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ANTIMICROBIAL STEWARDSHIP: A COMPREHENSIVE REVIEW WITH SURVEY BASED INSIGHT INTO AWARENESS, PRACTICES AND BARRIERS.

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ABSTRACT:
Antimicrobial stewardship, or AMS, is all about using antibiotics wisely. It means giving the right drug at the right dose, in the best way, for the right amount of time all while trying to cut down on resistance and side effects. When antibiotics are overused or misused, it speeds up antimicrobial resistance (AMR), which is a big problem. If we don't get a handle on this, some estimates say it could cause up to 10 million deaths a year by 2050 and damage economies worldwide. Usually, AMS involves a team of healthcare workers like doctors, pharmacists, nurses, microbiologists, and administrators working together. It's also important to look at the bigger picture since AMR doesn't just affect humans it spreads through animals and the environment too, through farming, trade, and sanitation. The article shares survey results showing how AMS is being put into practice across different healthcare settings. It emphasizes challenges like lack of funding, weak lab facilities, staff shortages, some doctors resisting change, and poor leadership. In lower income countries, limited lab access and fewer antibiotics mean doctors often rely on broader scope drugs, which can make resistance worse. The main point is that while eliminating AMR completely may not be realistic, we can better control it with stewardship programs, smarter antibiotic use based on resistance data, prevention, research, and global cooperation so we can keep these critical medicines effective for the future.

Keywords: Antimicrobial resistance (AMR), antibiotic misuse, bacterial resistance mechanisms, Antimicrobial Stewardship Programs (ASPs), global collaboration Remove Antimicrobial Stewardship Programs (ASPs), global collaboration

Abbreviations: AMS- Antimicrobial stewardship, AMR- Antimicrobial resistance, AST-Antibiotic Suppressive Therapy.

INTRODUCTION:

An antibiotic is a natural compound made by living creatures, mainly microorganisms that can stop bacteria from growing or even kill them. Most of these substances are produced by bacteria and fungi that live in the soil. The microbes responsible for producing antibiotics capable of fighting infections include certain bacteria and fungi. The discovery of penicillin in 1941 marked a turning point worldwide. Since then, antibiotics have revolutionized the way we treat bacterial infections in both humans and animals. But it's critical to keep in mind that antibiotics aren't effective against viruses.[1] Antimicrobial agents have truly changed public health, saving countless lives along the way. Even though humans have been using them for thousands of years, microbes eventually learned how to resist them. As using antimicrobials increased over time, resistance genes spread quickly among different microbes.[2] Antimicrobial stewardship, or AMS for short, is all about carefully coordinating efforts to ensure antibiotics and other antimicrobial drugs are used wisely.[3] Antimicrobial stewardship is still a relatively new area, and people are just starting to figure out how to measure success in a way that's practical and meaningful. Usually, they look at how antibiotics are being used, but it's also important to consider resistance trends and patient outcomes to really see the difference these programs make in hospitals and for patients. [4] The increasing challenge of antimicrobial resistance (AMR) has prompted a push for antimicrobial stewardship programs (ASPs) to better manage antibiotic use in healthcare environments. These programs typically focus on strategies like conducting prospective audits with feedback and interventions, and restricting certain drugs through formulary controls and preauthorization

requirements. Also, they often incorporate education efforts, clinical guidelines, treatment pathways, de-escalation practices, and switching from intravenous to oral antibiotics. [5]
By the year 2050, antimicrobial resistance could potentially lead to roughly 10 million deaths each year around the world. This isn't just a major health concern; it could also cause economic damage that reaches up to 100 trillion dollars.[6]

Emergence of stewardship:
The first time you see records for the search terms '(antimicrobial OR antibiotic) AND stewardship' is in 1996 on PubMed. By 2005, the number of articles published each year had climbed to over ten, and by 2008, that number increased to more than fifty annually. Come 2011, count soared past 100 per year. Overall, this search now reveals over 2,500 citations, a jump contributed by a sharp rise in usage over the past five years. [7] Unlike many other medications, antimicrobial drugs are quite special because every time someone uses them, both the individual patient and society as a whole feel the impact. While these powerful medicines can save lives, they also put pressure on bacteria to evolve, sometimes leading to the rise of drug-resistant strains. [8] The goal is to reduce the emergence and spread of resistant organisms, improve patient outcomes, and ensure the sustainability of antimicrobial treatments. Organizations such as the Infectious Diseases Society of America (IDSA), the Society for Healthcare Epidemiology of America (SHEA), and the American Society of Health System Pharmacists (ASHP) actively support these stewardship initiatives. They provide guidelines, training, research, and policy advocacy to strengthen antimicrobial stewardship efforts across hospitals, clinics, and other healthcare environments.[9] Five Right of antimicrobial therapy required for safer and rational antibiotic use are described below.[10] The right Antibiotic, for the right patient, at the right time, with the right dose, the right route causing

History of Antimicrobial Stewardship Program:
In the past, the term 'antimicrobial stewardship' mostly referred to initiatives within individual hospitals. During the 1990s and early 2000s, many countries started developing and rolling out such programs. In the US, pharmacists often led these efforts, while in Europe, they were usually spearheaded by specialists in infectious diseases or clinical microbiology, frequently working alongside pharmacists. Back in 1996, John McGowan and Dale Gerding introduced the term 'antimicrobial stewardship,' emphasizing the link between how we use antimicrobial agents and the rise of resistance. They emphasized needing large-scale, well-controlled studies on antimicrobial use, using advanced epidemiologic methods, molecular typing, and detailed analysis of how resistance develops. In a nutshell, Antimicrobial Stewardship (AMS) aims to choose the right antimicrobial, at the right dose, for the right amount of time, to achieve the best possible clinical results. It also strives to minimize side effects for patients while reducing the chances of resistance building up in the future.[11]

Antimicrobial Stewardship Principles:
The antibiotic committee can operate either as an independent group or as a part of the broader Drug and Therapeutics Committee within an institution. Its main job is to develop local guidelines or protocols to guide how antibiotics are used. Members of this committee should include various healthcare professionals: doctors who prescribe antibiotics—such as infectious disease specialists, intensive care physicians, internists, paediatricians, clinical pharmacologists, and surgeons; nurses, especially in countries where they have prescribing authority; specialized pharmacists who can provide valuable data on antibiotic usage; microbiologists who will contribute insights on bacterial resistance patterns and the mechanisms behind them; representatives from management; and members of the Infection Control Committee, which, in smaller facilities, is often led by the microbiologist. Additional members can be brought in as needed to ensure all relevant perspectives are covered.[12]

Eight key steps for implementing an Antimicrobial Stewardship Program:
1 Assess the motivations
2 Ensure accountability and leadership
3 Set up structure and organization
4 Define priorities and how to measure Progress and success
5 Identify effective interventions for your setting
6 Identify key measurements for improvement
7 Educate and Train
8 Communicate [13]

AMSP clinical importance and goals:
AMSP is often described as the best choice in terms of selecting the right drug, dosage, and duration of antimicrobial therapy to achieve the best clinical results. It aims to effectively prevent and fully treat infections while minimizing potential side effects for the patient. Besides, it seeks to reduce the risk of developing antibiotic resistance eventually.[14] Depending on the clinical setting AMS programs will target Their goals and outcomes based on available resources and Current short, mid and long-term opportunities. However, the Overarching goals fall under the following categories

1) Improve patient care and outcomes
2) Reduce collateral damage and
3) Impact costs.[15]

Core Elements of Outpatient Antibiotic Stewardship:
Showing commitment means you're serious about making sure antibiotics are used the right way, and that patients are kept safe. This isn't just about good intentions it means taking real steps to improve how antibiotics are prescribed.
Another key part is education. Make sure that both healthcare workers and patients understand why responsible antibiotic use is important. Give them helpful materials like flyers, online tools, or training sessions. Finally, make sure prescribers have access to experts, like pharmacists or infectious disease specialists, who can help them choose the best antibiotic for each situation.[16]

ANTIMICROBIAL RESISTANCE:

Completely getting rid of antimicrobial resistance (AMR) isn't really doable or even a good idea. If we did, we'd have to cut way back on using antimicrobials, which would also mean losing the good they do. It's about balancing what we need now with what might happen in the future. Several methods exist to control antimicrobial resistance (AMR), each applicable at different points. Certain methods work to stop new resistance from arising. Others focus on preventing existing resistance from spreading. Logically, spread can only happen after resistance appears. So, the main aim is to stop resistance from developing in the first place.[17] Prior studies showed that antibiotic resistance (AMR) varies across countries based on their economic status. AMR in developing countries is tied to factors like poor regulation of drugs, little AMR monitoring, misuse of antibiotics, and quality control issues. For example, antibiotics are readily available in Vietnam and Bangladesh, which leads to issues like misuse and a lack of awareness.

Developed countries have different issues, such as overuse of antimicrobials in agriculture and over-prescription. However, China, a developing country, is a major consumer of veterinary antimicrobials, while developed countries like the UK have cut antimicrobial sales. This suggests that AMR risk factors are starting to overlap between developing and developed nations.[18] The rise of antimicrobial resistance (AMR) across humans, animals, and the world around us is a mounting crisis. Factors such as growing populations of both people and animals, increased international travel and commerce, and closer interactions with wildlife all play a role in the increased spread of AMR. This makes it a worldwide worry for health. Addressing AMR needs teamwork that crosses international borders. Thinking about “One Health” is super important. AMR involves complicated, ever-changing relationships. Drug leftovers and bacteria that can resist medicines can move between people, animals, and the environment in many different ways. For example, animals can develop resistance through antibiotic use. Then, these resistant bacteria can spread to humans through direct contact, food, or water. The situation is the same for the environment. Waste from hospitals and animal farms can have drugs and resistant bacteria, polluting water and soil. People then get exposed through contaminated water or eating plants grown in polluted soil. International travel and trade also rapidly spread resistance across geographic areas. Travellers can carry resistant bacteria, introducing it to new places. Food products traded internationally can also spread bacteria from one place to another. Contact with wildlife increases the risk of novel resistances jumping species. Humans get exposed to new sources of resistance, further stressing the situation. Dealing with AMR requires understanding these interconnected pathways. Steps to take include using antimicrobials more carefully in human and animal medicine. Tracking the spread of resistance genes in different environments is also a need. It also involves improving sanitation and hygiene practices to prevent the spread of resistant bacteria. Strong global collaboration is critical to develop new methods of stopping the development and spread of AMR across the human-animal-environment interface. Education is needed to make sure that people know about the risks of incorrect antimicrobial use and how they can help.[19] Vaccines offer a line of defence against antimicrobial resistance (AMR) for several reasons. First, vaccines can prevent infections from AMR pathogens. Second, by reducing infections, vaccines reduce the need for antibiotics. Finally, vaccines can prevent bacterial growth, thus preventing the conditions that lead to resistance mutations. Current vaccines target AMR pathogens, like Streptococcus pneumoniae and Haemophilus influenzae. Also, many vaccines in clinical trials could prevent infections from major AMR bacteria, including Mycobacterium tuberculosis, Salmonella typhi, P. aeruginosa, S. aureus, pathogenic Escherichia coli, and Clostridium difficile. Advances in immunology, genetics, structural biology, and microbiology have improved vaccine technologies, increasing the chance of creating new vaccines that prevent infections from AMR pathogens.[20]

The starting treatment usually focuses on bacteria, but think about treatable viruses, fungi, and protozoa too. Guidance on when to include coverage for resistant bacteria will be discussed later. It's hard to create simple rules for all these things. While tools that use patient info to predict antibiotic therapy are coming out, they're not commonly used. Therefore, there's no real replacement for clinical judgment when picking a starting antibiotic treatment.[21]

Definitive therapies:

All patients in the cohort were given definitive treatment. The average time to correct treatment was 41.4 hours. For 117 patients, results existed before the treatment was given. The average time to get results was 33.9 hours. If ACC results were ready, 51 patients (30.5%) could have gotten treatment faster, cutting the time by 25.4 hours. In most of these cases, treatment was scaled down (92.2%), while it was increased in a few (7.8%). Enterobacteriaceae were the common germs when faster treatment could have helped, with E. coli (37.3%) and Klebsiella spp. (17.6%) being the most frequent. Reasons for ACC not speeding up treatment included: ACC didn't test for some susceptibilities (19%); chances to scale down treatment weren't taken (21.6%); patients were already getting the right treatment when ACC results would have been ready (39.7%); and ACC had technical issues (16.4%). Among the patients already on target treatment, RDT results were there to refine treatment for over half of them (54%).[22]

Prophylactic therapy:

From June 1, 1976, to September 30, 1977, every patient admitted to Grady Memorial Hospital's general and paediatric surgical units was considered for this study if they had planned gastric, biliary, or colon surgery. Written consent was taken from each patient, parent, or guardian. Records included age, race, sex, any other diseases, nutritional status, diagnoses, the operation performed, and any complications. Kidney, liver, and bone marrow function tests were done, including urine analysis, serum creatinine, and complete blood counts. Aerobic bacterial isolates were identified and tested for susceptibility to cefamandole and cephaloridine. Anaerobes were categorized by genus and occasionally by species.[23]

Suppressive therapies:

AST was defined as an oral antibiotic therapy without an end date, started with the intention to control the infection where curative treatment seems unachievable. The type and dosage were based on in vitro susceptibility of the cultured pathogens. Laboratory monitoring for potential toxicity and adverse events was performed. AST was considered to be successful in cases with retention of the prosthesis without clinical relapse of infection at final follow-up. In cases in which follow up had ended due to the death of the patient unrelated to (the treatment of) PJI, AST was considered successful. Failure was defined as death related to PJI or new surgical intervention at prosthesis side due to persistent or recurrent infection.[24]

ANTIBIOGRAM:

A hospital antibiogram is a regular report that shows how susceptible local bacteria are to antimicrobials. These bacteria samples are sent to the hospital's lab. Doctors often use these reports to understand local susceptibility rates, help them choose the right antibiotics, and keep an eye on how resistance changes in their hospital, Reports can be used to compare susceptibility rates between hospitals and follow resistance trends.[25]

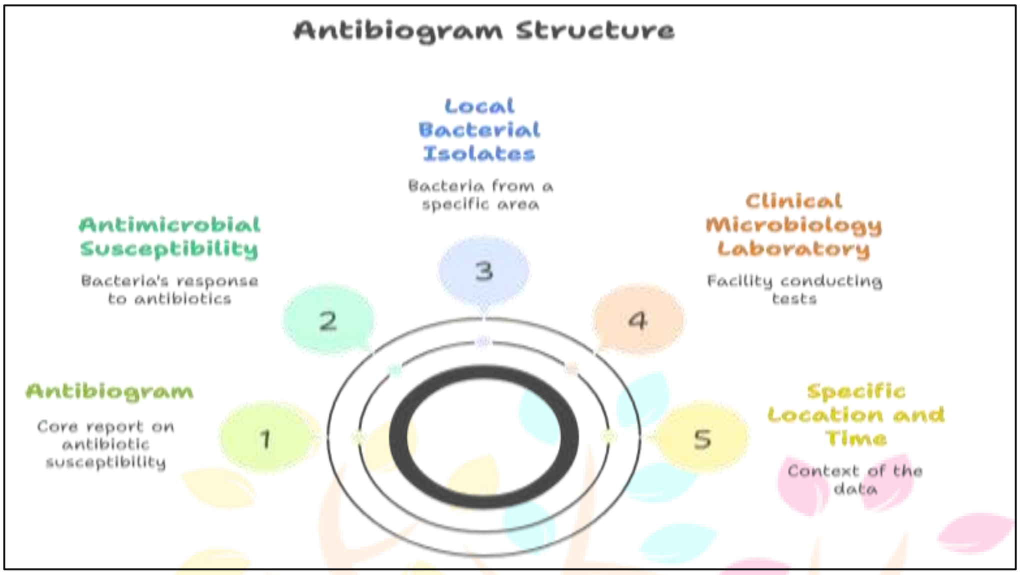


Fig:1: Antibiogram Structure

When prescribing antibiotics, several factors merit review to ensure treatment success. These include the microbe's vulnerability to the antibiotic, how the antibiotic moves inside the body (pharmacokinetics), and what the antibiotic does to the microbe (pharmacodynamics). Even something as basic as whether the antibiotic can reach the infection site matters. An important difference lies between antibiotics that halt bacterial growth (bacteriostatic) and those that kill bacteria (bactericidal). The ways an antibiotic stops growth can be distinct from how it kills, even for the same drug and bacteria. A good illustration is penicillin, which kills pneumococci but only stops the growth of enterococci.[26] This split could give a clearer view of susceptibility rates and organism origins, which could guide better treatment choices. Still, problems exist. Cultures might be taken after 48 hours even if the infection started in the community, leading to misclassification. Also, if a patient is already carrying an organism that later causes an infection, it might be labelled as hospital-acquired. A key problem is that regular antibiograms don't differentiate between organisms that cause disease and those that just live on the patient. Adding colonizing organisms into susceptibility calculations might alter the rates.[27] this study examines how smaller, local hospitals in the south eastern U.S. prepare antibiograms. We found these hospitals often have trouble preparing good antibiograms because they may have few staff in microbiology or informatics, cannot afford CLSI documents, get little support from doctors or teams, and have small sample sizes that make data hard to read. Some hospitals we studied lack infectious disease experts. This will give them dependable susceptibility data and allow them to monitor drug resistance.[28]

Actions within antimicrobial stewardship:

In this section, we'll look at some practical explants of actions taken to promote responsible antimicrobial use.[29]. These actions often aim directly at changing how prescribers, patients, vets, and farmers use antimicrobials think decision support tools or feedback mechanisms that encourage prudent prescribing, or measures like selective testing reports and formulary rules to restrict unnecessary use.[30] In hospitals, such efforts are usually called 'stewardship interventions' and are managed by a team of specialists forming an antimicrobial stewardship program.[31] This team chooses from various strategies, which can be customized depending on the hospital's setup considering factors like their role within the hospital, team composition, available patient data, and how much influence they have over prescribers. Hospital quality officers or advisers frequently assist these teams by using their knowledge of implementation techniques such as the Theory of Constraints, Six Sigma, or the Plan-Do-Study-Act cycle, and bringing in experts as necessary. Ex plants include hospitals providing resources and prioritizing stewardship teams, regional networks offering benchmarks and guidance, pharmaceutical companies limiting antimicrobial advertising while ensuring necessary drugs are available, and regulations that control how antimicrobials are dispensed and used in humans and animals. National bodies might run awareness campaigns or set licensing rules for healthcare providers, while laws might separate prescribing from dispensing. Additionally, governments should finance nationwide surveillance on antibiotic usage and resistance and include quality indicators into reimbursement schemes. [32-33]

Roles of individuals in antimicrobial stewardship program:

1. Why They Are Important:

- Infectious Diseases (ID) doctors play a very important role in programs that help hospitals use antibiotics more wisely.
- Their involvement makes sure that the hospital uses antibiotics based on the best medical
- knowledge, which helps protect patients.[34]

2. Their Main Responsibilities:

- Help design and run the antimicrobial stewardship program.
- Approve which antibiotics can be used, especially strong or special ones.
- Create and follow proper guidelines for using antibiotics.[34]

3. Challenges They Face:

- These doctors are already busy with patient care, research, and teaching.
- Running such a program, especially in medium or large hospitals, can take a lot of time.

- like ID fellows or trained pharmacists.[35]

4. Example of a Small Hospital Doing It Right:

- A 120-bed community hospital successfully ran an antibiotic program led by one ID doctor and a clinical pharmacist.
- This saved the hospital ₹1.47 crore ($177,000) in a year while only using 8–12 hours of the ID doctor's time weekly.[36]

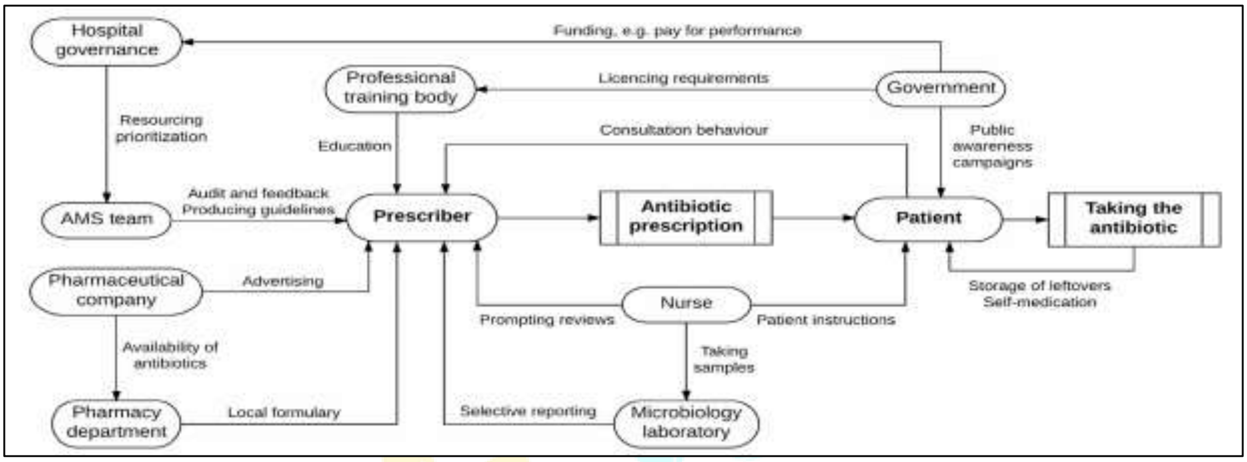


Fig:2 Examples of actors and actions within antimicrobial stewardship.[37]

Challenges of Antimicrobial stewardship program:

1. Limited leadership support & institutional:

Without strong management commitment, ASPs struggle to succeed, as effective leadership is essential for ensuring resources, accountability, and long-term sustainability.[38] Governance weaknesses such as poor leadership, lack of localized planning, and ineffective teamwork pose major barriers to implementing ASPs in South African public hospitals.[39]

2. Insufficient Funding & Human Resources:

Dedicated funding and staffing are absent in many ASPs; according to one survey, only 15% secured financial support for personnel. As a result, even economically efficient programs often fail to endure without investment.[40] In a study of 157 healthcare providers, 77% identified lack of funding and 75.8% pointed to inadequate staffing as key barriers.[41]

3. Weak Laboratory Capacity & Diagnostic Limitations:

Limited access to reliable microbiological services, such as antibiograms, greatly restricts evidence-based prescribing. In Nigeria, only 6% of public facilities had functional laboratories, and nearly two-thirds lacked trained personnel. Even so, the GIH lab offers services not available in many other hospitals in Nepal. In LMICs, inadequate microbiological support is a major barrier and has been associated with higher mortality.[42] A multi-country study in Sri Lanka, Kenya, and Tanzania identified limited diagnostic capacity, poor drug availability, and lack of confidence in laboratory results as key challenges. Lack of access to molecular and rapid identification methods in Nepal and other LMICs slows down or complicates targeted treatment.[43]

4. Prescriber Resistance:

Resistance to stewardship programs is common among prescribers who fear restrictions on their clinical autonomy. In Nepal, physician reluctance to accept guidelines highlighted the need for context specific engagement approaches. In Saudi MoH hospitals, physicians' concerns especially fear of liability pose a major barrier to ASP adoption. Many avoid changing prescriptions or reducing treatment duration, resorting instead to defensive prescribing. Decisions often prioritize current patients over future implications, while weak guideline enforcement, liability pressures, and personal behaviours further complicate efforts to influence prescribing practices.[44]

5. Cost Issues:

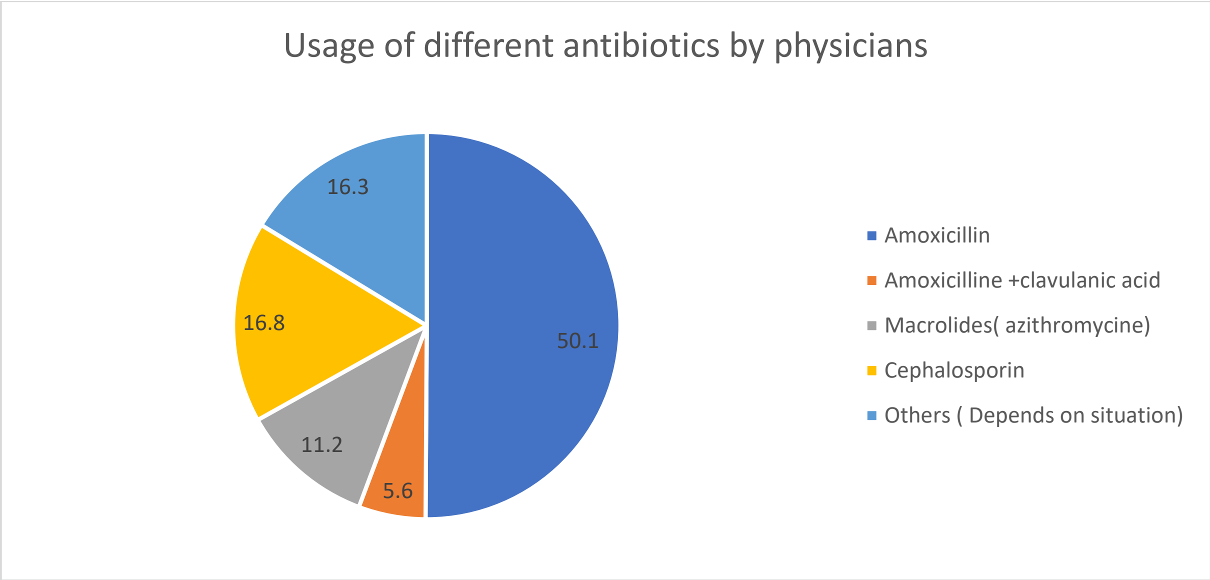
Other influencing factors included financial limitations of clients (34% [62/184]), disease location (30% [56/184]), severity of infection (27% [50/184]), and unusual findings on in-house cytology (18% [33/184]). Low-cost diagnostic methods, such as cytology, were consistently utilized in companion animal practice but were less commonly applied in equine and cattle practice.[45] A review from South Africa emphasized that inadequate infrastructure, commercially driven healthcare models, and uneven policy enforcement contribute to widening these gaps.[46]

6. Drug availability:

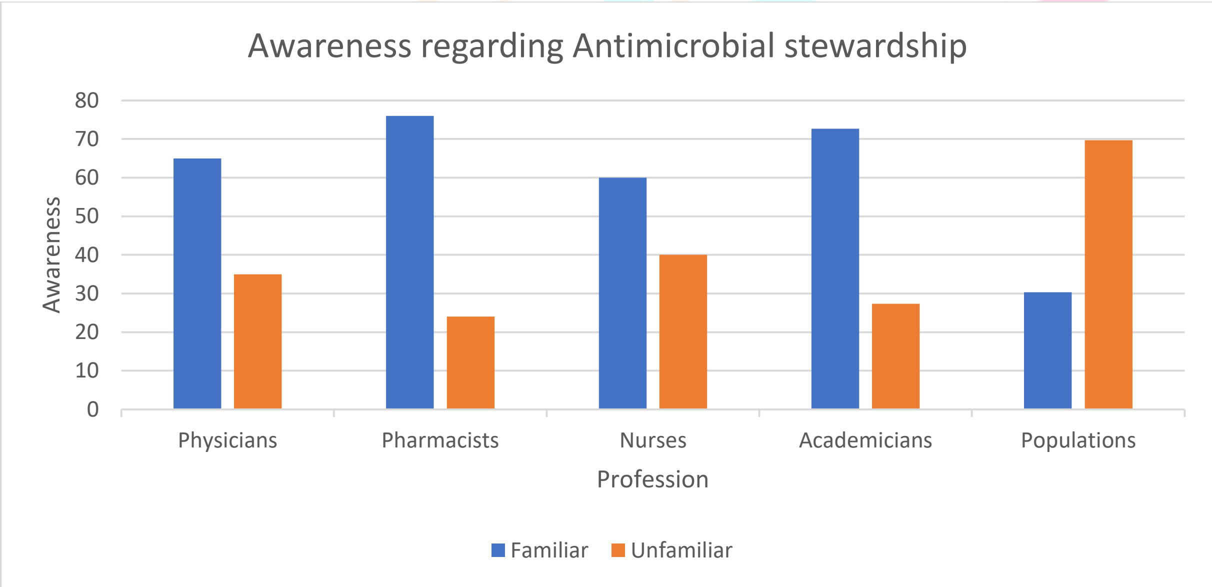
Limited availability of suitable antimicrobials often compels clinicians to rely on broad-spectrum agents or less effective alternatives. The absence of essential antimicrobials such as aztreonam and echinocandins has posed significant challenges, often leading to reliance on unnecessary broad-spectrum combinations. This limited access not only complicates the development of evidence-based guidelines but also hinders rational prescribing practices.[47]

INTERPRETATION OF SURVEY CONDUCTED ON ANTIMICROBIAL STEWARDSHIP:

The survey findings revealed variable levels of awareness and practice regarding antimicrobial stewardship (AMS) among different respondent groups. Physicians and pharmacists demonstrated relatively higher knowledge of antimicrobial resistance and stewardship guidelines compared to nurses, academicians, and the general population. However, even among healthcare providers, gaps were observed in translating knowledge into routine practice, with barriers such as lack of training, limited diagnostic support, and patient pressure influencing antibiotic prescribing. Pharmacists acknowledged challenges related to over-the-counter antibiotic dispensing and insufficient patient counselling. Nurses highlighted issues with compliance monitoring and infection control practices. The academic respondents indicated limited incorporation of AMS concepts into pharmacy curricula, suggesting the need for greater emphasis on education.



Graph:1: Usage of different antibiotics by physicians



Graph:2: Awareness regarding Antimicrobial stewardship

Group	**Awareness**	**Attitudes**	**Practices**	**Barriers Identified**
Physicians	High awareness of AMS, familiar with guidelines (WHO/ICMR)	Consider AMS a serious issue; supportive of AMS programs.	Prescribe antibiotics but sometimes without full diagnostic confirmation; occasional use of broad-spectrum antibiotics.	Patient demand, time pressure, limited diagnostic facilities.

Table:1:

Pharmacists	Good knowledge of antibiotic resistance; moderate awareness of AMS policies.	Recognize role in stewardship; positive attitude toward patient counselling.	Often dispense antibiotics without prescription; variable patient education.	Lack of strict regulation, commercial pressure, inadequate training.
Nurses	Moderate knowledge; limited exposure to AMS training.	Aware of importance of infection control and rational antibiotic use.	Focused on administration and monitoring; sometimes poor compliance checks.	Lack of authority in prescribing decisions; insufficient training.
Academician	Awareness varies; AMS concepts partially covered in curriculum.	Support inclusion of AMS in teaching; recognize long-term importance.	Limited direct involvement in prescribing/dispensing	Outdated curriculum, lack of training workshops.
General Population	Low awareness; misconceptions common (e.g., antibiotics for viral infection).	Do not fully perceive AMR as a serious issue.	Frequent self-medication, incomplete antibiotic courses, sharing leftover antibiotics.	Lack of awareness, easy availability of antibiotics, reliance on non-medical advice.

Interpretation of survey conducted on antimicrobial stewardship

CONCLUSION:

Inappropriate use of antibiotics in clinical and community settings is a major contributing factor to the persistent global issue of antimicrobial resistance (AMR). Our survey revealed that physicians and pharmacists demonstrated comparatively higher awareness of AMS principles, though practical challenges often hindered consistent application. Nurses and academicians showed moderate understanding, underscoring the need for structured training and curricular integration. The general population exhibited the lowest awareness, with frequent misconceptions, self-medication, and incomplete antibiotic courses contributing significantly to resistance.

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