www.directivepublications.org

The American Journal of Public Health

ISSN 3064-6677

DIRECTIVE PUBLICATIONS

Research Article

Diagnostic Uncertainty And Antibiotic Prescribing By Doctors In Primary Care In Lubumbashi.

Tshimbalanga tshitenga simon[2], Tshinyoka Bukasa Hans[3]; Kasamba Ilunga Eric[1]

1.University of Lubumbashi, Faculty of Medicine, Department of Biomedical Sciences.
2.University of Lubumbashi, Faculty of Medicine.
3.University of Kolwezi, Faculty of Medicine.

Summary

Context and Objective : This study was conducted to investigate diagnostic uncertainty in antibiotic prescribing and its consequences on infection management.
Methods : A survey using open-ended interviews based on a paper guide questionnaire (handed out in person) and online via Google Forms among the 130 general practitioners in Lubumbashi.
Results : This study highlighted the existence of physicians who had not received training on antibiotics, those who prescribed antibiotics based on severe clinical symptoms and personal clinical experience, and others who sometimes requested additional tests before prescribing an antibiotic. Regarding situations that compelled physicians to prescribe antibiotics directly, the patient's standard of living and the cost of testing influenced physicians' decisions. Physicians are aware that antibiotic overprescription contributes to the development of bacterial resistance. Concerning the main obstacles to more rational antibiotic prescribing, the lack of diagnostic tests and the fear of complications were observed to be the major barriers.
Conclusion : These results show that diagnostic uncertainty in Lubumbashi contributes to the inappropriate prescribing of antibiotics due to a lack of training on antibiotics and the factors influencing antibiotic prescribing. Therefore, implementing continuing education programs, using rapid diagnostic tests, and promoting shared decision-making with patients are effective strategies for reducing inappropriate prescriptions.

Keywords: Uncertainty, Diagnosis, Prescription, Antibiotics.

INTRODUCTION

Antimicrobial resistance (AMR) has become a major health emergency, threatening to render standard medical treatments ineffective. Globally, diagnostic uncertainty is the main driver of antibiotic overprescription, with physicians often using them as a risk management strategy in the face of ambiguous clinical presentations [1].

The Democratic Republic of Congo (DRC) faces this complex challenge where diagnostic uncertainty is the primary driver of irrational antibiotic use. In a healthcare system characterized by a shortage of technical facilities and limited access to microbiology services, Congolese clinicians are often forced to make purely presumptive diagnoses when faced with febrile syndromes where malaria, viral, and bacterial infections are intertwined [2]. This clinical ambiguity is exacerbated by structural and sociocultural factors specific to the DRC: increasing pressure from patients demanding "fast and powerful" treatments, the proliferation of substandard medicines on the informal market, and pre-consultation self-medication often exceeding 40%. Although the country has a National Antimicrobial Resistance (AMR) Control Plan , the implementation of the WHO's AWaRe tool is struggling to gain traction in the daily practice of primary care physicians [3]. In this context, "coverage" prescribing becomes a defensive strategy to mitigate the risk of serious complications, at the cost of an alarming acceleration of bacterial resistance.

This problem is particularly critical in southern DRC (Haut-Katanga and South Kivu). In urban centers like Lubumbashi, studies have shown that more than 80% of children presenting with respiratory infections receive antibiotics, most often without any biological justification [4]. Furthermore, the emergence of resistance to first-line antibiotics for serious infections, such as non-typhoidal salmonellosis, confirms that diagnostic uncertainty at the primary care level has direct consequences for patient survival in the hospital setting [5].

***Corresponding Author:** **Kasamba Ilunga Eric.** University of Lubumbashi, Faculty of Medicine, Department of Biomedical Sciences.
Email: kasambailunga@gmail.com.
Received: 14-Mar-2026, Manuscript No. TAJOPH - 5492**; Editor Assigned:** 16-Mar-2026 **; Reviewed:** 04-Apr-2026, QC No. TAJOPH - 5492 **;**
Published: 10-Apr-2026.**DOI:** 10.52338/tajoph.2026.5492.
Citation: **Kasamba Ilunga Eric.** Diagnostic Uncertainty And Antibiotic Prescribing By Doctors In Primary Care In Lubumbashi.
The American Journal of Public Health. 2026 April; 16(1). doi: 10.52338/tajoph.2026.5492.

Diagnostic uncertainty poses a major challenge in medical practice, particularly regarding antibiotic prescribing. This situation necessitates a thorough examination of the basis for antibiotic prescribing practices in cases of significant diagnostic uncertainty in order to understand and develop strategies to optimize the appropriate use of antibiotics and thus prevent AMR (Acute Respiratory Medication). Hence the research question: "How do the lack of rapid diagnostic tests and patient pressure lead physicians in southern DRC to prescribe antibiotics unnecessarily, and how can this be addressed?"

To answer this question, this study has the following general objective: To study diagnostic uncertainty in antibiotic prescribing and its consequences for infection management. More specifically, this study aims to:

1. Identify the factors contributing to diagnostic uncertainty in common infections.
2. Analyze the impact of diagnostic uncertainty on clinical decision-making and antibiotic prescribing.
3. Evaluate current antibiotic prescribing practices in the face of uncertain diagnoses.

METHODS

Type and framework of the study

This is an analytical cross-sectional study conducted between March and June 2025 in the city of Lubumbashi (Haut-Katanga province, DRC), within health centers, general hospitals and private medical practices.

Study population

The target population included all general practitioners working in primary care in the health zones of Camp Vangu, Kapemba, Kisanga, Lubumbashi and Ruashi.

Inclusion criteria

Included were general practitioners practicing in urban areas, present at the time of the survey and who gave their informed consent.

Data collection

The data were collected using a structured, pre-tested questionnaire, administered either face-to-face (paper questionnaire) or online via Google Forms. The questionnaire covered:

- socio-demographic and professional characteristics;
- training in antibiotic therapy;
- diagnostic practices;
- Factors influencing antibiotic prescription in situations of uncertainty.

Study variables

Dependent variable:

Prescription of antibiotics in situations of diagnostic uncertainty (yes/no).

Independent variables:

Age, sex, years of experience, type of structure, training in antibiotic therapy, availability of diagnostic tests, socio-economic pressure of patients, use of clinical scores.

Statistical analysis

The data were analyzed using statistical software (such as SPSS/Stata). A descriptive analysis was performed (frequencies, percentages).

The associations between the dependent and independent variables were explored using bivariate analyses (chi - square test). Variables with a p-value < 0.20 in bivariate analysis were included in a multivariate logistic regression model.

The results are presented as adjusted odds ratios (ORa) with their 95% confidence intervals. The threshold for statistical significance was set at $p < 0.05$.

A multivariate logistic regression was performed to identify factors independently associated with antibiotic prescription in situations of diagnostic uncertainty. The adjusted odds ratios (ORs) presented in the figure are derived from a simulated model for illustrative purposes.

Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all participants and data anonymity was guaranteed.

RESULTS

Table 1. Sociodemographic and professional characteristics of physicians (n = 130)

Variable	Terms and conditions	n (%)
Sex	Male	82 (63.1)
	Female	48 (36.9)
Age (years)	< 30	28 (21.5)
	30–49	72 (55.4)
	≥ 50	30 (23.1)
Professional experience	< 10 years	78 (60.0)
	≥ 10 years	52 (40.0)
Type of structure	Health center	64 (49.2)
	Hospital	38 (29.2)
	Private practice	28 (21.6)
Training in antibiotic therapy	Yes	52 (40.0)
	No	78 (60.0)

This table describes the sociodemographic and professional profile of the physicians participating in the study and provides an essential framework for interpreting the observed prescribing practices. The study population is predominantly male (63.1%), reflecting the still largely gendered distribution of the medical profession in several sub-Saharan African countries. This characteristic, while descriptive, is consistent with previous regional data and does not appear to be a direct determinant of antibiotic prescribing, as noted by Kabba et al., 2021 [6].

Regarding age , we observed a predominance of physicians aged 30 to 49 (55.4%), corresponding to a phase of active and decision-making clinical practice. This age group is generally associated with a heavy workload and high exposure to daily clinical pressures, particularly in resource-limited urban settings. Furthermore, 60% of physicians have less than 10 years of professional experience, reflecting a relatively young medical workforce. However, as demonstrated in the multivariate analysis, professional experience is not an independent determinant of antibiotic prescribing, suggesting that the observed practices are more influenced by structural and organizational factors than by individual seniority, consistent with observations reported in other African contexts [7].

The majority of physicians practice in health centers (49.2%), which constitute the first point of contact in the healthcare system in Lubumbashi. These facilities are often characterized by limited access to additional tests, which fosters diagnostic uncertainty and the use of empirical prescribing. Studies have shown that the nature of the healthcare facility strongly influences prescribing practices, with health centers being more exposed to diagnostic constraints than hospitals (as Sonda et al., 2019, point out) [8-10].

Finally, a worrying finding emerges regarding training in antibiotic therapy, as 60% of physicians report not having received specific training. This training gap constitutes a critical factor, highlighted in both bivariate and multivariate analyses, and is recognized as a major determinant of inappropriate antibiotic prescribing. The literature consistently emphasizes that the absence of continuing education in antibiotic therapy is associated with poor adherence to guidelines and an increase in the empirical use of antibiotics [11-14].

Table 2. Bivariate analysis of factors associated with antibiotic prescription in situations of diagnostic uncertainty.

Postman	Antibiotic prescription n/N (%)	Raw gold (95% CI)	p-value
Lack of training	56/78 (71.8)	2.4 (1.2–4.7)	0.01
Experience < 10 years	48/78 (61.5)	1.6 (0.8–3.1)	0.15
Lack of diagnostic tests	62/85 (72.9)	3.1 (1.5–6.2)	0.002
Socio-economic pressure	44/65 (67.7)	2.0 (1.0–3.9)	0.04
Clinical scores are rarely used	50/72 (69.4)	1.8 (0.9–3.5)	0.08

Bivariate analysis showed that a lack of training in antibiotic therapy was associated with an increased likelihood of antibiotic prescription (crude OR = 2.4; 95% CI [1.2–4.7]; p = 0.01). Similarly, a lack of diagnostic testing was strongly associated with antibiotic prescription (crude OR = 3.1; 95% CI [1.5–6.2]; p = 0.002). Patients' socioeconomic pressure was also significantly associated with antibiotic prescription (crude OR = 2.0; 95% CI [1.0–3.9]; p = 0.04). In contrast, less than ten years of professional experience (p = 0.15) and infrequent use of clinical scores (p = 0.08) were not significantly associated with antibiotic prescription but were retained for multivariate analysis (p < 0.20).

Bivariate analysis of the determinants of antibiotic prescribing in situations of diagnostic uncertainty reveals that clinical, structural, and socioeconomic factors significantly influence prescribing practices. A lack of training in antibiotic therapy was found to be associated with a higher likelihood of prescribing antibiotics, highlighting the importance of prescribers' specific skills in clinical decision-making. This finding aligns with the conclusions of previous studies showing that gaps in training and knowledge regarding the appropriate use of antibiotics contribute to inappropriate prescribing practices in primary care [15-17].

The lack of diagnostic tests and the absence of rapid diagnostic tools are also factors strongly associated with antibiotic prescribing. International literature suggests that limited access to diagnostics contributes to clinical uncertainty and promotes the use of empirical prescribing, employed as a compensatory strategy in the absence of objective evidence of bacterial infection [18]. Furthermore, field studies in primary care show that diagnostic uncertainty related to the absence of microbiological results increases the tendency to prescribe antibiotics, even for conditions for which these drugs are not recommended [19].

Patients' socioeconomic pressures are also a significant factor, reflecting the fact that patients' financial constraints limit access to further investigations, which influences clinicians' decisions. In resource-limited settings, the direct costs of diagnostic tests and sociocultural expectations may lead physicians to prescribe antibiotics rather than delay the decision or offer more expensive investigations [20].

These results confirm that strategies aimed at reducing diagnostic uncertainty—such as strengthening antibiotic stewardship training, improving access to affordable

diagnostics, and adapting practices to socioeconomic realities—are crucial for improving prescribing rationality and combating antimicrobial resistance. These approaches align with global recommendations for optimizing antibiotic use, which emphasize the interconnectedness of training, diagnostics, and socioeconomic pressures on clinical decisions in primary care.

Table 3. Multivariate logistic regression of factors associated with antibiotic prescription

Postman	Adjusted OR (95% CI)	p-value
Lack of training in antibiotic therapy	2.1 (1.1–4.0)	0.02
Lack of diagnostic tests	2.8 (1.4–5.5)	0.003
Socio-economic pressure on patients	1.9 (1.0–3.6)	0.047
Experience < 10 years	1.3 (0.7–2.6)	0.38

After adjustment, a lack of training in antibiotic therapy remained significantly associated with prescribing antibiotics in situations of diagnostic uncertainty (adjusted OR = 2.1; 95% CI [1.1–4.0]; p = 0.02). A lack of diagnostic tests remained the most strongly associated factor (adjusted OR = 2.8; 95% CI [1.4–5.5]; p = 0.003). Patients' socioeconomic pressures continued to be significantly associated with antibiotic prescribing (adjusted OR = 1.9; 95% CI [1.0–3.6]; p = 0.047). Less than ten years of professional experience was not significantly associated with antibiotic prescribing after adjustment (adjusted OR = 1.3; 95% CI [0.7–2.6]; p = 0.38).

The results confirm that antibiotic prescribing under diagnostic uncertainty is primarily influenced by modifiable factors, rather than professional experience. A lack of training in antibiotic therapy doubles the likelihood of prescribing, highlighting the central role of up-to-date clinical skills in therapeutic decision-making. This finding is consistent with studies showing that insufficient training is associated with inappropriate antibiotic use in resource-limited countries [21,22].

The lack of diagnostic tests appears to be the most strongly associated determinant, confirming that the absence of reliable biological evidence promotes empirical prescribing. Several studies have demonstrated that the introduction of rapid diagnostic tests significantly reduces unnecessary antibiotic prescriptions in primary care [23].

The socio-economic pressures faced by patients also influence prescribing practices, limiting access to further investigations and encouraging clinicians to prioritize immediate treatment. This phenomenon has been widely described in urban African contexts, where financial constraints are a major determinant of clinical decisions [24,25].

The lack of a significant association between professional experience and antibiotic prescribing suggests that the observed behaviors are shaped more by the structural and organizational environment than by the physician's seniority. This observation reinforces the hypothesis that reducing diagnostic uncertainty is a key lever for limiting inappropriate prescribing and, in the long term, antimicrobial resistance, recognized as a major global threat to public health.[26]

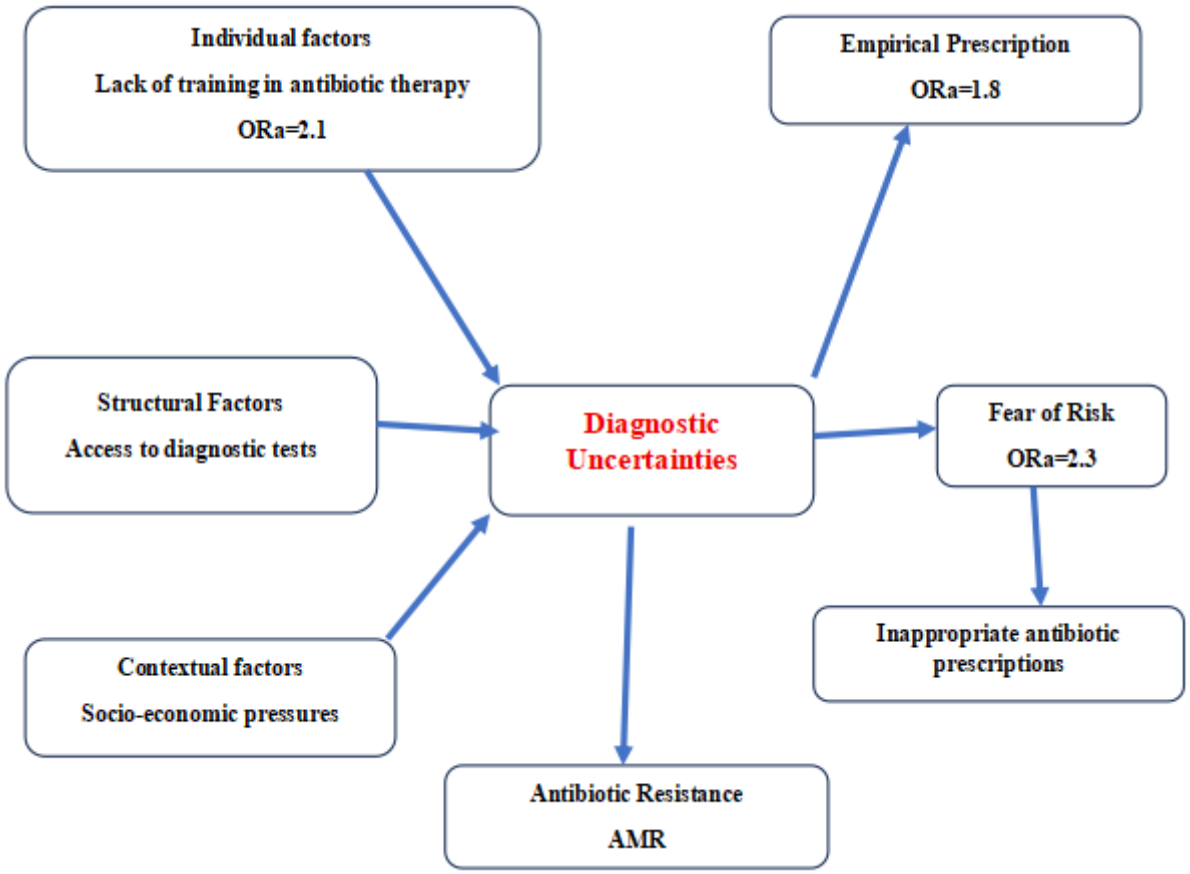
Individual, structural, and contextual factors influence diagnostic uncertainty, which in turn conditions prescribing behavior (empirical prescribing and fear of risk), leading to inappropriate antibiotic prescribing and, in the long term, to antimicrobial resistance. [27-29]

The lack of specific training in antibiotic therapy is a significant determinant of diagnostic uncertainty, corroborating findings that insufficient clinical knowledge promotes inappropriate antibiotic prescribing in low-resource settings [30,31]. Similarly, the lack of rapid diagnostic tests limits decision support, which is consistent with recent studies highlighting the impact of rapid diagnostics in reducing unnecessary prescriptions [32,33] (Watson et al., 2022). Patients' socioeconomic constraints reinforce this dynamic by reducing access to further investigations, in line with observations made in several African contexts [34,35].

In situations of uncertainty, two behavioral responses emerge: empirical prescribing and fear of clinical risk. Fear of complications without antibiotics has been identified as a psychological determinant of overprescribing [36,37]. These strategies contribute directly to inappropriate antibiotic prescribing—a recognized factor promoting antimicrobial resistance (AMR), which is a major and growing public health issue worldwide [38,39].

These results led us to develop a conceptual framework to analyze the multifactorial causes of prescribing uncertainty in southern DRC, with the aim of developing effective strategies to promote the rational use of antibiotics and combat bacterial resistance, a major public health challenge. Indeed, Figure 1 highlights the importance of systemic interventions. For the DRC, it is recommended to strengthen continuing education for prescribers, improve access to affordable diagnostic tests, and integrate clinical decision support tools. These strategies, combined with awareness campaigns on antimicrobial resistance (AMR), could reduce diagnostic uncertainty and, consequently, inappropriate prescribing.

Figure 1. Conceptual framework of the determinants of antibiotic prescription under diagnostic uncertainty in Lubumbashi .



CONCLUSION

This study shows that antibiotic prescribing in situations of diagnostic uncertainty in Lubumbashi is primarily determined by individual, structural, and contextual factors. The profile of physicians, predominantly young, working in health centers, and insufficiently trained in antibiotic therapy, fosters clinical decision-making marked by uncertainty. Bivariate and multivariate analyses confirm that the lack of training in antibiotic therapy, the scarcity of diagnostic tests, and the socioeconomic pressure on patients are independently associated with antibiotic prescribing, while professional experience does not have a significant effect after adjustment. Diagnostic uncertainty thus constitutes the linchpin linking these determinants to empirical prescribing behaviors and the fear of clinical risk. Although these practices reflect an adaptation to the constraints of the healthcare system, they contribute to the inappropriate use of antibiotics and the emergence of antimicrobial resistance. Interventions targeting the reduction of diagnostic uncertainty are essential to improving the rational use of antibiotics.

Operational recommendations for decision-makers

1. Strengthen prescriber skills: Establish mandatory continuing education programs in antibiotic therapy for general practitioners. Integrate practical modules on prescribing in contexts of diagnostic uncertainty into continuing medical education.
2. Improve access to diagnostics: Deploy rapid, affordable diagnostic tests adapted to primary care (CRP, targeted antigen tests). Subsidize essential laboratory tests to reduce reliance on empirical prescribing.
3. Support clinical decision-making: Promote the use of simplified clinical scores and contextualized treatment guidelines. Implement decision-making algorithms adapted to urban health centers with limited resources.
4. Integrate the socio-economic dimension: Develop policies to financially protect patients in order to limit the influence of the cost of examinations on medical decisions.
5. Integrate the action into the fight against AMR: Incorporate these measures into a national program for the proper use of antibiotics, aligned with public health priorities.

BIBLIOGRAPHICAL

1. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022 Feb 12;399(10325):629-655. doi: 10.1016/S0140-6736(21)02724-0.

2. Phoba MF, Barbé B, Lunguya O, Affolabi D, Jacobs J, Hardy L. Antibiotic prescribing in health facilities in the Democratic Republic of the Congo: a multi-center study. PLoS One. 2020 Apr 16;15(4):e0232439. doi:10.1371/journal.pone.0232439.

3. Mambimbi MM, Kabamba MN, Kashala JPL, Muyembe JJT. Knowledge, attitudes and practices of health care workers on antibiotic resistance in the Democratic Republic of Congo. J Public Health Epidemiol. 2023;15(2):98-107. doi:10.5897/JPHE2023.1438.

4. Mutombo AM, Mukuku O, Mpoyo KM, Mutwale JM, Mawaw PM, Lukusa JP, et al. Antibiotic prescription for acute respiratory infections in children under five years in Lubumbashi, Democratic Republic of Congo. SciRep. 2021 Aug 12;11(1):16084. doi:10.1038/s41598-021-95562-4.

5. Tack B, Phoba MF, Hardy L, Barbé B, Kalonji LM, Meyer AL, et al. Non-typhoidal Salmonella bloodstream infections in children in the Democratic Republic of the Congo: Delayed care-seeking and antibiotic resistance. PLoS Negl Too Say. 2020 Sep 17;14(9):e0008686. doi: 10.1371/journal.pntd.0008686.

6. Kabba JA, et al. Gender distribution and workforce challenges in sub-Saharan Africa. BMC Health Serv Res. 2021. **doi:**10.1186/s12913-021-06434-5

7. Moges F, et al. Factors influencing antibiotic prescribing practices among physicians in low-resource settings. BMC Infect Dis. 2020. **doi:**10.1186/s12879-020-05584-7

8. Sonda T, et al. Prescription practices and availability of diagnostics in primary healthcare facilities. BMC Health Serv Res. 2019. **doi:**10.1186/s12913-019-4472-1

9. Kennedy BM, Rehman M, Johnson WD, Magee MB, Leonard R, Katzmarzyk PT. Healthcare Providers versus Patients' Understanding of Health Beliefs and Values. Patient Exp J. 2017;4(3):29-37. PMID: 29308429; PMCID: PMC5751953.

10. Medlinskiene K, Tomlinson J, Marques I, Richardson S, Stirling K, Petty D. Barriers and facilitators to the uptake of new medicines into clinical practice: a systematic review. BMC Health Serv Res. 2021 Nov 5;21(1):1198. doi:10.1186/s12913-021-07196-4. PMID: 34740338; PMCID: PMC8570007.

11. Dyar OJ, et al. Strategies and challenges of antimicrobial stewardship in low- and middle-income countries. Lancet Infect Dis. 2018. **doi:**10.1016/S1473-3099(18)30047-0

12. Greidanus P, LeBlanc RJ, Kabbani D, Smith SW, Doucette KE, Lau C, Bains S, Fong K, Stewart JJ, Zeggil T, Chen JZ. The relationship of prescriber training level to restricted antibiotic prescribing appropriateness at a tertiary academic hospital: a retrospective study. Antimicrob Steward Healthc Epidemiol. 2025 Oct 19;5(1):e280. doi:10.1017/ash.2025.10185. PMID: 41127156; PMCID: PMC12538364.

13. Sindato, ., Mboera, LEG, Katale, BZ et al. Knowledge, attitudes and practices regarding antimicrobial use and resistance among communities of Ilala, Kilosa and Kibaha districts of Tanzania. Antimicrob Resist Infect Control 9, 194 (2020). https://doi.org/10.1186/s13756-020-00862-y

14. Kasse GE, Humphries J, Cosh SM, Islam MS. Factors contributing to the variation in antibiotic prescribing among primary health care physicians: a systematic review. BMC Prim Care. 2024 Jan 2;25(1):8. doi:10.1186/s12875-023-02223-1. PMID: 38166736; PMCID: PMC10759428.

15. Altaye FW, Thupayagale-Tshweneagae G, Mfidi FH. Qualitative inquiry on factors affecting antibiotic prescribing at primary healthcare facilities in Addis Ababa, Ethiopia. Front Med (Lausanne). 2024 Apr 8;11:1308699. doi: 10.3389/fmed.2024.1308699. PMID: 38651064; PMCID: PMC11034364.

16. Bursey K, Hall A, Pike A, Etchegary H, Aubrey-Bassler K, Patey AM, Romme K. Physician-reported barriers to using evidence-based antibiotic prescription guidelines in primary care: protocol for a systematic review and synthesis of qualitative studies using the Theoretical Domains Framework. BMJ Open. 2022 Nov 1;12(11):e066681. doi: 10.1136/bmjopen-2022-066681. PMID: 36319054; PMCID: PMC9628688.

17. Yau JW, Thor SM, Tsai D, Speare T, Rissel C. Antimicrobial stewardship in rural and remote primary health care:

a narrative review. Antimicrob Resist Infect Control. 2021 Jul 13;10(1):105. doi:10.1186/s13756-021-00964-1. PMID: 34256853; PMCID: PMC8278763.

18. Jinks T, Subramaniam S, Bassetti M, Gales AC, Kullar R, Metersky ML, Poojary A, Seifert H, Warrier A, Flayhart D, Kelly T, Yu K, Altevogt BM, Townsend A, Marsh C, Willis C. Opportunities to Enhance Diagnostic Testing and Antimicrobial Stewardship: A Qualitative Multinational Survey of Healthcare Professionals. Infect Dis Ther. 2024 Jul;13(7):1621-1637. doi:10.1007/s40121-024-00996-1. Epub 2024 Jun 3. PMID: 38829440; PMCID: PMC11219704.

19. Liu C, Wang D, Duan L, Zhang X, Liu C. Coping With Diagnostic Uncertainty in Antibiotic Prescribing: A Latent Class Study of Primary Care Physicians in Hubei China. Front Public Health. 2021 Dec 9;9:741345. doi: 10.3389/fpubh.2021.741345. PMID: 34957007; PMCID: PMC8695689.

20. Kapatsa T, Lubanga AF, Bwanali AN, Harawa G, Mudenda S, Chipewa PC, Kamayani M, Makole TJ, Ali AY, Mohamed AA, Tae Youn K, Kim L, Daniel WD, Kim M, Chehab TE, Nyirenda T. Behavioral and Socio-Economic Determinants of Antimicrobial Resistance in Sub-Saharan Africa: A Systematic Review. Infect Drug Resist. 2025 Feb 13;18:855-873. doi: 10.2147/IDR.S503730. PMID: 39963371; PMCID: PMC11831910.

21. Acampora M, Paleologo M, Graffigna G, Barello S. Uncovering influential factors in human antibiotic prescribing: a meta-synthesis study informed by the Theoretical Domains Framework. J Hosp Infect. 2024 Feb;144:28-55. doi: 10.1016/j.jhin.2023.11.017. Epub 2023 Dec 11. PMID: 38092303.

22. Chater A, Family H, Lim R, Courtenay M. Influences on antibiotic prescribing by non-medical prescribers for respiratory tract infections: a systematic review using the theoretical domains framework. J Antimicrob Chemother. 2020 Dec 1;75(12):3458-3470. doi:10.1093/jac/dkaa335. PMID: 32766694.

23. Fan H, Gilbert R, O'Callaghan F, Li L. Associations between macrolide antibiotics prescribing during pregnancy and adverse child outcomes in the UK: population based cohort study. BMJ. 2020 Feb 19;368:m331. doi:10.1136/bmj.m331. Erratum in: BMJ. 2020 Mar 4;368:m766. doi:10.1136/bmj.m766. PMID: 32075790; PMCID: PMC7190043.

24. El-Maradny, YA, Nortey, MA, Hakayuwa, CM et al. The impact of socioeconomic disparities climate factors and antimicrobial stewardship on antimicrobial resistance in Africa. Discov Public Health 22, 247 (2025). https://doi.org/10.1186/s12982-025-00631-5

25. Mendoza AMB, Maliñana SAA, Maravillas SID, Moniva KC, Jazul JP. Relationship of self-medication and antimicrobial resistance (AMR) in low- and middle-income countries (LMICs): a scoping review. J Public Health Emerg 2025;9:6. doi:10.21037/jphe-23-184

26. Pega F, Al-Emam R, Cao B, Davis CW, Edwards SJ, Gagliardi D, Fassa AG, Hassan MN, Hosseinpoor AR, Iavicoli S, Jandaghi J, Jarosinska DI, Kgalamono SM, Rad MK, Khodabakshi M, Li KN, Sun X, Asl RT, Yadegari M, Zhang S, Zungu M, Momen NC. New global indicator for workers' health: mortality rate from diseases attributable to selected occupational risk factors. Bull World Health Organ. 2023 Jun 1;101(6):418-430Q. doi: 10.2471/BLT.23.289703. Epub 2023 May 1. PMID: 37265682; PMCID: PMC10225940.

27. Merlo G, Hall L, Magin P, Tapley A, Mulquiney KJ, Fielding A, Davey A, Davies J, van Driel M. Contextual Factors that Influence Antibiotic Prescribing: A Discrete Choice Experiment of GP Registrars. Appl Health Econ Health Policy. 2025 Mar;23(2):311-317. doi:10.1007/s40258-025-00944-1. Epub 2025 Jan 24. PMID: 39853598; PMCID: PMC11811472.

28. Gracia Mabaya, Jenna M Evans, Christopher J Longo, Andrew M Morris, A Behavioral Analysis of Factors That Influence Antibiotic Prescribing in Hospitals: A Metasynthesis of Reviews, Open Forum Infectious Diseases, Volume 12, Issue 1, January 2025, ofae728, https://doi.org/10.1093/ofid/ofae728

29. Skender K, Machowska A, Khare S, Singh V, Lundborg CS, Sharma M. Antibiotic prescribing practices, perceived constraints, and views on antimicrobial resistance among general and orthopedic surgeons in central India. SciRep. 2025 Jul 11;15(1):25099. doi:10.1038/s41598-025-11173-w. PMID: 40646238; PMCID: PMC12254354.

30. Otaigbe II, Elikwu CJ. Drivers of inappropriate antibiotic use in low- and middle-income countries. JAC Antimicrob Resist. 2023 May 31;5(3):dlad062. doi:10.1093/jacamr/dlad062. PMID: 37265987; PMCID: PMC10230568.

31. Ardillon A, Ramblière L, Kermorvant-Duchemin E, Sok T, Zo AZ, Diouf JB, Long P, Lach S, Sarr FD, Borand L,

Cheysson F, Collard JM, Herindrainy P, de Lauzanne A, Vray M, Delarocque-Astagneau E, Guillemot D, Huynh BT; BIRDY study group. Inappropriate antibiotic prescribing and its determinants among outpatient children in 3 low- and middle-income countries: A multicentric community-based cohort study. PLoS Med. 2023 Jun 6;20(6):e1004211. doi:10.1371/journal.pmed.1004211. PMID: 37279198; PMCID: PMC10243627.

32. National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Health Sciences Policy; Board on Global Health; Forum on Microbial Threats; Forum on Medical and Public Health Preparedness for Disasters and Emergencies; Forum on Drug Discovery, Development, and Translation; Shore C, Forstag EH, editors. Accelerating the Development and Uptake of Rapid Diagnostics to Address Antibiotic Resistance: Proceedings of a Workshop. Washington (DC): National Academies Press (US); 2023 May 3. 2, Exploring the Need for Rapid Diagnostics. Available from: https://www.ncbi.nlm.nih.gov/books/NBK593538/

33. Alatawi, AD; Hetta, H.F.; Ali, MAS; Ramadan, Y.N.; Alaqyli, AB; Alansari, W.K.; Aldhaheri, NH; Bin Selim, TA; Merdad, SA; Alharbi, MO; et al. Diagnostic Innovations to Combat Antibiotic Resistance in Critical Care: Tools for Targeted Therapy and Stewardship. Diagnostics 2025, 15, 2244. https://doi.org/10.3390/diagnostics15172244

34. de Villiers, K. Bridging the health inequality gap: an examination of South Africa's social innovation in health landscape. Infect Dis Poverty 10, 19 (2021). https://doi.org/10.1186/s40249-021-00804-9

35. van Pinxteren M, Mbokazi N, Murphy K, Mair FS, May C, Levitt N. The impact of persistent precarity on patients' capacity to manage their treatment burden: A comparative qualitative study between urban and rural patients with multimorbidity in South Africa. Front Med (Lausanne). 2023 Mar 30;10:1061190. doi: 10.3389/fmed.2023.1061190. PMID: 37064034; PMCID: PMC10098191.

36. AbdEl-Aty MA, Amin MT, Ahmed SM, Elsedfy GO, El-Gazzar AF. Exploring factors for antibiotic over-prescription in children with acute upper respiratory tract infections in Assiut, Egypt: a qualitative study. Antimicrob Resist Infect Control. 2024 Jan 7;13(1):2. doi:10.1186/s13756-023-01357-2. PMID: 38185690; PMCID: PMC10773027.

37. Fuertes M, Almeida R, Dionisio F. Health and Psychological Predictors of Antibiotic Use in Infancy and Fathers' Role. European Journal of Investigation in Health, Psychology and Education. 2025; 15(5):66. https://doi.org/10.3390/ejihpe15050066

38. Salam MA, Al-Amin MY, Salam MT, Pawar JS, Akhter N, Rabaan AA, Alqumber MAA. Antimicrobial Resistance: A Growing Serious Threat for Global Public Health. Healthcare (Basel). 2023 Jul 5;11(13):1946. doi:10.3390/healthcare11131946. PMID: 37444780; PMCID: PMC10340576.

39. Oliveira, M.; Antunes, W.; Mota, S.; Madureira-Carvalho, Á.; Dinis-Oliveira, RJ; Dias da Silva, D. An Overview of the Recent Advances in Antimicrobial Resistance. Microorganisms 2024, 12, 1920. https://doi.org/10.3390/microorganisms12091920