ORIGINAL ARTICLE

Critical Gaps in Ethiopia's Microbiology Services: A Major Challenge in Combating Antimicrobial Resistance

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ABSTRACT

BACKGROUND: *Microbiological diagnostics, particularly culture and antimicrobial susceptibility testing, are among the least utilized diagnostic services in Ethiopia. This critical gap is also observed across healthcare systems in many sub-Saharan African countries. However, there is a paucity of data characterizing the limitations and operational challenges in microbiological service delivery. This study examines the gaps identified in public health facilities in Ethiopia.*

METHODS: *A laboratory-based survey assessing culture and antimicrobial susceptibility testing services was conducted in 13 public hospitals in Addis Ababa between January and March 2024. Data were collected through direct observation, laboratory logbook reviews, and interviews with laboratory personnel, following ethical approval.*

RESULTS: *There are 13 public hospitals in Addis Ababa serving a population exceeding five million. Of these, eight provide basic bacteriological culture and antimicrobial susceptibility testing services. None of these eight-offer advanced molecular or genotypic testing, nor do they provide anaerobic or fungal culture services. Furthermore, seven of the eight facilities face challenges in delivering comprehensive antimicrobial susceptibility testing, particularly in terms of the range of antibiotics tested. Sustaining uninterrupted services is also a major challenge in these facilities, largely due to financial constraints and weaknesses in the microbiology supply chain management system.*

CONCLUSION: *In the context of the growing clinical impact of antimicrobial resistance, addressing gaps in microbiological diagnostic services is imperative. The limited range and inconsistency of laboratory services in public health facilities are insufficient to meet current clinical demands and to effectively respond to the increasing threat of drug-resistant pathogens.*

KEYWORDS: *Microbiology, services, Ethiopia, gaps in services, antimicrobial resistance*

INTRODUCTION

Microbiology services, particularly bacteriological culture and sensitivity testing, are significantly underutilized in the Ethiopian health system (1). Several factors have contributed to this, with limited availability of services being the primary barrier. In Ethiopia, access to microbiology services is restricted to a small number of higher-level private and public hospitals and reference laboratories. Furthermore, these services are often not available year-round and generally lack comprehensiveness in the range of tests offered. As a result, healthcare providers in Ethiopia are compelled to rely heavily on clinical experience when diagnosing and treating patients with suspected infections.

In 1923, Louis Pasteur famously stated, "Without laboratories, men of science are soldiers without arms" (2). Although this statement was made a century ago, it remains highly relevant today. In many regions of Africa, clinical laboratories struggle to provide adequate services. In their paper highlighting the challenges faced by laboratory services in combating antimicrobial resistance (AMR), Vounba and colleagues discussed the detrimental impact of inadequate laboratory infrastructure on the quality of clinical care (3). This is particularly evident in microbiology laboratories, which require substantial investment to establish and maintain. Unfortunately, the laboratory sector is often significantly underfunded, reflecting broader challenges within the health system as a whole (2). Of the approximately 500 microbiology laboratories accredited to international standards in sub-Saharan Africa (SSA), only a small fraction offers bacteriology diagnostics (4). This critical gap in the African healthcare system was also highlighted by Bashar et al. (5), who demonstrated how the lack of access to microbiology services contributes to reliance on empirical treatment and the rise of AMR. Several other studies have similarly described the absence of microbiology services as a significant barrier to effective healthcare in Africa (6–8).

Ethiopia faces challenges similar to those of other African countries with respect to healthcare infrastructure and service delivery. However, there is a notable scarcity of data providing clear evidence on the gaps in microbiological diagnostic services. In a study conducted by Daniel et al. in 2022 in Northeast Ethiopia, only 63% (252/402) of health facilities had a diagnostic laboratory, and in a significant majority, services were confined to basic tests such as microscopy and serology. Only a few facilities provided bacteriological culture and sensitivity testing (9). Both of these studies show evidence of a national laboratory system constrained by significant resource limitations. The gaps noted would affect laboratory services in terms of quality, variety, and consistent availability.

This article seeks to address the paucity of data in this field and discusses the availability of microbiology culture and sensitivity services in public facilities in Ethiopia, reflecting on the gaps in service delivery.

METHODS

The study was conducted from January to March 2024 in Addis Ababa, the capital city of Ethiopia, which had an estimated population of 5.5 million in 2023 (10). The majority of advanced health facilities and microbiological diagnostic services in Ethiopia are concentrated in the capital, making Addis Ababa an appropriate setting for this study. Healthcare facilities in the city feature clinical laboratories offering basic diagnostic services. These include simple microscopy, serology, hematology, and blood chemistry tests, with blood bank services integrated into laboratory operations. In contrast, primary healthcare facilities (health centers) in Ethiopia offer only limited laboratory services. Bacteriological culture and antimicrobial susceptibility testing are available in only a small number of public and private hospitals, as well as in selected research centers.

All 13 public hospitals in Addis Ababa were included in this study. Among these, facilities providing culture and antimicrobial susceptibility testing were selected for detailed assessment. A laboratory survey was conducted by a trained physician using a structured checklist based on WHO recommendations for standard bacteriology services in low-resource settings. Data collected through interviews were cross-verified using laboratory logbooks and direct observations.

Interviews primarily targeted microbiology laboratory heads, their deputies, or quality officers to ensure data reliability. In addition, baseline data on hospital service delivery volumes were obtained from the Federal Ministry of Health (FMOH) District Health Information System (DHIS). Data collected during the laboratory survey were cleaned, organized, and summarized. Findings from the survey were then narrated.

Ethical clearance was obtained from the Addis Continental Institute of Public Health Ethical Review Committee, as well as from the ethical review boards of each participating hospital and the Addis Ababa Health Bureau.

The following operational definitions are used.

Availability: The presence of microbiology culture and sensitivity laboratory services between July 2022 and June 2023.

Comprehensiveness: The range of culture types (bacteriological, anaerobic, and fungal) and antimicrobial susceptibility test panels offered between July 2022 and June 2023, compared with WHO standards.

Outpatient volume: The number of patients visiting the outpatient department between July 2022 and June 2023.

Sample volume: The number of samples received and processed by the facility's microbiology laboratory from July 2022 to June 2023.

Wastage rate: The proportion of antibiotic discs discarded due to expiry out of the total number of antibiotic discs in stock over the past 12 months.

RESULTS

Background data on laboratories in public hospitals in Addis Ababa: All 13 hospitals included in this study had laboratory facilities, of which eight had established microbiology laboratories. Seven of these eight had been fully functional for at least two years (2022–2023), while one became operational only in March 2024. During the data collection period, preparations were underway to initiate microbiology services in two additional public hospitals. All eight operational microbiology laboratories were included in this survey. Table 1 summarizes the service delivery volume and capacity for each facility.

Table 1: Volume of service delivery and service capacity for facilities under survey in Addis Ababa, Ethiopia, 2024.

Facilities under survey	Bed capacity**	Annual no of admissions**	Average Bed Occupancy rate**	Total new outpatients seen**
Yekatit 12 *	455	27,342	83.90%	275,050
Zewditu Memorial Hospital	300	10,654	82%	166,488
Menelik II Hospital	350	8,145	67.1	72,845
Tikur Anbessa Specialized Hospital	592	18,139	81.7	554,985
St Paul's Hospital	561	24,746	83.3	476,918
St Peter Hospital	303	14,467	77.1	196,770
ALERT Hospital	507	14,000	80.6	393,076

* Data from Yekatit 12's maternal and child health facility (Abebech Gobena) is included under Yekatit 12.

** Data depicted shows DHIS annual report during the Ethiopian fiscal year July 2022-June 2023

A scoring system was employed to quantify the completeness of antimicrobial susceptibility testing (AST). A score of 10 was assigned if testing for a given antimicrobial was conducted throughout the year, while a score of 0 was assigned if the service was not available at all. Accordingly, a laboratory performing AST for all 32 antimicrobials year-round would achieve a maximum score of 320. Table 3 presents the AST availability for each facility, along with the scoring framework used.

Table 3: Completeness of drug sensitivity tests per facility.

Facility	Score out of 320	Scoring scheme	
Yekatit 12	300	Availability of AST for period of 12 months for an antimicrobial	Score
Abebech Gobena	247.5	12 months a year	10
ZMH	220	> 9months a year	7.5
Menelik II	NA [Service started recently]	> 6 months [but less than 9mo] a year	5
TASH	170	less than 6 months a year	2.5
SPH	245	Never	0
St Peter	265		
ALERT	225		

Five of the eight laboratories were able to sustain service provision only with support from one or more non-governmental partner organizations (NGOs). One laboratory procured supplies through importation, as most required materials were unavailable in the local market. The remaining two relied solely on the national reference laboratory for supplies and were only marginally able to secure sufficient materials to maintain services throughout the fiscal year. Furthermore, seven of the microbiology laboratories reported using expired antimicrobial discs—after performing quality control tests—in an effort to minimize wastage.

Service utilization: The number of specimens processed by the eight laboratories per month ranged from 20 to 884. Apart from the aforementioned service interruptions and limited year-round availability, seven of the laboratories did not report any unmet need in terms of microbiology services. The crude and adjusted sample volumes are presented in Table 4.

Table 4: Service utilization of labs in terms of sample volume

Facility	Monthly number of admissions*	Sample volume per month*	Adjusted monthly sample volume*
Yekatit 12 and Abebech Gobena	2,279	426	426
Zewditu Memorial Hospital	888	220	564.62
Menelik II Hospital	679	20	67.3
Tikur Anbessa Specialized Hospital	1,512	884	1332.43
St Paul's Hospital Millennium Medical College	2,062	777	858.77
St Peter Hospital	1,206	190	359.05
ALERT Hospital	1,167	275	537.04

*Data depicted shows District Health Information System (DHIS) annual report during the Ethiopian fiscal year July 2022-June 2023

Based on the data presented in Table 1, each public hospital in Addis Ababa serves an average of 16,785 admissions and 305,162 outpatient visits annually. The lack of bacteriology services in five of these facilities indicates a significant gap in diagnostic capacity. Moreover, this figure does not account for underserved populations (both reported and unreported) even in hospitals where bacteriology laboratories are available.

DISCUSSIONS

Among the findings of this survey, several are particularly noteworthy. The provision of culture and sensitivity testing by only eight public facilities in the capital, the restriction of these services to bacteriology, and the reported service interruptions collectively highlight significant limitations within the health sector. The reliance on support from non-governmental organizations

(NGOs) to sustain even these basic services further underscores the extent of this gap. The absence of microbiological antimicrobial susceptibility testing services in five of the thirteen hospital laboratories is not unexpected, given the level of infrastructure, technical expertise, and resources required to establish and maintain such facilities. This situation is not unique to Ethiopia; similar challenges are evident across other sub-Saharan African countries with limited resources. For example, in Benin, only 27 out of 150 clinical laboratories nationwide offer bacteriology culture and AST services (11). Supporting this observation, a large-scale multicenter laboratory survey conducted across 28 African countries between June and August 2022 provided compelling evidence on the state of microbiology services in SSA. Out of 131 clinical laboratories assessed, only 91 offered bacteriology AST. Notably, the survey evaluated both public- and private-sector laboratories, with only 6 to 10 bacteriology laboratories reported from Ethiopia (12). A study focusing on bacteriology services in low-resource settings also reported similar findings, noting the limited number of bacteriology services in SSA (4).

The observed service interruptions due to supply shortages, as well as gaps in the comprehensiveness of testing in some laboratories, can likewise be explained by resource limitations. This issue has been highlighted in a study by Daniel et al., conducted in northern Ethiopia, which examined the impact of resource constraints on the quality of service delivery. The study reported that only 63% of health facilities had diagnostic capabilities, and that only a small proportion provided culture and antimicrobial susceptibility testing services (9). In Ethiopia, an estimated 17–43% of laboratory services are interrupted at least once a year, primarily due to the absence of a comprehensive annual laboratory plan, inadequate equipment maintenance, and shortages of reagents and supplies. The frequency of service interruptions increases with the complexity of the diagnostic tests being performed (13,14).

Interruptions in laboratory services can lead to substantial human and economic consequences, including increased patient morbidity and mortality, unnecessary healthcare costs, and misuse of antibiotics. They may also harm the reputation of healthcare institutions and contribute to financial losses (15). Such disruptions are particularly detrimental to hospital functioning, as they are incompatible with the continuous nature of hospital operations and can have an immediate negative impact on high-acuity clinical services essential for acute care settings (16).

According to Africa CDC, 85% of microbiology laboratories in Africa face challenges in securing supplies (17). The African region consistently ranks low in the World Bank Logistics Performance Index (18). In their commentary titled “Slow, difficult and expensive: How the lab supply market is crippling African science,” Allen et al. highlighted the persistent difficulties in obtaining essential laboratory consumables and equipment. The authors identified slow procurement processes, limited direct access to manufacturers, and inadequate logistics infrastructure as the primary contributing factors (19). Similarly, in our study, all microbiology laboratories experienced difficulties in securing supplies, and five were able to maintain functionality only through external support. The absence of local manufacturers of laboratory supplies, the national foreign currency crisis, the high cost of microbiology consumables, and the lack of a clear logistics framework for microbiology equipment are among the contributing factors. The national reference laboratory, the Ethiopian Public Health Institute (EPHI), is the sole importer and supplier of microbiology consumables, and its capacity does not meet existing demand. Supporting NGOs have therefore resorted to directly importing required items. This situation was also widely reflected in the National AMR Surveillance Annual Review Meeting organized by EPHI in 2010 (20).

The sample volume processed by each facility was used as a surrogate marker for the utilization of microbiology services. Differences in volume were notable even after standardizing for inpatient load per facility. Academic institutions such as Tikur Anbessa, St. Paul’s, and Yekatit 12 had relatively higher sample volumes.

According to an unpublished AMR surveillance report by EPHI, Tikur Anbessa and St. Paul's recorded the highest sample volumes in Ethiopia, with Tikur Anbessa alone contributing approximately 30% of the national clinical microbiology data annually. Academic facilities often host more experienced clinicians and tend to conduct more thorough patient investigations (10). Both institutions also have infectious disease subspecialty services, which may promote evidence-based clinical care and increased utilization of microbiology services. Paradoxically, a study conducted at Tikur Anbessa Hospital identified hierarchical culture within medical schools as a significant driver of empirical infection management (21).

In addition to its impact on clinical care and the overall quality of healthcare services, deficiencies in microbiology laboratory services significantly hinder efforts to combat antimicrobial resistance (AMR). AMR has become a critical global public health concern, particularly in SSA and Ethiopia (22–29). However, the lack of robust laboratory data has created a substantial gap in the epidemiological understanding of AMR across both Ethiopia and the wider African continent (3,30–33). Although Ethiopia has initiated a nationwide laboratory-based AMR surveillance system, limitations in microbiology laboratory capacity have constrained its scope and effectiveness (33).

Similarly, across Africa, while the burden of AMR is believed to be high, this assumption is not adequately supported by comprehensive laboratory surveillance data (25,30). The Africa CDC policy brief, "The Crisis Within a Crisis," highlights this information gap, referring to it as "flying blind." The true magnitude, characteristics, and impact of AMR in sub-Saharan Africa remain largely unknown (32). Given that AMR is now recognized as one of the top ten global threats to human health (25,26), addressing the laboratory data gap must become an urgent priority if Africa is to effectively respond to this growing crisis.

This study seeks to address the significant information gap within Ethiopia's healthcare system regarding microbiology laboratory services. While this snapshot assessment provides valuable insights, it is important to acknowledge its limitations. A more comprehensive and detailed evaluation is necessary to fully understand the gaps, particularly if the goal is to inform programmatic interventions and long-term planning. Such an approach would also enable in-depth analysis of findings not captured in this study.

The choice of Addis Ababa as the study setting enabled access to a large number of laboratories; however, this may affect the generalizability of the findings. Laboratories in the capital are typically better resourced than those in other regions, potentially skewing the overall picture. Likewise, the exclusion of private-sector laboratories, some of which may be better equipped, may lead to an underestimation of national microbiology capacity. Unfortunately, the lack of comparable studies from the private sector limited further analysis. Finally, while the findings provide important observational data, the study did not assess the direct clinical impact of the identified gaps in laboratory services, highlighting an important area for future research.

The author strongly recommends the active engagement of all relevant stakeholders to address the critical service gaps identified in this study. Strategic planning should prioritize the expansion of microbiology services and the upgrading of existing laboratory infrastructure to support reliable, uninterrupted, and comprehensive bacteriology testing. Expanding the diagnostic scope to include anaerobic and fungal cultures, antimicrobial susceptibility testing, virology, and molecular diagnostics is essential to improve diagnostic accuracy and patient outcomes. Furthermore, service expansion should be guided by a well-coordinated strategy that ensures equitable distribution of microbiology services across regions. Establishing a tiered referral system is key to ensuring service delivery within defined catchment areas, and partnerships with private laboratories may provide a viable solution. Developing an efficient and reliable supply chain system will also be critical, alongside promoting local production of laboratory supplies to address the observed unmet demand for materials and equipment.

In conclusion, bridging the gaps in microbiology services will require coordinated efforts, sustained investment, and a long-term commitment to strengthening laboratory systems. Such efforts are not only vital for enhancing routine clinical care but are also indispensable in addressing emerging public health threats, including antimicrobial resistance.

REFERENCES

1. Alemkere G, Gilagil G, Gebrehiwot T, Tilahun Z, Mengist HM. Physicians' utilization of microbiologic reports and determinants of their preference to order culture in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. *BMC Research Notes.* 2018 Sep 21;11(1):675.
2. Okeke IN, Aboderin OA, Byarugaba DK, Ojo KK, Opintan JA. Growing Problem of Multidrug-Resistant Enteric Pathogens in Africa. *Emerg Infect Dis.* 2007 Nov;13(11):1640–6. doi:10.3201/eid1311.070674
3. Vounba P, Loul S, Tamadea LF, Siawaya JFD. Microbiology laboratories involved in disease and antimicrobial resistance surveillance: Strengths and challenges of the central African states. *Afr J Lab Med.* 2022 Mar 31;11(1):1570.
4. Barbé B, Yansouni CP, Affolabi D, Jacobs J. Implementation of quality management for clinical bacteriology in low-resource settings. *Clin Microbiol Infect.* 2017 Jul;23(7):426–33.
5. Gulumbe BH, Haruna UA, Almazan J, Ibrahim IH, Faggo AA, Bazata AY. Combating the menace of antimicrobial resistance in Africa: a review on stewardship, surveillance and diagnostic strategies. *Biol Proced Online.* 2022 Nov 23;24:19. doi:10.1186/s12575-022-00182-y
6. Perkins M, Dye C, Balasegaram M et al. Diagnostic preparedness for infectious disease outbreaks. *The Lancet.* 2017; 390, 2211-2214
7. Ombelet S, Ronat JB, Walsh T, Yansouni CP, Cox J, Vlieghe E, et al. Clinical bacteriology in low-resource settings: today's solutions. *The Lancet Infectious Diseases*. 2018 Aug 1;18(8):e248–58.
8. Cathy A. Petti, Christopher R. Polage, Thomas C. Quinn, Allan R. Ronald, Merle A. Sande, Laboratory Medicine in Africa: A Barrier to Effective Health Care. *Clinical Infectious Diseases.* 2006;42(3):377–382.
9. Abebe, D.D., Temesgen, M.M. & Abozin, A.T. Clinicians' satisfaction with laboratory services and associated factors at public health facilities in Northeast Ethiopia. *BMC Health Serv Res.* 2023;23:475.
10. Addis Ababa Population 2026. World Population Review. Retrieved April 1, 2026, from https://worldpopulationreview.com/cities/ethiopia/addis-ababa
11. Legba BB, Dougnon V, Koudokpon H, Mero S, Elovainio R, Parry M, et al. Assessment of blood cultures and antibiotic susceptibility testing for bacterial sepsis diagnosis and utilization of results by clinicians in Benin: A qualitative study. *Front Public Health.* 2023 Jan 16;10:1088590.
12. Jacobs JW, Adkins BD, Milner DA Jr, Bloch EM, Eichbaum Q, on behalf of the Vanderbilt Pathology Program in Global Health (VPPIGH). Survey of clinical microbiology and infectious disease testing capabilities among institutions in Africa. *American Journal of Clinical Pathology.* 2025 Apr 1;163(4):526–30.
13. Mulu T. Assessment of Laboratory Service Interruption and its Associated Factors in Public Hospitals, Addis Ababa, Ethiopia. Addis Ababa University; 2020. Available from: http://etd.aau.edu.et/handle/123456789/26110
14. 14. Zakir D, Mekonnen GK, Negash B, Marami D. Level of health laboratory service quality, service interruptions, and its predictors in public hospitals in Harar town, eastern Ethiopia. *Front Health Serv.* 2024 Nov 19;4:1492766.doi:10.3389/frhs.2024.1492766.

15. World Health Organization. Joint WHO-CDC conference on laboratory quality systems, Lyon, April 2008 — joint statement and recommendations, *Weekly Epidemiological Record.* 2008;83(32), 285 - 287.
16. Trevor F. Peter, Philip D. Rotz, Duncan H. Blair, Aye-Aye Khine, Richard R. Freeman, Maurine M. Murtagh, Impact of Laboratory Accreditation on Patient Care and the Health System. *American Journal of Clinical Pathology*. 2010;134(4):550–555.
17. Africa CDC. Africa requires skills to plug gaps in diagnostic capacity and disease surveillance. Available from: https://africacdc.org/news-item/africa-requires-skills-to-plug-gaps-in-diagnostic-capacity-and-disease-surveillance/
18. World Bank Group. Trade Logistics in the Global Economy | Logistics Performance Index (LPI). Available from: https://lpi.worldbank.org/
19. Allen Mukhwana, Oluwaseyi Shorinola, Deborah-Fay Ndlovu and Julius Osaso. Slow, difficult and expensive: How the lab supplies market is crippling African science. Nature Index, 2024. Available from: https://www.nature.com/nature-index/news/slow-difficult-expensive-how-lab-supplies-market-crippling-african-science
20. Ethiopian Health and Nutrition Research Institute. Report from Review Meeting of the National Laboratory System. September 2010. Available from: https://sl1nk.com/nrtxxtj
21. Gebretekle GB, Mariam DH, Abebe W, Amogne W, Tenna A, Fenta TG, et al. Opportunities and barriers to implementing antibiotic stewardship in low and middle-income countries: Lessons from a mixed-methods study in a tertiary care hospital in Ethiopia. P*LOS ONE.* 2018 Dec 20;13(12):e0208447.
22. World Health Organization (2015). Global action plan on antimicrobial resistance. World Health Organization. Available from: https://iris.who.int/handle/10665/193736
23. World Health Organization (2021). Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report: 2021. Available from: https://www.who.int/publications/i/item/9789240027336
24. Varma JK, Oppong-Otoo J, Ondoa P, Perovic O, Park BJ, Laxminarayan R, et al. Africa Centres for Disease Control and Prevention's framework for antimicrobial resistance control in Africa. *African Journal of Laboratory Medicine.* 2018 Dec 6;7(2):4. doi:10.4102/ajlm.v7i2.830
25. Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet.* 2022 Feb 12;399(10325):629–55. doi:10.1016/S0140-6736(21)02724-0
26. EClinicalMedicine. Antimicrobial resistance: a top ten global public health threat. EClinicalMedicine. 2021 Nov 24;41:101221. doi: 10.1016/j.eclinm.2021.101221. PMID: 34877512; PMCID: PMC8633964.
27. Mamuye Y. Antibiotic Resistance Patterns of Common Gram-negative Uropathogens in St. Paul's Hospital Millennium Medical College. *Ethiopian Journal of Health Sciences.* 2016 Mar 30;26(2):93–100. doi:10.4314/ejhs.v26i2.2
28. Eromo T, Tassew H, Daka D, Kibru G. Bacteriological Quality of Street Foods and Antimicrobial Resistance of Isolates in Hawassa, Ethiopia. E*thiopian Journal of Health Sciences*. 2016; 26(6):533–44.
29. Mulu W, Kibru G, Beyene G, Damtie M. Postoperative Nosocomial Infections And Antimicrobial Resistance Pattern Of Bacteria Isolates Among Patients Admitted At Felege Hiwot Referral Hospital, Bahirdar, Ethiopia. *Ethiopian Journal of Health Sciences.* 2012;22(1):7–18.
30. Kajumbula HM, Amoako DG, Tessema SK, Aworh MK, Chikuse F, Okeke IN, et al. Enhancing clinical microbiology for genomic surveillance of antimicrobial resistance implementation in Africa.

Antimicrobial Resistance & Infection Control. 2024 Nov 13;13(1):135.

31. Founou LL, Lawal OU, Djiyou A, Odih EE, Amoako DG, Fadanka S, et al. Enable, empower, succeed: a bioinformatics workshop Harnessing open web-based tools for surveillance of bacterial antimicrobial resistance. *BMC Microbiology.* 2025 Mar 19;25(1):156.
32. Africa CDC (2022). Incomplete Antimicrobial Resistance Data in Africa: The Crisis Within Crisis-Policy-Brief. Available from: https://sl1nk.com/90clg5y
33. 33. Hazim C, Ibrahim RA, Westercamp M, Belete GA, Kibret BA, Kanter T, et al. Establishment of a Sentinel Laboratory-Based Antimicrobial Resistance Surveillance Network in Ethiopia. *Health Secur.* 2018;16(Suppl 1):S30–6.