

Antibiotic Use Across One Health Sectors in Uganda: Temporal Alignment Between Antibiotic Introduction and Policy Guidance: A Scoping Review and Meta-Analysis

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Abstract

Background

Antimicrobial resistance (AMR) remains a major global health threat, driven by antibiotic use across human, animal, and environmental sectors. In Uganda, despite a National Action Plan and sector-specific policies, inappropriate antibiotic use persists through empiric prescribing, over-the-counter access, and non-therapeutic use in livestock production. These patterns reflect longstanding structural and historical legacies rooted in colonial medical and veterinary systems. This review traces the evolution of antibiotic use and stewardship alongside corresponding policy developments in Uganda and applies meta-analysis to estimate historical antibiotic use in human and animal health.

Objectives

The objectives of the scoping review were (i) To determine the most commonly used antibiotics in different One Health sectors (human, animal, and environmental) in Uganda and (ii) To determine temporal alignment between antibiotic introduction and policies and guidelines on antibiotic use in Uganda. For the meta-analysis we aimed to determine the prevalence of antibiotic use in the different One Health sectors in Uganda.

Methods

We conducted a scoping review following Joanna Briggs Institute methodology and reported according to PRISMA-ScR, based on a preregistered protocol on the Open Science Framework. Eligibility criteria included studies and documents on antibiotic use in Uganda across One Health sectors, covering antibiotic use, introduction timelines, and AMR policies, with no restriction on study design. Sources of evidence comprised peer-reviewed literature from PubMed and Web of Science, institutional repositories, and government and international agency documents. Two reviewers independently screened and extracted data using a Google Sheets form. Evidence was synthesised descriptively and narratively.

Results

Twenty two studies met the inclusion criteria, covering antibiotic use in human and animal sectors. Analysis of historical timelines revealed four stewardship phases; pre-antibiotic, pre-stewardship, stewardship, and post-stewardship, each characterised by distinct trends in antibiotic use, policy engagement, and availability of evidence. Human antibiotic consumption was consistently dominated by critically important classes, including cephalosporins, fluoroquinolones, and macrolides. Despite incremental policy efforts, stewardship and regulatory frameworks have lagged behind use over the past six decades, with a notable shift only after 2015 following the adoption of AWaRe-aligned national

policies. In the animal sector, tetracyclines and folate-pathway inhibitors accounted for most reported use but use in animals represented only 6% of total antibiotic consumption, reflecting historic fundamental sectoral differences in prescribing practices. It is noteworthy that the overlap in classes used in both sectors has grown. Our pooled estimates reveal substantial heterogeneity, suggesting fragmentation of information typical in systems with weak surveillance.

Conclusion

Antimicrobial use in Uganda remains high, particularly within the human health sector, likely reflecting persistent misalignment between policy frameworks and implementation. Although this gap has begun to narrow since 2016, sustaining and expanding these gains will require strengthened surveillance systems, enforceable and well-resourced stewardship mechanisms, and coherent One Health governance structures that can translate policy commitments into measurable, sustained reductions in antimicrobial use.

Background

Antibiotics have transformed human and veterinary medicine by revolutionising the treatment of infectious diseases, reducing morbidity and mortality, and supporting agricultural productivity. In human health, they are essential for treating bacterial infections, preventing post-surgical complications, and enabling complex medical care. In animal husbandry, they support disease control and productivity, while in agriculture, they protect against bacterial pathogens. However, these benefits are increasingly threatened by the global rise of antimicrobial resistance (AMR), driven by inappropriate, excessive, and poorly regulated antibiotic use across human, animal, and environmental sectors^{1,2}.

The Quadripartite Joint One Health Plan of Action calls for coordinated, cross-sectoral efforts to mitigate AMR, recognising the interdependence of human, animal, and environmental health³. In response, most African countries have established national One Health coordination platforms. However, their impact on AMR implementation and evaluation remains uncertain, largely due to limited domestic financing and reliance on external support. In Uganda, as in many countries across the Global South, robust antimicrobial stewardship policies coexist with widespread access to antibiotics without prescription in both human and animal health. Over-the-counter sales remain common, and in livestock production, antibiotics are still used for growth promotion, despite regulatory restrictions^{4,5}. Although limited public awareness contributes to inappropriate antibiotic use, the economic incentives associated with the distribution and sale of antibiotics are likely the strongest drivers^{6–8}. These historical regulatory enforcement weaknesses have also contributed to substantial environmental contamination with antibiotic residues, particularly in water bodies linked to agricultural runoff and pharmaceutical manufacturing⁹.

In 2018, Uganda launched its National Action Plan, aligned with the WHO Global Action Plan (WHO, 2016), to strengthen AMR surveillance, promote antimicrobial stewardship, and enhance multisectoral collaboration. However, implementation has been limited by inadequate domestic financing, fragmented data systems, and weak integration of surveillance across human, animal, and environmental sectors. This disparity between policy formulation and practice has important implications on the success of the NAPs and can be traced back to colonial times. However, to date, such historical accounts of practice-policy comparisons have relied on fragmented, often hard-to-access information.

To address these gaps, we conducted a scoping review and meta-analysis of antibiotic use across human, animal, and environmental sectors, complemented by a structured policy synthesis. The review questions were conceptualized using the Population–Concept–Context (PCC) framework. The population included humans, animals, and environmental systems in Uganda. The concept focused on antibiotic use, including the types of antibiotics commonly used, their prevalence, and patterns of use across sectors; and the national policies and guidelines governing antibiotic introduction and use. The context was the One Health framework in Uganda. Guided by this framework, the review sought to: (i) identify the most commonly used antibiotics across the different One Health sectors (human, animal, and environmental) in Uganda; and (ii) examine the temporal alignment between the introduction of antibiotics and the development of national policies and guidelines governing antibiotic use in Uganda. The review questions are well suited to a scoping review approach because they aim to map the breadth and characteristics of evidence on antibiotic use across the human, animal, and environmental sectors within a One Health framework in Uganda. Additionally, the meta-analysis aimed to estimate the prevalence of antibiotic use across the different One Health sectors in Uganda.

Evidence on antibiotic use was drawn from published literature. Policy and regulatory documents were obtained from official government repositories, including the Ministry of Health website and archives, the Uganda Legal Information Institute, and the Ministry of Agriculture, Animal Industry, and Fisheries. Aligning use data with policy timelines enabled a comprehensive assessment of how regulatory frameworks have evolved relative to antibiotic availability and consumption across One Health sectors in Uganda.

Methods

Scoping Review Approach

A scoping review design was employed, following the Joanna Briggs Institute (JBI) methodology and reported in accordance with PRISMA-ScR guidelines. An a priori protocol was registered on the Open Science Framework (OSF) to enhance transparency, methodological rigour, and reproducibility¹⁰.

A systematic search of PubMed was conducted using the following query: (“antibiotic use” OR “antimicrobial use” OR “antibiotic consumption” OR “antimicrobial consumption”) AND (“Uganda”) well as ("antibiotic use " (Topic) or "antibiotic consumption" (Topic) and "antimicrobial use" (Topic) or

"antimicrobial consumption" (Topic) and "in Uganda" (Topic)) in Web of Science. Although the review focused specifically on antibiotic use, the term "antibiotic consumption" was included to capture literature in which these terms were used interchangeably. During screening, studies that focused solely on antibiotic consumption without addressing use were excluded. For this review, antibiotic use was defined as the prescription, administration, or consumption of antibiotics. To broaden coverage, additional searches were conducted in Web of Science, with search terms adapted to each database.

Data Compilation

This study used three primary data sources to investigate antibiotic use patterns, clinical introduction timelines, and policy alignment in Uganda.

The first dataset consisted of antibiotic-use estimates extracted from peer-reviewed studies, compiled into a structured spreadsheet (Supplementary file AMU) that captured the antibiotic name, host sector (e.g., human), study location, publication year, and available quantitative consumption measures. The second dataset focused on the clinical introduction timelines of 34 antibiotics (Antibiotic Introduction), with each entry including the antibiotic's global year of introduction, the estimated year of use in Uganda, its antibiotic class, and the generation within that class. This dataset was derived from pharmaceutical reference sources, publicly available WHO and Ministry of Health Uganda records, and secondary literature.

The third dataset consisted of national and sector-specific policy documents addressing antimicrobial use and resistance. These included Uganda's 2018 National Action Plan on AMR¹¹, the 2023 updated draft National Action Plan, National Medicines Policies, AMR surveillance frameworks, and veterinary guidelines issued by the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF, 2025). MAAIF documents reviewed included guidelines for infection prevention and antimicrobial use in cattle, poultry, and aquaculture systems. All records were retrieved from official ministry portals, institutional repositories, and targeted Google searches.

Information Extraction and Analysis

Antibiotic use as evidenced from the literature

Published data on antibiotic consumption were systematically extracted and standardised across studies. Antibiotic information was reported either as individual antibiotic scientific names or as antibiotic classes, depending on the source. To ensure comparability, all antibiotic entries were harmonised to the antibiotic class level prior to analysis. Antibiotic names were extracted in lowercase, removed punctuation, and disaggregating records that reported multiple antibiotics. Individual antibiotics were then mapped to their corresponding classes (e.g., ceftriaxone to cephalosporins;

ciprofloxacin to fluoroquinolones), enabling aggregation across studies that reported consumption at varying levels of detail.

The dataset included information on antibiotic class, host species (limited to humans), geographic study location, publication year, sample size, and the number of individuals reported to have used antibiotics. Antibiotic use was defined as the proportion of study participants who reported taking at least one antibiotic during the study period, calculated as the number of individuals exposed to antibiotics divided by the total number of individuals enrolled in each study. This proportion-based definition enabled direct comparison across studies with differing population sizes, study designs, and reporting formats.

Descriptive summary of studies

Descriptive statistics were generated to summarise the frequency of antibiotic classes reported and to characterise geographic and temporal patterns of antibiotic use. Total use for each antibiotic class was estimated by summing exposure number of people that are using antibiotics across studies, and the ten most frequently reported antibiotic classes were identified and visualised using bar plots. Antibiotic use was summarised descriptively and visualised using stacked bar plots showing the distribution of antibiotic classes by host category. This representation allowed comparison of antibiotic class composition across hosts and facilitated identification of the classes that contributed most to overall population exposure. Analyses focused on descriptive comparison rather than formal temporal or spatial modelling, given heterogeneity in reporting across studies.

Meta-analysis of antibiotic use

For the meta-analysis, only studies reporting both numerators (the number of individuals or entities such as farms, sewers, or swimming pools that used antibiotics) and denominators (the total number of individuals or entities assessed) were included in the pooled quantitative analyses. Antibiotic use was calculated at the study level and subsequently aggregated by antibiotic class, thereby standardising the denominator across included studies. Studies reporting antibiotic quantities without a clearly defined population denominator were excluded from proportion-based analyses.

The use of a pooled estimate meta-analytic framework was particularly important given the substantial heterogeneity in how antibiotic use is reported in Ugandan literature. This approach provides a more robust estimate of antibiotic exposure patterns, facilitates stewardship performance assessment, and establishes a baseline against which the impact of antimicrobial policies on antibiotic use can be evaluated.

A timeline of antibiotic introduction in Uganda

For the antibiotic introduction timeline, a structured dataframe was developed to capture both the global and estimated Ugandan introduction years of 34 antibiotics. Each entry included the antibiotic's name,

class, and generation within its pharmacological group. This information was sourced from pharmaceutical reference texts, WHO publications, and national antibiotic lists maintained by the Ugandan Ministry of Health.

The data were used to construct a comparative timeline illustrating the global and regional sequence of antibiotic introductions. This timeline was visualized in R (ggplot2) and annotated with key policy milestones, including the launch of the WHO Global Antimicrobial Resistance Surveillance System (GLASS), Uganda's 2015 AMR Surveillance Plan, the 2018 AMR National Action Plan (NAP), and the 2023 draft NAP update. This overlay enabled assessment of whether stewardship policies were introduced before or after the availability of critical antibiotic classes within the Ugandan context.

Relationship between antibiotic use and policies and guidelines on antibiotic use in Uganda

Documents were identified through searches on the Ministry of Health's website, Google, and official databases. Metadata was entered into an Excel file Supplementary file AMU, with structured entries stored in the "Policies and guidelines" sheet.

Policy documents were reviewed in full and subjected to structured data extraction using a predefined matrix. Extracted variables included the document title, year of issue, issuing authority, target sectors (human, animal, environmental), policy scope, and level of One Health integration. Further content areas included the antibiotic classes mentioned, the types of infections addressed, treatment and diagnostic guidance, surveillance mechanisms, prescribing restrictions, veterinary regulation, budgetary provisions, public education strategies, and compliance monitoring indicators.

Data visualizations, including timelines and scatter plots for alignment assessments were developed using ggplot2 package in R (version 4.5.0). These charts integrated antibiotic usage studies, antibiotic introduction dates, and relevant policy guidelines.

Results

A total of 266 records were identified from the PubMed and Web of Science databases after removing duplicates. Synthesis was done on only the 22 studies that satisfied our eligibility criteria (Fig. 1). Notably the included articles were published in the last 13 years.

Data triage

Practice Antibiotic use as evidence in literature

Literature-based evidence on antibiotic use in Uganda

A total of 22 papers satisfied our eligibility criteria (Fig. 1), all published after 2016, covering animals, poultry, and Humans. A total of 24 distinct antibiotics were identified across the included studies Supplementary file AMU.

Overall, antibiotic use is highly concentrated in a small number of classes. For most antibiotic classes, human consumption accounts for nearly all use (Fig. 2). In contrast, animal consumption is minimal and visible only for a limited number of classes. It is noteworthy that our search didn't return any articles on antibiotic use in the environment.

Penicillins (25.19%), Nitroimidazoles (23.63%) and cephalosporins (22.69%) together account for approximately half of total antibiotic use, indicating a heavy reliance on agents commonly used for the empirical management of gastrointestinal, anaerobic, and systemic infections. These classes are used almost exclusively in humans, with animal contributions effectively negligible in the dataset. Penicillins (25.19%) represent the third-largest share of total use and are likewise dominated by human consumption; however, a small animal contribution of approximately 0.16% of total use is evident.

In contrast, other antibiotic classes contribute a smaller share to overall use and exhibit modest but more discernible contributions from animals. Fluoroquinolones (7.4%), aminoglycosides (4.97%), and macrolides (4.96%) form a secondary tier of consumption and are almost entirely attributable to human use, with animal contributions close to zero; macrolides show a marginal animal share of approximately 0.1% of total use. Nitrofurans (3.5%) are exclusively used in humans in this dataset. Despite their lower relative contribution, several of these classes, particularly fluoroquinolones and macrolides, are categorised by the World Health Organization as highest-priority critically important antimicrobials for human medicine, raising stewardship concerns even at moderate use levels.

Animal use has historically been dominated by tetracyclines and folate pathway inhibitors (trimethoprim–sulfamethoxazole). As an antibiotic class, tetracyclines represent 2.1% of total antibiotic use, with 75% of this used in animals and the rest in humans. Similarly, folate pathway inhibitors account for approximately 2.2% of total use, with 90% of this used in animals (Fig. 2). It is worth noting that the majority of the studies from which the data is extracted represent all but the central region (Mugezi et al., 2025), followed by Nayiga et al. (2020)¹² and Samuel et al. (2023)¹³.

Across studies, antibiotic use is heavily concentrated in a few dominant classes, with clear differences between hospital-based, community, and animal-sector data. For example, cephalosporins and nitroimidazoles dominate inpatient hospital settings. In multi-hospital stewardship evaluations by Kiggundu et al. (2023)¹⁴, cephalosporins and nitroimidazoles (primarily metronidazole) consistently accounted for the largest share of prescriptions across UTI, URTI, and surgical antibiotic prophylaxis (SAP), with particularly high cephalosporin counts in SAP (n = 4,173). In peri-operative prescribing as reported by Saito et al. (2020), ceftriaxone (a cephalosporin) and metronidazole dominate use data, reinforcing the central role of these two classes in inpatient surgical care. Penicillins and sulphonamides are commonly used in community-based prescribing. The refugee settlement study by Boniface et al.,

2021)¹⁵ reported penicillins as the leading class, followed by cephalosporins and fluoroquinolones. Indeed, the latter appears to be the workhorse of health as fluoroquinolones are used in almost equal measures in both hospital and outpatient contexts. Although some community and outpatient studies show a different pattern. Some studies report behavioural intervention (Ross et al., 2024)¹⁶ and show substantial use of fluoroquinolones and nitroimidazoles alongside penicillins.

Sulphonamides and nitrofurantoin were also substantial contributors to UTI and SAP populations. In contrast, the hospital-wide prevalence study by¹⁷ demonstrated broader class dispersion, with high contributions from fluoroquinolones, macrolides, penicillins, sulphonamides, and imidazoles, though carbapenem use remained minimal. Earlier community evidence from (Vialle-Valentin et al., 2012)¹⁸ highlighted strong reliance on sulphonamides and penicillins. It is noteworthy that carbapenems and antimycobacterials are comparatively rare across the dataset. Household surveys by (Nayiga et al., 2020)¹² identified tetracyclines, metronidazole (nitroimidazoles), amoxicillin (penicillins) as the most frequently used agents in both urban and peri-urban settings.

Tetracyclines are predominately used in livestock production systems, indeed this sector is characterised by narrower variety of use, with antimicrobial use overwhelmingly concentrated in tetracyclines in addition to sulphonamides. Sulphonamides appear to be the antibiotic of choice in poultry as reported by Samuel et al., 2023)¹³.

A pooled estimate for the prevalence of antibiotic use in different OneHealth domains in Uganda

An exploratory meta-analysis was conducted to estimate the prevalence of antimicrobial use (AMU) across One Health domains with published data i.e., humans and animals (or poultry). We estimated the pooled prevalence for the combined data (General AMU Prevalence) as well as one for humans (Human AMU Prevalence) and another for animals (Animal/Poultry AMU Prevalence) (Fig. 3).

Across all analyses, AMU prevalence was consistently high and accompanied by substantial between-study heterogeneity. The overall pooled analysis combining human and animal studies included 22 independent estimates with a total sample size of 16,012 participants, with study-level prevalence ranging from 0.24 to 1.00. The common-effects model yielded a pooled AMU prevalence of 0.63 (95% CI: 0.62–0.64), while the random-effects model produced an estimate of 0.70 (95% CI: 0.58–0.81), with extreme heterogeneity ($I^2 = 97.8\%$, $\tau^2 = 0.9376$, $p < 0.0001$). Human-specific analysis, comprising 20 studies and 15,270 participants, demonstrated prevalence estimates ranging from 0.24 to 1.00, with pooled prevalences of 0.63 (95% CI: 0.62–0.63) under the common-effects model and 0.68 (95% CI: 0.54–0.79) under the random-effects model ($I^2 = 97.7\%$, $\tau^2 = 0.7837$, $p < 0.0001$), indicating that approximately two-thirds of individuals reported antimicrobial use. In the animal sector, where poultry served as a proxy due to limited livestock-specific evidence, three studies comprising 742 observations reported prevalence estimates ranging from 0.57 to 0.91. The pooled prevalence was 0.79 under the common-effects model (95% CI: 0.75–0.82) and 0.79 under the random-effects model (95% CI: 0.23–

0.98), with very high heterogeneity ($I^2 = 97.4\%$, $\tau^2 = 1.0032$, $p < 0.0001$). The wide confidence interval observed in the animal analysis reflects the small number of studies and substantial variability in poultry production systems and antimicrobial use practices. Collectively, these findings indicate widespread antimicrobial exposure across One Health domains in Uganda, with consistently high use in humans and potentially higher, though less precise, use in poultry, underscoring the need for strengthened antimicrobial stewardship, surveillance, and integrated One Health interventions to mitigate antimicrobial resistance (Fig. 3). Studies like (Kiggundu et al., 2022, 2023)^{14,19} greatly played a role in the high numbers of metronidazole, which is a nitroimidazole.

The relationship between antibiotic use and policies and guidelines on antibiotic use in Uganda

The timeline of Uganda's policies and guidelines (Fig. 4) shows the shifting landscape especially after 2016, the trend is also consistent with observed availability of literature-based evidence on antibiotic use in Uganda. The potential impact of mis-match between evidence, policy and practice, not only is likely to affect policy performance but also its evaluation. For example, we note a delayed introduction of the Uganda Clinical Guidelines (UCG), which provide guidance on appropriate antibiotic use, began in 2003 but did not achieve widespread adoption until 2016. This delay likely impeded the collection and availability of antibiotic use data prior to UCG implementation.

Pre-Antibiotic Phase

During this period, we only had documents for “primary health-care (PHC) system of 1932,” emerged from missionary and colonial service delivery in a pre-antibiotic era, when care prioritised prevention, sanitation, basic curative services, and syndromic decision-making rather than laboratory-confirmed diagnosis (Doyle, 2015) to prevent and also manage diseases before the antibiotics were introduced; therefore, there was no data on Antibiotic use (Figs. 4 and 5).

This stage is characterised by a) no antibiotic use, b) limited policy guidance restricted to healthcare delivery and c) limited evidence on AMU and AMR.

Pre-Stewardship phase

By the early 1990s, antibiotics had become routine across the public and private sectors, necessitating a legal framework for an expanding pharmaceutical market. The introduction of antibiotics such as beta-lactams, tetracyclines, macrolides, and others created an urgency for policy development. Analysis of the antibiotic introduction timeline indicates that Uganda began using key antimicrobial agents soon after their global adoption²⁰. Penicillin and streptomycin, introduced globally in the 1940s, were adopted in Uganda by the 1950s²¹. A subsequent wave of beta-lactams, including ampicillin and oxacillin, was introduced between the 1960s and 1970s (Fig. 4).

Because of this demand for guidance on how to use these antibiotics, the Uganda Drug Cap of 1993 was enacted to provide a basis for the formation of the Uganda Drug Authority to manage drug importation

and distribution in the country. From this, we had the National Drug Policy, which provided guidance on who imported, distributed, and ensured drug safety, local drug safety, and local drug costs, giving rise to the stewardship phase. However, the Act primarily addressed drug system licensing, registration, and market control rather than clinical decision-making (who should receive which antibiotic and at what level of care). This established a critical pattern in Uganda's medicines governance: regulation of pharmaceutical products without equivalent regulation of clinical use.

This stage is characterised by a) increasing diversity of antibiotic use, b) with limited policy guidance and c) evidence on AMU and AMR.

Stewardship Phase

In the early 2000s, Clinical governance became more explicit with the Standard Treatment Guidelines (STGs), which translated the principle of rational use into practical guidance on what to prescribe, for which syndromes, and at which levels of care for human infections. This period coincided globally with growing resistance to older antibiotics and increasing reliance on broader-spectrum agents, particularly in hospitals. STGs, therefore, became the first substantive bridge between drug policy focused on availability and prescriber behaviour at the point of care, even as enforcement and diagnostic support remained limited.

The revised statutes of the Drug Act (2000) consolidated and clarified Uganda's legal framework for medicines governance, reinforcing coherence among the law, the National Drug Policy, and emerging clinical guidelines. This consolidation marked a phase of increasing formalisation, creating a stable regulatory platform into which later antimicrobial resistance (AMR) instruments could be integrated, despite the underlying system not being designed for resistance containment.

From 2003 to 2016, we had different versions of the Uganda Clinical Guidelines, which provided guidance on antibiotic use for all infections and age groups and classified these antibiotics into different treatment lines. At this point, we had literature on antibiotic use starting to rise due to factors like global funding, as well as the rise of resistance to some antibiotics. As this period ended, a major shift occurred with the Uganda AMR Surveillance Plan (2018), which moved the national response from guidance towards measurement. The plan established laboratory networks, reporting structures, and priority pathogen lists to detect and track resistance patterns. For the first time, antibiotic policy could be informed by microbiological evidence, addressing the longstanding reliance on empirical prescribing that characterised earlier decades.

This stage is characterised by a) slow progress in policy formulation, b) accelerated antibiotic use and diversity of classes c) but limited evidence on AMU and AMR

Post Stewardship phase

Most of the literature on antibiotic use is from this era, when we have policies and guidelines on how to use antibiotics, alongside an increase in policies not only for humans, as in previous phases, but also for

animals such as cattle, goats, pigs, and fish. This extended antibiotic governance beyond human health into animal production systems, forming the One Health “expansion layer” of the policy framework. Historically, antimicrobial regulation focused on human medicine, while use in livestock and aquaculture expanded through intensification, informal access, and limited veterinary oversight. These guidelines established structured mechanisms to define appropriate antimicrobial use in production systems, strengthen husbandry and biosecurity to reduce reliance on antibiotics, and align animal-sector practices with national AMR goals set out in the National Action Plan, which implemented more strict measures on antibiotic use in all sectors of one health to control the growing problem of antibiotic resistance. There was no data on antibiotic use in the environment, nor policies on antibiotic use in the environment, except those policies like the National Action plan and AMR surveillance, which talked about antibiotic use at the one health level.

The NAP reframed AMR as both a public-health and development challenge and explicitly linked surveillance of resistance (what is occurring), surveillance of antimicrobial use (how antibiotics are used), clinical guidance (what prescribers should do), and regulatory mechanisms (what the market can legally supply), while the Antimicrobial Use (AMU) Surveillance Guidelines (2020) (Fig. 3) and Antimicrobial Stewardship Manual (2025) explain why those trends may be occurring by quantifying antimicrobial consumption. These guidelines introduced standardised metrics, data sources, and reporting mechanisms that allow monitoring of shifts such as increasing reliance on broad-spectrum agents, outpatient use of Watch antibiotics, and temporal or regional variation in consumption. Together with STGs and the Uganda Clinical Guidelines (UCGs), AMU surveillance provides the empirical basis for revising clinical guidance and designing stewardship interventions.

This stage is characterised by a) accelerated progress in policy formulation, b) limited new antibiotic classes and falling use of antibiotics c) but increased availability of evidence on AMU and AMR

To further understand the statistical significance of the policy lag with antibiotic introductions, we constructed a scatter plot (median delay = 37.5 years, IQR = 35–40.8). A one-sample Wilcoxon signed-rank test also showed that this delay was significantly greater than zero ($V = 170$, $p < 0.001$), indicating that antibiotics were typically incorporated into national policy frameworks several decades after their introduction. (Figs. 4 and 5)

A summary of trends, gaps opportunities and critical control points for AMU stewardship in Uganda

Domain	Historical context	Current state (evidence from this review)	Future implications if unchanged	Key determinants & leverage points
Behavioural practices	Longstanding reliance on antibiotics as first-line solutions; self-medication normalised; limited AMR awareness	Persistently high and heterogeneous AMU across humans and animals; informal access is common	Normalisation of misuse; sustained selection pressure; declining antibiotic effectiveness	Public awareness, prescription-only enforcement, behaviour change communication
Clinical practice	Empirical prescribing due to limited diagnostics; early guideline adoption without stewardship infrastructure	Frequent use of broad-spectrum and Watch antibiotics, including in outpatient care	Increased treatment failure; escalation to Reserve antibiotics	Diagnostics, antimicrobial stewardship programmes, audit and feedback
National policies & guidelines	Late development of AMR-specific policies; initial focus on access over regulation	Policy alignment with the WHO frameworks, but weak enforcement and monitoring	Policy fatigue without impact; widening implementation gaps	Regulatory enforcement, compliance indicators, and routine policy evaluation
International policies	Emergence of global AMR agenda (WHO GAP-AMR, FAO–WOAH One Health)	Strong normative guidance but uneven national translation	Growing global inequities in AMR burden and response capacity	Sustainable financing, technical assistance, policy harmonisation
One Health integration	Historically siloed governance of human, animal, and environmental health	Synchronous high AMU across domains; fragmented One Health implementation	Intensified cross-domain AMR transmission	Integrated surveillance, shared indicators, cross-sector coordination
Government support & systems	Limited investment in surveillance and regulation; competing health priorities	Partial, donor-driven AMR activities; limited domestic financing	Unsustainable AMR responses; dependency on external funding	Political commitment, institutional capacity, and domestic resource mobilisation
Priority actions	Missed opportunities: • Absence of early stewardship	Immediate needs: • Enforce prescription-only access	Strategic priorities: • Target high-use settings	Enablers: • Integrated One Health governance

Domain	Historical context	Current state (evidence from this review)	Future implications if unchanged	Key determinants & leverage points
	• Limited cross-sector coordination • Weak regulation of legacy antibiotics	• Integrate AWaRe into routine reporting • Strengthen veterinary regulation • Identify AMU hotspots	• Align human–animal stewardship • Link AMU to AMR outcomes • Embed AMR into UHC agendas	• Sustainable financing • Surveillance linked to genomics • Accountability & enforcement

Discussion

Antimicrobial use pattern reflections

The national action plan represents Uganda’s commitment to tackling the intractable challenge of antibiotic resistance. However its ability to deliver on this depends on alignment between evidence, policy and practice. Here we aimed to unravel this axis by examining the historical perspective and estimate the scale of use using a scoping review and meta-analysis. We show that Uganda’s human population has heavily relied on broad-spectrum antibiotics, particularly nitroimidazoles, cephalosporins, and penicillins. Some of these agents, including penicillins and third-generation cephalosporins, are critically important for human medicine because they are used to treat infections caused by priority pathogens such as *Escherichia coli*, *Klebsiella pneumoniae*, and *Salmonella species*²².

Animal usage has historically been restricted to a few classes including tetracyclines and folate pathway inhibitors, but the overall literature suggests that this sector accounts for a very small proportion of the overall antibiotic use in Uganda. It is reported that classes such as Penicillins, aminoglycosides, macrolides, and fluoroquinolones are used in livestock production(i.e. in cattle, poultry, pigs and small ruminants) to treat and prevent bacterial infections. However, their use is motivated by accessibility, cost, and broad-spectrum action, especially with limited veterinary supervision. This has led to the increased risk of resistance amplification in commensal and zoonotic bacteria like *Salmonella spp.*, *Campylobacter spp.*, and *E. coli*, the overlap in antibiotic classes used in human and animal health suggests shared selective pressures across One Health domains. These infections may be spread through direct contact, food chains, and environmental pathways. This is consistent with research from Uganda and neighbouring countries demonstrating the extensive use of tetracyclines and sulfonamides in poultry, cattle, and small ruminants due to price, accessibility, and little veterinary monitoring^{23–25}.

Thus, livestock antibiotic use presents a key policy tension within a One Health framework: while limiting use may reduce public health risks associated with antimicrobial resistance, excessive restriction without viable alternatives could undermine animal health, livestock productivity, and ultimately food security in low-resource agricultural systems.

A comparison of policy and practice

Pre-Antibiotic Phase

The pre-antibiotic phase was characterised by fear of infectious diseases at that time Tuberculosis and Influenza were global burdens, while typhoid, cholera, pneumonia, sepsis during childbirth, and wound were more local causes of death. These infections were managed through isolation of the infected, improving hygiene/sanitation, use of herbal remedies, supportive care (fluids), and antiseptics (carbolic acid)^{26–28}.

During this period, there were no organised health systems in Uganda, as people lived under kingdoms, but this changed with the arrival of missionaries, who introduced primary health care systems focused on IPC. This was in use until 1993, when Uganda came up with the Drug Act Cap that led to the formation of the Uganda National Drug Authority.

Pre-Stewardship phase

This scoping review suggests that policy formulation did not drive antibiotic introduction; instead, it influenced antibiotic use and preparedness for antimicrobial resistance. This period is also called the golden antibiotic age that marked the rapid growth of antibiotic introduction. As antibiotics were introduced into clinical use, there were no policies, not even guidelines on how to use them in Uganda, until the standard treatment guidelines were introduced in 2000, showing a lag between policy and practice. This was not the case internationally, as there were policies, though most of them focused on standardising and boosting production rather than controlling antibiotic use^{29,30}.

There is no reliable information on local hospital or clinic-level policies during this period because they may not have been documented or may have been lost over time. In a publication like²⁹, it was written that "Western countries' early regulation of this period focused on protecting supplies of a still scarce resource as well as human and non-human antibiotic users from toxic side effects and residues in food and milk. " Such regulations could have triggered similar ones in Uganda, like the Uganda National Drug policy that also focused on antibiotic safety and distribution, other than use³¹.

Despite the knowledge of antibiotic resistance in the early 1900s³², concerns about this remained isolated globally and here in Uganda. The alarm of increased antibiotics on the market initiated treatment and clinical guidelines in humans in Uganda, but these guidelines also primarily focused on dosages of the antibiotics. This rise in resistance may partly reflect poor implementation of policy guidelines, which has contributed to increased use of certain antibiotics, including cephalosporins. It is noteworthy that most of Uganda's AMR policies closely mirror global AMR governance frameworks. Key international milestones, such as the World Health Organization Global Action Plan on AMR (2015) and the establishment of the Global Antimicrobial Resistance and Use Surveillance System (GLASS), as well as the One Health framework promoted by the Food and Agriculture Organization, World Organisation for Animal Health, and United Nations Environment Programme, preceded the development of major

national instruments in Uganda, including the AMR Surveillance Plan and National Action Plan (2018) and the AMU Surveillance Guidelines (2020). This sequencing suggests that the implementation of national policies has mostly been reactive rather than proactive. Although Uganda has adopted AWaRe principles in accordance with WHO guidelines ³³, a significant portion of antibiotic use remains.

Stewardship mechanisms for drug use were implemented only after the first broad-spectrum, vital antibiotic had been introduced in routine practice, even though alignment with international standards has improved consistency; before antibiotics were introduced, we relied on IPC ³⁴.

Implications for Current AMR Governance

The pre-stewardship phase reveals several structural conditions that continue to shape the challenges facing Uganda's National Action Plans on antimicrobial resistance. First, antibiotic use in both human and animal health systems expanded for decades before formal stewardship mechanisms were introduced. As a result, prescribing practices, pharmaceutical supply chains, and informal antibiotic distribution networks became deeply embedded in everyday healthcare long before regulatory oversight developed. This historical trajectory means that current stewardship policies must attempt to modify long-established behaviours rather than guide antibiotic use from the outset. Second, the historical lag between drug introduction and policy development illustrates a broader pattern of reactive governance in which regulatory frameworks emerge only after antimicrobial use has already become widespread. If future iterations of NAPs do not address this structural delay through stronger surveillance systems, regulatory enforcement, and behavioural interventions, they risk facing the same difficulty observed in this earlier phase namely that policies attempt to correct entrenched practices rather than prevent them. Finally, the experience of the pre-stewardship period highlights the importance of integrating infection prevention, diagnostic capacity, and antimicrobial monitoring into routine health system operations. Without strengthening these foundational systems, the goals of Uganda's AMR policies may remain difficult to achieve despite the existence of comprehensive national strategies ³⁵.

Stewardship Phase

Most antimicrobial stewardship policies and surveillance plans in Uganda emerged during this phase, particularly after 2018. This period also marked a noticeable increase in academic publications and reports on antibiotic use in Uganda, reflecting broader developments within the global antimicrobial resistance (AMR) agenda following the Global Action Plan on AMR introduced in 2015². In many countries, including Uganda, stewardship initiatives developed through a process of policy diffusion in which international governance frameworks encouraged rapid adoption of national AMR strategies even where surveillance systems and regulatory infrastructure were still developing. Influential international initiatives including the 2016 AMR Review¹, the WHO Global Action Plan, and the launch of the Global Antimicrobial Resistance Surveillance System (GLASS) encouraged countries to develop national surveillance systems and stewardship frameworks^{1,29,36}.

The temporal clustering of antimicrobial use (AMU) studies after 2016 is a notable feature of the evidence base identified in this study. This increase reflects the delayed emergence of research capacity, surveillance infrastructure, and external financing focused on AMR in low- and middle-income countries rather than a sudden rise in antibiotic consumption³⁷. Much of the research produced during this period therefore represents retrospective analysis of long-standing prescribing patterns rather than real-time monitoring of emerging antimicrobial use trends. Consequently, AMU studies often functioned as diagnostic tools for identifying entrenched practices rather than as proactive mechanisms guiding stewardship policy³⁸.

The absence of historical antimicrobial use data significantly shaped the development of stewardship policies in Uganda. Prior to the 2000s, empirical antibiotic prescriptions in both human and animal health sectors were rarely documented, and routine monitoring of antimicrobial consumption was largely absent³⁹. Early health and veterinary policies focused primarily on infection treatment, access to essential medicines, and syndromic care rather than on optimising antimicrobial use^{40,41}. The lack of early AMU research therefore reflects the absence of systematic surveillance rather than limited antibiotic exposure^{42–44}.

This gap was particularly pronounced in the veterinary sector, for example; prior to the introduction of livestock and aquaculture antimicrobial guidelines in 2020, Uganda lacked formal veterinary prescription standards, antimicrobial classification frameworks, and reporting requirements^{23,45}. In practice, antibiotic use in livestock production was shaped largely by market availability, informal advisory networks, and productivity pressures rather than formal regulatory oversight^{46,47}. Tetracyclines and sulfonamides dominated the veterinary antibiotic market, and antimicrobial use expanded for decades before systematic regulatory attention emerged. The absence of early veterinary stewardship frameworks contributed to the cross-sectoral antibiotic class overlap identified in this research.

Long before the introduction of antibiotics, infection prevention formed the foundation of both human and animal healthcare systems, a pattern that persisted even after antimicrobial therapies became widely available³⁴. In contexts where diagnostic capacity remains limited and regulatory enforcement is weak, preventing infection often remains the most practical strategy for reducing disease burden and limiting antimicrobial use. The renewed emphasis on infection prevention within AMR strategies therefore reflects not only scientific recognition of antimicrobial resistance but also the persistence of structural healthcare conditions similar to those that existed before the widespread availability of antibiotics⁴⁸.

The development of antimicrobial stewardship policies in Uganda was also shaped by global health governance and donor-driven policy diffusion. Following the WHO Global Action Plan on AMR, many low- and middle-income countries including Uganda developed National Action Plans with technical and financial support from international partners such as the UK Fleming Fund⁴⁹. While these initiatives accelerated policy development and strengthened surveillance capacity, they also meant that national

strategies were sometimes introduced in response to international policy momentum rather than purely domestic regulatory demand. In such contexts, policy frameworks can emerge more rapidly than the institutional systems required to implement them effectively.

This dynamic helps explain why antimicrobial stewardship policies in Uganda often developed reactively. The late emergence of AMU research, the absence of historical consumption data, and the delayed formalisation of veterinary and human stewardship standards illustrate how AMR policy has frequently responded to already established antimicrobial use patterns rather than preventing them⁵⁰. In many cases, scientific evidence and regulatory attention followed widespread antibiotic use rather than guiding it.

Following global policy templates and donor-supported initiatives, the period after 2015 saw a rapid expansion of national AMR strategies across many low- and middle-income countries. This wave of policy development coincided with increased international funding for AMR surveillance and research, which likely contributed to the growth in antibiotic use studies observed in Uganda during this period. At the same time, pharmaceutical markets were also evolving. With pharmaceutical companies increasingly relying on the sale of generic antibiotics rather than new patented drugs, countries such as Uganda have become important growth markets for inexpensive antimicrobial products⁵¹, contributing to the continued availability and promotion of widely used drugs such as metronidazole.

In this sense, antimicrobial stewardship in Uganda during this phase reflects the interaction of three forces: global policy agendas, domestic health system limitations, and expanding pharmaceutical markets. Together, these forces shaped both the timing and the character of stewardship initiatives.

Lessons for Future National Action Plans

Several important lessons emerge from this phase of antimicrobial stewardship development in Uganda. First, policy frameworks should be introduced alongside the institutional capacity required for their implementation. The experience of early stewardship initiatives demonstrates that surveillance systems, regulatory enforcement mechanisms, and diagnostic infrastructure must be established before policies can effectively influence antimicrobial use practices. Second, future National Action Plans should prioritise sustained investment in routine antimicrobial use monitoring across human, animal, and environmental sectors rather than relying primarily on short-term research projects or donor-funded surveillance initiatives. Third, stewardship policies must explicitly address informal antibiotic distribution networks and entrenched prescribing behaviours that shape antimicrobial consumption in everyday practice. Without strengthening these structural components, future NAPs risk repeating the pattern observed during this phase—where policy development progresses rapidly while meaningful control of antimicrobial use remains limited.

Post Stewardship Phase

The current phase of antimicrobial stewardship in Uganda is characterised by the formal establishment of governance frameworks, particularly the National Action Plan (NAP) on antimicrobial resistance,

alongside increasing participation in the global antimicrobial resistance (AMR) agenda. Unlike earlier periods where antibiotic use was largely unregulated, the current phase includes national surveillance efforts, policy guidelines for prudent antimicrobial use, and attempts to coordinate activities across human health, animal health, and environmental sectors under the One Health approach. These developments reflect Uganda's alignment with international AMR strategies promoted by organisations such as the World Health Organization and other global health partners.

Despite these developments, implementation of stewardship policies remains uneven. While national-level policies and strategic frameworks have been developed by the Ministry of Health in collaboration with institutions such as the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), the translation of these policies into routine practice at healthcare facilities, veterinary services, and pharmaceutical distribution points remains limited. Monitoring systems for antibiotic consumption and resistance patterns are still developing, and regulatory enforcement across the supply chain remains inconsistent. As a result, stewardship initiatives often remain concentrated at national policy levels while operational capacity at district and facility levels continues to lag behind.

Evaluation of the NAP has revealed persistent gaps between policy commitments and practical outcomes. The continued widespread use of antibiotics classified under the WHO AWaRe "Watch" category, such as ceftriaxone, suggests that stewardship interventions have not yet substantially altered prescribing and dispensing behaviour. This indicates that while policy structures exist, the mechanisms required to influence daily clinical and agricultural practices such as routine auditing, antimicrobial stewardship teams, prescribing oversight, and antimicrobial use surveillance are not yet fully institutionalised within the health system.

Several challenges contribute to these implementation gaps. First, regulatory enforcement remains weak, allowing antibiotics to be widely accessible through informal and private-sector channels. Second, surveillance systems for antimicrobial use and resistance remain incomplete, limiting the ability of policymakers to evaluate the effectiveness of stewardship interventions. Third, resource constraints including shortages of trained personnel, diagnostic capacity, and laboratory infrastructure restrict the ability of health systems to support rational prescribing. Finally, entrenched prescribing habits and patient demand for antibiotics continue to influence antimicrobial use patterns. These challenges highlight the structural difficulty of translating national policy commitments into behavioural change across diverse healthcare and agricultural contexts.

Addressing these challenges requires strengthening both institutional capacity and accountability mechanisms. Improved surveillance systems for antimicrobial use and resistance would enable more effective monitoring and evaluation of NAP implementation. Strengthening regulatory enforcement across pharmaceutical supply chains could reduce inappropriate antibiotic access, while expanding diagnostic capacity would support evidence-based prescribing decisions. In addition, sustained training for healthcare workers and veterinarians, combined with public awareness initiatives, may help shift long-standing prescribing and consumption behaviours. Strengthening coordination between human

health, animal health, and environmental sectors will also be essential for operationalising the One Health approach envisioned in the NAP.

In summary, Uganda's current stewardship phase reflects a transition from policy development to implementation. The effectiveness of the NAP will depend not only on the existence of national frameworks but on the country's ability to operationalise stewardship activities across sectors and translate policy commitments into measurable changes in antimicrobial use. Without stronger institutional capacity, enforcement mechanisms, and behavioural interventions, stewardship policies risk remaining largely aspirational while antimicrobial consumption and resistance continue to rise.

Limitations

No quantitative environmental AMU data were identified in this study, reflecting surveillance gaps, limited methodological standardization, and insufficient funding for quantifying AMU in environmental compartments. Antibiotics and resistant organisms enter the environment through wastewater effluent, agricultural runoff, animal waste, and pharmaceutical disposal; however, the absence of environmental data constrains assessment of selective pressures on environmental microbiota and highlights a gap in AMR surveillance systems in many LMICs. In addition, substantial between-study heterogeneity was observed across analyses ($I^2 > 97\%$), reducing the precision and comparability of pooled AMU prevalence estimates. This likely reflects differences in study designs, populations, and reporting practices, as well as variability in data quality and potential publication bias. The limited number of studies in the animal sector further contributed to wide confidence intervals and reduced estimate stability. Accordingly, pooled estimates should be interpreted as indicative of overall patterns rather than precise quantitative measures.

Conclusion and Recommendations

Conclusion: Despite being well articulated policies, existing stewardship regulations have not yet led to quantifiable reductions in antimicrobial exposure, as evidenced by Uganda's consistently high antimicrobial use in both the human and animal sectors. Prioritising enforcement, regularly monitoring antimicrobial use indicators, regulating veterinary antimicrobial practices, and integrating stewardship initiatives across One Health domains, all of which will need ongoing government support and domestic funding, are necessary to close this implementation gap.

Declarations

Competing interests

The authors declare that they have no competing interests.

Funding

Declaration

No funding was directed to this study.

Author Contribution

DPK, AM, DN, SK, DJ, RG, and GM supervised the work and manuscript writing. NP, SN, WO, RE, KCN and HA extracted data from the literature as well as analysis. GK and SK downloaded the dataset from GISAID, and NP, KCN, HA and EA wrote the manuscript. All participated in the manuscript review and compiling.

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Data Availability

The data generated in this study is available here

"https://docs.google.com/spreadsheets/d/16LnUXx_Kd3rUjD9Ss-cnNmVCUk4AhvzIPvZqk7hH2es/edit?usp=sharing"

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Figures

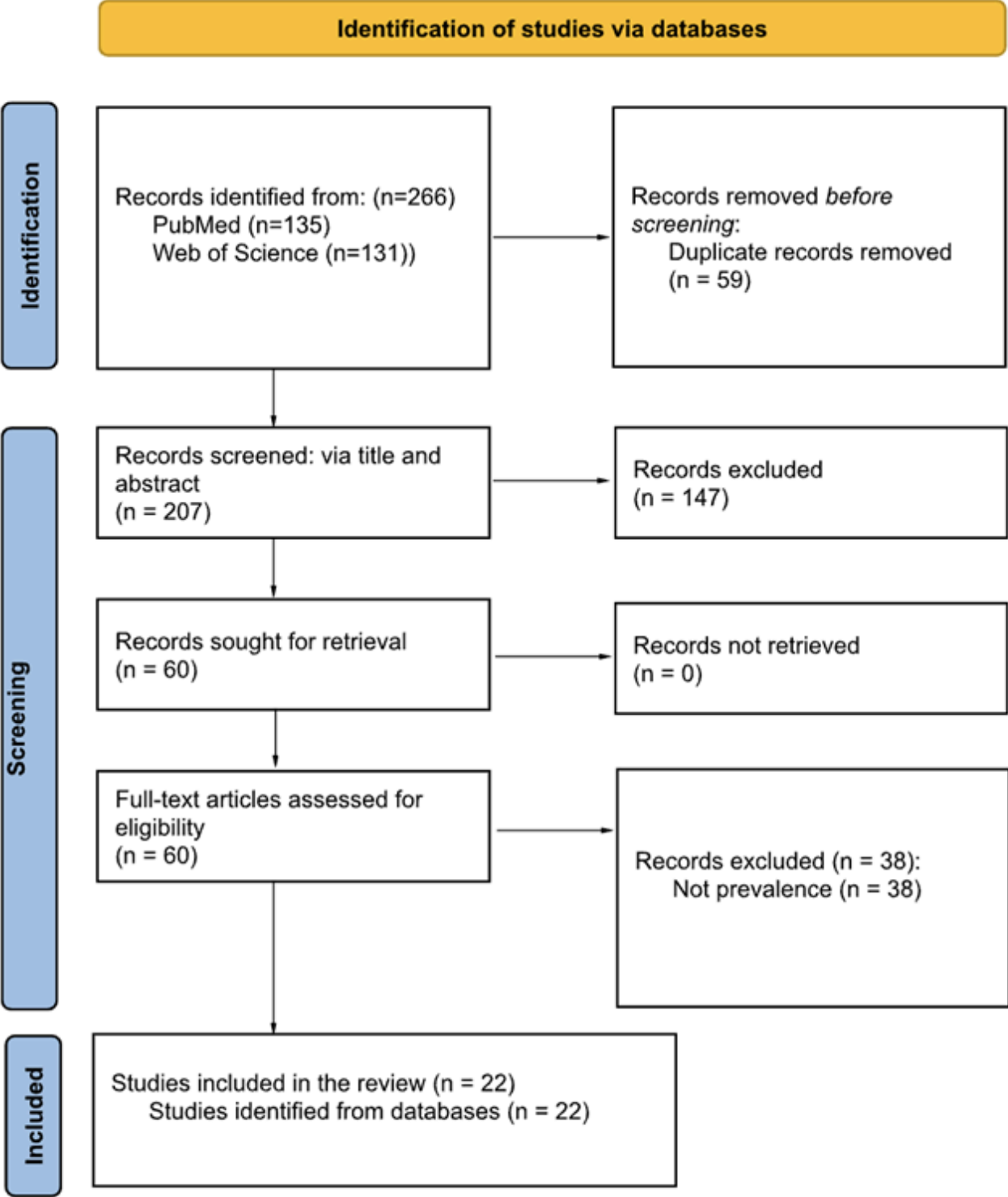


Figure 1

This diagram shows the systematic process followed to include studies captured by our search. We screened 266 unique records and only 22 studies satisfying our eligibility criteria were included in the qualitative synthesis.

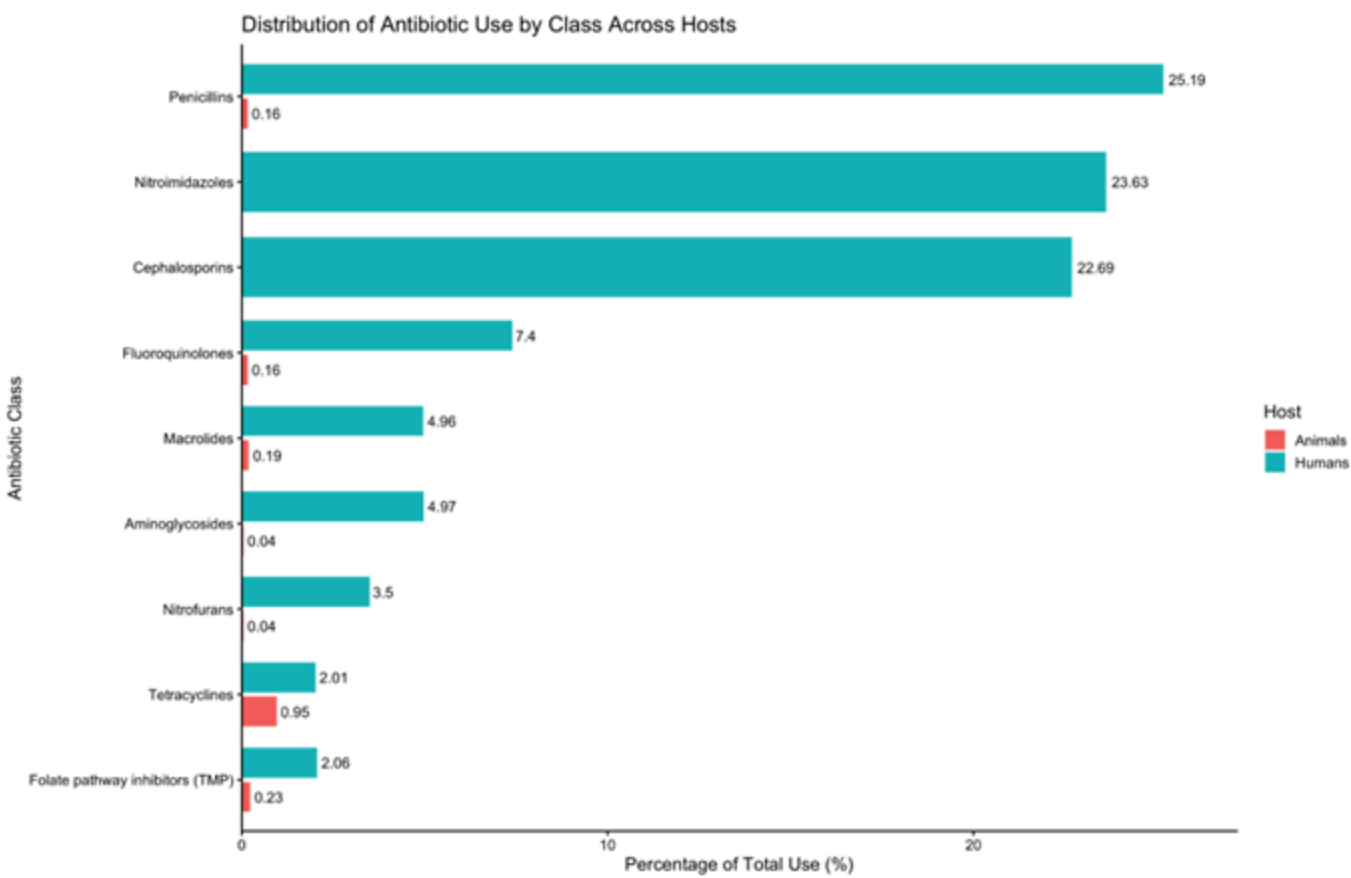


Figure 2

Distribution of antibiotic use by class in different OneHealth domains in Uganda.

Horizontal bar chart showing the percentage contribution of major antibiotic classes to total reported antibiotic use in humans and animals. Human use (teal) accounts for the majority of reported consumption across all classes, with nitroimidazoles (25.4%), cephalosporins (24.8%), and penicillins (20.6%) representing the most frequently used antibiotics. In animals (red), reported use is comparatively low and concentrated primarily in tetracyclines (0.6%) and folate pathway inhibitors (0.3%), with minimal use of other classes. Values next to each bar indicate the percentage of total antibiotic use attributed to that class within each host group. Notably, no articles were returned on antibiotic use in the environment.

Fig 3a

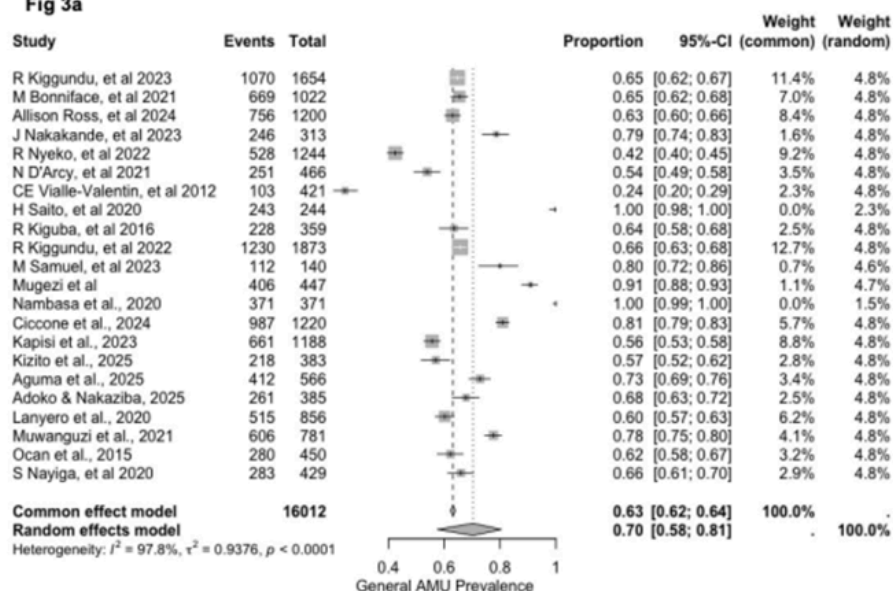


Fig 3b

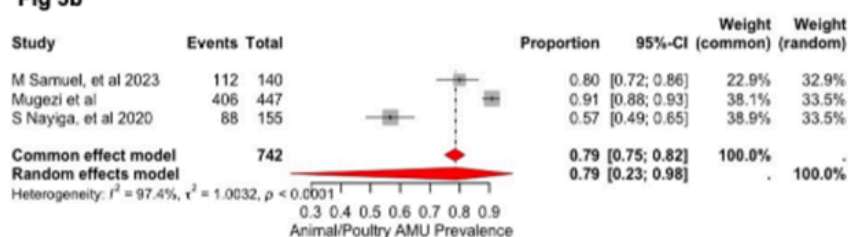


Fig 3c

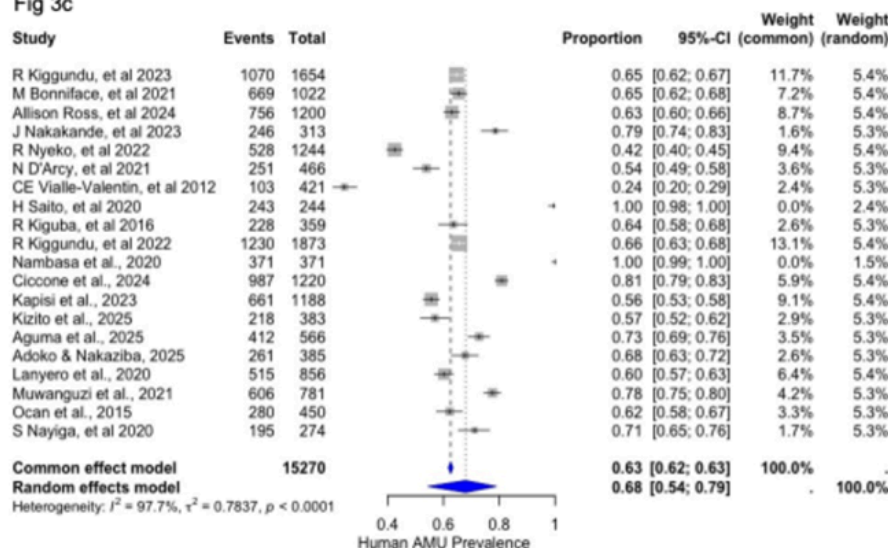


Figure 3

Pooled Prevalence of Antimicrobial Use (AMU) Across Animals/Poultry, Humans, and Overall Populations

This figure presents three meta-analyses summarising AMU prevalence in animals/poultry, humans, and combined populations. Each square represents an individual study estimate, with size proportional to its weight; horizontal lines indicate 95% confidence intervals (CIs). Diamonds show pooled estimates. Two

models were reported: common (fixed) effects, which assume a single true prevalence and give greater weight to larger studies, and random effects, which account for between-study variability (τ^2) and produce wider CIs. Heterogeneity was quantified by I^2 (percentage of variability due to real differences), τ^2 (between-study variance), and p-value (Cochran's Q-test). Across all analyses, heterogeneity was extremely high.

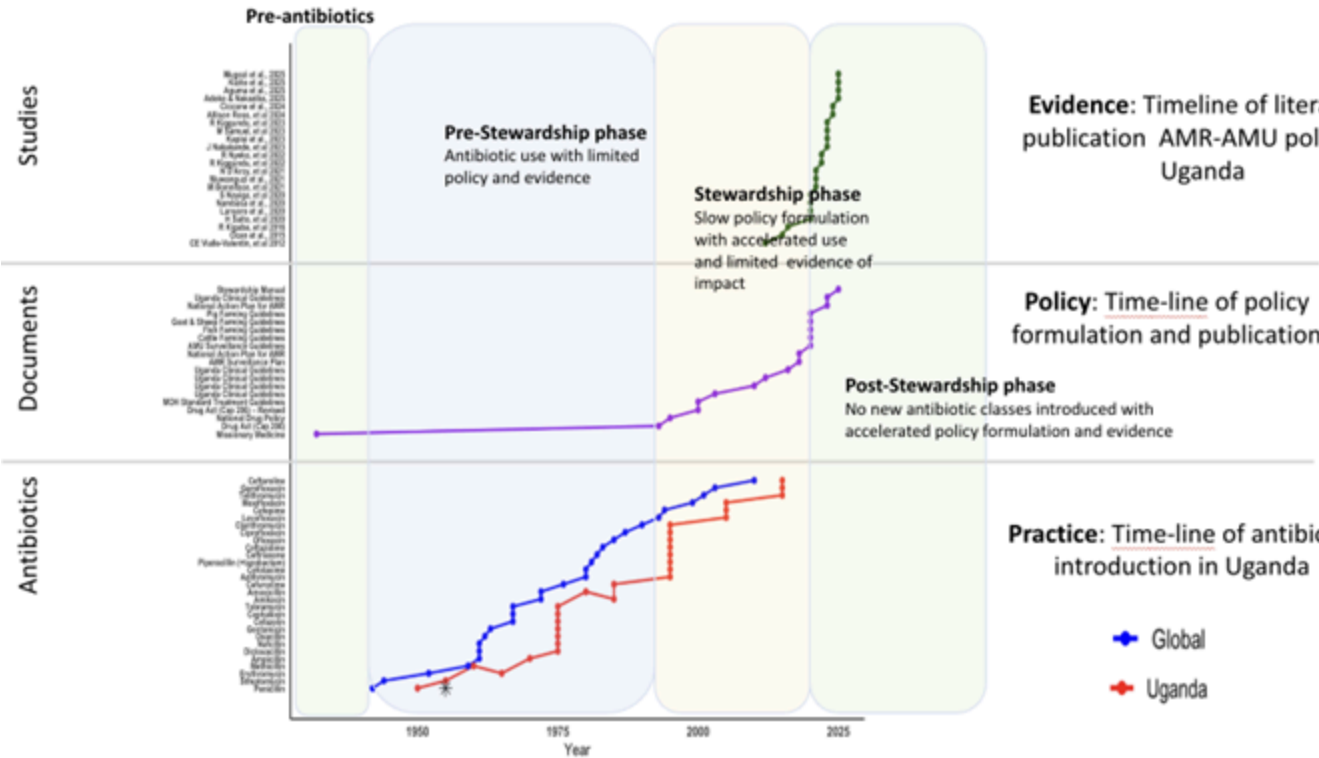


Figure 4

Timeline of antibiotic introductions (global vs. Uganda) and major policy milestones, as well as antibiotic use in Uganda

The first line plot (green) shows the timeline for the published literature on antibiotic use in Uganda. The next line plot (purple) shows the timeline for the different policies and guidelines in Uganda, as well as the last plot at the bottom, which shows global (blue) and Ugandan (red) antibiotic introductions accordingly.

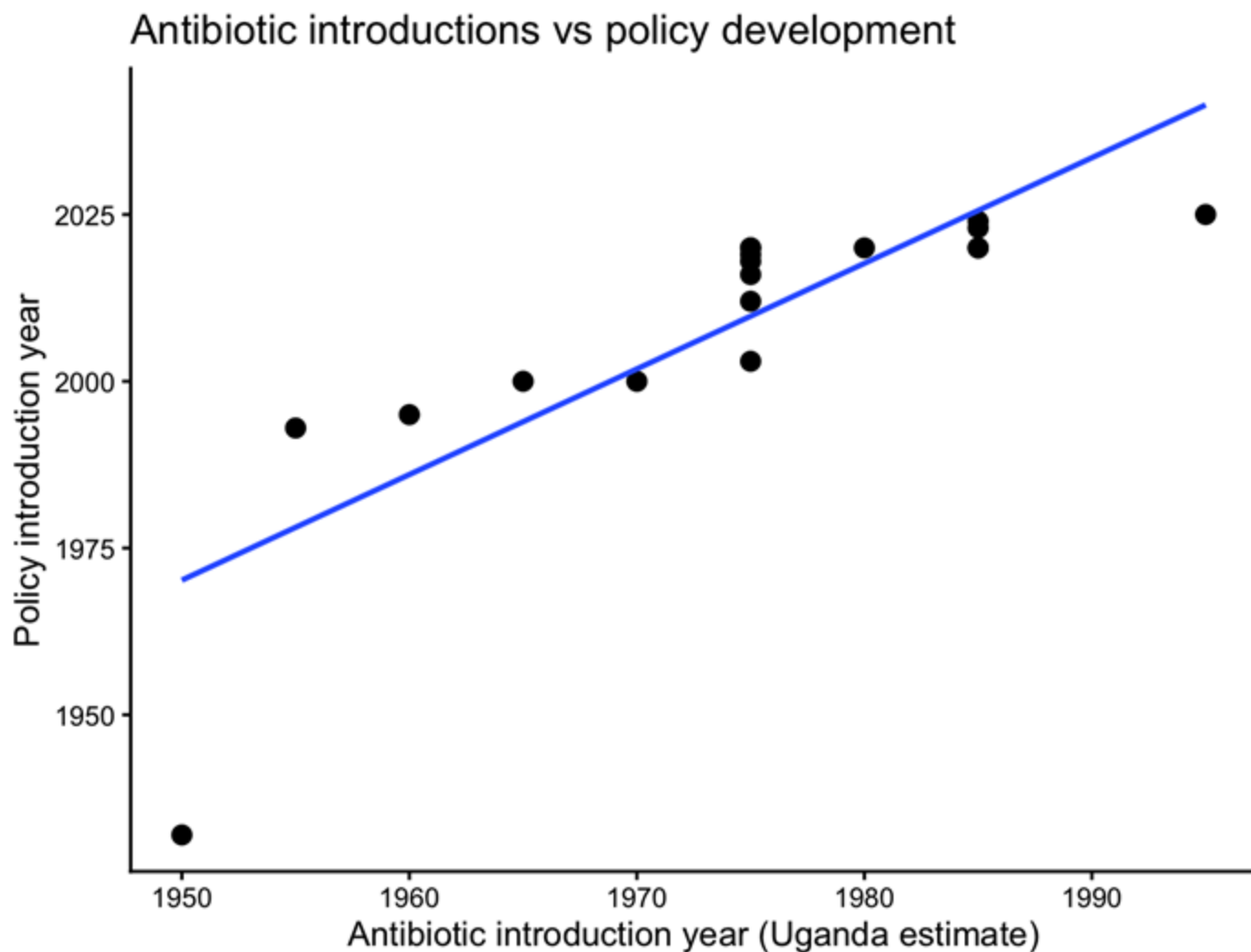


Figure 5

Temporal relationship between antibiotic introduction and policy development in Uganda.

Scatter plot showing the estimated year of antibiotic introduction in Uganda (x-axis) against the year corresponding policies or guidelines were introduced (y-axis). Each point represents an antibiotic-policy pair. The blue line represents the fitted linear regression, indicating a positive temporal association in which antibiotics introduced later tend to have policies developed in more recent years. Several antibiotics show long delays between introduction and policy development, highlighting historical gaps between drug availability and formal guideline implementation.