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The role of pharmacists in antimicrobial stewardship programs: Strategies for optimal antibiotic use

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***Abstract*---**The rapid rise of antimicrobial resistance is one of the greatest threats to public health today. This resistance occurs when bacteria mutate or adapt to the use of antibiotics to which they were previously susceptible. When bacteria are allowed to adapt, a small number of them acquire antibiotic-resistant properties and are able to survive and pass these properties on to their offspring. This process leads to population-level increases in antibiotic-resistant bacteria, even when exposure to antibiotics is limited. Patients contribute to this phenomenon by using antibiotics unnecessarily or inappropriately. Antibiotic misuse includes using the wrong drug for an infectious organism and using antibiotics in situations where they do not prevent infection. Therefore, continued antibiotic stewardship and careful prescribing of antimicrobials are imperative to maintaining the longevity of our current antibiotic arsenal now and in the future. Antibiotic prescribing is an important component of preventing and managing the infections they are used to treat.

***Keywords*---**pharmacists, antimicrobial, stewardship, antibiotic, infections.

1. Introduction

One of the greatest public health threats today is the rapid increase in antibiotic resistance. This resistance occurs when bacteria mutate or adapt to the use of antibiotics to which they have been previously susceptible. When bacteria are allowed to adapt, a few of them that have acquired antibiotic-resistance properties are able to survive and pass on these properties to their progeny. This process results in population-wide increases in bacteria with resistance to antibiotics, even when exposure to antibiotics is limited. Patients contribute to this phenomenon through the use of unnecessary or inappropriate antibiotics. Misuses of antibiotics include using the wrong agent for an infecting organism

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and using antibiotics in situations where they will not prevent infections. Thus, the continuance of antibiotic stewardship and careful antimicrobial prescribing is imperative to maintain the longevity of our current antibiotic armamentarium now and in the future.

Antibiotic prescribing is an important component of preventing and managing the infections for which they are needed. A growing body of evidence indicates that pharmacists can and should be involved in activities that optimize antibiotic prescribing practices and other clinical pharmacy functions that help to manage antimicrobial use. In turn, pharmacists can play a critical role in antimicrobial stewardship at all levels of care. This review looks at five strategies pharmacists can employ to aid in optimal antimicrobial use through various stewardship models. Reducing population trends of the antimicrobial-resistance phenomenon requires building on these and other proposed strategies. Pharmacists bring a wealth of knowledge about infectious diseases and pharmacotherapy to patient care teams. They also practice in many environments and modalities of care delivery. They have been identified to make significant contributions to antimicrobial stewardship programs. Pharmacists have the unique knowledge, skills, and training to contribute effectively toward optimal antimicrobial use for a variety of different patient populations and settings. Pharmacists have the potential to expand their role as authorities in aspects of antimicrobial stewardship, such as surveillance, self-management, and prevention of healthcare-associated infections. We will describe the remarkable potential contributions of pharmacists to patient care and will highlight potential new areas of research into these areas of care and professional practice.

2. Antimicrobial Stewardship Programs

Antimicrobial stewardship programs are systematic approaches to ensure the optimal utilization of antibiotics. The key terms are "antimicrobial," a substance directly or indirectly acting against microorganisms; "stewardship," the careful and responsible management of resources under one's care; and "programs," a deliberate undertaking with a set of goals or objectives. Most importantly, antimicrobial stewardship programs aim to obtain optimal clinical outcomes attributable to antibiotic use. These effects are obtained through the avoidance of harmful side effects, including selecting for pathogen resistance resulting from antibiotic use. Additionally, data support programs are utilized to reduce health care costs and preserve financial resources. They also provide credible information to consumers and payers about efficient services and treatments. The additional benefit of antimicrobial stewardship programs is the reduction of patient-related costs, including patient discomfort and time off work.

The ultimate goals of antimicrobial stewardship programs are to assure safe and appropriate therapy, improve patient outcomes, prevent overutilization, reduce toxicity and cost, and minimize resistance. Antibiotic programs are directed at four levels of the health care industry. The pharmacist team is a critical stakeholder group due to the roles that its members play as therapeutic drug care advisors and their professional knowledge and expertise. A proactive direction toward patient care, a broader knowledge of disease states and related therapies, and an intimate knowledge of the pharmacotherapeutic profiles of antibiotics are

specializations of the pharmacist. Pharmacists can design and implement multidisciplinary antibacterial control programs, evaluate these programs against established goals, and recommend alternative strategies to prescribing physicians when appropriate. In addition, physician groups, nursing groups, and individuals can proactively participate in treatment decisions. Consumer groups and governmental regulatory agencies potentially promote and influence antibacterial stewardship programs. Values and support of the involved stakeholders are primary in the development and promotion of any program. Evidence-based administrations have promoted higher patient outcomes and lower health care costs. An outcome-based evaluation of antimicrobial stewardship that uses local health care and microbial profiles encourages collaboration of all involved stakeholders for achieving mutual interest goals. Several nonspecific target health care indicators favor antibiotic stewardship as another dimension of promoting medical efficiency. Evolution and modification of all ASP strategies are possible and consistent with changes in health care mores, culture, infrastructure, and management systems.

2.1. Definition and Importance

Antimicrobial stewardship refers to a systematic approach to optimizing antibiotic use. These programs are implemented by health care institutions to address antimicrobial resistance issues by focusing on sustainable system changes, inclusive of developing policies and guidelines for appropriate selection of agents, doses, and durations of therapy. Overprescribing antibiotics can have significant implications for patients and health care systems, including unnecessary side effects and greater rates of infections. Antimicrobial resistance is now a significant global issue. Infections with resistant organisms are associated with greater lengths of stay, higher treatment costs, and higher rates of mortality than those caused by sensitive organisms. As a result, the development of a variety of antimicrobial stewardship programs has accelerated. Recommendations for developing an antimicrobial stewardship program advise collaboration with a diverse group of health care professionals, including physicians, pharmacists, and administrators.

The rate of antimicrobial-resistant infections is growing while the development of new medicines slows. This results in a decreasing ability to treat common infectious diseases through the use of antibiotics. These activities have resulted in alarming rates of antimicrobial resistance. Efforts to raise awareness and support the development of strategies focused on appropriate antimicrobial use have been multiplying. Pharmacists play a unique role in contributing to this issue and are part of the solution. Each organization defines the role of pharmacists within their antimicrobial stewardship programs somewhat differently but agrees that they are critical to the success of the program. To date, excellent clinical evidence exists that describes the role of the clinical pharmacist in antimicrobial stewardship program implementations. In fact, pharmacists were at the forefront of research in the early 2000s that started to define the important roles that qualified experts in drug therapy could hold within our health human resources.

2.2. Components of Antimicrobial Stewardship Programs

The essential components in a successful antimicrobial stewardship program are leadership commitment, accountability, and implementing the drug expertise of pharmacists with prescriber habits for the best outcomes. The implementation of practical guidelines and protocols, along with the capacity for tracking antibiotic prescribing patterns, can improve individual patient outcomes and demonstrate the commitment to continuous improvement. A multidisciplinary collaboration, including pharmacy, is required to be successful. Education strategies aimed at staff or patients at the point of antimicrobial drug prescribing or supply are essential. Pharmacists are well placed to undertake most of the required education. When selecting interventions, consideration should be given to the constraints of the intervention and the local context. For example, in places with minimal capability, persuasive interventions may not be the first priority. Internally promoting or incentivizing interventions is important. The role of the pharmacist in an antimicrobial stewardship program is crucial throughout the process. Pharmacists are capable of cooperating with fellow healthcare professionals in the development and execution of protocols and guidelines for resourceful and effective antimicrobial usage. Pharmacists can help monitor and control medication use and patient outcomes. In the promotion of instructions on antimicrobial treatment, international regulatory boards continually suggest the involvement of a pharmacist. In all aspects of the antimicrobial stewardship operation, several creators suggest that a pharmacist is required. A systematic review recognized the requirements for a clinical pharmacist in adult antimicrobial treatment. Pharmacists are skilled and fully capable of contributing extensively to most of the proposed essential components in effective antimicrobial stewardship programs in hospitals.

3. Pharmacists' Role in Antimicrobial Stewardship

Pharmacists are key cogs in the wheel of antimicrobial stewardship programs. Their expertise, especially in the practice of medication management and patient education, enables the development of an optimal antibiotic therapy regimen. Pharmacists use their clinical knowledge to identify gaps in current practice and initiate or re-engineer processes to improve antibiotic use in a given healthcare setting. They offer input from the perspective of a healthcare provider who is also involved in patient care, which can be directed at both the extent to which prescribed medications contribute to therapy and the extent to which the patient will absorb, distribute, process, and eliminate the drug. For decades, pharmacists have been involved in clinical activities that have helped foster a culture of safe and effective medication usage in healthcare. Pharmacists are generally familiar with skills such as medication review, patient education and counseling, medication management, and many other interventions. Owing to variation in job duties, pharmacists can fill more than one role as part of a multidisciplinary antimicrobial stewardship team. In addition, pharmacists can provide education to patients, staff, or clinicians regarding the correct use of antibiotics. It is unwise for healthcare practitioners to prescribe or initiate therapy without collaborating with the professionals who provide medication guidelines and recommendations for using drugs appropriately. They can also be responsible for evaluating preliminary data outcomes and planning further strategies as they interpret

pharmacokinetic data, perform sensitivity testing, and discuss practice with other staff. Massive variations exist with respect to the key benchmarks that antimicrobial stewardship undergoes and the multidisciplinary makeup of the teams. The important part, however, is that measurements are being taken and responsibilities are met, regardless of which staff are included or what benchmarks are necessary. The role of pharmacists operating alone, or as team members with other practitioners, is pivotal in achieving success in the total impact of antimicrobial stewardship programs within targeted healthcare facilities.

3.1. Education and Training

As pharmacists become more actively involved in implementing and leading antimicrobial stewardship programs, it is recommended that individuals possess relevant training and expertise in antibiotics and resistance to effectively contribute. This can include knowledge areas such as the indications, pharmacokinetics, and pharmacodynamics of individual antibiotic agents, the clinical syndromes caused by resistant pathogens, and the mechanisms of resistance. Training for practice across a range of facilities and national standards can contribute to higher competency among pharmacists. Education and training for in-service and pre-service levels have the potential to shape a pharmacist's skill set in regard to responsible antibiotic prescribing. A systematic review of the impact of educational interventions on antibiotic prescribing found that participants in educational programs were more likely to select antibiotic prescriptions in line with guidelines. Working in multidisciplinary teams can be a challenging aspect of antimicrobial stewardship. A study investigating physician and pharmacist stewardship attitudes found that clinical pharmacists held different perceptions of what the role of the pharmacist within a stewardship program should include. Attitudes towards collaboration with other healthcare professionals were not varying for physicians, while up to 50% of the pharmacist respondents did not believe in optimal collaboration between physicians and pharmacists. Consequently, education that is delivered across healthcare disciplines may be more beneficial in fostering collaborative practice in stewardship. Educational resources that include an adult-learning framework are more likely to be effective. Resource design should be tailored to respond to learning styles, allowing practice pharmacists to relate their learning to real-life experiences.

3.2. Clinical Decision Support

Over the past decade, technology has been proposed as one possible solution to help optimize the work of pharmacists. Clinical decision support (CDS) describes the use of patient- and program-specific information, combined with a database of up-to-date guidelines and evidence, to generate patient-specific assessments or recommendations that may assist clinicians and their patients in making superior decisions about their health care. Antibiotic CDS tools provide information and help guide individual patient care, therapy, or laboratory testing. This approach is anticipated to help pharmacists improve their decision-making and establish an optimal antibiotic, dose, or duration. Clinical support systems have been shown to reduce clinical errors and adverse drug reactions. Currently, they are used in

the ordering of many other laboratory and medical tests and have the unique potential to provide patient-specific advice in real time. Thus, CDS tools have the potential to advance the role of pharmacists and contribute to the ASPs. (Qin et al., 2013)(George et al.2013)(Divecha et al.)

A number of studies and systematic reviews have demonstrated the positive impact of clinical decision support in terms of enhancing the appropriateness of healthcare decision-making, as well as health-related outcomes. They have displayed utility in providing recommendations for drug prescribing, lab requests, and diagnoses. In the context of antibiotic stewardship, such systems are exploring the potential to assist pharmacists in making optimal treatment recommendations. While the role of clinical pharmacists as part of an antimicrobial stewardship team is well established, the impact of such teams can be limited by their ability to optimally staff and the need for prospective audit and feedback of treatment recommendations. This is where technologies that aid pharmacists in their roles may offer an opportunity to increase their reach and influence within an organization. Despite these potential benefits, to date, the utilization of these tools has remained low for a variety of reasons. Until recently, limited and cumbersome data sources have restricted their flexibility and effectiveness. While data and support for developing such CDS are increasing, there is still a lack of a standardized method to design such systems, and erroneous decisions could lead to patient harm. Furthermore, these systems generally provide advice only for the user of the CDS and do not directly impact the care of the patient.

3.3. Collaboration with Healthcare Team

The guidelines for the use of antibiotics suggest that such guidelines should be developed by a team of healthcare professionals working together to improve clinical practice. Professional societies will play a major role in promoting positive outcomes from antibiotic guideline implementation by educating healthcare professionals and generating new knowledge in clinical practice through the evaluation of antimicrobial stewardship outcomes.

There is a large body of evidence supporting the essential need for collaboration among physicians, nurses, and pharmacists to prescribe, dispense, and administer medications, all of which are vital to patient care. By creating cohesive and multitasking work units, facilities with small numbers of healthcare professionals may effectively provide the same comprehensive ASP services provided by facilities more completely staffed with healthcare professionals. Effective communication techniques are vital to empower other healthcare professional team members to work together with pharmacists to ensure optimal patient management through a rational and infectious disease-specific approach to achieving goals. Strategies for giving feedback on prescribing decisions and facilitating monitoring and control measures after initial antimicrobial guideline implementation are varied and are based largely on specific institutional resources and the healthcare professional knowledge and staff skills.

4. Strategies for Optimal Antibiotic Use

Adhering to established guidelines through appropriate prescribing and dispensing of antimicrobials, incorporating dosing, duration, route of administration, and dose adjustment based on the patient's renal function, can enhance optimal antimicrobial use. These guidelines can assist prescribers in the development of appropriate and safe treatment plans. It is essential that prescribers adhere to these guidelines in order to prevent patient harm, secondary infections, and Clostridium difficile. Pharmacists are ideally placed to monitor and evaluate appropriate antibiotic therapy. This service not only improves patient safety but also reduces the usage and cost of antibiotics. It is also essential to engage patients in discussions about antibiotic necessity, possible side effects, and what they should do if these side effects occur at both the time of prescribing and dispensing. These cross-disciplinary interventions can play a significant role in a patient-centered approach to stewardship.

One of the most effective ways to change practice and encourage optimal antimicrobial use is to implement targeted interventions involving educational components. Audit and feedback mechanisms have also been proven to be effective strategies to improve antimicrobial prescribing and dispensing, leading to modest reductions in targeted prescriber- and patient-related outcomes. It has also been recommended that continuous education of healthcare providers is required as guidelines are frequently updated. Continuing education can assist pharmacists and other healthcare professionals who are not specializing in the area of infectious diseases and pharmacotherapy to adhere to best current practice in prescribing and dispensing antimicrobial therapy. Pharmacists, therefore, play a very important leadership role in promoting antimicrobial stewardship. In doing so, they have the opportunity to reduce the burden of bacterial resistance and save many lives. They can adopt several strategies to intervene in any part of the patient journey in order to optimize the use of antimicrobials for the benefit of individual patients and communities as a whole.

4.1. Guideline Adherence

The adherence to locally adapted clinical guidelines is one of the key strategies in antimicrobial stewardship, ensuring that antibiotics are prescribed in appropriate doses for the right indication and for the shortest necessary duration. Many societies have established evidence-based clinical guidelines to promote appropriate antibiotic use in hospitals and in the community. The pharmacist can play a critical role in promoting guideline adherence within the institution by raising awareness and providing training with the latest guidelines, incorporating recommendations into order entry systems, and educating colleagues and patients. Major challenges to guideline adherence include the wide variability in clinical practice, lack of awareness of guidelines and education, and concerns related to legal liability and reimbursement. Information technology solutions may help to avoid these challenges, such as requiring a clinical decision support alert to have an override or requiring documentation in case of wide deviation from guidelines. Adherence to guidelines reduces resistance rates and improves patient outcomes. (Kakkar et al. 2013)(Mendelson et al. 2013)(Gitaka et al. 2013)

The pharmacist can play a role in this regard by working with antimicrobial stewardship team members to promote ongoing development and updating of guidelines, ensuring that they are rational, practical, and simple to implement. The pharmacist should actively promote guideline adherence, understanding the importance of timely initiation of therapy, including early administration of empirical therapy, early de-escalation to optimal broad-spectrum antibiotic therapy, and prompt initiation of definitive therapy when susceptibility data are available. Early identification and treatment ensure higher cure rates and less rebound illness. Using the highest level of evidence in guidelines ensures a rational approach to managing pharmaceutical products. Educational efforts for guideline development and adherence need to occur for both patients and providers.

4.2. Antibiotic Stewardship Interventions

Various interventions to optimize antibiotic use have been implemented and studied. A few examples of interventions include formulary restrictions, involving hospital pharmacists with interventions such as prior authorization and formulary changes, and the use of audit-feedback interventions. Implementing targeted interventions in the inpatient and outpatient settings for conditions known to result in unnecessary antibiotic use has been shown to be effective. These interventions encompass the involvement of pharmacists in the stewardship process and are ideal for hospital pharmacists to undertake. Many pharmacists across the country are involved in co-managing patient care, counseling, and being a part of medical rounds with physicians. Pharmacists can participate in raising awareness, improving overall knowledge of antimicrobial resistance, and promoting actions that take into consideration the global burden of resistance. Unfortunately, many hospital and clinical pharmacists have yet to get involved.

A review of antimicrobial stewardship focusing on the role of the pharmacist discusses the variety of interventions pharmacists can utilize to optimize antimicrobial use. An in-depth discussion regarding each type of intervention and how it can be utilized within antimicrobial stewardship is included, such as those stated above as well as "post-prescription review" conducted by a pharmacist. Case studies demonstrate the effectiveness of pharmacist-led interventions in antimicrobial stewardship. Examples of operational challenges highlight the practicality of initiating antimicrobial stewardship at their institution. Joining a multi-disciplinary team is emphasized as a key factor for successful implementation and adherence to the stewards' recommendations. Additionally, it indicates that "real-world" challenges exist in implementing these interventions. Given these examples, it is important to assess the willingness of the community and the healthcare team to participate in stewardship activities. Additionally, team customization is of the utmost importance, and formulary restrictions, audit-backs, and restrictions are expansions on the basic concept modified to meet the regional needs of each institution. Formulary approvals take into account factors such as antimicrobial resistance patterns in the area, the disease state, and the prescribing physician. However, it is essential to ensure that the practical challenges highlighted are managed effectively to ensure the success of stewardship interventions and compliance. Some formularies may be too long and

cumbersome for the medical staff, thus eliminating the restriction process. Additionally, it is important to avoid difficulty establishing antimicrobial infections. In essence, it is crucial to focus on implementing stewardship in routine care. Encouraging your colleagues to buy into the program and the ongoing evaluation and modification of interventions as outlined is essential for the program's potential success.

5. Conclusion and Future Directions

The importance of optimizing antibiotic use cannot be overstated, not only to improve patient outcomes but also to try to stem the tide of emerging resistance. Pharmacists play an integral role in promoting optimal antibiotic use as part of an interprofessional team, and their impact is further enhanced when involvement is part of a formal ASP. Strategies that pharmacists can employ to enhance their role in an ASP focus on interprofessional education, prescriber engagement, leadership, and collaboration.

As more practice-based research is conducted and programs evolve, continued commitment to innovation is important. Potential future research into the role of pharmacists in ASP may examine whether the positive relationship between pharmacist involvement and ASP success can be causally attributed to ASP involvement, and whether it is pharmacists in particular who affect success. More robust evidence on the effectiveness, cost, and sustainability of different strategies employed by pharmacists in antibiotic stewardship will also likely have a significant impact. However, continued progress in ASP participation will be necessary, and this will be facilitated by policy change. Furthermore, improvement of the wider public's understanding of the need for AMS is important, given that public demand for antibiotics can drive inappropriate prescribing regardless of availability.

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دور الصيادلة في برامج الإشراف على مضادات الميكروبات: استراتيجيات الاستخدام الأمثل للمضادات الحيوية

1. مقدمة

تُعدّ الزيادة السريعة في مقاومة مضادات الميكروبات من أكبر التهديدات التي تواجه الصحة العامة اليوم. تحدث هذه المقاومة عندما تتحور البكتيريا أو تتكيف مع استخدام المضادات الحيوية التي كانت حساسة لها في السابق. عندما يُسمح للبكتيريا بالتكيف، فإن عددًا قليلاً منها يكتسب خصائص مقاومة للمضادات الحيوية ويكون قادرًا على البقاء على قيد الحياة ونقل هذه الخصائص إلى ذريته. تؤدي هذه العملية إلى زيادات على مستوى السكان في البكتيريا المقاومة للمضادات الحيوية، حتى عندما يكون التعرض للمضادات الحيوية محدودًا. يساهم المرضى في هذه الظاهرة من خلال استخدام المضادات الحيوية غير الضرورية أو غير الملائمة. يشمل إساءة استخدام المضادات الحيوية استخدام العقار الخاطئ لكائن حي مُعدٍ واستخدام المضادات الحيوية في الحالات التي لا تمنع فيها العدوى. وبالتالي، فإن استمرار الإشراف على المضادات الحيوية ووصف مضادات الميكروبات بعناية أمر حتمي للحفاظ على طول عمر ترسانتنا الحالية من المضادات الحيوية الآن وفي المستقبل.

يُعد وصف المضادات الحيوية مكونًا مهمًا في الوقاية من العدوى التي تُستخدم لعلاجها وإدارتها. تشير مجموعة متزايدة من الأدلة إلى أن بإمكان الصيادلة، بل وينبغي عليهم، المشاركة في الأنشطة التي تُحسّن من ممارسات وصف المضادات الحيوية وغيرها من وظائف الصيدلة السريرية التي تساعد في إدارة استخدام مضادات الميكروبات. في المقابل، يمكن للصيادلة أن يلعبوا دورًا حاسمًا في الإشراف على مضادات الميكروبات على جميع مستويات الرعاية. تستعرض هذه المراجعة خمس استراتيجيات يمكن للصيادلة توظيفها للمساعدة في الاستخدام الأمثل لمضادات الميكروبات من خلال نماذج إشراف مختلفة. يتطلب الحد من الاتجاهات السكانية لظاهرة مقاومة مضادات الميكروبات البناء على هذه الاستراتيجيات وغيرها من الاستراتيجيات المقترحة. يُقدّم الصيادلة ثروة من المعرفة حول الأمراض المعدية والعلاج الدوائي لفرق رعاية المرضى. كما أنهم يمارسون المهنة في العديد من البيئات وطرائق تقديم الرعاية. وقد تم تحديدهم لتقديم مساهمات كبيرة في برامج الإشراف على مضادات الميكروبات. يمتلك الصيادلة المعرفة والمهارات والتدريب الفريد للمساهمة بفعالية نحو الاستخدام الأمثل لمضادات الميكروبات لمجموعة متنوعة من السكان والإعدادات المختلفة. يتمتع الصيادلة بإمكانية توسيع دورهم كسلطات في جوانب الإشراف على مضادات الميكروبات، مثل المراقبة والإدارة الذاتية والوقاية من العدوى المرتبطة بالرعاية الصحية. سنصف