

DOI: <https://doi.org/10.63332/joph.v4i3.3374>

Pharmacology and the Nursing Role in Combating Antibiotic Resistance: A Comprehensive Review

AREEJ MAHAJA ALANAZI¹, MOHAMMAD SAAD MOHAMMAD ALQAHTANI², SHAYEEAA FAEH ALOTABI³, TAHANI SUAD AL OTAIBI⁴, MESHAL ABDULLAH OMAR ALJASER⁵, DAWLAT IBRAHIM HANTOOL⁶, ABEER ALI SULAIS⁷, NAJLAA MOHAMMED ALSOFYANI⁸, MARIAM ABDULWAHAB SALEH AL OUF⁹, HUSSAIN MOHAMMED ALMASKEEN¹⁰, ZAHRA MOHAMMED ALSALAH¹¹, ZAINAB HASSAN ALMASHHAD¹², GADAH MOHAMMED DHAIFALLAH ALMABADI¹³, EMAN ABDULAZIZ AL-QUDAIHI¹⁴

Introduction

Chapter 1: Foundations of Antibiotic Pharmacology

Antibiotics represent one of the most significant breakthroughs in modern pharmacology, drastically reducing morbidity and mortality associated with infectious diseases. Their discovery revolutionized medical practice, making once-deadly bacterial infections curable and preventable. From penicillin to broad-spectrum antimicrobials, their role has been central to public health advancements (Khattak et al., 2021). However, the effectiveness of these drugs depends heavily on proper pharmacological application, including correct dosing, selection, and adherence. Nurses, as frontline healthcare providers, play a vital role in ensuring these principles are upheld, especially in the context of antibiotic stewardship (Kvarnström et al., 2021; Sugandh et al., 2023).

Pharmacology explains how antibiotics interact with pathogens and host tissues, focusing on absorption, distribution, metabolism, and excretion. These pharmacokinetic and pharmacodynamic processes determine drug concentration at the site of infection, ensuring therapeutic efficacy while minimizing toxicity. Misunderstanding these principles often leads to

¹ PHARMACIST PRINCE SULTAN MILITARY MEDICAL CITY.

² NURSING HEALTH ASSISTANT PRINCE SULTAN MILITARY MEDICAL CITY.

³ NURSING ALHAWAYA EAST

⁴ GENERAL NURSING JALIL PHC

⁵ PHARMACIST KING FAHD SPECIALIST HOSPITAL , BURAYDAH

⁶ PHARMACY TECHNICIAN KING ABDULAZIZ HOSPITAL IN JEDDAH

⁷ PHARMACIST EAST JEDDAH HOSPITAL

⁸ GENERAL NURSE UMALSALAM PHCC, ALTHAGER HOSPITAL

⁹ QATIF CENTRAL HOSPITAL NURSING TECHNICIAN

¹⁰ NURSE PRINCE MOHAMMED BIN FAHAD

¹¹ SENIOR SPECIALIST-ONCOLOGY AND PALLIATIVE CARE NURSING DAMMAM MATERNITY AND CHILDREN HOSPITAL

¹² NURSE PRINCE MOHAMMED BIN FAHAD

¹³ NURSING HERA GENERAL HOSPITAL

¹⁴ NURSING MIDDLE JUBAIL ALRAZY PHC



underdosing or overuse, both of which contribute to resistance. Nurses must understand these concepts to administer drugs effectively and educate patients about their importance. Linking pharmacological science to practice improves patient safety and outcomes, particularly in hospital and community settings (Konstantinou et al., 2020; Kelley et al., 2022).

Antibiotics exert their action through several mechanisms: inhibiting bacterial cell wall synthesis, interfering with protein translation, disrupting nucleic acid synthesis, and inhibiting metabolic pathways. Understanding these mechanisms enables nurses to appreciate why particular antibiotics are chosen for specific infections. Equally important is recognizing how misuse of these drugs allows bacteria to adapt, leading to resistance. Nurses' pharmacological awareness directly influences adherence to treatment protocols and enhances the overall effectiveness of antibiotic therapy (De Baetselier et al., 2021; Alemmede et al., 2024).

Antibiotic resistance emerges primarily due to misuse, including unnecessary prescriptions, incomplete treatment courses, and incorrect dosing. This resistance poses one of the most serious global threats to healthcare systems, undermining decades of progress. Pharmacological misuse creates selective pressure, allowing resistant strains to thrive and spread. Nurses, equipped with pharmacological knowledge, are uniquely positioned to intervene by monitoring patient adherence, reinforcing education, and advocating for rational use. Their actions at the bedside and in communities can significantly delay resistance development (Gil-Guillen et al., 2022; Burnier, 2024).

Patient adherence is one of the most critical determinants of antibiotic success. Even the most effective drugs fail without consistent, appropriate use. Research shows that poor adherence increases treatment failure, exacerbates infections, and accelerates resistance. Nurses are instrumental in ensuring adherence by providing clear instructions, addressing side effects, and motivating patients to complete their regimens. The pharmacological understanding of drug schedules and mechanisms helps nurses explain to patients why adherence is essential for both individual recovery and public health (Pruette & Amaral, 2021; Alsaihati et al., 2024).

Pharmacists play an indispensable role in antibiotic stewardship by optimizing drug therapy, preventing harmful interactions, and simplifying regimens. Yet, the nurse's role is equally important as they frequently serve as the bridge between patient and therapy. Nurses' daily monitoring of drug effects and adherence allows early identification of problems. Their collaboration with pharmacists ensures patients receive the right antibiotic, at the right dose, for the right duration. This integration of pharmacological expertise with nursing care strengthens the fight against resistance (Balogun et al., 2024; Ferreri et al., 2020).

As primary points of contact, nurses are ideally positioned to educate patients about antibiotics, correcting misconceptions such as using them for viral infections. They can integrate pharmacological knowledge into patient-centered communication, explaining why certain drugs are prescribed and the consequences of non-adherence. Moreover, nurses' ability to assess patient barriers—such as cost, fear of side effects, or complex dosing schedules—makes their role critical in ensuring pharmacological principles translate into real-world outcomes (Yang et al., 2022; While, 2020).

A collaborative care model integrating pharmacists and nurses is essential in antibiotic stewardship. This approach enhances pharmacological decision-making, strengthens patient education, and ensures continuity of care. Nurses identify patient difficulties with medication routines, while pharmacists provide in-depth drug counseling. Together, they improve

adherence, optimize outcomes, and reduce resistance risk. Pharmacological knowledge becomes actionable when supported by teamwork, highlighting the importance of interdisciplinary collaboration in combating resistance (Al-Worafi, 2023; Alyami et al., 2024).

A patient-centered approach is essential in applying pharmacology to antibiotic use. Nurses must understand each patient's unique challenges, including lifestyle, literacy level, and socioeconomic barriers, before tailoring education and support. By simplifying regimens, using reminders, and providing clear communication, nurses translate complex pharmacological principles into practical, manageable strategies for patients. Empathy and individualized care help ensure adherence, making pharmacological effectiveness possible in real-world contexts (Hamrahian et al., 2022; Oakley & Ream, 2024).

Technology enhances adherence and pharmacological effectiveness in antibiotic therapy. Smart pill bottles, reminder apps, and electronic health records allow healthcare teams to monitor usage and intervene promptly. Nurses play a central role in teaching patients to use these tools effectively, ensuring technology supports pharmacological goals. Pharmacology, combined with digital solutions, helps optimize dosing intervals and adherence, reducing missed doses and preventing resistance (Toscos et al., 2020; Haleem et al., 2021).

Cultural and social factors heavily influence antibiotic use and pharmacological outcomes. Some patients may prefer traditional remedies, while others face language or financial barriers. Nurses, informed by pharmacology, can address these concerns by providing culturally sensitive education and ensuring access to affordable medications. Building trust allows patients to better understand antibiotic mechanisms and the risks of resistance. Social determinants of health must be considered to ensure pharmacological principles are effectively applied (Kasahun et al., 2022; Seixas et al., 2020).

The consequences of poor antibiotic adherence are severe, ranging from treatment failures to higher healthcare costs. Patients with partial adherence may relapse, develop complications, or spread resistant organisms. Pharmacological failure at this level extends beyond individual patients, threatening public health systems worldwide. Nurses mitigate these risks by emphasizing adherence, simplifying regimens, and ensuring timely follow-up. Their role ensures pharmacological knowledge translates into safe, effective, and sustainable antibiotic use (Kvarnström et al., 2021; Sugandh et al., 2023).

The future of pharmacology in antibiotic resistance will be increasingly shaped by technology, personalized medicine, and interdisciplinary care. Advances in artificial intelligence and precision therapy promise more tailored approaches to antibiotic prescribing. Yet, the nurse's role in translating these innovations into patient adherence remains essential. Pharmacological knowledge combined with nursing care creates a powerful strategy against resistance, integrating science, technology, and human touch (Coman et al., 2024; Al-Jaroodi et al., 2020).

In conclusion, the foundations of antibiotic pharmacology provide the scientific backbone for combating resistance. Nurses, with their unique role in patient care, transform this knowledge into practice through education, monitoring, and advocacy. Their partnership with pharmacists ensures antibiotics are used effectively and responsibly. By linking pharmacology with frontline nursing practice, the healthcare system can delay resistance, preserve antibiotic efficacy, and protect global health for future generations (Konstantinou et al., 2020; Kelley et al., 2022).

Chapter 2: The Global Burden of Antibiotic Resistance

Antibiotic resistance is a mounting global challenge, recognized as one of the greatest threats to modern healthcare. Its impact stretches across every healthcare system, increasing morbidity, mortality, and costs. Pharmacists, through medication management, ensure that patients receive correct antibiotics in the right dosages, minimizing errors that fuel resistance. By evaluating prescriptions for drug-drug and drug-disease interactions, pharmacists reduce risks of inappropriate therapy, directly protecting patients from harm (Al-Dosari et al., 2024; Coutsouvelis et al., 2020). This pharmacological expertise is vital in controlling resistance by ensuring treatment precision.

Medication Therapy Management (MTM) provides a structured pathway to optimize antibiotic use. Comprehensive reviews, patient counseling, and ongoing monitoring ensure that antibiotics remain effective and safe. Pharmacists delivering MTM assess full regimens, identify duplicate or unnecessary therapies, and simplify complex plans to improve adherence. These interventions are crucial in chronic disease management, where improper use of antibiotics exacerbates resistance. MTM enhances patient understanding, reduces misuse, and strengthens outcomes. By applying pharmacological knowledge systematically, pharmacists protect both individual patients and public health (Ferrerri et al., 2020; Jarab et al., 2022).

Patient education forms a cornerstone in combating resistance. Misunderstanding about antibiotic use—such as stopping treatment early or using them for viral infections—contributes significantly to resistance. Pharmacists, with their accessibility and expertise, educate patients about timing, dosages, and potential side effects. This knowledge empowers patients to follow regimens accurately, preventing resistant strains from emerging. By reinforcing the importance of adherence, pharmacists reduce the risk of treatment failure and public health crises linked to resistant bacteria (Alqarni et al., 2023; Alemede et al., 2024).

Counseling on adherence is another vital pharmacist role. Patients who skip doses or discontinue treatment prematurely create conditions that allow resistant bacteria to survive and multiply. Pharmacists explain the risks of poor adherence, including relapse and severe complications. They also provide tools like pill organizers, reminders, or synchronized medication schedules. These practical strategies translate pharmacological science into real-world outcomes, strengthening patient commitment to treatment (Konstantinou et al., 2020; Balogun et al., 2024).

Complex regimens frequently undermine adherence, increasing resistance risk. Many patients manage multiple conditions and face overwhelming drug schedules. Pharmacists simplify regimens by recommending combination pills, altering dosing intervals, or adjusting formulations to suit patient needs. Simplification reduces confusion and errors, ensuring consistent antibiotic use. By aligning pharmacological knowledge with patient realities, pharmacists foster better engagement and adherence, decreasing misuse that accelerates resistance (Al-Anzi et al., 2024; Darlow et al., 2023).

Concerns about side effects often discourage patients from adhering to antibiotic therapies. Fear of adverse reactions leads some to discontinue treatment prematurely. Pharmacists address this by providing evidence-based information about expected side effects and strategies for managing them. They explain adjustments, such as timing doses with meals, and intervene when severe effects occur by liaising with physicians. This counseling ensures patients remain adherent to safe and tolerable regimens, directly reducing resistance risks (Alemede et al., 2024; Chavan et al., 2023).

In chronic disease management, antibiotics are sometimes necessary to control secondary

infections. Here, consistent adherence prevents complications and reduces resistance development. Pharmacists educate patients about the role of antibiotics in preventing disease exacerbations and maintaining stability. By emphasizing links between adherence and reduced hospitalizations, pharmacists highlight the pharmacological foundation for long-term success. Their efforts directly enhance survival, quality of life, and healthcare system sustainability (Hamrick et al., 2020; Abdulhussein et al., 2024).

Collaboration between pharmacists and nurses amplifies efforts against resistance. Nurses reinforce pharmacists' education by integrating it into daily patient care. Pharmacists provide nurses with updated drug information, ensuring accuracy in communication and administration. Together, they identify adherence barriers and tailor strategies to overcome them, creating a consistent, united approach. This collaboration ensures pharmacological insights are applied seamlessly across healthcare, protecting patients and reducing resistance risk (Kiles et al., 2022; Raza et al., 2022).

Technology provides new opportunities to strengthen antibiotic stewardship. Electronic health records (EHRs) allow pharmacists to review histories and identify adherence gaps. Mobile health apps and digital reminders empower patients to stay consistent with regimens. Real-time communication through digital platforms ensures rapid adjustments to therapy. These innovations bring pharmacology into the digital era, helping pharmacists and nurses monitor use and intervene quickly when adherence falters (Ravi et al., 2022; Kiles et al., 2022).

Barriers to adherence, such as cost, forgetfulness, or limited knowledge, are common contributors to resistance. Pharmacists identify these obstacles and propose practical solutions, such as generics for affordability or synchronization programs to simplify refills. Addressing these barriers ensures that antibiotic regimens are completed properly, minimizing the survival of resistant strains. Pharmacists' problem-solving approach transforms pharmacological expertise into meaningful patient support (Bethishou, 2024; Ngamdee et al., 2024).

Monitoring adherence is equally crucial in preventing resistance. By reviewing refill records, conducting medication checks, and tracking patient progress, pharmacists detect non-adherence early. They can then counsel patients and coordinate with nurses to intervene. This ongoing surveillance allows healthcare teams to protect patients from relapse and prevent resistant organisms from proliferating. Continuous monitoring represents a key extension of pharmacology into practice (Ekong et al., 2020; Bethishou, 2024).

Pharmacists' expertise in pharmacology extends beyond dispensing to holistic patient care. Their ability to identify risks, simplify regimens, and educate patients ensures antibiotics are used effectively and safely. By tailoring treatment to patient needs, pharmacists reduce inappropriate use and its contribution to resistance. Their role reflects a balance of scientific knowledge and human-centered care, aligning pharmacology with public health objectives (Patton et al., 2021; Syrnyk & Glass, 2023).

Global healthcare systems face escalating costs and health burdens due to resistance. The inappropriate use of antibiotics undermines treatments, leading to longer hospital stays, more complex therapies, and increased mortality. Pharmacists, through patient-centered interventions, prevent these outcomes by promoting adherence, simplifying regimens, and addressing barriers. Their collaboration with other professionals strengthens systems against resistance, preserving antibiotics for future generations (Al-Dosari et al., 2024; Coutsouvelis et al., 2020).

In conclusion, the global burden of antibiotic resistance highlights the critical need for

pharmacist-led interventions. By combining pharmacological expertise with patient education, adherence strategies, and collaboration, pharmacists reduce resistance development. Nurses, physicians, and pharmacists must continue working together to implement sustainable solutions. Technology and patient-centered care enhance these efforts, ensuring antibiotics remain effective tools in fighting infection. Pharmacists are indispensable in this global struggle, bridging science and practice to protect public health (Patton et al., 2021; Syrnyk & Glass, 2023).

Chapter 3: Nurses' Role in Antibiotic Stewardship

Effective communication between pharmacists and nurses is a cornerstone of antibiotic stewardship. Nurses often have firsthand insight into patient adherence challenges, while pharmacists provide expertise on pharmacological regimens. Clear, consistent communication ensures the patient's care plan is coordinated, reducing risks of misuse and resistance. Establishing structured communication protocols, such as shared electronic health records, strengthens collaboration. These mechanisms enable real-time interventions, prevent duplication, and ensure patients receive consistent messages. By fostering this partnership, healthcare professionals align stewardship strategies with patient needs, ultimately reducing inappropriate antibiotic use (White et al., 2022; Ravi et al., 2022).

When nurses and pharmacists align their goals, antibiotic stewardship becomes more effective. Nurses monitor patient responses and adherence, while pharmacists evaluate drug efficacy and side effect profiles. By setting measurable goals, such as improving adherence rates or reducing medication errors, both professionals can track outcomes over time. Unified goals create accountability and focus, ensuring timely interventions when adherence falters. This alignment not only reduces resistance but also promotes optimal use of limited antibiotic resources. A collaborative framework enables both professions to act cohesively in safeguarding antibiotic effectiveness (Schmid et al., 2022; Wheat et al., 2020).

Joint patient education programs represent a powerful collaborative strategy in combating resistance. Pharmacists explain technical aspects, such as dosage and drug interactions, while nurses contextualize this within patients' daily lives. These sessions, delivered individually or in groups, reinforce consistent messages and address practical barriers. Patients benefit from a comprehensive understanding of why adherence is critical and how to manage side effects effectively. Education bridges knowledge gaps, empowering patients to complete therapy as prescribed, thereby preventing resistance. By uniting education efforts, pharmacists and nurses deliver holistic care that strengthens stewardship programs (Balogun et al., 2023; Dilles et al., 2021).

A patient-centered care model strengthens stewardship by tailoring interventions to individual needs. Nurses often understand social and behavioral barriers to adherence, while pharmacists adjust drug regimens to accommodate those realities. Personalized strategies may include once-daily dosing, simplified regimens, or reminder systems. Together, pharmacists and nurses provide solutions that align with the patient's lifestyle, improving adherence and minimizing misuse. By integrating pharmacological expertise with practical, patient-specific insights, this collaboration ensures antibiotics are used effectively and sustainably, reducing the risk of resistance spreading within communities (White et al., 2022; Jaffer et al., 2023).

Coordinating follow-up care ensures continuous monitoring of antibiotic use. Nurses, through frequent contact, can detect early signs of non-adherence or adverse effects, alerting pharmacists for timely adjustments. Pharmacists then provide targeted counseling or adjust therapy to

mitigate risks. Regular follow-ups reinforce adherence, strengthen patient education, and create accountability. This partnership prevents minor adherence issues from escalating into treatment failures or resistant infections. By institutionalizing collaborative follow-up systems, healthcare teams promote responsible antibiotic use and improve long-term outcomes in stewardship initiatives (Lott et al., 2021; Forsyth et al., 2023).

Technology significantly enhances collaboration in antibiotic stewardship. Shared electronic health records facilitate seamless information exchange between pharmacists and nurses, enabling coordinated monitoring of adherence. Mobile apps and digital reminders empower patients to take medications correctly, reducing nurse workload while ensuring accuracy. Pharmacists can also use telehealth to provide virtual consultations, supporting patients remotely. These innovations strengthen adherence monitoring, improve patient engagement, and ensure antibiotics are used rationally. By integrating digital tools into stewardship efforts, healthcare professionals enhance both efficiency and effectiveness (Coutsouvelis et al., 2020; Rahayu et al., 2021).

Identifying and addressing barriers to adherence is crucial for stewardship. Nurses, through close patient contact, recognize challenges such as forgetfulness, fear of side effects, or financial strain. Pharmacists respond by simplifying regimens, recommending generics, or implementing medication therapy management programs. Collaborative efforts ensure patients receive tailored support, reducing non-adherence and inappropriate antibiotic use. By sharing responsibility, nurses and pharmacists create comprehensive care solutions that sustain adherence and protect antibiotic efficacy over time (Al-Worafi, 2023; Lott et al., 2021).

Patient empowerment is an essential element of stewardship. Nurses encourage patients to recognize the importance of antibiotics in recovery, while pharmacists provide detailed explanations of drug functions and side effects. This shared educational effort builds patient confidence and fosters active participation in treatment. Empowered patients are more likely to adhere to therapy, reducing misuse and resistance. The joint efforts of pharmacists and nurses thus transform patients into partners in stewardship, enhancing long-term outcomes (Pruette & Amaral, 2021; Schmid et al., 2022).

A problem-solving approach strengthens collaboration when patients struggle with adherence. Nurses may notice missed doses or reluctance, bringing these concerns to pharmacists. Pharmacists then identify solutions such as alternative formulations, financial support, or educational reinforcement. Together, they implement tailored interventions that directly address root causes of non-adherence. This dynamic collaboration reduces the likelihood of treatment failure and resistant infections, ensuring that antibiotic regimens remain both effective and sustainable (Tadros et al., 2023; Passey et al., 2021).

Multidisciplinary team meetings enhance stewardship by uniting professionals around patient care. Nurses provide insights into patient behavior, while pharmacists contribute pharmacological expertise. These meetings encourage shared responsibility, align strategies, and identify opportunities for regimen optimization. By reviewing cases collectively, the team can adjust therapies, strengthen education, and implement proactive adherence strategies. Structured teamwork creates a culture of accountability, ensuring antibiotics are used responsibly and effectively in clinical settings (O'Toole et al., 2022; Balogun et al., 2023).

Trust between patients and healthcare professionals underpins adherence. Nurses, often closest to patients, build rapport through compassionate care and open communication. Pharmacists

reinforce this trust by offering clear explanations and ongoing counseling. Together, they create an environment where patients feel safe discussing challenges, such as side effect concerns or doubts about antibiotics. Trust encourages honesty, enabling tailored interventions that strengthen adherence and prevent resistance (Bhattarai et al., 2021; Schneider & Burnier, 2023).

Collaboration also requires evaluating outcomes to ensure strategies are effective. Both pharmacists and nurses can track adherence using refill rates, pill counts, or patient self-reports. Regular evaluation identifies strengths and areas needing adjustment, ensuring interventions remain relevant. Documenting results supports continuous improvement in stewardship practices, making efforts sustainable over time. By committing to systematic evaluation, healthcare professionals ensure stewardship interventions achieve lasting impact (Jaffer et al., 2023; Tadros et al., 2023).

The integration of pharmacists and nurses in stewardship creates a culture of accountability, where both professions actively safeguard antibiotics. Nurses contribute patient-centered insights, while pharmacists ensure pharmacological precision. Together, they form a powerful alliance capable of reducing misuse, improving adherence, and slowing resistance. This partnership underscores the multidisciplinary nature of stewardship and the shared responsibility of healthcare professionals in preserving antibiotic efficacy (White et al., 2022; Wheat et al., 2020).

In conclusion, collaborative nursing roles in antibiotic stewardship emphasize communication, education, patient-centered care, and technology-driven solutions. Nurses identify patient challenges, pharmacists provide pharmacological expertise, and together they design interventions that sustain adherence. By building trust, solving problems collaboratively, and measuring outcomes, both professions strengthen stewardship strategies. Their combined efforts are essential in reducing global antibiotic resistance, ensuring that life-saving treatments remain effective for future generations (O'Toole et al., 2022; Schneider & Burnier, 2023).

Chapter 4: Pharmacological Competencies for Nursing Practice

Medication adherence remains a significant challenge in chronic disease management, often influenced by patients' fears about side effects. Nurses must possess strong pharmacological competencies to educate patients, alleviate concerns, and reinforce the importance of continuing treatment. By collaborating with pharmacists, nurses can explain which side effects are temporary and how to manage them effectively. Empowering patients with this knowledge reduces discontinuation and enhances trust in treatment. Nurses' pharmacological understanding directly supports adherence and ensures continuity of care (Sugandh et al., 2023; Jarab et al., 2022).

Cost frequently prevents patients from adhering to prescribed regimens, making affordability an essential competency for nurses to address. Understanding generic alternatives, patient assistance programs, and cost-reduction strategies equips nurses to advocate effectively for their patients. By working alongside pharmacists, nurses can help adjust treatment plans that balance clinical efficacy with financial feasibility. This role highlights the importance of pharmacological knowledge in navigating economic barriers to care. When nurses understand these cost-related considerations, they play a central role in improving adherence and outcomes (Al-Jaroodi et al., 2020; Wheat et al., 2020).

Forgetfulness is one of the most common reasons patients fail to adhere to medications. Nurses, drawing on pharmacological competencies, can advise on strategies such as pill organizers,

alarms, or apps designed to support medication management. By collaborating with patients and families, nurses can embed routines that promote consistency. Pharmacological knowledge also enables nurses to simplify regimens when possible, reducing patient burden. This proactive approach ensures treatments are followed correctly and reliably, strengthening the impact of prescribed therapies (Kvarnström et al., 2021; O'Toole et al., 2022).

Many patients underestimate the importance of medications, discontinuing them prematurely due to poor understanding. Nurses trained in pharmacology can clearly explain mechanisms of action, therapeutic goals, and the consequences of non-adherence. This patient-centered education builds motivation, trust, and long-term engagement with treatment. Pharmacological competence allows nurses to bridge communication gaps and empower patients with accurate, understandable knowledge. Through this role, nurses contribute significantly to adherence and the prevention of complications in chronic diseases (Alqarni et al., 2023; Bhattarai et al., 2021).

Psychological barriers such as anxiety or depression significantly impact adherence behaviors. Nurses with pharmacological training are uniquely positioned to address these issues by reinforcing the importance of continuing treatment even during periods of emotional distress. They can collaborate with pharmacists to adapt regimens or refer patients to mental health services when needed. Pharmacological literacy allows nurses to link adherence with improved physical and mental health outcomes, ensuring holistic patient care (Yang et al., 2022; Horvat et al., 2024).

Complex treatment regimens can overwhelm patients, leading to errors and missed doses. Nurses with pharmacological expertise can help simplify regimens in collaboration with prescribers and pharmacists. They can teach patients correct administration methods and use visual aids or reminders to reinforce instructions. Simplification reduces stress, enhances adherence, and ensures patients understand their treatments. By integrating pharmacological insights with patient education, nurses help reduce errors and strengthen therapeutic success (Talens et al., 2021; Konstantinou et al., 2020).

Social and environmental barriers also affect adherence, including lack of support and limited access to healthcare. Nurses with pharmacological competencies can identify these challenges and advocate for interventions like home delivery services or caregiver involvement. Pharmacological understanding ensures nurses can explain the risks of discontinuation and provide practical solutions. Addressing social determinants of health becomes a critical nursing competency in safeguarding adherence (Alyami et al., 2024; Patton et al., 2021).

Regular follow-up is another critical competency for nurses in improving adherence. Without ongoing support, patients often lose motivation or become disengaged. Nurses with pharmacological knowledge can perform monitoring, identify emerging side effects, and reinforce treatment goals. Their proactive involvement ensures adherence challenges are identified and addressed early. Integrating follow-up into routine nursing practice ensures sustained patient engagement and prevents complications (Bastani et al., 2021; Alemede et al., 2024).

Nurses frequently act as the first line of defense in detecting adherence issues. With pharmacological training, they can recognize signs such as skipped doses or misunderstanding instructions. Collaboration with pharmacists enhances their ability to respond effectively. By sharing observations and advocating for patient-centered adjustments, nurses contribute to individualized care. Pharmacological competence ensures that these interventions are timely,

accurate, and effective (Gutierrez & Sakulbumrungsil, 2021; Hughes et al., 2022).

Patient counseling is central to nursing practice, requiring robust pharmacological understanding. Nurses can explain drug purposes, dosages, side effects, and missed-dose protocols in simple terms. Counseling empowers patients, reducing confusion and fostering ownership of their health. Pharmacological knowledge also enables nurses to anticipate and address common patient concerns. Providing accurate information strengthens adherence, reduces risks, and enhances trust in healthcare providers (Yang et al., 2022; Gatwood et al., 2022).

Collaboration with pharmacists enhances the effectiveness of nursing interventions. Pharmacological literacy allows nurses to engage meaningfully in discussions about regimens, adjustments, and patient barriers. Working together, they provide consistent messaging and comprehensive support. Nurses' frontline observations combined with pharmacists' technical expertise create an integrated care system that promotes adherence. Such collaboration underscores the value of pharmacological competencies in multidisciplinary care (Hamrick et al., 2020; Ekong et al., 2020).

Long-term management of chronic disease requires nurses to sustain pharmacological vigilance. Nurses with these competencies can monitor patients over time, adapting education and support as circumstances change. Regular reinforcement, education, and counseling ensure adherence remains consistent, even when challenges arise. This long-term partnership reflects the critical role of nursing pharmacology in sustaining health outcomes (Okolo et al., 2024; Alemede et al., 2024).

In conclusion, pharmacological competencies are vital to nursing practice in promoting adherence and preventing resistance. Nurses serve as educators, monitors, advocates, and collaborators, applying pharmacological knowledge to empower patients and improve outcomes. Their role bridges patient concerns with pharmacological science, ensuring sustainable treatment success in chronic disease management (Sugandh et al., 2023; Bhattarai et al., 2021).

Chapter 5: Future Directions in Nursing and Antibiotic Resistance Control

Medication fatigue and side effect concerns remain barriers to adherence, particularly in chronic disease management. Future nursing practice must integrate advanced pharmacological education to address these fears proactively. By reassuring patients, offering coping strategies, and emphasizing long-term benefits, nurses can strengthen adherence and mitigate resistance. This competency will remain essential as antibiotic regimens become more targeted yet complex (Sugandh et al., 2023; Jarab et al., 2022).

Financial barriers are likely to intensify as healthcare costs rise. Future nursing roles must include advocating for cost-effective therapies and assisting patients in accessing generics or assistance programs. Nurses trained in pharmacology will be better positioned to collaborate with providers and ensure treatments are both effective and affordable. Addressing cost will remain a cornerstone of sustaining adherence (Al-Jaroodi et al., 2020; Wheat et al., 2020).

Forgetfulness will continue to challenge adherence, especially with aging populations. Nurses must increasingly use technology—such as reminder apps, smart devices, and caregiver support systems—to ensure consistency. Pharmacological knowledge will help nurses design simplified regimens aligned with patient needs, reducing complexity and error. These strategies represent

essential future directions in adherence promotion (Kvarnström et al., 2021; O'Toole et al., 2022).

Education will remain a central focus in the future of stewardship. Nurses with advanced pharmacological expertise will be responsible for bridging patient knowledge gaps and countering misinformation. Clear communication about mechanisms, benefits, and risks will strengthen trust and adherence. This role will grow in importance as antimicrobial stewardship initiatives expand globally (Alqarni et al., 2023; Bhattarai et al., 2021).

Mental health challenges will increasingly impact adherence, requiring nurses to integrate psychological support with pharmacological education. Recognizing the interplay between mental and physical health, future nursing practice must include routine screening, referral, and counseling. By addressing psychological barriers alongside pharmacological needs, nurses can ensure holistic patient care (Yang et al., 2022; Horvat et al., 2024).

Future stewardship will demand simplification of increasingly complex regimens. Nurses with pharmacological competencies will be critical in advocating for once-daily dosing, combination therapies, and patient-friendly formulations. Simplification will reduce errors, strengthen adherence, and preserve antibiotic effectiveness (Talens et al., 2021; Konstantinou et al., 2020).

Social inequities will remain significant barriers to adherence. Nurses must expand their roles to include advocacy for vulnerable populations, ensuring equitable access to medications and support systems. Pharmacological understanding will equip nurses to communicate the risks of non-adherence and the benefits of consistent therapy. These advocacy roles are central to the future of stewardship (Alyami et al., 2024; Patton et al., 2021).

Follow-up will become more structured and technology-driven. Nurses will lead in implementing virtual consultations, automated reminders, and telehealth-based monitoring. Pharmacological knowledge will enable them to interpret patient data effectively and adjust education accordingly. This continuous engagement will prevent lapses in adherence and sustain long-term outcomes (Bastani et al., 2021; Alemede et al., 2024).

Future nursing practice will require even closer collaboration with pharmacists. Shared pharmacological expertise will enable both professions to anticipate challenges, identify risks, and develop patient-centered solutions. Together, they will build resilient stewardship models that integrate education, monitoring, and patient advocacy (Gutierrez & Sakulbumrungsil, 2021; Hughes et al., 2022).

Patient counseling will evolve to include digital platforms, video education, and interactive resources. Nurses with pharmacological competencies will ensure these tools remain accurate, accessible, and patient-friendly. Counseling will remain a vital nursing role, reinforcing adherence across diverse patient populations (Yang et al., 2022; Gatwood et al., 2022).

Multidisciplinary collaboration will continue to shape stewardship. Nurses will increasingly engage in team-based interventions, contributing pharmacological insights alongside other professionals. This integration ensures sustainable adherence and resistance control (Hamrick et al., 2020; Ekong et al., 2020).

Future stewardship efforts will emphasize lifelong support. Nurses, with pharmacological expertise, will play a central role in sustaining adherence across decades of treatment. Ongoing monitoring, reinforcement, and counseling will become defining features of nursing practice (Okolo et al., 2024; Alemede et al., 2024).

In conclusion, the future of nursing in antibiotic resistance control lies in advanced pharmacological training, patient-centered education, and interdisciplinary collaboration. Nurses will remain at the forefront of stewardship, shaping sustainable healthcare outcomes by bridging pharmacological science with compassionate practice (Sugandh et al., 2023; Wheat et al., 2020).

References

- Abdulhussein, N. N., Al-Azzawi, A. K., & Ajel, A. R. (2024, October). Design and implementation of closed-loop drug management in the pharmaceutical industry. In AIP Conference Proceedings (Vol. 3232, No. 1). AIP Publishing.
- Al-Anzi, E. A. M., Al Harbi, Y. S. S., Al-Harbi, A. A. H. A., Al-Anzi, F. A. T., Alenazi, M. A. O., Alenazi, M. K. M., ... & Al Mutairi, A. Z. S. (2024). Publics' Perceptions of Community Pharmacists role in Patient Care Services. *Journal of International Crisis and Risk Communication Research*, 1400-1407.
- Al-Dosari, D. F., Al-Dosari, D. F., Al-Massifri, H. S. M., Alrajhi, E. A., Al-Jumaiah, N. S., Alenazi, R. H., & Al-Dosari, A. N. (2024). Enhancing Patient Outcomes: The Role of Pharmacists in OTC Drug Selection and Counseling. *Journal of International Crisis and Risk Communication Research*, 2038-2045.
- Alemede, V., Nwankwo, E. I., Igwama, G. T., Olaboye, J. A., & Anyanwu, E. C. (2024). Pharmacists as educators: Enhancing patient understanding and access to specialty medications through community workshops. *Magna Scientia Advanced Biology and Pharmacy*, 13(1), 1-9.
- Alemede, V., Nwankwo, E. I., Igwama, G. T., Olaboye, J. A., & Anyanwu, E. C. (2024). Designing state-level policies to support independent pharmacies in providing specialty care services in rural regions. *Magna Scientia Advanced Biology and Pharmacy*, 13(1), 19-29.
- Al-Jaroodi, J., Mohamed, N., & Abukhousa, E. (2020). Health 4.0: on the way to realizing the healthcare of the future. *Ieee Access*, 8, 211189-211210.
- Alqarni, M. A., Alshammari, N. A., Aljohani, A. A., Alenezi, B. H., Alsubhi, I. M., Al-Harbi, H. R., ... & Aljabry, S. (2023). The Role Of Community Pharmacists In Educating Patients About Drug Interactions And Medication Safety. *Journal of Survey in Fisheries Sciences*, 10(5), 276-281.
- Alsaihati, F. M., Alsultan, F. M., Bujubarah, M. M., Alsharyawi, F. M. S., Aljaffar, B. H., & Hussain, F. (2024). Integrative Approaches in Primary Care: The Roles of Dentistry, Nursing, and Pharmacy. *Letters in High Energy Physics*, 643-656
- Al-Worafi, Y. M. (2023). Pharmaceutical Care. In *Handbook of Medical and Health Sciences in Developing Countries: Education, Practice, and Research* (pp. 1-23). Cham: Springer International Publishing.
- Alyami, A. M. O., Alsulayyi, M. S. M., Alruwaili, F. N. S., Alruwaili, A. S. A., Alenezi, F. S. K., Alruwaili, R. M. M., ... & Najai, A. M. N. (2024). Role of Nurses in Improving Medication Adherence among Elderly Patients. *Journal of International Crisis and Risk Communication Research*, 310-332.
- Balogun, O. D., Ayo-Farai, O., Ogundairo, O., Maduka, C. P., Okongwu, C. C., Babarinde, A. O., & Sodamade, O. T. (2023). Innovations in drug delivery systems: A review of the pharmacist's role in enhancing efficacy and patient compliance. *World Journal of Advanced Research and Reviews*, 20(3), 1268-1282.
- Balogun, O. D., Ayo-Farai, O., Ogundairo, O., Maduka, C. P., Okongwu, C. C., Babarinde, A. O., & Sodamade, O. T. (2024). The role of pharmacists in personalised medicine: a review of integrating pharmacogenomics into clinical practice. *International Medical Science Research Journal*, 4(1), 19-36.

- Bastani, P., Bikineh, P., Ravangard, R., Rezaee, R., & Kavosi, Z. (2021). Determinants affecting medication adherence in the elderly: A qualitative study. *Aging Medicine*, 4(1), 35-41.
- Bethishou, L. (2024). The Role of Pharmacy in Supporting Safe and Effective Transitions of Care. *Journal of Contemporary Pharmacy Practice*, 71(2), 23-33.
- Bhattarai, B., Walpola, R., Khan, S., & Mey, A. (2021). Factors associated with medication adherence among people living with COPD: Pharmacists' perspectives. *Exploratory Research in Clinical and Social Pharmacy*, 3, 100049.
- Burnier, M. (2024). The role of adherence in patients with chronic diseases. *European Journal of Internal Medicine*, 119, 1-5.
- Chavan, A. A., Kumbhar, S. B., Shinde, V. R., Thorat, A. A., Jadhav, P. B., Jadhav, A. R., ... & Kumbhar, D. D. (2023). Role of pharmacist in healthcare system. *GSC Biological and Pharmaceutical Sciences*, 24(1).
- Coman, L. I., Ianculescu, M., Paraschiv, E. A., Alexandru, A., & Bădărău, I. A. (2024). Smart Solutions for Diet-Related Disease Management: Connected Care, Remote Health Monitoring Systems, and Integrated Insights for Advanced Evaluation. *Applied Sciences*, 14(6), 2351.
- Coutsouvelis, J., Siderov, J., Tey, A. Y., Bortz, H. D., O'Connor, S. R., Rowan, G. D., ... & Percival, M. A. (2020). The impact of pharmacist-led strategies implemented to reduce errors related to cancer therapies: a systematic review. *Journal of Pharmacy Practice and Research*, 50(6), 466-480.
- Darlow, B., Brown, M., Hudson, B., Frew, G., Clark, J., Vincent, L., ... & Briggs, A. M. (2023). Knee osteoarthritis and the knowledgeable, trustworthy pharmacist: Patient and pharmacist perceptions of community pharmacy-based education and support. *Musculoskeletal Care*, 21(1), 3-15.
- De Baetselier, E., Dilles, T., Batalha, L. M., Dijkstra, N. E., Fernandes, M. I., Filov, I., ... & Van Rompaey, B. (2021). Perspectives of nurses' role in interprofessional pharmaceutical care across 14 European countries: A qualitative study in pharmacists, physicians and nurses. *PloS one*, 16(5), e0251982.
- Dilles, T., Heczkova, J., Tziaferi, S., Helgesen, A. K., Grøndahl, V. A., Van Rompaey, B., ... & Jordan, S. (2021). Nurses and pharmaceutical care: interprofessional, evidence-based working to improve patient care and outcomes. *International journal of environmental research and public health*, 18(11), 5973.
- Ekong, G., Chou, C., Lakin, J., Hardin, A., Fox, B., Hunt, C., & Kavookjian, J. (2020). Pharmacist-led motivational interviewing for diabetes medication adherence in a worksite wellness program. *Journal of the American Pharmacists Association*, 60(6), e224-e229.
- Ferreri, S. P., Hughes, T. D., & Snyder, M. E. (2020). Medication therapy management: current challenges. *Integrated Pharmacy Research and Practice*, 71-81.
- Forsyth, P., Radley, A., Rushworth, G. F., Marra, F., Roberts, S., O'Hare, R., ... & Maguire, B. (2023). The collaborative care model: realizing healthcare values and increasing responsiveness in the pharmacy workforce. *Research in social and administrative pharmacy*, 19(1), 110-122.
- Gatwood, J., Brooks, C., Meacham, R., Abou-Rahma, J., Cernasev, A., Brown, E., & Kuchtay, R. W. (2022). Facilitators and barriers to glaucoma medication adherence. *Journal of Glaucoma*, 31(1), 31-36.
- Gil-Guillen, V. F., Balsa, A., Bernárdez, B., Valdés y Llorca, C., Márquez-Contreras, E., de la Haba-Rodríguez, J., ... & Gómez-Martínez, J. (2022). Medication non-adherence in rheumatology, oncology and cardiology: a review of the literature of risk factors and potential interventions. *International Journal of Environmental Research and Public Health*, 19(19), 12036.
- Gutierrez, M. M., & Sakulbumrungsil, R. (2021). Factors associated with medication adherence of hypertensive patients in the Philippines: a systematic review. *Clinical hypertension*, 27, 1-15.

- Haleem, A., Javaid, M., Singh, R. P., & Suman, R. (2021). Telemedicine for healthcare: Capabilities, features, barriers, and applications. *Sensors international*, 2, 100117.
- Hamrahian, S. M., Maarouf, O. H., & Fülöp, T. (2022). A critical review of medication adherence in hypertension: barriers and facilitators clinicians should consider. *Patient preference and adherence*, 2749-2757.
- Hamrick, J., Augustine, J. M., Pinkerton, D., Klein, C. M., & Elliott, J. (2020). Simulated medication adherence: First and second-year pharmacy students' perceptions of adhering to a multi-drug medication regimen. *Currents in Pharmacy Teaching and Learning*, 12(7), 858-863.
- Horvat, M., Eržen, I., & Vrbnjak, D. (2024, August). Barriers and facilitators to medication adherence among the vulnerable elderly: a focus group study. In *Healthcare* (Vol. 12, No. 17, p. 1723). MDPI.
- Hughes, T. D., Cutrell, S., Minshew, L. M., Brown, P., & Ferreri, S. P. (2022). An exploration of barriers, facilitators, and practical solutions for adopting medication synchronization into community pharmacies: A qualitative analysis. *Exploratory Research in Clinical and Social Pharmacy*, 5, 100111.
- Jaffer, U., Nassir, C. M. N. C. M., & Ahmed, M. A. (2023). Medication adherence: understanding the challenges among the elderly. *Psychology*, 8(52), 865-874.
- Jarab, A. S., Al-Qerem, W., Mukattash, T. L., Abuhishmah, S. R., & Alkhdour, S. (2022). Pharmacists' knowledge and attitudes toward medication therapy management service and the associated challenges and barriers for its implementation. *Saudi Pharmaceutical Journal*, 30(6), 842-848.
- Kasahun, A. E., Sendekie, A. K., Mekonnen, G. A., Sema, F. D., Kemal, L. K., & Abebe, R. B. (2022). Impact of personal, cultural and religious beliefs on medication adherence among patients with chronic diseases at university hospital in Northwest Ethiopia. *Patient preference and adherence*, 1787-1803.
- Kelley, A. T., Incze, M. A., Baylis, J. D., Calder, S. G., Weiner, S. J., Zickmund, S. L., ... & Bridges, J. F. (2022). Patient-centered quality measurement for opioid use disorder: Development of a taxonomy to address gaps in research and practice. *Substance abuse*, 43(1), 1286-1299.
- Kiles, T. M., Peroulas, D., & Borja-Hart, N. (2022). Defining the role of pharmacists in addressing the social determinants of health. *Research in Social and Administrative Pharmacy*, 18(9), 3699-3703.
- Konstantinou, P., Kassianos, A. P., Georgiou, G., Panayides, A., Papageorgiou, A., Almas, I., ... & Karekla, M. (2020). Barriers, facilitators, and interventions for medication adherence across chronic conditions with the highest non-adherence rates: a scoping review with recommendations for intervention development. *Translational behavioral medicine*, 10(6), 1390-1398.
- Kvarnström, K., Westerholm, A., Airaksinen, M., & Liira, H. (2021). Factors contributing to medication adherence in patients with a chronic condition: a scoping review of qualitative research. *Pharmaceutics*, 13(7), 1100.
- Lott, B. E., Anderson, E. J., Zapata, L. V., Cooley, J., Forbes, S., Taylor, A. M., ... & Warholak, T. (2021). Expanding pharmacists' roles: Pharmacists' perspectives on barriers and facilitators to collaborative practice. *Journal of the American Pharmacists Association*, 61(2), 213-220.
- Nisar Khattak, M., Muhammad, N., & Robinson, D. (2021). Understanding the interplay between support agencies and small and medium-sized enterprises in a conflict environment from an institutional theory perspective. *Asia-Pacific Journal of Business Administration*, 13(2), 256-271.
- Ngamdee, N., Chumfang, N., Chiangkhong, A., Satuswan, A., & Sukdee, S. (2024). Behavioral Patterns and Barriers to Medication Adherence in Older Adults with Diabetes. *International Journal of Geoinformatics*, 20(3), 64-73.
- O'Toole, J., Krishnan, M., Riekert, K., & Eakin, M. N. (2022). Understanding barriers to and strategies for medication adherence in COPD: a qualitative study. *BMC pulmonary medicine*, 22(1), 98.
- Oakley, C., & Ream, E. (2024, February). Role of the Nurse in Patient Education and Engagement and Its

- Importance in Advanced Breast Cancer. In *Seminars in Oncology Nursing* (Vol. 40, No. 1, p. 151556). WB Saunders.
- Okolo, C. A., Arowoogun, J. O., Chidi, R., & Adeniyi, A. O. (2024). Telemedicine's role in transforming healthcare delivery in the pharmaceutical industry: A systematic review. *World Journal of Advanced Research and Reviews*, 21(2), 1836-1856.
- Passey, D. G., Healy, R., Qualls, J., Halwani, A., & Sauer, B. C. (2021). Pharmacist-led collaborative medication management programs for oral antineoplastic therapies: A systematic literature review. *Journal of the American Pharmacists Association*, 61(3), e7-e18.
- Patton, D. E., Ryan, C., & Hughes, C. M. (2021). Enhancing community pharmacists' provision of medication adherence support to older adults: a mixed methods study using the theoretical domains framework. *Research in social and administrative pharmacy*, 17(2), 406-418.
- Pruette, C. S., & Amaral, S. (2021). Empowering patients to adhere to their treatment regimens: a multifaceted approach. *Pediatric transplantation*, 25(1), e13849.
- Rahayu, S. A., Widiyanto, S., Defi, I. R., & Abdulah, R. (2021). Role of pharmacists in the interprofessional care team for patients with chronic diseases. *Journal of multidisciplinary healthcare*, 1701-1710.
- Ravi, P., Pfaff, K., Ralph, J., Cruz, E., Bellaire, M., & Fontanin, G. (2022). Nurse-pharmacist collaborations for promoting medication safety among community-dwelling adults: A scoping review. *International Journal of Nursing Studies Advances*, 4, 100079.
- Raza, M. A., Aziz, S., Noreen, M., Anjum, I., & Raza, S. M. (2022). A portrait of the pharmacy profession globally: pharmacist universal professional identity and establishment of global pharmacy council. *INNOVATIONS in pharmacy*, 13(1).
- Schmid, S., Schlosser, S., Gülow, K., Pavel, V., Müller, M., & Kratzer, A. (2022). Interprofessional collaboration between ICU physicians, staff nurses, and hospital pharmacists optimizes antimicrobial treatment and improves quality of care and economic outcome. *Antibiotics*, 11(3), 381.
- Schneider, M. P., & Burnier, M. (2023). Partnership between patients and interprofessional healthcare providers along the multifaceted journey to medication adherence. *British Journal of Clinical Pharmacology*, 89(7).
- Seixas, A., Conners, C., Chung, A., Donley, T., & Jean-Louis, G. (2020). A pantheoretical framework to optimize adherence to healthy lifestyle behaviors and medication adherence: the use of personalized approaches to overcome barriers and optimize facilitators to achieve adherence. *JMIR mHealth and uHealth*, 8(6), e16429.
- Sugandh, F. N. U., Chandio, M., Raveena, F. N. U., Kumar, L., Karishma, F. N. U., Khuwaja, S., & Kumar, S. (2023). Advances in the management of diabetes mellitus: a focus on personalized medicine. *Cureus*, 15(8).
- Syrnyk, M., & Glass, B. (2023). Pharmacist interventions in medication adherence in patients with mental health disorders: a scoping review. *International Journal of Pharmacy Practice*, 31(5), 449-458.
- Tadros, E., Barbini, M., & Kaur, L. (2023). Collaborative healthcare in incarcerated settings. *International Journal of Offender Therapy and Comparative Criminology*, 67(9), 910-929.
- Talens, A., Guilabert, M., Lumbreras, B., Aznar, M. T., & López-Pintor, E. (2021). Medication experience and adherence to oral chemotherapy: A qualitative study of patients' and health professionals' perspectives. *International Journal of Environmental Research and Public Health*, 18(8), 4266.
- Toscós, T., Drouin, M., Pater, J. A., Flanagan, M., Wagner, S., Coupe, A., ... & Mirro, M. J. (2020). Medication adherence for atrial fibrillation patients: triangulating measures from a smart pill bottle, e-prescribing software, and patient communication through the electronic health record. *JAMIA open*, 3(2), 233-242.

- Wheat, L., Roane, T. E., Connelly, A., Zeigler, M., Wallace, J., Kim, J. H., & Segal, R. (2020). Using a pharmacist–community health worker collaboration to address medication adherence barriers. *Journal of the American Pharmacists Association*, 60(6), 1009-1014.
- While, A. (2020). Medication adherence: understanding the issues and finding solutions. *British Journal of Community Nursing*, 25(10), 474-479.
- White, A., Fulda, K. G., Blythe, R., Chui, M. A., Reeve, E., Young, R., ... & Xiao, Y. (2022). Defining and enhancing collaboration between community pharmacists and primary care providers to improve medication safety. *Expert opinion on drug safety*, 21(11), 1357-1364.
- Yang, C., Lee, D. T. F., Wang, X., & Chair, S. Y. (2022). Effects of a nurse-led medication self-management intervention on medication adherence and health outcomes in older people with multimorbidity: a randomised controlled trial. *International Journal of Nursing Studies*, 134, 104314.