RESEARCH PAPER

A Comprehensive Overview of How Multidisciplinary Healthcare Teams Contribute to Antimicrobial Stewardship Programs

Fahad Salem Sharaf Alsharif[1], Sami Mohammed Safer[2], Ali Hamoud Almutari[2], Saad Ayidh Ateeq Al Shaibani[3], Turki Abdullah Alotaibi[4], Maram Saud Bin Dous[5], Reham Ali Mohammed MoPrince[6], Noha Khalifah Alsuliman[3], Ghaliah Khalifah Alsuliman[3]

[1]*Molecular cell biology, Prince Sultan Hospital Military, Taif, Saudi Arabia*
[2]*Clinical laboratory since, Prince Sultan Hospital Military, Taif, Saudi Arabia*
[3]*Pharmacy Technician, Prince Sultan Military Medical City, Riyadh, Saudi Arabia*
[4]*Pharmacist, Prince Sultan Military Medical City, Riyadh, Saudi Arabia*
[5]*Social services, Prince Sultan Military Medical City, Riyadh, Saudi Arabia*
[6]*Medical Secretary, Prince Sultan Military Medical City, Riyadh, Saudi Arabia*

ABSTRACT

Background: Antimicrobial resistance (AMR) represents one of the most pressing global health challenges of the 21st century, with an estimated 1.27 million deaths directly attributable to bacterial antimicrobial resistance in 2019. Antimicrobial stewardship programs (ASPs) have emerged as critical interventions to optimize antimicrobial use, reduce resistance, and improve patient outcomes. While traditionally focused on physicians and clinical pharmacists, contemporary ASPs increasingly recognize the vital contributions of multidisciplinary healthcare teams, including nursing specialists, pharmacy technicians, dental technologists, health information technicians, medical informatics technicians, radiology technicians, and health assistant nurses.

Objective: This comprehensive review examines the evidence for multidisciplinary involvement in antimicrobial stewardship, evaluates the specific roles and contributions of various healthcare professionals, assesses knowledge, attitudes, and practices toward AMR and infection prevention, and identifies barriers and facilitators to effective implementation.

Methods: A narrative review was conducted based on current literature (2023-2025) focusing on multidisciplinary antimicrobial stewardship programs, healthcare workers' knowledge and practices regarding AMR, infection prevention and control education, and outcomes of team-based interventions. Evidence from systematic reviews, meta-analyses, cohort studies, and quality improvement initiatives was synthesized.

Results: Global meta-analyses reveal that healthcare workers demonstrate moderate knowledge of AMR (56.5% with good knowledge), positive attitudes (74%), but suboptimal preventive practices (44%). Multidisciplinary ASP interventions consistently demonstrate significant improvements in antibiotic utilization (reductions of 15-48% in defined daily doses per 100 patient-days), improved guideline adherence (from 47% to 72.5%). Pharmacy technicians, nursing staff, laboratory personnel, and allied health professionals play increasingly recognized roles in medication verification, patient education, specimen collection, diagnostic stewardship, and infection control implementation.

Conclusion: Effective antimicrobial stewardship requires integration of the entire healthcare team, with clearly defined roles, structured training programs, interprofessional collaboration, and institutional support. Targeted educational interventions must address the knowledge-practice gap, particularly in resource-constrained settings. Future ASPs should formalize contributions from all healthcare disciplines, implement competency-based training frameworks, and foster a culture of collective accountability in combating antimicrobial resistance

Keywords: Antimicrobial stewardship, multidisciplinary team, antimicrobial resistance, infection prevention and control, healthcare workers, pharmacy technicians, nursing specialists, allied health professionals, patient safety, quality improvement

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INTRODUCTION

Background

The Global Crisis of Antimicrobial Resistance

Antimicrobial resistance has emerged as one of the defining public health threats of the 21st century, fundamentally

**Author for Correspondence: Orthopedica245@gmail.com*

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challenging the foundations of modern medicine. The antimicrobial resistance collaborators estimate that bacterial antimicrobial resistance was directly responsible for 1.27 million global deaths in 2019 and overall contributed to 4.95 million deaths worldwide. This staggering toll positions AMR as a leading cause of death globally, surpassing many well-recognized conditions. Projections suggest that without effective interventions, antimicrobial resistance could lead to 1.91 million deaths annually by 2050, with the burden disproportionately affecting low- and middle-income countries (1) .

The economic implications of AMR are equally severe. Healthcare systems face escalating costs associated with prolonged hospitalizations, need for more expensive antibiotics, increased intensive care utilization, and management of treatment failures. Beyond direct healthcare expenditures, AMR threatens the viability of routine surgical procedures, cancer chemotherapy, organ transplantation, and management of chronic diseases—all of which depend on effective antimicrobial prophylaxis and treatment.

The Role of Antimicrobial Stewardship Programs

In response to this crisis, antimicrobial stewardship programs have been developed and implemented across healthcare settings globally. The Society of Healthcare Epidemiology of America and Infectious Diseases Society of America Joint Committee defines antimicrobial stewardship as activities that optimize antimicrobial therapy, ensuring the best clinical outcome for patients while lowering the risk of subsequent development of antimicrobial resistance (2) . These programs represent coordinated interventions designed to improve and measure the appropriate use of antimicrobials by promoting the selection of the optimal antimicrobial drug regimen, dose, duration of therapy, and route of administration.

The World Health Organization elevated antimicrobial stewardship to a global priority following the World Health Assembly's adoption of the Global Action Plan on Antimicrobial Resistance in 2015. This plan established a framework for combating AMR through five strategic objectives: improving awareness and understanding of AMR, strengthening knowledge through surveillance and research, reducing the incidence of infection, optimizing the use of antimicrobial medicines, and ensuring sustainable investment in countering AMR.

Evolution Toward Multidisciplinary Approaches

Historically, antimicrobial stewardship programs were often conceptualized as physician-centric or pharmacy-driven initiatives, with infectious disease specialists and clinical pharmacists serving as primary stewards. However, contemporary understanding recognizes that effective antimicrobial stewardship requires the engagement and coordination of all healthcare team members. The challenge of AMR is closely linked to the development and spread of healthcare-associated infections, necessitating comprehensive infection prevention and control measures that extend far beyond prescribing decisions (5) .

A recent systematic review examining healthcare professionals' knowledge, attitudes, and practices found significant variability across different professional groups, underscoring the need for targeted interventions that address the specific roles, challenges, and opportunities of each healthcare discipline (3) . Further to findings from this comprehensive assessment, researchers identified that while many healthcare professionals possess robust knowledge of infection prevention and control guidelines, substantial gaps persist particularly in antimicrobial stewardship implementation and adherence to best practices.

The recognition that approximately 80% of antimicrobials are prescribed and dispensed in primary care settings, combined with evidence that healthcare workers at all levels contribute to infection transmission and antimicrobial use patterns, has catalyzed a paradigm shift toward truly multidisciplinary antimicrobial stewardship models (10) . This evolution acknowledges that sustainable progress in combating AMR requires the active participation of nursing specialists, pharmacy technicians, laboratory personnel, dental professionals, radiologic technologists, health information specialists, and support staff—each bringing unique expertise and perspectives to the stewardship mission.

Rationale for Multidisciplinary Engagement

The rationale for multidisciplinary antimicrobial stewardship is grounded in both theoretical frameworks and empirical evidence. From a systems perspective, antimicrobial prescribing and use occur within complex healthcare environments where multiple professionals interact with patients, medications, diagnostic information, and each other. Each touchpoint represents an opportunity for stewardship intervention—or a potential vulnerability where suboptimal practices may occur.

Pharmacy technicians verify medication orders, prepare antimicrobial infusions, and often serve as the first line of detection for dosing errors or inappropriate regimens (8) . Nursing staff administer antimicrobials, monitor for adverse effects, educate patients about medication adherence, and collect crucial specimens for microbiological diagnosis. Laboratory technicians perform diagnostic tests that guide antimicrobial selection and de-escalation decisions. Dental technologists address oral health infections that may require antimicrobial therapy. Health information and medical informatics technicians manage electronic health record systems that can support decision-making through alerts, order sets, and antimicrobial use tracking. Radiology technicians perform imaging studies essential for infection source identification and treatment monitoring.

A systematic review of community health workers' involvement in antimicrobial stewardship across Africa identified seven key roles: provision of clinical services, community mobilization, health promotion, provision of preventive services, epidemiological surveillance, advocacy, and medical waste management (1) . These findings, while focused on community settings, illustrate

the breadth of contributions that healthcare workers beyond traditional prescribers can make to antimicrobial stewardship efforts.

Current Challenges and Opportunities

Despite growing recognition of the need for multidisciplinary antimicrobial stewardship, significant challenges remain. A global meta-analysis of 108 studies involving 29,433 healthcare workers found that only 56.5% demonstrated good knowledge of AMR, with considerable geographic variation (2) . While 74% of healthcare workers expressed positive attitudes toward AMR prevention, only 44% demonstrated good preventive practices, revealing a critical knowledge-practice gap that must be addressed through targeted educational interventions and systemic changes.

These challenges are compounded by inconsistent training standards, lack of formalized roles for non-prescribing healthcare professionals in stewardship programs, inadequate institutional support, resource limitations particularly in low- and middle-income countries, and cultural factors that may not prioritize antimicrobial stewardship. However, these challenges also present opportunities for innovation, capacity building, and development of context-specific solutions that leverage the full potential of multidisciplinary healthcare teams.

This comprehensive review synthesizes current evidence on the roles, contributions, and impact of multidisciplinary teams in antimicrobial stewardship. By examining specific interventions, outcomes, educational approaches, and implementation strategies across various healthcare settings and professional groups, this review aims to provide a foundation for strengthening antimicrobial stewardship programs and optimizing the contributions of all healthcare team members in the fight against antimicrobial resistance.

Literature Review

Systematic Evidence on Healthcare Workers' Knowledge, Attitudes, and Practices

A comprehensive understanding of healthcare workers' knowledge, attitudes, and practices (KAP) regarding antimicrobial resistance and stewardship is essential for designing effective educational interventions and implementation strategies. Recent systematic reviews and meta-analyses have provided robust evidence on the current state of KAP across diverse healthcare settings and professional groups.

A landmark systematic review published in 2025 examined self-reported knowledge, attitudes, and practices among healthcare professionals in infection management and antimicrobial stewardship (9) . This extensive review, which analyzed 113 studies from 10,990 records, revealed significant variability in KAP measures, complicating direct comparisons between studies. Notably, the review found discrepancies between objective knowledge assessments and perceived knowledge, with many healthcare workers overestimating their understanding of AMR and stewardship principles.

Further to findings from a global meta-analysis involving 29,433 healthcare workers across 108 studies, researchers found that the pooled proportion of healthcare workers with good knowledge of AMR was only 56.5% (95% CI: 50.4-62.6%) , with substantial geographic variation (12) . The highest prevalence of good knowledge was observed in Europe (70.3%) , while the Western Pacific region showed the lowest (45.9%) . This geographic disparity suggests that contextual factors, including healthcare infrastructure, educational systems, and regional AMR burden, significantly influence healthcare workers' preparedness to address antimicrobial resistance.

Attitudes toward AMR and stewardship were generally more positive, with 74% of healthcare workers across 51 studies (13,660 participants) demonstrating favorable attitudes. Most healthcare professionals acknowledged AMR as a critical global health issue and recognized the importance of antimicrobial stewardship in combating resistance. However, the translation of knowledge and positive attitudes into actual practice remained problematic. Only 44% of healthcare workers across 43 studies (10,569 participants) demonstrated good preventive practices, revealing a substantial knowledge-practice gap that represents a critical target for interventions.

Infection Prevention and Control Competencies

The relationship between infection prevention and control (IPC) practices and antimicrobial stewardship is intimate and bidirectional. Effective IPC reduces the incidence of infections, thereby decreasing the need for antimicrobials. Simultaneously, preventing healthcare-associated infections reduces the likelihood of encountering multidrug-resistant organisms that complicate treatment decisions and drive broader-spectrum antimicrobial use.

A study examining nurses' knowledge of infection control practices in intensive care units found that 95.8% of participants endorsed good knowledge levels, 83.5% reported positive attitude levels, and 91.2% endorsed good practice levels toward infection control precautions (8). The study identified gender (being female) , attending training programs on infection control, and having good baseline knowledge as significant predictors of superior infection control practices. These findings underscore the importance of structured training programs and suggest that targeted educational interventions can effectively enhance IPC competencies.

Further to findings from a review on infection prevention and control education for healthcare students, researchers identified significant gaps in standardized curricula and variability in educational approaches across institutions and countries. The review emphasized that while many educational programs include IPC content, the depth, consistency, and practical application components vary considerably, potentially leaving students inadequately prepared for real-world infection control challenges.

A narrative review focusing on preventing and controlling healthcare-associated infections emphasized that infection prevention represents the first principle of every antimicrobial stewardship program (5) . The authors

presented seven essential measures that all healthcare workers, regardless of direct involvement in IPC tasks, must know, support, and embrace. These include hand hygiene, appropriate use of personal protective equipment, environmental cleaning and disinfection, safe injection practices, antimicrobial stewardship, diagnostic stewardship, and surveillance of infections and antimicrobial resistance patterns.

Global Perspectives on Community Health Workers

The role of community health workers and frontline healthcare providers in antimicrobial stewardship has received increasing attention, particularly in resource-limited settings where these professionals often serve as the primary point of healthcare contact for large populations. A scoping review published in BMJ Global Health examined the involvement of community health workers in antimicrobial stewardship interventions across low- and middle-income countries (4) .

Further to findings from this comprehensive review, researchers identified eight studies from Uganda, Tanzania, Zambia, Pakistan, Bangladesh, and Kenya that documented community health workers' engagement in various antimicrobial stewardship activities. These activities included infection prevention, detection and treatment of conditions requiring antimicrobials (such as pneumonia and gastrointestinal infections) , health education, appropriate antibiotic prescription when authorized, and improved adherence to clinical guidelines.

The review reported positive outcomes associated with community health worker interventions, including reduced inappropriate antibiotic use, improved adherence to treatment guidelines (thereby reducing treatment failure and development of resistance) , and increased community awareness of antimicrobial resistance challenges. One particularly noteworthy study demonstrated improvements in handwashing practices, medication adherence, and advances in AMR prevention in animal husbandry following community health worker-led educational interventions.

However, the review also identified significant implementation barriers that hinder the full potential of these interventions. These barriers included inconsistent training, lack of standardized guidelines, limited resources, inadequate supervision, and shortages of essential medical supplies. These challenges highlight the need for systemic support, policy frameworks, and sustained investment to enable community health workers to contribute effectively to antimicrobial stewardship efforts.

Pharmacy Professionals and Technicians in Antimicrobial Stewardship

Pharmacy professionals, including both clinical pharmacists and pharmacy technicians, occupy a unique and increasingly vital position within antimicrobial stewardship programs. Their expertise in pharmacokinetics, pharmacodynamics, drug interactions, and medication safety positions them as natural leaders and essential contributors to stewardship efforts.

A systematic review examining the role of clinical pharmacists in antimicrobial stewardship programs found consistent evidence of positive impacts across multiple domains (21) . Pharmacist-led interventions were associated with improved antimicrobial selection, optimized dosing regimens, reduced antimicrobial consumption, decreased costs, and in many cases, improved clinical outcomes including reduced mortality and length of stay. The review emphasized that pharmacists' ability to integrate clinical data, microbiological results, and patient-specific factors enables them to make evidence-based recommendations that optimize therapeutic outcomes while minimizing resistance development.

Further to findings from a study evaluating the effectiveness of antimicrobial stewardship training on pharmacists' competence and hospital implementation in Indonesia, researchers found that structured training significantly improved pharmacists' knowledge, skills, and professional attitudes (6) . The study involved 103 pharmacists from 29 hospitals and demonstrated that 94.2% of participants showed improvement in competence category following training. However, the study also revealed an important insight: individual pharmacist competence alone was insufficient to drive systemic improvement in antimicrobial stewardship programs. Effective implementation required strong institutional support, engagement of attending physicians, and collaboration among multidisciplinary healthcare professionals.

The expanding role of pharmacy technicians in antimicrobial stewardship represents an important evolution in program structure and capacity. Traditionally focused on dispensing and technical functions, pharmacy technicians are increasingly taking on specialized antimicrobial stewardship roles that leverage their unique position within medication management workflows. A study evaluating the impact of a certified pharmacy technician in an antimicrobial stewardship program found that daily chart audits conducted by the technician using a clinical checklist resulted in an average of 452 monthly audits sent to antimicrobial stewardship pharmacists, generating 185 related interventions (8) . While this intervention did not achieve statistical significance in reducing overall ceftriaxone utilization, it stabilized utilization trends and demonstrated the feasibility of extending antimicrobial stewardship review capacity through trained technicians.

Further to findings from a quality improvement initiative in Scotland, researchers demonstrated that a targeted antimicrobial pharmacy technician ward service significantly improved antimicrobial stewardship and patient-centered care for commonly prescribed higher-risk antimicrobials (7) . The pharmacy technicians provided patient counseling, managed drug interactions, documented stop dates for antimicrobial courses, and made a median of 3 interventions per patient (IQR 4) . The most common interventions included changes in dose (30.0%) , frequency (32.2%) , and agent selection (56.7%) . This study illustrated how pharmacy technicians, with appropriate training and clear protocols, can substantially expand the

reach and effectiveness of antimicrobial stewardship programs.

An innovative program implementing pharmacy technician-led virtual ward rounds for patients on protected antimicrobials demonstrated the potential for technology-enabled stewardship interventions (20) . The specialist antimicrobial stewardship technician conducted daily reviews to ensure appropriate authorization codes were in place for protected antimicrobials, escalating cases requiring updates to clinical teams. This approach addressed inconsistent review practices that had led to overuse and prolonged continuation of protected antimicrobials, demonstrating how clearly defined technician roles can fill critical gaps in antimicrobial monitoring.

The contribution of pharmacy professionals extends beyond hospital settings. A scoping review of antimicrobial stewardship interventions involving community pharmacy teams found that community pharmacists are rarely considered as part of antimicrobial stewardship activities despite being positioned at a critical interface where approximately 80% of antimicrobials are prescribed and dispensed (10) . The review identified community pharmacy teams as an underused resource with potential key roles in educating the public on optimal antimicrobial use, supporting appropriate self-care decisions for minor infections, detecting inappropriate prescribing, and reinforcing prescriber guidance on antimicrobial use and adherence.

The Role of Nursing Professionals in Antimicrobial Stewardship

Nursing Contributions to Infection Prevention and Antimicrobial Optimization

Nursing professionals represent the largest component of the healthcare workforce and occupy a pivotal position in antimicrobial stewardship through their continuous patient contact, medication administration responsibilities, and critical role in infection prevention and control. A meta-synthesis examining nurses' role in antimicrobial stewardship explored their involvement in promoting change and identified key barriers and facilitators that impact their participation (13) .

Further to findings from this comprehensive analysis, researchers identified that nurses contribute to antimicrobial stewardship through multiple mechanisms: timely collection of microbiological specimens before antimicrobial initiation, accurate medication administration and monitoring for adverse effects, patient and family education about antimicrobial use and adherence, documentation of clinical responses to therapy, identification of opportunities for intravenous-to-oral antimicrobial conversion, and active participation in multidisciplinary rounds where antimicrobial decisions are made. However, the review also identified significant barriers including lack of formal recognition of nurses' stewardship roles, limited inclusion in decision-making processes, insufficient education and training on antimicrobial stewardship principles, and time constraints related to competing clinical priorities.

A study examining nurses' knowledge of infection control practices in intensive care units found high levels of knowledge (95.8%) , positive attitudes (83.5%) , and good practices (91.2%) . The study highlighted nurses' strong understanding of key infection prevention principles including hand hygiene (98% agreed that hand washing or alcohol-based antiseptics decrease healthcare-acquired infection transmission) , appropriate use of personal protective equipment (94% agreed gloves should be worn if blood or body fluid exposure is anticipated) , and environmental disinfection practices (92% reported applying antiseptic hand rub to clean hands and practicing high-level disinfection where sterilization was not applicable) .

However, studies of nursing students' knowledge and practices reveal areas requiring strengthening. A study examining infection control knowledge among nursing students found generally high knowledge levels but identified specific gaps in needle stick injury prevention methods and awareness of certain precautionary measures (24) . While students demonstrated strong knowledge of hand hygiene importance (all respondents identified hand cleaning as crucial) , personal protective equipment use, and proper disposal of contaminated materials, some lacked awareness of specific occupational safety protocols. These findings underscore the importance of comprehensive infection prevention and control education that addresses both common and specialized infection control scenarios.

Nurses as Change Agents in Antimicrobial Stewardship

The potential for nurses to serve as change agents and champions for antimicrobial stewardship is increasingly recognized but remains underutilized in many settings. Nurses' continuous presence at the bedside, their relationships with patients and families, and their role as coordinators of care position them ideally to identify stewardship opportunities and implement interventions. Several successful programs have demonstrated the impact of empowering nurses to take active stewardship roles.

Key nursing interventions in antimicrobial stewardship include:

1. **Specimen Collection Stewardship**: Ensuring that microbiological specimens are collected appropriately and before antimicrobial initiation maximizes the likelihood of identifying causative pathogens and enables targeted therapy. Nurses' role in recognizing infection signs, communicating with physicians about specimen collection needs, and ensuring proper collection and transport techniques is fundamental to diagnostic stewardship.
2. **Medication Administration and Monitoring**: Nurses administer antimicrobials and are often the first to observe therapeutic responses or adverse effects. Their documentation of clinical improvements, lack of response, or adverse reactions provides critical information for antimicrobial optimization decisions. Nurses who understand stewardship principles can alert physicians to

opportunities for de-escalation, duration optimization, or need for regimen modification.

3. **Patient Education**: Nurses spend significant time educating patients and families about medications, including the importance of completing prescribed antimicrobial courses, recognizing adverse effects, and understanding when antimicrobials are and are not appropriate. This educational role extends antimicrobial stewardship beyond the hospital into patients' homes and communities.

4. **Antimicrobial Time-Outs**: Some antimicrobial stewardship programs have successfully implemented nurse-facilitated antimicrobial time-outs, where nurses prompt clinical teams to reassess antimicrobial therapy at predetermined intervals (typically 48-72 hours after initiation). This structured pause creates a dedicated moment for de-escalation decisions based on clinical and microbiological data.

5. **Intravenous-to-Oral Conversion**: Nurses can identify patients who meet criteria for switching from intravenous to oral antimicrobials, facilitating earlier hospital discharge, reducing complications associated with intravenous access, and decreasing healthcare costs. Programs that empower nurses to initiate or recommend these conversions have demonstrated significant impact on antimicrobial stewardship metrics.

Allied Health Professionals and Support Staff in Antimicrobial Stewardship

Laboratory and Diagnostic Personnel

Medical laboratory technicians and microbiologists play an indispensable role in antimicrobial stewardship through diagnostic stewardship—optimizing test selection, specimen quality, result interpretation, and communication of findings. Timely and accurate microbiological diagnosis is fundamental to targeted antimicrobial therapy and de-escalation from empiric broad-spectrum regimens.

Laboratory personnel contribute to antimicrobial stewardship through several mechanisms:

1. **Specimen Quality Assessment**: Rejecting inadequate specimens (such as contaminated urine samples or improperly collected respiratory specimens) prevents misleading results that could drive inappropriate antimicrobial use. Laboratory technicians who assess specimen quality and provide feedback to clinical teams enhance diagnostic accuracy.

2. **Rapid Diagnostic Testing**: Implementation and optimization of rapid diagnostic technologies, including molecular tests for pathogen identification and resistance genes, enables faster targeted therapy. Laboratory staff who champion and facilitate adoption of these technologies directly support antimicrobial stewardship goals.

3. **Antimicrobial Susceptibility Testing and Reporting**: Selective reporting of susceptibility results—where first-line agents are reported preferentially and broader-spectrum agents are reported only when necessary—can guide prescribers toward narrower-spectrum options. Laboratory directors and microbiologists who implement evidence-based susceptibility reporting practices support antimicrobial stewardship.

4. **Communication of Critical Results**: Timely communication of positive blood cultures, identification of resistant organisms, and susceptibility results enables prompt antimicrobial optimization. Laboratory personnel who prioritize rapid result communication and provide interpretive guidance support better antimicrobial decisions.

5. **Antimicrobial Resistance Surveillance**: Laboratory information systems contain valuable data on antimicrobial resistance patterns. Laboratory personnel who analyze and report these patterns through antibiograms and resistance trend reports provide essential information for empiric therapy guidelines and stewardship interventions.

Health Information and Medical Informatics Technicians

Health information technicians and medical informatics specialists manage electronic health record systems that increasingly incorporate antimicrobial stewardship decision support tools. Their expertise in data management, system configuration, and workflow optimization enables implementation of technology-enabled stewardship interventions.

Contributions of informatics personnel to antimicrobial stewardship include:

1. **Clinical Decision Support Systems**: Designing and implementing alerts, order sets, and guidelines that promote appropriate antimicrobial selection, dosing, and duration. Informatics specialists who balance decision support effectiveness with alert fatigue considerations optimize the impact of these tools.

2. **Antimicrobial Use Tracking and Reporting**: Developing dashboards and reports that track antimicrobial consumption, guideline adherence, and stewardship intervention rates. These tools enable antimicrobial stewardship teams to identify areas for improvement and demonstrate program impact.

3. **Integration of Diagnostic Data**: Ensuring that microbiological results, including organism identification and susceptibility data, are prominently displayed and linked to antimicrobial orders facilitates culture-directed therapy and de-escalation decisions.

4. **Documentation Templates**: Creating structured documentation templates for indications, planned duration, and reassessment plans improves antimicrobial prescribing quality and facilitates subsequent stewardship review.

Dental Technologists and Oral Health Professionals

Dental professionals, including dental technologists, dentists, and dental hygienists, play an important role in antimicrobial stewardship given the frequency of antimicrobial prescribing for oral and dental infections. Odontogenic infections, periodontal disease, and prophylaxis for dental procedures represent significant sources of antimicrobial use, and inappropriate prescribing in dental settings contributes to overall antimicrobial resistance burden.

A review examining the multidisciplinary defense against surgical site infections emphasized the importance of dental clearance in eliminating occult foci of infection before surgical procedures (25) . Poor oral health and untreated dental infections can serve as sources of bacteremia and surgical site infections, particularly in procedures involving implantable devices or prosthetic materials. Dental professionals who identify and treat oral infections before elective surgeries contribute to infection prevention and reduce the need for antimicrobial therapy.

Dental professionals contribute to antimicrobial stewardship through:

1. **Adherence to Evidence-Based Prescribing Guidelines**: Following guidelines for antimicrobial prophylaxis before dental procedures, which have become increasingly restrictive as evidence has accumulated regarding the limited benefit and potential harms of overly broad prophylaxis practices.
2. **Appropriate Management of Odontogenic Infections**: Recognizing that many dental infections can be managed with source control (drainage, extraction, or debridement) alone or with minimal antimicrobial therapy, rather than relying primarily on antimicrobials.
3. **Patient Education**: Teaching patients about oral hygiene, prevention of dental infections, and appropriate expectations regarding antimicrobial use for dental conditions.
4. **Collaboration with Medical Teams**: Communicating with patients' physicians regarding antimicrobial prophylaxis needs before dental procedures, particularly for patients with cardiac conditions or prosthetic joints, ensuring recommendations are based on current guidelines rather than outdated practices.

Radiology and Imaging Technicians

While often overlooked in discussions of antimicrobial stewardship, radiology technicians and imaging specialists contribute to diagnostic accuracy and source control identification—both essential elements of optimal antimicrobial therapy. Appropriate imaging studies enable clinicians to distinguish between infections requiring antimicrobials and non-infectious processes, identify infection sources requiring drainage or debridement, and monitor treatment response.

Radiology professionals support antimicrobial stewardship by:

1. **High-Quality Imaging Acquisition**: Ensuring optimal image quality enables accurate diagnosis of infections, abscesses, and complications. Poor quality imaging may lead to diagnostic uncertainty and prolonged empiric broad-spectrum antimicrobial therapy.
2. **Facilitation of Source Control Procedures**: Interventional radiology technicians assist with image-guided drainage procedures that provide definitive source control for abscesses and infected fluid collections. Effective source control often allows for shorter antimicrobial courses or, in some cases, eliminates the need for antimicrobials altogether.
3. **Patient Safety and Infection Control**: Maintaining strict infection control practices in radiology departments prevents healthcare-associated infections that would require antimicrobial treatment.
4. **Communication and Coordination**: Facilitating timely completion of imaging studies when infections are suspected enables faster diagnostic certainty and targeted antimicrobial therapy.

Multidisciplinary Antimicrobial Stewardship Program Structures and Outcomes

Core Components of Multidisciplinary Programs

Successful multidisciplinary antimicrobial stewardship programs share several core components that enable effective collaboration and sustained impact. These components provide a framework for institutions seeking to implement or enhance team-based stewardship approaches.

1. Leadership and Governance

Effective programs require dedicated leadership that champions multidisciplinary engagement. This typically includes an antimicrobial stewardship program director (often an infectious disease physician) , a pharmacy leader (clinical pharmacist with stewardship expertise) , and representation from nursing leadership, laboratory services, infection prevention, and quality improvement. Administrative support from hospital leadership is essential for securing resources, prioritizing stewardship initiatives, and fostering a culture that values appropriate antimicrobial use.

2. Defined Roles and Responsibilities

Clarity regarding each team member's responsibilities prevents duplication of efforts and ensures comprehensive coverage of stewardship activities. Written descriptions of roles for physicians, pharmacists, pharmacy technicians, nurses, laboratory personnel, and other team members establish expectations and accountability. These role descriptions should recognize professional scope of practice while empowering team members to work at the top of their licenses and training.

3. Education and Training

Ongoing education for all healthcare team members is fundamental to building stewardship capacity. The World Health Organization has published competency frameworks and curricula guides for health workers' education and training on antimicrobial resistance, emphasizing that training should be tailored to specific roles and incorporate behavioral change strategies (14) . Further to findings from systematic reviews of antimicrobial stewardship education, researchers emphasize that effective training extends beyond didactic knowledge transfer to include practical skills, case-based learning, simulation exercises, and interprofessional education that fosters collaborative practice.

4. Data Infrastructure and Feedback

Antimicrobial stewardship programs require robust data systems for tracking antimicrobial use, monitoring outcomes, and providing feedback to prescribers and healthcare teams. This infrastructure enables identification of inappropriate use patterns, evaluation of intervention

effectiveness, and demonstration of program value. Health information technicians and data analysts play critical roles in developing these capabilities.

5. Interventions and Workflow Integration

Stewardship interventions must be integrated into clinical workflows in ways that support rather than disrupt patient care. This integration requires understanding of how different healthcare professionals interact with patients, medications, and information systems. Interventions may include prospective audit and feedback, formulary restrictions with preauthorization, clinical decision support alerts, antimicrobial time-outs at specified intervals, automatic stop orders for specified duration, intravenous-to-oral conversion protocols, and dose optimization protocols.

Evidence of Program Effectiveness

Multiple studies have demonstrated the effectiveness of multidisciplinary antimicrobial stewardship programs in improving antimicrobial use and clinical outcomes. The consistency of these findings across diverse settings and populations provides strong evidence for the value of team-based approaches.

A quasi-experimental study evaluating the impact of a multidimensional antimicrobial stewardship program in an internal medicine ward at a tertiary hospital in Italy found remarkable results (22) . The program involved a multidisciplinary team including infectious disease consultants, pharmacists, microbiologists, nurses, and hygienists who conducted bi-weekly ward-based audits over one year (September 2023-August 2024) . Further to findings from this comprehensive intervention, researchers reported a significant reduction in antimicrobial consumption from 107.7 to 84.4 defined daily doses per 100 patient-days ($p < 0.05$) . Importantly, these reductions were achieved without compromising patient outcomes—no significant changes in length of stay or mortality were observed. The program also generated substantial cost savings, with antimicrobial costs falling by 48.8%, representing approximately €57,100 in savings. The study concluded that multidisciplinary collaboration, regular audits, and education were essential components of successful antimicrobial stewardship.

Further to findings from a study examining the effect and sustainability of a stepwise multidisciplinary antimicrobial stewardship program in a university hospital emergency department in Germany, researchers demonstrated both immediate and sustained improvements in guideline adherence (15) . The study, which included 1,324 patients across four time periods from 2017 to 2021, showed that initial distribution of guideline pocket cards increased adherence from 47% to 58.6% ($P = 0.005$) . However, adherence decreased after three years to 57.3%, highlighting the challenge of sustainability. The addition of daily antimicrobial stewardship ward rounds with multidisciplinary team engagement resulted in further significant improvement to 72.5% guideline adherence ($P < 0.001$) . Importantly, adherence increased not only during workdays but also on weekends and nightshifts. Adherence to antimicrobial stewardship specialist recommendations was excellent at 91.3%, and significant reductions in antibiotic consumption were observed.

A study from Saudi Arabia examining the impact of a multidisciplinary antimicrobial stewardship program on non-ICU patients reported significant improvements across multiple metrics (23) . The intervention included involvement of an infectious diseases clinical pharmacist, review of orders by attending infectious diseases physicians, utilization of electronic resources, and improved documentation. Further to findings from this analysis, researchers found significant reductions in both defined daily dose per 100-patient days and days of therapy per 100-patient days. Clinical outcomes also improved significantly: in-hospital mortality decreased from 20.8% to 13% ($P = 0.037$) , 30-day readmission rates fell from 33.8% to 20.5% ($P = 0.003$) , overall hospital length of stay decreased from 22 to 14 days ($P < 0.001$) , and ICU length of stay decreased from 9 to 3 days ($P < 0.001$) . The study demonstrated that multidisciplinary antimicrobial stewardship programs can simultaneously improve antimicrobial use patterns and patient outcomes.

Program Implementation Strategies

Successful implementation of multidisciplinary antimicrobial stewardship programs requires careful attention to local context, organizational culture, available resources, and identified needs. Several implementation strategies have been associated with program success:

Stakeholder Engagement

Early and ongoing engagement of all relevant stakeholders is critical for program acceptance and sustainability. This includes not only healthcare professionals who will participate in stewardship activities but also hospital administrators who control resources, information technology staff who enable data systems and decision support, and patient advocacy groups who can support patient education initiatives. Creating opportunities for stakeholder input into program design and implementation fosters ownership and addresses concerns proactively.

Phased Implementation

Many successful programs implement interventions in phases rather than attempting comprehensive changes simultaneously. Phased approaches allow teams to refine processes, demonstrate early wins that build momentum, address unforeseen challenges without overwhelming system capacity, and incorporate lessons learned before scaling to additional areas. A stepwise implementation approach, as demonstrated in the German emergency department study, can achieve sustained improvements by building on foundational interventions with increasingly sophisticated stewardship activities.

Education as Foundation

Comprehensive education that precedes and accompanies intervention implementation is essential for program success. Education should be tailored to the specific roles and responsibilities of different healthcare professionals,

incorporate interactive and case-based methods rather than relying solely on didactic presentations, address knowledge gaps identified through baseline assessments, and emphasize the rationale for stewardship—why appropriate antimicrobial use matters for patients, institutions, and society.

Further to findings from a study examining the impact of an antimicrobial stewardship clinical pharmacy specialist, researchers found that education-driven policies, procedures, and interventions successfully reduced antimicrobial days of therapy from 3.47 ± 2.46 days to 3.21 ± 2.52 days ($p < 0.04182$) (16) . The number of documented pharmacist interventions increased significantly from 75 pre-intervention to 102 post-intervention ($p = 0.0092$) , demonstrating that systematic education and empowerment of stewardship personnel drives measurable improvements.

Measurement and Feedback

Programs that systematically measure antimicrobial use, stewardship intervention rates, and outcomes—and provide regular feedback to healthcare teams—achieve better results than those relying on episodic or informal assessment. Measurement serves multiple purposes: identifies opportunities for intervention, demonstrates program impact to stakeholders, enables continuous quality improvement, and provides recognition for teams achieving stewardship goals. Publicly sharing antimicrobial use data (e.g., through unit-level or prescriber-specific reports) creates positive peer pressure and accountability while recognizing exemplary performance.

Technology Optimization

Leveraging available technology to support stewardship activities enhances program efficiency and reach. Electronic health record-based interventions, including clinical decision support alerts, antimicrobial-specific order sets that incorporate guidelines, automated duration protocols, and antimicrobial use dashboards, extend stewardship influence to prescribing moments when stewardship teams cannot physically be present. However, technology implementation must be thoughtful—poorly designed alerts that interrupt workflow without providing value contribute to alert fatigue and may be overridden without consideration.

Knowledge-Practice Gap and Educational Interventions

Characterizing the Gap

One of the most consistent findings across studies of healthcare workers' antimicrobial stewardship and infection prevention competencies is the existence of a substantial knowledge-practice gap—situations where individuals possess knowledge about appropriate practices but do not consistently translate that knowledge into action. Understanding the drivers of this gap is essential for designing effective interventions.

A meta-analysis examining healthcare workers' knowledge, attitudes, and practices toward antimicrobial resistance in sub-Saharan Africa found that while healthcare workers demonstrated moderate knowledge (63%) and positive attitudes (74%) toward AMR, good preventive practices remained low at only 44% (30) . This pattern—positive attitudes and reasonable knowledge not translating into consistent practice—has been observed across multiple settings and countries.

Several factors contribute to the knowledge-practice gap:

1. Systems and Environmental Factors

Even well-informed healthcare workers may struggle to implement best practices when system-level barriers exist. These barriers include inadequate staffing and time constraints that limit ability to implement time-intensive practices, lack of necessary resources (e.g., alcohol-based hand rubs, personal protective equipment, isolation rooms) , inadequate infrastructure (e.g., insufficient hand hygiene facilities, lack of medication storage systems that facilitate first-in-first-out antimicrobial use) , and information system limitations that make accessing guidelines, antibiograms, or culture results cumbersome.

2. Organizational Culture and Norms

The culture within healthcare organizations powerfully influences practice patterns. In environments where antimicrobial stewardship is not prioritized, where prescribing autonomy is valued more than collaborative decision-making, or where infection prevention is seen as someone else's responsibility, individual practitioners face challenges implementing best practices even when they possess relevant knowledge. Leadership that explicitly champions appropriate antimicrobial use and models desired behaviors can shift organizational culture to support stewardship.

3. Lack of Practical Skills

Knowledge of principles does not automatically translate into practical competence. Healthcare workers may understand that hand hygiene prevents infection transmission but not have mastered the technique to perform it effectively. Similarly, knowing that microbiological specimens should be collected before antimicrobial initiation differs from having practiced the coordination and communication required to ensure this happens reliably in busy clinical environments. Educational interventions that incorporate simulation, skills practice, and real-world application experiences are more effective at bridging knowledge-practice gaps than didactic instruction alone.

4. Competing Priorities and Cognitive Load

Healthcare workers face multiple, often competing demands on their attention and time. In acute situations, immediate clinical needs may overshadow stewardship considerations. Decision support tools that prompt consideration of stewardship principles at relevant moments can help by reducing cognitive load and making stewardship considerations easier to incorporate into workflow.

Effective Educational Approaches

Research on healthcare workers' education and training for antimicrobial stewardship and infection prevention has identified several approaches that effectively improve both knowledge and practice.

Interprofessional Education

Educational interventions that bring together healthcare professionals from different disciplines to learn about and practice stewardship collaboratively have demonstrated particular effectiveness. Interprofessional education fosters understanding of each profession's roles and contributions, develops communication and teamwork skills essential for collaborative stewardship, creates opportunities to address interprofessional conflicts and establish shared goals, and builds relationships that facilitate collaboration in clinical practice. Studies evaluating interprofessional antimicrobial stewardship education have reported improvements in knowledge, attitudes, confidence in stewardship roles, and intention to engage in stewardship practices.

Simulation and Experiential Learning

A systematic review examining preparedness for infection prevention and control practice among healthcare students found that simulation-based education, particularly high-fidelity simulation, significantly improved knowledge, practical skills, confidence, and attitudes compared to traditional learning methods alone (28) . Further to findings from this review, researchers reported that 55% of studies showed improved knowledge, practice, attitudes, and confidence in infection prevention and control following implementation of technological approaches including didactic instruction combined with virtual simulation. The review emphasized that hands-on experience through clinical simulations allows learners to practice coordination, communication, and technical skills in realistic but safe environments where mistakes become learning opportunities rather than patient safety events.

Competency-Based Training Frameworks

The World Health Organization's competency framework for antimicrobial resistance education provides guidance on vital competencies relevant for health workers across the healthcare delivery spectrum (14) . This framework includes core and additional competencies across four key areas: awareness of antimicrobial resistance, appropriate use of antimicrobial agents, infection prevention and control, and diagnostic stewardship and surveillance. Competency-based approaches clarify learning objectives, enable assessment of whether training has achieved intended outcomes, support progressive skill development from novice to expert levels, and allow customization to local needs and priorities while maintaining core standards.

Longitudinal Education with Reinforcement

Single educational sessions, while potentially increasing knowledge in the short term, rarely result in sustained behavior change. Effective educational programs incorporate longitudinal learning with periodic reinforcement, booster sessions that refresh key concepts and introduce new information, feedback on performance that highlights successes and identifies areas for improvement, and just-in-time learning resources accessible when questions arise in clinical practice. The German emergency department study demonstrated the importance of reinforcement—after initial improvement in guideline adherence following pocket card distribution, adherence declined after three years, necessitating refresher interventions and ongoing stewardship rounds to maintain performance.

Behavioral Science Integration

Applying insights from behavioral science to antimicrobial stewardship education enhances effectiveness by addressing psychological and social factors that influence prescribing and infection prevention behaviors. Behavioral interventions may include social norming—providing feedback on how an individual's or team's antimicrobial use compares to peers, creating subtle pressure to align with professional norms; commitment devices—asking prescribers to make explicit commitments to stewardship practices; default options—structuring order sets and protocols so that stewardship-aligned choices are the default, requiring active decisions to deviate; and audit and feedback—providing timely, actionable feedback on antimicrobial prescribing or infection prevention practices. Systematic reviews have found that behavioral interventions can significantly improve antimicrobial prescribing appropriateness.

Barriers and Facilitators to Multidisciplinary Stewardship

Common Barriers

Despite strong evidence supporting multidisciplinary antimicrobial stewardship, numerous barriers can impede implementation and effectiveness. Understanding these barriers is essential for developing strategies to address them.

Resource Limitations

Insufficient dedicated personnel time for antimicrobial stewardship activities remains one of the most frequently cited barriers. Many healthcare facilities, particularly smaller hospitals and community health centers, lack dedicated infectious disease physicians or clinical pharmacists with stewardship training. Even when stewardship expertise exists, competing clinical responsibilities may limit time available for stewardship activities. The 2024 ASHP National Survey of Pharmacy Practice in Hospital Settings reported that over 80% of pharmacy directors perceived shortages of experienced technicians, and about 60% reported perceived shortages of clinical specialists and clinical coordinators (26) . These workforce shortages directly impact antimicrobial stewardship capacity.

Financial constraints limit investment in technology infrastructure, education programs, and additional staffing needed to support comprehensive stewardship efforts.

Inadequate diagnostic laboratory capacity, particularly in resource-limited settings, compromises ability to perform culture and susceptibility testing that enables targeted therapy. Further to findings from the systematic review of community health workers' antimicrobial stewardship roles in Africa, researchers identified that total reliance on foreign funding and inadequate remuneration threaten program sustainability (1) .

Lack of Formal Role Definition

Many healthcare professionals beyond physicians and pharmacists lack formally defined antimicrobial stewardship roles within their job descriptions and competency expectations. This ambiguity can lead to uncertainty about expectations, lack of accountability for stewardship activities, missed opportunities for intervention, and insufficient recognition or compensation for stewardship contributions. The meta-synthesis examining nurses' roles in antimicrobial stewardship identified lack of formal recognition as a significant barrier to nurse engagement (13) .

Inadequate Education and Training

Gaps in pre-service education for antimicrobial stewardship and infection prevention mean that many healthcare professionals enter practice without essential knowledge. While in-service training can address these gaps, limited access to continuing education, training programs not tailored to specific professional roles, and insufficient emphasis on practical application rather than theoretical knowledge compromise effectiveness. A systematic review examining antimicrobial stewardship education for pre-registration medical and healthcare students found inconsistent coverage of stewardship principles across programs and disciplines, with variable emphasis on capability, opportunity, and motivation factors necessary for stewardship practice.

Professional Hierarchy and Culture

Healthcare traditionally operates within professional hierarchies that can inhibit contributions from all team members. When antimicrobial stewardship is perceived as the domain of physicians or senior clinicians, other healthcare professionals may hesitate to raise concerns or suggest alternatives. Fear of conflict with prescribers, perceptions that stewardship recommendations undermine professional autonomy, and lack of psychological safety to speak up about inappropriate antimicrobial use create cultural barriers to multidisciplinary stewardship. Building cultures of collaborative practice and mutual respect is essential for overcoming these barriers.

Resistance to Change

Established prescribing patterns and clinical routines can be difficult to change even when evidence supports alternatives. Cognitive biases, including overconfidence in clinical judgment despite diagnostic uncertainty, availability heuristic leading to overestimation of rare but memorable infections, and omission bias where harms from not prescribing antimicrobials feel more significant than harms from inappropriate use, contribute to resistance. Healthcare professionals may also resist stewardship interventions perceived as criticism of clinical competence.

Key Facilitators

Conversely, numerous factors facilitate successful multidisciplinary antimicrobial stewardship implementation and effectiveness.

Leadership Commitment and Support

Strong, visible commitment from organizational leadership provides essential support for antimicrobial stewardship programs. Leadership facilitates success by allocating resources (personnel, time, technology, education budgets) , prioritizing stewardship in institutional goals and strategic plans, recognizing and rewarding stewardship achievements, and modeling behaviors that demonstrate valuing appropriate antimicrobial use. In settings where leadership champions stewardship, programs achieve broader engagement and sustained impact.

Clear Role Definition and Empowerment

When all healthcare team members understand their specific stewardship responsibilities and feel empowered to fulfill those roles, multidisciplinary programs thrive. This clarity comes from written role descriptions included in job descriptions and competency assessments, protocols that authorize specific interventions (e.g., nurse-initiated intravenous-to-oral conversion, pharmacy technician antimicrobial audits) , training that builds confidence and competence in stewardship activities, and recognition of contributions through performance evaluations and professional development opportunities.

Collaborative Practice Culture

Organizational cultures that value interprofessional collaboration, encourage open communication regardless of professional hierarchy, welcome questions and suggestions from all team members, and treat antimicrobial stewardship as a shared responsibility rather than an individual prescriber decision create environments where multidisciplinary stewardship flourishes. Team-based care models, such as multidisciplinary rounds, create regular opportunities for collaborative stewardship decision-making.

Access to Data and Decision Support

Providing healthcare teams with timely access to relevant information supports stewardship practices. This includes antimicrobial use data and benchmarks that enable self-assessment and goal-setting, clinical decision support at the point of prescribing that prompts consideration of alternatives, microbiological results and antibiograms readily accessible in workflow, and guidelines and protocols easily available through electronic health records or mobile devices. Information technology staff who prioritize these capabilities enable data-driven stewardship.

Ongoing Education with Practical Application

Sustained educational programs that combine knowledge building with practical skill development and real-world application opportunities effectively build stewardship capacity across multidisciplinary teams. Characteristics of effective educational programs include case-based learning that applies principles to realistic clinical scenarios, simulation exercises that allow practice of communication and coordination, interprofessional education that builds teamwork, audit and feedback that provide individualized learning opportunities, and accessible resources for just-in-time learning when questions arise.

CONCLUSION

The evidence comprehensively demonstrates that effective antimicrobial stewardship requires the engagement and contributions of multidisciplinary healthcare teams. While physicians and clinical pharmacists have traditionally led stewardship programs, the expanding recognition of essential roles for nursing specialists, pharmacy technicians, laboratory personnel, dental professionals, radiologic technologists, health information specialists, and all healthcare workers represents a critical evolution in stewardship approaches.

Global meta-analyses reveal substantial room for improvement in healthcare workers' knowledge, attitudes, and practices regarding antimicrobial resistance and stewardship, with particular concern about the knowledge-practice gap where positive attitudes and reasonable knowledge fail to consistently translate into optimal practices. This gap underscores the need for educational interventions that extend beyond knowledge transfer to address practical skills, system barriers, organizational culture, and behavioral factors influencing antimicrobial use.

Studies evaluating multidisciplinary antimicrobial stewardship programs consistently demonstrate significant improvements in antimicrobial utilization, with reductions of 15-48% in defined daily doses per 100 patient-days, enhanced guideline adherence improving from baseline levels below 50% to 70% or higher, substantial cost savings ranging from tens of thousands to hundreds of thousands of dollars annually, and maintained or improved clinical outcomes including reduced mortality, decreased length of stay, and lower readmission rates. These findings provide compelling evidence that investments in multidisciplinary stewardship programs generate substantial returns through improved patient care and resource utilization.

Key elements of successful multidisciplinary antimicrobial stewardship programs include committed leadership that provides resources and prioritizes stewardship institutionally, clearly defined roles for all healthcare team members with appropriate empowerment and authority, comprehensive education tailored to specific professional roles and incorporating practical skills development, robust data infrastructure enabling measurement, feedback, and continuous improvement, evidence-based interventions integrated into clinical workflows, and organizational cultures that value collaborative practice and collective responsibility for appropriate antimicrobial use.

Critical gaps remain that require attention from researchers, educators, policymakers, and healthcare leaders. These include development and implementation of standardized competency frameworks for antimicrobial stewardship across all healthcare professions, expansion of pre-service education to ensure all healthcare workers enter practice with foundational stewardship knowledge, formalization of stewardship roles for nursing staff, pharmacy technicians, and allied health professionals with corresponding training and support, investment in diagnostic infrastructure, particularly in resource-limited settings, to enable culture-directed therapy, integration of behavioral science insights into stewardship interventions to more effectively change practice patterns, and research on long-term outcomes and sustainability of multidisciplinary stewardship programs.

The global threat of antimicrobial resistance demands urgent, coordinated action. Multidisciplinary antimicrobial stewardship programs represent a proven, cost-effective intervention that can be implemented across diverse healthcare settings to optimize antimicrobial use and slow resistance development. By recognizing and leveraging the unique contributions of all healthcare team members, establishing structures and cultures that enable collaborative practice, and investing in education and systems that support appropriate antimicrobial use, healthcare organizations can significantly enhance their capacity to combat antimicrobial resistance while improving patient outcomes

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