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Research Article

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Relationship Between Education and the Use of Antibiotics Across Countries

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ABSTRACT
Antimicrobial resistance (AMR) has been a clinical and research focus in recent years due to its long-term negative impact. Failure to quickly control the use of antibiotics may cause AMR to surpass all other causes of mortality worldwide by 2050. This study investigated factors that might affect the overuse of antibiotics in 52 regions worldwide. The results show that access and watch percentages of antibiotics in consumption were associated with a total use of antibacterials, expressed as the defined daily dose per 1,000 inhabitants per day. Government expenditure on education (as a percentage of the gross domestic product) was found to be positively associated with the access percentage but negatively associated with the watch percentage of antibiotics in consumption across regions.

Keywords: Antimicrobial Resistance, AMR, Antibiotics, Education, Aware Framework

Introduction

First-generation antibiotics were developed over 100 years ago and have since transformed the field of medicine while extending human lifespans [1]. The development of antibiotics has provided considerable benefits to humanity, as these drugs are regarded as essential for treating life-threatening acute bacterial infections, managing surgical infections, and providing effective prophylaxis [2]. Given these benefits, antibiotics have been administered globally for decades. For example, Browne used data from 209 surveys involving 284,045 children younger than 5 years in 101 countries between 2000 and 2018 to show high rates of antibiotic consumption in both high- and upper-middle-income countries in North America, Europe, and the Middle East [3].

This global use of antibiotics has led scientists to extensively study and discuss the concept of antimicrobial resistance (AMR) in recent years. The World Health Organization [4] classifies antibiotics as antimicrobials, and AMR occurs when bacteria, viruses, fungi, and parasites no longer respond to antimicrobial medicines. This phenomenon has not only caused antibiotics and other antimicrobial medicines to become ineffective but also has made infections difficult or even impossible to treat. Therefore, AMR is regarded as a serious threat to global public health because it has increased the risks of disease spread, severe illness, disability, and death.

AMR also has severe long-term negative impacts. According to Ahmed, by 2050, AMR could potentially surpass all other causes of mortality worldwide if preventive measures are not taken. Ahmed also suggested that the global number of fatalities directly linked to AMR would exceed 1.2 million in 2019, with estimates projecting a further increase to approximately 10 million deaths annually by 2050 if adequate measures are not implemented. The authors of that study referred to AMR as a silent pandemic, because its prevalence is attributed to the consequences of overuse or irresponsible use of antibiotics in diverse contexts, such as in clinical treatment, agricultural practices, animal healthcare, war crises, and food systems. As major global risks to human health have been attributed to the overuse of antibiotics, this study aimed to investigate the factors that might influence their usage across countries [5].

Methodology

This study used data from 2023 on the total use of antibacterials, expressed as the defined daily dose (DDD) per 1,000 inhabitants per day, across 52 regions [6]. This is considered the standardized method of measuring antibiotic consumption in a population. Three national-level patterns of antibiotic consumption in 2023 were also included: (1) access percentage, (2) reserve percentage,

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and (3) watch percentage [7]. Access percentage refers to the proportion of narrow-spectrum antibiotics that are effective against a wide range of common infections. A high access percentage suggests successful reliance on safer first-line treatments for common illnesses. Watch percentage refers to the proportion of broad-spectrum antibiotics that carry an elevated risk of causing bacterial resistance. Such medicines are vital for treating specific serious infections but should not be used as first-line treatments when access drugs would suffice. A high watch percentage is a warning sign that antibiotics are being over-prescribed for simple infections, which may accelerate the development of AMR. Reserve percentage refers to last-resort antibiotics, which should be used only to treat life-threatening infections caused by multidrug-resistant bacteria. A high reserve percentage indicates a national crisis in which standard antibiotics are no longer effective.

Robertson previously measured antibiotic usage by calculating the DDD per 1000 inhabitants per day to determine the average daily use in a population. Next, they reviewed the percentages of different antibiotic groups (access, watch, reserve), checked changes over time, and compared results with the World Health Organization guideline stating that at least 60% of the total usage should involve access antibiotics. Finally, they analyzed the drug utilization 75% rate, which identifies medicines that comprise the majority of antibiotic use. Together, these measures demonstrate the overall level of antibiotic consumption and whether countries are following the World Health Organization's recommended patterns [8].

This study also included governments' expenditure on education (as a percentage of the gross domestic product, GDP) in 2020 as a variable [9]. Fifty-two regions were included in the study (see Appendix). The Statistical Package for the Social Sciences (SPSS) was used to analyze data from these 52 regions, and both bivariate correlations and linear regression analyses were conducted. There were no missing data on variables for these 52 regions. Bivariate correlation, Pearson correlation coefficients, and the two-tailed test of significance were applied. For linear regression analysis, the method called 'enter' was applied.

Results

According to Table 1, education expenditure as a percentage of the GDP was positively and significantly correlated with access percentage. The watch percentage was negatively and significantly correlated with the access percentage. The total use of antibacterials was negatively and significantly correlated with the access percentage but positively and significantly correlated with the watch percentage.

Table 1: Correlations of Variables (N = 52)

	1	2	3	4	5
1. Education (%GDP)	1.00				
2. Access	.31*	1.00			
3. Reserve	–.01	–.10	1.00		
4. Watch	–.29*	–.98**	.03	1.00	
5. Antibacterial usage	–.27	–.41**	–.17	.36**	1.00

Note: ** Correlation is significant at the.01 level (two-tailed);
* Correlation is significant at the.05 level (two-tailed).

According to Table 2, 10% of the total variance in the access percentage was significantly associated with education expenditure with respect to GDP: total df = 52, F = 5.34, Sig =.03, lower and upper bounds = .34 and 4.78, respectively.

Table 3 shows that 9% of the total variance in the watch percentage was significantly associated with the education expenditure with respect to GDP: total df = 52, F = 4.75, Sig =.03, lower and upper bounds = –4.26 and –.18, respectively.

Table 2: Regression Analysis Model for Predicting the Access Percentage (N = 52)

Variables	B	SE B	β
Education (%GDP)	2.56	1.11	.31*

Note: R^2 = .10; *p < .05; ** p < .01; ***p < .001.

Table 3: Regression Analysis Model for Predicting the Watch Percentage (N = 52)

Variables	B	SE B	β
Education (%GDP)	-2.21	1.02	-.29*

Note: R^2 = .09; *p < .05; ** p < .01; ***p < .001.

Table 4 indicates that 35% of the total variance in the total use of antibacterials was significantly but negatively associated with the access, reserve, and watch percentages: total df = 52, F = 6.37, Sig =.00. The lower and upper bounds are given in the table. Importantly, the access and watch percentages had a tolerance of 0.27 and variance inflation factors of 37.53 and 36.93, respectively, indicating high multicollinearity between these two independent variables. Therefore, two more regression analyses were run in which either the access or watch percentage was dropped (see Tables 5 and 6) to demonstrate that the two independent variables remained reliable and were not driven by collinearity effects.

Table 4: Regression Analysis Model for Predicting Antibacterial Usage (N = 52)

Variable	B	SE B	Β	Lower Bound	Upper Bound
Education (%GDP)	–.72	.55	–.16	–1.83	.39
Access	–1.27	.39	–2.36**	–2.05	–.50
Reserve	–2.18	.76	–.37**	–3.71	–.65
Watch	–1.18	.42	–2.00**	–2.02	–.34

Note: R^2 =.35; *p <.05; ** p <.01; ***p <.001.

Table 5 indicates that 19% of the total variance in the total use of antibacterials was significantly but negatively associated with the access percentage: total df = 52, F = 5.12, Sig =.00, lower and upper bounds = –.35 and –.06, respectively.

Table 6 indicates that 15% of the total variance in the total use of antibacterials was significantly and positively associated with the watch percentage: total df = 52, F = 4.03, Sig =.01, lower and upper bounds = .03 and .34, respectively.

Table 5: Regression Analysis Model for Predicting Antibacterial Usage (N = 52)

Variables	B	SE B	Β	Lower Bound	Upper Bound
Education (%GDP)	–.78	.59	–.17	–1.96	.41
Access	–.20	.07	–.38**	–.35	–.06
Reserve	–1.31	.74	–.22	–2.80	.19

Note: R^2 =.19; *p <.05; ** p <.01; ***p <.001.

Table 6: Regression analysis model for predicting antibacterial usage (N = 52)

Variables	B	SE B	Β	Lower Bound	Upper Bound
Education (%GDP)	–.88	.60	–.20	–2.09	.33
Reserve	–1.14	.76	–.19	–2.67	.39
Watch	.18	.08	.31*	.03	.34

Note: R^2 =.15; *p <.05; ** p <.01; ***p <.001.

Discussion

According to the results from 52 regions, percentages of access and watch antibiotics in consumption were associated with a total use of antibacterials, as expressed in DDD per 1,000 inhabitants per day. In other words, the overall total amount of antibiotics consumed decreased when larger percentages of antibiotics from the access group was used. This is an interesting finding. One plausible explanation is that this category reflects stricter stewardship, more rational prescribing, and more restricted availability of certain drugs [10]. As mentioned in the introduction of this article, access antibiotics are considered basic, first-line medicines, and their greater use usually indicates careful, targeted prescribing. Because this category is linked to stricter rules and smarter prescribing, countries that follow the World Health Organization's Aware framework tend to avoid unnecessary antibiotic use [11].

World Health Organization developed the Aware framework in 2017 and it is a global antibiotic classification and stewardship tool to help curb antimicrobial resistance and optimize prescribing practices [11]. This framework includes the access, watch, and reserve categories and serves as an objective, user-friendly tool for combatting AMR [12]. Mudenla also indicated that since the introduction of Aware, various countries have implemented national policies and guidelines for antimicrobial stewardship programs and have adopted prescribing protocols and surveillance systems to monitor antimicrobial use and AMR. Countries that have implemented appropriate measures receive guidance on which antibiotics to use for specific diseases, and prescribers are instructed on the appropriate dosages for particular infections. The results of this study regarding the relationships between the access, watch, and reserve percentages and the total use of antibacterials (expressed as DDD per 1,000 inhabitants per day) suggest that stricter prescribing guidelines are an effective and valuable strategy for preventing AMR. This could explain why higher percentage in access group was associated with lower overall consumption (measured as DDD per 1,000 inhabitants per day).

On the other hand, a possible reason for the positive relationship between watch percentage and the total amount of antibiotics used is that when doctors prescribe a lot of antibiotics, they may also prescribe more of these stronger drugs to patients since there may be uncertainty or resistance to first-line treatments.

Another notable finding from this study is that government expenditure on education (as a percentage of GDP) was positively associated with the access percentage of antibiotics in consumption but negatively associated with the watch percentage. Given these results, one might speculate that when countries increase their investment in education and populations become better educated, people tend to make more appropriate medical decisions and are less likely to self-prescribe antibiotics. For example, in a longitudinal study, Fletcher and Frisvold analyzed a group of 10,000 Wisconsin high school graduates who were tracked for nearly five decades and found that college attendance was linked to a 5%–15% higher likelihood of using various forms of preventive care among participants who enrolled in the early 1960s. This study indicated that education could influence preventive health behaviors and that increasing educational attainment can have lasting spillover effects on long-term health decisions [13].

In terms of the negative relationship between education expenditure and the watch percentage, an educated population is more likely to have stronger health literacy, meaning that both patients and healthcare staff should be more aware of the risks of AMR. This awareness reduces dependency on broad-spectrum watch-class drugs. The positive relationship between education expenditure and access percentage may reflect an increased likelihood of educated populations to seek appropriate medical care rather than to self-medicate or request unnecessary antibiotics. Ultimately, this may lead to an increase in the proportional use of recommended access drugs.

Conclusion

According to the results of this study, governments could try to increase their budget allocation for education to equip residents with greater knowledge and stronger critical-thinking skills, enabling them to understand the dangers of frequently using inappropriate medicines and antibiotics. In addition, countries would benefit from establishing strict laws that regulate how doctors and pharmacists prescribe medicines and antibiotics to citizens. If antibiotics are too easily accessible in the market, people may purchase them without seeking advice from doctors or pharmacists. Such a situation increases the risk of "sleepwalk[ing] into a global health disaster" [14]. Finally, researchers must identify other factors that could affect the overuse of antibiotics to reduce AMR.

Limitations

Importantly, this study applied data from a small sample (52 regions) and in specific years; therefore, the results cannot be generalized to other settings, and causation cannot be inferred. The aim of the study was to explore how some medical and non-medical factors could be associated with antibiotic usage across countries; other researchers are encouraged to continue this line of investigation. The results of correlation and regression analyses indicated high multicollinearity between the access and watch percentages. To provide readers with a clearer overview, two additional tables have been included to avoid incorporating both variables in a single analysis.

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Appendix
Regions included in the study:
1. Armenia, 2. Austria, 3. Bangladesh, 4. Belarus, 5. Belgium, 6. Benin, 7. Bhutan, 8. Burkina Faso, 9. Cote d'Ivoire, 10. Canada, 11. Columbia, 12. Croatia, 13. Denmark, 14. Estonia, 15. Ethiopia, 16. Finland, 17. France, 18. Georgia, 19. Germany, 20. Honduras, 21. Hungary, 22. Iceland, 23. Indonesia, 24. Ireland, 25. Italy, 26. Jordan, 27. Lao People's Democratic Republic, 28. Latvia, 29. Lithuania, 30. Malaysia, 31. Nepal, 32. Norway, 33. Oman, 34. Papua New Guinea, 35. Poland, 36. Portugal, 37. Qatar, 38. Republic of Korea, 39. Romania, Russian Federation, 40. Senegal, 41. Singapore, 42. Slovenia, 43. South Africa, 44. Spain, 45. Switzerland, 46. Tajikistan, 47. Tunisia, 48. Uganda, 49. Ukraine, 50. United Kingdom of Great Britain and North Ireland, 51. United Republic of Tanzania, 52. Zambia.

References
1. Hutchings MI, Truman AW, Wilkinson B. Antibiotics: past, present and future. Current Opinion in Microbiology. 2019. 51: 72-80.
2. Weledji EP, Weledji EK, Assob JC, Nsagha DS. Pros, cons and future of antibiotics. New Horizons in Translational Medicine. 2017. 4: 9-14.
3. Browne AJ, Chipeta MG, Haines-Woodhouse G, Kumaran EPA, Kashef Hamadani, et al. Global antibiotic consumption and usage in humans, 2000–18: a spatial modelling study. The Lancet Planetary Health. 2021. 5: 893-904.
4. World Health Organization. Antimicrobial resistance. 2023.
5. Ahmed SK, Hussein S, Qurbani K, Ibrahim RH, Fareeq A, et al. Antimicrobial resistance: impacts, challenges, and future prospects. Journal of Medicine, Surgery, and Public Health. 2024. 2: 100081.
6. World Health Organization. Antibiotic use: Total use of antibiotics expressed as DDD per 1000 inhabitants per day. 2026a, May 1.
7. World Health Organization. Pattern of antibiotic consumption at national level. 2026b, May 1.
8. Robertson J, Vlahović-Palčevski V, Iwamoto K, Högberg LD, Godman B, et al. ESAC-Net Study Group WHO Europe AMC Network Study Group. Variations in the consumption of antimicrobial medicines in the European Region. Frontiers in Pharmacology. 2021. 12: 639207.
9. World Bank Group. Education Statistics. 2026.
10. UK Health Security Agency. UK access, watch, reserve, and other classification for antibiotics (UK-AWaRe antibiotic classification). 2025.
11. World Health Organization. The WHO AWaRe (Access, Watch, Reserve) antibiotic book. World Health Organization. 2022.
12. Mudenla S, Daka V, Matafwali SK. World Health Organization AWaRe framework for antibiotic stewardship: Where are we now and where do we need to go? An expert viewpoint. Antimicrobial Stewardship & Healthcare Epidemiology. 2023. 3: 84.
13. Fletcher JM, Frisvold DE. Higher education and health investments: Does more school affect preventive health care use? Journal of Human Capital. 2009. 3: 144-176.
14. Balasegaram M. As new infections outpace new drugs, are we sleepwalking into a global health disaster. The Guardian. 2025.