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Hospital Antimicrobial Stewardship in Resource-Limited Settings: Implementation Evidence

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Abstract

Hospital antimicrobial stewardship (AMS) may improve prescribing in resource-limited hospitals, but differences in staffing, diagnostics, and information systems complicate implementation. This structured evidence review examined hospital-focused reviews and implementation studies, prioritizing publications from 2022 to September 2026 and retaining relevant foundational sources. PubMed-indexed publications and publisher pages informed source identification; studies were considered for hospital relevance, intervention features, context, and outcomes, then compared through a qualitative matrix of intervention mechanisms, resource requirements, organizational determinants, and indicators. The review was not an exhaustive systematic search, and screening totals and formal risk-of-bias scores were unavailable. Hospital evidence more consistently suggests improvements in prescribing appropriateness, antibiotic exposure, or costs than in mortality or length of stay; study heterogeneity limits causal inference. Leadership, actionable feedback, and usable prescribing information appear important for implementation, although their effects vary by context. The review distinguishes these evidence-supported functions from a proposed, unvalidated minimum viable AMS model combining accountable leadership, targeted review, local guidance, and feasible monitoring. Its practical contribution is a capacity-sensitive sequence for hospital pilots that measures patient safety alongside antibiotic use. Prospective validation across different hospital settings remains necessary.

Keywords: *Antimicrobial Stewardship, Antibiotic Prescribing, Hospitals, Implementation, Resource-Limited Settings.*

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INTRODUCTION

Antimicrobial resistance has moved from a microbiological concern to a direct constraint on routine clinical care, increasingly affecting the safety, effectiveness, and sustainability of hospital-based treatment across health systems. The global analysis of bacterial antimicrobial resistance estimated a substantial mortality burden associated with resistant infections, with the consequences extending beyond individual treatment failure to increased pressure on health services and therapeutic options (Murray et al., 2022). The problem is particularly consequential in resource-limited settings, where high infectious disease burdens coexist with restricted diagnostic capacity, constrained medicine supplies, and limited systems for monitoring antimicrobial use. Antimicrobial stewardship therefore cannot be reduced to an antibiotic-reduction strategy because its clinical purpose is to improve the probability that patients receive an effective agent, dose, route, and duration while minimizing unnecessary exposure that promotes resistance or causes drug-related harm. The World Health Organization's AWaRe framework has further strengthened the emphasis on appropriate antibiotic selection, monitoring, and optimization as components of responsible antimicrobial use (World Health Organization, 2023). At the hospital level, stewardship has consequently evolved into a quality-of-care function that connects prescribing decisions with infection management, patient safety, resistance containment, and health-system sustainability.

Hospital antimicrobial stewardship uses prospective audit and feedback, authorization or restriction, local treatment guidance, dose review, intravenous-to-oral conversion, and surgical-prophylaxis review to influence prescribing (Barlam et al., 2016). Hospital-based syntheses associate these approaches with improved policy adherence and reduced unnecessary antibiotic exposure, but intervention packages and definitions of appropriateness differ substantially (Davey et al., 2017;

Setiawan et al., 2022). An African hospital meta-analysis reported improvements in prescribing, utilization, and costs without a comparable or consistent signal for mortality or length of stay (Siachalinga et al., 2022). Condition-specific evidence, including hospital-acquired pneumonia, also requires attention to clinical pathways rather than extrapolation from aggregate consumption alone (Ablakimova et al., 2026). Existing reviews establish the potential of individual or combined interventions, but provide less guidance on which underlying functions can be delivered reliably when staffing, laboratory support, and information systems are limited. This unresolved implementation question, rather than a new estimate of pooled clinical effectiveness, motivates the present synthesis.

Translating stewardship evidence into routine hospital work is difficult when specialist staffing, laboratory access, prescribing records, and protected review time are limited. Reviews of least-developed and low-income settings document uneven access to protocols, surveillance, diagnostic services, and multidisciplinary stewardship structures (Mzumara et al., 2023). Related implementation evidence identifies workforce and information constraints that can prevent guidelines from reaching the bedside (Shamas et al., 2023). These observations distinguish the existence of a written policy from the ability to identify a prescribing problem, discuss it with a clinician, and document the subsequent action. A multi-professional investigation across the Global-PPS network also emphasizes the distribution of practical responsibilities between clinicians, pharmacists, and other hospital staff (Pauwels et al., 2025). The implication is not that low-resource hospitals require a single standardized program, but that reported benefits must be interpreted against the resources needed to activate each intervention.

Implementation is additionally influenced by the timing of feedback, prescriber relationships, organizational authority, and access to clinically useful information. Asian evidence links local stewardship performance to leadership, communication, training, diagnostic capability, and data infrastructure (Limato et al., 2025). A scoping review similarly identifies professional and organizational factors affecting adoption and continuity (Harun et al., 2024). Evidence from Indonesian hospitals illustrates persistent differences between formal expectations and operational readiness (Sinto et al., 2024). These findings overlap with previous descriptions of resource shortages but highlight a distinct causal pathway: weak authority or delayed feedback can interrupt a stewardship intervention even when guidelines or staff are nominally available. A useful synthesis must therefore examine how professional arrangements and institutional capacity interact with specific prescribing interventions over time.

Limited resources do not necessarily preclude measurable stewardship activity. A hospital can investigate prolonged surgical prophylaxis, delayed antibiotic review, inappropriate empirical choice, duplicate coverage, or missed intravenous-to-oral conversion using selected medication records. Surgical-care evidence supports focused prophylaxis assessment against defined prescribing criteria (Martinez-Sobalvarro et al., 2022), while pharmacist-led audit-feedback may provide an actionable route from prescription review to clinician discussion (Jawhar et al., 2026). Such findings support the feasibility of particular components, not proof that a comprehensive minimum program has been validated across hospital types. A staged package comprising assigned responsibility, selected review targets, local guidance, and basic monitoring is therefore advanced here as an implementation proposal, consistent with calls for local adaptation rather than direct replication of high-resource programs (Cox et al., 2017). Its feasibility and safety require prospective evaluation under different staffing and diagnostic conditions.

Prior systematic and scoping reviews have assessed stewardship interventions, prescribing outcomes, or implementation barriers, but often treat these domains separately or combine facilities with different levels of care. The present structured review adds an implementation-oriented synthesis that explicitly links three questions: which prescribing mechanisms have hospital-based support, what institutional resources are needed to operate them, and how functionality and patient safety can be monitored sustainably. Its analytical contribution is a distinction between evidence-supported intervention mechanisms and a proposed sequence for implementing them under variable capacity. The review therefore compares hospital evidence, identifies the limited transferability of findings from primary care or broader health systems, and interprets heterogeneous results rather than estimating new pooled effects. Its objectives are to identify credible stewardship functions, classify essential versus capacity-dependent requirements, assess contextual barriers and feedback mechanisms, and propose feasible outcome measures. The suggested minimum viable model is a hypothesis for operational testing, not an empirically validated standard for every resource-limited hospital.

RESEARCH METHODS

This study used a structured, non-empirical evidence review of antimicrobial stewardship (AMS) implementation in hospitals with constrained workforce, diagnostics, information systems, or surveillance capacity. It did not recruit participants, collect patient-level data, or undertake a de novo meta-analysis. The source base prioritized peer-reviewed systematic reviews, meta-analyses, scoping reviews, hospital implementation studies, and relevant methodological or consensus publications from January 2022 to 14 September 2026; earlier foundational sources were retained when needed (Pulcini et al., 2019). The documented discovery pathways were PubMed-indexed records and publisher-hosted bibliographic or full-text pages; independent searches of Embase, Scopus, or Web of Science cannot be verified. The recorded search concepts combined 'antimicrobial stewardship' or 'antibiotic stewardship' with 'hospital' or 'inpatient', resource-limited or low- and middle-income settings, and terms such as implementation, audit, feedback, pharmacist, microbiology, surgical prophylaxis, and antibiotic utilization. These concepts describe the available search record, not a preserved verbatim Boolean query. Publications were considered for the core synthesis if their setting, intervention, outcome, or organizational findings informed hospital AMS; duplicate reports and unsupported commentaries were excluded. Evidence from primary care or mixed settings was used only for contextual comparison, not as direct hospital-effectiveness evidence.

Screening was based on publication relevance followed by full-text assessment of setting, intervention type, implementation context, outcome definitions, and practical implications. Extracted characteristics were organized in a narrative evidence matrix, with eight representative sources displayed in Table 1; that table is not a complete enumeration of every citation or a quantitative screening flow. No contemporaneous search log, deduplicated record total, full-text exclusion tally, dual-screening record, or formal risk-of-bias scores are available in the manuscript materials. A PRISMA-style count or numerical certainty grade therefore cannot be reported without inventing information; the review should not be interpreted as an exhaustive systematic review (Page et al., 2021). The present critical synthesis weighs evidence qualitatively by directness to hospital care, study design, clarity of outcome measurement, and consistency of findings across independent hospital-focused sources. Convergence is considered more credible when multiple hospital reviews report improvements in the same proximal domain; isolated reports, mixed-setting evidence, and conflicting or unmeasured distal outcomes are qualified rather than pooled. Disagreement was examined in relation to different intervention packages, follow-up durations, diagnostic capacity, and baseline clinical risk. Four analytic domains structured interpretation: intervention architecture, minimum resource requirements, organizational determinants, and resource-sensitive outcomes (Cox et al., 2017). The proposed model reflects this interpretation and was not externally validated; no ethics approval was needed for analysis of published, non-identifiable information.

RESULTS AND DISCUSSION

Evidence Architecture of Stewardship in Resource-Limited Hospitals

The strongest recurring hospital-based signal for antimicrobial stewardship (AMS) concerns proximal prescribing processes, not definitive effects on mortality. Hospital reviews commonly evaluate guideline concordance, choice and duration of treatment, route, and antibiotic exposure; their multifaceted interventions limit attribution to any single component (Setiawan et al., 2022). In African hospitals, a systematic review and meta-analysis identified favorable prescribing, utilization, or cost findings, but inconsistent evidence for mortality and length of stay (Siachalinga et al., 2022). This difference is substantively important: a prescribing improvement is closer to audit or feedback activity, whereas death and hospital duration depend on infection severity, diagnostic accuracy, case mix, and other care processes (Schuts et al., 2016). Absence of a clear distal benefit cannot be interpreted as proof of no clinical value, and favorable utilization changes alone cannot establish patient benefit. The evidence supports cautious claims about the mechanisms most directly measured while leaving their net clinical effects context dependent.

Stewardship packages are not interchangeable even when studies use the same program label. Earlier LMIC hospital evidence found variation in designs, implementation intensity, professional participation, and reporting quality, reducing confidence in direct cross-study comparisons (Van Dijck et al., 2018). Guidelines may be available without uptake; prospective review may be introduced

without timely feedback; education may raise awareness without changing repeated prescribing decisions. These are plausible implementation failures that help explain why seemingly similar programs can yield divergent observations, although the available synthesis does not quantify failure rates. The predominance of multifaceted packages also makes it difficult to separate audit-feedback effects from restriction, formulary changes, diagnostic improvement, or concurrent infection-prevention measures. Consequently, evidence quality and fidelity matter at least as much as the formal presence of a stewardship activity. The present framework treats AMS as connected clinical functions with potentially breakable links, rather than an assumed effective bundle (Cox et al., 2017).

Infrastructure determines whether the components of such a system function repeatedly. Studies from least-developed and low-income countries show uneven policy coverage, diagnostic services, and surveillance capability (Mzumara et al., 2023), while broader LMIC evidence describes recurrent workforce, laboratory, and information barriers (Shamas et al., 2023). These conditions can interrupt identification, assessment, communication, or follow-up of a prescribing problem, creating implementation failure despite formal committee formation. Conversely, carefully targeted review may be practicable with basic records and available clinicians, but evidence does not show that this will work equally well in every hospital. Table 1 juxtaposes core hospital sources with contextual evidence to make this limitation visible. The distinction between direct inpatient evidence and evidence from other care environments is retained throughout the analysis.

Tabel 1. Evidence Base for Hospital Antimicrobial Stewardship in Resource-Limited Settings

Source	Study Design	Setting and Stewardship Focus	Implementation Signal
Setiawan et al., 2022	Scoping review	LMIC hospitals; audit-feedback, guidelines, restriction, education	Hospital programs were feasible but highly heterogeneous; prescribing behavior and antibiotic use were dominant outcomes.
Siachalinga et al., 2022	Systematic review and meta-analysis	Hospital inpatients in Africa; multifaceted AMS interventions	Improved compliance and antibiotic utilization/cost common; mortality/LOS effects limited/inconsistent.
Mzumara et al., 2023	Systematic review	Hospitals in least-developed/low-income countries; protocols, policies, stewardship practice	Formal structures, diagnostics, surveillance, governance uneven.
Shamas et al., 2023	Implementation-focused review	LMIC health systems; AMS tools and implementation	Resource, workforce, lab, information constraints repeatedly limited uptake.
Limato et al., 2025	Scoping review + expert survey	Healthcare facilities in Asia; context-specific implementation determinants	Leadership, communication, training, diagnostics, data systems shaped implementation priorities.
Babatunde et al., 2026	Systematic review	Low/lower-middle-income primary care (contextual comparator only); implementation barriers	Resource barriers described in primary care; not direct inpatient effectiveness evidence.
Van Dijck et al., 2018	Systematic review	Hospitals in LMICs; hospital stewardship interventions	Contextualized interventions feasible, but evidence quality/comparability limited.
Pierce et al., 2020	International position statement	Global, LMIC focus; stewardship principles/scalable actions	Progressive, locally adapted stewardship favored over direct transfer of high-resource models.

Table 1 shows convergent descriptions of audit-feedback, prescribing guidance, restriction, and education, but the source types provide different levels of inference. Hospital-focused systematic and scoping reviews are most directly relevant to inpatient prescribing, while their heterogeneous definitions and intervention combinations weaken causal attribution (Setiawan et al., 2022; Van Dijck et al., 2018). The African meta-analysis offers quantitative synthesis for selected outcomes, but the inconsistent mortality and length-of-stay results do not justify broad clinical-effectiveness claims (Siachalinga et al., 2022). Asian and national implementation studies add information on the institutions needed to deliver these functions rather than independent proof of their clinical effect (Limato et al., 2025; Sinto et al., 2024). Primary-care evidence on resource barriers (Babatunde et al., 2026) is included only as a contextual comparator: different disease severity, prescribing pathways, and staffing prevent its results from being treated as equivalent to inpatient intervention evidence. This hierarchy of relevance supports an implementation proposal but not a pooled effectiveness ranking.

Professional ownership further strengthens the architecture because stewardship recommendations only become clinically consequential when they are incorporated into actual prescribing decisions. Multi-professional evidence from low- and middle-income countries indicates that implementation is shaped by multidisciplinary ownership, resource availability, data access, and local adaptation, reinforcing the need to connect AMS with routine clinical responsibilities rather than treating it as an isolated administrative activity (Pauwels et al., 2025). Evidence from Indonesia likewise identifies persistent implementation gaps and barriers across hospitals, demonstrating that formal stewardship expectations do not automatically produce equivalent facility-level capacity (Sinto et al., 2024). These findings suggest that stewardship functionality depends on the interaction between technical interventions and the people responsible for applying, communicating, and monitoring them. The architecture therefore extends beyond antibiotic policies to include professional authority, communication pathways, information availability, and mechanisms for recurrent feedback. A resource-limited hospital does not necessarily require every component found in high-resource stewardship programs, but it does require sufficient organizational capacity for the core prescribing-feedback cycle to operate repeatedly. The next analytical question is consequently not whether a hospital can reproduce a comprehensive high-resource AMS model, but which minimum functions can generate reliable stewardship activity within its actual resource constraints.

Minimum Viable Stewardship Model and Resource Requirements

Hospitals with limited resources may need to sequence stewardship activities rather than establish all recommended components simultaneously. International guidance identifies leadership responsibility, intervention, monitoring, reporting, and education as relevant program functions (Barlam et al., 2016); LMIC position statements also support contextual adaptation (Pierce et al., 2020). These sources justify the selection of plausible ingredients, but do not validate one specific minimum viable package across facilities. The model presented here is therefore a practice-oriented proposal derived from the synthesis, not a directly tested intervention. Its initial operational core comprises accountable clinical leadership, accessible prescribing records, targeted review with feedback, locally feasible guidance, and periodic checks of prescribing appropriateness and safety. More complex microbiology, digital reporting, and ecological surveillance should be added according to local capacity and clinical need. Implementation success must be judged by whether each selected function operates as intended, not simply by its inclusion in a policy document.

Assigned ownership is an essential organizational prerequisite in the proposed model. A designated physician or pharmacist can coordinate prescribing priorities, reviews, recommendations, and escalation to hospital management, provided that clinical authority and protected time are sufficient. LMIC implementation studies identify leadership and multidisciplinary engagement as facilitators but also document workforce shortages that can prevent these roles from operating consistently (Harun et al., 2024). The recommendation does not require the creation of a specialist post in every hospital; responsibility could initially be integrated into existing duties where workload and oversight permit. Prescriber engagement remains necessary, since a coordinator cannot independently secure adoption of guidance. Appointment, coverage during staff absence, escalation routes, and regular feedback should therefore be evaluated as observable elements of accountability rather than assumed from nominal committee membership.

A limited audit-feedback workload is more feasible than universal prescription review where clinical staffing is scarce. Potential initial targets include prolonged empirical courses, selected broad-spectrum agents, surgical prophylaxis, and patients who may be eligible for intravenous-to-oral conversion. Pharmacist-led audit-feedback has evidence of prescribing improvement, but the design and clinical context of the underlying studies vary (Jawhar et al., 2026). Target selection should depend on local prevalence, treatment risk, and records available for review, not an assumption that the same intervention must be prioritized everywhere. A patient chart and accessible reviewer may suffice for a basic review point, whereas culture-guided de-escalation requires timely laboratory reporting and clinical interpretation. Workload, recommendation acceptance, treatment adequacy, and patient-safety outcomes should be documented alongside changes in utilization. These requirements make the proposed model testable without presenting its expected benefits as established.

Table 2. Proposed Stewardship Functions, Resource Requirements, and Feasible Indicators

Proposed function / tier	Minimum Resource	Primary Purpose	Feasible Indicator
Named stewardship lead (core)	Clinician/pharmacist with protected responsibility	Ownership/escalation/ continuity	Appointment document; monthly activity log
Targeted audit and feedback (core)	Basic patient chart access and reviewer time	Corrects specific prescribing decisions	Review coverage; accepted actions; patient-safety checks
Local prescribing guidance (core)	Simple syndrome pathways and formulary information	Reduces unwarranted variation	Guideline concordance; restricted-agent use
Antibiotic review point (core)	Medication chart or reminder at 48–72h	Prevents unnecessary continuation	Proportion reviewed; de-escalation/stop rate
Surgical prophylaxis control (target-dependent)	Operating list + medication record	Limits unnecessary timing/duration	Correct agent, timing, redosing, duration
IV-to-oral conversion (target-dependent)	Daily/periodic medication review	Reduces line exposure/resource use	Eligible cases converted; IV days avoided
Basic microbiology linkage (capacity-dependent)	Culture access where available	Supports de-escalation/local guidance	Culture-before-antibiotic rate; result-to-action time
Management feedback (core)	Simple monthly dashboard	Maintains visibility/accountability	Trend in 2–4 selected indicators

Table 2 distinguishes a proposed operational core from targets or capabilities whose feasibility depends on local conditions. Core functions are a named lead, accessible prescribing review and feedback, practical treatment guidance, a review point, and a small reporting cycle; their implementation still requires staff time and institutional cooperation. Surgical prophylaxis checks and intravenous-to-oral conversion are examples of initial targets where the relevant clinical service and records are available, rather than mandatory universal components. Microbiology linkage and advanced indicators are capacity-dependent and should expand when specimen collection, result turnaround, and clinical communication permit valid use. Surgical-prophylaxis research provides evidence for targeted prescribing checks (Martinez-Sobalvarro et al., 2022), but the complete sequence in Table 2 has not been prospectively tested. Feasibility should be judged by review coverage, documented action, accuracy of clinical eligibility assessment, and operational burden, not solely by lower antibiotic use.

Monitoring should use a small set of consistently defined indicators and connect them to prescriber feedback. Guideline concordance and documented review can often be counted from sampled medication records, whereas days of therapy or defined daily doses require more reliable utilization data and denominators. Selection should consider both clinical relevance and the risk of missing or inconsistent records. A monthly audit can record the eligible population, cases actually reviewed,

recommendations made, and actions accepted, permitting identification of low coverage as distinct from low prescriber adherence. Such measures reflect the need for actionable information emphasized in LMIC implementation research (Pauwels et al., 2025). Hospitals should compare like patient groups and track changes in formulary access or case mix before inferring improvement from a utilization trend. The monitoring cycle is a proposed management practice, and its cost-effectiveness remains to be tested.

Education is best viewed as an enabling function rather than proof of improved care by itself. Behaviour-focused stewardship education research identifies mechanisms worth linking to active clinical feedback, but variation across study designs limits assumptions about sustained benefit (Turner et al., 2026). Resource-limited facilities may integrate teaching with case audit, orientation, and recurrent review of local errors to reduce the incremental workload. The proposed implementation sequence starts with responsibility, a clinically justified target, timely review, and basic feedback; training is tailored to recurring barriers. More complex electronic decision support, extensive microbiology linkage, and ecological surveillance are later options, not prerequisites for every initial program. Because the combined minimum model lacks direct comparative validation, hospital pilots should prospectively assess uptake, workload, prescribing appropriateness, and patient safety before scale-up.

Contextual Determinants, Professional Roles, and Implementation Sustainability

Leadership, clinical hierarchy, diagnostic capacity, staffing, data infrastructure, and professional communication interact rather than acting as independent barriers to antimicrobial stewardship (AMS). Asian implementation evidence identifies these institutional determinants but does not imply that improving one alone guarantees prescribing change (Limato et al., 2025). A hospital may have a functioning laboratory yet lack a mechanism for communicating culture results; a trained pharmacist may identify a prescribing issue but lack access to the responsible clinician. Conversely, a small hospital can maintain selected review activities where management grants time and prescribers engage with feedback despite limited technology. The relevant unit of analysis is thus the entire clinical decision pathway, from recognition of a problem to review, agreement, action, and monitoring. This interpretation is a proposed explanation of heterogeneous implementation findings rather than a formally tested causal model.

Stewardship requires complementary roles and explicit accountability across prescribing, pharmacy, laboratory, nursing, and infection prevention. Multi-professional evidence highlights the importance of ownership and data access (Pauwels et al., 2025), but shared committee membership does not necessarily resolve resistance to recommendations. Prescribers may question the clinical relevance of general guidance, perceive audit as punitive, or face treatment uncertainty when diagnostic evidence is scarce. Practical responses include locally agreed eligibility criteria, peer-to-peer discussion, rapid escalation of disagreements, and feedback showing when recommendations were accepted or rejected. Pharmacy review is most useful when clinical responsibility for changes remains clear and a prescriber can respond in time. Table 3 connects these activities to an outcome hierarchy that should assess clinical safety as well as policy adherence.

Table 3. Outcome Levels for Resource-Sensitive Antimicrobial Stewardship Evaluation

Outcome Level	Examples	Operational Sensitivity	Typical Time Horizon	Interpretive Caution
Process	Guideline concordance; documented 48–72h review; recommendation acceptance	High	Weeks	Best for early implementation monitoring
Antibiotic exposure	Days of therapy; defined daily doses; duration; IV days	Moderate	Weeks-months	Requires stable denominator/drug data

Economic	Antibiotic acquisition cost; avoidable IV costs	Moderate	Weeks-months	Useful for management support but prices may fluctuate
Patient safety	Adverse drug events; treatment failure; readmission	Moderate-low	Months	Monitor undertreatment as well as drug harm; definitions/follow-up must be stable
Clinical	Mortality; length of stay; ICU transfer	Low for small programs	Months-years	Strongly confounded by severity/case mix
Ecological	Resistance prevalence; C. difficile; MDRO incidence	Low without surveillance	Long term	Requires reliable microbiology/sufficient observation

The indicator hierarchy in Table 3 reflects both proximity to intervention and data requirements, not a ranking of clinical importance. Guideline concordance, review documentation, and recommendation response are sensitive to whether stewardship is functioning; antibiotic exposure adds information only when denominators and dispensing data are reliable. Treatment failure, adverse drug events, readmission, and other patient outcomes are clinically essential counterbalances even if they are harder to measure consistently. Mortality and length of stay may be insensitive to a small intervention and strongly confounded by illness severity or concurrent care (Schuts et al., 2016). Evidence on pharmacist-led review supports process measurement but does not eliminate this need for safety monitoring (Jawhar et al., 2026). Facilities should choose an achievable process indicator paired with at least one locally recordable measure of treatment adequacy or harm, using consistent definitions and appropriate escalation when concerning trends emerge.

Institutional barriers may reinforce one another and become persistent when no budget or management process addresses them. Scarce staff time reduces review coverage, inconsistent prescribing records undermine feedback, and weak prescriber acceptance can make additional audits ineffectual (Harun et al., 2024). Funding instability can interrupt pharmacist time, data entry, education, and microbiology services even after an initial project demonstrates activity. The proposed response is to place stewardship responsibilities and modest recurrent operating costs within routine hospital plans rather than rely indefinitely on an external project or one motivated staff member. Table 4 identifies operational responses that can be scaled, although their feasibility and cost have not been tested against a common benchmark. Sustainability should be assessed through continuity of review coverage, accountability for unresolved recommendations, and retention of essential activities during staff or budget changes.

Table 4. Implementation Barriers and Resource-Sensitive Responses for Hospital Antimicrobial Stewardship

Barrier	Likely Consequence	Resource-Sensitive Response
Limited specialist workforce	Low review coverage; dependence on one champion	Target high-risk antibiotics/wards; train pharmacists/general clinicians; standardize review forms
Weak microbiology access	Empiric therapy persists; poor de-escalation	Prioritize specimen pathways; build antibiograms from available data; focus early targets not requiring cultures
Fragmented prescribing data	Cannot quantify use or feedback	Manual sentinel audits; define 2–4 stable indicators before digitization
Low prescriber acceptance or professional resistance	Recommendations ignored	Peer dialogue; non-punitive feedback; record response/rejection reasons
Insufficient leadership support or recurrent funding	No protected time/authority	Named accountability; protected time; recurring operating budget; management review

Drug shortages/formulary instability	Guidelines impractical	Align guidance with real formulary; document stock-outs
One-off training model	Short-lived knowledge effect	Link education to recurrent case audit and measured errors
Program complexity too early	High workload/data failure	Stage implementation; stabilize core functions before advanced metrics

Table 4 illustrates how different institutional constraints may disrupt the same review-feedback pathway. Limited staffing favors selection of high-risk cases; weak laboratory access favors initial targets that do not require susceptibility data; fragmented records favor periodic sentinel audits. These are pragmatic adaptations, not evidence that every hospital can achieve identical effects with fewer resources. Implementation research supports contextual adjustment while underscoring continuing constraints (Ochoa-Hein & Galindo-Fraga, 2024). Prescriber resistance requires clinical dialogue rather than administrative enforcement alone, and disagreements about recommendations should be documented and reviewable. Leadership support should extend beyond endorsement to protected work time, accountability for prescribing responses, and a recurring operational budget. The model's durability can then be assessed by whether its core functions persist despite changes in personnel, formulary access, or laboratory capability.

Long-term stewardship depends on institutional governance and recurrent financing as well as technical competence. Indonesia's national hospital evidence documents persistent implementation gaps despite formal attention to AMS (Sinto et al., 2024), while professional perceptions can shape adherence in South African practice (Reddy et al., 2023). Hospital administrators should assign a responsible unit, approve protected review time, budget minimal data and training requirements, and review selected indicators at routine clinical governance meetings. Clinicians and pharmacists need a transparent method for responding to rejected recommendations, and managers should examine whether disagreements reflect clinical exceptions, unsuitable guidance, or insufficient authority. Repeated case-based education can address changing workforce needs but should be evaluated with actual prescribing measures (Turner et al., 2026). These actions may improve continuity; they are policy implications of the synthesis rather than demonstrated effects of a validated financing model.

Outcome Measurement, Clinical Interpretation, and Implications for Hospital Practice

Outcome selection must follow the stewardship mechanism and the data a hospital can collect accurately. Prescribing appropriateness, documented review, guideline concordance, and treatment duration are direct process outcomes; mortality and length of stay are more distant, case-mix-sensitive outcomes. Hospital syntheses report more consistent improvement in prescribing or utilization than in those distal endpoints (Siachalinga et al., 2022), while pneumonia-specific evidence demonstrates the value of considering disease context (Ablakimova et al., 2026). Process indicators were prioritized in the proposed hierarchy because they can detect whether feedback occurred and whether action followed, not because patient outcomes are less important. A basic evaluation should pair a process outcome with an exposure measure and a safety counterbalance where reliable clinical follow-up is available. This structure protects against equating a fall in drug consumption with improved care.

Antibiotic exposure measures add a useful but potentially biased intermediate outcome. Days of therapy and intravenous days require reliable individual medication dates and patient-day denominators; defined daily doses can depend on dispensing completeness and may obscure pediatric dosing or dose adjustments. Changes in ward occupancy, case mix, stock-outs, or data capture can falsely suggest better stewardship when observed use declines. WHO AWaRe categories may support descriptive comparisons, but shifts between Access, Watch, and Reserve agents still require indication-specific clinical interpretation (World Health Organization, 2023). Cost measures likewise depend on changing prices and procurement practices, even when interventions are associated with reported savings (Krishnamoorthy et al., 2025). Hospitals should document data completeness, keep indicator definitions stable, and review therapy appropriateness before interpreting consumption or expenditure trends as benefits.

Patient safety must be monitored alongside exposure reduction. Lower antibiotic consumption can reflect shorter unnecessary treatment, but it can also reflect drug stock-outs, delayed initiation, premature discontinuation, or undertreatment of serious infection. Clinical review should record

appropriate initial coverage and subsequent modification where feasible, with warning indicators such as treatment failure, unplanned escalation, infection-related readmission, or adverse drug events. These outcomes have different data demands and should be selected according to the hospital's ability to follow patients reliably; adverse trends should prompt case review rather than automatic attribution to AMS. Pneumonia evidence supports evaluating prescribing together with clinical consequences (Ablakimova et al., 2026), while the access-versus-adherence perspective is particularly relevant to LMIC settings (Shchepanik et al., 2026). Reduced use should count as improvement only when its clinical appropriateness and safety are credible.

Diagnostic limitations can create both clinical uncertainty and measurement bias. Culture availability, specimen quality, turnaround time, and communication of results determine whether de-escalation opportunities can be recognized reliably. Evidence on point-of-care testing in lower-resource settings indicates potential links to antimicrobial decision-making, although findings from children or non-hospital contexts cannot automatically be generalized to adult inpatients (Gres et al., 2025). Hospitals with limited laboratory services should record whether culture results were clinically available before classifying persistent empirical treatment as inappropriate. If testing expands during the evaluation period, apparent changes in resistance or de-escalation rates may partly reflect altered ascertainment rather than intervention effectiveness. Interpretation therefore requires documenting the diagnostic conditions under which a prescribing decision occurred.

Resistance and infection-related ecological outcomes require stable surveillance over longer periods. Changes in multidrug-resistant organism incidence or Clostridioides difficile infection reflect antimicrobial pressure but also transmission, testing intensity, infection-prevention practice, and community exposures (Murray et al., 2022; Zumla et al., 2022). A sudden increase in culture sampling may raise measured resistance prevalence even when underlying incidence is unchanged; a decline in tested patients may create the opposite impression. Early-stage hospitals should therefore avoid using sparse laboratory data as decisive evidence of stewardship impact. Ecological monitoring can be added when specimens, denominators, laboratory methods, and observation periods become sufficiently consistent. Such outcomes remain important longer-term goals, not reliable universal endpoints for a small initial program.

A practicable evaluation sequence starts with a small number of prescribing-process measures, adds valid exposure indicators, and preserves a parallel check on clinical safety. Process documentation should distinguish prescriptions eligible for review from those actually reviewed, while exposure calculations should report stable denominators and missing-data limitations. Clinical appropriateness, failure or escalation signals, and drug availability should accompany any claim of reduced antibiotic use. Economic monitoring can inform administrators, but unit-price and supply changes must be separated from improvements in prescription quality. Educational activity may assist the process when paired with observed prescribing errors and recurrent feedback (Turner et al., 2026). This layered approach is proposed as a feasible measurement strategy, not a validated causal hierarchy, and future comparisons should test its reliability across hospitals with different record systems and diagnostic capacity.

CONCLUSION

Hospital-based evidence indicates that antimicrobial stewardship (AMS) can improve proximal prescribing and antibiotic-use measures in some resource-limited settings, although findings are heterogeneous and effects on mortality and length of stay are uncertain (Setiawan et al., 2022; Siachalinga et al., 2022). Implementation depends on whether professional responsibility, clinical review, actionable feedback, treatment guidance, and basic information can function together. The proposed minimum viable model combines those functions with a limited set of indicators; it is an implementation-oriented interpretation of published evidence, not a program validated across hospitals. For administrators, the immediate implication is to designate accountable clinical leadership, protect time for a manageable audit target, ensure access to relevant prescribing records, and pair utilization measures with patient-safety checks. For policymakers, enabling priorities include feasible local standards, workforce support, pragmatic surveillance requirements, and stable funding for core activities rather than mandatory high-technology packages. These actions should be adapted to actual staffing and diagnostic capacity, since identical program labels may conceal widely different operational conditions.

The conclusions are limited by heterogeneous intervention packages, inconsistent outcome definitions, indirect evidence from mixed health-system or primary-care settings, and the absence of an auditable search flow or formal risk-of-bias scoring in the available review record. No pooled estimates were recalculated, and the present synthesis cannot establish the comparative effectiveness or cost-effectiveness of the complete proposed model. Future prospective evaluations should compare feasible packages across hospitals, document implementation fidelity and staff workload, assess prescriber acceptance and recurring costs, and measure treatment adequacy or patient harm alongside antibiotic exposure. Repeated measurement with stable denominators, documented diagnostic context, and attention to case mix is essential before inferring clinical benefit. Hospitals can use the framework to organize initial local pilots, while broader adoption should depend on evidence that the selected components remain effective, safe, and sustainable in the relevant healthcare environment.

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