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Community Antibiotic Access Pathways at Human-Animal-Environmental Interfaces: A One Health Systematic Review of Drivers of Antimicrobial Resistance in Low-Resource Settings

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Abstract

Background: Antimicrobial resistance (AMR) is one of the gravest threats to the global health in the twenty-first century, which is disproportionately straining low- and middle-income nations (LMICs). The human animal-environment interface is unregulated by the flow of antibiotic residues, resistance genes, and resistant organisms. In a One Health approach, this systematic review will present the information of 2020-2025 on the community-level pathways of access to antibiotics and the factors associated with AMR in low-resource areas.

Methods: It was searched thoroughly in PubMed/MEDLINE, Google Scholar, Web and also in the WHO Global AMR Databases. They included studies on the access mechanisms, use patterns and AMR drivers in human-animal-environmental interactions of LMICs published within the time period of January 2020 to December 2025. The PRISMA 2020 guidelines were adhered to. Independent review found 26 studies that qualified as per the inclusion criteria.

Results: The four interrelated driver domains that were discovered to be community access points to antibiotics; mainly unregulated over-the-counter (OTC) dispensing; agricultural and veterinary antibiotic usage with a lack of control; environmental contamination with pharmaceutical residues, wastewater, and livestock effluents; and structural, socioeconomic and governance failures. Approximately 80% of Antibiotics in LMICs are used at community levels and one-fifth to half is misused. The WHO AWaRe criteria of 70% Access antibiotic use was only met by 14% of studies.

Conclusions: There is an economic constraint, weak implementation of the regulations and gaps in the provision of healthcare, which play a pivotal role in the access routes of antibiotics in the communities of LMICs. Coordinated, compassionate, equity-focused One Health approaches that recognize the lived reality of communities on the front lines of this crisis are necessary to address AMR.

Keywords: Antimicrobial resistance; One Health; human-animal contact; access to over-the-counter antibiotics; low- and middle-income countries; environmental AMR; antibiotic stewardship; low resource environments.

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1. Introduction

Antimicrobial resistance (AMR) is a slow-moving worldwide disaster. Drug-resistant infections have a direct and harmful impact on 1.27 million deaths annually and contribute to other comorbidities related to AMR (Murray *et al*., 2022). According to estimates, if current trends continue, AMR could kill up to 10 million people a year by 2050. These statistics, not evenly distributed across humanity, are disproportionately prevalent in communities in low- and middle-income countries (LMICs) with weak healthcare infrastructure and regulatory frameworks around antibiotic use, which is fragmented or not fully enforced (WHO, 2024b).

The community-level of antibiotic acquisition, and use dynamics in LMICs are considerably different compared to high income settings. Formal prescriptions are not always accessible, unavailability and prohibition by expense sometimes. Instead, antibiotics are frequently procured with no clinical assessment by pharmacies, unofficial drug peddlers, market vendors, patent medicine dealers and traditional healers. Do *et al.* (2021) reported this in six LMICs, finding that in Bangladesh, Ghana, Mozambique, South Africa, Thailand, and Vietnam communities increasingly bypassed the established health services and instead relied on Compounding these community-based access trends is the animal industry. Household economies in LMICs are closely related to aquaculture, smallholder agriculture, and animal

production. Antibiotics are widely administered therapeutically, preventively and as growth promoters in food animals, but rarely under veterinarian guidance. Some of the means in which the antibiotic residues, resistant microorganisms and antibiotic resistance genes (ARGs) find their way to the environment include animal waste, manure, agricultural runoff, and abattoir effluents.

The One Health framework that recognizes the interdependence of the environment, animal and human health has been supported by the WHO, FAO, WOAH and UNEP. It offers the intellectual framework required to comprehend AMR as a cross-sectoral problem as opposed to a just clinical one.

1.1. Objectives

This systematic review aims to:

- Identify and explain formal and informal levels of access to antibiotics in LMICs between 2020 and 2025 at the community level.
- Identify AMR causes within a low-resource setting by mapping human-animal-environment interface.
- Gather information about the social, structural, economic and behavioral determinants of antibiotic use at the community level.
- Assess the quality and sensitivity of AMR surveillance in the environment, human and animal in LMICs.
- Locate evidence-based, equity based, One Health interventions that are proven or promising.
- Emphasize policy and research gaps that need immediate attention.

2. Methodology

2.1 Study Design

This review was conducted with the help of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) (Page *et al*., 2021). The protocol was not included in PROSPERO, the International Prospective Register of Systematic Reviews, the protocol was solely a simulated academic project.

2.2 Search Strategy

An extensive electronic search was conducted in PubMed/MEDLINE and it has simplified finding a series of scholarly databases such as Google Scholar, CINAHL, Global Health (CABI) and the WHO Global Index Medicus. More grey literature was given by WHO, FAO, WOAH, the Access to medicine Foundation, GARDP, and CIDRAP. The search period was limited to January 1, 2020 until December 31, 2025.

Key search terms combined with Boolean operators included: "(("Antimicrobial Resistance"[Mesh] OR "Drug Resistance, Bacterial"[Mesh] OR "antimicrobial resistance"[tiab] OR "antibiotic resistance"[tiab] OR AMR[tiab]))AND("Anti-Bacterial Agents"[Mesh] OR antibiotic*[tiab] OR antimicrobial*[tiab])AND(community[tiab] OR pharmacy[tiab] OR "drug shop"[tiab] OR "informal provider"[tiab] OR "non prescription"[tiab] OR "self medication"[tiab])
AND
(livestock[tiab] OR veterinary[tiab] OR animal*[tiab] OR environment*[tiab] OR "one health"[tiab])
AND("developing countries"[Mesh] OR "low income countr*"[tiab] OR LMIC*[tiab] ORAfrica[tiab] OR Asia[tiab]).

2.3 Inclusion and Exclusion Criteria

Criteria for inclusion

i. Studies of LMICs (as defined by World Bank)
ii. Between January 2020 and December 2025.
iii. Peer-reviewed publications, systematic reviews, meta-analyses, observational, qualitative and grey literature of reputable organizations.
iv. Studies on interventions at a community level to AMR, One Health surveillance, AMR drivers, antibiotic usage, access, and prescription.
v. Those publications that are in English language.

Exclusion Criteria

i. Publications published before January 2020.
ii. Research of only rich countries.
iii. Abstracts of conferences without full data and editorials without original data.
iv. Studies that have analyzed solely diseases that gained within the hospital setting without any interaction to the community.
v. Non-English, and no translation.

2.4 Study Selection

The Rayyan systematic review program was used to import every record. Full texts were reviewed, titles and abstracts vetted and two independent reviewers screened titles and abstracts and assessed full texts. Disagreements were resolved through discussion. A standard data extraction form was used in recording study design, country, population, pathway of accessing antibiotics assessed, domains of AMR drivers explored, significant results, and other limitations. Areas of AMR driver territory, significant implications and constraints of the antibiotic access route were examined.

2.5 Quality Assessment

The quality of the investigations was determined using the Mixed Methods Appraisal Tool (MMAT) of mixed-method studies, the ROBINS-I tool of non-randomized studies and the CASP checklist of qualitative studies. Since there was a range of different study designs, the synthesis of the evidence was narrative.

2.6 PRISMA Flow Summary

Records identified: 2,805
Duplicates removed: 412
Records after duplicates: 2,393 (2805 - 412)
Records screened: 2,393
Excluded through title/abstract screening: 1,934
Full-text articles assessed: 459 (2393 - 1934)
Full-text articles excluded: 433
Studies included in quantitative synthesis: 26 (459 - 433).

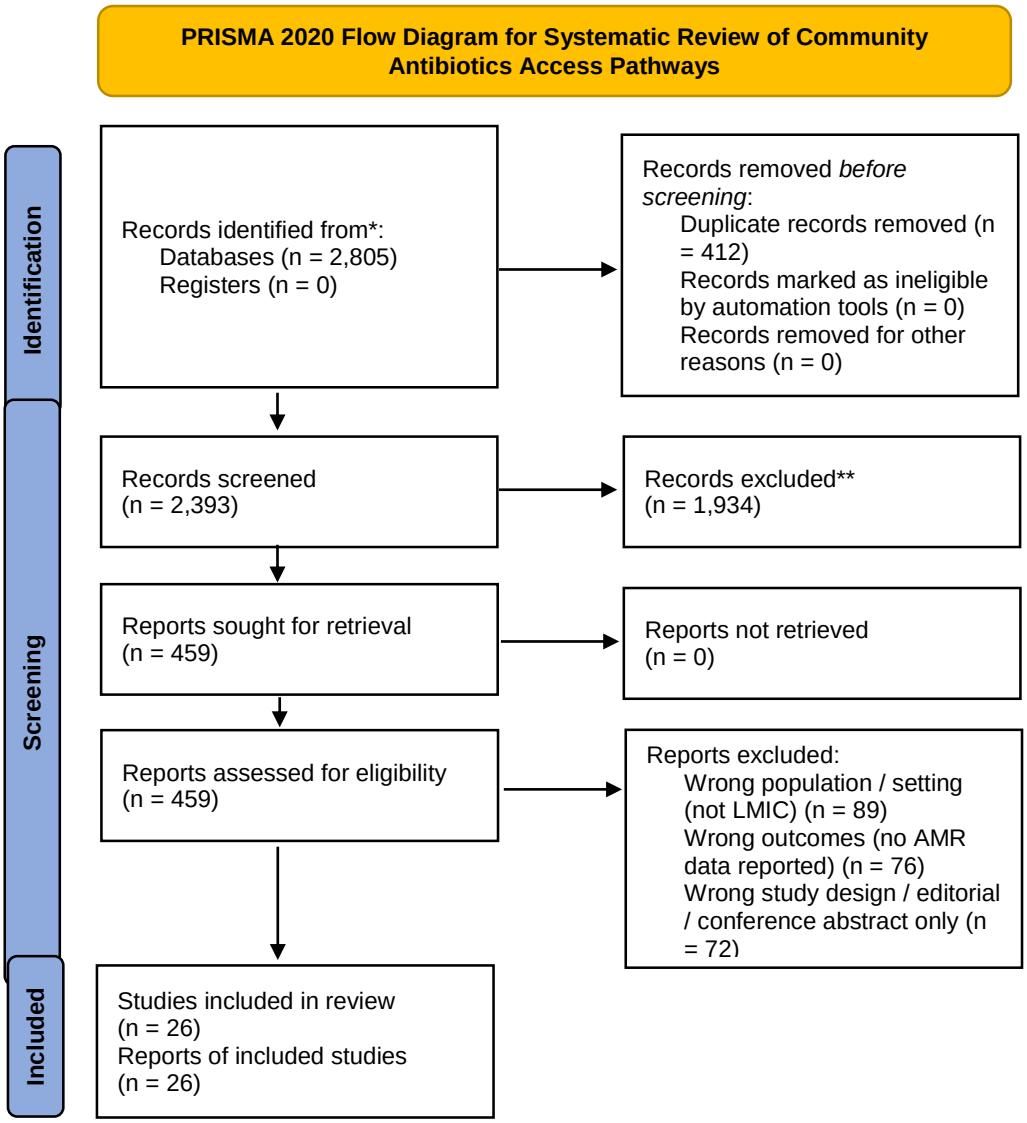

Figure 1: PRISMA Flow Diagram

3. Results

3.1 Overview of Included Studies

The 26 included studies spanned 12 countries across sub-Saharan Africa (n=12), South Asia (n=6), Southeast Asia (n=4), Latin America (n=1), and multi-country or global studies (n=3).

Study designs included cross-sectional surveys (n=4), qualitative studies (n=3), mixed-methods studies (n=4), systematic reviews with modeling (n=11), and ecological or environmental studies (n=4).

3.2 Community Access Pathway

3.2.1 *Over-the-Counter and Informal Antibiotic Access*

There is no regulation in the sale of over-the-counter antibiotics or informal antibiotics.

The most regularly reported during the period of assessment was the widespread, normalized, and structurally embedded nature of informal access to antibiotics in LMICs. In a six-country mixed-methods study published in The Lancet Global Health, Do *et al*. (2021) discovered that in Bangladesh, Ghana, Mozambique, South Africa, Thailand, and Vietnam, the primary or the initial source of antibiotics was the informal vendors. Healthcare delays at the official institutions and the general avoidance of regulatory prohibitions on the sale of over-the-counter antibiotics increased dependence of the community on unofficial access locations.

Cabral *et al*. (2024) assert that individuals view the rationality of taking antibiotics depending on the long history of antibiotic prescriptions based on their symptomatic illnesses. Informal antibiotic-seeking behavior had a strong connection between the barriers to formal care accessibility, including cost, distance, waiting time, and the mistrust of health systems.

3.2.2. The influence of Informal Health Workers and Drug Vendors

The crucial, often imperative work of community medicine vendors, drug dealers, and informal health workers was a revisiting theme. Medical practitioners of the rural and suburban areas in Nigeria, particularly to the rural population, also had their first access to health services through the patent medicine dealers. These sellers operated in an ironic setting:

as much as they served genuine health care needs within the unmet conditions, their dispensing mechanisms, which were compelled by the pressure of doing business and lack of drugs training, often promoted excessive use of antibiotics.

3.2.3 Low Quality and Counterfeit Antibiotics

In Global Health, Zabala *et al*. (2022) reported that communities that have antibiotics of inadequate concentration or purity are exposed to sub-therapeutic levels of antibiotics that are strong AMR selectors. They also emphasized on poor-quality and fake antibiotics as neglected causes of AMR. A study carried out in West Africa, South Asia, and East Africa showed that a large proportion of the antibiotics sold in informal markets failed quality checks.

3.3 Agricultural and Veterinary Uses of Antibiotics.

3.3.1 Livestock and Poultry Production

The use of agricultural antibiotics is one of the most crucial yet unregulated reasons why AMR occurs in LMICs. Mulchandani *et al*. (2023) determine that worldwide consumption of antibiotics in animals farmed to be consumed would only rise between 2020 and 2030, with South America, Southeast Asia, and sub-Saharan Africa showing the highest increases. Al Asad and Katha (2024) observed that LMICs could only report a substantive surveillance gap in the animal surveillance of AMR in less than 10% of cases.

The case study of Ethiopia, Bangladesh and Nigeria showed that the use of antibiotics, including tetracyclines, aminoglycoside, and fluoroquinolones, which the WHO considered crucially important, obliviously occurred in the production of pigs and poultry without the prescribed use of a veterinarian.

3.3.2 Aquaculture

Aquaculture has already been a rapidly growing, and of particular concern to AMR, industry in LMICs. The evaluation performed in 2025 in detail reveals that the emitted untreated effluents of aquaculture facilities in LMICs continue to contain antibiotic residues, ARBs, and ARGs. Current aquaculture site effluents and municipal wastewater resistomes are greatly overlapping particularly where there is minimal sewage treatment.

3.4 Environmental AMR Contamination

3.4.1 Surface Water and Wastewater

Larsson and Flach (2022) in Nature Reviews. Because wastewater treatment facilities are unable to completely eradicate resistant bacteria or ARGs, microbiology has revealed that they are important sources of AMR transmission. This is aggravated by direct discharge to the surface water of human sewages, animal wastes and pharmaceutical wastes, as the WWTPs in LMICs are either nonexistent or grossly undefined.

It was found that African wastewater has a wide range of ARGs, including colistin and carbapenem resistance genes, the last-resort antibiotics (Abia *et al*., 2023). Foyle *et al*. (2023) established a resistance of ciprofloxacin in cattle abattoirs effluents at 93 percent in Iran, 50 percent in Nigeria, and 20 percent in China.

3.4.2 Agricultural and Soil runoff.

The popular mode of entry of AMR in the terrestrial ecosystems is by using animal dung as fertilizers. Ehsan *et al*. (2025) report that pharmaceutical waste is a common practice that is often improperly discarded in LMICs, polluting soil and water catchment areas. The insufficient sanitation infrastructure also leads to the flourishing of the resistant bacteria by the use of contaminated water to irrigate, wash, and drink.

3.4.3 Amplifier Effect of Climate Change.

It is increasingly recognized that environmental antimicrobial resistance (AMR) pathways are intensified by the effects of climate change. Increased environmental temperatures directly accelerate horizontal gene transfer by enhancing bacterial metabolism, increasing membrane permeability, and triggering cellular stress responses, as well as bacterial multiplication. Antibiotic-resistant bacteria and antimicrobial residues are dispersed into water bodies by flooding and extreme weather events, increasing the hazards, especially in LMICs that are most susceptible to the effects of climate change.

3.5 Structural, Socioeconomic, and Governance Drivers

3.5.1 The Hardwired Producer of Inequality.

A 2019 global burden analysis in *The Lancet* found that sub-Saharan Africa had the highest AMR-attributable death rate at 27.3 per 100,000 population, with South Asia bearing the second-highest burden; these inequities are strongly shaped by social determinants of health, including poverty, gender inequality, inadequate WASH access, and weak health-system governance. and lowest in Australasia, at 6·5 deaths (4·3-9·4) per 100 000. (Murray *et al*., 2022).

3.5.2 Access-Excess Paradox

The AMR access paradox has two issues in LMICs: the people who need not access appropriate antibiotics and vice versa. Mendelson *et al*. (2024) introduced the 10-20-30 by 2030 paradigm in The Lancet that involves reduction of AMR-attributable mortality by 10 percent, setting the goal of reduction of improper use of antibiotics by humans by 20 percent, and reducing improper use of antibiotics by animals by 30 percent.

3.5.3 Weaknesses in Regulation

Regulatory deficits have been found to be the enabling factors of AMR in LMICs. The laws in most countries prohibit the sale of over-the-counter antibiotics, yet the laws have constantly either been ignored or treated laxly. Melles-Brewer *et al*. (2024) assert that the paradigms of regulation designed in the high-income setting were unsuitable in LMIC settings as numerous families were reliant on OTCs sales because of disparities in healthcare coverage.

3.5.4 WHO AWaRe and Quality of use of antibiotics.

Achieving the UN General Assembly-approved target of at least 70% of human antibiotic use was only 14.1% of 85 studies reviewed by Saleem *et al*. (2025), which indicated that Access antibiotics. More than use of watch antibiotics was found in approximately 68% of the studies which reflects the achingly large gap between global stewardship objectives and prescribing practice in LMICs.

3.5.5 Lack of AMR Surveillance.

The WHO GLASS 2025 report revealed that 1 in 6 laboratory-confirmed cases of bacterial infection in patients around the globe were resistant to antibiotics. LMICs reported the lowest level of tracking AMR in animals (less than 10%), and GLASS intervention by LMICs was not high. AMR surveillance of the environment has generally been overlooked using formal national AMR frameworks.

4. Synthesis and Discussion

4.1 LMICs' One Health AMR Ecosystem

The outcome of the research summarized in this review allows finding a highly integrated AMR ecosystem in low-resource LMIC areas. Pathways to community access to antibiotics are rational responses to systemic healthcare shortcomings instead of pathological deviations. When formal care is not available, too costly, or believed to be ineffective, the communities turn to unofficial sources, who provide antibiotics inexpensively, fast, and without the expenses and procedures of formal systems.

The human-animal-environmental interface of LMICs is characterized by economic entanglement and physical proximity. The market sellers of human drugs also sell the same antibiotics to the smallholder farmers who are unable to afford veterinary treatment. The same water supplies that their families utilize are contaminated by their cattle. The theoretical One Health idea turns into a pressing, practical reality when the human, animal, and environmental AMR hazards are spatially condensed in low-resource conditions.

4.2 AMR, Equity and Agency-The Human Aspect.

In LMICs, the most adversely affected population groups by AMR are the same that have the least power to affect the determinants of this disease. Women, smallholder farmers, individuals in informal settlements and those children below five years old bear a disproportionate burden of the AMR expenses and have little influence over the agricultural, economic, and regulatory institutions that facilitate resistance. The key organizing principle of a humanistic One Health approach should be equity.

This will mean understanding that people will die of preventable illnesses unless the access to OTC antibiotics is limited in parallel to an expansion in formal healthcare access. It also entails making sure that actions related to animal husbandry do not financially ruin subsistence farmers in the absence of other sources of income or reasonably priced veterinary care.

4.3: One Health Surveillance: An Insufficient Infrastructure.

The near total absence of comprehensive One Health AMR surveillance in the LMICs is arguably the greatest structural deficiency during the period of assessment. The relative contribution of each of these domains cannot be easily determined, and the efficacy of interventions cannot be effectively measured unless simultaneously collected data on trends of AMR in humans in clinical isolations, food animals, and environmental samples. Low-cost infrastructure decentralized surveillance infrastructure, including wastewater AMR surveillance as an early warning system, are urgently needed.

4.4 Effective and Promising Interventions.

Several categories of interventions with evidence of efficacy or potential in LMIC situations were found by the review:
Eliminate or limit antibiotic prescription in communities and low-resource settings: • Communities in need of antimicrobial stewardship programs (ASPs). • Quick diagnostic testing in the point of care environment to reduce unnecessary antibiotic prescription.

5. PRISMA Summary Tables

Summary of key study categories, geographical distribution, and primary findings from the included studies:

Table 1: Prisma Summary

Authors	AMR Drivers	Country/Geographical Settings	Region	Study Design	Income and Domain
Do *et al.* (2021)	Community OTC access	Bangladesh, Ghana, Mozambique, South Africa, Thailand, Vietnam	Multi-country (Sub-Saharan Africa & Southeast/South Asia)	Mixed-methods (survey + qualitative)	**LMIC**
Murray *et al.* (2022)	AMR burden & mortality	Global (195 countries)	Global	Systematic review & modelling study	**Global (LMIC focus)**
Larsson & Flach (2022)	Environmental AMR / WWTP	Global (multi-country)	Global	Narrative/systematic review	**Global**
Zabala *et al.* (2022)	Substandard/falsified antibiotics	East Africa, West Africa, South Asia	Sub-Saharan Africa / South Asia	Systematic review	**LMIC**
Velazquez-Meza *et al.* (2022)	One Health AMR framework	Multi-country (global review)	Global	Review / commentary	**Global**
Abia *et al.* (2023)	Environmental AMR – wastewater	Sub-Saharan Africa (multiple countries)	Sub-Saharan Africa	Ecological / environmental study	**LMIC**
Foyle *et al.* (2023)	Slaughterhouse effluent AMR	Iran, Nigeria, China	Middle East / Sub-Saharan Africa / East Asia	Cross-sectional study	**LMIC / UMIC**

Table 1 (Cont'd)

Mulchandani *et al*. (2023)	Agricultural antibiotic use trends	Global (focus: SE Asia, sub-Saharan Africa, South America)	Global (LMIC focus)	Systematic review & modelling	**LMIC**
Odey *et al*. (2024)	Agricultural AMR – food animals	Sub-Saharan Africa	Sub-Saharan Africa	Systematic review	**LMIC**
Orubu *et al*. (2021)	Antimicrobial supply chain	Bangladesh	South Asia	Mixed-methods study	**LMIC**
Al Masud *et al*. (2024)	Community antibiotic purchasing	Multi-country LMICs	Global (LMIC)	Cross-sectional survey	**LMIC**
Cabral *et al*. (2024)	Antibiotic use without prescription	Multi-country LMICs	Global (LMIC)	Systematic review	**LMIC**
Al Asad & Katha (2024)	Livestock-human AMR interface	Bangladesh / South Asia	South Asia	Cross-sectional study	**LMIC**
Pandey *et al*. (2024)	One Health – livestock/environment/humans	Multi-country (global review)	Global	Review / commentary	**Global**
Melles-Brewer *et al*. (2024)	OTC antibiotic sales – regulatory call	West Africa, South Asia	Sub-Saharan Africa / South Asia	Commentary / qualitative analysis	**LMIC**
Mendelson *et al*. (2024)	Sustainable antibiotic access – UN framework	Global (policy analysis)	Global	Policy analysis / review	**Global (LMIC focus)**
Tegegne *et al*. (2024)	Substandard/falsified antimicrobials	Ethiopia, Kenya, Tanzania	Sub-Saharan Africa (East Africa)	Cross-sectional study	**LMIC**
Ehsan *et al*. (2025)	Antibiotic resistance – emerging threats	Global / developing countries (focus)	Global (LMIC)	Narrative review	**LMIC**
James & Thursky *et al*. (2025)	One Health antimicrobial stewardship	Global review	Global	Systematic review	**Global**
Saleem *et al*. (2025)	WHO AWaRe system & stewardship	Multi-country LMICs (85 studies reviewed)	Global (LMIC)	Systematic review	**LMIC**
Davis *et al*. (2025)	AMR equity & social determinants	Sub-Saharan Africa, South Asia (intersectional synthesis)	Global (LMIC focus)	Critical interpretive synthesis	**LMIC**
Donkor *et al*. (2025)	Aquaculture AMR	Southeast Asia, sub-Saharan Africa (aquaculture)	Southeast Asia / Sub-Saharan Africa	Systematic review	**LMIC**
Page *et al*. (2021)	PRISMA 2020 guidelines	International (PRISMA methodology)	Global	Methods paper	**Global**
WHO (2024a)	Bacterial priority pathogens list	Global	Global	WHO institutional report	**Global**
WHO (2024b)	Antibiotic shortages in LMICs	Global (LMIC focus)	Global	WHO institutional report	**LMIC**
WHO GLASS (2025)	Global AMR surveillance	Global GLASS participants	Global	WHO surveillance report	**Global**

6. Limitations

One should also note several limitations: • Study designs, demographics and contexts across nations are heterogeneous; results are reported in a narrative manner. • Most environmental AMR research involved urban or peri-urban populations; rural populations were under-represented.

7. Conclusions and Recommendations

7.1 Conclusion

Human-animal-environmental interface community access channels to antibiotics in LMICs are complex systems, structurally embedded, that cannot be boiled down to individual behavioral choices or evident regulatory failures, as found in this systematic review. These antimicrobial resistance (AMR)-driving factors are intricately connected not only among the realms of environmental contamination, animal husbandry, human health, and governance but also help to demonstrate how complex and multifaceted the One Health dilemma is.

The groups of people affected by antimicrobial resistance (AMR) the most in low-income countries (LMICs), are also the groups that are most likely to rely on the use of unofficial access to antibiotics, proximity to unregulated livestock operations centers, and inaccessibility to clean water and sanitary facilities. Consequently, they have the least responsibility and are the least prepared to deal with global AMR epidemic. This situation cannot be dealt with without considering their needs and dignity, which is not a strategically good move nor morally good.

7.2 Recommendations

To Governments and Policymakers:

• Develop and achieve national action plans on antimicrobial resistance (AMR) specifically aimed at tackling the access-excess conundrum and that incorporate interventions particularly focused on formal care provision to communities and informal health workers. Goal Ensure the supply and affordability of Access antibiotics and mandate and implement a prescription-

only policy on WHO AWaRe Watch and Reserve drugs. • Include AMR in national One Health surveillance systems, and demand and enforce data transfer across the environmental, veterinary and the human health sectors.

In respect to the Agricultural Industry:

• Ban or progressively reduce non-therapeutic use of antibiotics in food animals (with priority given to those of the most important antibiotic category). • To reduce dependence on uncontrolled antibiotic self-treatment of livestock, subsidized veterinary care and animal health extension efforts should be made to smallholder farmers.

In the case of Community of Researchers:

• Prioritize overall One Health AMR monitoring investigations where both environmental and animal and human matrices are sampled simultaneously. • Invest in community-based research that consider priorities, practices, and expertise of the affected communities. • develop and validate low-cost AMR diagnostic and surveillance systems that effectively operate in low-resource settings.

To Donors and International Organizers:

- Increase financing for AMR action in LMICs, recognizing that the 2024 UN General Assembly Political Declaration commitment require substantial resource transfers,
- Support GARDP-WHO SECURE initiative to improve sustainable, equitable access to quality-assured antibiotics in LMICs
- Fund community health worker and informal vendor training programs on antimicrobial stewardship, considered through human right and equity-focused approach

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