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PHARMACIST-LED, LABORATORY-GUIDED ANTIMICROBIAL STEWARDSHIP IN HOSPITALIZED ADULTS: A SYSTEMATIC REVIEW OF CLINICAL AND MICROBIOLOGICAL OUTCOMES

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Abstract

Background: Antimicrobial resistance is driven by excessive and suboptimal antibiotic use in hospitals. Pharmacist-led antimicrobial stewardship (AMS) that explicitly uses microbiology and laboratory biomarkers to guide therapy may optimize antibiotic exposure and improve outcomes, particularly in resource-limited settings and high-risk units. To synthesize evidence on pharmacist-led, laboratory-guided AMS interventions in adult inpatients and describe their clinical and microbiological impact. **Methods:** A systematic review was conducted according to PRISMA 2020. Electronic databases were searched for interventional or quasi-experimental hospital studies in adults where clinical pharmacists led AMS activities and used laboratory data (cultures, susceptibility testing, procalcitonin, therapeutic drug monitoring, antibiograms) to guide decisions. Two reviewers screened, extracted data, and assessed risk of bias. **Results:** Five studies met the eligibility criteria, including four quasi-experimental before–after cohorts and one retrospective cohort across neurosurgical intensive care, multidisciplinary medical wards, and tertiary hospitals in Ethiopia, Japan, China, the United States, and the United Arab Emirates. Pharmacist-led, lab-guided AMS consistently reduced broad-spectrum antibiotic use, shortened or optimized length of therapy, decreased healthcare-associated Clostridioides difficile infection, lowered multidrug-resistant organism rates, and reduced drug expenditure, with no signal for increased mortality. Prescriber acceptance of pharmacist recommendations ranged from high to very high. **Conclusion:** Pharmacist-led, laboratory-guided AMS programs in adult inpatients are feasible across diverse settings and are associated with improved antimicrobial utilization, better microbiological profiles, and stable or improved clinical outcomes. Wider adoption and high-quality comparative trials are warranted.

Keywords: Antimicrobial Stewardship; Clinical Pharmacist; Procalcitonin; Therapeutic Drug Monitoring; Antimicrobial Resistance; Hospitalized Adults; Laboratory-Guided Therapy.

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INTRODUCTION

The global action plan on antimicrobial resistance (AMR) underscores the need to optimise antibiotic use in hospitals as a core strategic objective [1]. International professional societies recommend formal antimicrobial stewardship programs (ASPs) with dedicated leadership, monitoring of antibiotic use, and regular feedback to prescribers [2]. The US Centers for Disease Control and Prevention (CDC) placed “pharmacist expertise” among the core elements of hospital ASPs, highlighting clinical pharmacists as key stewards of antimicrobial therapy [3]. More recently, The Joint Commission specified that pharmacists with infectious diseases or AMS training should be recognized as appropriate leaders or co-leaders of hospital stewardship activities [4]. Systematic reviews show that clinical pharmacists embedded in ASP teams reduce unnecessary antibiotic exposure, length of stay, and treatment costs, while maintaining clinical outcomes [5,6]. Pharmacist-led interventions in medium-sized hospitals and intensive care units (ICUs) have shortened antimicrobial courses, reduced broad-spectrum therapy, and lowered Clostridioides difficile infection (CDI) rates without increasing mortality [7–9]. However, a substantial proportion of these programs rely mainly on guideline-based or syndromic approaches, with only partial or ad hoc use of microbiology and biomarker data. Laboratory services, blood cultures, susceptibility testing, antibiograms, therapeutic drug monitoring (TDM), and biomarkers such as procalcitonin, are crucial for rational antibiotic decisions. When these data are actively interpreted and applied by pharmacists, they can support early de-escalation, timely discontinuation once a sufficient treatment duration is reached, and rapid response to local AMR trends [10–12]. In neurosurgical intensive care, pharmacist-led AMS using microbiology and MDRO data has reduced the use of antipseudomonal β-lactams, improved Gram-negative susceptibilities and decreased multidrug-resistant organism (MDRO) infections [13]. In a large Ethiopian referral hospital, a pharmacist-led, laboratory-supported audit-and-feedback intervention showed that more than half of audited antibiotic courses could be safely discontinued, with sustained increases in antibiotic consumption and mortality once the intervention ceased [10]. Procalcitonin-based decision support tools have similarly enabled pharmacists to prevent or optimize substantial numbers of antibiotic days in patients with low probability of bacterial infection [12]. Clinical pharmacist–driven AMS in a tertiary hospital in the United Arab Emirates has demonstrated improvements in use of reserve agents, hospital antibiograms, and drug costs [14]. Despite these promising reports, the specific contribution of pharmacist-led, explicitly laboratory-guided AMS to clinical and microbiological outcomes in adult inpatients has not been synthesized. This systematic review focuses on interventional studies where clinical pharmacists lead AMS activities and use quantitative laboratory data to guide antibiotic therapy in hospitalized adults.

METHODS

This review followed the PRISMA 2020 statement for reporting systematic reviews [15].

Eligibility criteria

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We included original research studies that met the following criteria:

Population: Hospitalised adults (≥18 years). Studies including mixed adult–paediatric populations were eligible if adult medical wards formed a major component [10].

Intervention: Pharmacist-led or pharmacist-driven AMS activities in which clinical pharmacists had a defined leadership or co-leadership role, and in which microbiology or laboratory data (blood cultures, antimicrobial susceptibility, procalcitonin, TDM, or cumulative antibiograms) were explicitly used to inform recommendations [10–14].

Comparator: Pre-intervention period, usual care, or non-pharmacist-led stewardship.

Outcomes: Clinical outcomes (length of stay, mortality, CDI, MDRO infections) and, or microbiological outcomes (susceptibility patterns, MDRO rates), alongside measures of antimicrobial use (days of therapy, defined daily doses).

Design: Randomised, non-randomised, or quasi-experimental interventional studies and observational cohorts with a clear intervention component.Reviews, commentaries, paediatric-only cohorts, and studies without an identifiable pharmacist-led component were excluded [5,6].

Search Strategy

We searched MEDLINE, Embase, Web of Science, and the Cochrane Library from inception to November 2025 using combinations of terms related to “pharmacist”, “antimicrobial stewardship”, “hospital”, “laboratory”, “procalcitonin”, “therapeutic drug monitoring”, and “antibiogram”. Reference lists of key guidelines and systematic reviews were screened to identify additional studies [1–3,5,6,16–18]. Only full-text articles in English were included.

Study Selection and Data Extraction

Two reviewers independently screened titles and abstracts, followed by full-text assessment against eligibility criteria. Disagreements were resolved by discussion. For each included study, we extracted data on setting, design, population, details of the pharmacist-led intervention (including how laboratory data were used), and clinical, microbiological, and antimicrobial-use outcomes [10–14].

Risk of Bias and Synthesis

Given the predominance of quasi-experimental designs, we considered domains described for interrupted time-series and before–after evaluations of AMS interventions [16,17], including clarity of the intervention period, potential secular trends, and co-interventions. Risk of bias was assessed qualitatively rather than by formal scoring. Heterogeneity of settings, laboratory modalities, and outcome measures precluded meta-analysis; instead, we present a structured narrative synthesis and a comparative table of study characteristics.

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RESULTS

Study selection and overview

Table 1: Characteristics of included pharmacist-led, laboratory-guided AMS studies in adult inpatients

First author, year	Country, setting	Design and population	Pharmacist-led, lab-guided intervention	Main clinical outcomes	Main microbiological, utilisation outcomes
Gebretekle 2020 [10]	Ethiopia; 700-bed referral hospital, 2 adult and 2 paediatric medicine wards	Single-centre prospective quasi-experimental; intervention phase with pharmacist-led AMS followed by post-intervention phase (audit only); 1,109 patients	AMS team led by clinical pharmacists and an ID specialist; weekly audit of antibiotic prescriptions with verbal and written feedback; intervention emphasised treatment duration and appropriateness; laboratory support included culture results and evolving susceptibility patterns	During the active intervention, recommendations to discontinue antibiotics were common, with acceptance in >95% of cases; once feedback ceased, average duration of antibiotic courses and length of stay increased, and in-hospital mortality rose from ~7% to ~15% [10]	Over half of audited antibiotic courses were deemed unnecessary at time of review; cessation of audit-feedback led to a >50% increase in total antimicrobial use and greater reliance on broad-spectrum agents [10]
Uda 2021 [11]	Japan; 934-bed university hospital	Quasi-experimental; comparison of pre-intervention period (May–Dec 2017) and post-intervention period (May–Dec 2018)	A full-time pharmacist specialising in antimicrobial therapy joined the AMS team; daily monitoring of broad-spectrum antipseudomonal and anti-MRSA agents; prospective audit and feedback to prescribers; educational lectures; heavy reliance on blood culture results and guideline-based durations [11]	No adverse change in 30-day mortality; hospital-onset CDI incidence fell from 1.12 to 0.54 cases per 10,000 patient-days [11]	Decreases in use of antipseudomonal agents and anti-MRSA drugs; improved timing and rate of blood culture collection before antibiotics; stewardship targeted de-escalation based on culture and susceptibility data [11]
Watkins 2021 [12]	USA; academic medical centre	Retrospective cohort evaluating a procalcitonin-	The AMS program integrated a pharmacist-directed electronic “Daily Checklist” alert for patients on antibiotics with	Among 53 interventions, there were no differences in length of stay between patients with and without	The tool led to prevention or optimisation of 181 antibiotic days; the most frequent pharmacist

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		based clinical decision support tool	normal procalcitonin (<0.25 μg, L); clinical pharmacists reviewed cases and recommended narrowing, IV-to-oral switch, dose optimisation, duration shortening, or discontinuation [12]	interventions and no safety signal: only two cases required escalation of therapy within 48 hours [12]	actions were narrowing therapy, IV-to-oral switch, and dose optimisation; vancomycin discontinuation rates were significantly higher in the intervention group [12]
Yu 2023 [13]	China; neurosurgical ICU, tertiary hospital	Pre–post cohort (6-month pre-AMS vs 6-month post-AMS period)	Comprehensive pharmacist-led AMS program involving regular ward rounds with an infectious diseases physician, prospective audit and feedback, and optimisation of empiric and targeted therapy; stewardship decisions informed by microbiology results, MDRO surveillance, and Gram-negative susceptibilities [13]	No significant difference in mortality or baseline severity between periods; reductions in empirical use of antipseudomonal β-lactams (from ~61% to ~44%) and in MDRO infection rate (from ~18% to ~11%) [13]	Increased appropriateness of de-escalation, reduced polymyxin utilisation, and improved susceptibility of Gram-negative bacilli to APBLs after AMS implementation [13]
Elnajjar 2025 [14]	United Arab Emirates; tertiary hospital	Single-centre quasi-experimental pre–post study (pre-intervention July 2021–June 2022; post-intervention July 2022–June 2023)	Clinical pharmacist-driven ASP focused on hospitalised adults; ID clinical pharmacists joined multidisciplinary rounds, conducted post-prescription review, and led education; laboratory data used included culture and susceptibility results, therapeutic drug monitoring, and antibiogram-based surveillance; key performance indicators and pre-authorisation processes defined for “ASP-focused” broad-spectrum agents [14]	Clinical outcomes were not the primary endpoint; no signal of harm was reported. Program emphasised optimisation of therapy and safety through structured review of dosing, route, and duration [14]	Significant reduction in utilisation of broad-spectrum agents (carbapenems, fluoroquinolones, antifungals), improved susceptibilities for selected pathogens on the hospital antibiogram, and marked decreases in antimicrobial expenditures [14]

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The search identified a small but diverse body of work directly addressing pharmacist-led, laboratory-guided AMS in adult inpatients. Five studies met the inclusion criteria: a quasi-experimental cohort from a referral hospital in Ethiopia [10], a conference-proceedings-derived quasi-experimental study from a Japanese tertiary hospital [11], a retrospective cohort from a US academic centre evaluating a procalcitonin-based decision support tool [12], a pre–post cohort in a neurosurgical intensive care unit in China [13], and a quasi-experimental pre–post study from a tertiary hospital in the United Arab Emirates [14]. All five described clinical pharmacists in leadership or co-leadership roles, with explicit use of laboratory data. Table 1 summarizes key characteristics of the included studies.

Narrative Synthesis

Settings and Pharmacist Roles

All studies were hospital-based, but contexts varied. The Ethiopian program was implemented in a low-resource setting where intense antibiotic consumption co-existed with gaps in laboratory infrastructure [10]. There, clinical pharmacists organised weekly audit-and-feedback sessions, focusing on treatment duration and necessity. The authors explicitly describe the intervention as a pharmacist-led laboratory-supported strategy, acknowledging that local culture and susceptibility data were used when available [10].

In the Japanese and Chinese studies, pharmacists were embedded in AMS teams within large tertiary hospitals [11,13]. In Japan, a full-time antimicrobial pharmacist joined an existing program to implement daily monitoring of broad-spectrum antibiotics and to lead educational activities [11]. In China, a neurosurgical ICU AMS program formalised the regular presence of a clinical pharmacist and infectious diseases physician, with structured prospective audits, feedback, and de-escalation based on microbiology data [13]. The US study centred on empowering pharmacists through an electronic decision support tool integrated into the electronic health record. Normal procalcitonin values triggered a pharmacist alert, prompting case review and recommended adjustments to therapy [12]. The UAE program moved stewardship leadership from physicians and infection control teams to ID-trained clinical pharmacists, who became responsible for post-prescription reviews, therapeutic drug monitoring, and antibiogram-driven guideline refinement [14]. Across all five studies, pharmacists did not act in isolation: they coordinated with physicians, microbiologists, and infection prevention teams. However, pharmacists were consistently the primary drivers of stewardship actions, identifying cases, interpreting laboratory results in clinical context, and formulating specific recommendations.

Clinical Outcomes

Two studies reported clear changes in hard clinical outcomes. In Ethiopia, cessation of the pharmacist-led audit-and-feedback intervention was followed by a marked worsening in patient outcomes. Compared with the intervention phase, mean duration of antibiotic therapy increased by about four days per patient, length of stay increased, and crude in-hospital mortality approximately doubled from around 7% to 15% [10]. Importantly, this

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deterioration occurred despite continuation of basic auditing, emphasizing the importance of active feedback and pharmacist presence. In Japan, hospital-onset CDI incidence declined from 1.12 to 0.54 cases per 10,000 patient-days after the pharmacist-led intervention [11]. The authors attribute this to reduced use of broad-spectrum antipseudomonal and anti-MRSA agents and better adherence to guideline-recommended durations [11]. No increase in mortality was observed. The procalcitonin-guided decision support study provides an example of safety-focused stewardship. Among patients with normal procalcitonin, pharmacist interventions led mainly to narrowing therapy, IV-to-oral switch, and shortening of duration. The authors report that these interventions safely prevented or optimized 181 antibiotic days, with only two cases requiring escalation of antibacterial therapy within 48 hours and no difference in length of stay between groups [12]. In the neurosurgical ICU study, overall disease severity and mortality did not differ between pre-AMS and post-AMS periods, despite substantial reductions in broad-spectrum use and polymyxin exposure [13]. The UAE program focused primarily on utilization and cost outcomes; the authors did not report excess mortality or overt safety concerns after the pharmacist-driven transition [14].

Microbiological and Utilisation Outcomes

All included studies reported improvements in antimicrobial use metrics. In Ethiopia, the AMS team recommended discontinuation of antibiotics in more than half of audited prescriptions, and prescribers accepted over 96% of recommendations [10]. When active feedback ceased, antimicrobial consumption rose by more than 50%, and broad-spectrum agents such as meropenem became more common [10]. This quasi-“natural experiment” strengthens the causal link between pharmacist-led stewardship and rational antibiotic use. In Japan, daily pharmacist review and education reduced the use of antipseudomonal and anti-MRSA agents and improved blood culture practices. The reported halving of hospital-onset CDI suggests that focusing on treatment duration and spectrum, guided by cultures and institutional guidelines, can translate into tangible infection-control benefits [11].

The procalcitonin-based tool in the US study illustrates how biomarker-guided stewardship can target patients with low likelihood of bacterial infection. The pharmacist-directed checklist triggered 53 interventions, most of which either narrowed therapy or transitioned patients from intravenous to oral agents. Vancomycin discontinuation was much more frequent in the intervention group, and there was no penalty in length of stay [12]. In China’s neurosurgical ICU, after AMS implementation there was a sharp reduction in empiric use of antipseudomonal β-lactams (from about 61% to 44%) and a significant drop in MDRO infections (from about 18% to 11%) [13]. The authors also report improved de-escalation and higher susceptibility of Gram-negative bacilli to APBLs in the AMS period [13]. This supports the idea that pharmacist-guided de-escalation based on culture and susceptibility data can slow the accumulation of resistance in high-risk units. The UAE study provides a detailed description of how a clinical pharmacist-driven program can use antibiograms, TDM, and pre-authorization for “ASP-focused antimicrobials” to shape hospital-wide prescribing [14]. Following the intervention, use of carbapenems,

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fluoroquinolones, and antifungal agents declined, susceptibilities improved for selected pathogens, and antimicrobial expenditures fell markedly [14]. The study demonstrates how pharmacists can lead stewardship in a system aligned with national AMR surveillance networks. Overall, the included studies consistently show that pharmacist-led, laboratory-guided AMS can reduce broad-spectrum antibiotic use, support de-escalation, and improve microbiological profiles without harming patients. The magnitude of benefit varies by setting, but the direction of effect is remarkably consistent.

DISCUSSION

This systematic review synthesizes evidence from five interventional studies in which clinical pharmacists led AMS activities and explicitly used laboratory data to guide therapy [10–14]. Across diverse hospital settings, from a resource-limited Ethiopian referral centre to neurosurgical intensive care and a tertiary hospital in the Gulf region, pharmacist-led, lab-guided stewardship was associated with improved antimicrobial utilization and either stable or improved clinical outcomes.

The findings align with broader literature demonstrating that clinical pharmacists are pivotal members of effective multidisciplinary stewardship teams [5,6,8,9]. In medium-sized hospitals without infectious disease specialists, non-certified pharmacist-led programs focusing on therapy duration have reduced length of stay, shortened courses of antipseudomonal and anti-MRSA agents, and lowered antimicrobial costs without compromising mortality [7]. Pharmacist-led education-based AMS strategies in ICUs similarly reduce treatment duration and total antibiotic consumption [8]. Paediatric intensive care units in the Gulf region have reported successful reductions in broad-spectrum antimicrobial use and improved prescribing appropriateness when pharmacists take stewardship responsibilities [9]. The present review adds that when pharmacists deliberately integrate laboratory information, cultures, susceptibility testing, procalcitonin, and TDM, these benefits extend to microbiological outcomes such as MDRO rates and susceptibility patterns [10–14].

The Ethiopian study illustrates the interplay between pharmacist expertise and laboratory capacity in low- and middle-income settings [10]. Despite limited resources, a pharmacist-led audit-and-feedback program, supported by available culture data, halved unnecessary antibiotic courses and was associated with lower mortality and shorter hospital stays. Once active feedback stopped, antibiotic consumption, length of stay, and mortality all increased [10]. This pattern reinforces global arguments that strengthening both stewardship and laboratory infrastructure is fundamental to implementing the WHO action plan on AMR in resource-constrained hospitals [1,6].

Biomarker-guided stewardship represents another important frontier. The procalcitonin-based checklist evaluated by Watkins and colleagues demonstrates how a simple laboratory threshold can be embedded into pharmacists' workflow, prompting review of patients with low likelihood of bacterial infection [12]. The study shows that pharmacist-driven application of this biomarker can safely prevent or optimize a substantial number of antibiotic days without prolonging hospitalization [12].

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Similar strategies are increasingly seen in anti-infective consultation models, where clinical pharmacists integrate biomarkers, cultures, and pharmacokinetic data to optimize regimens and have reported large improvements in clinical response and cost outcomes [16]. Nevertheless, the body of evidence specific to pharmacist-led, laboratory-guided AMS remains limited. Most identified studies were single-centre, with quasi-experimental designs and potential confounding by secular trends and co-interventions [16,17]. Only one study focused on a single high-risk ICU [13], and only one described a structured, pharmacist-driven transition within a national AMR surveillance framework [14].

Important outcomes such as resistance trends over longer periods, patient-centred endpoints (readmissions, quality of life), and cost-effectiveness were variably reported. Formal risk-of-bias assessment is hampered by incomplete reporting of how non-pharmacy elements (infection-control measures, formulary changes) evolved over time. Future research should therefore priorities multi-centre, rigorously designed evaluations comparing pharmacist-led, lab-guided AMS with more traditional stewardship approaches. Adaptive designs and interrupted time-series methods, as recommended in methodological guidance for AMS evaluations [16,17], could better disentangle the effects of pharmacist-led laboratory integration from concurrent initiatives.

Trials should also examine the incremental value of specific laboratory tools, procalcitonin, rapid diagnostics, TDM, and unit-specific antibiograms, when interpreted and actioned by pharmacists. Despite these limitations, the current evidence supports international guidance that pharmacists with infectious diseases or AMS expertise should be recognized as leaders or co-leaders of hospital stewardship programs [2–4]. When paired with functional laboratory services, pharmacist-led AMS can translate global policies into measurable reductions in unnecessary antibiotic exposure, improved microbiological outcomes, and in some contexts, better survival [10–14].

CONCLUSION

Pharmacist-led, laboratory-guided antimicrobial stewardship programs in adult hospitalized patients are feasible in a variety of health-care settings, including low-resource environments, tertiary hospitals, and intensive care units. The limited but consistent evidence indicates that when clinical pharmacists use culture results, susceptibility patterns, biomarkers, and TDM to guide antibiotic decisions, broad-spectrum use and treatment duration are reduced, microbiological profiles improve, and clinical outcomes are maintained or enhanced. Strengthening both pharmacy and laboratory capacity, and embedding pharmacists in multidisciplinary AMS teams, should be central to national strategies aiming to curb antimicrobial resistance in hospitals.

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