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Evaluating the Role of Pharmacists in Managing Antibiotic Use and Combating Multi-Drug Resistance in Hospital Settings

Ruchita S. Math[1,*], Jay B. Prajapati[2], Dhvanil J. Desai[2], Krishna J. Desai[2], Jalpesh B. Rathod[2]

Abstract

Antibiotic resistance is now one of the crucial health issues of the world, especially in hospitals where high usage of antimicrobials is increasing the rate at which multi-drug resistant (MDR) organisms appear. Misprescription, extended treatment, and over-use of broad-spectrum antibiotics play a large role in the development of resistance resulting in the growth of morbidity, mortality and health care expenditure. This review analyses the essentiality of pharmacists in controlling the use of antibiotics and preventing MDR with the help of antimicrobial stewardship programs (ASPs). Pharmacists can play a role in prescription review and optimization, dose change, therapeutic drug monitoring, de-escalation plan, intravenous–oral conversion, and adverse drug reaction surveillance. It has been shown that pharmacist-based interventions lead to a decrease in the use of inappropriate antibiotics, increase in clinical outcomes, hospital length of stay, health care spending, and the stabilization or reducing MDR rates. Even though challenges of implementation include resource constraints and policy gaps, institutional support can be strengthened by implementing advanced technologies and improving the effectiveness of stewardship. Owing to the above, pharmacist-led antimicrobial stewardship is a sustainable approach and cost-efficient in maintaining antibiotic efficacy and enhancing patient safety within hospitals.

Keywords: Multidrug resistance, antibiotic resistance, antimicrobial stewardship, clinical pharmacist, hospital settings, rational antibiotic use, healthcare outcome

INTRODUCTION

Antibiotic resistance has become one of the most critical worldwide population health issues of the twenty-first century, putting decades of medical advances in jeopardy and threatening the effective prevention and control of infectious diseases. Antibiotics which were initially regarded as wonder-working drugs, have been extensively applied both in human healthcare, veterinary medicine, and agricultural fields, and have been used inappropriately and abused, which has contributed to the emergence and dissemination of resistant microorganisms [1]. The development of resistance in bacteria occurs in various ways, in which genetic mutations, horizontal gene transfer, enzyme degradation of the antibiotic, drug targets, and the activation of efflux pumps are some of the ways. These processes keep on accumulating, leading to multi-drug resistant (MDR) organisms that are resistant to at least one agent in three or more classes of antimicrobial agents [2]. The rise in the number of MDR pathogens in this case, methicillin-resistant Staphylococcus aureus (MRSA) extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae, carbapenem-resistant Acinetobacter baumannii, and

***Author for Correspondence**
Ruchita S. Math
E-mail ruchitamath8@gmail.com

[1]Assistant Professor, Department of Pharmacy, Shetty Institute of Pharmaceutical Sciences, Gulbarga, Karnataka, India
[2]Researcher, Department of Pharmacy Practice, Maliba Pharmacy College, Uka Tarsadia University, Bardoli, Gujarat, India

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multidrug-resistant *Pseudomonas aeruginosa,* is a concerning global trend in developed and developing nations as seen in Figure 1. Hospitals are one of the most important epicenters of the development and spread of these resistant strains because of high rates of antibiotic use, susceptible patient groups, invasive treatment, extended hospitalizations, and ICU. Poor prescribing habits, including unnecessary use of broad-spectrum antibiotics, inappropriate dosage, longer period of therapy, and inability to de-escalate treatment using culture information, also enhance the development of resistance. As a result, antibiotic resistance not only raises morbidity and mortality but also extends hospitalization, increases health care expenses, and reduces therapeutic choices, which pose a danger to the patient and sustainability of health care systems across the world (Figure 1) [3].

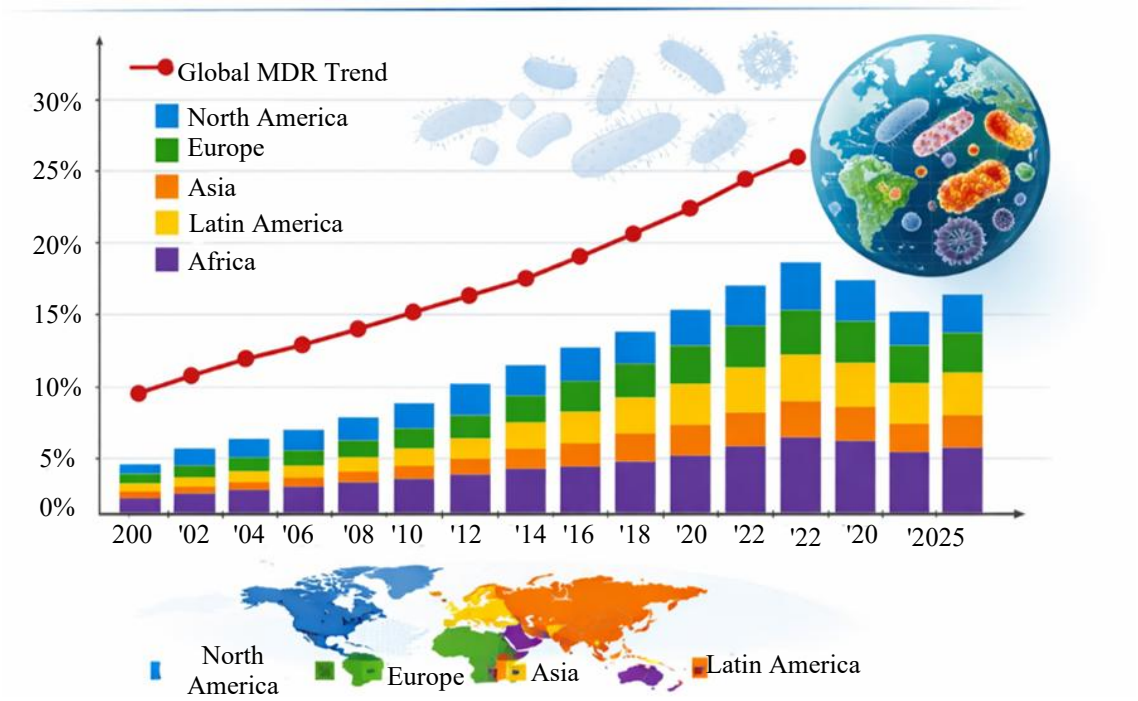

Figure 1. Global trends in multi-drug resistance (MDR) prevalence (2000–2025).

As a solution to this escalating crisis, hospital-based antibiotic stewardship programs (ASPs) have been identified as a foundational approach to maximize antimicrobial use and reduce resistance transmission. Antibiotic stewardship is organized actions aimed to enhance and quantify the correct utilization of antimicrobials through the advancement of the optimal drug regimen, dose, duration, and route of administration [4]. Best stewardship initiatives are interdisciplinary programs, usually comprising infectious disease physicians, microbiologists, and infection control experts, and most notably, clinical pharmacists. In the hospital, stewardship activities are intended to achieve prescribing that is evidence-based, diminished exposure to broad-spectrum agents, de-escalation promoted where required by microbiological information, and intravenous–oral conversion of intravenous de-escalation encouraged where appropriate. Such interventions are necessary not just to reduce the trends of resistance, but to enhance the clinical outcomes and adverse drug events. Due to the growing global disease burden of MDR organisms, as depicted in Figure 1, reinforced hospital-based stewardship programs have taken over as a pressing necessity in healthcare systems across the globe [5].

This review is intended to critically assess the importance of pharmacists in governing the use of antibiotics and countering multidrug resistance in hospital settings. Pharmacists are in unique positions that can affect antimicrobial prescribing by reviewing prescriptions, therapy drug monitoring, optimizing dosage, attending clinical rounds, educating healthcare professionals, and adopting the stewardship protocols. This review aims to summarize the existing evidence to emphasize the role of pharmacist-led interventions in preventing inappropriate prescription and dispensing, enhancing patient

outcomes, and stemming out the trend of resistance. Finally, the role of the pharmacist should be interpreted and strengthened to respond to the growing threat of multidrug resistance on a global scale and to provide sustainability of successful antimicrobial treatment in hospitals [6].

ANTIBIOTIC RESISTANCE AND MULTI-DRUG RESISTANCE

Antibiotic resistance is a phenomenon whereby microorganisms develop mechanisms that curb or eradicate the efficacy of antimicrobial agents that are used to treat or prevent infections. Genetic mutations and horizontal gene transfer are the major causes of this phenomenon, which allows bacteria to evolve quickly when they are subjected to selective pressure due to exposure to antibiotics. The mechanisms of resistance are multi-factorial and are enzymatic (e.g., beta-lactamases, which inactivate penicillins and cephalosporins), alteration of drug targets (e.g., penicillin-binding proteins, which can change their shape), decreased membrane permeability, which limits drug uptake, and active efflux pumps, which expels antibiotics out of bacterial cells [7]. Moreover, biofilm formation is a major contributor of resistance as it acts as a protective barrier to allow antibiotics entry and leads to improved survival of the bacteria. All these biological changes have the overall result of decreased vulnerability to various antimicrobial classes and eventually to multi-drug resistance (MDR). Complicated interactions between these mechanisms are depicted in Figure 2, which shows how bacteria evolve and maintain resistance to antimicrobial pressure in clinical environments [8].

The appearance and dissemination of MDR pathogens is especially worrying in the hospital setting because of the high rates of antibiotic use, the critical condition of patients, invasive surgeries, and extended hospitalization. Methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus (VRE), and extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* and Klebsiella pneumoniae, carbapenem-resistant Acinetobacter baumannii, and multidrug-resistant *Pseudomonas aeruginosa* are common MDR pathogens that are commonly found in healthcare facilities [9]. Such organisms are commonly linked to hospital-acquired infections which include ventilator-associated pneumonia, bloodstream infections, urinary tract infections as well as surgical site infections. The intensive care units (ICUs) are large reservoirs of these pathogens because of the high rate of antibiotic exposure and the immunocompromised patients. Contaminated surfaces, hands of healthcare workers, medical equipment, as well as insufficient processes of infection control may contribute to the spread of resistant organisms and worsen the issue in hospitals (Figure 2) [10].

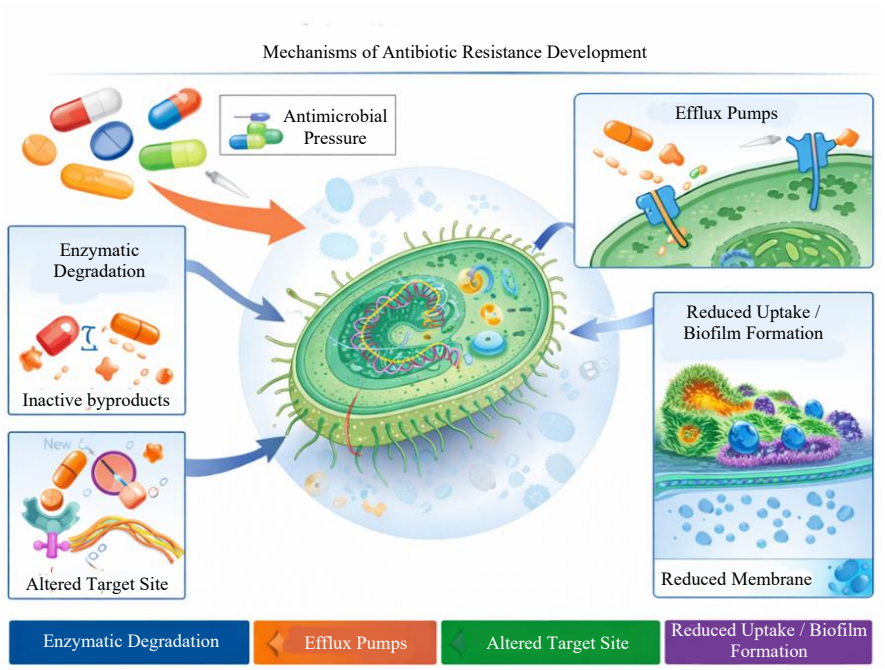

Figure 2. Mechanism of antibiotic resistance developments.

The MDR infections have extreme clinical consequences that result in the delay in the appropriate therapy types, the high rates of treatment failures, the increased morbidity, and the high rate of mortality. Infected patients may need more time in hospital care, combination therapy, or the administration of final resort medicines, like colistin or linezolid, which can be highly toxic. Furthermore, the financial cost incurred due to antibiotic resistance is high. The length of stay, extra diagnostic tests, second or third-line antimicrobials, and heightened infection control are associated with higher costs to hospitals [11]. On a larger scale, the productivity of healthcare systems is decreased, insurance claims are high, and there is strain on scarce medical resources. The increased occurrence of MDR pathogens not only undermines patient outcomes but poses a threat to the sustainability of the contemporary medical practice, such as surgery, organ transplantation, or cancer chemotherapy, which heavily depend on the efficacy of antimicrobial prophylaxis. Hence, it is important to learn the mechanisms of resistance and the effect of MDR organisms as illustrated in Figure 2 to develop specific antimicrobial stewardship plans and reinforce hospital-based interventions to curb the rising resistance crisis [12].

ROLE OF PHARMACISTS IN ANTIBIOTIC STEWARDSHIP

The pharmacist is central to antibiotic stewardship programs (ASPs) in hospital facilities in managing the rational, safe, and effective use of antimicrobial agents. Prescription review and optimization is one of their main roles and it entails the critiquing of antibiotic prescriptions regarding their suitability basing on clinical indication, microbiological results, local antibiogram data and recommended treatment guidelines. Pharmacists detect inappropriate initiation of antibiotics, inappropriate choice of broad-spectrum agents, incorrect dosage, duplication of therapy, extended period of treatment, and possible drug–drug interactions through prospective audit and feedback mechanisms. They can recommend timely and evidence-based changes that can decrease the exposure of antibiotics that are inappropriate and decrease the selective pressure that is part of the emergence of multi-drug resistant (MDR) organisms [13].

Another essential sphere of the pharmacist activity is dose adjustment and therapeutic drug monitoring (TDM). The dosing strategies of many antibiotics – such as vancomycin, aminoglycosides, and some beta-lactams – need to be individually tailored to attain the best pharmacokinetic and pharmacodynamic goals. To identify suitable dosing regimens, pharmacists measure patient specific parameters including renal and hepatic functioning, body mass, age, infection severity, and comorbidities. They must achieve this by maintaining therapeutic levels and avoiding toxicity through periodic checks of serum drug levels and other applicable laboratory indicators. This accuracy-driven method enhances the effectiveness of treatment, reduces the chance of adverse effects, and minimizes the chances of subtherapeutic dosage, causing the development of resistance [14].

Pharmacists are also actively engaged in the deployment of de-escalation measures and intravenous (IV)-to-oral switch measures. De-escalation is the process of reducing the range of antibiotic therapy after microbiological findings are obtained to identify the pathogen and susceptibility pattern. Such a selective strategy helps to prevent unjustified use of the broad-spectrum antibiotics and retain their power in case of serious infections. Likewise, the conversion of patients to oral therapy is clinically stable, thus, shortened hospital length of stay, decreased healthcare expenses, and lowered complications that arise when patients have extended access to intravenous therapy. To ensure therapeutic continuity and patient safety, pharmacists consider both clinical improvement and gastrointestinal functions, drug bioavailability, and the severity of infections since such transitions must be carried out before their recommendations (Figure 3) [15].

The other crucial aspect of stewardship activities is monitoring adverse drug reactions (ADRs). Antibiotics are associated with nephrotoxicity, hepatotoxicity, hypersensitivity, haematological and Clostridioides difficile-associated diarrhea. Pharmacists review laboratory findings in a structured way, evaluate clinical manifestations and symptoms and record suspected ADRs to facilitate the prompt detection and treatment. Fast detection and treatment of such reactions can contribute to patient safety, decrease morbidity, and increase the overall quality of antimicrobial therapy in hospitals [16].

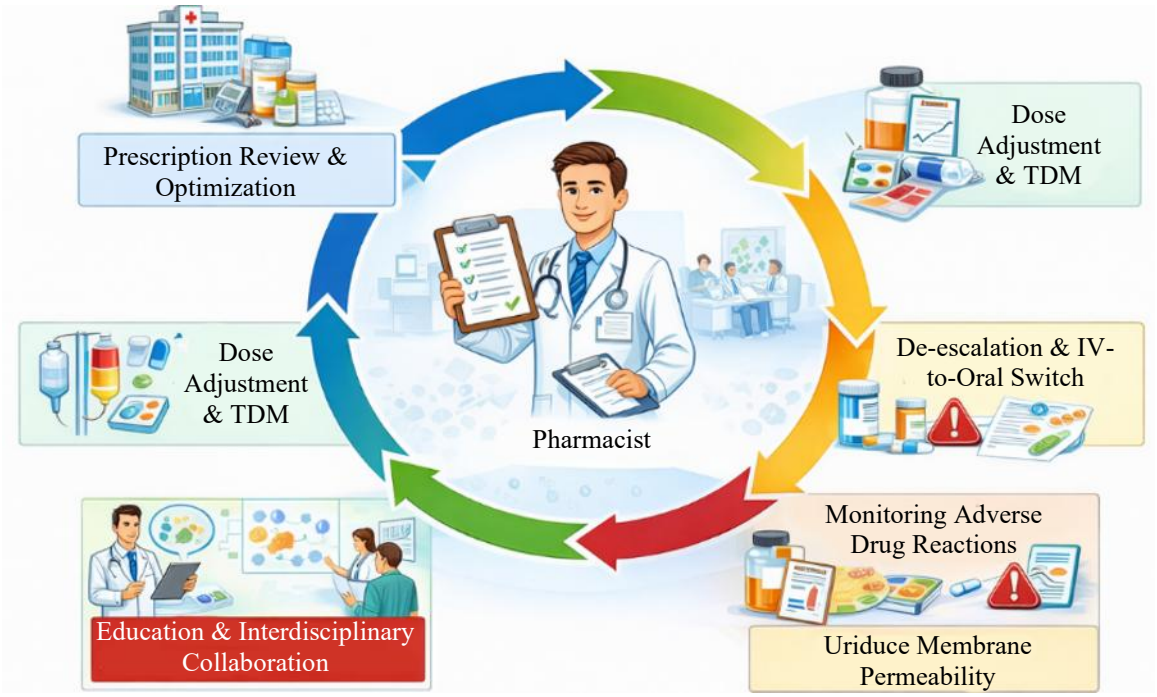

Figure 3. Role of pharmacists in antibiotic stewardship.

IMPACT OF PHARMACIST-LED INTERVENTIONS

Pharmacist-based interventions in the framework of antimicrobial stewardship programs (ASPs) have proven to have quantifiable and clinically relevant effects on the patterns of antibiotic use, patient outcomes, resistance, and health expenditure in hospitals. Inappropriate use of antibiotics is one of the outcomes that have been reported consistently. Pharmacists detect the unneeded start of antibiotics, a longer period of treatment, unsuitable broad-spectrum control, and improper dosage timetable through perspective audit and feedback, formulary restriction, guideline execution, and live prescription check-ups. These interventional measures lead to a significant reduction in irrational prescribing and the encourage evidence-based antimicrobial choices. Research has revealed declines in the total daily antibiotic use, defined daily dose (DDD) and length of treatment after the input of the pharmacist, thus reducing the selective pressure which causes antimicrobial resistance [17].

Pharmacist-led stewardship efforts in addition to optimizing the use of the antibiotics lead to better clinical outcomes. Prompt dose changes, therapeutic drug surveillance, culture-driven de-escalation and IV to oral switch programs can increase the effectiveness of treatment and decrease complications. There is reduction in hospital stay, treatment failure rates, cases of antibiotic-related adverse drug reactions, and mortality in severe infections among patients placed under pharmacist-guided stewardship models. The pharmacists contribute to the overall patient safety and quality of care by making sure that the pharmacodynamic and pharmacokinetic targets are met so that the therapeutic benefit is maximized in relation to toxicity [18].

The other important effect of pharmacist involvement is the decrease in the rate of multi-drug resistant (MDR) in healthcare institutions. Stewardship programs also decrease the selective force that promotes resistance strains by reducing unnecessary exposure to broad-spectrum antibiotics like carbapenems, fluoroquinolones, and third generation cephalosporins. With time, the incidence of methicillin-resistant Staphylococcus aureus (MRSA), extended-spectrum beta-lactamase (ESBL)-producing organisms and carbapenem-resistant pathogens have been reported to stabilize or decrease with the implementation of structured pharmacist-led interventions in the hospital. This is vital in the preservation of the effectiveness of current antimicrobial agents and safeguarding future treatment options [19].

Another important advantage of pharmacist-led stewardship programs is the cost-effectiveness. The decreased use of antibiotics leads directly to the decrease in the cost of drug acquisition, whereas the decreased length of stay in the hospital and the number of complications will lead to the costs in healthcare being less. Also, MDR infection prevention lowers the cost of last-line therapies or intensive care treatment. In economic analyses, stewardship has proved to be a clinical and economic priority since investment in pharmacist-led ASPs can save the healthcare institutions a significant amount of money. Table 1 summarizes the overall effect of these interventions and shows the correlation between the activities of the pharmacists and the objective outcomes that are measurable as they are reflected in clinical and institutional [20].

Table 1. Summary of pharmacist interventions and outcomes.

Pharmacist intervention	Key activities	Clinical outcomes	Impact on MDR	Economic impact
Prescription Review & Audit	Guideline-based evaluation, feedback to prescribers	Reduced inappropriate prescribing, improved therapy selection	Decreased selective pressure	Lower antibiotic expenditure.
Dose Adjustment & TDM	Renal/hepatic dose optimization, serum level monitoring	Improved efficacy, reduced toxicity	Prevents subtherapeutic exposure	Reduced complication-related costs.
De-escalation Strategy	Narrowing spectrum based on culture results	Reduced treatment duration, improved outcomes	Lower MDR emergence	Decreased use of costly broad-spectrum agents.
IV-to-Oral Switch	Early transition to oral therapy	Shorter hospital stay	Reduced hospital-acquired resistance risk	Lower hospitalization costs.
ADR Monitoring	Early detection of adverse reactions	Improved patient safety	Reduced unnecessary antibiotic changes	Avoided additional treatment costs.

CHALLENGES AND FUTURE DIRECTIONS

Antimicrobial stewardship programs (ASPs) are not only able to be effective but also experience numerous challenges in implementation in hospitals. Little institutional support and resource constraints are one of the major obstacles. Most of the health care institutions especially in the low- and middle-income countries do not have special specialists in infectious diseases, trained clinical pharmacists, microbiology facilities, and electronic surveillance systems that would enable them to practice effective stewardship [21]. Poor staffing and workload also limit the capacity of pharmacists to perform detailed audit of prescription and therapeutic drug monitoring and post prescription follow-ups. The barrier to consistent compliance with stewardship recommendations is also represented by resistance by prescribers, hierarchical clinical culture, and a lack of awareness about antimicrobial resistance (AMR). Moreover, evidence-based decision-making is susceptible to such problems as the absence of standardized local treatment guidelines and real-time access to the data on antibiograms. All these operational and behavioral barriers diminish the effectiveness and sustainability of interventions directed by pharmacists [22].

Regulatory and policy assistance is important in enhancing the implementation of stewardship. Nation plans of action in line with the international systems, like the World Health Organization's Global Action Plan on Antimicrobial Resistance, have focused on surveillance, prudent antibiotic usage, and preventing infections. Nevertheless, there is a wide disparity in implementation of antimicrobial policies by different regions. Poor prescription laws, availability of antibiotics over-the-counter, and inadequate surveillance mechanisms remain playing a key role in promoting resistance in most environments [23]. More binding regulations of the ASPs that are hospital-based, the quality of accreditation and reporting the pattern of antibiotic use and resistance may also greatly increase accountability. Compliance can also be further encouraged by integration of stewardship indicators in quality measures of hospitals and healthcare reimbursement policies. Funding and institutional commitment by the government is necessary to promote workforce training, laboratory empowerment, and digital health technologies to facilitate the provision of data-driven stewardship practices [24].

As future projections are concerned, there is increased demand of sophisticated stewardship models which integrate novel technologies and precision medicine strategies. Electronic prescribing systems, clinical decision support tools, artificial intelligence-based resistance prediction models, and fast diagnostic testing can be useful in improving the early detection of pathogens and maximizing the use of antibiotics. Personalized dosage plans and pharmacogenomics can also enhance antimicrobial treatment by expanding treatment regimens to the unique characteristics of the individual patient [25]. Besides, real-time surveillance dashboards and data analytics platforms will be able to support ongoing surveillance of the trends of antibiotic usage and pattern of resistance. The development of multidisciplinary leadership roles of pharmacists in the ASPs will be essential in maintaining these developments. Finally, it will be necessary to defeat the existing obstacles and implement technologically advanced and evidence-based stewardship models to successfully resist the threat of multi-drug resistance in hospitals, which is constantly changing [4].

CONCLUSION

To sum up, antibiotic resistance and the proliferation of multi-drug resistant (MDR) organisms is a significant health menace in the world and especially in hospital environments where there is high usage of antibiotics and high populations of vulnerable patients are concentrated. The case is always that incorrect prescribing, long-term treatment, and excessive taking of broad-spectrum antimicrobials have a major role in the emergence and transmission of resistance. In this regard, pharmacists are at the center of the stage and cannot be excluded in antimicrobial stewardship programs (ASP). Pharmacists can use systematic prescription review, dosage optimization, therapeutic drug monitoring, de-escalation, intravenous to oral equivalence, and adverse drug reaction surveillance, among others, to enhance rational and evidence-based antibiotic use. Such interventions are not only effective in decreasing the use of the inappropriate antibiotics but also enhancing the clinical care, decreasing the length of stay, decreasing the incidence of drug-toxicity, and lowering the cost of health care in general. Importantly, drug stewardship programs at the pharmacist level will help to stabilize or reduce the rate of MDR due to reduced exposure to high-risk antimicrobials, as well as stimulate targeted therapy, according to microbiological information. Even though low resources, inadequate policy implementation, and inconsistent institutional backing continue to be some of the challenges, reinforcing regulatory frameworks and incorporating sophisticated technologies can increase the success and sustainability of stewardship initiatives. In the future, it will be necessary to give pharmacists more clinical authority, access to live data and institutional, institutional support to better optimize the use of antimicrobials. Finally, the strengthening the role of pharmacist into multi-disciplinary stewardship teams is a cost-effective strategy of multi-drug resistance control and maintaining the effectiveness of the available antibiotics in the future generation.

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