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Diagnostic Stewardship for Combating Antimicrobial Resistance in Resource-Limited Healthcare Settings: From Better Testing to Better Treatment

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ABSTRACT

Background: Antimicrobial resistance (AMR) is sustained not only by inappropriate antimicrobial use but also by diagnostic failure. Unnecessary testing can trigger treatment of colonization or contamination, whereas absent, delayed, or poorly communicated testing encourages prolonged empirical broad-spectrum therapy. Diagnostic stewardship seeks to ensure that the right test is obtained from the right patient, at the right time, and that its result is interpreted and acted upon correctly.

Objective: To synthesize the role of diagnostic stewardship in AMR control, with emphasis on implementation in resource-limited healthcare settings.

Methods: A targeted narrative review of peer-reviewed literature and World Health Organization guidance published primarily from 2015 through October 2026 was undertaken. Evidence concerning conventional microbiology, biomarkers, rapid and point-of-care tests, clinical decision support, laboratory strengthening, and linkage with antimicrobial stewardship was prioritized.

Findings: Diagnostic tools have greatest clinical value when embedded in a pathway that links appropriate test selection and specimen quality to timely reporting and antimicrobial-stewardship action. Rapid tests paired with stewardship can shorten time to optimal treatment and may improve survival in bloodstream infection. Lower-cost approaches—including specimen criteria, reflex testing, selective reporting, clinical decision support, and locally adapted laboratory quality systems—can reduce low-value testing and improve use of existing capacity. Major constraints include weak laboratory infrastructure, supply instability, workforce shortages, fragmented clinical-laboratory communication, and limited evaluation of patient-centered outcomes.

Conclusion: Diagnostic stewardship should be treated as a clinical system rather than a technology-purchasing exercise. Resource-limited facilities can begin with high-burden syndromes, strengthen the pre-analytic and post-analytic pathway, connect results to treatment decisions, and monitor safety alongside antimicrobial use.

KEYWORDS: Antimicrobial Resistance; Antimicrobial Stewardship; Diagnostic Stewardship; Clinical Microbiology; Rapid Diagnostic Tests; Resource-Limited Settings

1. Introduction

Antimicrobial resistance is a clinical, public-health, and health-system threat. The Global Burden of Disease 2021 analysis forecast that, under its reference scenario, approximately 1.91 million deaths could be attributable to bacterial AMR in 2050, with the largest future mortality rates expected in South Asia and Latin America and the Caribbean [1]. Although antimicrobial development and infection prevention remain essential, the quality and availability of diagnosis determine whether existing antimicrobials are used promptly, safely, and selectively.

The diagnostic gap is substantial. The Lancet Commission on diagnostics described inequitable access to basic diagnostic services across levels of care and argued that diagnostics must be understood as an integral component of universal health coverage rather than an optional technical add-on [2]. In many resource-limited settings, clinicians must make treatment decisions without reliable culture, antimicrobial susceptibility testing, biomarkers, imaging, or timely result communication. This uncertainty encourages empirical broad-spectrum treatment. Conversely, indiscriminate testing can identify colonization, contamination, or clinically irrelevant targets and thereby provoke avoidable antimicrobial use.

Diagnostic stewardship addresses both underuse and overuse. World Health Organization (WHO) guidance frames it as coordinated action to improve appropriate microbiological diagnosis and antimicrobial susceptibility testing so that patient management and AMR surveillance become more reliable [3]. More recent WHO guidance emphasizes selecting the right test, collecting the right specimen correctly, and using the result at the right time [4]. The purpose is not simply to reduce the number of tests. It is to improve the probability that each test produces information that changes management in a beneficial way.

This narrative review examines diagnostic stewardship across the testing pathway; summarizes evidence for conventional, biomarker-based, rapid, and digitally supported approaches; and proposes a staged implementation framework for resource-limited healthcare facilities. The central argument is that a diagnostic device has limited value unless the surrounding clinical system converts its result into an appropriate treatment decision.

2. Review approach

This article is a targeted narrative review. Searches were performed in PubMed and on WHO websites using combinations of the terms “diagnostic stewardship,” “antimicrobial stewardship,” “antimicrobial resistance,” “rapid diagnostic test,” “point-of-care testing,” “clinical decision support,” “low-resource,” and “low- and middle-income countries.” Literature published primarily between January 2015 and October 2026 was considered, together with older or foundational sources where needed. Priority was given to systematic reviews, meta-analyses, randomized trials, implementation studies, international guidance, and papers directly addressing resource-constrained settings. Because study selection was purposive rather than exhaustive and no duplicate screening or formal risk-of-bias assessment was performed, the work should not be interpreted as a systematic review.

3. Diagnostic stewardship as a clinical pathway

Diagnostic stewardship and antimicrobial stewardship are complementary. Antimicrobial stewardship focuses on the choice, dose, route, and duration of treatment. Diagnostic stewardship improves the information on which those decisions depend. The integrated antimicrobial, infection-prevention, and diagnostic stewardship model recognizes that these activities share patients, workflows, data, and institutional objectives [5]. Separation into independent programs can create predictable failures: a laboratory may produce a result that reaches the ward too late; a rapid test may be ordered for patients with a low pre-test probability; or a resistance marker may be reported without guidance on what it does and does not predict.

The testing pathway can be divided into three linked phases. In the *pre-analytic phase*, clinicians decide whom to test, what specimen to obtain, and when and how to collect it. Errors include testing

patients without a compatible syndrome, drawing inadequate blood-culture volume, collecting after antimicrobials have started, or submitting contaminated material. In the *analytic phase*, the laboratory selects and performs methods, ensures quality control, and determines which results require confirmation. In the *post-analytic phase*, results are interpreted, communicated, and translated into action. Diagnostic stewardship can intervene at every phase through ordering criteria, specimen-rejection rules, reflex algorithms, selective susceptibility reporting, rapid notification, interpretive comments, and prospective antimicrobial-stewardship review.

Rapid molecular diagnostics illustrate why the entire pathway matters. They can identify organisms or resistance determinants hours earlier than conventional methods, but detection is not equivalent to disease and a genetic marker does not always provide a complete susceptibility phenotype. Appropriate patient selection and expert interpretation remain necessary. Reviews of rapid-diagnostic implementation consistently emphasize that trained clinicians and stewardship teams are required to convert faster results into faster optimization of therapy [6,7].

4. Diagnostic modalities and stewardship applications

4.1 Conventional microbiology and antimicrobial susceptibility testing

Culture and phenotypic susceptibility testing remain foundational because they can establish organism viability and provide a clinically interpretable susceptibility profile. Their limitations—turnaround time, vulnerability to pre-analytic error, dependence on viable organisms, and infrastructure requirements—are especially important in resource-limited settings. Stewardship should therefore begin with basic reliability: correct specimen selection, adequate volume, timely transport, standardized methods, internal quality control, external quality assessment where feasible, and a clear system for urgent-result communication.

Laboratory strengthening does not always require immediate purchase of the most advanced platform. At a referral hospital in Ethiopia, a bundle comprising needs assessment, adapted standard operating procedures, training, supervision, quality systems, and an automated blood-culture platform increased average specimen volume from 15 to 75 per day and blood cultures from approximately 2 to more than 45 per day during the first 18 months; antimicrobial susceptibility testing and institutional antibiograms were also introduced [8]. This experience supports staged investment in people, process, and quality management alongside equipment.

4.2 Biomarkers

Biomarkers can reduce diagnostic uncertainty but must be used within syndrome-specific algorithms. In a randomized trial involving primary-care patients with non-severe acute respiratory infection in Vietnam, point-of-care C-reactive protein testing reduced reported antibiotic use within 14 days from 78% to 64% without prolonging symptom resolution [9]. Procalcitonin-guided protocols have also reduced antibiotic exposure in respiratory infection and critical-care populations, although effects vary by setting, protocol adherence, and the decision being supported [10]. Biomarkers should therefore modify rather than replace clinical assessment. Thresholds, repeat-testing rules, exceptions, and safety-netting must be explicit.

4.3 Rapid organism identification and resistance detection

Rapid diagnostic tests include antigen assays, nucleic-acid amplification, multiplex polymerase chain reaction panels, matrix-assisted laser desorption/ionization time-of-flight mass spectrometry, rapid phenotypic susceptibility methods, and emerging microfluidic or biosensor platforms. Their most compelling use case is a time-sensitive syndrome in which earlier information changes treatment. Bloodstream infection is the best-studied example.

A 2024 network meta-analysis of 88 reports and 25,682 patient encounters found that rapid testing combined with an antimicrobial-stewardship program was associated with lower mortality than conventional blood culture alone (odds ratio 0.72, 95% confidence interval 0.59–0.87) and shortened

time to optimal therapy by 29 hours. Rapid testing alone did not show the same survival advantage [11]. This distinction is central: analytical speed is only an intermediate outcome. The clinical intervention is the combination of a timely result, a person or system that recognizes its significance, and an authorized treatment response.

Economic value is likewise context dependent. A decision-analytic model of bloodstream-infection diagnostics found that several rapid-test strategies could be cost-effective, and that pairing testing with stewardship increased the probability of cost-effectiveness [12]. However, such models depend on local test cost, pathogen prevalence, baseline turnaround time, length-of-stay assumptions, and the ability to act on results. Facilities should avoid importing economic conclusions without local sensitivity analysis.

4.4 Clinical decision support and result reporting

Diagnostic stewardship can produce benefit without introducing a new assay. Electronic or paper-based decision support can require an indication, display minimum clinical criteria, discourage duplicate testing, or trigger reflex laboratory pathways. In a systematic review of clinical decision support for urinary-tract-infection diagnosis, all nine studies with statistical comparisons reported lower urine-culture use after intervention; four studies included in meta-analysis yielded a pooled post-intervention versus pre-intervention incidence-rate ratio of 0.56 [13]. Evidence about patient-centered outcomes and unintended effects was less mature, underscoring the need for balancing measures.

Post-analytic changes may include cascade reporting, in which narrower agents are displayed before broader agents; interpretive comments that distinguish colonization from infection; suppression of selected low-value results; and direct notification of critical or actionable findings. Urine-culture stewardship demonstrates how coordinated changes to ordering, processing, and reporting can reduce treatment of asymptomatic bacteriuria [14]. Such approaches must include exemptions for populations in whom common rules do not apply, and they should be monitored for delayed or missed treatment.

Broader implementation reviews and WHO stewardship guidance likewise emphasize that diagnostic interventions should be paired with clear prescribing actions, trained personnel, and continuous audit and feedback [15,16].

5. Why implementation is difficult in resource-limited settings

5.1 Infrastructure and supply chains

Reliable electricity, temperature control, water, specimen transport, equipment maintenance, consumables, and quality-assurance materials are prerequisites for dependable diagnostics. A donated instrument can become unusable if proprietary cartridges, service engineers, or foreign currency are unavailable. Procurement decisions should therefore consider total cost of ownership, supply continuity, maintenance response, waste disposal, and availability of alternative workflows—not only the purchase price [4,7,8].

5.2 Workforce and communication

Diagnostic stewardship requires cooperation among prescribers, nurses, microbiology staff, pharmacists, information-technology personnel, infection-prevention teams, and administrators. Staffing shortages may make continuous specialist review impossible. Facilities can respond with standardized algorithms, scheduled rather than continuous review, tiered notification, telemicrobiology, and focused training of local champions. These adaptations should reduce dependence on a single individual [4,6,7,15].

5.3 Clinical trust and behavioral incentives

Clinicians may distrust negative results when test sensitivity, specimen quality, or laboratory reliability is uncertain. Patients may expect antibiotics, and prescribers may view empirical treatment as the safer option when follow-up is difficult. Education alone rarely resolves these pressures. Stewardship

interventions should address the behavior at the point of decision through accessible guidelines, peer comparison, audit and feedback, senior clinical endorsement, and an explicit escalation pathway when a patient deteriorates [4,16].

5.4 Information systems and turnaround time

A clinically useful turnaround time includes the interval from the decision to test through specimen collection, transport, analysis, result verification, communication, and treatment change. Measuring only laboratory processing time can conceal the main delay. Where electronic records are unavailable, simple registers, messaging protocols, standardized telephone read-back, and daily stewardship-laboratory huddles can close the loop. Any use of consumer messaging platforms must comply with local privacy requirements [4,6].

5.5 Evidence transferability and equity

Much of the high-certainty evidence for advanced rapid testing originates from well-resourced hospitals. Baseline mortality, organism distribution, laboratory practice, staffing, and drug availability differ across settings. A test that identifies resistance without access to an effective alternative drug may improve surveillance but not the individual patient's outcome. Similarly, centralizing sophisticated testing can widen disparities if rural facilities cannot transport specimens or receive results promptly. Equity must therefore be an explicit implementation outcome [2,7].

6. A staged implementation framework

A practical program can begin with one syndrome and one measurable decision rather than attempting institution-wide transformation. The proposed framework in Table 1 synthesizes WHO guidance and implementation evidence [3,4,7].

Table 1. Staged framework for diagnostic stewardship

Stage	Core actions	Example outputs
1. Define the clinical problem	Select a high-burden syndrome; describe current testing and prescribing; identify harm caused by delay, overtesting, contamination, or non-action.	Baseline pathway map; agreed problem statement; target population.
2. Repair the basic pathway	Standardize indications, specimen collection, labeling, transport, quality control, result ownership, and urgent communication.	Standard operating procedures; collection checklist; escalation roster.
3. Select the intervention	Compare workflow redesign, reflex testing, biomarkers, culture improvement, and rapid testing using local prevalence, feasibility, and total cost.	Business case; selection criteria; implementation protocol.
4. Link results to action	Create treatment algorithms; define who receives results and by when; authorize de-escalation or escalation; integrate pharmacy or stewardship review.	Result-to-action algorithm; notification script; clinician training.
5. Pilot and monitor safety	Start in one ward or clinic; measure process, antimicrobial, clinical, economic, and equity outcomes; review adverse events.	Run chart or dashboard; incident-review process; revised workflow.
6. Sustain and scale	Embed responsibilities, supplies, competencies, audit, maintenance, and financing; adapt before spreading to new syndromes or sites.	Annual budget; competency records; quality indicators; scale-up plan.

Intervention selection should be syndrome specific. For suspected bloodstream infection, the first priority may be adequate blood volume, contamination reduction, reliable incubation, and immediate communication of positive cultures. For respiratory infection in primary care, a biomarker algorithm plus safety-netting may be more feasible. For suspected urinary infection, indication prompts and reflex-culture criteria may have greater value than a new molecular test. The “best” technology is

therefore the one that resolves the dominant local decision failure at an affordable opportunity cost [4,9,14].

7. Measurement and evaluation

Evaluation should extend beyond test counts. Process measures can include the proportion of eligible patients tested, specimen adequacy, contamination rate, transport delay, laboratory turnaround time, time from result availability to acknowledgement, and time to treatment modification. Antimicrobial outcomes can include time to effective therapy, time to optimal or narrower therapy, days of therapy, broad-spectrum days, guideline concordance, and discontinuation when bacterial infection is unlikely [4,7].

Clinical outcomes should include mortality where appropriate, treatment failure, readmission, length of stay, complications, and adverse drug events. Economic measures should distinguish laboratory costs from total episode-of-care costs. Balancing measures are essential: missed infection, delayed treatment, repeat attendance, inappropriate withholding of antimicrobials, and unequal access across sex, age, geography, or ability to pay. A reduction in tests is not success if it shifts harm to patients who already face access barriers [2,4,7,16].

When randomization is impractical, interrupted time-series designs provide stronger inference than simple before-and-after comparisons by modeling the pre-intervention trend [17]. Qualitative interviews or structured feedback can reveal why clinicians override a prompt, why samples are delayed, or why a result does not change therapy. Mixed-method evaluation is particularly useful because diagnostic stewardship is a sociotechnical intervention.

8. Future priorities

Research should move from analytical accuracy alone to implementation effectiveness. First, more pragmatic trials are needed in district hospitals, primary care, pediatric populations, and rural settings. Second, studies should report the full diagnostic timeline and the proportion of results that produce an appropriate treatment change. Third, economic evaluations should use local costs and compare diagnostics with alternative investments such as specimen transport, staff training, conventional laboratory improvement, or additional pharmacy capacity [7,11,12].

Digital connectivity offers opportunities for remote interpretation, automated alerts, cumulative antibiograms, and regional surveillance, but algorithms trained in one setting may perform poorly in another. Transparent validation, human oversight, data governance, and downtime procedures are necessary [2,4,7]. Finally, national essential-diagnostics policies should be linked to essential medicines, laboratory networks, AMR surveillance, and stewardship training. Expanding diagnosis without access to effective treatment—or expanding treatment without reliable diagnosis—cannot deliver equitable AMR control [2,3,4,16].

9. Limitations

This narrative review used a targeted rather than systematic search. Study selection and interpretation may therefore be subject to author judgment, and no formal risk-of-bias assessment was conducted. The evidence base is heterogeneous across syndromes, technologies, outcomes, and health-system contexts. Several quantitative findings derive from high-income hospitals and may not transfer directly to resource-limited settings. The proposed implementation framework is a synthesis for practical use and requires prospective evaluation.

10. Conclusion

Diagnostic stewardship is a necessary bridge between laboratory information and responsible antimicrobial use. Its purpose is not maximal testing or minimal testing, but clinically appropriate testing followed by timely, interpretable, and actionable results. Evidence from bloodstream infection, respiratory infection, and urinary diagnostics shows that benefit depends on linkage to treatment decisions [6,7,11,15]. For resource-limited facilities, foundational investments in specimen quality,

conventional microbiology, communication, workforce capability, and measurement may produce greater and more sustainable value than isolated acquisition of advanced platforms. Programs should begin with a defined clinical problem, redesign the complete pathway, pair results with stewardship action, and monitor both benefit and unintended harm.

Declarations

Ethics approval and consent to participate: Not applicable. This narrative review used publicly available published literature and did not involve human participants, identifiable data, or animals.

References

1. GBD 2021 Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. *Lancet*. 2024;404(10459):1199–1226. doi:[10.1016/S0140-6736\(24\)01867-1](https://doi.org/10.1016/S0140-6736(24)01867-1).
2. Fleming KA, Horton S, Wilson ML, et al. The Lancet Commission on diagnostics: transforming access to diagnostics. *Lancet*. 2021;398(10315):1997–2050. doi:[10.1016/S0140-6736\(21\)00673-5](https://doi.org/10.1016/S0140-6736(21)00673-5).
3. World Health Organization. *Diagnostic stewardship: a guide to implementation in antimicrobial resistance surveillance sites*. Geneva: WHO; 2016. WHO/DGO/AMR/2016.3. Available from: [WHO publication page](https://www.who.int/publications/m/item/diagnostic-stewardship-a-guide-to-implementation-in-antimicrobial-resistance-surveillance-sites).
4. World Health Organization Regional Office for the Western Pacific. *Strengthening clinical diagnostic stewardship in the Western Pacific Region: a practical manual*. Manila: WHO Regional Office for the Western Pacific; 2026. ISBN 978-92-9-062136-2. Available from: [WHO publication page](https://www.who.int/publications/m/item/strengthening-clinical-diagnostic-stewardship-in-the-western-pacific-region-a-practical-manual).
5. Dik JWH, Poelman R, Friedrich AW, et al. An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID). *Future Microbiol*. 2016;11(1):93–102. doi:[10.2217/fmb.15.99](https://doi.org/10.2217/fmb.15.99).
6. Messacar K, Parker SK, Todd JK, Dominguez SR. Implementation of rapid molecular infectious disease diagnostics: the role of diagnostic and antimicrobial stewardship. *J Clin Microbiol*. 2017;55(3):715–723. doi:[10.1128/JCM.02264-16](https://doi.org/10.1128/JCM.02264-16).
7. Moore LSP, Villegas MV, Wenzler E, et al. Rapid diagnostic test value and implementation in antimicrobial stewardship across low-to-middle and high-income countries: a mixed-methods review. *Infect Dis Ther*. 2023;12(6):1445–1463. doi:[10.1007/s40121-023-00815-z](https://doi.org/10.1007/s40121-023-00815-z).
8. Yansouni CP, Seifu D, Libman M, et al. A feasible laboratory-strengthening intervention yielding a sustainable clinical bacteriology sector to support antimicrobial stewardship in a large referral hospital in Ethiopia. *Front Public Health*. 2020;8:258. doi:[10.3389/fpubh.2020.00258](https://doi.org/10.3389/fpubh.2020.00258).
9. Do NTT, Ta NTD, Tran NTH, et al. Point-of-care C-reactive protein testing to reduce inappropriate use of antibiotics for non-severe acute respiratory infections in Vietnamese primary health care: a randomised controlled trial. *Lancet Glob Health*. 2016;4(9):e633–e641. doi:[10.1016/S2214-109X\(16\)30142-5](https://doi.org/10.1016/S2214-109X(16)30142-5).
10. Schuetz P, Wirz Y, Sager R, et al. Effect of procalcitonin-guided antibiotic treatment on mortality in acute respiratory infections: a patient level meta-analysis. *Lancet Infect Dis*. 2018;18(1):95–107. doi:[10.1016/S1473-3099\(17\)30592-3](https://doi.org/10.1016/S1473-3099(17)30592-3).
11. Peri AM, Chatfield MD, Ling W, Furuya-Kanamori L, Harris PNA, Paterson DL. Rapid diagnostic tests and antimicrobial stewardship programs for the management of bloodstream infection: what is their relative contribution to improving clinical outcomes? A systematic review and network meta-analysis. *Clin Infect Dis*. 2024;79(2):502–515. doi:[10.1093/cid/ciae234](https://doi.org/10.1093/cid/ciae234).
12. Pliakos EE, Andreatos N, Shehadeh F, Ziakas PD, Mylonakis E. The cost-effectiveness of rapid diagnostic testing for the diagnosis of bloodstream infections with or without antimicrobial stewardship. *Clin Microbiol Rev*. 2018;31(3):e00095-17. doi:[10.1128/CMR.00095-17](https://doi.org/10.1128/CMR.00095-17).

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13. Hojat LS, Saade EA, Hernandez AV, Donskey CJ, Deshpande A. Can electronic clinical decision support systems improve the diagnosis of urinary tract infections? A systematic review and meta-analysis. *Open Forum Infect Dis.* 2023;10(1):ofac691. doi:[10.1093/ofid/ofac691](https://doi.org/10.1093/ofid/ofac691).
 14. Coffey KC, Claeys K, Morgan DJ. Diagnostic stewardship for urine cultures. *Infect Dis Clin North Am.* 2024;38(2):255–266. doi:[10.1016/j.idc.2024.03.004](https://doi.org/10.1016/j.idc.2024.03.004).
 15. Minejima E, Wong-Beringer A. Implementation of rapid diagnostics with antimicrobial stewardship. *Expert Rev Anti Infect Ther.* 2016;14(11):1065–1075. doi:[10.1080/14787210.2016.1233814](https://doi.org/10.1080/14787210.2016.1233814).
 16. World Health Organization Regional Office for Europe. *Antimicrobial stewardship interventions: a practical guide*. Copenhagen: WHO Regional Office for Europe; 2021. ISBN 978-92-890-5626-7. Available from: [WHO publication page](#).
 17. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. *Int J Epidemiol.* 2017;46(1):348–355. doi:[10.1093/ije/dyw098](https://doi.org/10.1093/ije/dyw098).