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Addressing antibiotic resistance through interdisciplinary collaboration between nursing and pharmacy

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Abstract--Background: By compromising the effectiveness of life-saving therapies and driving up healthcare expenses, antibiotic resistance (AR) is a serious danger to global public health. Effective mitigation solutions are desperately needed, as the World Health Organization (WHO) has declared AR a high global health concern. As frontline healthcare professionals, nurses and pharmacists have distinct and complementary roles in antimicrobial stewardship (AMS).

Their capacity to have a collaborative impact is still untapped, though.

Aim: this research is to analyze the multidisciplinary cooperation between pharmacy and nursing in tackling AR, emphasizing how well it works to improve patient outcomes, lower resistance rates, and strengthen AMS programs. The research highlights obstacles, investigates facilitators, and offers practical suggestions for incorporating these functions into a unified approach to counter AR.

Methods: To better understand interdisciplinary approaches to AR management, a thematic assessment of peer-reviewed literature, clinical guidelines, and case studies was carried out. To find trends of cooperation, common difficulties, and proof of achievement, data were combined. **Results:** By optimizing antibiotic use, enhancing patient education, and guaranteeing adherence to infection control guidelines, interdisciplinary collaboration between nursing and pharmacy improves AMS. Inappropriate antibiotic prescriptions and resistance rates are significantly decreased when nurses and pharmacists collaborate, according to case studies. Institutional silos, a lack of interdisciplinary training, and insufficient funding are some of the obstacles that have been identified. Strong lines of communication, technology integration, and policy support are examples of enablers.

Conclusion: nursing and pharmacy working together presents a viable strategy for overcoming AR. The results of AMS can be greatly enhanced by healthcare systems through the promotion of collaboration among various disciplines. In order to overcome highlighted obstacles, future policies should give priority to multidisciplinary frameworks and offer specialized training.

Keywords---antimicrobial stewardship, nursing, pharmacy, interdisciplinary teamwork, antibiotic resistance, and healthcare tactics.

Introduction

The reduced effectiveness of medicines in treating bacterial infections is known as antibiotic resistance (AR), and it is one of the most urgent issues facing global healthcare. This phenomenon occurs when antimicrobial drugs cause bacterial infections to adapt and persist, making conventional therapies ineffective. In addition to raising morbidity and mortality, AR places a heavy financial strain on healthcare systems around the globe. AR is one of the top ten worldwide public health problems of the twenty-first century, according to the World Health Organization (WHO), which highlights the need for interdisciplinary solutions to lessen its effects. Antimicrobial stewardship (AMS), a paradigm that aims to maximize antibiotic use, enhance patient outcomes, and prevent the evolution of resistance, is essential to tackling this epidemic. Professionals in nursing and pharmacy have important but different responsibilities in AMS. Through joint responsibilities in patient care, medication administration, and health education, their partnership presents special opportunity to improve the effectiveness of AR mitigation methods.

The importance of AR encompasses societal, economic, and ethical aspects in addition to its clinical ramifications. The interdependence of environmental, animal, and human health in the spread of resistance is highlighted by theoretical frameworks like the "One Health" approach [1, 2]. Moreover, multidisciplinary cooperation is emphasized by frameworks such as the "Antibiotic Stewardship Model" as a fundamental component of successful AR management [3]. In this regard, a key element of all-encompassing AMS initiatives is the incorporation of nursing and pharmaceutical knowledge inside healthcare systems. According to recent studies, interdisciplinary initiatives have the potential to improve infection control protocol compliance, decrease inappropriate antibiotic use by up to 30%, and improve patient education regarding antibiotic consumption [4, 5].

Current AR trends highlight the need for a comprehensive response. First off, treatment plans around the world have become more complex due to the emergence of multidrug-resistant organisms, such as methicillin-resistant *Staphylococcus aureus* (MRSA) and carbapenem-resistant Enterobacterales [6]. Second, precision medicine is becoming more and more popular, with pharmacists helping to develop customized antibiotic treatments based on pharmacokinetic and pharmacodynamic factors [7]. Last but not least, the COVID-19 pandemic exposed weaknesses in international AMS policies by exacerbating AR through the extensive and frequently inappropriate use of antibiotics [8]. These findings highlight how urgently nursing and pharmacy must work together in an organized manner to treat AR in its entirety.

This essay is set up to offer a thorough examination of the multidisciplinary cooperation between pharmacy and nursing in the fight against AR. A thorough examination of AR's therapeutic and financial effects is provided in the first section, which also addresses the technology's scope and difficulties. The special responsibilities of nurses and pharmacists in AMS are examined in the second section, with a focus on their contributions to drug management, patient education, and infection control. With the help of case studies and evidence-based procedures, the third portion examines the synergistic advantages of interdisciplinary collaboration. The fourth section lists obstacles to cooperation and suggests ways to get around them, like multidisciplinary training initiatives and policy changes. The conclusion summarizes the main conclusions and makes suggestions for additional study and policy creation.

Global Perspective on Antibiotic Resistance: Epidemiology and Data on Trends in Antibiotic Resistance and Its Scope and Challenges

One of the biggest risks to world health is antibiotic resistance (AR), which reduces the efficacy of antibiotics that are necessary for treating infections, makes medical procedures more difficult, and raises healthcare expenses. Around 700,000 fatalities worldwide are attributed to AR each year, and if nothing is done, estimates indicate that number might rise to 10 million by 2050 [9, 10]. The financial toll is as severe, with productivity losses from AR exceeding \$35 billion worldwide and healthcare expenses linked to AR exceeding \$20 billion annually in the US alone [11]. Because of their inadequate healthcare systems and widespread use of over-the-counter antibiotics, regions like South Asia, Sub-Saharan Africa, and Eastern Europe have disproportionately heavy loads [12].

The concerning frequency of multidrug-resistant (MDR) infections is highlighted by recent statistics. Vancomycin-resistant *Enterococcus faecium* (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), and carbapenem-resistant *Acinetobacter baumannii* were recognized by the World Health Organization (WHO) as serious risks that needed immediate attention [13]. The abuse of antibiotics in agriculture exacerbates the issue in low- and middle-income countries (LMICs) and plays a major role in the spread of resistant genes in the environment [14]. Regional differences in AR trends have been shown by surveillance initiatives like the WHO's Global Antimicrobial Resistance Surveillance System (GLASS), highlighting the critical need for concerted international actions [15].

Microbial Mechanisms: A Summary of the Formation and Transmission of Resistance

Microbial genetic modifications that allow bacteria to withstand antibiotic agents are the main cause of antibiotic resistance. These processes include target alteration, efflux pump activation, biofilm formation, and the enzymatic breakdown of antibiotics [16]. Horizontal gene transfer (HGT) through conjugation, transformation, or transduction, or spontaneous genetic alterations during bacterial replication, might result in resistance. Resistance genes are frequently carried via integrons, transposons, and plasmids, which facilitates the quick spread of resistance both within and between bacterial species [17].

In healthcare settings, environmental pollution, poor hand hygiene, and insufficient infection control are the main ways that resistance spreads [18]. For example, overuse of broad-spectrum antibiotics and poor sanitation procedures have led to the proliferation of resistant *Klebsiella pneumoniae* strains in critical care units (ICUs) [19]. Uncontrolled antibiotic use and inadequate sanitation contribute to the emergence of resistant bacteria in community settings. Since resistance genes from agriculture sometimes enter human pathogens through water systems or direct contact, the problem is made worse by the junction of human, animal, and environmental health [20].

Limitations of the Healthcare System: Present Deficits in Effectively Addressing Antibiotic Resistance

Antimicrobial stewardship programs (ASPs) have advanced, but healthcare systems around the world still have a lot of obstacles when it comes to dealing with AR. First, patient demand and diagnostic ambiguity continue to be major factors in the widespread overprescription and abuse of antibiotics. According to studies, up to 50% of antibiotic prescriptions written in outpatient settings are unnecessary, which directly leads to the emergence of resistance [21]. Since the selling of over-the-counter antibiotics is frequently uncontrolled in LMICs, this problem is made worse [22].

Second, the capacity to precisely monitor resistance developments is hampered by the underfunding of AR surveillance programs. For example, there are significant gaps in resistance data since fewer than half of LMICs take part in global surveillance programs like GLASS [23]. Even while surveillance systems are more

advanced in high-income nations, quick reaction to new threats is hampered by the absence of real-time data integration across institutions [24].

Third, the number of newly developed antibiotics is worryingly low. The enormous expenses and low financial returns of antibiotics have caused pharmaceutical corporations to primarily redirect their focus away from this research. Only 15 new antibiotics were approved worldwide between 2010 and 2020, and the majority were not unique drugs but rather adaptations of pre-existing classes [25]. Because of this lack of innovation, medical professionals are now dependent on a smaller supply of potent antibiotics.

Lastly, insufficient infection prevention and control procedures plague the hospital sector. Research shows that less than 50% of healthcare settings worldwide follow hand hygiene guidelines, which greatly increases the risk of hospital-acquired infections (HAIs) brought on by resistant bacteria including *Clostridium difficile* and MRSA [26]. Furthermore, the efficacy of antimicrobial stewardship programs is sometimes compromised by a lack of interdisciplinary coordination among healthcare workers, such as nurses and pharmacists.

Nurses' Function in the Management of Antibiotic Resistance

Nurses have a critical and diverse role in the fight against antibiotic resistance (AR), including patient education, infection control, advocacy, and outcome monitoring. Nurses are in a unique position to work across disciplines in antimicrobial stewardship programs (ASPs) and to carry out interventions that directly address AR because they are frontline healthcare professionals. Their efforts are crucial to ensuring that antibiotics are used sensibly, stopping the spread of infections that are resistant to them, and enhancing patient outcomes.

Patient Education: Raising Knowledge of Proper Use of Antibiotics



Figure 1. In order to improve antimicrobial stewardship and lower antibiotic resistance, the picture presents the 10 Golden Rules for Optimal Antibiotic Use in Hospital Settings

One of the most important things nurses can do to help patients manage AR is to teach them how to use antibiotics. Inappropriate use of antibiotics is greatly influenced by misconceptions about them, such as the idea that they work well to treat viral illnesses like the flu or colds. Targeted patient education is crucial, as studies show that up to 30% of antibiotic prescriptions in outpatient settings are unnecessary [27]. Through direct patient interactions, nurses, as dependable healthcare professionals, are in a good position to dispel these myths.

Explaining the function of antibiotics, the dangers of abuse, and the significance of finishing recommended regimens are all part of effective patient education. The risks of self-medicating with leftover antibiotics or getting them without a prescription, which is common in many low- and middle-income countries (LMICs), must also be stressed by nurses [28]. Educational initiatives can be strengthened by evidence-based resources such as educational booklets, visual aids, and mobile health technologies. Nurse-led education initiatives have been shown to dramatically lower the usage of unnecessary antibiotics in both inpatient and community settings [29].

Additionally, nurses may help patients identify the symptoms of infections that need medical attention, which can help them avoid unnecessary medical visits and the risk of obtaining antibiotics in the wrong way. Nurses have a direct

impact on lowering the abuse that fuels AR by promoting greater knowledge about antibiotics and how to use them appropriately.

Infection Control: Putting Hygiene Procedures into Practice and Tracking Adherence

A key component of managing AR is infection control, and nurses are leading the charge in putting hygiene measures into place and keeping an eye on them to stop the spread of microorganisms with resistance. AR is made worse by healthcare-associated infections (HAIs), which are a serious risk to patient safety and are frequently brought on by multidrug-resistant organisms (MDROs) such as *Clostridium difficile* and MRSA. According to estimates from the Centers for Disease Control and Prevention (CDC), one in every 31 hospitalized patients in the US gets a healthcare-associated infection (HAI) every day, with resistant microorganisms being a common cause [30].

Nurses are in charge of making sure that common infection control practices are followed, such as washing hands, using personal protective equipment (PPE), and properly disinfecting medical equipment. With adherence rates averaging just 50% in many healthcare settings, hand hygiene compliance in particular is still below ideal levels worldwide [31]. It has been demonstrated that nurse-driven programs including training, feedback, and audits greatly increase adherence to cleanliness guidelines, which in turn slows the spread of resistant bacteria [32].

Nurses are essential in not only carrying out procedures but also keeping an eye on patient and healthcare worker compliance. This entails carrying out surveillance to spot violations of protocol and taking swift corrective action to fix them. Nurse-led infection control strategies have been linked to significant decreases in infection rates in high-risk settings, such as intensive care units (ICUs), where resistant microorganisms are more prevalent [33].

Additionally, nurses participate in multidisciplinary teams to address resistant infection outbreaks and help design policies for infection prevention. Their proficiency in infection management lessens the total burden of AR in healthcare institutions while also safeguarding individual patients.

Ensuring Compliance with Antimicrobial Stewardship Programs (ASPs) via Advocacy

Programs such as antimicrobial stewardship (ASP) are essential for maximizing the use of antibiotics and reducing the development of resistance. By encouraging adherence to these programs among patients, healthcare providers, and institutional stakeholders, nurses act as champions for ASPs. One of their responsibilities is to make sure that antibiotics are prescribed correctly, taking into account microbiological cultures, evidence-based guidelines, and patient-specific variables including age, comorbidities, and immunological state [34].

By working with doctors and pharmacists to assess and improve treatment plans, nurses promote the responsible use of antibiotics. When a narrower-spectrum antibiotic is enough, this may entail suggesting de-escalation of treatment; when

antibiotics are no longer required, it may entail arguing for withdrawal. Studies have indicated that the participation of nurses in ASPs results in notable enhancements in prescribing procedures and decreases in the usage of antibiotics [35].

Nurses can support ASPs by influencing institutional policies in addition to clinical advocacy. This entails advocating for resources like specialized stewardship staff, electronic health record (EHR) systems that make tracking antibiotics easier, and continuous training for staff members. Involving patients and their families in stewardship initiatives is another crucial function of nurses, who make sure that they comprehend the reasoning behind treatment choices and the significance of following recommended routines [36]. Nurses advance the battle against AR by serving as advocates for ASPs, which closes the gap between clinical practice and institutional objectives.

Tracking Results: Evaluating Adverse Events and Treatment Effectiveness

To guarantee both patient safety and therapeutic effectiveness, it is crucial to track the results of antibiotic therapy. By screening potential problems including secondary infections, detecting adverse drug reactions, and assessing clinical signs of improvement, nurses play a crucial role in this process. Their insights can reduce the danger of prolonged antibiotic exposure or therapeutic failure by enabling prompt modifications to treatment protocols [37].

The detection and reporting of adverse events linked to the use of antibiotics is one of the main duties of nurses in outcome monitoring. These could include gastrointestinal issues, allergic responses, or serious side effects including *Clostridium difficile* infections. Prompt action, which minimizes patient harm and stops the use of needless antibiotics, is made possible by early diagnosis of such events [38].

By monitoring infection resolution using clinical indicators including fever decrease, wound healing, and test parameter normalization, nurses also help assess the efficacy of treatment. Patients with weakened immune systems or chronic illnesses, who might need specialized antibiotic regimens, should pay special attention to this surveillance.

Nurses also help with post-discharge monitoring, which makes sure patients keep their follow-up visits and take their prescribed medications. Telehealth programs, in which nurses conduct virtual consultations to monitor patient progress, have become powerful instruments for community-based outcome monitoring [39]. Nurses contribute to the overall success of ASPs, improve the quality of care, and lower the chance of resistance development by closely monitoring treatment outcomes.

Pharmacists' Function in Antibiotic Stewardship

In order to counteract the growing problem of antibiotic resistance (AR), pharmacists are essential members of antibiotic stewardship programs (ASPs), using their knowledge of pharmacology and healthcare systems. Their

contributions include a wide range of important topics, such as policy formation, patient counseling, pharmacovigilance, and drug management. As important participants in the healthcare process, pharmacists serve as a liaison between patients, prescribers, and institutional systems, guaranteeing the best possible use of antibiotics to enhance patient outcomes and prevent the development of resistance.

Medication Management: Improving the Choice, Dosage, and Duration of Antibiotics

Making sure that antibiotic medicine is chosen, dosed, and administered for the right amount of time is one of the main duties of pharmacists in ASPs. Optimizing the use of antibiotics entails striking a balance between the necessity of efficient infection control and the possibility of resistance and side effects. In order to do this, pharmacists check antimicrobial prescriptions to make sure they are in compliance with microbiological data, evidence-based guidelines, and patient-specific variables such as age, renal function, comorbidities, and immunological state [40].

Once infections and susceptibilities have been discovered, pharmacists are in a unique position to direct antibiotic de-escalation techniques, which entail a switch from broad-spectrum to narrow-spectrum drugs. Research has shown that pharmacist-led treatments in ASPs can lower the incidence of *Clostridium difficile* infections by up to 50% and decrease the abuse of broad-spectrum antibiotics [41]. In order to maintain therapeutic drug levels without raising the risk of toxicity, pharmacists are also essential in dose modifications, especially for patients with hepatic or renal impairments.

Pharmacists work with prescribers to create local antibiograms in addition to direct interventions. These antibiograms offer useful information on patterns of antibiotic susceptibility and can inform the selection of empirical therapies [42]. They can suggest the best dose schedules, like prolonged or continuous beta-lactam infusions, to improve therapeutic efficacy against resistant organisms because of their knowledge of pharmacokinetics and pharmacodynamics [43].

Pharmacovigilance: Tracking Patterns of Adverse Reactions and Antibiotic Resistance

One of the main responsibilities of pharmacists in ASPs is pharmacovigilance, which is the methodical monitoring of medication safety and effectiveness. Pharmacovigilance in the context of AR entails monitoring developments in resistance and detecting adverse drug reactions (ADRs) linked to the use of antibiotics. Pharmacists and microbiology labs work together to track resistance trends, which helps identify new multidrug-resistant organisms (MDROs) early [44].

Pharmacists' resistance surveillance data is essential for directing regional and institutional antibiotic policy. Pharmacists in ASPs, for instance, usually spot resistance tendencies associated with the abuse of particular antibiotic classes, like carbapenems, and push for limitations or substitute treatments to maintain

their effectiveness [45]. In order to guarantee that patient safety is given top priority during antibiotic therapy, pharmacists also keep an eye out for adverse drug reactions (ADRs), such as nephrotoxicity, allergic reactions, or drug-drug interactions.

When prescribing antibiotics, pharmacists also use real-time clinical decision support technologies that are incorporated into electronic health records (EHRs) to identify possible problems, like contraindications or duplicate medicines [46]. These tools lower the chance of treatment failures or consequences by empowering pharmacists to act quickly.

Additionally, by keeping an eye on antibiotic usage in long-term care institutions and alerting prescribers to incorrect prescriptions, pharmacists in outpatient settings support pharmacovigilance. In community healthcare settings, such approaches have been linked to notable decreases in the development of antibiotic resistance and antibiotic overuse [47].

Patient Counseling: Teaching Patients to Follow Their Prescriptions

One essential component of pharmacists' responsibilities in ASPs is patient education. Treatment failures and resistance development are frequently caused by noncompliance with recommended antibiotic regimens. By educating patients about the significance of following recommended regimens, the perils of missing doses, and the risks of sharing drugs or taking leftover antibiotics, pharmacists are in a unique position to address this issue [48].

Simplifying complicated medical information into a patient-friendly language is the first step in providing effective patient counseling. Pharmacists, for example, describe how antibiotics function, why they don't work against viral illnesses, and how misuse leads to resistance. According to research, patient adherence to antibiotic regimens is much enhanced by pharmacist-led counseling, which also lowers the risk of resistance and enhances clinical outcomes [49].

Pharmacists offer remote counseling and medication adherence reminders in addition to in-person consultations using technology-driven alternatives including telehealth platforms and smartphone apps. These resources are especially useful for connecting with patients in underserved or rural areas where access to medical treatment may be restricted [50].

In order to improve the effectiveness of therapy, pharmacists can also help patients manage frequent antibiotic side effects, like gastrointestinal problems, and offer advice on suitable dietary or pharmaceutical changes. Pharmacists can lower the risks of noncompliance by helping patients have a better understanding of antibiotics and enabling them to actively participate in their care.

Contributions to Policy: Establishing Institutional ASPs

At the institutional level, pharmacists play a key role in the creation, application, and assessment of ASPs. They are in a position to lead the development of policies that encourage the prudent use of antibiotics because of their knowledge of

healthcare systems and antimicrobial pharmacology. To create ASP protocols that are specific to their institutions' requirements, pharmacists work with interdisciplinary teams that include nurses, microbiologists, and infectious disease specialists [51].

Formulary limitations, which restrict the use of some high-risk antibiotics to situations with obvious reasons, are one of the major policy contributions made by pharmacists. To ensure that antibiotics are administered sparingly, these limitations are sometimes combined with preauthorization requirements or pharmacist-performed post-prescription audits [52].

Additionally, pharmacists support the incorporation of ASP objectives into more general institutional policies, like those pertaining to infection prevention and control initiatives. To lessen the total burden of infectious diseases, they, for instance, try to coordinate the prescription of antibiotics with campaigns for immunization, environmental cleaning procedures, and hand hygiene activities [53].

Pharmacists participate in training programs, public health campaigns, and guideline development to support national and worldwide ASP activities in addition to local legislation. Their work contributes to the standardization of procedures, the dissemination of best practices, and the improvement of stewardship programs' overall global impact [54].

Advantages of Multidisciplinary Cooperation

Addressing the intricate problems of healthcare, especially the fight against antibiotic resistance (AR), requires interdisciplinary cooperation between nursing and pharmacy specialists. Through the utilization of each discipline's distinct knowledge, this synergy improves patient outcomes, communication, coordinated care planning, and collaborative decision-making. These cooperative initiatives are essential to maximizing antibiotic use, lowering resistance rates, and managing healthcare expenses within the framework of antimicrobial stewardship programs (ASPs).

Improved Interaction: Filling up the Gaps Between Pharmacy and Nursing Roles

A key component of interdisciplinary teamwork is effective communication, which makes it easier for nurses and pharmacists to share information. In the past, compartmentalized responsibilities and little interaction have hindered the exchange of vital patient data, frequently leading to less-than-ideal treatment choices. By creating organized communication channels including frequent team meetings, electronic health record (EHR) updates, and shared patient progress reviews, interdisciplinary collaboration fills these gaps [55].

While nurses offer vital insights into patient behavior, symptoms, and treatment plan adherence, pharmacists bring extensive expertise of pharmacology. These specialists can coordinate their efforts to resolve inconsistencies in antibiotic prescriptions and guarantee prompt interventions by improving communication.

For example, pharmacists' interpretation of laboratory results and nurses' observations of clinical symptoms in suspected infection cases result in more precise diagnosis and customized antibiotic treatment [56].

Research shows that better communication between pharmacy and nursing staff improves ASP efficiency and lowers prescription mistakes. Structured interdisciplinary rounds with nurses and pharmacists enhanced adherence to evidence-based guidelines and decreased antimicrobial prescription errors by 25%, according to a study done in hospital settings [57]. Therefore, encouraging strong communication channels is essential for successful interdisciplinary cooperation.

Coordinated Care Plans: Teamwork in Patient Care Techniques

Coordinated treatment plans that incorporate behavioral, pharmacological, and clinical viewpoints can be developed through interdisciplinary teamwork. In the treatment of infections, when improper antibiotic usage or noncompliance might have serious repercussions, such programs are crucial. When nurses and pharmacists collaborate, they can find care gaps, including insufficient diagnostic workups or needless usage of broad-spectrum antibiotics, and suggest solutions [58].

In difficult instances, such as those involving patients with comorbid illnesses or infections resistant to many drugs, coordinated care regimens are especially beneficial. While pharmacists make ensuring that antibiotic medication is maximized for both safety and efficacy, nurses are essential in monitoring patients' physiological responses and adherence to treatment plans. By working together, the chances of treatment failures, negative drug reactions, and the emergence of resistance are reduced [59].

Coordinated care plans in outpatient settings incorporate community-based interventions in addition to clinical settings. For instance, nurses' ability to offer home-based care and education is enhanced by pharmacists' proficiency in drug administration. Jointly created care plans greatly enhance treatment continuity and results by guaranteeing that patients receive evidence-based, consistent care in any setting [60].

Combining clinical and pharmacological expertise in shared decision-making

Effective interdisciplinary collaboration is characterized by shared decision-making, which promotes respect for one another and the integration of many patient care specialties. This procedure is especially important in ASPs because it guarantees that clinical observations and pharmacological data are used to inform antibiotic prescribing decisions. Together, nurses and pharmacists assess whether antibiotic prescriptions are appropriate, taking into account patient-specific factors, pathogen susceptibility, and infection type [61].

While nurses contribute real-time assessments of patient progress and adherence, pharmacists offer comprehensive insights into drug selection, dosing strategies, and potential interactions. Decisions are guaranteed to be both

contextually appropriate and scientifically sound because to this combination of viewpoints. For instance, nurses offer input on patients' medication response and tolerance, while pharmacists may suggest alternate medicines based on resistance data in the management of hospital-acquired infections [62].

Additionally, a culture of accountability and ongoing learning among healthcare professionals is fostered via shared decision-making. Institutions foster cross-disciplinary information exchange by bringing nurses and pharmacists together in cooperative conversations, which eventually improves the efficacy of ASPs. According to studies, shared decision-making greatly increases patient satisfaction with care and can cut down on improper antibiotic use by up to 20% [63].

Better Patient Results: Proof of Lower Healthcare Expenses and Resistance

Improving patient outcomes is the ultimate goal of interdisciplinary collaboration, and there is ample evidence to support its efficacy in accomplishing this goal. Significant drops in antibiotic resistance rates and medical expenses have been linked to ASPs where nurses and pharmacists work together. Over the course of five years, hospitals that implemented interdisciplinary ASPs, for example, reported a 30% decrease in the usage of broad-spectrum antibiotics and a comparable decrease in resistance rates [64].

Shorter hospital stays, fewer readmissions, and lower rates of healthcare-associated infections (HAIs) are further indicators of improved patient outcomes. Pharmacists' knowledge of antibiotic optimization and nurses' involvement in infection prevention combine to provide a complete approach to care that meets patients' short- and long-term needs. For instance, prompt cooperation between pharmacists and nurses in sepsis situations guarantees the prompt administration of the right medications, greatly lowering death rates [65].

Saving money emphasizes the importance of interdisciplinary cooperation even more. Coordinated care lessens the financial strain on patients and healthcare organizations by averting complications like drug-related adverse events or resistant infections. According to a comprehensive analysis, ASPs conducted by pharmacists and nursing staff saved hospitals about \$200,000 a year, mostly by reducing the use of unneeded antibiotics and shortening hospital stays [66].

Obstacles to Successful Cooperation

Addressing complicated healthcare issues like antibiotic resistance (AR) requires interdisciplinary cooperation. The smooth integration of pharmacy and nursing skills in antimicrobial stewardship programs (ASPs) is, nevertheless, hampered by important obstacles. The effectiveness of ASPs is limited, and attempts to improve patient care and fight AR are hampered by these obstacles, which include institutional difficulties, educational gaps, and professional silos.

Institutional Difficulties: Absence of Structures to Encourage Multidisciplinary Methods

One of the biggest challenges to successful interdisciplinary collaboration is institutional barriers. The mechanisms required to facilitate coordinated efforts

between pharmacy and nursing practitioners are frequently absent from healthcare systems. These difficulties are made worse by structural problems such as inadequate staffing, unclear roles, and restricted access to decision-making procedures [67]. For example, despite their crucial responsibilities in patient education and antibiotic management, many institutions do not formally include nurses or pharmacists in ASP leadership.

Collaboration is made much more difficult by the lack of well-defined interdisciplinary protocols. Physicians make the majority of decisions on antibiotics in many healthcare settings, which leaves little room for nurses' and pharmacists' opinions. The impact of ASP programs is diminished by this hierarchical structure, which frequently results in fragmented treatment [68]. The significance of organizational support is highlighted by research showing that adherence to antibiotic prescribing guidelines improves significantly when institutional regulations explicitly include nursing and pharmacy responsibilities in ASPs [69].

Collaboration is also hampered by resource limitations, such as a lack of funds and a poor technology infrastructure. Integrated electronic health records (EHRs) and decision-support technologies that enable interdisciplinary teams to communicate and share data in real time are lacking at many institutions. Reforming policies, increasing funding for ASP resources, and creating comprehensive frameworks that value transdisciplinary methods are all necessary to close these institutional gaps.

Educational Gaps: Inadequate Instruction in ASPs and Teamwork

Another significant obstacle to productive teamwork is a lack of education. The precise roles of these specialists in ASPs and the concepts of interdisciplinary teamwork are not sufficiently emphasized in many nursing and pharmacy curriculum. Because of this, graduates frequently join the industry knowing very little about how to operate well in a diverse team [70].

Fostering respect and understanding between healthcare workers requires interdisciplinary education. There are notable gaps in understanding regarding antibiotic resistance and stewardship principles, though, as research indicates that less than 40% of nursing and pharmacy programs offer formal instruction on ASPs [71]. This lack of training lessens the overall impact of ASP activities and erodes confidence when interacting with other disciplines.

Furthermore, alternatives for continuing education for working professionals are either unavailable or limited. Although there are ASP-related training programs, they are usually only available to doctors, leaving out nurses and pharmacists who are essential to the execution of stewardship initiatives. By providing all team members with the information and abilities required for successful involvement in ASPs, increasing access to multidisciplinary training courses, workshops, and certifications can improve collaboration [72].

Particularly promising approaches to closing these educational gaps include case-based learning models and interdisciplinary simulations. These strategies support

a better comprehension of the contributions of each field and cultivate the cooperative mindset required to successfully battle AR by enabling nursing and pharmacy students to collaborate on realistic situations involving antimicrobial prescribing and monitoring.

Professional Silos: Opposition to Cross-Disciplinary Shared Responsibilities

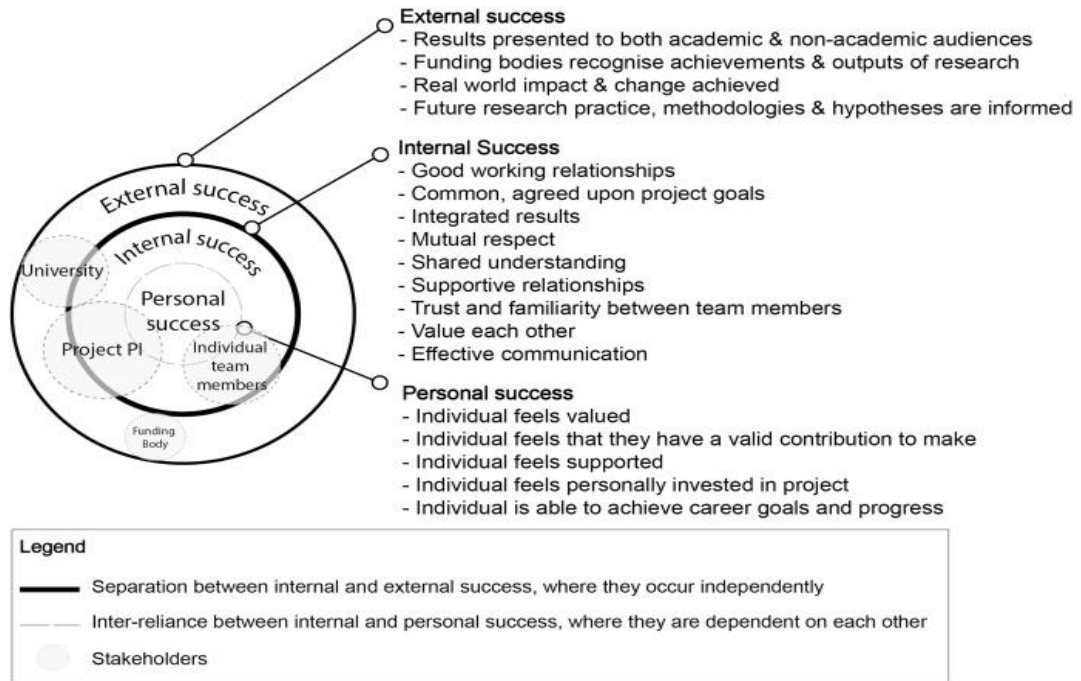


Figure 2. Three interconnected dimensions—External Success, Internal Success, and Personal Success—make up the conceptual model of success in cooperative research or project contexts depicted in the picture

One major cultural impediment to collaboration is the existence of professional silos, which are defined by inflexible borders across disciplines. Pharmacists and nurses frequently operate in different professional fields with little opportunity for collaboration or shared duties. This division can result in misconceptions regarding the contributions and roles of each profession, which undermines trust and prevents productive teamwork [73].

The idea of role encroachment is one of the main causes of professional silos. For instance, pharmacists' suggestions for changes to antibiotic medication may be seen by certain medical professionals as a violation of their clinical authority. In a similar vein, nurses' participation in ASPs can be underestimated or viewed as outside of their conventional area of expertise. These viewpoints reinforce hierarchical dynamics that impede interdisciplinary efforts and encourage opposition to shared decision-making [74].

According to research, healthcare organizations must change their culture in order to address professional silos. These obstacles can be removed by

encouraging team members to communicate openly, respect one another, and take responsibility for one another. It has been demonstrated that collaborative governance models, in which pharmacy and nursing personnel take equal role in ASP leadership and decision-making, improve team dynamics and increase the efficacy of stewardship initiatives [75].

A more integrated approach to patient care can also be promoted and relationships can be cultivated through frequent interdisciplinary meetings and collaborative training sessions. Healthcare organizations can break down professional boundaries and realize the full potential of interdisciplinary teams by cultivating a collaborative culture.

The efficiency of interdisciplinary collaboration in ASPs is hampered by a combination of institutional difficulties, educational gaps, and professional silos. Systemic adjustments are needed to remove these obstacles, such as the creation of institutional frameworks that are supportive, the growth of interdisciplinary education, and changes in the culture of healthcare teams. Healthcare organizations may improve antibiotic stewardship efforts and fight the worldwide threat of AR by investing in these solutions, which will improve nursing and pharmacy professional collaboration.

Techniques for Successful Multidisciplinary Practices

Addressing complicated healthcare issues like antibiotic resistance (AR) requires effective interdisciplinary collaboration. In order to overcome obstacles and optimize group competence, nursing, pharmacy, and other healthcare professionals must be successfully integrated into antimicrobial stewardship programs (ASPs). Improved education and training, technological integration, policy creation, and community involvement are important tactics. These programs facilitate communication, promote understanding between people, and take stewardship activities outside of conventional contexts.

Education and Training: Initiatives Promoting Role Mutual Understanding
Effective teamwork is based on interdisciplinary education. Fostering a collaborative culture requires programs that encourage understanding amongst nurses, pharmacists, and other healthcare workers regarding their unique and complementary roles. The emphasis on discipline-specific training in healthcare education has historically frequently overlooked the value of multidisciplinary teamwork in ASPs. Interprofessional education (IPE) must be incorporated into nursing and pharmacy curriculum in order to close this gap, and continuing education for working professionals must be provided [76].

IPE programs emphasize collaborative learning experiences where experts and students from various fields collaborate on real-world problems, such treating illnesses that are resistant to drugs. Through these simulations, participants are encouraged to value one another's contributions and hone the communication skills required for productive teamwork [77]. Research has shown that IPE dramatically increases participants' competence and confidence in applying ASPs, which improves patient outcomes and antibiotic prescribing behaviors [78]. Even for professionals who are currently employed, continuing education is

crucial. Knowledge and skills can be improved through ASP-based workshops, seminars, and certification programs. Moreover, collaborative case reviews and interdisciplinary team-building activities foster mutual respect and trust among team members, which supports ASP initiatives even more. Global advancement in the fight against AR depends on increasing access to such programs, particularly in environments with limited resources.

Technology Integration: Monitoring Resistance Trends with Electronic Health Records

The integration of electronic health records (EHRs) with decision-support technologies is one way that technology transforms multidisciplinary practices. By offering a consolidated platform for accessing patient data, such as lab results, antibiotic prescriptions, and clinical progress, EHRs facilitate smooth communication between team members. Nurses, pharmacists, and other medical professionals can work together to make well-informed decisions because to this real-time access, which lowers care delays and errors [79].

The use of clinical decision support systems (CDSS) in EHRs is among the most important developments in ASPs. By highlighting possible drug interactions, recommending alternate treatments based on local antibiograms, and reminding physicians to evaluate or stop prescription antibiotics as necessary, these systems offer warnings and suggestions for antibiotic prescribing. According to research, institutions that adopt EHR-integrated CDSS report decreased rates of inappropriate antibiotic usage and higher compliance with ASP guidelines [80].

Technology is also used by nurses and pharmacists to monitor resistance patterns and evaluate the results of stewardship initiatives. Automated data analytics technologies, for instance, can produce information on patient outcomes, resistance rates, and prescribing trends, enabling focused ASP improvements. Applications for mobile health (mHealth) increase the reach of these technologies by facilitating communication and remote monitoring in outpatient and community settings [81].

Institutions must make investments in user-friendly systems, train all healthcare workers, and guarantee platform compatibility if they want to fully benefit from technology. These initiatives make sure that technical advancements support interdisciplinary cooperation rather than impede it.

Developing Policies: Establishing Multidisciplinary ASPs

For ASPs to institutionalize transdisciplinary practices, strong policy frameworks are necessary. Clear duties and responsibilities for pharmacy and nursing personnel are outlined in policies that promote accountability and facilitate teamwork. In order to ensure alignment with infection prevention, quality improvement, and patient safety activities, institutions must create and execute policies that include ASP goals into more comprehensive healthcare plans [82].

The creation of collaborative governance models, in which nurses, pharmacists, and other medical professionals equally engage in decision-making processes, is one successful strategy. All team members are empowered to contribute to ASP goals and shared accountability is encouraged by this paradigm. For instance, it

has been demonstrated that requiring pharmacists and nurses to assess antimicrobial prescriptions jointly improves adherence to stewardship recommendations and decreases inappropriate antibiotic use [83]. Healthcare organizations should promote regional and national frameworks that encourage transdisciplinary ASPs in addition to local policies. Professional associations and regulatory bodies can offer resources, funds, and recommendations to help standardize procedures and promote cooperation. The impact of stewardship initiatives is further enhanced by policies that require data reporting, invest in ASP infrastructure, and provide incentives for interdisciplinary training [84].

Community Involvement: Increasing Cooperation in Community Health Outside of Hospitals

To treat AR at the community level, interdisciplinary collaboration must be extended outside of medical settings. A wide range of stakeholders, including primary care physicians, public health officials, and community leaders, must be involved in addressing many AR issues, such as the improper use of antibiotics in outpatient care and agricultural contexts. Because of their proficiency in drug management, patient education, and public health outreach, nurses and pharmacists are in a unique position to spearhead these initiatives [85].

Through partnerships with neighborhood organizations, immunization programs, and education campaigns, community-based ASPs work to promote the ethical use of antibiotics. For example, nurses can educate patients about infection prevention and the risks of self-medication, and pharmacists can work with primary care physicians to track antibiotic prescription trends in outpatient clinics. One of the main causes of AR in community settings is the incidence of inappropriate antibiotic usage, which is decreased by these activities [86].

The scope of community involvement initiatives has been further extended by telehealth and mHealth technologies. Patients in distant or underserved locations can receive advice on antibiotic use and adherence from pharmacists and nurses via virtual consultations. It has been demonstrated that mobile applications that provide educational materials and reminders increase patient adherence to recommended regimens, lowering the likelihood of resistance development [87]. Community-based ASPs are further strengthened by forming alliances with businesses, educational institutions, and agricultural interests. For instance, educational initiatives aimed at farmers and schoolchildren can promote ethical behavior in human and animal health and increase knowledge of AR. Interdisciplinary teams can address the underlying causes of AR and advance sustainable solutions by bringing collaboration to the community level.

Systemic and cultural impediments to collaboration must be addressed in order for multidisciplinary approaches to be effective. Policy development institutionalizes ASP goals, technology integration improves communication and decision-making, training and education programs promote mutual awareness of roles, and community participation expands stewardship efforts beyond conventional settings. Healthcare systems can tackle the worldwide danger of AR, maximize antibiotic use, and improve interdisciplinary teamwork by putting these measures into practice.

Successful Models and Case Studies

In the fight against antibiotic resistance (AR), effective interdisciplinary teamwork between nursing and pharmacy experts has shown quantifiable results. Case studies, real-world applications, institutional success stories, international instances, and important lessons learned offer priceless insights on replicability, obstacles, and solutions. These illustrations demonstrate the revolutionary potential of cooperative antimicrobial stewardship program (ASP) techniques, providing a model for healthcare systems around the world.

Examples from Around the World: Nations with Successful Nursing-Pharmacy Partnerships

As part of their ASPs, a number of nations have effectively included nursing-pharmacy partnerships, exhibiting enhanced antibiotic stewardship and decreased rates of resistance. The "Start Smart-Then Focus" campaign was started by the National Health Service (NHS) in the United Kingdom, with an emphasis on early interdisciplinary collaboration in antibiotic prescribing. The program's nurses and pharmacists played a crucial role in ensuring that local prescribing guidelines were followed and that antimicrobial medicines were reviewed on time. Significant improvements in patient outcomes and a 30% decrease in needless antibiotic prescriptions were the results of this campaign [88].

Likewise, the Antimicrobial Stewardship Clinical Care Standard in Australia offers a structure for combining pharmaceutical and nursing knowledge in ASPs. Pharmacists analyze medications and suggest changes based on culture findings, while nurses make bedside assessments and inform patients about antibiotics. According to reports, this partnership has reduced the usage of broad-spectrum antibiotics in Australian hospitals by 25%, which has helped to diminish the prevalence of resistance in bacteria like *Klebsiella pneumoniae* and *Escherichia coli* [89].

Interdisciplinary teamwork is ingrained in primary care and hospital settings in Sweden, a nation known for having low rates of antibiotic resistance. In order to ensure that antibiotics are provided sparingly, nurses and pharmacists take the lead in patient consultations and public education initiatives. Sweden continues to have one of the lowest antibiotic consumption rates in Europe thanks in large part to this cooperative strategy [90].

Institutional Achievements: Medical Facilities with Lower AR By Working Together

Strong evidence of the value of nursing-pharmacy collaboration in lowering AR has been presented by hospital-based ASPs. The University of Maryland Medical Center (UMMC) in the US is one prominent example. Nurses and pharmacists collaborate closely to monitor antibiotic use and optimize therapy as part of UMMC's team-based ASP. While pharmacists examine antimicrobial orders and suggest de-escalation or discontinuance as necessary, nurses spot early infection symptoms and make sure prescribed antibiotics are administered on time. Over a five-year period, this approach has resulted in a 20% decrease in the prevalence

of healthcare-associated infections (HAIs) brought on by microbes resistant to drugs [91].

An interdisciplinary ASP was developed at Tan Tock Seng Hospital in Singapore, which focuses on surgical wards where improper use of antibiotics is prevalent. All surgical prophylactic orders were checked by pharmacists, and nurses kept an eye out for infection symptoms and made sure patients followed their treatment plans. The length of postoperative prophylaxis was shortened by 40% as a result of this partnership, and surgical site infections also decreased [92].

Another example is from the Netherlands, where a hospital-based ASP managed carbapenem-resistant *Acinetobacter baumannii* with amazing success. Pharmacists spearheaded initiatives to limit the use of carbapenem, while nurses were entrusted with implementing infection control measures, such as isolation protocols and hand cleanliness. The efficacy of concerted efforts was demonstrated by the 50% reduction in the prevalence of carbapenem-resistant illnesses within two years [93].

Lessons Acquired: Understanding of Obstacles, Remedies, and Replicability

The aforementioned case studies and models offer insightful guidance on how to get over obstacles and duplicate effective ASPs in various healthcare environments. The significance of institutional commitment and leadership support is one important realization. Hospital administrators gave ASPs top priority in all successful projects by assigning funds, including interdisciplinary teams in decision-making, and encouraging a collaborative culture. In order to overcome opposition to change and guarantee the sustainability of interventions, this support was crucial [94].

The necessity of customized approaches that tackle particular institutional or regional issues is another lesson. For instance, hospitals with limited funding can concentrate on focused interventions that have a high impact but need little financial outlay, such pharmacist-led antimicrobial reviews or nurse-led hand hygiene campaigns. Similarly, to lessen antibiotic abuse in outpatient settings, community-based ASPs can learn from Sweden's public education initiatives [95].

Replicability of these approaches is contingent upon strong education and training programs. Specialized training in ASP principles was provided to nurses and pharmacists in successful programs, which improved their capacity for productive teamwork. As shown in the US and Australia, institutions can use interdisciplinary simulation-based training programs to get teams ready for real-world problems [96].

Another crucial element in scaling these approaches is the incorporation of technology. Communication between team members is facilitated by EHR systems and decision-support tools, allowing for data-driven decision-making and real-time cooperation. Such tools improve the effectiveness and impact of ASP treatments, as demonstrated in Singapore and the Netherlands, and they are highly reproducible in both resource-rich and resource-limited countries [97].

Last but not least, identifying areas for improvement and guaranteeing long-term success require consistent monitoring and evaluation. Metrics including shifts in antibiotic use, rates of resistance, and patient outcomes must be established by institutions to gauge the effects of ASPs. Interdisciplinary teams can improve their strategies and adjust to new problems by using ongoing feedback loops [98].

The transformative potential of interdisciplinary collaboration in ASPs is demonstrated by international instances, institutional success stories, and lessons learned. These approaches, which range from the NHS's Start Smart-Then Focus initiative to hospital-based initiatives in Singapore and the Netherlands, show how nursing and pharmacy cooperation can enhance patient outcomes, decrease antibiotic usage, and lower rates of resistance. Healthcare systems around the world may duplicate and expand these achievements to counter the global danger of AR by removing obstacles, adjusting tactics, and making investments in technology, teaching, and assessment.

Conclusion

Antibiotic resistance (AR) is a global concern that demands an immediate, coordinated response that incorporates the knowledge of medical specialists from all disciplines. In order to combat AR through antimicrobial stewardship programs (ASPs), this research emphasizes the vital role that multidisciplinary collaboration between nursing and pharmacy plays. Nurses and pharmacists can maximize the use of antibiotics, improve patient outcomes, and slow the emergence of resistance by utilizing their complementary expertise. Improving communication, encouraging teamwork through training and education, incorporating cutting-edge technologies, and creating strong institutional and community-level regulations are important tactics.

Reducing needless antibiotic use, decreasing unpleasant medication effects, and addressing the underlying reasons of resistance have all been successfully accomplished through interdisciplinary teamwork. Case studies from institutional programs and global contexts show that concerted efforts result in quantifiable benefits, such as decreased rates of resistance, cheaper medical expenses, and more patient satisfaction. The full potential of collaborative methods is nevertheless constrained by enduring obstacles such as institutional difficulties, educational disparities, and professional silos. Systemic changes are needed to address these challenges, such as focused educational initiatives, the implementation of evidence-based policies, and culture changes within healthcare teams that encourage respect for one another and shared accountability.

Future work must concentrate on extending ASPs outside of hospital settings to encompass community health initiatives and scaling effective collaborative models. Investing in cutting-edge technologies, developing a culture of continuous learning, and fortifying regional and international alliances will be essential to advancing the battle against AR. Healthcare systems can provide long-lasting and efficient answers to one of the most important public health issues of the twenty-first century by placing a high priority on interdisciplinary collaboration.

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معالجة مقاومة المضادات الحيوية من خلال التعاون متعدد التخصصات بين التمريض والصيدلة الملخص:

الخلفية: تحديًا عالميًا رئيسيًا يهدد فعالية العلاجات المضادة للبكتيريا، مما يزيد من معدل الوفيات والمراضة (AR) تعد مقاومة المضادات الحيوية ويثقل كاهل الأنظمة الصحية عالميًا. يحتاج هذا التحدي إلى تدخلات مبتكرة تعتمد على التعاون متعدد التخصصات. يلعب كل من التمريض ، حيث يمكن لتكامل جهودهما أن يحسن من كفاءة (ASPs) . والصيدلة أدوارًا حيوية في برامج الإشراف على استخدام المضادات الحيوية استخدام المضادات الحيوية ويقلل من تطور المقاومة

الهدف: يهدف هذا البحث إلى استكشاف كيفية تعزيز التعاون بين فرق التمريض والصيدلة لمواجهة مقاومة المضادات الحيوية، مع التركيز على استراتيجيات التنفيذ، التغلب على العوائق، وتحسين نتائج المرضى

الطرق: يعتمد البحث على مراجعة منهجية للدراسات السابقة، تقارير المؤسسات الصحية، ودراسات الحالات الدولية، مع التركيز على البرامج التي تعزز التعاون متعدد التخصصات. تم تحليل البيانات لتحديد الأنماط المشتركة وعوامل النجاح

النتائج: أظهرت النتائج أن التعاون بين فرق التمريض والصيدلة يمكن أن يقلل بشكل كبير من وصف المضادات الحيوية غير الضرورية بنسبة تصل إلى 30%، كما يحسن الالتزام بالإرشادات، ويعزز تثقيف المرضى. تتضمن العوائق الرئيسية نقص الأطر المؤسسية، والفجوات التعليمية، والانقسامات المهنية. تم تحديد الحلول الممكنة، مثل دمج التدريب متعدد التخصصات واستخدام التكنولوجيا الحديثة مثل السجلات الصحية الإلكترونية لدعم برامج الإشراف

الخلاصة: يوفر التعاون بين التمريض والصيدلة نموذجًا فعالاً لمعالجة مقاومة المضادات الحيوية، من خلال تحسين استخدام المضادات الحيوية وتقليل تأثير المقاومة. توصي الدراسة بتطوير سياسات داعمة، وتوسيع برامج الإشراف لتشمل الرعاية المجتمعية، وتعزيز التدريب المستمر لتحقيق استدامة الجهود

الكلمات المفتاحية: مقاومة المضادات الحيوية، التعاون متعدد التخصصات، التمريض، الصيدلة، برامج الإشراف على المضادات الحيوية.