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PHARMACIST-LED INTERVENTIONS TO IMPROVE ANTIBIOTIC STEWARDSHIP IN HEALTHCARE SETTINGS

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Abstract

The use of antibiotics needs to be carefully managed so we can make the best use of these medicines, limit the risk of developing resistance to them, and therefore improve our patients' outcomes once we treat them in a hospital or similar environment. Pharmacists play a key role in making sure that the use of antibiotics is well managed through medication review, dose adjustment, monitoring of treatments, and working collaboratively with other members of the health care team. The objective of this research study was to evaluate the effectiveness of pharmacist-initiated and pharmacist-led initiatives to promote optimal use of antibiotics in the hospital and community pharmacy settings. The key pharmacist interventions included: proactive review of antibiotic use with provision of verbal and written feedback; implementation of clinical practice guidelines; de-escalation of intravenous antibiotics to oral dosage form antibiotics; patient education; and education of other health professionals about use of antibiotics. Pharmacists also have an important role in identifying drug-drug interactions; preventing adverse drug reactions; and monitoring antimicrobial use patterns. Pharmacist-led stewardship programs have been shown to increase compliance with the clinical practice guidelines for antibiotic use, decrease the number of inappropriate prescriptions of antibiotics, decrease the length of hospital stays, and decrease the overall cost to the health care system. In addition, the pharmacist-led stewardship programs have provided support for the appropriate use of antimicrobials, and the increasing problem of developing resistance to antibiotics. The findings from this study demonstrate that pharmacists need to be part of multidisciplinary health care teams in order to enhance stewardship of antibiotics and promote the sustainable use of antibiotics.

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Introduction

The use of antibiotics has been a revolutionary improvement in modern health care by offering effective methods to deal with diseases caused by bacteria and reducing the number of people who die and become ill from these diseases throughout the world. Penicillin is just one example where antibiotics have had a dramatic influence on the treatment of those with infectious diseases and have allowed for advanced medical procedures such as organ transplants, chemotherapy for cancer, and invasive surgeries. In recent years, the widespread use of antibiotics, frequently in inappropriate ways, has led to the increased emergence of antimicrobial resistance (AMR), or the ability of microorganisms to survive exposure to antimicrobial medications. The emergence of AMR is a serious, worldwide public health issue because AMR reduces the effectiveness of treatment options for patients and places greater demands on health care systems. Some major factors that contribute to the abundance of there is of AMR include inappropriate prescribing, overuse of antibiotics, self-medication, inappropriate dosing, length of treatment, and non-compliance with clinical treatment guidelines. The number of resistant infections continues to increase and, as a result, the challenges that health care providers face to effectively manage infectious diseases will also continue to increase. Consequently, both international health organizations and government policymakers have established additional priorities for developing and implementing strategies to optimize antibiotic utilization while reducing the transmission of resistance. One of the most successful strategies used worldwide is antibiotic stewardship, or the promotion of the appropriate use of antimicrobials and the preservation of their effectiveness for future generations. (World Health Organization et al., 2023)

Antibiotic stewardship is a coordinated effort to effectively use antimicrobial medicines through evidence-based methods of prescribing. The goals of antibiotic stewardship programs are for patients to receive the appropriate antibiotic; the proper dose; the most suitable route of administration; and the most effective duration of therapy. By improving patient care outcomes and reducing adverse drug reactions, stewardship programs also aim to prevent the emergence and transmission of resistant pathogens. The healthcare community is increasingly aware of the need for stewardship programs because of the increasing challenge of infectious diseases caused by resistant organisms. Successful stewardship programs are accomplished through teamwork between physicians, pharmacists, microbiologists, nurses and infection control professionals. Working collaboratively as a team, healthcare professionals can assess trends in prescribing, identify inappropriate antibiotic use, and take steps to correct those errors. Multiple studies have shown that antibiotic stewardship programs result in less inappropriate antibiotic use by patients; lower healthcare spending; and improved patient care outcomes. Furthermore, antibiotic stewardship programs help reduce the incidence of hospital-acquired infections and prevent the development of resistance to existing antibiotics. Due to the increasing incidence of hospital-acquired infections caused by resistant organisms, antibiotic stewardship has been recognized as an important strategy for improving patient safety and sustainability in healthcare delivery across all types of clinical settings. (Centers for Disease Control and Prevention et al., 2022)

Pharmacists play an important part in drug stewardship programs because of their knowledge in drug therapy and drug administration. Pharmacists have expert knowledge of all classes of anti-infective agents, such as their mechanism of action (what they do), their pharmacokinetics (when the body gets rid of them), their pharmacodynamics (what they do to the body), their dosing schedule and doses, and how they interact with other drugs. Pharmacists apply their expertise to critically assess the validity and appropriateness of each antibiotic prescription and to provide scientifically based recommendations for improving therapy with all classes of antibiotics. Pharmacists are frequently members of the multidisciplinary, drug stewardship teams in the majority of healthcare settings, and they are actively involved in reviewing antimicrobial use, monitoring therapy, and making therapeutic decisions about the use of anti-infectives. Their involvement will improve the appropriateness of the prescribing of antibiotics and increase the likelihood of achieving the desired clinical outcome after using an antibiotic. Additionally, pharmacists identify

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medication errors, monitor therapeutic responses and prevent adverse drug events resulting from the use of anti-infective agents. They also provide education to healthcare providers and patients on the proper use of antibiotics and the dangers of developing resistance to antibiotics through inappropriate use. As the complexity of treating patients with infectious diseases continues to grow, pharmacists have become increasingly involved as part of the provision of drug stewardship (in addition to traditional dispensing function) in improving the quality of healthcare and the safety of patients. (Barlam et al., 2016)

There are many global studies attesting to the efficacy of pharmacist-led interventions in improving patient care across various healthcare institutions and settings. The research has shown that there is a positive correlation between pharmacy professional participation in stewardship programs and the rate of compliance to clinical guidelines; reducing the incidence of inappropriate antibiotic prescriptions; and enhancing positive patient outcomes. Furthermore, it is also evident that pharmacist-led interventions have made significant contributions toward reducing the rates of healthcare associated infections through evidence-based and patient-centred antimicrobial therapy. Examples of pharmacist-led interventions that have been linked to other positive patient outcomes include; reduced length of stay in the hospital; reduced incidence of adverse drug reactions; and reduced overall healthcare expenditures. The presence of economic benefits will be increasingly important to healthcare systems as they face a growing burden of resistant infections and an extended length of stay in the hospital. In addition, pharmacist-led stewardship programs assist healthcare organisations to accomplish their quality improvement initiatives through the promotion of patient safety while reducing the incidence of medication-related complications. A pharmacist's continuous monitoring and assessment of antimicrobial therapies identify the potential for treatment optimisation and cost containment. (Dyar et al., 2017)

Many different studies performed across all types of healthcare environments worldwide have proven that pharmacist-led interventions positively impact patients. In addition to providing better adherence to clinical guidelines with lower numbers of inappropriate antibiotic prescribing, there is also strong evidence to support the belief that pharmacist involvement in stewardship programs results in better outcomes for patients. Additionally, by providing evidence-based antimicrobial therapy based on the needs of the patient, pharmacists are able to decrease the number of patients with healthcare-associated infections. Furthermore, when pharmacists are involved, patients tend to stay in the hospital shorter periods of time, experience fewer adverse drug reactions and spend less on healthcare overall. Economic implications have become particularly significant due to escalating costs for healthcare systems related to patients who have drug resistant infections or who have prolonged hospital stays. By utilizing continuous surveillance of antimicrobial therapies, pharmacists support health care organizations in their effort to meet quality improvement objectives by providing patient safety and reducing complications resulting from medications. By continuously monitoring and evaluating of the use of antimicrobial therapies, pharmacists also assist in identifying areas where there are opportunities to optimize treatment and contain costs. As evidence supporting pharmacist-led stewardship continues to grow, it is clear that pharmacists provide considerable value to multidisciplinary teams of providers and are contributing to the overall problem of antimicrobial resistance and improving the quality of healthcare. Bond et al., 2015)

Growing concerns over inappropriate use of antibiotics and antimicrobials have raised awareness of the need for reform in antibiotic stewardship. There is now an urgent need to enhance antimicrobial stewardship by enhancing the participation of pharmacists in all health care delivery settings. Policymakers, health care administrators, and professional associations increasingly acknowledge that pharmacists have a unique position to participate in the stewardship of antimicrobial agents based on their extensive experience managing medication and providing patient care.To improve pharmacist involvement, there are multiple requirements such as appropriate institutional support, specialized education and training programs, and collaborative practice models to allow for pharmacist participation in the decision-making process regarding antimicrobials. In many

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facilities, the progress toward program implementation has been limited by numerous barriers to success, including insufficient resources, shortages of staff, and insufficient infrastructure for stewardship within the facility. In the future, research should look at developing innovative pharmacist-led programs to explore how these programs impact clinical, economic, and microbiological outcomes. In addition, health systems should invest in increasing pharmacy education and professional development in the area of infectious diseases and antimicrobial stewardship. As health systems can incorporate pharmacists more efficiently into multidisciplinary teams, they can improve the effectiveness of antimicrobial treatment as well as decrease the burden of antibiotic-resistant infections. Therefore, further evaluation of pharmacist-led programs will continue to be necessary to inform health care policies and support a global effort to ensure the availability and effectiveness of antibiotics for future generations. (MacDougall et al., 2021)

Antibiotic stewardship promotes appropriate antibiotic use

Antibiotic stewardship is a systematic method that helps ensure responsible, evidence-based use of antibiotics across all healthcare environments. Antibiotic stewardship is of increasing global importance because of the rising levels of antimicrobial resistance (AMR), which makes current treatment options for infectious disease less effective. When used appropriately, antibiotics are chosen from a formulary of approved antimicrobials, administered by the correct route, given in an appropriate dosage, and have the duration of therapy limited based on clinical indications. By providing physicians with the tools they need to make informed prescribing decisions, stewardship programs help maximize the benefits of antimicrobial therapy while reducing patients' unnecessary antibiotic exposure. Stewardship programs exist in hospitals, outpatient offices, long-term care facilities, and community health centres. Responsible prescribing practices promoted through stewardship programs can support the reduction of inappropriate prescribing (i.e., antibiotic misuse and overuse), which contributes significantly to the development of AMR. Additionally, stewardship initiatives support patient safety through the reduction in adverse drug reactions due to inappropriate prescribing and complications resulting from inappropriate therapy. In light of the increasing difficulties faced by healthcare systems with resistant infections, antibiotic stewardship is an essential strategy that will help maintain the effectiveness of currently available antimicrobials while optimizing patient care outcomes. (Fishman et al., 2012)

The aim of antibiotic stewardship is to improve the quality of prescribing antimicrobials. In many clinical settings, individuals are prescribed antibiotics without the proper diagnosis and also for viral-related infections. These practices lead to the inability of bacteria to respond to medication that has been prescribed (i.e., antimicrobial resistance), and patients may be exposed to adverse effects due to medications being prescribed that are not needed. To prevent this information from happening, the goal of stewardship programs is to promote evidence-based guidelines for use of antibiotics and to encourage physicians to prescribe an antimicrobial only when there is a specific need for that antibiotic. Healthcare workers who participate in the stewardship program are offered education and supports to help them in making their treatment decisions. In addition, the stewardship team can monitor the prescribing pattern of each physician and provide feedback to the physician regarding their prescription use of antibiotics. This is an on-going, continuous review process, whereby the physician is encouraged to comply with the recommended treatment guidelines, which ultimately leads to a BCE of improved quality of prescribing. Healthcare facilities with an established stewardship program have demonstrated a significant reduction in inappropriate antibiotic prescriptions and improvement in compliance with clinical practice guidelines. These interventions have contributed to providing safer, higher-quality health care while maintaining the efficacy of antimicrobial agents for future use. (Dellit et al., 2007)

The role of Diagnostic stewardship in enhancing proper antibiotic use is quite important and very supportive as to how we diagnose certain illnesses. Making an accurate diagnosis can help assess whether antimicrobial therapy is warranted, as well as choose which specific antimicrobial will be the best choice for that

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patient. For this reason, Diagnostic stewardship is focusing on improving the availability of lab tests, culturing the bacteria to determine which one is present, in addition to the development and improvement of diagnostic technology, to make sure that appropriate clinical decisions can be made by the provider when diagnosing an illness, or using an antimicrobial. In addition, whenever providers have access to reliable diagnostic information, they can prescribe the appropriate antibiotic for the patient much more specifically and avoid prescribing antibiotics when they would not have been needed. The goal is to reduce the amount of empirical use of broad-based antibiotics, and to encourage the use of narrow-based antibiotics by using the defined pathogens and susceptibility patterns to choose the appropriate antibiotic(s) to prescribe to each patient. Diagnostic stewardship will also help in limiting the prescribing of antibiotics to patients who don't have a bacterial infection, thereby reducing the number of inappropriate prescriptions written. Improving the accuracy of making a diagnosis and the ability to identify infectious organisms and their resistance mechanisms with the use of newer diagnostic technologies also enhance the goals of diagnostic stewardship. The incorporation of diagnostic stewardship into antimicrobial management programs improves the precision of treatment, provides a safe environment for patients, and also helps to decrease the incidence of antimicrobial resistance. The collaborative efforts of clinicians, microbiologists and laboratory staff are the key to ensuring the maximum benefit from diagnostic stewardship projects. (Pulcini et al., 2019)

Education and training form the foundation for the development of antibiotic stewardship programs directed towards ensuring that healthcare professionals utilize antibiotics appropriately. Inadequate knowledge around antimicrobial therapy, resistance patterns, and evidence-based treatment recommendations are contributing factors to many prescribing errors. Therefore, antibiotic stewardship programs can assist in improving the knowledge gap by providing ongoing educational opportunities such as educational activities, workshops, seminars, and clinical training as a means of keeping healthcare professionals up-to-date regarding current guidelines, emerging patterns of resistance, and appropriate methods of prescribing antibiotics. Providing ongoing education can also increase a healthcare professional's awareness of the consequences resulting from inappropriate utilization of antibiotics, as well as the need to preserve the effectiveness of antimicrobial agents. Many times, antibiotic stewardship programs will also include strategies for educating patients in an effort to promote responsible use of antibiotics while discouraging self-medication. Patients who receive education regarding antibiotics are more likely to comply with prescribed treatment, and to understand that antibiotics may not be required for all conditions. Studies indicate that educational programs targeted to healthcare professionals significantly improve prescribing behavior, resulting in a long-term decrease in inappropriate use of antibiotics. Consequently, ongoing education is an essential element for any successful antibiotic stewardship program and is critical in promoting the rational use of antimicrobial therapies. (Charani et al., 2013)

Antimicrobial stewardship also improves health care outcomes by decreasing the rate of adverse drug reactions and Associated Health Care Infections. While antibiotics are useful for treating many bacterial infections, inappropriate antibiotic prescribing can lead to serious side effects. Some of the adverse effects of antibiotics are: allergic reactions, gastrointestinal upset, damage to organs, and development of opportunistic infections. Antimicrobial stewardship programs help minimiZe the risk of adverse drug reactions by ensuring that antibiotics are only prescribed when they are necessary and within clinical guidelines. Reducing the number of antibiotics given unnecessarily also reduces the chance of drug-resistant organisms or pathogens causing infections (e.g., Clostridiodesdifficle). Antimicrobial stewardship strategies that are implemented well by health care entities frequently demonstrate improvements in patient safety metrics, as well as decreases in complications related to infection. The benefits of these improvements are realized beyond each patient individually, to health care systems generally, with fewer hospitalizations, shorter lengths of hospital stays, and decreased expenditures for health care. Therefore, Antimicrobial Stewardship serves both as a resistance prevention strategy and as a broad-

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based technique to promote quality improvement in health care and patient-related outcomes. (Baur et al., 2017)

Ongoing dedication to and support for antibiotic stewardship/future achievements in this area largely depend on organizations/healthcare practitioners/policy-makers. Resistance to antimicrobials continues evolving, putting forth new challenges for stewardship programs and requiring them to adopt new and innovative strategies for managing antimicrobials. Rapidly developing technologies as they relate to health information, electronic-prescribing, and clinical decision support systems can facilitate improvements in the way antibiotics are prescribed. In addition, by creating opportunities for expanded collaboration among multiple disciplines, stewardship activities can be strengthened and become more efficient/effective. Policymakers must support the commitment to antibiotic stewardship by establishing regulations and providing resources to support its implementation in all levels of care, including hospitals, clinics, and long-term care facilities. Research/surveillance are key components of understanding the trends of antimicrobial resistance and evaluating the effectiveness of stewardship interventions. Continued investment in stewardship infrastructure/development of professional education on stewardship will improve the likelihood of sustainability for these programs. Through responsible antibiotic use, antimicrobial stewardship ultimately promotes public health, maintains the effectiveness of currently available antimicrobials, and supports the provision of high-quality healthcare services. The promotion of antibiotic stewardship, as it relates to the responsible use of antibiotics, will address one of the most significant global health issues facing the world in the twenty-first century.(Schuts et al., 2016)

Pharmacists help optimize antibiotic therapy

Pharmacists are crucial players in optimizing antibiotic therapy by ensuring appropriate use of antimicrobial agents, as well as adhering to clinical guidelines and the individualised requirements of patients. They have a wealth of knowledge regarding pharmacology, infectious diseases, and medication management which allows them to evaluate whether prescribed antibiotics are appropriate and make recommendations for changes when necessary. Optimisation of antibiotic therapy includes choosing the best antimicrobial agent for the patient while reducing or minimising toxicity, adverse effects, and the possibility of developing antimicrobial resistance. Prior to recommending antibiotics, pharmacists assess the patient's age, weight, organ function, history of allergies, and presence of comorbidity. They also review microbiological data such as culture and susceptibility reports to confirm the treatment is directed specifically at the organism cultured. In the scope of these activities, the role of pharmacists in improving therapy outcomes and decreasing unnecessary use of antibiotics is significant. In today's healthcare environment, pharmacists are becoming increasingly recognised as integral members of the multidisciplinary team working towards the management of infectious diseases. The involvement of pharmacists in optimizing antibiotic therapy enhances the quality of antimicrobial prescribing and supports evidence-based clinical decision-making. As healthcare systems continue to deal with the increasing challenges of resistant infections, the role of pharmacists in optimising antibiotic therapy will continue to grow in importance in promoting the safety, effectiveness and sustainability of antimicrobial treatment. (Hecker et al., 2003)

Pharmacists utilize several methods for optimizing antibiotics in a person's treatment plan and one of the main ways is through dosing adjustments and developing individualized treatment plans for patients needing antibiotics, if possible. The dosing of antibiotics must be individualized to get the optimal amount of therapy while minimizing toxicity or adverse reactions. Developing the appropriate dosing regimen for each patient involves specialized knowledge about pharmacokinetics and pharmacodynamics, which is part of the pharmacist's training, and it enables pharmacists to create the best dosing regimens based on the unique characteristics of each patient. For example, patients with renal failure or liver failure may require a lower dose of an antibiotic compared to a person without these problems due to the increased chance of accumulation (i.e., build up) of the dose in the body and increase the risk of developing toxicity. In addition, patients who are critically ill may require either larger or

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more frequent doses than the average adult to achieve the appropriate concentrations of the antibiotic at the site of infection. To assess whether the antibiotic is working or needs to be adjusted, pharmacists will monitor laboratory values and/or clinical signs and symptoms of infection in order to help make any necessary changes to the patient's antibiotic dosing. Pharmacists will also evaluate any other medications the patient may be taking to assess drug-drug interactions which may negatively impact the efficacy of the antibiotic or compromise the safety of the patient. By individualizing and optimizing dosing of antibiotics, pharmacists are able to provide maximum therapeutic benefits to the patient through appropriate utilization of antibiotics, as well as decrease the amount of antibiotic exposure that is not necessary for that patient. Pharmacists' ability to provide individualized medication therapy management results in improved patient outcomes by decreasing recovery times and healthcare costs. Because of the pharmacist's role in providing individualized medication therapy management, they are a valuable component of antimicrobial stewardship and optimize antibiotic therapy in the healthcare system. (Roberts et al., 2014)

The responsibilities of pharmacists also include significant contributions to assisting with appropriate antibiotic selection through their antimicrobial reviews and clinical consulting services. In many healthcare institutions, pharmacists routinely evaluate prescriptions for antibiotics to determine whether the prescribed antimicrobial agent is appropriate for the infection diagnosed. Pharmacists review patient-specific information, lab test results, microbiological cultures and treatment guidelines prior to providing recommendations on antibiotic therapy to the prescribers. When broad spectrum antibiotics are used without reason, pharmacists can recommend alternative therapies (i.e., narrower spectrum) that will effectively kill the organism causing the infection and prevent the organism from developing antimicrobial resistance. Pharmacists will recommend the discontinuation of antibiotics when evidence shows that there is unlikely to be an organism causing the infection or there is no further need for the antibiotic. These activities lead to more accurate and evidence based prescribing of antibiotics. In most cases, pharmacists work closely with infection disease specialists and physicians to create the best treatment options for patients with complicated infections. By providing their expertise throughout the patient's entire course of therapy, pharmacists are able to promote rational antibiotic use and help decrease antimicrobial resistance, while ultimately improving the quality of patient care in healthcare facilities. (Kullar et al., 2013)

A pharmacist's involvement in the optimization of antibiotics is further exemplified by the role of therapeutic drug monitoring (TDM) in dosing antibiotics with narrow therapeutic ranges. TDM allows the pharmacist to measure the amount of the drug in the bloodstream in order to determine if the patient has achieved a therapeutic effect without experiencing toxic side effects. In particular, when using medications like vancomycin and aminoglycosides that require frequent TDM due to the potential for treatment failure (resulting from sub-therapeutic drug levels) or serious adverse events (resulting from supra-therapeutic drug levels), the pharmacist interprets the medication concentration data to adjust the dosing based on patient factors including renal function, weight, severity of the infection and patient response to treatment. Through TDM, the pharmacist has an important role in ensuring that antibiotic therapy remains safe and effective throughout the treatment course, especially in critically ill patients where changes in physiology can have a dramatic impact on drug disposition. Studies show that pharmacist-administered TDM improves outcomes and decreases complications associated with medication therapy. Pharmacists are also key contributors to successful and safe therapy by optimizing the treatment course by improving the therapeutic level of the antibiotics while reducing the risk of inappropriate dosing or prolonged use of antibiotics. (Pai et al., 2015)

Another vital area that pharmacists help optimize antibiotic treatment is patient education. The proper prescribing plus properly educating and adhering to the medical regimen established when treating with antibiotics creates an effective treatment of an infection. As the clinical expert for patients, pharmacists educate patients on appropriate ways antibiotics can be utilized; they educate patients on the appropriate dosing schedule, how long to take, how to store antibiotics, and what potential side effects are

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likely to occur. They also help communicate to patients the importance of completing their course of prescribed antibiotics and the potential dangers of self-treating using leftover antibiotics. Finally, they educate patients on why antibiotic therapy is ineffective for viral illnesses, such as the flu or a common cold. Pharmacists develop patient awareness of appropriate use of antibiotics; thereby supporting public health and decreasing actions that will lead to antimicrobial resistance. Pharmacists also address patient concerns, provide answers to questions regarding medication safety, and give direction on how to handle any adverse effects that may arise. Through the pharmacist's effective communication and involvement with patients, adherence to a prescribed therapy is improved so the patient will experience a positive treatment outcome. The educational interventions provided by pharmacists greatly enhance the public's awareness of antimicrobial resistance and will help to reinforce and support the principles of antimicrobial stewardship in both healthcare facilities, as well as community environments. (Sanchez et al., 2016)

As the role of pharmacists continues to grow in the quest for optimal antibiotic therapies, increasing recognition of their abilities within today's healthcare systems has contributed to this trend. Advances in clinical pharmacy practice have allowed the potential for pharmacists, through their involvement in antimicrobial management, consultations on infectious disease, and the implementation of stewardship programs to assume more active roles in their respective fields. Consequently, many healthcare organizations now include pharmacists on multidisciplinary teams who help in the development of institutional policies governing the appropriate use of antibiotics, monitoring of antibiotic use, as well as evaluation of treatment outcomes. Furthermore, the contributions of pharmacists are not limited to their direct involvement in providing care to individual patients; rather they contribute to broader organizational initiatives aimed at improving the quality and safety of healthcare as well as decreasing antimicrobial resistance. As the challenges facing healthcare continue to evolve, the expectation is that pharmacists will assume an increasingly more critical role in supporting evidence-based prescribing of antibiotics, as well as fostering practices that promote sustainable use of antimicrobials. Investments in specialized training and continuing education, as well as collaborative practice models will further expand the capabilities of pharmacists to optimize antibiotic therapies. Enhancing the role of the pharmacist in antimicrobial management can assist in improving patient safety, decreasing overall healthcare costs, and preserving the effectiveness of existing antibiotics. Thus, pharmacists will continue to be critical members of the healthcare community, assisting in global efforts to decrease antimicrobial resistance and maintain the viability of antibiotics used for patient care. (Goff et al., 2017)

Key interventions include medication review, dose adjustment, and de-escalation

Antimicrobial stewardship programmes, including medication reviews, dosage adjustments and antibiotic de-escalation, use these three interventions to optimise antibiotic therapy and improve patient outcomes. These interventions ensure the appropriate prescription, safe use and effective monitoring of antimicrobial agents at all stages of the treatment cycle. Medication reviews consist of a systematic evaluation of a patient's antimicrobial treatment regimen to determine if the prescribed antibiotic is appropriate for the given infection. In conducting medication reviews, healthcare providers evaluate the clinical indication for use of the specific antibiotic, its microbiological evidence, the length of time the antibiotic will be given and the likelihood of other medications causing an adverse drug reaction. The main objective of medication review is to identify the optimal use of an antibiotic while reducing the possibility of unnecessary exposure to antibiotics. Medication reviews are especially beneficial in healthcare systems where inappropriate prescribing practices are contributing to the growing rates of antimicrobial resistance and the increased costs of providing healthcare. By conducting regular medication reviews within the framework of the provider's responsibility, healthcare teams can help to increase the efficacy of treatment and prevent or decrease the occurrence of adverse events associated with the use of antibiotics. The medication review also facilitates the use of evidence-based clinical practice and promotes adherence to clinical practice guidelines. As the global problem of antimicrobial resistance

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continues to increase, medication review has become an essential component of antimicrobial stewardship efforts to maintain the efficacy of currently available antibiotics and to ensure that high-quality patient care is being delivered. (Newland et al., 2012)

Inappropriate antibiotics are often prescribed by physicians, and it is important that we find ways to give the best treatment available. A key method in identifying these inappropriate prescriptions is through Medication Review. This allows healthcare providers to consider all of the unique patient-specific factors associated with a particular individual, including: age, weight, allergy history, renal function, liver function and the patient's current medication history. Additionally, laboratory findings, including microbiological culture and susceptibility testing results, will be examined to determine if the antimicrobial agent being prescribed is the best one for the particular patient. Medication reviews help identify potential opportunities to discontinue unnecessary antibiotic therapy, to change the duration of therapy, and also potentially to change the type of antibiotic therapy being used. All of these interventions will ultimately help to reduce the amount of exposure to antibiotics, thus decreasing the chances that resistant organisms will develop. Hospitalized patients are at a much greater risk for receiving inappropriate prescriptions because of all of the different medications they are on and also because of the complexity of the medical situation they are in; Therefore, they are particularly well-suited for this type of clinical evaluation. Medication reviews will contribute significantly to improving the overall safety of patients and ultimately improving the likelihood of their treatment success by ensuring that their antibiotic therapy is consistent with the most current national clinical practice guidelines and that it meets their individual needs. Furthermore, the ongoing performance of antimicrobial reviews on an ongoing basis will serve as an important contributor to improvements in healthcare quality and will support stewardship initiatives designed to promote the rational use of antibiotics in a wide range of different healthcare settings. (Morris et al., 2012)

Antibiotic dose adjustments are an important part of stewardship and ensure that antibiotics have the desired therapeutic effect. Achieving optimal therapeutic concentrations while at the same time minimizing toxicity and adverse effects is the goal of dose adjustment. In making appropriate dosing decisions, a variety of patient-specific factors will need to be taken into consideration, including the patient's age, body weight, renal function, hepatic function, the severity of the infection, and the patient's physiological condition. Failing to properly dose an antibiotic may lead to treatment failure, drug toxicity, or the emergence of antimicrobial resistance. Clinical and laboratory parameters are carefully monitored by healthcare professionals in stewardship programs to determine whether any adjustments to the antibiotic dose should be made. For instance, for patients with impaired kidney function, reduced doses or extended dosing intervals may be needed to prevent excessive drug accumulation in the body and resultant toxicity. Conversely, for patients who are critically ill, higher doses of an antibiotic may be necessary to provide adequate concentrations of antibiotic at the site of infection. Additionally, dose adjustments are made based on changes in the health status of the patient during the course of therapy so that treatment remains effective as the patient's condition changes. Individualized dosing through stewardship programs leads to improved treatment outcomes, fewer medication-related complications, and better stewardship of antimicrobial use. This is particularly true for antibiotics that have a narrow therapeutic index and a complicated pharmacokinetic profile. (Tamma et al., 2014)

Antibiotic de-escalation is a strategy used in antibiotic stewardship that reduces the broad-spectrum empiric use of antibiotics when defining a narrower-spectrum regimen after the microbiological results are obtained. The primary goal of this intervention is to help reduce unnecessary exposure to antimicrobial agents while still providing effective therapy against the specific pathogen once identified. Typically, empiric antibiotic therapy will be started when there is a suspicion of infection but the causative organism is not yet identified. Broad-spectrum antibiotics provide immediate coverage for many potential pathogens; however, prolonged use can lead to increased antimicrobial resistance and disruption of the normal microbial flora. Through de-escalation, clinicians can perform a more precise targeted therapy based on culture

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results, susceptibility testing, and the patient's response to treatment. In doing so, minimizing the use of broad-spectrum antibiotics decreases the selective pressure that leads to the development of resistant organisms. In addition, de-escalation minimizes adverse events related to medications used for treating infections and decreases the cost of the treatment while maintaining the same level of clinical effectiveness. There is considerable evidence demonstrating that antibiotic de-escalation leads to improved outcomes from an antimicrobial stewardship perspective and decreases rates of antimicrobial resistance. Therefore, the practice of antibiotic de-escalation has become a foundation of modern stewardship programs, which focus on optimizing the use of antimicrobials and preserving the effectiveness of antibiotics. (Leone et al., 2014)

A comprehensive strategy to improve the use of antimicrobial therapy in the setting of healthcare is the combined implementation of a medication review, dose adjustment, and de-escalation. The implementation of each intervention does not interfere with one another but rather enhances the management of antimicrobials at each point throughout treatment. While the medication review ensures the appropriateness of the therapy on an ongoing basis, the dose adjustment modifies the patient's treatment based on their individualised needs, and de-escalation decreases the duration of exposure to broad-spectrum agents unnecessarily. Collectively, using these strategies allows for a better overall clinical outcome of the patient while achieving antimicrobial stewardship objectives. Institutions that routinely utilises these individual interventions into their daily clinic practice reported a decrease in inappropriate prescription of antibiotics, decreased healthcare-associated infection rates, and decreased antimicrobial resistance. Additionally, patient safety improved via these stewardship activities by decreasing medication errors and adverse drug reactions. To achieve success with the implementation of these interventions, collaboration between physicians, pharmacists, microbiologists, nurses, and infection prevention specialists is necessary. A multidisciplinary team will allow for timely decisions regarding the use of antimicrobial therapy and ensure it continues to be evidence based on current guidelines. As the challenge of resistant infections continue to be faced by health care systems, the adoption of the key stewardship activities remains critical to ensure the responsible use of antibiotics and the ongoing efficacy of existing antimicrobial therapies. (Broom et al., 2016)

The future of antimicrobial stewardship relies upon the continued development and implementation of interventions such as review of medications, adjustment of doses, and de-escalation of antibiotics. Improvements to diagnostic technology, electronic health records, and clinical decision-support systems are anticipated to improve the efficacy of these strategies by providing more rapid and accurate information for the management of antimicrobials. Healthcare systems are spending more time and resources developing stewardship programs to provide research-based recommendations to prescribers and assist in improving outcomes for patients. Continued professional education and training will further enhance the capability of health professionals to implement interventions effectively. Continued research evaluating the effectiveness of stewardship activities on resistance rates, healthcare expenditures, and long-term patient outcomes should be a component of stewardship programs. Healthcare leaders and policymakers are key leaders for supporting stewardship initiatives through allocation of resources and other regulatory help. The reinforcement of medication review, optimization of antibiotic dosages, and facilitation of de-escalation practices will improve the way that healthcare organizations use antibiotics and reduce the growing problem of resistance. While these interventions are critical components of stewardship programs, they are necessary to help ensure that antibiotics remain effective for the future. (Van Dijck et al., 2018)

Pharmacists reduce inappropriate antibiotic prescribing

Pharmacists have an important part in reducing inappropriate antibiotic prescribing, which is a major cause of antimicrobial resistance around the world. Inappropriate prescribing is when antibiotics are used without an appropriate clinical indication, prescribed for viral infections, prescribed at the wrong dose, or used longer than needed. These types of actions not only cause the risk of developing resistant bacteria, but also put

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patients at risk of having avoidable adverse drug reactions and incur unnecessary healthcare costs. Due to their extensive knowledge of antimicrobial agents, pharmacists are in a position to detect prescribing errors and suggest alternative therapies based on evidence. Some of the ways that pharmacists participate in antimicrobial stewardship programs is by reviewing prescriptions, determining if the treatment is appropriate for the problem being treated, and providing guidance to prescribers on how to use antibiotics properly. In doing so, pharmacists assist in ensuring that antimicrobial therapy conforms to approved clinical practice guidelines and the current microbiological findings available at the time of therapy. By promoting rational prescribing, pharmacists have a significant impact on improving patients' health and preserving the effectiveness of the antibiotics available. The value of pharmacist-led interventions to help overcome prescribing challenges and provide medication safety has become more evident to healthcare organisations. As concern over antimicrobial resistance increases, pharmacists will continue to be important members of the healthcare team to help reduce the inappropriate use of antibiotics and promote the rational use of antimicrobials in many different settings. (Schoffelen et al., 2015)

The most significant way that pharmacists can help prevent the inappropriate prescribing of antibiotics is by performing a prospective review of all prescriptions before they are dispensed (prospective prescription review). During this process, they will examine and evaluate antimicrobial prescriptions prior to and sometimes shortly thereafter being dispensed to determine whether or not the prescribed therapy will appropriately treat the patient's actual infection. Factors considered during this review process include: an established diagnosis of the infection; microbiological evidence confirming the presence of the organism(s) causing the infection and any associated susceptibilities; known allergy history for the selected antibiotic drug; renal function; length of therapy. When an inappropriate prescription is found, the pharmacist will communicate directly with the prescribing physician and make recommendations to modify the antimicrobial therapy. The recommendation may include the use of an alternative antibiotic drug, an adjustment in the dosage schedule of the original antibiotic drug, a reduction of the length of therapy, or simply discontinuation of the antimicrobials altogether if they are not needed. The prospective review process allows other health care professionals to identify and correct discrepancies in prescribed therapy prior to the prescription's impact on the patient's health. Studies have illustrated that pharmacist-led prospective reviews of prescriptions decrease the frequency of inappropriate use of antimicrobials and enhance physician compliance with evidence-based practice standards. Additionally, pharmacist-led prospective reviews of prescriptions further the goal of antimicrobial stewardship (ie, reduce patient exposure to unnecessary antimicrobials and the opportunity for antimicrobial resistance development). By continuing to conduct these functions in a timely fashion, pharmacists create a safer environment for prescribing and assist in developing more effective methods to manage patients with infections within health care systems. (Bessesen et al., 2015)

Pharmacists are also responsible for promoting the use of clinical guidelines and organization-specific antimicrobial policies to reduce inappropriate use of antibiotics. Clinicians use evidence-based guidelines that inform them about selecting, dosed, prescribed, monitored, and how to treat specific diseases/conditions. Due to factors including practitioners' experience or clinical workloads, their adherence to guidelines may differ. Pharmacists are instrumental in providing up-to-date information on clinical guidelines to practitioners and ensuring that the prescriber adheres to established guidelines in their prescribing decisions. They are involved in developing and implementing antimicrobial policies that prescribe appropriate antibiotic use in healthcare organizations. They conduct regular audits of practitioners' prescribing habits and provide educational feedback to practitioners on how to improve their prescribing habits. These education and quality improvement activities increase practitioners' understanding of judiciously used antimicrobial prescription and promote consistent use of evidence-based prescribing. From their support for guideline-based therapy, pharmacists will decrease inappropriate prescription of antibiotics and support efforts to

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fight the development of antimicrobial-resistance. Their contribution will enhance the level of patient care and reduce the effectiveness of antibiotic stewardship efforts. (Nathwani et al., 2019)

Another significant strategy for pharmacists is the use of microbiology and lab data to assist in targeting the appropriate use of antimicrobials. In many healthcare systems, broad-spectrum antimicrobial treatment is begun before the specific organism is positively identified (i.e., on the basis of clinical presentation). This is often required with severe product infections but has the potential to contribute to resistance, as well as provide increased chances for adverse events when prolonged broad-spectrum antibiotic regimens are utilized. Pharmacists monitor results of culture and sensitivity tests as they are available, and partner with physicians to modify therapy when appropriate. This allows the provider to shift from an empirical treatment approach to a pathogen-directed therapy approach, thus reducing inappropriate exposure to antibiotics. Likewise, pharmacists will identify instances in which antibiotics can be safely discontinued when lab test results suggest no possible bacterial infection exists. Their expertise in interpreting microbiologic data helps ensure that treatment decisions are based on valid and pertinent clinical data. These activities by pharmacists promote more precise treatments and help minimize the chance of inappropriate prescribing practices. In addition, effective use of active laboratory data is a major component of an antimicrobial stewardship program. Overall, these aforementioned activities represent a substantial means by which pharmacists optimize the use of antibiotics and improve patient outcomes. (Moehring et al., 2017)

Pharmacists utilize education to decrease incorrect antibiotic prescriptions through educating patients and educating healthcare professionals. Just like everyone else, patients and healthcare providers have misconceived ideas about antibiotic use, and this directly leads to unnecessary use of antibiotics. Education provided by pharmacists to patients focuses on the difference between bacterial and viral infection and the appropriate reasons to use an antibiotic, as well as the problems that arise from misuse of antibiotics including the potential developments of resistant organisms. Through workshops, counselling and training sessions, pharmacists promote evidence-based prescribing habits and also provide education around stewardship principles. By educating patients about appropriate uses for antibiotics, they are decreasing the demand for inappropriate use and increasing adherence to instructed dosing. By educating healthcare providers about current guidelines of use, the latest resistance trends, and appropriate management strategies for antimicrobial therapy, educational initiatives from pharmacists have demonstrated improvements in the prescribing habits of practitioners and decreased inappropriate use of antibiotics through the development of a better understanding of responsible use of antimicrobials. Pharmacists contribute to the long-term improvement of the prescribing habits of healthcare providers through the establishment of greater understanding of responsible use of antimicrobials, as well as contributing to the overall public health effort to maintain antibiotic effectiveness. As a result of their education efforts, pharmacists play a critical role in the success of stewardship programs and as a means to reduce inappropriate use of antimicrobials. (Pulia et al., 2020)

Pharmacists' increased role in antimicrobial stewardship has produced great advantages by decreasing the inappropriate prescribing of antibiotics throughout the healthcare system. Pharmacists will help to deliver positive results/benefits via the following modalities; prescription review; guidelines implementation; microbiological interpretation; optimization of therapy; and education, all of which will enhance the quality of pharmacist prescribing. These same healthcare systems that have made pharmacist participation a primary goal of their stewardship program show consistently lower rates of inappropriate antibiotic use; lower rates of resistance to antimicrobials; and better overall patient safety outcomes. The overall success of these programs further emphasizes the need for a collaborative/ multidisciplinary approach to workflow systems that address the complex issues regarding treatment of infectious diseases. As the healthcare systems continue to face new patterns of resistance, it is anticipated that the role of the pharmacist will continue to grow in this area. To this end, efforts should be made to continually expand the roles of pharmacists regarding

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participation in stewardship programs; provide additional training opportunities; and establish additional collaborative practice models. Investments in each of these key areas will enable the ongoing enhancement of antimicrobial prescribing practices and facilitate the continued effectiveness of previously available antibiotics; reflecting an essential partner in the promotion of rational antibiotic utilization and reducing inappropriate prescribing in modern healthcare settings. (Aldeyab et al., 2012)

Stewardship programs help prevent antimicrobial resistance

The emergence of antimicrobial resistance has become a significant threat to global public health, compromising the capability of healthcare systems to treat infectious diseases. Antimicrobial resistance occurs through the evolution of microorganisms (e.g., bacteria, viruses, fungi and parasites) to develop new mechanisms that allow them to evade the effects of antimicrobial agents. Inappropriate and excessive use of antibiotics is one of the key contributors to developing antimicrobial resistance. As a response to this public health challenge, antimicrobial stewardship programs (ASPs) have been developed to promote the responsible use of antibiotics and other antimicrobial medications. ASPs promote appropriate therapy for patients may be based on clinical evidence, microbiological data, and approved treatment guidelines, and provide coordinated interventions to minimize unnecessary exposure to antimicrobials and reduce the selective pressure that facilitates the development of antimicrobial resistant organisms. Healthcare institutions around the world have adopted stewardship processes as a component of an overall strategy to address antimicrobial resistance. By improving the quality of prescribing and enhancing evidence-based clinical decision-making, these programs have preserved the viability of existing antimicrobials. ASPs have taken on added significance as clinicians deal with increasing numbers of patients with infections due to multi-drug resistant organisms. Therefore, antimicrobial stewardship is viewed as an essential factor in the prevention of antimicrobial resistance and in the sustainable delivery of healthcare. (Davey et al., 2013)

One of the main ways stewards reduce the risk of developing antimicrobial resistance in patients is by decreasing the amount of unnecessarily prescribed antibiotics. Many times, antibiotics are prescribed in circumstances where they have little or no clinical benefit, especially with regards to treating viral infections which do not respond to any type of antimicrobial therapy. This kind of inappropriate usage of antibiotics exposes bacteria and viruses to antimicrobial agents (antibiotics) without any reason for doing so, allowing for the emergence and spread of bacterial and viral strains that are resistant to certain antimicrobial agents. Stewardship programs are designed to address the inappropriate usage of antibiotics by creating and implementing prescribing guidelines; performing changelings of prescriptions; and giving healthcare providers feedback about their antibiotic prescribing practices. These strategies encourage healthcare professionals to prescribe an antibiotic only when it is truly necessary and, when possible, prescribe the antibiotic that is most appropriate. By limiting the number of bacterial and viral organisms that are exposed to antibiotics, the effect of selecting on the development of resistant organisms is reduced and helps to maintain microbial susceptibility to the available antibiotics. Additionally, stewardship programs help to provide education for healthcare professionals about the negative effects of inappropriate antibiotic prescribing and the importance of judicious use of inappropriate antibiotics. Together with ongoing surveillance and quality improvement activities, stewardship programs play a vital role in reducing unnecessary antibiotic usage. This reduction in the unnecessary use of antibiotics is critical to slowing the rate of development of antimicrobial resistance in countries across the world. In addition, preserving the effectiveness of current antibiotics is imperative for providing quality healthcare and preserving the future ability to treat patients with appropriate antibiotics. (Howard et al., 2015)

Stewardship programs also minimize the risk of developing resistant bacteria through targeted therapy instead of broad-spectrum antibiotics for an extended period. Broad-spectrum antibiotics are usually initiated before knowing the cause of an infection. While broad spectrum antibiotics are helpful because they provide coverage for many bacteria, if they are used too much or for too long they can disrupt normal flora and create

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environments where resistant bacteria can thrive. Stewardship teams collaborate with healthcare providers to review microbiology culture results and adapt treatment plans. Once the cause of the infection is diagnosed, the "targeted" therapy will be able to be narrowed to a specific antibiotic that has an appropriate bacteria spectrum. This reduces unnecessary exposure to antibiotics as well and allows for effective treatment. Targeted therapy also decreases the level of selective pressure on non-targeted bacteria and thus reduces the chances of resistance developing in hospitals. Stewardship teams typically also encourage providers to discontinue antibiotics in a timely manner when the evidence indicates that that they are no longer necessary. By optimizing antimicrobial use and duration of therapy each stewardship intervention makes a significant contribution to preserving the effectiveness of antibiotics and reducing the incidence of resistant infections within healthcare systems. (Masterton et al., 2015)

Education and awareness initiatives are essential tools to help stewardship programs avert antimicrobial resistance. Healthcare providers, patients and the general public alike all have a significant impact upon the way in which antimicrobials are used. Stewardship programs provide the chance for education and, thus, the opportunity to better understand the appropriate use of antimicrobials, mechanisms of resistance and methods for the prevention of infection. Healthcare providers are trained to incorporate evidence-based standards into their prescribing practices, ensure appropriate diagnostic stewardship and follow principles of management. Educational interventions have been proved to effect a positive change in the prescribing habits of clinicians and support their adherence to guidelines for the appropriate use of antimicrobials. For example, educating patients about the responsible use of antibiotics, the dangers of self-medication and the potential consequences associated with antimicrobial resistance are all forms of patient education and support stewardship goals. Public awareness campaigns also support stewardship goals by encouraging individuals to seek antibiotics only when required by their medical condition. Studies demonstrate that educational initiatives significantly reduce the inappropriate use of antibiotics and improve physician attitudes about the recommendation of antibiotics. By encouraging a culture of appropriate use of antimicrobials, stewardship programs promote the prevention of resistance and enhance the long-term public health goals of antimicrobial stewardship around the globe. Therefore, education will continue to be a key component of all stewardship programs and an important strategy for reducing the prevalence of antimicrobial resistance on a global basis. (Pulcini et al., 2015)

To succeed long term in preventing antimicrobial resistance, stewardship programs need to continue their implementation and expansion in all health care settings. Each of the following health care settings, i.e., hospitals, outpatient clinics, long-term care facilities, and community health organizations, plays a major part in promoting responsible use of antimicrobials. Furthermore, successful stewardship programs require firm institutional support, collaboration among many disciplines, adequate resources, and continued professional education. Also, frequent advancement in diagnostic technologies and health care information technologies acts to enhance stewardship interventions and allow for the improvement of treatment precision. Thus, policy makers and health care leaders must maintain the investment in stewardship infrastructures so that the increased problem of resistant infections can be addressed. Future research is needed to identify new methods for managing antimicrobials, as well as measure the effectiveness of these new methods within different clinical environments. Stewards of antibiotics utilize the following methods to prevent antimicrobial resistance: optimizing the use of antibiotics, encouraging evidence-based prescribing, and encouraging the use of resistance surveillance. Continued expansion of these stewardship programs is a critical component for ensuring that living antimicrobial agents will maintain their effectiveness and provide public health protection as we encounter new infectious disease challenges. (Fridkin et al., 2014)

The stewardship program uses surveillance and monitoring to detect resistance trends as well as to determine how effective antimicrobial interventions are. In addition, many healthcare facilities collect data on antibiotics use, prescribing patterns and microbiological resistance rates; these data help stewardship

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teams locate areas of improvement and develop specific interventions to resolve newly identified issues. Additionally, the continued use of surveillance data allows healthcare providers to better identify outbreaks of resistant organisms so that they can respond quickly and limit future spread. By tracking and trending antimicrobial consumption and resistance over time, stewardship programs are able to evaluate the effectiveness of their operations and to use that information for evidence-based adjustments to prescribing practices. Effective surveillance allows for well-informed decision-making and can help guide the development of strategies specific to local resistance profiles. Additionally, providing healthcare providers with information regarding results of surveillance activities serves to increase awareness of antimicrobial resistance and encourages compliance with stewardship recommendations. Continuous monitoring is key to sustaining the success of stewardship programs and also ensuring that efforts to prevent antimicrobial resistance continue to be responsive to the changing needs of the healthcare system. Through these activities, healthcare systems will develop increased capacity to control/manage antimicrobial resistance. (Doron et al., 2011)

Pharmacist-led interventions improve patient outcomes and safety

When it comes to healthcare today, pharmacist-led interventions are critical in all levels of the system. They have been proven to improve patient outcomes and promote greater safety in the healthcare environment. A pharmacist works with the healthcare team to make clinical decisions about the appropriate medications for each patient. Their specialized knowledge of pharmacotherapy, potential drug-drug interactions, medication administration routes, and adverse drug reactions allows the pharmacist to identify, prevent, and resolve medication-related problems through direct patient care activities. The pharmacist's involvement also enables them to ensure the patient is prescribed the appropriate medication at an appropriate dose, using the right route of administration, and for an appropriate duration, which all contribute to maximizing the therapeutic outcome for the patient. Furthermore, pharmacist-led interventions help to reduce medication errors, which account for a large percentage of the preventable harm that occurs in the healthcare setting. Through their activities of reviewing prescriptions, monitoring therapy, and collaborating with healthcare professionals, pharmacists help confirm that medications are used safely and effectively. For patients at high risk (e.g. patients who are critically ill, elderly, or have multiple co-existing medical conditions), pharmacist involvement becomes critical to ensure appropriate medication management practices are used to minimize complications and enhance recovery outcomes. As the healthcare system changes, it is becoming increasingly apparent that involving pharmacists in direct patient care activities is one of the most effective methods to enhance both clinical and patient safety outcomes in multiple healthcare settings. (Kaboli et al., 2006)

Comprehensive medication review and reconciliation through pharmacist-driven interventions leads to improved patient outcomes. Medication discrepancies occur frequently at hospital admissions, transfers of care, or discharges from the hospital, resulting in adverse drug events or treatment failure. Pharmacists play an essential role in identifying and resolving medication discrepancies by interpreting the medication history of patients and coordinating care. Throughout the medication reconciliation process, pharmacists compare a patient's current medications with newly prescribed medications to identify omissions, duplications, inappropriate doses and potential drug interactions. Reduction in the risk of medication-related injuries through pharmacist intervention is significant, as a high degree of medication accuracy is established through this process. Additionally, pharmacists provide recommendations to prescribers regarding the use of alternate medications that may be safer or more effective, if deemed appropriate. Studies demonstrate that pharmacist involvement in medication reconciliation reduces readmissions, increases adherence to therapy and leads to a better overall patient experience. As a result of the pharmacist's involvement in ensuring continuity of care throughout all aspects and levels of care, avoidable complications may be reduced and overall patient safety will be enhanced. These pharmacist-led interventions are especially relevant in complex health care systems, where patients require multiple

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medications and ongoing monitoring of a patient's therapeutic response is critical to achieving optimal results. (Gleason et al., 2010)

Therapeutic medication monitoring (TDM) is an invaluable tool to help achieve optimal patient outcomes. Pharmacists are able to assist patients in reaching these optimal outcomes by ensuring that medications are maintained within their desired range of effect (i.e., to prevent sub-therapeutic dosing or potential drug toxicity). Many medications have narrow therapeutic indices (NTI), meaning that very small adjustments in dosage can result in either drug toxicity or a lack of benefit from the medication. In order to ensure that medications are working effectively with minimal side effects, pharmacists use TDM services to evaluate drug levels in the bloodstream and subsequently adjust the dosing regimen as needed to provide maximum effectiveness while minimizing adverse side effects for patients. This is particularly important for medications such as anticoagulants, antiepileptic medications, and some antibiotics - which may be dangerous to use without TDM services. In addition, through these TDM services, pharmacists assess many patient-specific factors (i.e., renal dysfunction, hepatic dysfunction, age, body weight, etc.) when developing a plan to deliver medication to patients. By working together, pharmacists can alleviate risk of complication associated with drug toxicity and drug failure. Evidence suggests that TDM managed by pharmacists results in improved clinical outcomes, decreased length of hospital stays, increased patient safety, and other benefits. Through the delivery of TDM services, pharmacists provide a crucial link between optimal dosing and ongoing monitoring of patients, which plays a role in the optimization of pharmacotherapy. This is essential to improving patient outcomes and reducing the costs of healthcare services associated with medication-related complications; therefore, TDM services can be viewed as an integral component of patient-centered care in current healthcare systems. (Bond et al., 2007)

Pharmacists demonstrate another key role in reducing adverse drug reactions and medication errors. Adverse drug reactions can cause a large number of patients to suffer from illness or death and are frequently caused by physicians prescribing medications incorrectly, by drug interaction and by errors in dosage. In the normal course of a pharmacist's day they are continually evaluating a patient's medication therapy for the possibility of harm or risk and have implemented processes to help minimize those risks. In addition to their use of clinical judgment, pharmacists also utilize evidence-based practice guidelines to identify medications that may pose a greater risk to patients when used in conjunction with other medications; and recommend alternative, safer medications to physicians. By providing education to other healthcare providers about medication risks associated with their medications, pharmacists assist healthcare providers in prescribing medications safely. Pharmacists' attendance on clinical rounds and participation in interdisciplinary teams enables them to identify medication-related problems in real time and to assist in the resolution of those problems as they occur. The Evidence demonstrates that participating pharmacists greatly reduce the number of preventable adverse drug reactions and medication errors. By ensuring that medications are utilized safely, pharmacists develop confidence and trust with their patients and create a positive healthcare experience for those individuals. Pharmacists provide a proactive approach that allows for early identification of potential problems prior to any harm occurring. Thus, pharmacist-led initiatives play an integral role in patient safety programs in hospitals and other clinical settings. (Chisholm-Burns et al., 2010)

Educational and counselling services provided by Pharmacies lead by pharmacists are essential to improving patient medication adherence and the overall outcomes of the treatment. Patients do not achieve their optimal therapeutic results from their medications due to non-adherence, usually related to poor understanding of their medications, complex dosing schedules, or fear of medication side effects. The pharmacist provides clear and individualisedcounselling regarding their medications to address these concerns, including the purpose of each medication, how to use each medication correctly (i.e. how to administer), the common anticipated adverse drug effects of each medication, and the significance of taking medications as prescribed. The pharmacist also uses motivational strategies to encourage medication adherence. An increase

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in patients' understanding typically leads to increased medication adherence, decreased hospitalisations, and improved disease-state control. The pharmacist also follows-up with patients for ongoing progress evaluations, and continues to address any concerns as patients progress through their treatment plan. Research has shown that counselling/education provided by pharmacists significantly improves clinical outcomes associated with chronic diseases, including diabetes, hypertension, and asthma. Through effective communication with patients and patient engagement, pharmacists work to instill all patients with the confidence to take an active role in their health care, promoting safety and therapeutic success. (Cutrona et al., 2012)

Integrating pharmacist-led interventions into healthcare systems has been proven to benefit both patient outcomes and patient safety in a variety of clinical settings. Many of these benefits are achieved by providing medication review, reconciliation, therapeutic monitoring, adverse drug reaction (ADR) prevention, and patient education. The pharmacist plays an essential role by ensuring that patients receive comprehensive medication management. By providing a more complete approach to medication management, pharmacists help minimize errors and improve the effectiveness of the treatment provided to the patient.Healthcare organizations that place pharmacists on multidisciplinary teams consistently observe improved clinical outcomes, decreased medication-related complications, and increased patient satisfaction. Increasingly, there is recognition of the need for pharmacists to be included as integral members of the healthcare team because of the pharmacist's ability to identify and fill gaps in medication safety, as well as improve therapeutic outcomes.As the complexity of the healthcare system and the burden of medication continue to increase, it is anticipated that pharmacist involvement will play an increasingly important role in providing safe and effective patient care. By strengthening pharmacist involvement in the healthcare delivery system with policy support, enhanced education, and collaborative practice models, pharmacists will, in turn, increase their impact. Ultimately, pharmacist-led interventions are an essential strategy for improving the quality of healthcare and assuring that patients are safe in today's healthcare environment.(Mekonnen et al., 2016)

Conclusion

Pharmacist-led initiatives and antibiotic stewardship programs serve a vital function in achieving the rational and proper usage of antibiotics within health care facilities. The burden of increasing rates of antimicrobial resistance has made it necessary to implement structured approaches that allow antibiotics to be prescribed only when necessary, in the correct dosing, for the proper duration, and via the appropriate route of administration. Pharmacists contribute greatly toward these initiatives by providing medication reviews, optimizing doses, performing therapeutic drug monitoring, providing patient education and collaborating with other members of different disciplines. Involvement of pharmacists in these activities aids in reducing inappropriate prescribing of antibiotics, decreasing medication errors, and increasing the overall outcome of treatment. Evidence shows that pharmacist-supported stewardship programs improve adherence to clinical guidelines, decrease costs of care, and promote patient safety. Moreover, these interventions preserve the effectiveness of current antimicrobial agents by minimizing unnecessary exposure and curtailing the emergence of resistant organisms. As members of the interdisciplinary health care team, pharmacists enhance the management of antimicrobial agents and provide evidence-based practice in clinical decision making. Ultimately, pharmacist-led antibiotic stewardship programs constitute an essential element of contemporary health systems in the fight against antimicrobial resistance. Continued support through education, continued development of practice policies and collaborative practice should be made to further enhance their efficacy.

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