ACADEMIA Health Sphere Journal

Antimicrobial Resistance Patterns in Hospital-Acquired Infections: A Cross-Sectional Study

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Received: 06 August 2025 | **Revised:** 29 August 2025 | **Accepted:** 15 September 2025

ABSTRACT

HAIs have become a significant clinical issue to healthcare systems in every part of the world particularly due to the development of antimicrobial resistance (AMR). One of the conditions that led to the prolongation of hospitalization, the rise in healthcare expenses and the rise in morbidity and mortality rates is the transfer of multidrug-resistant pathogens in hospitals. It is a cross-sectional study, which tries to assess the antimicrobial resistance pattern of the common bacterial pathogen in association with HAIs. The collected data were based on clinical isolates of the patients who were admitted to different patient wards of a hospital within a 6-month period of time. Laboratory testing was done to find out the patterns of susceptibility based on standardized microbiological tests. The findings have revealed that resistance to the most commonly prescribed antibiotics is very high and this brings out a call to create an antimicrobial stewardship and infection control strategies. The research contributes to the improved understanding of the tendencies in AMR in hospitals and informs the interventions that should be applied to address the burden of HAIs in specific manners.

Keywords: Hospital-acquired infections, antimicrobial resistance, multidrug resistant bacteria, cross sectional study, infection control.

INTRODUCTION

HAIs have been one of the major public health concerns across the globe that brings about a lot of morbidity, deaths, and extra healthcare expenses. HAIs are contracted in an inpatient or after treatment, as a result of a vast array of bacterial, viral and fungal pathogens, (World Health Organization [WHO], 2022). The most common and the most challenging amongst them are the bacterial infections due to the emergence of antimicrobial resistance (AMR). AMR is a scenario in which microorganisms acquire resistance because of mechanisms of adaptation to the drugs that are intended to kill them due to generating a comparatively resistant infection that is extremely difficult to treat (Laxminarayan et al., 2020). Diffusion of the multidrug-resistance bacteria within the hospital environment has also led to length of hospital stay, cost treatment and patient morbidity and mortality. The lack of infection control measures against them contributes to increased burden of HAIs in low-income countries (LMICs) and middle-income nations (MMCs), as well as the lack of access to laboratory facilities and misuse of antibiotics (O'Neill, 2016; Allegranzi et al., 2011).

Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Acinetobacter baumannii are the usual pathogen organisms that are commonly isolated in HAIs. These bacteria include listed bacteria have been found to resist most commonly used antibiotics including beta-lactams, cephalosporins, fluoroquinolones and carbapenems (Kumar et al., 2022). Of interest are methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae due to the high prevalence and limited number of treatment options (World Health Organization [WHO], 2022). Monitoring the resistance patterns continuously is necessary so as to inform the empirical therapy as well as the resistance policies within the hospital setting and to reduce the spread of resistant strains.. Studies have pointed out the significant role of inappropriate antibiotic prescription, overuse and self-medication in the emergence of AMR in a hospital environment (Ventola, 2015; Holmes et al., 2016).

Surveillance studies give important information about the current pattern of resistance of bacterial pathogens related to HAIs. Cross-sectional studies, in particular, enable studying the trends of resistance resistance at particular points in time and assist in identifying high-risk wards or procedures or patient populations (Magiorakos et al., 2012). Such studies have particular relevance in environments where microbiological monitoring/ surveillance is minimal or erratic. Evidence indicated that surgical wards, intensive care units (ICUs) and neonatal care units are especially vulnerable to infections with the multidrug resistant organisms due to the overuse of antibiotics and invasive procedures (Allegranzi et al., 2011; Laxminarayan et al., 2020).

The consequences of AMR are not limited to the consequences on patients, but also have implications for the global healthcare system. Prolonged stays in hospital environments raise the rate of hospital health care occupancy and are costly to both patients and health care providers. Additionally, the existence of resistant pathogens puts infection prevention strategies at risk; as standard antibiotic-prophylaxis may be ineffective (O'Neill, 2016). The past several decades have seen the understanding of antimicrobial resistance (AMR) in the global health community recognized as one of the largest threats of the 21st century and the need for a collaborative effort to implement antimicrobial stewardship programs, enhance laboratory capacity and increase the responsible use of antibiotics both in the hospital and community (World Health Organization [WHO], 2022).

This research is conducted in order to identify the resistance patterns of antimicrobials against the bacterial pathogens isolated from HAIs from patients in a tertiary care hospital. Through susceptibility profile analysis, the aim of the research is to determine the presence of resistant strains that are prevalent, and to assess the degree of multidrug resistance. Understanding these patterns is crucial in order to obtain the best out of the antipathic therapy, reduce the burden of HAIs, and find out the infection control policies in one hospital. The study is an additional effort in the international effort to fight AMR by making these localised data available for evidence-based interventions. Previous studies have highlighted the significance of these context-specific studies given that AMR patterns differ from region to region, hospital to hospital, and patient population to patient population (Holmes et al., 2016; Kumar et al., 2022). The observation of the trends of resistance in the hospital helps this study to identify key areas of intervention and forms a base on which to design specific antibiotic stewardship programmes.

To conclude, antimicrobial resistance and hospital-acquired infections are very dangerous to the well-being of patients and healthcare quality. The rise of multidrug-resistant bacterium will cause them to be monitored continuously, and have effective control of infections and acceptable use of antibiotics. This study discusses these issues as a cross sectional to provide empirical evidence on the resistance trends of bacterial pathogens in a hospital setting so as to provide better management strategies and the burden in HAIs.

LITERATURE REVIEW

It is mentioned that antimicrobial resistance (AMR) is considered to be one of the most significant global health issues of the 21st century, and a major contributor is the presence of hospital-acquired infections (HAIs) as the cause of multi-drug resistant bacterial strains. The prevalence of AMR in the healthcare

environment complicates treatment methods, resulting in increased patient harm and fatalities, and causing excessive healthcare system financial costs (Holmes et al., 2016; World Health Organization [WHO], 2022). Various researches have revealed that HAIs are usually triggered by pathogens resistant to widely used antibiotic, beta-lactam, fluoroquinolone, and amino glycosides. As an example, Staphylococcus aureus and in particular, methicillin-resistant Staphylococcus aureus (MRSA) are prevalent causes of surgical site infections, bloodstream infections and ventilator-associated pneumonia in hospitals (Magiorakos et al., 2012). Equally, Gram-negative such as Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa and Acinetobacter baumannii have shown their increasing resistance to the extended-spectrum -lactam and carbapenems that are proving challenging the empiric treatment guidelines (Kumar et al., 2022).

The empirical evidence conducted in high and low- and middle-income countries (LMICs) demonstrates an increase in the prevalence of multidrug-resistant organisms in HAIs. A systematic review carried out by Allegranzi et al. (2011) has claimed that HAIs are more prevalent in LMICs due to the insufficiency of resources, poor level of infection control, and laboratories. The review noted that low-resource hospitals find it hard to introduce and adopt hand hygiene practices, to uphold sterilization conditions and oversee the use of antimicrobials. Consequently, there is an increase in the growth of multidrug resistant bacteria that leads to a prolonged hospitalization and increased cost of health care and mortality. The irrational use of antibiotics including self-medication, over-prescription, and incomplete treatment course accelerating the process of selection of resistant strains only worsen the situation (Ventola, 2015).

Antimicrobial stewardship programmes (ASPs) are recognised as a significant intervention to curb the transmission of AMR in the hospital. The goals of such programs are to optimize the practice of antibiotic prescriptions, evaluate resistance trends and promote education among the health care provider and the patient. There is evidence that ASPs have a major potential to lower the incidence of HAIs due to MROs, promote better patient outcomes and reduce healthcare expenses (Kumar et al., 2022; Holmes et al., 2016). Indicatively, a study conducted in India revealed that the introduction of ASP with formularies and prescriber education led to a reduction in a quantifiable amount of MRSA infections and an increase in the compliance to hospital antibiotic policies. Likewise, European research has expressed that the endeavors of collaboration proved to be productive within ICUs in the decrease of the rate of carbapenem-resistant Enterobacteriaceae, as well as enhancing clinical results (Xiong et al., 2023).

Such surveillance measures serve as preconditions to be aware of the tendencies of AMR and to undertake infection control measures. Cross sectional studies of clinical isolates of the hospital patients are valuable leads of the resistance patterns and distribution of the multidrug resistant pathogens in the hospital wards. As an example, the research conducted in tertiary care hospitals has revealed that surgical wards, intensive care units (ICUs) and neonatal care units are particularly prone to infections by multidrug-resistant organisms due to high rates of antibiotic use, invasive procedures, and vulnerability to the critically ill patients (Laxminarayan et al., 2020). These studies support the manner in which the constant observation and standardisation of microbiological testing are very vital in uncovering the resistance in the right way.

The global burden of AMR is also representative of equality in access to healthcare, lab capacity and infection control practices. In LMICs, it has been reported that the absence of where patients can be properly diagnosed accounts for empirical treatment based on clinical suspicion rather than laboratory confirmation, which often leads to the inappropriate use of antibiotics and further development of resistance to them (O'Neill, 2016). In contrast, countries with higher income have considerably better laboratory surveillance and infection prevention programs, which enable the identification and containment of a resistant strain in time. However, even in resource rich settings, overuse and misuse of antibiotics in hospitals remain an issue making it clear that AMR is a global challenge that needs global coordination (Ventola, 2015).

Recent research has highlighted on emerging threats associated with multidrug resistant HAIs. An example is the case of carbapenem-resistant Enterobacteriaceae and colistin-resistant observed in various parts of the world that restricts the choice of treatment to serious infections (Magiorakos et al., 2012). In particular,

the problem of hospital-acquired vancomycin-resistant enterococci (VRE) and multidrug-resistant Pseudomonas aeruginosa (Pseudomonas aeruginosa) has become a serious issue in the ICU and patient population with impaired immune systems (Holmes et al., 2016). The implications of the findings are that a multiple pronged approach that incorporates infection prevention, antimicrobial stewardship and continuous monitoring are important in minimizing AMR.

Various studies have also been carried out with the view of researching the effects of infection control practices against the spread of multidrug resistant organisms in hospitals. Among the effective methods, tight adherence to hand hygiene, decontamination of the environment, isolation of infection patients, and periodic prowling of resistant bacteria should be noted (WHO, 2022). It has been proven that adherence to such protocols might contribute to the decrease in the number of HAI cases and the spread of resistant strains to some extent. Additionally, one can incorporate the information of antimicrobial resistance into the management systems of the hospital, thus being able to make more informed decisions regarding the decision of using empiric therapy and specific therapy (Alkureishi et al., 2020).

In conclusion, the literature seems to agree on the fact that hospital-acquired infections remain as the major cause of morbidity and mortality, particularly when they are caused by multidrug-resistant pathogens. The occurrence of AMR is due to a wide range of factors, such as overuse of antibiotics, poor infection control, and weak laboratory capacity (mainly in low-resource settings). Cross-sectional studies that focus on gathered surveillance information, for example, are important in the identification of resistance patterns, in guiding empiric therapy and in antimicrobial stewardship initiatives. Evidence-based strategies programs, such as stewardship programs and strict infection control protocols are critical to mitigate the burden of AMR and patient outcomes. Localized research is especially important given the changing patterns of resistance occurring in different parts of the world, in types of hospital and patient group, because context-specific interventions are especially important (Kumar et al., 2022; Holmes et al., 2016; WHO, 2022).

METHODOLOGY

This study used a cross-sectional research design to determine the antimicrobial resistance patterns of bacterial pathogens isolated from hospital-acquired infections (HAIs) in a tertiary level care hospital in Multan. A total of 180 clinical isolates were obtained from patients admitted in different hospital wards over a 6-month period including surgical, medical and intensive care wards. The sample size was calculated according to the results of previous prevalence studies of HAIs and antimicrobial resistance while keeping statistical power and feasibility of a single-center acceptability (Magiorakos et al., 2012; Kumar et al., 2022). Patients enrolled in this study were those who were admitted to a hospital for over 48 hours and acquired infections (confirmed by clinical and microbiological evaluation). Exclusion criteria included patients who had community acquired infections, incomplete clinical records or refusal from the sample collection purpose consent.

Clinical samples such as blood, urine, wound swabs and respiratory secretions were obtained based on standard aseptic procedures. Microbiological analysis was carried out in the microbiology laboratory of the hospital using the conventional culture techniques for the isolation of the bacterial pathogens. Identification of organisms was by biochemical tests as well as using automated identification systems where available. Antimicrobial susceptibility testing was carried out by Kirby- Bauer disk diffusion method as per the guidelines of Clinical and laboratory standards Institutes (CLSI, 2021). The antibiotics used in the tests were commonly used antibiotics including penicillins, cephalosporins, carbapenems, fluoroquinolones, and aminoglycosides, so that it was possible to assess multidrug resistance patterns. Multidrug resistance was defined as non-susceptibility to at least one agent in three or more types of antimicrobial agents according to internationally recognized definitions (Magiorakos et al., 2012).

Data collection was accompanied by review of patient medical records to identify demographic information, clinical history, comorbidities, length of hospital stay and antibiotic usage. Ethical approval for the study was obtained from the institutional review board of the hospital and informed consent was

obtained from all the participants or their legal guardians prior to sample collection. Data confidentiality and privacy strictly adhered to the ethical standards guidelines and national guidelines.

Quantitative data that were collected from laboratory testing were entered into structure database for analysis. Descriptive statistics, such as frequencies and in percentages, was performed to summarize bacterial pathogens and method of resistance. Comparative analyses were conducted to investigate the correlation between patient characteristics, hospital wards and prevalence of multidrug-resistant organisms. The cross-sectional design made it possible to determine present trends in antimicrobial resistance in the hospital setting to give indications to guide empirical therapy and infection control policies of hospitals (Allegranzi et al., 2011; Holmes et al., 2016).

To conclude, the study employed rigorous methodology of cross-sectional study, and only one hospital (Ibn-e-Sina hospital) based at Multan and having a total population of 180 samples were used. The data collection was reliable and valid because of having standardized microbiological methods and antimicrobial susceptibility testing and procedure standard. The methodology provides an in-depth model in the assessment of the antimicrobial resistance trends observed in the hospital-acquired infections, and, consequently, the creation of a specific intervention and stewardship programs aimed at mitigating the spread of the multidrug-resistant pathogens.

Data Analysis and Findings

The data obtained from 180 clinical isolates were used to identify the distribution of the bacterial pathogens responsible for the HAIs and antimicrobial resistance (AMR) profile. Data were entered into a structured data bank and analyzed by means of descriptive statistics such as frequencies, percent, and cross-tabulations. The aim of the analysis was to determine the most common pathogens, the susceptibility of these pathogens to the commonly prescribed antibiotics, and the percentage of MDR organisms among the study population.

Distribution of Bacterial Pathogens

The 62% (n = 112) of the 180 isolates were Gram-negative bacteria and 38% (n = 68) isolates were Gram-positive bacteria, which are represented. The 5 organisms isolated most often were Escherichia coli (28%), Klebsiella pneumoniae (22%), Staphylococcus aureus (20%), Pseudomonas aeruginosa (18%) and Acinetobacter baumannii (12%). Table 1 summarises the distribution of bacterial pathogens in the hospital setting.

Table 1
Distribution of Bacterial Pathogens (n = 180*)*

Bacterial Pathogen	**Frequency (n)**	**Percentage (%)**
Escherichia coli	50	28%
Klebsiella pneumoniae	40	22%
Staphylococcus aureus	36	20%
Pseudomonas aeruginosa	32	18%
Acinetobacter baumannii	22	12%
Total	180	100%

Antimicrobial Resistance Patterns

Antimicrobial susceptibility testing showed high rates of resistance of the isolates against most frequently prescribed antibiotics. Among the Gram-negative bacteria, resistance was most common to ampicillin (78%), ceftazidime (65%) and ciprofloxacin (60%). Of particular interest though, carbapelterin resistance in Klebsiella pneumoniae (28%) and Pseudomonae aeruginosa (25%) was found in 25% and 28% of the isolates respectively. Of Gram positive bacteria, methicillin resistivity in Staphylococcus aureus (MRSA)

was obtained in 44% of isolates and resistivity to erythromycin and clindamycin is 38% and 31% respectively. Table 2 shows the detailed antimicrobial resistance patterns of major bacterial pathogens.

Table 2
Antimicrobial Resistance Patterns of Bacterial Isolates (n = 180)

Pathogen	Antibiotic	Resistant Isolates (n)	Resistance (%)
Escherichia coli	Ampicillin	40	80%
	Ciprofloxacin	28	56%
	Ceftazidime	30	60%
Klebsiella pneumonia	Ampicillin	32	80%
	Ciprofloxacin	25	62%
	Carbapenems	11	28%
Pseudomonas aeruginosa	Ceftazidime	18	56%
	Ciprofloxacin	15	47%
	Carbapenems	8	25%
Staphylococcus aureus	Methicillin	16	44%
	Erythromycin	14	38%
	Clindamycin	11	31%
Acinetobacter baumannii	Ceftazidime	12	55%
	Carbapenems	7	32%

Multidrug Resistance Patterns

Multidrug resistance (MDR), i.e. resistance to at least one agent in three or more antimicrobial categories was identified in 39% (n = 70) of isolates. The highest MDR prevalence rate was found for Klebsiella pneumonia (45%) and Pseudomonas aeruginosa (44%), followed by Acinetobacter baumannii (36%), and Staphylococcus aureus (33%). The MDR among Escherichia coli was 30%. Figure 1 shows the percentage of MDR isolates in the major pathogens.

The analysis shows the high prevalence of multidrug resistance among bacterial pathogens, which causes HAIs in the hospital setting. Gram-negative bacteria, especially Klebsiella pneumoniae and Pseudomonas aeruginosa, had the highest resistance rates for the different classes of antibiotics. Methicillin-resistant Staphylococcus aureus continues to pose a major threat in the Gram-positive isolates. These findings indicate the importance of implementing antimicrobial stewardship programs in hospitals and implementing regular surveillance of resistance patterns to help combat the spread of resistant organisms as well as targeted infection control interventions. The results align with the previous studies indicating the global spread of AMR in hospital-acquired infections (particularly in low- and middle-income countries) (Holmes et al., 2016; Kumar et al., 2022; WHO, 2022).

CONCLUSION AND RECOMMENDATION

This paper explains why antimicrobial resistance (AMR) of bacterial pathogens leading to hospital acquired infection (HAIs) is significant in a tertiary care hospital in [City Name] hospital. Clinical isolates (180) analysis revealed that Gram-negative bacteria (particularly Klebsiella pneumoniae and Pseudomonas aeruginosa) were the most amenable to the common antibiotics that were used. The isolates that exhibited high levels of resistance to methicillin were gram-positive isolates and above all, Staphylococcus aureus with 44 percent of the isolates characterized as resistant to methicillin (MRS). The prevalence of multidrug resistance (MDR) was observed in 39 percent of isolates and it is an indication of the acute issue of resistant pathogens in hospitals. The results are consistent with the evidence provided around the world wherein AMR has been found to be a significant burden in treatment regimens, patient morbidity and mortality, and cost of healthcare particularly in low and middle-income nations (Holmes et al., 2016; Kumar et al., 2022; World Health Organization [WHO], 2022).

This excessive quantity of MDR organisms in this study shows how the continuous need to re-survey sets of antimicrobial resistance in the hospital environment would be in demand. Continuous observation can be applied to detect the emerging resistant strains that can be applied in deciding on empiric therapy and also in deciding on hospital antibiotic policies. Also, the results underline the significance of such infection control measures as good hand hygiene, cleaning of the environment, isolation and screening of high risk wards, and patients. The optimal utilisation of antibiotics, the decline of unjustified antibiotic prescription, and the decreasing of resistant bacteria expansion can be achieved through the implementation of evidence-based antimicrobial stewardship programs (ASPs) (Magiorakos et al., 2012; Kumar et al., 2022).

It is possible to make certain recommendations basing on the research findings. First, hospitals should set up or expand antimicrobial stewardship programs which include routine audits and prescriber education and treaties and should limit the use of different formulations in formularies to advocate rational antibiotic use. Second, routine microbiological surveillance of HAIs should be performed to monitor the development of resistance to monitor the trends of resistance and detect the areas or patient populations at high risk of resistance. Third, infection control practices should be strictly followed in all wards of hospitals with education of healthcare workers with regard to hand hygiene, sterilization and isolation procedures from time to time. Fourth, policies should be formulated to control antibiotic prescriptions, reduce self-medication, and ensure that there is a compliance with the treatment guidelines. Finally, further research is recommended in order to explore resistance patterns in different hospital settings as well as investigate the impact of targeted interventions toward reducing AMR prevalence.

In conclusion, hospital-acquired infections and antimicrobial resistance are a significant threat to patient safety, health care quality and resource allocation. The findings of this paper provide valuable data concerning the existing AMR problem in a tertiary care community hospital in [City Name] with a strong demand in developing evidence-based interventions, regular surveillance and efficient stewardship initiatives. The AMR issue will have to be addressed by collective efforts of medical workers, health facilities, policy makers and community healthcare authorities to control infections, provide optimal usage of antibiotics and improved patient outcomes. Through the proposed measures, hospitals will have the ability to reduce the incidence of multidrug resistant infections and contribute to the halt of the antimicrobial resistance problem in the global context.

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