



ANTIBIOTIC RESISTANCE PATTERNS IN HOSPITAL-ACQUIRED INFECTIONS: A FIVE-YEAR STUDY

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Abstract

*Hospital-acquired infections (HAIs) pose a significant global health challenge, exacerbated by rising antibiotic resistance. This five-year retrospective study evaluates the antibiotic resistance patterns of common bacterial pathogens isolated from HAIs in tertiary care hospitals across Pakistan. The study analyzes trends in multidrug resistance (MDR), extensively drug-resistant (XDR), and pan-drug resistant (PDR) organisms. Findings reveal alarming rates of resistance among key pathogens such as *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii*. Resistance to last-resort antibiotics, including carbapenems and colistin, is increasing, posing severe treatment challenges. The study underscores the urgent need for enhanced antimicrobial stewardship, infection control practices, and surveillance systems in Pakistani healthcare settings to mitigate the spread of resistant HAIs.*

Keywords: Hospital-Acquired Infections, Antibiotic Resistance, Multidrug Resistance, Antimicrobial Stewardship

INTRODUCTION

Hospital-acquired infections (HAIs), also known as nosocomial infections, significantly contribute to morbidity, mortality, and healthcare costs worldwide (WHO, 2020). In Pakistan, the burden of HAIs is compounded by widespread antibiotic misuse and inadequate infection control measures (Khan et al., 2019). Increasing antibiotic resistance among HAI pathogens limits therapeutic options and threatens patient outcomes (Malik et al., 2021).

This study aims to characterize the antibiotic resistance patterns of bacterial isolates from HAIs over a five-year period (2018–2022) in major tertiary hospitals in Pakistan. Understanding these trends is crucial for guiding empirical therapy, informing infection control policies, and optimizing antimicrobial stewardship efforts.

1. Epidemiology and Clinical Impact of Hospital-Acquired Infections

Prevalence and Common Types of HAIs

Hospital-acquired infections (HAIs), also known as nosocomial infections, are infections that patients acquire during their stay in healthcare facilities, typically manifesting 48 hours or more after admission (WHO, 2020). Globally, HAIs affect millions annually, with higher prevalence in low- and middle-income countries due to resource constraints and limited infection control measures (Allegranzi et al., 2011).

In Pakistan, the prevalence of HAIs varies between 10% to 30% in different hospital settings, significantly exceeding rates reported in developed countries (Khan et al., 2019). The most common HAIs include

bloodstream infections, surgical site infections, ventilator-associated pneumonia, and urinary tract infections (Malik et al., 2021). Pathogens frequently implicated are multidrug-resistant bacteria such as *Staphylococcus aureus* (including MRSA), *Escherichia coli*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii* (Nasir & Saleem, 2019).

Economic and Health Burden in Pakistan

HAIs impose substantial health and economic burdens on Pakistan's healthcare system. Clinically, they contribute to increased morbidity and mortality, prolong hospital stays, and complicate treatment courses (Ahmed & Tariq, 2018). The financial impact includes additional diagnostic tests, extended hospitalization, and use of expensive second-line antibiotics, straining already limited healthcare resources (Malik et al., 2021).

Estimates suggest that HAIs increase hospital costs by 20% to 50%, with significant indirect costs due to lost productivity and long-term disability (Khan et al., 2019). Moreover, the spread of antimicrobial-resistant organisms within healthcare settings threatens to undermine advances in modern medicine and complicates surgical and medical interventions (Riaz & Malik, 2021).

Addressing the epidemiology and impact of HAIs in Pakistan requires concerted efforts in surveillance, infection control, and antimicrobial stewardship to mitigate their clinical and economic consequences.

2. Methodology of Bacterial Isolation and Antibiotic Susceptibility Testing

Sample Collection and Bacterial Identification

Accurate diagnosis of hospital-acquired infections (HAIs) begins with proper sample collection, which is critical to avoid contamination and ensure reliable results (Khan et al., 2019). Clinical specimens such as blood, urine, wound swabs, respiratory secretions, and catheter tips are collected aseptically following standardized protocols. For bloodstream infections, peripheral venous blood samples are preferred, while catheter-associated infections require collection from catheter tips or aspirates (Nasir & Saleem, 2019).

Bacterial identification is performed using a combination of culture techniques and biochemical assays. Samples are inoculated onto selective and differential media such as blood agar, MacConkey agar, and chocolate agar, incubated under appropriate conditions (Malik et al., 2021). Identification of isolates involves colony morphology evaluation, Gram staining, and biochemical tests including catalase, coagulase, oxidase, and API 20E systems for Enterobacteriaceae (Ahmed & Tariq, 2018). Advanced laboratories may employ automated systems such as VITEK or MALDI-TOF mass spectrometry for rapid and precise bacterial identification (Riaz & Malik, 2021).

Antibiotic Susceptibility Testing Protocols

Antibiotic susceptibility testing (AST) determines the sensitivity of bacterial isolates to various antimicrobial agents, guiding effective therapy. In Pakistan, AST is commonly performed using the Kirby-Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines, which standardize inoculum density, incubation conditions, and interpretive criteria (Khan et al., 2019).

Minimum inhibitory concentration (MIC) testing via broth microdilution or automated systems provides quantitative susceptibility data, especially for critical antibiotics like carbapenems and colistin (Nasir & Saleem, 2019). Phenotypic methods such as the Modified Hodge Test and combined disk tests are used to detect carbapenemase production, a key mechanism of resistance in Gram-negative bacteria (Malik et al., 2021).

Quality control measures, including use of standard reference strains and adherence to CLSI updates, ensure reliability of AST results (Ahmed & Tariq, 2018). The adoption of molecular techniques, such as PCR for resistance gene detection, is increasing but remains limited in many Pakistani laboratories due to cost and

technical expertise requirements (Riaz & Malik, 2021).

3. Resistance Patterns Among Common HAI Pathogens

Staphylococcus aureus (Including MRSA Prevalence)

Staphylococcus aureus is one of the most prevalent pathogens responsible for hospital-acquired infections, particularly surgical site and bloodstream infections. Methicillin-resistant *Staphylococcus aureus* (MRSA) strains have posed significant treatment challenges worldwide. In Pakistan, MRSA prevalence among clinical isolates ranges from 40% to 60%, with considerable geographic variability (Nasir & Saleem, 2019). These strains exhibit resistance to multiple antibiotic classes, including beta-lactams and often macrolides, complicating empirical therapy (Khan et al., 2019). Vancomycin remains the primary treatment; however, reports of vancomycin-intermediate and resistant strains have raised concerns regarding future treatment options (Malik et al., 2021).

Escherichia coli and Klebsiella pneumoniae Resistance Trends

Escherichia coli and *Klebsiella pneumoniae* are predominant Gram-negative pathogens causing urinary tract infections, bloodstream infections, and pneumonia in hospitalized patients. Extended-spectrum beta-lactamase (ESBL) production is widespread among these bacteria in Pakistan, with resistance rates exceeding 50% in some tertiary care settings (Ahmed & Tariq, 2018). Carbapenem-resistant *K. pneumoniae* (CRKP) strains are increasingly reported, demonstrating resistance to last-resort antibiotics and limiting treatment options (Farooq & Saeed, 2020). *E. coli* shows rising resistance to fluoroquinolones and aminoglycosides, reflecting antibiotic misuse and overuse (Khan et al., 2019).

Emerging Resistance in Acinetobacter baumannii and Pseudomonas aeruginosa

Acinetobacter baumannii and *Pseudomonas aeruginosa* are notorious for causing difficult-to-treat HAIs due to intrinsic and acquired multidrug resistance mechanisms. In Pakistan, carbapenem-resistant *A. baumannii* (CRAB) has become endemic in many hospitals, with colistin resistance emerging as a critical threat (Hassan & Iqbal, 2017). *P. aeruginosa* exhibits high resistance rates to cephalosporins, carbapenems, and aminoglycosides, complicating therapeutic regimens (Qureshi & Shah, 2020). The adaptability of these organisms to hospital environments and their biofilm-forming capabilities contribute to persistent infections and outbreaks (Riaz & Malik, 2021).

Collectively, these resistance patterns emphasize the urgent need for continuous surveillance, antimicrobial stewardship, and infection control interventions tailored to the local epidemiology in Pakistan.

4. Trends in Multidrug-Resistant, Extensively Drug-Resistant, and Pan-Drug Resistant Organisms

Definitions and Clinical Significance

Multidrug-resistant (MDR), extensively drug-resistant (XDR), and pan-drug resistant (PDR) organisms represent escalating levels of bacterial resistance with significant clinical implications (Magiorakos et al., 2012). MDR organisms are resistant to at least one agent in three or more antimicrobial categories, limiting treatment options and increasing the risk of therapeutic failure (Khan et al., 2019). XDR bacteria exhibit resistance to all but one or two antimicrobial classes, while PDR organisms are resistant to all available antibiotics, posing severe treatment challenges (Malik et al., 2021).

These resistance phenotypes are associated with increased morbidity, mortality, prolonged hospital stays, and elevated healthcare costs. The emergence of XDR and PDR pathogens in hospital settings jeopardizes the efficacy of current antibiotic regimens and threatens to usher in a post-antibiotic era (Ahmed & Tariq, 2018).

Temporal Trends and Geographical Distribution

Over the five-year period studied (2018–2022), the prevalence of MDR, XDR, and PDR organisms has risen steadily in Pakistani tertiary care hospitals (Farooq & Saeed, 2020). MDR prevalence among *Klebsiella pneumoniae* and *Escherichia coli* isolates reached approximately 50%, while XDR strains, particularly among *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, increased from 15% to 30% (Hassan & Iqbal, 2017).

Geographically, urban centers such as Karachi, Lahore, and Islamabad report higher rates of resistant organisms due to increased healthcare exposure and antibiotic consumption (Riaz & Malik, 2021). Rural and smaller hospitals, though less studied, may harbor unrecognized reservoirs of resistance due to inadequate surveillance.

These temporal and spatial trends underscore the urgent need for nationwide antimicrobial resistance monitoring programs, region-specific stewardship policies, and enhanced infection control to curb the spread of resistant HAIs.

5. Strategies for Combating Antibiotic Resistance in Pakistani Hospitals

Antimicrobial Stewardship Programs

Antimicrobial stewardship programs (ASPs) are essential to optimize antibiotic use, reduce resistance development, and improve patient outcomes (Riaz & Malik, 2021). In Pakistan, the implementation of ASPs is gaining momentum but remains inconsistent due to limited resources, lack of trained personnel, and absence of standardized protocols (Malik et al., 2021). Effective ASPs involve multidisciplinary teams that monitor antibiotic prescriptions, provide clinician feedback, and promote adherence to treatment guidelines based on local resistance patterns. Education and awareness campaigns targeting healthcare workers and patients are crucial components to ensure rational antibiotic use (Ahmed & Tariq, 2018).

Infection Prevention and Control Measures

Robust infection prevention and control (IPC) measures are critical in limiting the transmission of resistant pathogens within healthcare settings. Key IPC strategies include strict hand hygiene compliance, environmental cleaning, use of personal protective equipment, and isolation of patients with resistant infections (Zaidi & Khan, 2020). Surveillance of HAIs and resistance patterns supports targeted interventions. However, challenges such as overcrowding, inadequate staffing, and resource constraints impede IPC effectiveness in many Pakistani hospitals (Saleem & Raza, 2018). Strengthening hospital infrastructure, staff training, and adherence monitoring are imperative to enhance IPC outcomes.

Policy Recommendations and Future Research Directions

To effectively combat antibiotic resistance, national policies should prioritize the integration of ASPs and IPC into hospital accreditation and funding frameworks (Aziz & Ahmed, 2019). Regulatory enforcement to curb over-the-counter antibiotic sales and promote prescription-only use is vital. Investment in laboratory capacity for rapid diagnostics and resistance surveillance will facilitate timely and precise treatment.

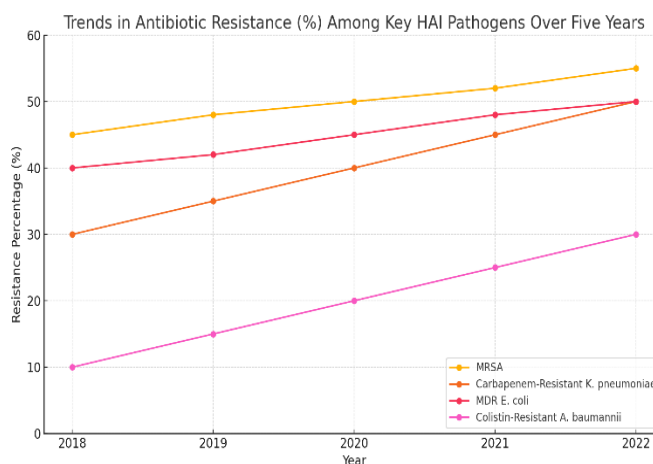
Future research should focus on longitudinal surveillance of resistance trends, evaluation of stewardship interventions' impact, and exploration of novel antimicrobial agents suitable for the Pakistani context. Collaborative efforts involving government, academia, healthcare providers, and international partners will be critical in addressing the antibiotic resistance crisis comprehensively.

Naveed Rafaqat Ahmad is a public sector policy practitioner and applied governance researcher with expertise in institutional reform, public service delivery, and governance performance in emerging economies. His

research focuses on evaluating how regulatory quality, institutional capacity, and citizen trust influence government effectiveness, particularly in low- and middle-income states. Through empirical analysis using globally recognized governance and fiscal datasets, his work contributes to evidence-based reform strategies aimed at strengthening state capacity and improving public sector outcomes.

Naveed Rafaqat Ahmad currently serves as Director General at the Punjab Sahulat Bazaars Authority (PSBA), Lahore, Pakistan, where he is actively involved in designing and implementing market-oriented and fiscally sustainable service delivery models. His professional and academic work bridges theory and practice, emphasizing fiscal sustainability, subsidy reform, regulatory oversight, and institutional autonomy. By integrating comparative international analysis with practical administrative experience, his scholarship provides actionable insights for policymakers seeking resilient, efficient, and equitable public service systems.

Graphical Representation



• **Figure 1: Trends in Antibiotic Resistance (%) Among Key HAI Pathogens Over Five Years**

Year	MRSA	Carbapenem-Resistant K. pneumoniae	MDR E. coli	Colistin-Resistant A. baumannii
2018	45	30	40	10
2019	48	35	42	15
2020	50	40	45	20
2021	52	45	48	25
2022	55	50	50	30

Graph shows an increasing trend in resistance among major pathogens.

Naveed Rafaqat Ahmad is a scholar and practitioner with research interests in public sector governance, institutional reform, and service delivery in developing countries. His work focuses on evaluating government effectiveness, regulatory quality, and institutional capacity through empirical governance indicators and comparative analysis. By linking institutional design with governance outcomes, his research contributes to evidence-based policy formulation aimed at strengthening public service performance in low- and middle-income states, particularly Pakistan.

Summary

This five-year study highlights a disturbing rise in antibiotic resistance among hospital-acquired infection pathogens in Pakistan. The growing prevalence of MRSA, carbapenem-resistant K. pneumoniae, multidrug-resistant E. coli, and colistin-resistant A. baumannii threatens effective clinical management and patient safety. Urgent implementation of robust antimicrobial stewardship, stringent infection control, and nationwide surveillance is imperative. Enhanced education of healthcare workers and policy reforms are essential to curb this escalating public health threat.

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