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Review Article

Clinical Pharmacists vs. Antimicrobial Resistance: Evidence-Based Strategies and Stewardship Impact in Modern Healthcare: A Review

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Abstract

Background: Antimicrobial resistance (AMR) has been a significant problem to human health as antibiotics are misused and overused. Due to antimicrobial stewardship programs (ASPs), the emergence of antimicrobial resistance is hindering the performance of healthcare systems, and clinical pharmacists have become a necessity in these programs.

Objectives: This review discusses the changing role of clinical pharmacists in the fight against AMR through evidence-based methods.

Methods: Various strategies were reviewed including drug optimization, de-escalation, intravenous-to-oral conversions, therapeutic drug monitoring, and educating prescribers. The role of clinical pharmacists as part of multidisciplinary teams performing evidence-based interventions in real-time was emphasized.

Results: Intervention by pharmacists has been shown to significantly reduce inappropriate antibiotic use, hospital-acquired infections, resistance patterns, and healthcare expenditures, while improving patient outcomes and compliance with stewardship procedures. Additionally, their role in surveillance, audit-feedback systems, and policy development enhances the clinical effectiveness of ASPs in both hospital and community-based settings.

Conclusion: Challenges to the implementation of clinical pharmacist-led ASP initiatives such as limited resources, interprofessional barriers, and specialized training still exist. Nonetheless, the strategic integration of clinical pharmacist initiatives into ASPs is possibly the sustainable path forward to maintaining optimal antibiotic efficacy. This review emphasizes the importance of expanding pharmacist roles, promoting ongoing training, and promoting interprofessional collaboration to mitigate the global threat posed by AMR.

Keywords: Clinical pharmacists, Antimicrobial resistance (AMR), Antimicrobial stewardship (AMS), Evidence-based interventions, Drug optimization, Healthcare-associated infections

INTRODUCTION

Antimicrobial resistance (AMR) is capable of hindering the health of the whole world, and it is defined as the fact that microorganisms (such as bacteria, viruses, fungi, and parasites) resist treatment that used to control them in the past. The main cause of this resistance is the misuse and overuse of the antimicrobials in human, animal and farming environments [1]. Directly, AMR killed about 1.27 million people and directly contributed to close to 5 million deaths worldwide in 2019, causing inflicted illness, long stays in hospitals, increased healthcare expenditure, and even threatening such vital medical interventions as surgeries and cancer treatment. The spread of inappropriate antibiotic use during the COVID-19 pandemic only contributed to the rising pace of AMR. Given the growing nature of this crisis, the World Health Organization (WHO) published the 2024 Bacterial Priority Pathogens List (BPPL) and identified 24 priority pathogens by threat levels namely critical, high, and medium in determining global research priorities and responses in the field of public health. Simultaneously, antimicrobial stewardship (AMS) initiatives have also come to the fore as one of the critical approaches to mitigate AMR, being based on rational use of antimicrobials in terms of their choice, dose, duration and route of administration [2]. These synchronised interventions have been found effective to not only decrease inappropriate prescriptions but also enhance patient outcomes and preserve antibiotic effectiveness and thus AMS is an imminent part of any global health

system and the wider One Health system that opts to chip in animal, human, and environmental health strategies.

The pharmacist as clinic pharmacists have emerged as crucial stakeholders in antimicrobial stewardship (AMS) programs because of their expertise in pharmacotherapy, as well as direct involvement with patients. Their roles play a vital role towards optimizing antimicrobial use, reduction of inappropriate prescriptions and in dealing with antimicrobial resistance (AMR) [3]. They attend all sorts of AMS activities, such as: performing prospective audits (with prescribing feedback), performing formulary management, assisting with escalation out of generic broad-spectrum antibiotics to narrow ones, developing and applying institutional guidelines, teaching providers and patients. They also interpret microbiological data to make a difference between colonization and true infection, as well as participant in multidisciplinary stewardship rounds. It has been demonstrated that their participation can increase the quality of prescription, reduce antibiotic duration, cost of healthcare delivery, improve the adherence to the standards of prescribing treatment, and respective patient outcomes. The purpose of this review is to be able to fully evaluate evidence with regard to the role of clinical pharmacists in AMS programs within diverse healthcare settings. It will look at their emerging roles, the effectiveness of their interventions, the barriers and facilitators to their contributions, effective models of integrating them in in-patient care, out- patient care, and future policy, education and research. The review looks to a broad spectrum of new publications, amongst them clinical trials and systematic reviews to carry out a comprehensive analysis of their involvement in AMS [3].

MECHANISMS AND BURDEN OF ANTIMICROBIAL RESISTANCE

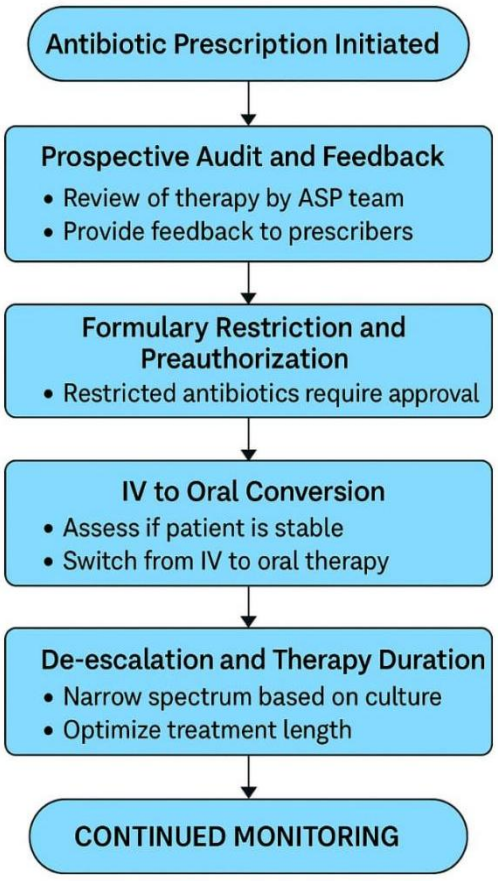
Bacteria have a number of well-defined mechanisms in which they employ to counter the effects of the antibiotics, thus resisting the effects of the antibiotics and surviving even during the treatment. The genes which encode 3-lactamases enzymes responsible inactivating 3-lactam-based antibiotics including penicillin and cephalosporins are the main strategy used. 3-lactamases enzymes remove the 3-lactam ring of 3-lactam based antibiotics. An even stronger form of resistance is observed, in the case of extended-spectrum beta-lactamases (ESBLs), since they target a broader class of the 1-lactams. The second usual form of resistance is efflux pumps-proteins in the bacterial membrane actually remove the antibiotics through the membrane and decrease the ability to kill the cell. Multidrug resistance is all too frequently ascribed to these pumps in bacteria, especially the biofilm-associated ones [4]. Also, bacteria are able to change sites of antibiotic action as the result of genetic mutations or acquisition of new genes, which disrupt drug interactions. As an example, modification of penicillin binding proteins (e.g. mecA gene in MRSA), ribosomal RNA methylation, or mutation of antibiotic sensitive protein such as DNA gyrase serves as the cause of resistance to most of the antibiotics. Some of the other forms of resistance involve decreasing the permeability of the membranes to prevent the entry of drugs, or using enzymes to modify the chemical nature of antibiotics in order to nullify the effect of the antibiotics. These mechanisms tend to work in concert and treatment becomes very complicated and underscores the emerging problem of antimicrobial resistance worldwide [5].

The problem of antimicrobial resistance (AMR) remains a severe and growing danger to world health and the World Health Organization (WHO) revealed that in 2019 alone, AMR caused directly 1.27 million deaths and more than 4 million associated deaths [6,7]. The Global Antimicrobial Resistance and Use Surveillance System (GLASS) of WHO is important in tracking international trends, providing an outcome that is used in guidance of policies and efforts to control infections. It is projected that antibiotic-resistant infections will claim more than 39 million lives by 2050, which will increase by almost 70 percent relative to 2022, and the proportionally high contribution is made by the aged population. On a regional basis, the United States suffers more than 2.8 million cases of resistant infections annually and 35,000 deaths per year, whereas, Southeast Asia and Africa are the regions recording the highest mortality child rates (primarily due to more intake of high-risk antibiotics). Hospital-acquired infections resistance is still high in Europe. Lab-wise, AMR causes more sickness and longer stays in hospitals and difficulties in managing infections, such as central line-associated bloodstream infections and pneumonia. AMR is economically expensive, costing $4.6 billion and more every year in the U.S. only, and its worldwide consequences are reduced productivity and increased disability. It is important to strengthen surveillance, prevention, stewardship, and invest in new antibiotics and diagnostics to fight this growing global challenge [8].

ANTIMICROBIAL STEWARDSHIP PROGRAMS (ASPS)

Antimicrobial stewardship programs (ASPs) are the designed efforts to build on the right utilisation of the antimicrobial agents by optimum selection of drugs, dosage, duration of use and route of administration. Their main goals to ensure the best patient outcomes, decrease adverse effects and development of resistance, decrease the unnecessary consumption of antibiotics, increase compliance with clinical guidelines, and provide patients with the safest care at a reduced cost of healthcare. Successful ASPs depend on diverse-skill workers usually comprising infectious disease physicians, clinical pharmacists, microbiologists, infection control personnel, hospital epidemiologists, IT professionals as well as employees. Clinical pharmacists (and in particular those who specialize in infectious diseases) are especially involved in this process. Pharmacists are more than likely to be the key players in any stewardship initiative and might be involved in prescription review, therapeutic optimization, audit, formulary stewardship as well as education of healthcare professionals. Their management and daily engagement in the ASP activities have also been regularly associated with improved prescription patterns and lower levels of antimicrobial resistance [9].

The following are some of the critical strategies used by antimicrobial stewardship programs (ASPs) As shown in Flowchart.1, in encouraging the responsible use of antibiotics to facilitate patient care. Prospective audit and feedback are one such solution as it entails using stewardship team to periodically review active antibiotic prescriptions and give direct suggestions to prescribers resulting in better prescribing practices and decrease in medical-related infection like Clostridium difficile. The restriction in the formulary and preauthorization also restricts the use of some of the high-risk or broad-spectrum antibiotics, and hence need to be preauthorized so that they can be used only based on clinical evidence. Dose optimization means individualising the dose of antibiotics to patient variables such as renal function, infection severity and pathogen sensitivity with the aim of improving treatment and reducing acute and chronic toxicity as well as resistance. IV to oral switch strategy facilitates the use of oral antibiotic instead of using IVs in patients in the case of safe and effective without increasing IV-related complications, hospital stays, and cost reduction. We also include de-escalation and proper length of therapy that entails adjusting the choice of antibiotics to the culture outcomes and discontinuation of therapy after its necessity ends, it can help reduce excess exposure and acquisition of resistance. Such approaches can work most effectively in the context of the entire flexible ASP incorporating education, digital tools, and collaborative culture in hospital and outpatient care settings [10,11].



Flowchart 1: Antimicrobial Stewardship Process Flowchart: Optimizing Antibiotic Use

CLINICAL PHARMACISTS: ROLES AND RESPONSIBILITIES IN ANTIMICROBIAL STEWARDSHIP PROGRAMS:

Effective management of antimicrobial use is based on the right choice of the drug, its doses and continuous observation. Instantaneously, empirical selection of an antibiotic should rely on the type of infection, risk factors of a particular patient, geographical resistance trends as well as clinical guidelines. As an example, whenever there is disease like acute appendicitis, the choice of empiric antibiotics depends on the possibility of resistant organisms carried by a patient and this will be more in cases of a patient with sepsis or long-term conditions. Adjustments of doses are also necessary and should consider pharms. bios. and also, should consider the infection severity, the renal or the liver function as well. Studies have revealed that dosing errors are very common, particularly in the outpatient, which is why the role of stewardship is very essential. Therapeutic drug monitoring (TDM), especially of drugs with narrow therapeutic indexes such as vancomycin, can be used to optimize both therapeutic efficacy and toxicity by keeping target doses in the therapeutic range. Increasingly, AUC-based monitoring is becoming the preferred method of conventional trough levels. Moreover, pharmacists cannot define whether it is a real infection or non-infectious colonization, which is critical to prevent the use of antibiotics without the real necessity. As soon as the data on culture and sensitivity appears, there should be optimization of the antibiotic treatments- narrow spectrum agents will be chosen instead of broad ones. All these efforts make the application of antimicrobial therapy not only elective but also safe, personal, and consistent with the strategy of prevention of resistance [12].

Clinical pharmacists are an indispensable part of Antimicrobial Stewardship Programs (ASPs) as they may educate and counsel the patients on a proper use of antibiotics. They offer counselling to patients on how to properly use the prescribed antibiotics and the need to follow with it and the dangers of failure to do so or practicing self-dose, which is likely to lead to resistance. Patients are also made aware of the possible side effects and drug reactions by the pharmacists thus know when they need to consult. They also reduce inappropriate demand of antibiotics by overcoming common misconceptions, e.g. the idea that antibiotics are used to treat viral diseases. They also prevent additional infections by attending to hygiene and by vaccination. In the event of a claim or change of custody or care, pharmacists during the hospital discharge talk to the patient extensively to make sure they understand their antibiotic schedule, the necessity of the full course of treatment and possible follow up. These activities have a strong and significant impact on patient outcomes, minimize the inappropriate use of antibiotics, and contribute to the success of the stewardship program in general [13].

Clinical pharmacists also play a significant role in the process of drug-drug interaction determination and adverse reactions prevention of antibiotic-related events

within the scope of antimicrobial stewardship programs (ASPs). They take a close look at the medication records of patients to identify treatment interactions e.g. those of oral fluoroquinolones and supplements or other agents that may affect the utility of antibiotics or lead to an amount of toxicity. They also observe any adverse effect including allergic reactions and organ toxicity, which contains patient safety and the most efficient use of antimicrobials. In the case of drugs that have small therapeutic ranges, such as vancomycin or aminoglycosides, pharmacists use therapeutic drug monitoring (TDM) in order to achieve an efficacy safety balance. In addition to treating, pharmacists play an instrumental role in capturing all stewardship actions used in drugs selections, dose adjustments, observation in both medical records and databases. They also draft and examine information about antibiotic retrieval and patient outcomes to determine the efficacy of stewardship intercessions. They work in cyber-monitoring systems such as the CDCs NHSN Antimicrobial Use Option to help in benchmarking and quality improvement. In addition, by reporting the outcomes to the prescribers and the overall stewardship group, pharmacists assist in ongoing refinement and the ability to reliably make decisions based on evidence, which eventually contributes to the safety, efficacy and effectiveness of antimicrobial therapy [14,15].

EVIDENCE-BASED IMPACT OF CLINICAL PHARMACISTS IN COMBATING AMR

Antimicrobial stewardship would not comprehend clinical pharmacists, especially in reducing inappropriate use of antibiotics. As mention in Table.1, Those responsibilities involve prescription auditing to identify unnecessary prescriptions, duplication, and feedback to prescribers, education of healthcare professionals and patients in appropriate antibiotic use, and the early de-escalation or discontinuation of treatment with regards to clinical course and culture outcomes. In different care settings, these interventions have been elucidated to curb ill-bred prescription of antibiotics by a range of between 20 percent and 36 percent. Moreover, the pharmacists can influence improvement of the adherence to clinical protocols by authoring and renewing antimicrobial guidelines, educating clinicians about evidence-based antimicrobial measures, surveillance of adherence, and coordination of multidisciplinary rounds to make the selection of antibiotics appropriate. These programs tend to create adherence rates with prescribing guidelines of more than 80-90%, which affect better control of infections, decreased resistance, and patient outcomes. All in all, through focusing on the misuse and strengthening of the guideline-based practice, clinical pharmacists play a major role in making the antibiotic treatment safer, more efficient, and prolonged.

Table 1: Impact of Pharmacist Contributions on Antimicrobial Stewardship Outcomes

Stewardship Outcome	Pharmacist Contribution	Impact
Reduction in inappropriate use	Audit, Feedback, Education, De-Escalation	20-30% reduction in misuse
Guideline-adherent prescribing	Guideline development, education and monitoring	>80-90% compiled better outcomes

The programs used to control antimicrobial stewardship (ASPs) have demonstrated extensive benefit in terms of combat against the Clostridioides difficile infections (CDI) and antimicrobial-resistant organisms. A retrospective 12 years analysis in Saudi Arabia suggests a significant reduction in CDI rates after implementation of stewardship with the toxigenic C. difficile positivity decreasing to 7.4%. During the stewardship initiatives aimed at reducing fluoroquinolones in the U.S., the use of fluoroquinolone reduced by 21 percent and monthly falls in post-discharge CDI cases by CDI reduced by 2.5 percent. In the same light, ASPs have shown fewer multidrug-resistant blood infections and reliance on broad-spectrum antibiotics such as meropenem in the high-risk patient populations such as oncology and transplant patients. Community-based programs (with increased diagnostic stewardship and infection control required) have managed to reduce hospital-onset CDI by up to 95 percent. On the economical level, ASPs will help reduce hospital stays and healthcare costs as the result of antibiotic overuse, resistant infections, and CDI will be minimized, which also limits the necessity of expensive treatment and prolonged stays. These results are constantly supported by meta-analyses, which have demonstrated that ASPs not only make clinical outcomes better but also make substantial savings especially in various care settings. The overall approaches, including the audit and feedback, formulary restrictions, dose optimization, and enhanced diagnostics are required to ensure the maximum clinical and economic utilities [16,17].

CASE STUDIES AND SUCCESSFUL MODELS

The institutional structure is very different in different countries, as mentioned in Table.2, and this is conditioned by historical, political, and social background. Prison work programs are a system used in the United States wherein rehabilitation and punishment are to be combined together and there are still debates concerning whether prison work programs are effective in a reduction of repeat offenses and economic effects. Saudi Arabia is ruled by a king and the royal family enjoys immense power with other institutions having only advisory powers and the citizens are slowly incorporated in the governance structure. In the United Kingdom, universities are operated under different legal jurisdictions, some by royal charter, some (statutory bodies or companies) subject to a regulatory regime of degree-awarding powers. Institutions of National Importance to India include IIT, AIIMS and others, and are created in parliamentary acts and play important

roles akin to education and research which are, however, highly autonomous and funded. Such examples lead to understanding the disparity of the institutional roles and governance in different countries [18].

Table 2.: Institutional Structures and Functions Across Selected Countries

Country	Example Institution	Functions
USA	Prison work programs	The US prison system implements various work programs for inmates, aiming to balance punishment with rehabilitation. These programs are controversial regarding their effectiveness in reducing recidivism and their impact on the labour market.
Saudi Arabia	Monarchy and Government Structure	The Saudi government is dominated by the royal family. The King holds legislative, executive, and judicial powers, appoints ministers, and presides over the Council of Ministers. There is also a Consultative Assembly with advisory roles but no legislative power. Municipal councils exist but have limited authority, and only recently have women been allowed to participate in elections.
UK	Universities (e.g., Oxford, Cambridge, Durham, London)	UK universities have varied legal statuses: some are statutory corporations (e.g., Newcastle), others chartered, and some are companies limited by guarantee. The Education Reform Act 1988 define recognized and listed bodies for higher education, with degree-granting authority regulated by Royal Charter or Act of Parliament.
India	Institution of National Importance (e.g., IITs, IIMs, AIIMS, BHU, University of Delhi)	These institutions are established by acts of parliament and are recognized for their national significance in education, research, and specialized fields, they have statutory backing and receive special funding and autonomy from the central government.

Interventions in community pharmacies are organized interventions offered by community pharmacists in community settings and are designed to achieve health outcome improvements, promote adherence to medication and contribute to population health. These interventions cover various fields like individual-based approaches to enhancing compliance-motivational counselling and follow-ups in particular to chronic illnesses like diabetes and heart disease. Other ways in which businesses contribute to disease prevention is through provision of pharmacy services like disease vaccinations, screening, smoking cessation and health education. Pharmacists educate patients and empower them with the necessary skills of self-care such as using drugs properly and managing diseases. Collaboration care models execution in partnership between the caregivers and health care providers and institutions also further support such efforts. It has been found that the interventions of this kind cause a severe reduction in nonadherence, increase the level of knowledge and quality of life in patients and provide community health care that is affordable and unthreatening. To ensure an effective implementation, it is necessary to have clear goals, patient-centered strategies, staff training, and evaluation of the implementation on a continuous basis. Such services, where the pharmacy is at the forefront, are significant and growing elements of the contemporary health system of delivery [19].

Resource-constrained settings with clinical pharmacist-led models to advance medication use, patient safety, and resolve community health concerns have become effective even within a poorly developed structure. One of the major roles played by pharmacists is verification or improvement of a prescription, especially in the reduction of inappropriate medicines as observed in studies where most pharmacist recommendations were adhered to by the physicians especially in the high-risk population groups such as the elderly. During antimicrobial stewardship, pharmacists have been able to employ cost effective intervention that is effective even in geographically remote settings and they tend to fill in the gap the absence of infectious disease specialist create. Pharmacist and trained non-physicians health workers have the capability to cover gaps in service through task-shifting, thereby addressing tasks in services like neonatal and mental health service provision. Capacity strengthening of these models can be done through offering specialised clinical training and certification, inclusion of pharmacists into interdisciplinary teams and employing newer technologies in education such as augmented reality to engineer capacity. The availability of community and communication with other medical workers in the sphere is also crucial to the success and sustainability of such interventions to work in the low-resource context [20,21].

CHALLENGES FACED BY CLINICAL PHARMACISTS IN ASPS

Access to microbiological data and interprofessional cooperation are usually barriers to the success of antimicrobial stewardship and infection control in low-resource environments. Most healthcare institutions do not have access to locally-appropriate microbiology services to enable them to monitor local resistance

patterns, or establish evidence-based antibiotic policies. The problems of non-captive reporting, lack of resistance data, and stock shortages exacerbate the issue of antibiotic use, even in the presence of laboratories. As a survey conducted in Ukraine indicates, a lot of healthcare workers perceive diagnostic constraints as a great barrier. At that, facilities are recommended to use available information to draw simple antibiograms. Particularly crucial is the difficulty of collaboration of the healthcare professionals, such as communication barriers, absence of team spirit, doctor opposition and poor awareness of antimicrobial resistance. Shortened staff created these barriers, which are compounded by the lack of consistent prioritization of stewardship initiatives. Such issues need to be handled on a larger scale, such as frequent training, multidisciplinary teams, sharing the data on AMR, and good antibiotic policies. Such obstacles are critical to overcome to increase antimicrobial stewardship and promote patient safety even in resource-limited environments [22].

Lack of funding and proper expertise are major challenges affecting implementation of effective antimicrobial stewardship (AMS) in low- and middle-income countries. Numerous healthcare facilities have a problem with the understaffing, the lack of funds, and limited access to the necessary means of work such as diagnostics and IT infrastructure. Economic instability, supply chain problems, and ineffective retention of staff also work to increase these problems. There is a lack of universal guidance and organized programmes which undermine AMS and infection control activities. Such creative ideas as hub and spokes model in India whereby secondary hospitals work hand in hand with central expert institutions by conducting training and developing policies have proved to take advantage of limited resources. The low level of specific AMS training is equally urgent since, in most instances, the education in this field is underestimated and underfinanced, which is alarming given the rising risk of antimicrobial resistance. The opportunities which provide a venture with structured learning are limited, and the rapid development of AMS requires constant education in the conventional and digital forms. Online course, blending learning, and on the site mentorship are some of the programs that have registered good outcomes but need to be supported more to be implemented extensively. These obstacles require prudent investment in human resource development, new capacity building models and long-term planning on resource allocations [23,24].

FUTURE DIRECTIONS AND RECOMMENDATIONS

Continuously growing is the need of more advanced antimicrobial stewardship (AMS) education and certification programs, and the inclusion of the digital tools and clinical decision support systems in order to an adequate way of combat the antimicrobial resistance and adequate use of antibiotics. All sorts of custom AMS training solutions are also offered nowadays all over the world, with the focus being different, depending on the level of a professional in his/her career. Examples of programs that focus on implementation, leadership, and program evaluation includes Certificate Course in Antimicrobial Stewardship (CCAMS) by the Public Health Foundation of India, a holistic certificate program by SIDP, continuing education accredited modular training by the CDC, and higher-level curricula by the IDSA, ESCMID, and MAD-ID. At the same time, AI-based systems, real-time dashboards and automated prescription feedback tools are digital innovations that are revolutionizing AMS, as they allow making data-driven decisions, tracking prescribing behavior, and providing timely interventions. The use of such technologies is particularly useful in a low resource setting as it provides scalable adjustable solutions to maximize the benefits of AMS and help clinicians comply with treatment guidelines. The combination of technological, as well as training enhancements, is needed to create powerful and responsive implementations of AMS systems all over the world [25].

As a result of high rates of inappropriate antibiotic administration and increased threats of antimicrobial resistance almost everywhere, antimicrobial stewardship (AMS) programs are rapidly spilling out of hospitals into the community and long-term care settings. The prescriptions of antibiotics in long-term care facilities (LTCFs) are frequently unnecessary, especially use of antibiotics to treat urinary tract infections that lead to resistance and cross-setting integration of drug-resistant organisms. These AMS interventions in LTCFs (ongoing physician education, provision of guidelines, web material and staff education) have proven to lead to improved prescribing and decreased inappropriate usage. Measures such as the weekly audit and comments regarding abatement of antibiotic use by the chiefs of infectious diseases have caused prominent decreases in antibiotic consumption. Severe lifestyle habits are however difficult to maintain following remedial measures. Also, there are a lack of data about the long-term effect and population scope of AMS in the community and primary care frameworks, and the implementation of the procedure is complicated by organizational culture, the resistance of professionals, under-resourcing, and unsuitable diagnostics. These issues need to be handled with thorough investigation of successful integration patterns and specific policy assistance. The funding of policies, training of workforce, access to diagnostics, interprofessional collaboration, and implementation of the national strategies to facilitate the surveillance and best practice should be prioritized. The question of further success in the implementation of AMS outside the hospital setting rests on the ability to fill research gaps, despite the practical limitations, and secure robust policy support [26,27].

CONCLUSION

Clinical pharmacists are considered a crucial part of antimicrobial stewardship programs (ASPs) and are regarded as the fundamental experts in the global effort against antimicrobial resistance (AMR). Their evidence-based measures have shown great results in the area of antibiotic use and patient outcome optimization, such as antibiotics selection, doses, and duration optimization, IV-to-oral transitions, and de-escalation strategies support. They play a role in helping to decrease hospital-

acquired infections, health expenditures, and stewardship programs adherence as part of multidisciplinary teams. They also contribute to the clinical and operational success of ASPs in terms of bringing contribution to education, surveillance, and policy development. Although there are continued limitations like resource and interprofessional barriers, requirement of specialized training' the strategic implementation of clinical pharmacists into AMS projects is the way to go. Healthcare systems should invest in self-education, electronic decision-support systems and community- and long-term care environments to have the greatest impact. The further enhancement of their role is vital in terms of maintenance of antibiotic effectiveness and directing at the increased crisis of the AMR.

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