in favor of other health issues, while rising rates of resistant infections continue to drive this trend [42, 44].

Based on our findings, we recommend implementing targeted antimicrobial stewardship programs in outpatient care to optimize antibiotic use, particularly broad-spectrum and Watch group antibiotics. Updating national prescribing guidelines, improving provider education on rational use, and strengthening the enforcement of prescription-only antibiotic sales are crucial. Additionally, public awareness campaigns and improved surveillance systems will support efforts to curb antibiotic misuse and resistance.

The observed trends reflect key challenges identified in the WHO Global Action Plan on AMR, particularly in optimizing antimicrobial use and improving surveillance. Strengthening national stewardship efforts will be essential for Montenegro to meet the strategic objectives outlined in both the WHO plan and its national AMR strategy.

Limitations

This study has several limitations that should be taken into account when interpreting the results. The analysis relies on aggregated sales data rather than patient-level prescribing or dispensing records. While sales data provide useful insights into availability and distribution, they may not fully represent actual consumption due to factors such as stockpiling, wastage, or non-adherence. In addition, the study does not incorporate AMR data, which limits the ability to assess direct correlations between antibiotic use and resistance patterns at the national level. Including such data would have strengthened the implications for public health and stewardship strategies. Furthermore, although the use of the DDD metric enables standardized comparisons, it may not accurately reflect local prescribing habits, especially in pediatric or geriatric populations where dosing commonly deviates from the standard DDD. Finally, the retrospective design of the study and reliance on secondary data sources preclude a detailed analysis of contextual factors, such as changes in prescribing practices, regulatory interventions, or public awareness efforts, which may have influenced antibiotic use trends over the study period. Despite these limitations, the findings offer a meaningful overview of long-term antibiotic consumption patterns in Montenegro and can serve as a valuable reference for informing future surveillance efforts and policy development.

Conclusion

This study highlights the surge in outpatient antibiotic use related to the COVID-19 pandemic and its subsequent stabilization in Montenegro, with levels remaining higher than before the pandemic. These trends are concerning and underscore the urgent need for sustained, context-specific stewardship interventions to reduce overuse and mitigate antimicrobial resistance. Tailored strategies should include enhanced surveillance, updates to national prescribing guidelines, and targeted educational campaigns to promote rational antibiotic use. Future research should investigate prescribing behaviors and evaluate the effectiveness of interventions, especially those targeting high-risk antibiotic classes such as the Watch group. Given the global nature of antimicrobial resistance, international collaboration remains essential to support national efforts and align with the goals of the World Health Organization Global Action Plan and regional antimicrobial resistance strategies.

Conflict of interest

The authors declare no conflict of interest.

R E F E R E N C E S

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