

Antimicrobial Stewardship: An Essential Strategy to Combat Antimicrobial Resistance

Misal Snehal N., Wadekar Vishal B., Phad kapil S.
Savitribai Phule University Pune

Abstract

Antimicrobial resistance (AMR) has emerged as one of the most serious global public health concerns of the twenty-first century. The irrational and excessive use of antibiotics in healthcare settings, agriculture, and animal husbandry has accelerated the development of resistant microorganisms, leading to increased morbidity, mortality, prolonged hospital stay, and higher healthcare costs. Antimicrobial stewardship (AMS) programs play an essential role in promoting the rational use of antimicrobial agents and preserving the effectiveness of existing antibiotics. The present review discusses the concept, objectives, and core components of antimicrobial stewardship programs, including leadership commitment, accountability, education, tracking, reporting, and intervention strategies. The article also highlights the growing burden of antimicrobial resistance, the role of stewardship in improving patient outcomes, and the importance of multidisciplinary collaboration in combating resistance. In addition, the review emphasizes the significance of the One Health approach, which integrates human, animal, and environmental health to control the spread of resistant pathogens. Effective implementation of antimicrobial stewardship programs can reduce inappropriate antibiotic use, decrease antimicrobial resistance, improve clinical outcomes, and support sustainable healthcare practices. Strengthening stewardship activities at local, national, and global levels is necessary to preserve antibiotics for future generations.

Keywords

Antimicrobial Stewardship; Antimicrobial Resistance; Antibiotics; Rational Drug Use; Infection Control; Healthcare-Associated Infections; Antibiotic Resistance; One Health; Multidrug-Resistant Organisms; Patient Safety

Introduction

The discovery of penicillin revolutionized modern medicine and marked the beginning of the antibiotic era. Since then, antimicrobial agents have become an indispensable component of healthcare, supporting not only the treatment of infectious diseases but also advanced medical procedures such as organ transplantation, cancer chemotherapy, and major surgical interventions. However, the inappropriate and excessive use of antibiotics has resulted in the rapid emergence of antimicrobial resistance (AMR), which is currently considered one of the greatest threats to global public health.

Unlike most other medications, antibiotics affect both the individual patient and society as a whole. While these drugs successfully eliminate harmful microorganisms, they also create selective pressure that allows resistant organisms to survive and multiply. Over time, this reduces the effectiveness of available antimicrobial agents and limits treatment options for infectious diseases.

Between 1935 and 2003, nearly fourteen new classes of antibiotics were introduced into clinical practice. However, the development of new antimicrobial agents has slowed considerably in recent decades. Only a few antibiotics with novel mechanisms of action have been approved since the late 1990s. The high cost of drug

development, lower financial returns compared with medications for chronic diseases, and scientific challenges associated with antibiotic discovery are major reasons for the declining antibiotic pipeline.

Due to the increasing burden of antimicrobial resistance and the limited development of new antibiotics, antimicrobial stewardship (AMS) has gained global importance. Antimicrobial stewardship refers to coordinated interventions designed to improve and measure the appropriate use of antimicrobial agents. The main objective of AMS is to ensure optimal selection, dose, route, and duration of antimicrobial therapy to achieve the best clinical outcomes while minimizing toxicity, adverse effects, and resistance.

Need for Antimicrobial Stewardship

According to the Centers for Disease Control and Prevention (CDC), approximately 20–50% of antibiotic prescriptions in acute care hospitals are either unnecessary or inappropriate. Similar findings have been observed in nursing homes and long-term care facilities, where inappropriate prescribing rates range from 40–75%. These statistics highlight the urgent need for responsible antimicrobial prescribing practices across all healthcare settings.

In response to this growing concern, organizations such as the CDC, Centers for Medicare and Medicaid Services (CMS), Society for Healthcare Epidemiology of America (SHEA), and The Joint Commission have established antimicrobial stewardship standards for healthcare institutions. In 2019, CMS mandated that all hospitals in the United States implement antimicrobial stewardship programs.

The major goals of AMS programs include:

- Promoting rational antimicrobial prescribing practices
- Reducing unnecessary antibiotic use
- Minimizing antimicrobial resistance
- Preventing antibiotic-related adverse effects
- Improving patient outcomes
- Reducing healthcare costs

Stewardship programs also encourage healthcare professionals to follow the “5 Ds” of antimicrobial therapy:

1. Right Drug
2. Right Dose
3. Right Drug Route
4. Right Duration
5. Timely De-escalation of therapy

Core Elements of Antimicrobial Stewardship Programs

Leadership Commitment

Strong institutional support is essential for the successful implementation of AMS programs. Healthcare administrators should provide adequate financial resources, staff training, information technology support, and infrastructure necessary for stewardship activities. Leadership commitment also helps establish accountability and encourages adherence to stewardship policies.

Accountability and Drug Expertise

A successful AMS program requires dedicated leadership by trained healthcare professionals. Infectious disease physicians often serve as program leaders, while clinical pharmacists contribute significantly through medication management and therapeutic monitoring. Studies have shown that multidisciplinary stewardship teams improve antibiotic use and patient outcomes.

Stewardship Interventions

AMS interventions are designed to improve prescribing practices and optimize antimicrobial therapy. Common interventions include:

- Antibiotic time-outs after 48–72 hours
- Prior authorization for restricted antibiotics
- Prospective audit and feedback
- Development of facility-specific treatment guidelines
- Dose optimization and therapeutic drug monitoring
- Intravenous-to-oral antibiotic conversion

Pharmacists play an important role in identifying inappropriate therapy, dose adjustments in renal dysfunction, drug interactions, and overlapping antimicrobial coverage.

Syndrome-specific interventions also focus on common infections such as urinary tract infections, pneumonia, skin and soft tissue infections, methicillin-resistant *Staphylococcus aureus* (MRSA), and *Clostridioides difficile* infection.

Tracking and Reporting

Regular monitoring of antimicrobial use and resistance patterns is necessary to evaluate the effectiveness of stewardship programs. Healthcare institutions track antibiotic prescribing trends, treatment outcomes, and resistance data to identify areas requiring improvement.

The CDC developed the Antibiotic Use (AU) module within the National Healthcare Safety Network (NHSN), which enables hospitals to collect and analyze antimicrobial usage data electronically. Continuous reporting and evaluation improve accountability and support evidence-based prescribing practices.

Education

Education is a key component of AMS. Healthcare professionals should receive regular updates regarding antimicrobial prescribing guidelines, resistance patterns, and infectious disease management. Educational strategies may include workshops, seminars, academic detailing, online training programs, and clinical discussions.

Educational interventions are more effective when combined with monitoring systems and feedback mechanisms.

Antimicrobial Resistance: A Global Health Threat

Antimicrobial resistance has emerged as a major public health crisis worldwide. Resistant pathogens contribute to increased morbidity, mortality, prolonged hospital stay, and higher healthcare costs. It is estimated that by 2050, AMR could result in nearly 10 million deaths annually if effective interventions are not implemented.

According to the CDC, more than 2.8 million antibiotic-resistant infections occur annually in the United States, causing thousands of deaths each year. Common multidrug-resistant organisms include:

- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Vancomycin-resistant enterococci (VRE)
- Carbapenem-resistant Enterobacteriaceae
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant *Neisseria gonorrhoeae*

The World Health Organization (WHO) has also identified priority pathogens requiring urgent research and development of new antimicrobial agents.

Clinical Significance of Antimicrobial Stewardship

Antibiotics have significantly reduced mortality from infectious diseases and enabled advancements in modern medicine. However, studies indicate that nearly 30% of antibiotics prescribed in hospitals are unnecessary or inappropriate.

Inappropriate antibiotic use may result in serious adverse effects such as:

- Allergic reactions
- Renal toxicity
- Bone marrow suppression
- *Clostridioides difficile* infection
- Increased risk of resistant infections

Broad-spectrum antibiotic use has also been associated with prolonged hospitalization, increased healthcare costs, and higher readmission rates.

Numerous studies have demonstrated the benefits of antimicrobial stewardship programs, including:

- Reduction in antimicrobial resistance
- Lower incidence of *Clostridioides difficile* infection
- Improved clinical outcomes
- Reduced mortality rates
- Better antibiotic dosing practices
- Decreased healthcare expenditure

Reports from the CDC have shown significant reductions in resistant infections such as MRSA, VRE, and multidrug-resistant *Pseudomonas aeruginosa* following implementation of effective stewardship interventions.

Antimicrobial Use in Agriculture and the One Health Approach

The misuse of antibiotics is not limited to human healthcare. Antimicrobial agents are widely used in livestock farming for treatment, disease prevention, and growth promotion. Excessive use of medically important antibiotics in food-producing animals contributes to the development of resistant bacteria that may spread to humans through contaminated food products, direct animal contact, and environmental exposure.

The World Health Organization and CDC support the “One Health” approach, which recognizes the close relationship between human health, animal health, and environmental health. Restricting non-therapeutic antibiotic use in animals and encouraging responsible antimicrobial practices in veterinary medicine are essential strategies for controlling AMR.



Potential stewardship measures in agriculture include:

- Avoiding routine antibiotic use for growth promotion
- Improving infection prevention and hygiene practices
- Encouraging antibiotic-free food production
- Strengthening surveillance of antibiotic use in livestock
- Educating farmers and consumers about AMR

Role of Healthcare Professionals

Antimicrobial stewardship requires collaboration among physicians, pharmacists, nurses, microbiologists, infection control teams, and hospital administrators. Each member of the healthcare team contributes to optimizing antibiotic use and preventing resistance.

The Agency for Healthcare Research and Quality (AHRQ) introduced the “Four Moments of Antibiotic Decision Making,” which encourages clinicians to:

1. Determine whether antibiotics are truly necessary
2. Obtain appropriate cultures and select empiric therapy
3. Reassess therapy after 48–72 hours
4. Decide the appropriate duration of treatment

This structured approach promotes rational prescribing and improves patient safety.

Conclusion

Antimicrobial resistance is a growing global threat that endangers the effectiveness of life-saving antibiotics. The irrational and excessive use of antimicrobial agents in healthcare and agriculture has accelerated the emergence of resistant pathogens. Antimicrobial stewardship programs play a critical role in promoting the appropriate use of antibiotics, improving patient outcomes, reducing healthcare costs, and preserving antimicrobial effectiveness for future generations.

Successful stewardship requires strong leadership, multidisciplinary collaboration, continuous education, surveillance, and responsible prescribing practices. Strengthening antimicrobial stewardship across healthcare systems and communities is essential to control antimicrobial resistance and ensure sustainable healthcare worldwide.

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