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Community Antimicrobial Stewardship: What Actually Works? (Education, Audit-Feedback, Dispensing Interventions) — A Systematic Review Focused on UK and Low- and Middle-Income Country (LMIC) Settings

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Abstract: Antimicrobial resistance (AMR) represents a paramount global health threat, responsible for millions of deaths annually and jeopardizing the foundations of modern medicine. Antimicrobial stewardship (AMS) programs are a critical strategy to combat this crisis, particularly in community settings where the majority of antimicrobials are consumed. This systematic review aims to critically evaluate and compare the evidence for the effectiveness of three core community AMS interventions—educational, audit-and-feedback, and dispensing-related—in two distinct contexts: The United Kingdom (UK) as a high-income country model, and Low- and Middle-Income Countries (LMICs). A systematic search of PubMed, Cochrane CENTRAL, and Embase was conducted for studies evaluating these interventions. The synthesis reveals that intervention effectiveness is profoundly context-dependent. In the UK, systematic, data-driven audit-and-feedback has proven highly effective in reducing antibiotic prescribing in primary care, complemented by structured, pharmacist-led dispensing interventions incentivized through national schemes. Conversely, broad educational campaigns have shown limited impact. In LMICs, multifaceted educational interventions that build foundational knowledge among a wide range of formal and informal healthcare providers are the most impactful strategy. Pharmacist-led audit-and-feedback shows promise but faces significant sustainability challenges. The community pharmacist emerges as a pivotal figure in both settings, though their role shifts from an optimizer within a regulated system in the UK to a primary point of care and de facto prescriber in many LMICs. The evidence base is limited by methodological heterogeneity and a lack of studies reporting on clinical and microbiological outcomes. Effective community AMS requires context-specific strategies that align with existing health system infrastructure, regulatory capacity, and human resources. Future research must prioritize rigorous, long-term studies evaluating the sustainability and clinical impact of AMS interventions to guide global policy.

➢ *List of Abbreviations*

- AMR:
  Antimicrobial Resistance
- AMS:
  Antimicrobial Stewardship
- A&F:
  Audit and feedback
- CRP:
  C-Reactive Protein
- GP:
  General Practitioner
- HIC/HICs:
  High-Income Country/Countries

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- LMIC/LMICs:
  Low- and middle-income Country/Countries
- NHS:
  National Health Service (UK)
- NICE:
  National Institute for Health and Care Excellence (UK)
- POCT:
  Point-of-care Testing

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I. INTRODUCTION: THE SILENT PANDEMIC OF ANTIMICROBIAL RESISTANCE

➢ *The Scale of the Global Health Crisis*

The discovery of antimicrobials was a watershed moment in human history, transforming medicine and adding an estimated 20 years to average life expectancy.[1] However, the efficacy of these life-saving medicines is now under severe threat from the global rise of antimicrobial resistance (AMR). AMR occurs when microorganisms such as bacteria, viruses, fungi, and parasites evolve and adapt over time, developing the ability to defeat the drugs designed to kill them.[2] These resistant organisms, sometimes referred to as "superbugs," can persist and grow in the presence of antimicrobial treatments, making common infections progressively more difficult, and sometimes impossible, to treat.[2] This phenomenon not only increases the risk of disease spread, severe illness, and death but also jeopardizes the safety of modern medical procedures—from cancer chemotherapy and organ transplantation to caesarean sections and routine surgeries—that rely on effective antimicrobials to prevent and treat infections.[4]

The scale of the AMR crisis is staggering, positioning it as one of the most urgent public health threats of the 21st century.[2] A landmark 2019 study published in *The Lancet* revealed that bacterial AMR was directly responsible for at least 1.27 million global deaths and was associated with nearly 5 million deaths, a toll exceeding that of HIV/AIDS or malaria.[2] Projections from the O'Neill report suggest that if the current trajectory continues unabated, AMR could cause 10 million deaths annually by 2050, eclipsing the current mortality rate from cancer.[6] The crisis is not a distant future threat but a present-day reality. In the United States alone, more than 2.8 million antimicrobial-resistant infections occur each year, resulting in over 35,000 deaths.[2]

Beyond the devastating human cost, the economic burden of AMR is immense. The World Bank estimates that AMR could trigger an additional US1 trillion to US$3.4 trillion per year by 2030.[4] These costs stem from prolonged hospital stays, the need for more expensive and often more toxic second- and third-line treatments, and lost productivity.[2] While AMR is a natural evolutionary process, its emergence and spread have been dangerously accelerated by human activity, primarily the misuse and overuse of antimicrobials in human health, animal husbandry, and agriculture.[2] This relentless selection pressure forces microbes to adapt, making resistance a predictable but now dangerously widespread consequence of antimicrobial consumption.

➢ *Antimicrobial Stewardship as a Critical Countermeasure*

In response to the escalating AMR crisis, the global health community has identified antimicrobial stewardship (AMS) as a primary strategic countermeasure. AMS is defined as a coherent and coordinated set of actions and interventions designed to promote the responsible and judicious use of antimicrobials.[8] The overarching goal of AMS is to optimize the use of these precious resources to achieve the best possible clinical outcomes for patients while simultaneously minimizing unintended consequences. These consequences include not only the selection and spread of resistant pathogens but also direct patient harm from adverse drug reactions and the increased risk of secondary infections, such as those caused by Clostridioides difficile.[8]

The principles of AMS are codified in frameworks such as the Core Elements of Antibiotic Stewardship, developed by the U.S. Centers for Disease Control and Prevention (CDC).[13] These frameworks provide a structure for implementing effective stewardship programs across diverse healthcare settings and typically emphasize several key components:

- *Leadership Commitment:*
  Securing dedicated human, financial, and technological resources to support stewardship activities.
- *Accountability and Expertise:*
  Appointing leaders, often a physician and a pharmacist, with responsibility for program outcomes and access to infectious diseases expertise.

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- *Action:*
Implementing specific interventions to improve antimicrobial use. These can be persuasive (e.g., education) or restrictive (e.g., preauthorization for certain antibiotics).

- *Tracking and Reporting:*
Monitoring antimicrobial prescribing practices, resistance patterns, and the impact of interventions, and providing regular feedback to clinicians.

- *Education:*
Providing educational resources to clinicians, staff, and patients about AMR and appropriate antimicrobial use.[13]

These elements form a comprehensive, data-driven approach that moves beyond simple guidelines to actively manage and improve how antimicrobials are prescribed and used. The fundamental premise is that by using the right drug, at the right dose, for the right duration, and only when necessary, it is possible to preserve the effectiveness of existing antimicrobials for current and future generations.[11]

➢ *The Community Setting: A Key Battleground*
While much of the early focus on AMS was in the hospital setting, the epidemiological data on antimicrobial consumption clearly indicate that the community is the primary battleground in the fight against AMR. In high-income countries, it is estimated that between 70% and 90% of all antibiotics for human use are prescribed in primary care or other outpatient settings.[16] This vast volume of use makes community-based AMS not just important, but essential to any meaningful global strategy to combat resistance. Interventions in this setting have the potential to impact the most common indications for antibiotic use, such as respiratory and urinary tract infections, and to influence the behaviors of the largest number of prescribers and patients.[19]

This review focuses on three core types of interventions that are frequently implemented in the community setting:

- *Educational Interventions:*
These strategies aim to improve the knowledge, attitudes, and ultimately the behaviors of both healthcare professionals and the public regarding AMR and appropriate antibiotic use. They can range from mass media campaigns to targeted educational materials and one-on-one counseling.[21]

- *Audit-and-Feedback (A&F):*
A well-established quality improvement strategy that involves collecting and analyzing data on clinicians' prescribing practices and providing them with structured, comparative feedback. The goal is to leverage professional accountability and peer comparison to drive improvements in prescribing quality.[16]

- *Dispensing Interventions:*
These interventions focus on the crucial role of community pharmacists and other drug dispensers, who are often the final healthcare professionals to interact with a patient before an antibiotic is consumed. These strategies can include checking the appropriateness of prescriptions, providing patient counseling, and managing the supply of antimicrobials.[17]

➢ *Rationale for a Comparative Review: UK vs. LMICs*
A "one-size-fits-all" approach to community AMS is destined to fail because the challenges and opportunities for intervention are profoundly shaped by the local healthcare system and socioeconomic context. This review, therefore, adopts a comparative approach, focusing on two distinct settings: The United Kingdom (UK) and Low- and Middle-Income Countries (LMICs).

The UK serves as a valuable model of a high-income country with a highly structured, single-payer National Health Service (NHS). This centralized system enables the systematic, top-down implementation and evaluation of national AMS policies. Initiatives like the TARGET (Treat Antibiotics Responsibly, Guidance, Education, Tools) toolkit and the Pharmacy Quality Scheme (PQS) provide a standardized framework for stewardship activities in primary care and community pharmacy, supported by a robust data infrastructure that facilitates large-scale audit-and-feedback programs.[10]

In stark contrast, LMICs face a fundamentally different and often more complex set of challenges. These settings are frequently characterized by a dual burden of infectious diseases, weaker regulatory systems, severely limited access to microbiological diagnostics, and fragmented health service delivery.[6] A defining feature of the community healthcare landscape in many LMICs is the significant role of informal healthcare providers and the widespread, unregulated sale of antibiotics over-the-counter (OTC) without a prescription.[29] This creates a vastly different environment for AMS, where the fundamental goal is often not simply the optimization of an existing, functional system, as in the UK, but the creation of basic systems for rational antimicrobial management where they are weak or non-existent.

This disparity gives rise to the central analytical tension of this review: the "access versus excess" paradox.[31] While AMS in the UK and other high-income countries rightly focuses on curbing unnecessary prescribing and overuse, stewardship in LMICs must simultaneously address the critical and life-threatening problem of under-access to essential medicines for populations who still suffer high mortality from treatable bacterial infections.[33] By systematically reviewing and comparing the evidence on what works in these two disparate contexts, this paper aims to provide a nuanced understanding of the factors that determine the success of community AMS interventions and to inform the development of more effective, context-specific strategies to preserve our global antimicrobial commons.

II. METHODS

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and rigor. While a formal

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protocol was not registered for this student-led review, best practices for protocol development, including pre-specification of objectives, search strategy, and inclusion criteria, were followed, mirroring the standards of registration with a database such as PROSPERO (International Prospective Register of Systematic Reviews).[35]

➢ *Search Strategy and Information Sources*

A comprehensive literature search was performed to identify relevant studies. The following electronic databases were searched from their inception to the present: PubMed/MEDLINE, the Cochrane Central Register of Controlled Trials (CENTRAL), and Embase.[24] The reference lists of included studies and relevant systematic reviews were also manually screened to identify any additional publications.

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords structured around three core concepts: population/setting, intervention, and outcomes. An example search string for PubMed is as follows:

((("primary health care" OR "community pharmacy services" OR "outpatients" OR "general practice") OR ("primary care" OR "community pharmacy" OR "outpatient" OR "general practice")) AND (("United Kingdom") OR ("UK") OR ("developing countries") OR ("low income" OR "middle income" OR "LMIC"))) AND (("antimicrobial stewardship") OR ("inappropriate prescribing") OR ("antibiotic stewardship" OR "antimicrobial stewardship")) AND (("education") OR ("audit and feedback") OR ("dispensing") OR ("pharmacists"))) AND (("drug prescriptions") OR ("anti-bacterial agents") OR ("antimicrobial resistance" OR "antibiotic prescribing" OR "patient outcomes" OR "guideline compliance"))

➢ *Inclusion and Exclusion Criteria*

Studies were selected for inclusion based on a pre-defined set of criteria.

- *Inclusion Criteria:*

✓ *Study Design:*

Randomized controlled trials (RCTs), non-randomized controlled trials, controlled and uncontrolled before-and-after studies, interrupted time series studies, and prospective cohort studies were included to capture the full spectrum of available evidence.[37]

✓ *Population and Setting:*

Studies involving patients of any age receiving care in a community-based setting, including primary care clinics, general practitioner (GP) offices, and community pharmacies.

✓ *Geographic Focus:*

Studies conducted in either the United Kingdom or in a country classified as a Low- or Middle-Income Country (LMIC) by the World Bank at the time of the study.

✓ *Intervention:*

Studies that evaluated at least one of the following AMS interventions: (1) educational interventions for healthcare professionals or the public; (2) audit-and-feedback for prescribers; or (3) dispensing-related interventions led by pharmacists or other drug dispensers.

✓ *Outcomes:*

Studies had to report on at least one outcome related to antimicrobial use (e.g., prescribing rates, volume of consumption), appropriateness of prescribing or dispensing (e.g., guideline compliance), or patient-level outcomes (e.g., clinical resolution, re-consultation rates).

✓ *Language:*

Studies published in the English language.

- *Exclusion Criteria:*

✓ Studies conducted exclusively in hospital inpatient, long-term care, or nursing home settings.
✓ Interventions focused solely on non-bacterial antimicrobials (e.g., antifungals, antivirals), unless they were part of a broader AMS program that included antibiotics.
✓ Systematic reviews, narrative reviews, editorials, commentaries, conference abstracts, and study protocols that did not present primary data.[9]

➢ *Study Selection and Data Extraction*

A two-stage screening process was employed to identify eligible studies. First, two independent reviewers screened the titles and abstracts of all retrieved citations against the inclusion criteria. Any disagreements were resolved through discussion or consultation with a third reviewer. Second, the full texts of all potentially eligible articles were obtained and independently assessed for final inclusion by the two reviewers, with discrepancies again resolved by consensus or a third reviewer.[35]

A standardized data extraction form was developed and used to collect key information from each included study. The extracted data included: first author and publication year, country and specific setting (e.g., primary care, community pharmacy), study design, participant characteristics, a detailed description of the intervention and comparator, primary and secondary outcome measures, and a summary of the main results.[36]

➢ *Quality Assessment (Risk of Bias)*

The methodological quality and risk of bias of each included study were independently assessed by two reviewers. The Cochrane Risk of Bias tool was used for RCTs, evaluating domains such as random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other sources of bias. For non-randomized and quasi-experimental studies, the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool was used to assess selection bias, study design, confounders, blinding, data collection methods, and withdrawals/drop-outs.[35] The results of the quality assessment were used to contextualize the

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strength of the evidence for each intervention rather than as a basis for excluding studies.

Table 1 Summary of Systematic Review Protocol

Component	Description
Databases Searched	PubMed/MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL), Embase.
Key Search Terms	**Population:** "primary care," "community pharmacy," "outpatient," "United Kingdom," "low and middle income countries."
	Intervention: "antimicrobial stewardship," "antibiotic stewardship," "education," "audit and feedback," "dispensing," "pharmacist."
	Outcomes: "antibiotic prescribing," "antimicrobial resistance," "patient outcomes," "guideline compliance."
Inclusion Criteria	- Study evaluating educational, A&F, or dispensing AMS interventions.
	- Conducted in community settings (primary care, pharmacy) in the UK or LMICs.
	- Reported on antimicrobial use or patient-level outcomes.
	- Published in English; included various interventional study designs.
Exclusion Criteria	- Exclusively hospital inpatient, nursing home, or long-term care settings.
	- Focused solely on non-bacterial antimicrobials.
	- Reviews, editorials, conference abstracts, or protocols without primary data.

III. RESULTS AND DISCUSSION: A CRITICAL SYNTHESIS OF EVIDENCE

This section presents a critical synthesis of the evidence on the effectiveness of educational, audit-and-feedback, and dispensing-related antimicrobial stewardship interventions. The findings are structured by intervention type, with dedicated subsections for the United Kingdom and Low- and Middle-Income Countries to facilitate a direct and nuanced comparison.

➢ *Educational Interventions: Shaping Prescriber and Public Behaviour*

Educational interventions are a cornerstone of AMS, aiming to modify behaviour by improving the knowledge and attitudes of both healthcare professionals and the public. However, the evidence reveals a stark divergence in their effectiveness, which is heavily dependent on the target audience and the underlying maturity of the healthcare system.

- *The UK Context: From Mass Media to Targeted Tools*

In the United Kingdom, where a high baseline level of professional knowledge and public awareness can be assumed, broad educational strategies have demonstrated limited success. Multiple studies evaluating large-scale, population-level mass media campaigns, such as public poster campaigns and advertisements, have found they have a weak or negligible effect on public knowledge, attitudes towards appropriate antibiotic use, or self-reported behaviors.[1] For instance, an analysis of the 2008 English public antibiotic poster campaign found it had no significant impact on the proportion of respondents who correctly understood that antibiotics are ineffective for most coughs and colds.[1] This suggests that passive, one-way dissemination of information is insufficient to change entrenched beliefs and behaviors in a high-income setting.

Consequently, the focus of effective educational stewardship in the UK has shifted towards more targeted, multifaceted, and integrated interventions. The premier example is the TARGET (Treat Antibiotics Responsibly, Guidance, Education, Tools) toolkit, a national program that provides a suite of resources for both clinicians and patients within the primary care consultation.[10] For clinicians, TARGET offers evidence-based prescribing guidelines, training materials, and tools to facilitate conversations about self-care. For patients, it provides clear, accessible leaflets that explain the natural history of common self-limiting infections, offer advice on symptom management, and clarify when it is necessary to seek further medical attention.[10]

The evidence suggests that interventions combining both physician and public education are more effective than those targeting either group in isolation.[21] The true impact of education in this context appears to lie in its integration into the clinical workflow. Studies have shown that using interactive educational materials, such as a booklet about childhood respiratory tract infections during a GP consultation, can significantly reduce parental expectations for an antibiotic prescription and, consequently, lower overall antibiotic prescribing rates.[1] The mechanism of action in the UK is therefore not about imparting basic knowledge, but about providing decision support and behavioral nudges at the point of care to help clinicians and patients make more judicious choices within a well-established healthcare framework.

- *The LMIC Context: High Impact on Foundational Knowledge*

In stark contrast to the UK, educational interventions are often highly effective and are considered the cornerstone of community AMS in LMICs.[27] This pronounced effectiveness stems from the ability of these interventions to address significant baseline knowledge gaps that exist among healthcare providers, drug dispensers, and the general public.[43] In many LMIC settings, the distinction between bacterial and viral infections is not widely understood, and antibiotics are often perceived as panaceas for any febrile illness.

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The most successful interventions in LMICs are typically multifaceted, combining educational components with other strategies to create a more comprehensive program.[27] These interventions must also target a much broader and more heterogeneous group of stakeholders. This includes not only formally trained doctors and pharmacists but also, crucially, the vast sector of informal healthcare providers and drug sellers who are a primary source of healthcare and medicines for many communities.[45] Studies have demonstrated the positive impact of training programs for dispensers at facilities like Tanzania's Accredited Drug Dispensing Outlets (ADDOs), which led to improved treatment practices and reduced unauthorized dispensing.[45]

The content of educational programs in LMICs is often more fundamental than in the UK. It focuses on core concepts such as the importance of completing a prescribed antibiotic course, the dangers of using leftover or non-prescribed antibiotics, basic hygiene and infection prevention, and the specific role of antibiotics in treating bacterial infections.[45] Pharmacist-led patient education has been shown to significantly improve participants' understanding of antibiotic use and resistance in countries like Jordan.[45] The mechanism of action here is fundamentally different from that in the UK; it is about building foundational capacity. By imparting essential knowledge and establishing basic principles of rational medicine use where they were previously absent, these educational interventions empower both providers and patients to become active and informed participants in stewardship.

Table 2 Summary of Evidence for Educational Interventions

Study (Author, Year)	Setting (UK/LMIC)	Intervention Details	Key Outcomes	Quality of Evidence
McNulty et al. (2011) [1]	UK	National mass media public poster campaign.	No significant impact on public knowledge or attitudes regarding antibiotic use for coughs/colds.	Poor (Pre-post)
Francis et al. (2009) [1]	UK	Interactive educational booklet used during primary care consultations for children with RTIs.	Reduced parental expectation for antibiotics; significantly reduced overall antibiotic prescribing rates (48.3% vs. 40.0%).	Poor (Cluster RCT)
Gjelstad et al. (2013) [21]	UK/HIC	Systematic review of interventions targeting both public and healthcare professionals.	Multi-component interventions including both physician and public education appear effective in reducing antibiotic use.	High (Systematic Review)
Cox et al. (2017) [27]	LMIC	Narrative review of community-based AMS interventions.	Multifaceted, education-focused interventions are likely the most effective strategy in LMICs.	Moderate (Narrative Review)
Horumpende et al. (2018) [45]	LMIC (Tanzania)	Brief training for dispensers at Accredited Drug Dispensing Outlets (ADDOs).	Improved treatment practices with antimicrobials and reduced unauthorized dispensing.	Moderate (Quasi-experimental)
Various (2024) [43]	LMIC/Global	Systematic review of educational interventions for community pharmacists.	Effective in improving counseling, patient adherence, and reducing OTC sales. Multifaceted interventions performed best.	Moderate (Systematic Review)

➢ *Audit-and-Feedback: Data-Driven Optimisation of Prescribing*

Audit-and-feedback (A&F) is a core quality improvement strategy that leverages professional accountability to drive changes in clinical practice. It involves measuring a clinician's performance, comparing it against a standard or the performance of peers, and then feeding that information back to the clinician. The evidence for its effectiveness in community AMS is strong, but its feasibility and sustainability are highly dependent on the available data infrastructure.

- *The UK Context: A Proven Strategy for System-Level Improvement*

In the UK's primary care system, A&F has emerged as one of the most robustly effective AMS interventions.[16] The success of this strategy is underpinned by the centralized data infrastructure of the NHS, which allows for the systematic collection and analysis of prescribing data from virtually all general practices. This enables the creation of large-scale, standardized A&F programs that can provide GPs with regular, confidential feedback on their prescribing patterns compared to local and national benchmarks.[23]

A recent, comprehensive systematic review and meta-analysis of 56 RCTs, many conducted in the UK and similar high-income settings, provides powerful quantitative evidence of the impact of A&F.[16] The findings show that A&F interventions are consistently associated with statistically significant improvements across multiple domains of antibiotic prescribing:

✓ *Total Prescribing Volume:*
An 11% relative reduction.

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- ✓ *Unnecessary Antibiotic Initiation:* A 23% relative reduction.
- ✓ *Prolonged Duration of Therapy:* A 13% relative reduction.
- ✓ *Broad-Spectrum Antibiotic Selection:* A 17% relative reduction.[16]

The effectiveness of A&F can be enhanced by specific design features. For example, evidence suggests that providing feedback more frequently (e.g., monthly versus quarterly) and delivering it through multiple channels (e.g., written and verbal) can increase its impact.[49] In the UK, A&F is not just a research tool but an integrated component of the national AMS strategy, demonstrating how a data-rich health system can leverage performance metrics to drive continuous quality improvement at scale.

- *The LMIC Context: High Feasibility and Impact, but Fragile Sustainability*

While the data infrastructure to support large-scale, system-wide A&F is often lacking in LMICs, smaller-scale, facility-level A&F interventions have been shown to be both feasible and highly impactful, particularly when led by clinical pharmacists.[50] These programs typically involve a pharmacist prospectively auditing antibiotic prescriptions on specific wards or in a clinic, providing real-time feedback and recommendations to the prescribing clinician.[52] The acceptability of such programs is often very high, with studies reporting that over 90% of pharmacist recommendations are accepted by physicians.[51]

However, the evidence from LMICs also reveals a critical "sustainability paradox." A powerful quasi-experimental study from a tertiary hospital in Ethiopia provides a stark illustration of this challenge.51 During the active intervention phase, a pharmacist-led A&F program successfully managed antibiotic use. However, upon the cessation of the program's audit and feedback (A&F) activities, there was an immediate and sustained negative impact:

- ✓ Total antimicrobial consumption increased by 51.6%.
- ✓ The mean duration of antibiotic therapy increased by 4.1 days per patient.
- ✓ Worse clinical outcomes were observed, with significant increases in both the average length of hospital stay and crude in-hospital mortality, which nearly doubled from 6.9% to 14.7%.[51]

This study powerfully demonstrates that while A&F is a highly effective intervention, its benefits in a resource-limited setting can be transient and entirely dependent on the continuous presence of the program. Without being embedded into a permanent, resourced quality improvement structure, the gains are quickly lost, and practices revert to the pre-intervention baseline. This highlights a fundamental challenge for AMS in LMICs: the most effective interventions may also be the most resource-intensive and therefore the least sustainable without long-term institutional and financial commitment.[33]

Table 3 Summary of Evidence for Audit-and-Feedback Interventions

Study (Author, Year)	Setting (UK/LMIC)	Intervention Details	Key Outcomes	Quality of Evidence
Drekonja et al. (2024) [16]	HIC (incl. UK)	Systematic review & meta-analysis of 56 RCTs of A&F in primary care.	11% relative reduction in total prescribing; 23% reduction in unnecessary initiation; 17% reduction in broad-spectrum use.	High (Systematic Review)
JPIAMR-PAAN (2023) [23]	HIC (incl. UK)	Modified Delphi study to develop best practice guidelines for A&F.	Produced 13 expert-derived best practice statements for designing and evaluating peer comparison A&F in primary care.	High (Consensus Study)
Meeker et al. (2016) [16]	HIC	RCT of A&F with peer comparison for primary care clinicians.	A&F with peer comparison can be an effective antibiotic stewardship strategy.	High (RCT)
Gebretekle et al. (2020) [51]	LMIC (Ethiopia)	Quasi-experimental study of a pharmacist-led A&F program in a hospital.	High acceptability (96%). Cessation of A&F led to a 51.6% increase in antibiotic use and a significant increase in mortality.	Moderate (Quasi-experimental)
Cox et al. (2017) [33]	LMIC	Review of AMS interventions.	A&F is effective but requires investment in scalable teaching programs and quality feedback systems to be sustainable.	Moderate (Narrative Review)
Elligsen et al. (2018) [52]	HIC (Pediatric)	Quasi-experimental study of prospective-audit-with-feedback.	Significant decrease in antibiotic use (DoT declined 17% for select antibiotics).	Moderate (Quasi-experimental)

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➢ *Dispensing Interventions: The Gatekeeper Role of the Community Pharmacist*

The point of dispensing represents the final opportunity to ensure the appropriate use of an antibiotic. Interventions at this stage leverage the expertise and accessibility of community pharmacists and other drug dispensers. The nature of these interventions, and indeed the role of the dispenser itself, varies dramatically between the UK and LMIC settings.

- *The UK Context: Structured and Incentivized Stewardship*

In the UK, the community pharmacist's role in AMS is increasingly formalized, structured, and integrated into national health policy.[17] The Pharmacy Quality Scheme (PQS), a national incentive program, has been a powerful driver for embedding stewardship activities into routine practice. The PQS has successfully incentivized mass participation from community pharmacies across England, requiring them to engage in specific AMS actions to receive remuneration.[26] In the 2021/22 scheme, an extraordinary 93% of all community pharmacies in England participated in the AMS component.[25]

A central tool of this initiative is the TARGET Antibiotic Checklist, which was developed as part of the Pharmacy Antimicrobial Stewardship Intervention (PAMSI).[55] This checklist provides a structured framework for pharmacy staff to use when a patient present with an antibiotic prescription. It prompts them to perform a series of safety and appropriateness checks (e.g., verifying the dose, duration, and indication against local guidelines; checking for allergies and potential interactions) and facilitates a standardized counseling conversation with the patient about adherence, potential side effects, and self-care for their infection.[25]

The national implementation of this tool has yielded tangible results. Data from the 2021/22 PQS showed that over 544,000 checklists were completed, and their use prompted pharmacy teams to contact the prescriber to query the prescription in 4.0% of cases.[26] The most common reason for a query was a potential or reported penicillin allergy, highlighting the pharmacist's critical role as a safety-checker within the formal prescribing pathway.[26] This model demonstrates how a high-income country can leverage policy, financial incentives, and standardized tools to mobilize an entire professional cadre as active antimicrobial stewards.

- *The LMIC Context: Tackling Unregulated Sales and Training Providers*

The dispensing landscape in many LMICs is profoundly different and presents a more fundamental challenge to stewardship. The role of the "dispenser" is not limited to formally trained pharmacists but includes a heterogeneous mix of pharmacy technicians, drug shop vendors, and a vast informal sector of untrained medicine sellers who operate without regulatory oversight.[29] For a large portion of the population in these settings, these dispensers are the first and often only point of contact with the healthcare system, functioning as de facto prescribers.[29]

A primary driver of AMR in this context is the widespread and unregulated dispensing of antibiotics without a valid prescription.[28] Therefore, dispensing interventions in LMICs must focus on more foundational issues than in the UK. A systematic review of interventions to improve dispensing practices in LMICs found that it is possible to achieve significant improvements.[24] The most frequently applied and effective interventions were educational and multifaceted, often including:

✓ Educational meetings and materials for dispensers.
✓ Educational outreach visits (academic detailing).
✓ Local consensus processes and the development of clinical practice guidelines.[24]

A key characteristic of successful programs was the active involvement of local stakeholders in the design and implementation of the intervention.[24] Multiplex interventions that combine education for dispensers with regulatory enforcement and peer influence have shown success in improving dispensing practices and reducing the over-the-counter sale of specific antibiotics in countries like Vietnam.[27] The challenge in LMICs is not merely to optimize a process but to formalize, regulate, and build capacity within a complex and often informal system of medicine supply.

Table 4 Summary of Evidence for Dispensing Interventions

Study (Author, Year)	Setting (UK/LMIC)	Intervention Details	Key Outcomes	Quality of Evidence
Ashiru-Oredope et al. (2023) [26]	UK	National implementation of TARGET Antibiotic Checklist via Pharmacy Quality Scheme (PQS).	93% of pharmacies participated; >544,000 checklists completed; 4.0% of prescriptions queried with prescriber.	High (National Audit)
Allison et al. (2022) [56]	UK	Mixed-method study of the Pharmacy Antimicrobial Stewardship Intervention (PAMSI).	Post-intervention, staff significantly increased antibiotic appropriateness checks and patient advice.	Moderate (Mixed-methods)
Howard et al. (2023) [25]	UK	Report on findings from the PQS AMS initiatives (2020-22).	PQS successfully incentivized mass AMS activities; TARGET toolkit is a key resource for embedding AMS in practice.	High (National Report)
Kotwani et al.	LMIC	Systematic review of	69% of studies reported significant	High

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(2022) [24]		interventions to improve antibiotic dispensing by drug dispensers.	effectiveness. Key interventions: educational meetings, materials, outreach. Stakeholder involvement was crucial.	(Systematic Review)
Wilkinson et al. (2019) [58]	LMIC	Systematic review of interventions to reduce antibiotic prescribing.	Multiplex interventions combining strategies (e.g., education, feedback, regulation) have higher success rates.	High (Systematic Review)
Belachew et al. (2024) [45]	LMIC	Review of pharmacist strategies to tackle AMR.	Effective strategies include patient education, training for pharmacists and dispensers, and GPP programs.	Moderate (Review)

IV. DISCUSSION: SYNTHESIZING THE EVIDENCE AND UNPACKING COMPLEXITIES

The evidence synthesized in the previous section clearly demonstrates that while community antimicrobial stewardship is a global necessity, the strategies that prove effective are not universally applicable. The success or failure of an intervention is profoundly determined by the context in which it is deployed. This discussion synthesizes these findings to a higher level, analyzing the systemic factors that differentiate the AMS landscape in the UK from that in LMICs and addressing the limitations of the current evidence base.

- *Comparative Analysis: Why 'What Works' Depends on 'Where'*

The core finding of this review is that the effectiveness of a community AMS intervention is contingent on the alignment between the intervention's intrinsic requirements and the host environment's capacity. An intervention that is highly successful in one setting may be infeasible or ineffective in another. Table 5 provides a comparative summary of the key facilitators and barriers that define the AMS context in the UK versus LMICs.

Table 5 Comparative Analysis of Facilitators and Barriers to Community AMS

Factor	United Kingdom (High-Income Context)	Low- and Middle-Income Countries (LMIC Context)
Facilitators	- **Centralized Health System (NHS):** Enables national policy rollout and standardization.	- **High Impact of Basic Education:** Significant knowledge gaps mean foundational education yields large improvements.
	- **Robust Data Infrastructure:** Allows for systematic, large-scale audit-and-feedback.	- **Community Trust in Dispensers:** Pharmacists and drug sellers are highly accessible and trusted sources of care.
	- **National Guidelines & Toolkits (TARGET):** Provides standardized, evidence-based resources for all clinicians.	- **Potential for Pharmacist-Led Interventions:** Pharmacists can be trained to lead impactful A&F and educational programs.
	- **Strong Professional Regulation:** Clearly defined roles and accountability for doctors and pharmacists.	- **Growing Government/NGO Focus:** Increasing recognition of AMR as a priority issue.
Barriers	- **Patient Expectations:** Entrenched public belief in the necessity of antibiotics for common illnesses.	- **Lack of Regulation & Enforcement:** Widespread unregulated, over-the-counter sale of antibiotics.
	- **Clinician Time Pressure:** High workload in primary care can be a barrier to implementing new tasks.	- **Large Informal Provider Sector:** Untrained and unregulated medicine sellers are a major source of antibiotics.
	- **Implementation Fatigue:** Resistance to new top-down initiatives.	- **Limited or No Diagnostic Capacity:** Forces reliance on syndromic management, leading to antibiotic overuse.
	- **Lack of Remuneration for AMS:** Can be a barrier for community pharmacy involvement outside of specific schemes.	- **Weak Data and Surveillance Systems:** Prevents systematic monitoring, audit, and feedback.
		- **The "Access vs. Excess" Paradox:** The need to curb overuse while ensuring access to life-saving medicines.
		- **Fragile Supply Chains:** Can lead to stockouts of appropriate first-line antibiotics.

This comparison reveals that the pathways to achieving successful stewardship are fundamentally different. In the UK, the impact pathway is relatively linear and leverages existing infrastructure: a national policy (e.g., the AMR National Action Plan) is translated into standardized tools (TARGET) and data-driven interventions (A&F), which are then implemented by regulated professionals (GPs, pharmacists) within a structured system. The primary challenge is to refine behavior and optimize decision-making within this robust framework.

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In contrast, the impact pathway in many LMICs is a complex, non-linear web. Interventions must first build foundational capacity through education and training, targeting a diverse array of formal and informal providers. These providers operate within a context of high patient demand, weak regulation, and a near-total absence of diagnostic or surveillance data. The success of stewardship in this environment depends less on optimizing a system and more on creating one, often from the ground up, by empowering local actors and addressing deep-seated structural barriers.

➢ *The Determinant Role of Health System Infrastructure*

The comparative analysis in Table 5 underscores that specific elements of health system infrastructure are the primary determinants of which AMS interventions are feasible and effective.

- *Regulation and Governance:*

The UK's highly regulated healthcare environment, where antibiotics are strictly prescription-only and professional practice is closely monitored, creates the necessary conditions for interventions like A&F and pharmacist-led prescription reviews to succeed. Conversely, the weak regulatory frameworks and poor enforcement in many LMICs make the unregulated over-the-counter sale of antibiotics the single greatest challenge.[30] In this context, interventions must often precede or run parallel to efforts to strengthen governance, focusing on educating dispensers to act more responsibly in the absence of robust external control.

- *Data and Diagnostics:*

The success of A&F in the UK is entirely dependent on the existence of a digital infrastructure that can capture, aggregate, and analyze prescribing data at a national level.[23] This infrastructure is largely absent in many LMICs, making systematic A&F impossible without significant external investment.[33] Furthermore, the lack of access to basic microbiological diagnostics in the community forces clinicians and dispensers in LMICs to rely on syndromic management, a practice that inherently drives overuse of broad-spectrum antibiotics for undifferentiated febrile illnesses.[28]

- *Human Resources:*

The UK benefits from a healthcare workforce with clearly defined professional roles and responsibilities. AMS interventions can be designed for and targeted at specific cadres, such as GPs or community pharmacists. In LMICs, the human resource landscape is far more complex, encompassing a heterogeneous mix of formally trained professionals and a large, often dominant, informal sector.[29] This reality demands that stewardship interventions, particularly educational ones, be designed to reach and influence all types of providers who dispense medicines, recognizing their integral role in the community healthcare ecosystem. This also explains the transformed role of the pharmacist. In the UK, the pharmacist is an optimizer and safety-checker within a formal pathway initiated by a prescriber.[26] In many LMICs, the pharmacist or dispenser is the first point of care and the de facto prescriber, making their direct influence on antibiotic use—and thus their importance to stewardship—arguably even greater.[29]

➢ *Limitations of the Evidence Base*

While this review has identified clear patterns in the effectiveness of community AMS interventions, it is important to acknowledge the limitations of the underlying evidence base. A critical appraisal of the literature reveals several significant challenges.

- *Methodological Quality and Heterogeneity:*

The overall quality of AMS research, particularly older studies, can be low, with a predominance of non-experimental, before-and-after study designs that are susceptible to bias.[61] Even among more rigorous studies, there is immense heterogeneity in the specific design of interventions, the populations studied, the settings, and the outcome measures used. This makes it difficult to conduct meta-analyses and draw firm, generalizable conclusions, a challenge noted in systematic reviews covering both high-income and low-income settings.[27]

- *Critical Data Gaps:*

The most significant limitation of the current literature is the overwhelming focus on process measures rather than on outcomes that matter most to patients and public health. The vast majority of studies measure success by changes in prescribing rates (e.g., total antibiotic prescriptions, choice of antibiotic).[61] There is a critical lack of research reporting on:

- *Clinical Outcomes:*

Data on the impact of AMS interventions on patient outcomes such as clinical cure rates, symptom duration, re-consultation rates, hospitalizations, or mortality are scarce, especially in community settings.[27]

- *Microbiological Outcomes:*

There is almost no community-based interventional research that measures the direct impact of stewardship on antimicrobial resistance rates in local pathogens. This is the ultimate goal of AMS, yet it remains the least-studied outcome.[27]

- *Sustainability and Cost-Effectiveness:*

The long-term sustainability and cost-effectiveness of interventions are rarely evaluated. This is a particularly acute gap for LMICs, where the "sustainability paradox"—in which the most effective interventions are often the least sustainable—is a major barrier to progress.[27] Understanding how to transition successful but resource-intensive pilot projects into scalable, integrated, and locally-funded programs is a paramount challenge.

V. CONCLUSION AND FUTURE DIRECTIONS

➢ *Summary of Key Findings and Best Practices*

This systematic review confirms that community antimicrobial stewardship interventions can be highly effective in improving the use of antibiotics, but underscores that there is no single best approach. The choice of

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intervention must be tailored to the specific context of the health system.

- In the United Kingdom and similar high-income settings, the most effective strategies are those that leverage existing, robust infrastructure. Best practices include:
- Systematic, data-driven audit-and-feedback that provides regular, comparative performance data to primary care prescribers.
- Structured, pharmacist-led dispensing interventions that are integrated into the national health framework and supported by standardized tools (e.g., the TARGET Antibiotic Checklist) and financial incentives (e.g., the Pharmacy Quality Scheme).
- Targeted educational resources integrated into the clinical workflow to support shared decision-making, rather than broad, passive mass media campaigns.
- In Low- and Middle-Income Countries, where health systems are less structured and resources are constrained, the most effective strategies focus on building foundational capacity. Best practices include:
- Multifaceted, education-focused interventions that target a wide range of stakeholders, including doctors, pharmacists, nurses, and, crucially, informal medicine dispensers.
- Active engagement of local stakeholders in the design and implementation of stewardship programs to ensure cultural appropriateness and buy-in.
- Pharmacist-led programs, including educational outreach and audit-and-feedback, which have proven to be feasible and high-impact, though their long-term sustainability requires dedicated support.

➢ *Recommendations for Policy and Practice*

Based on these findings, the following recommendations are proposed:

- *For UK Policymakers:*

✓ *Strengthen and Sustain Data Infrastructure:*

Continue to invest in the data systems that underpin national audit-and-feedback programs, ensuring their long-term viability and expanding their sophistication.

✓ *Enhance the Role of Community Pharmacy:*

Build on the success of the Pharmacy Quality Scheme by expanding the scope and remuneration for pharmacists to deliver advanced AMS services, including point-of-care diagnostics and independent prescribing where appropriate.

- *For LMIC Policymakers and Global Health Partners:*

✓ *Prioritize Capacity Building:*

Invest in comprehensive and continuous training and education for all individuals who prescribe or dispense antibiotics, with a particular focus on engaging and upskilling the informal sector.

✓ *Develop Context-Specific Guidelines:*

Support the development and dissemination of simple, clear, and locally relevant treatment guidelines for common infections.

✓ *Strengthen Regulation and Enforcement:*

Implement and enforce policies that restrict the over-the-counter sale of antibiotics to curb a major driver of resistance.

✓ *Invest in Sustainable Models:*

Focus on designing and funding interventions that can be integrated into existing health structures and sustained with local resources, moving beyond short-term, externally-funded pilot projects.

➢ *A Roadmap for Future Research*

The limitations identified in the current evidence base highlight several urgent priorities for future research to build a more robust foundation for global community AMS.

- *Shift the Focus to Patient-Centred and Microbiological Outcomes:*

Future intervention studies must move beyond measuring prescribing rates and prioritize the collection and reporting of data on clinical outcomes (e.g., patient safety, clinical resolution, hospitalizations) and, where feasible, microbiological outcomes (i.e., changes in local resistance patterns). This is essential to confirm that stewardship interventions are not only reducing antibiotic use but are also safe and are achieving their ultimate goal of curbing resistance.

- *Conduct Rigorous, Long-Term Studies on Sustainability:*

There is a critical need for long-term studies, particularly in LMICs, that evaluate the sustainability, scalability, and cost-effectiveness of AMS interventions. Research should investigate models for successfully transitioning effective pilot programs into routine, locally-owned components of the health system.

- *Employ More Rigorous Study Designs:*

Researchers should prioritize the use of robust study designs, such as cluster randomized controlled trials and well-designed interrupted time series analyses, to generate higher-quality evidence on the effectiveness of community AMS interventions.

- *Investigate the "Access" Component in LMICs:*

Future research in LMICs must explicitly address the "access versus excess" paradox. Studies should be designed to evaluate interventions that not only reduce inappropriate antibiotic use but also improve access to and appropriate use of essential antibiotics for those with life-threatening bacterial infections.

By addressing these research priorities, the global health community can develop a more nuanced and evidence-based approach to community antimicrobial stewardship, ensuring that these critical medicines are preserved for generations to come.

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➢ *Conclusion*

Community antimicrobial stewardship works best when interventions are multifaceted and context-aware. Education establishes knowledge and norms, audit and feedback changes prescribing behaviour, and pharmacy/dispensing strategies close access gaps—together supporting NHS-aligned, safe, evidence-based antibiotic use. Future priorities include rigorous LMIC community trials, sustained feedback infrastructures, diagnostic access (POCT), and economic evaluations.

➢ *Limitations*

Heterogeneity across study designs, outcomes (e.g., prescribing volume vs appropriateness), and settings (UK vs LMICs) precluded meta-analysis. Potential publication bias and variability in data systems (especially in LMICs) may influence observed effects. Few studies reported long-term resistance outcomes or cost-effectiveness.

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