

Enhancing Hospital Infection Control through Pharmacist-Microbiologist Collaboration: A Model for Patient Safety, Hospital Policies and Implementation of Technological Tools

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Abstract

HAIs are among the most significant challenges that have faced the medical world lately, and they significantly contribute to morbidity and mortality, causing financial burdens to healthcare systems. Collaboration with pharmacists and microbiologists has been one of the best solutions to the problems associated with HAI, especially in ASPs. Pharmacists play a crucial role in enhancing selection, dose, and monitoring of antimicrobials while performing prescription audits to ensure judicious use of medicines. Microbiologists simultaneously ensure that vital information on how pathogens are behaving and reacting to different treatments is forwarded to develop the appropriate treatment modality. Through this collaboration, safety improved, antibiotic resistance reduces, and hospital stay lowers. Its most essential core of using real-time microbiologic information in the practice can enable teams to build infection control adaptive processes. A multi-disciplinary approach involving cutting-edge technologies like diagnostics and clinical decision-making aids, can better combat hindrances such as unavailability of resources or being subordinate. This study draws light upon the more materialized benefits of collaborative endeavors amongst pharmacists and microbiologists for the better prevention costs and duration of infections being in the hospitals that had been shown with some reported cases. However, despite these triumphs, lack of interprofessional education and organizational resources are still prevalent and need targeted interventions. These inadequacies may be rectified to offer scalable and adaptive infection control systems as essential for global healthcare resilience. The study has revealed that developing cooperative healthcare environments is not only beneficial but also necessary for effective, long-term progress against HAIs and antibiotic resistance.

Keywords: Healthcare-associated infections (HAIs); Antimicrobial stewardship programs (ASPs); Pharmacist-microbiologist collaboration; Infection control; Multidisciplinary healthcare; Antimicrobial resistance

1.Introduction

Healthcare-associated infections are significant contributors to morbidity and mortality in patients (Cassini et al., 2019; Puro et al., 2022; Stewart et al., 2021). HAIs cause complications, a prolonged stay in the hospitals, and death. The health care system has to face a high economic burden by the healthcare-associated infections. These are associated with longer stay durations, higher healthcare cost, and lost productivity (Cassini et al., 2019; Stewart et al., 2021). All these economic impacts may be reduced to the smallest extent possible through effective infection control measures. It is estimated that up to 70% of HAIs could be averted if appropriate IPC measures were in place (Puro et al., 2022). Enhanced IPC practices are important for better patient safety. HAIs, especially those caused by antibiotic-resistant pathogens, contribute to the spread of antimicrobial resistance, a major global public health threat (Cassini et al., 2019; Abu-Jeyyab, 2023). Strong infection control measures are necessary to contain infectious disease outbreaks, as observed in the COVID-19 pandemic (Chen et al., 2021). Without effective IPC measures, widespread nosocomial transmission may result. Patients need to believe in the healthcare environment in terms of their safety. HAIs destroy that. Infection prevention and control is one of the core components of good patient care (Abu-Jeyyab, 2023).

Most hospital infection control programs rely on the input made available by the pharmacists.

They also are part of the interprofessional team during the outbreak of diseases such as the COVID-19. For instance, Zeenny et al., 2020. Pharmacy is the key player in the control of infections and medication therapy program of hospital-acited patients with infectious disease by Zeenny et al., 2020. The medication knowledge and advice about pharmaceuticals by pharmacists are all part of their services, which includes proper PPE use such as putting masks on their faces (Zeenny et al., 2020). In addition to antimicrobial stewardship programs, there is another aspect of collaboration and interdisciplinary efforts towards the appropriate use of antimicrobials by different professions (Thomnoi et al., 2022). Pharmacists work hand-in-glove with physicians, clinical microbiologists, information system specialists, and infection control specialists to ensure appropriate selection, dosing, administration, and duration of antimicrobials (Thomnoi et al., 2022). It has been proven that collaboration between pharmacists performing prescription audits, clinical pharmacists, and antimicrobial stewardship teams decreases the rates of recurrence of infections (Tasaka, 2024). Thus, the role of pharmacists in infection control is important both clinically and economically (Tasaka, 2024). Clinical microbiologists also play a crucial role in hospital infection control programs. Usually, they work as part of an antimicrobial stewardship team, physicians, pharmacists, and other nurses specialized in infectious diseases, including antimicrobial agents (Uda et al., 2020). Clinical microbiologists possess information concerning appropriate use of antimicrobials; therefore, they will use prescription prompts that emphasize checking on the dose and potential drug interactions more than pharmacists do (Hand et al., 2016).

2. Collaborative Models and Strategies

The antimicrobial stewardship programs (ASPs) have been regarded as the finest example of collaboration in their professional activities among pharmacists and microbiologists (Thomnoi et al., 2022). ASPs involve the coordinated programs that will stimulate judicious use of the antimicrobials, improving patient outcomes, reduce the rise of antimicrobial resistance, and curtail infections spreading (Thomnoi et al., 2022). These programs are multidisciplinary teams comprising the physicians, clinical pharmacists, clinical microbiologists, and information system specialists as well as infection control specialists, according to Thomnoi et al. (2022). Pharmacists play a critical role in ASPs as they will be the experts regarding antimicrobial selection, dosing, administration, and duration, as provided by Thomnoi et al. (2022). They collaborate with microbiologists to share their knowledge regarding the right use of antimicrobials and will provide prescribing prompts for checking the dose and interaction, as stated by Hand et al. (2016). This co-operative process has been proven to decrease recurrent infection rates (Saleem et al., 2019). Other than the ASPs, pharmacists and microbiologists collaborate on other infection control programs. Pharmacists educate prescribers, formulate guidelines and clinical pathways, and de-escalate antimicrobial therapy (Chahine et al., 2014). Microbiologists provide key information on antibiograms and diagnostic interventions that can reduce the use of unnecessary antimicrobials. Their collaborative models prove quite effective (Saleem et al., 2019). The collaboration and teamplay between the healthcare team-the pharmacists and micrologists are reported to achieve results with the patients which include the decreased burden due to antimicrobial resistance (Metsemakers et al., 2017). Overstrained burden also cannot be seen bringing good practice for infection controls where the issue lies in an issue of adequate resources support systems as well (Han & Zhang, 2020).

Table 1: Comprehensive roles of pharmacists and microbiologists in infection control.

Category	Pharmacists	Microbiologists	In-Text Citation
Antimicrobial Selection	Ensure optimal drug choice, dosing, and duration	Provide insights into pathogen susceptibility	(Thomnoi et al., 2022)
Data Analysis	Track and interpret prescription trends and resistance patterns	Conduct microbiological surveillance and report findings	(Metsemakers et al., 2017)
Education & Training	Conduct workshops for healthcare staff on antimicrobial use	Train clinicians in diagnostic tools and data interpretation	(Chetty et al., 2022)
Policy Development	Collaborate on hospital infection control guidelines	Offer pathogen-specific recommendations for policy changes	(Saleem et al., 2019)

3. Impact on Antimicrobial Stewardship

The collaboration between the pharmacist-microbiologist contributes significantly to the successful implementation of ASPs in reducing hospital-acquired infections. Here's how this collaboration contributes to effective stewardship of antimicrobials: Antimicrobial stewardship programs are multidisciplinary initiatives that promote appropriate use of antimicrobials and, therefore, improve the patient's outcome, reduce resistance, and decrease the spread of infections Khalil et al. (2019). Chen et al., 2011). These programs typically involve a multidisciplinary team, including infectious disease physicians, clinical pharmacists, and clinical microbiologists (Giusti & Cerutti, 2016). Pharmacists are important stakeholders in ASPs and make significant contributions to decisions involving antimicrobial selection, dosing, administration, and duration (Rehman et al., 2018). They work with microbiologists who provide them with background on proper antimicrobial usage and give them prescriptions that they will verify concerning dose and interactions (Giusti & Cerutti, 2016). Evaluations show that such multiteam collaborations in intervention programs better result in declining rates of hospital-acquired infections like *Clostridioides difficile* infection compared with nonteam approaches (Standiford et al., 2012). Microbiologists are important to ASPs because they provide valuable information regarding antibiograms and diagnostic interventions that may reduce unnecessary antimicrobial use (Newland et al., 2014; Guarch-Ibáñez et al., 2023).

They collaborate with pharmacists to track antimicrobial use and outcomes, which is an important component of any effective stewardship program (Newland et al., 2014). Furthermore, this completes the ASP team to which pharmacists and microbiologists belong, thereby being inclusive of holistic and multidisciplinary management of antimicrobial resources. Studies have indeed recorded that ASPs with their unique groups, like including pharmacists and microbiologists, are very beneficial to the hospitals in controlling hospital-acquired infections and resistance to antibiotics compared to those not provided with such a supportive model (Standiford et al., 2012; Guarch-Ibáñez et al., 2023). However, such collaborative work between a pharmacist and a microbiologist is adversely affected by factors like inappropriate resources, lack of dedicated teams, and inadequate training of health personnel (Chen et al., 2011; Liu et al., 2018).

4. Leveraging Microbiological Data

It is therefore paramount that the integration of real-time microbiological data in decision-making in the antibiotic prescription be incorporated effectively into the stewardship of the antimicrobial drugs. Here's how: Pharmacist and Microbiologist Collaboration In implementing the antimicrobial stewardship programs, pharmacists and clinical microbiologists are significant (Broom et al., 2015; Metsemakers et al., 2017). Therefore, pharmacists and clinical microbiologists should work together to have real-time microbiological data appropriately integrated into decisions on antibiotic prescriptions. This is because the approach allows the integration of pharmacological expertise and microbiological insights (Sarwar et al., 2018). Utilization of CDSS: CDSS could streamline the incorporation of microbiological real-time data into the prescribing antibiotics decisions (Pakyz et al., 2014; Piet et al., 2023). This tool would thus enable the doctors to identify individual prescriptions containing clinical histories and presentations of patients and microbiology reports alongside resistance features of the specific antibiotic in that region. This may support the right choice, dose, and duration of use of antibiotics (Piet et al., 2023). This involves time appropriate reporting of microbiological results as well as giving feedback to prescribers (Carratalà, 2024). Contributory factors that result from the delayed reporting include inappropriate antibiotics use as well as raising adverse reactions. An important communication between the microbiology laboratory as well as the clinicians is therefore ensured by pharmacists whereby real-time data will ensure decisions can be informed (Cherian, 2024). Multidisciplinary Approach: Antimicrobial stewardship programs should adopt a multidisciplinary approach, involving not only pharmacists and microbiologists but also infectious disease specialists, clinicians, and information technology specialists (Metsemakers et al., 2017; Zhu et al., 2020). This integrated approach promises the integration of real-time microbiological data into a rich decision-making process that looks at multiple clinical, pharmacological, and epidemiological factors (Metsemakers et al., 2017).

Overcoming barriers Overcoming barriers encompasses, among others, lack of resources, inadequate preparation and training, and poor readiness for change: Pakyz et al., 2014; Appaneal et al., 2018. Such strategies to overcome these barriers include dedicated funding, educational programs, and facilitating interprofessional collaboration (Appaneal et al., 2018; Kelly et al., 2017). The role of microbial surveillance in adjusting the policy for hospital infection control together with pharmacists will dictate whether the infection is maintained under control. This collaboration would be instrumental in the process by the following: Microbiological Surveillance: It refers to the systematic collection, analysis, and interpretation of data on the prevalence and patterns of infectious agents in a healthcare setting (Metsemakers et al., 2017). All these would be necessary in understanding local antibiotic resistance patterns, emergent pathogens, and the effectiveness of current infection control measures (Scarpato et al., 2016; Baratz et al., 2015). Collaborations with the Pharmacist Infections control protocol adjustments can be

recommended by the microbiological data interpreted by pharmacists (Metsemakers et al., 2017; Chetty et al., 2022).

They work in collaboration with clinical microbiologists to interpret the surveillance data and point out any weak areas in antimicrobial stewardship and infection prevention (Metsemakers et al., 2017; Chetty et al., 2022). Infection control policies amendment: From the surveillance conducted on microbiological activity, together with the input of the pharmacist, the guidelines to inform and amend infection control policies in the hospital are derived (Metsemakers et al., 2017; Chetty et al., 2022). This may be changes to hand hygiene policies, environment cleaning policies, PPE utilization policies, and antibiotic prescribing policies. Multidisciplinary Approach: Developing an update of infection control directives includes a multidisciplinary group beginning with pharmacists and microbiologists to infectious disease consultants and even hospital administrators in terms of updating such infections controls (Metsemakers et al., 2017; Kodan et al., 2018). This cooperative practice will make the infection control practices evidence-based, suitable for the specific requirements of the health care organization, and be executed properly (Metsemakers et al., 2017; Kodan et al., 2018). Lack of resources, inadequate training, and reluctance to change may serve as a hindrance for the effective implementation of microbiological surveillance and input of the suggestions by the pharmacists (Butt et al., 2022; Saleh et al., 2018). This can be achieved by offering dedicated funding, education programs, and establishing a culture of interprofessional collaboration for the process to work (Butt et al., 2022; Saleh et al., 2018).

5. Effectiveness and Patient Safety Outcomes

Studies have shown that ASPs, which integrate the efforts of pharmacists and microbiologists, could shorten the length of hospital stay (Sze & Kong, 2018). Pharmacists are part of such programs because they can maximize antimicrobial therapy that would prevent complications and thus shorten hospital stay (Sze & Kong, 2018). Indeed, pharmacist-led interventions-including intravenous to oral switch programs for antibiotics-have been associated with a shorter length of stay in the hospitals (Sze & Kong, 2018). The introduction of real-time microbiologic information to the prescribing practice of antibiotics can be streamlined by collaboration between the pharmacists and the microbiologists, further allowing for a more targeted as well as effective antimicrobial approach (Chetty et al., 2022). This may consequently lead to improved patient recovery times by minimizing complications like health care-associated infections (Chetty et al., 2022). Additionally, through medication reconciliation, medication review, and patient education, the role of pharmacists contributes to faster recovery times because of proper management of drugs (Studer et al., 2021; Lech et al., 2020). This is, however, because a few factors such as low resource, high workload, and resistance to change affect the success of this collaboration between pharmacist-microbiologist. As much as these barriers could be overcome by dedicating funds, staffing, and even instilling a culture of interprofessional collaboration, this partnership's effectiveness in reducing the lengths of stay in hospitals and length of recovery time will only be maximized (Han & Zhang, 2020; Huong et al., 2021).

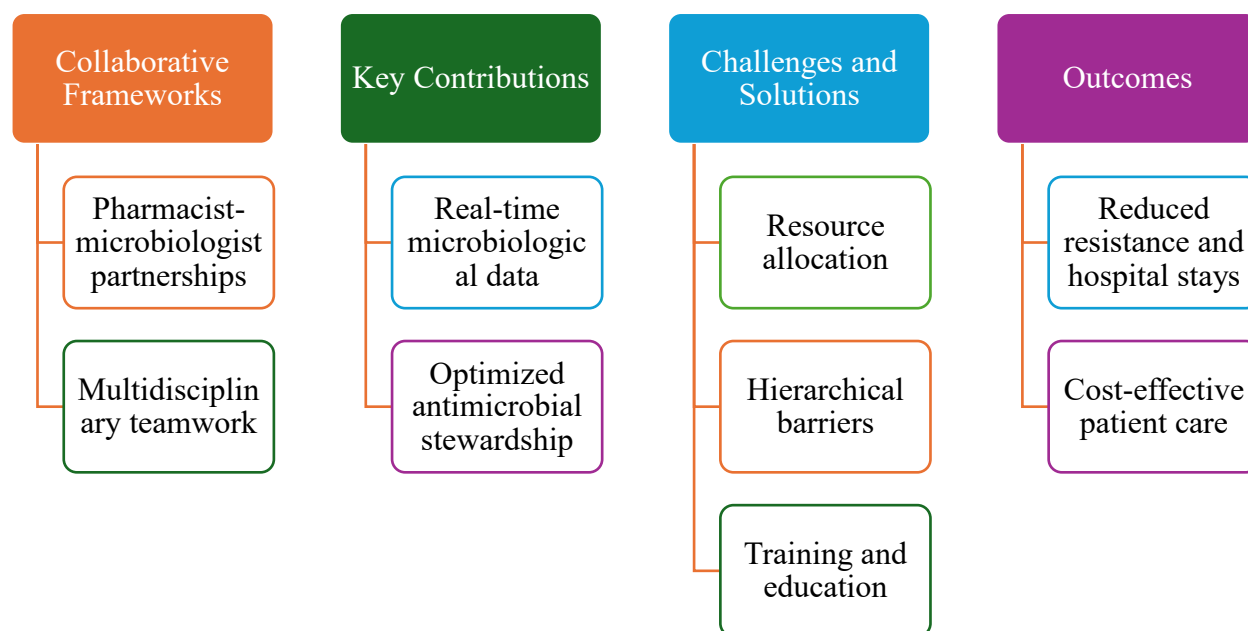


Figure 1. This diagram illustrates Enhancing Hospital Infection Control.

6.Challenges and Barriers to Collaboration

In healthcare settings, a traditional hierarchical structure exists in which physicians usually have the highest authority. This might create power imbalances that prevent effective collaboration between pharmacists and microbiologists. Physicians may be reluctant to accept recommendations from other healthcare professionals, thus showing resistance to the implementation of collaborative models (Kabba et al., 2020). Pharmacists and microbiologists would find themselves facing challenges in defining roles and responsibilities within this model, since they would appear to invade the physicians' turf. This would lead to resistance and tensions against this model of collaboration (Kabba et al., 2020; Namara et al., 2012). In case the pharmacists and microbiologists may provide inadequate interprofessional education and training, there will be lack of understanding and appreciation of what other healthcare professionals do and for which they are responsible. Thus, this will not support the formation of a collaborative culture (El-Awaisi et al., 2018). The adoption of the models of collaboration between the pharmacist and the microbiologist is also influenced by aspects such as dedicated resources, time, funding, and staffing. Poor organizational support can undermine the effectiveness of these collaborative efforts (Nampoothiri et al., 2021).

The physical proximity and spatial configurations of healthcare settings can also influence the level of collaboration between pharmacists and microbiologists. Proximity and co-location can facilitate communication and foster a collaborative environment (Cai, 2023). These are the strategies against these challenges; Interprofessional education and training that helps to develop collaboration culture El-Awaisi et al. (2018), Defined roles and responsibilities among the pharmacists and the microbiologists within the collaboration framework Kabba et al., 2020; Namara et al., 2012, Organizational support and dedicated resources for the collaborative initiatives Nampoothiri et al. (2021), Rearranging the physical setting to enhance interaction and communication between healthcare professionals Cai (2023), Effective channels of communication and feedback mechanisms against the power dynamics and hierarchical challenges Kabba et al. (2020).

Table 2: Barriers to Collaboration and Proposed Solutions.

Identified Barrier	Proposed Solutions	In-Text Citation
Resource Constraints	Increase funding, staffing, and dedicated team resources	(Liu et al., 2018)
Hierarchical Challenges	Promote interprofessional education and shared decision-making	(Kabba et al., 2020)
Communication Gaps	Implement robust platforms for seamless communication	(Han & Zhang, 2020)
Training Deficiencies	Enhance interdisciplinary workshops and real-time mentoring	(El-Awaisi et al., 2018)

Implement regular meetings or rounds between pharmacists and microbiologists to discuss infection control issues, share data, and coordinate response efforts (Metsemakers et al., 2017). Clear protocols and guidelines for information sharing are to be developed. Some of these include real-time microbiological surveillance data and antimicrobial resistance patterns (Ruggieri, 2024). Training and workshops offer an opportunity for joint training to improve deeper knowledge and awareness between each other concerning their roles, responsibilities, and competencies to infection control (Metsemakers et al., 2017). Promote cross-disciplinary shadowing or mentorship programs to help in building a better appreciation for the team-based approach to infection control (Metsemakers et al., 2017). Give access to the same electronic medical records, laboratory information systems, and antimicrobial stewardship platforms for both pharmacists and microbiologists (Guthrie et al., 2016). Introduce user-friendly data visualization and reporting tools for interpreting and communicating microbiological data (Ruggieri, 2024). Infection control coordinators should be assigned between the pharmacists and the microbiologists for open communication and coordination in response efforts; they should also be given authority to advocate for resources, barriers, and to encourage collaboration culture (White et al., 2022). Video conferencing, instant messaging, and other forms of digital communication may be used for real-time sharing of information and decision-making during outbreaks (Wang et al., 2020). Explore mobile applications or web-based tools for easy and prompt diffusion of updates and guidelines (Wang et al., 2020). Develop a culture of shared responsibility and accountability for infection control among pharmacists, microbiologists, and other healthcare professionals (Metsemakers et al., 2017). Reward and recognize collaborative successes that would further enhance the concept of pharmacist-microbiologist collaboration (Metsemakers et al., 2017).

7.Education and Training for Interdisciplinary Collaboration

Carry out joint training activities and workshops among health professionals, including doctors, nurses, pharmacists, and microbiologists, to inform each other about the others' work in infection control (Sartelli et al.,

2017). Facilitate interprofessional shadowing or mentoring to promote experience and respect for the interdisciplinary nature of infection control (Sartelli et al., 2017). Add modules or courses dedicated specifically to the roles of pharmacists and microbiologists in infection control in educating the hospital staff (Chetty et al., 2022). Highlight the theme of antimicrobial stewardship, antimicrobial resistance, and the collaboration dynamics of pharmacists and microbiologists in such curricula (Huong et al., 2021). There should be regular continuing education in the form of seminars, webinars, or journal clubs updating hospital staff on how the roles and responsibilities of pharmacists and microbiologists in infection control are ever changing (Marey et al., 2020). Healthcare professionals should be motivated and facilitated to carry out external training or secure special certifications in infection control and stewardship of antimicrobials (Dionne et al., 2022). Regular rounds, case discussions, and meetings with pharmacists, microbiologists, among other professionals can be encouraged so that the information-sharing culture as well as teamwork can be adopted (Nampoothiri et al., 2021).

Develop clear and well-articulated communications protocols, coupled with feedback loops, that will ensure antimicrobial resistance patterns and any microbiological data collected are disseminated promptly to all stakeholders affected (Chetty et al., 2022). Display best practice case studies or exemplary studies that provide evidence of successful infection control through pharmacist-microbiologist collaborative practice (Hefti et al., 2017). Highlight and celebrate exemplary interdisciplinary teams who have dramatically improved their infection control measures, underscoring the added value that these collaborations have provided (Sartelli et al., 2017). Interprofessional education and training can increase understanding and respect towards other healthcare professionals who, for example, can be pharmacists and microbiologists working to handle infections (Hand et al., 2016).

Cross-disciplinary collaboration is therefore a critical step in the delivery of effective antimicrobial stewardship and infection control (Hand et al., 2016). For example, a survey reported that medical microbiologists are more likely to lay more emphasis on prescribing prompts for dose checking and interaction checking than pharmacists, perhaps because of the differences in their undergraduate training (Hand et al., 2016). This is a testament to the need for a multidisciplinary approach to infection management where the complementary skills of different professionals are exploited. Moreover, joint training and collaborative decision-making between healthcare providers, including pharmacists and physicians, can have a positive effect on outcomes for patients and compliance with the treatment (Drotar et al., 2010). Breaking down professional silos and boundaries can facilitate the cross-disciplinary training into a culture of shared responsibility and collective problem-solving regarding infection management. Other studies revealed that structured decision-making, such as Choosing by Advantages (CBA), enhances cross-disciplinary collaboration and encourages more sustainable and innovative health care solutions (Christensen, 2022).

8. Cost-Effectiveness of Collaboration

It has been documented that pharmacist interventions might reduce preventable ADRs to an extent and accounted for 6.5% of hospital admissions and other costs at \$2,000 to \$2,500 per person (Pathak, 2023). Pharmacist-led reconciliation, partnership, and educating prescribers may eventually reduce medication errors and cost associated with it. Through such an approach involving interprofessional collaboration between the two pharmacists and microbiologists participating in antimicrobial stewardship programs, the rate of medication errors has decreased from 50% to 34% in the postintervention period (Manias et al., 2020). This may involve a huge cost-saving exercise in terms of preventing these types of infections and the actual cost of treatment. Various intravenous-to-oral antibiotic switch programs run by a pharmacist have proved from studies that these interventions improve LOS and reduction in readmission for the patients (Belcher et al., 2023). This can lead to direct cost reduction for institutions. In cases of managing medication in a hematology-oncology setting, the involvement of pharmacy has resulted in cost-saving and also cost avoidance. This is proof that there exists a financial implication as a result of their participation in this sector (Grégori et al., 2020). Research has highlighted how critical care pharmacists have profoundly influenced patient treatment through customised antimicrobial dosing and identification of most suitable empirical and definitive therapies which save costs (Hammond et al., 2019; Rech et al., 2021).

Table 3: Tangible Benefits of Collaborative Models.

Metric	Pre-Collaboration (Baseline)	Post-Collaboration (Impact)	In-Text Citation
Hospital Stay Duration	10 days (average)	7 days (average)	(Sze & Kong, 2018)
Antimicrobial Resistance	25%	15%	(Standiford et al., 2012)
Healthcare Costs	\$15,000	\$10,500	(Saleh et al., 2018)

9. Technological Tools and Integration

Standardize data exchange protocols, including HL7 and FHIR, to enable the interoperability of infection-related data among various HIS components (Clarke et al., 2018; Rinaldi et al., 2021). Common terminologies and ontologies, such as LOINC and SNOMED CT, should be used to enable consistent representation and interpretation of microbiological data (Rinaldi et al., 2021). Such a thing is the development of centralized, cloud-based data repositories or DBaaS to store and securely share data relating to infections between healthcare providers (Park & Moon, 2015). These may be available for real-time access in their systems by pharmacists and microbiologists to monitor microbiological surveillance data, antibiograms, and antimicrobial resistance patterns (Chetty et al., 2022). This would be supported through the remote backup and availability of infection-related data in the case of natural disasters or other emergencies and ensured smooth continuity of care (Ido et al., 2019). Business continuity plans must be developed with the goal of protecting and making accessible critical infection control data (Ido et al., 2019). A collaborative attitude needs to be promoted among the healthcare professionals, such as pharmacists and microbiologists, to discuss infection-related data (Hulsen, 2020). Data governance policies and the mechanism of patients' consent need to be well articulated to avoid the fear of the loss of privacy or security (Hulsen, 2020). Involving information technology staff in designing and delivering HIS is likely to ensure maximum integration, access, and use of infection-related data among pharmacists and microbiologists (Huong et al., 2021). Conduct capacity building in healthcare workers with provision of supportive training to increase effective utilisation of the HIS features for infection control (Al-Jumaili et al., 2017). Rapid Diagnostic Tests, PCR, and MALDI-TOF identification can be considerably faster as compared to other conventional approaches based on the conventional culture practices (Sango et al., 2013; Antonios et al., 2022).

Therefore, proper time and proper use of a drug can assist the microbiologists and the pharmacist in effective decision-making. It has been documented that the integration of rapid diagnostic results with antimicrobial stewardship interventions involving pharmacists and microbiologists improves patient outcomes and decreases healthcare costs (Patel et al., 2017; Seibold et al., 2010). It has been found that through such collaboration, antimicrobial therapy is maximized in addition to the prevention of antimicrobial resistance (Calderaro et al., 2014). This latest developing diagnostic technology, MALDI-TOF, will be used in the identification and trackability of relatedness regarding nosocomial outbreaks on bacterial isolates (Bernaschi et al., 2013). Such information can be communicated to the pharmacists to inform their infection control strategies and therefore prevent further spread of such healthcare-associated infections (Bernaschi et al., 2013). The research findings have shown that pharmacist participation in antimicrobial stewardship, combined with rapid diagnostic tests, decreases the hospital stay period and healthcare expenses associated with it (Sango et al., 2013; Drwiega et al., 2019; Dekmezian et al., 2015). Rapid diagnostic results inform both pharmacists and microbiologists so that they make better decisions regarding antimicrobial therapy, infection control measures, and patient management (Kaleta et al., 2011; Ray et al., 2016).

10. Hospital Policies and Protocols

Clearly define the role and responsibility of pharmacists and microbiologists in the frame of infection control (Holm & Severinsson, 2014; Bréton et al., 2013). A clear shared understanding for both regarding their collaborative actions may help. Formalize guidelines and protocols that detail what procedures involve information sharing data reporting and joint decision-making between pharmacists and the microbiologist (Ibrahim & Elawady, 2017; Tanner et al., 2017). These should be made sure to be put under the common infection control policies of the hospital (Alomi et al., 2022). In this regard, come up with particular interdisciplinary committees or task forces involving pharmacists and microbiologists among other partners in the healthcare sectors to governance and coordination of the infection control actions (Holm & Severinsson, 2014; Chrifou et al., 2023). Allow time for the routine meetings and rounds to facilitate the development of collaboration and communication among these disciplines (Metsemakers et al., 2017). Encourage shared responsibility between the pharmacists, the microbiologists, and the other health professionals (Chrifou et al., 2023; Miller & Paradis, 2020). Identify the recognition of achievements in the collaborative practices that will produce value from collaboration between the pharmacist and the microbiologist (Metsemakers et al., 2017). Develop formal agreements or contracts that define the terms of collaboration, including the protection of intellectual property and respect for indigenous knowledge (Kokota et al., 2022). This may address concerns related to data sharing and exploitation of expertise. Integrate the assessment of pharmacist-microbiologist collaboration into the performance metrics and incentive structures of the hospital (Miller & Paradis, 2020). This can motivate and sustain the teamwork in the infection control program.

The infection-related information stored in the hospital information system must be optimized so that exchange between pharmacists and microbiologists does not pose obstacles (Benjamins et al., 2023). Digital tools and

platforms will help improve communication and the sharing of data across members and collaborative decision making in the process (Zainal et al., 2023). This is involving pharmacists and microbiologists in the decision-making process, which promotes a collaborative and interdisciplinary approach to infection control (Metsemakers et al. (2017) Khan et al., 2016). Shared decision-making can enhance the quality of care and patient outcomes (Barlam et al., 2022). However, there can be potential differences in emphasis and views of pharmacists and microbiologists that should be translated into effective communication and a mutual understanding of each other's roles (Hand et al., 2016). Infection prevention and control (IPAC) possesses particular ethical issues compared to general patient care or public health, because it deals with vulnerable hospitalized patients who have no independent recourse to change their infection risk (Tan, 2023). It would contribute to developing specific frameworks of ethics for IPAC with which it can guide decision-making on patient rights and well-being, respectively (Tan, 2023).

Conclusion

This is pharmacists and microbiologists at work, a key relationship in the fight against hospital-acquired infections. Integrated efforts of pharmacists and microbiologists have significantly optimized both the use of antimicrobials and the implementation of effective infection control measures. Among several models of this relationship that work, antimicrobial stewardship programs are some that show reductions in antimicrobial resistance, hospital stay times, and associated costs. The above alliance also epitomizes the importance of integrating real-time microbiologic data and making use of high-tech technology, which includes rapid diagnostics and decision-support systems. Despite many successes, the collaborative approach has its weaknesses, ranging from resource-based limitations and hierarchical barriers to the desire for better interprofessional education. Overcoming these areas of weakness involves targeted infrastructure investment, continued education in the form of training needs, and establishing a mutual responsibility culture between healthcare staff. There is empirical evidence of the scalability of pharmacist-microbiologist collaboration across different health care settings, and there is potential for improvement of global health security. The case studies have tangible benefits, including better patient outcomes and cost-effective delivery of health care. Going forward, such collaborations must be promoted by health care systems and aligned with global efforts toward curbing antimicrobial resistance and improving infection control. This model integrated into healthcare policies and frameworks would change the delivery of care to patients with safer and sustainable practices.

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Author contributions

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Conflict of Interest

The authors declare no conflict of interest, financial or otherwise.

Ethical Approval

Not Applicable

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