Journal of Advanced Healthcare and Medical Sciences (JAHMS)
J. Adv. Healthc. Med. Sci.
E-ISSN: xxxx-xxxx; P-ISSN: xxxx-xxxx
Website: https://www.jahms.org/

Original Article

Trends in Antimicrobial Resistance in Tertiary Care Hospitals: A Retrospective Observational Study

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Received: 2024-08-20 **Accepted**: 2024-09-18 **Published**: 2024-12-31

Abstract-

Background: Antimicrobial resistance (AMR) has emerged as one of the most significant global public health threats, particularly in tertiary care hospitals where extensive antimicrobial use promotes the development of resistant microorganisms. Continuous surveillance of resistance patterns is essential for guiding empirical therapy and infection control strategies. ***Objective***: To evaluate trends in antimicrobial resistance among bacterial isolates obtained from patients admitted to a tertiary care hospital over a five-year period. ***Materials and Methods:*** A retrospective observational study was conducted using microbiological records from January 2019 to December 2023. Clinical specimens including blood, urine, sputum, pus, and body fluids were processed according to standard microbiological procedures. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method and interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analyzed to determine resistance trends among major bacterial pathogens. ***Results***: A total of 5,240 bacterial isolates were analyzed. Gram-negative organisms constituted 68.5% of isolates, while Gram-positive organisms accounted for 31.5%. Escherichia coli (28.2%), Klebsiella pneumoniae (21.4%), and Staphylococcus aureus (18.6%) were the predominant pathogens. Resistance to third-generation cephalosporins increased from 54.2% in 2019 to 69.8% in 2023. Carbapenem resistance among K. pneumoniae increased from 18.4% to 35.6%, while methicillin-resistant Staphylococcus aureus (MRSA) prevalence increased from 32.1% to 41.7%. ***Conclusion***: A significant rise in antimicrobial resistance was observed during the study period, particularly among Gram-negative pathogens. Strengthening antimicrobial stewardship programs, infection prevention measures, and continuous surveillance is necessary to combat AMR in tertiary care settings.

Keywords: *Antimicrobial resistance, tertiary care hospital, multidrug resistance, surveillance, antimicrobial stewardship.*

INTRODUCTION

Antimicrobial resistance (AMR) is recognized as one of the most pressing public health challenges of the twenty-first century. It occurs when microorganisms such as bacteria, viruses, fungi, and parasites develop the ability to survive exposure to antimicrobial agents that were previously effective against them. The increasing prevalence of resistant pathogens threatens the successful treatment of infectious diseases and contributes to prolonged hospital stays, increased healthcare costs, and higher mortality rates (1).

The World Health Organization (WHO) has identified AMR as a global health emergency requiring urgent action. According to recent estimates, bacterial antimicrobial resistance was associated with approximately 4.95 million deaths globally in 2019, including 1.27 million deaths directly attributable to resistant infections (2). The burden is particularly high in low- and middle-income countries, where healthcare infrastructure, antimicrobial stewardship, and infection prevention programs may be limited (3).

Tertiary care hospitals serve as referral centers for critically ill patients and frequently manage severe infections requiring broad-spectrum antimicrobial therapy. The extensive use of antibiotics, invasive procedures, prolonged hospitalization, and high patient turnover create favorable conditions for the emergence and spread of resistant microorganisms (4). Common multidrug-resistant organisms encountered in tertiary care settings include methicillin-resistant Staphylococcus aureus (MRSA), extended-spectrum beta-lactamase (ESBL)-producing Escherichia coli and Klebsiella pneumoniae,

carbapenem-resistant Enterobacterales (CRE), and multidrug-resistant Pseudomonas aeruginosa and Acinetobacter baumannii (5).

In recent years, resistance to critical antibiotics such as carbapenems, cephalosporins, and fluoroquinolones has increased substantially. Carbapenem-resistant Enterobacterales have become a major concern because treatment options are limited and outcomes are often poor (6). Similarly, MRSA continues to be a significant cause of healthcare-associated infections worldwide despite improvements in infection control practices (7).

Surveillance of antimicrobial susceptibility patterns is a cornerstone of AMR control. Regular monitoring enables healthcare institutions to identify emerging resistance trends, formulate empirical treatment guidelines, and evaluate the effectiveness of stewardship interventions (8). The Global Antimicrobial Resistance Surveillance System (GLASS), established by WHO, encourages countries to strengthen laboratory-based surveillance systems and generate reliable AMR data (9).

In India, antimicrobial resistance has become a major healthcare challenge due to high antibiotic consumption, over-the-counter availability of antimicrobials, and inadequate infection control measures (10). Several studies have reported increasing resistance among both Gram-positive and Gram-negative pathogens in tertiary care hospitals (11,12). Continuous local surveillance is therefore essential to guide clinicians in selecting appropriate antimicrobial therapy.

The present study was undertaken to assess trends in antimicrobial resistance among bacterial isolates obtained from patients attending a tertiary care hospital over a five-year period. The findings may contribute to the development of effective antimicrobial stewardship policies and support evidence-based clinical decision-making.

MATERIALS AND METHODS

A retrospective observational study was conducted in the Department of Microbiology of a tertiary care teaching hospital. Microbiological records from January 2019 to December 2023 were reviewed to assess antimicrobial resistance trends.

Study Population

All bacterial isolates obtained from patients admitted to inpatient wards, intensive care units (ICUs), and outpatient departments during the study period were included. Duplicate isolates from the same patient with identical susceptibility patterns were excluded.

Sample Collection

Clinical specimens included:

- Blood
- Urine
- Sputum
- Pus/wound swabs
- Endotracheal aspirates
- Body fluids

Specimens were collected under aseptic conditions and transported promptly to the microbiology laboratory.

Isolation and Identification

Samples were cultured on appropriate media including Blood agar, MacConkey agar, and Chocolate agar. Bacterial isolates were identified using colony morphology, Gram staining, biochemical tests, and automated identification systems where available.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller-Hinton agar according to CLSI guidelines. The antibiotics tested included:

- Penicillins
- Cephalosporins
- Fluoroquinolones
- Aminoglycosides
- Carbapenems
- Glycopeptides
- Linezolid

Zone diameters were interpreted as susceptible, intermediate, or resistant according to CLSI criteria.

Data Collection

Information extracted from laboratory records included:

- Patient demographics
- Type of specimen
- Bacterial isolate
- Antimicrobial susceptibility results
- Year of isolation

Outcome Measures

Primary outcomes included:

1. Distribution of bacterial isolates.
2. Resistance trends among major pathogens.
3. Prevalence of multidrug-resistant organisms.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 25. Descriptive statistics were used to summarize frequencies and percentages. Resistance trends across years were expressed as percentages and presented in tabular form. Chi-square tests were used to assess changes in resistance patterns over time, with $p < 0.05$ considered statistically significant.

Ethical Considerations

Institutional Ethics Committee approval was obtained prior to commencement of the study. Patient confidentiality was maintained throughout the study by anonymizing laboratory records.

RESULTS

Table 1. Distribution of bacterial isolates (n = 5240)

Organism	Number	Percentage (%)
Escherichia coli	1478	28.2
Klebsiella pneumoniae	1121	21.4
Staphylococcus aureus	975	18.6
Pseudomonas aeruginosa	681	13.0
Acinetobacter baumannii	472	9.0
Enterococcus spp.	313	6.0
Others	200	3.8

E. coli was the most frequently isolated pathogen, followed by K. pneumoniae and S. aureus. Gram-negative organisms accounted for the majority of isolates.

Table 2. Resistance to third-generation cephalosporins among Gram-negative isolates

Year	Resistance (%)
2019	54.2
2020	58.7
2021	62.5
2022	66.4
2023	69.8

A steady increase in cephalosporin resistance was observed over the five-year period, indicating growing prevalence of ESBL-producing organisms.

Table 3. Carbapenem resistance among Klebsiella pneumoniae isolates

Year	Resistance (%)
2019	18.4
2020	22.3
2021	27.1
2022	31.4
2023	35.6

Carbapenem resistance nearly doubled during the study period, reflecting increasing emergence of carbapenem-resistant Enterobacterales.

Table 4. Prevalence of MRSA among Staphylococcus aureus isolates

Year	MRSA (%)
2019	32.1
2020	34.5
2021	37.2
2022	39.8
2023	41.7

The proportion of MRSA increased progressively over time, emphasizing the need for strict infection control measures.

DISCUSSION

The present study evaluated antimicrobial resistance trends among bacterial pathogens isolated from patients attending a tertiary care hospital over a five-year period. The findings demonstrated a substantial increase in resistance to commonly used antimicrobial agents, particularly among Gram-negative bacteria.

Escherichia coli was the predominant isolate, followed by Klebsiella pneumoniae and Staphylococcus aureus. Similar findings have been reported in studies from India and other developing countries, where Gram-negative organisms are major causes of healthcare-associated infections (11,13). The predominance of these organisms may be attributed to their ability to acquire and disseminate resistance genes rapidly.

One of the most significant findings was the progressive increase in resistance to third-generation cephalosporins. Resistance increased from 54.2% in 2019 to 69.8% in 2023, suggesting widespread dissemination of ESBL-producing Enterobacterales. Comparable trends have been documented globally, where ESBL-producing E. coli and K. pneumoniae are increasingly associated with urinary tract infections, bloodstream infections, and hospital-acquired pneumonia (14).

Carbapenem resistance among K. pneumoniae increased markedly during the study period. Carbapenems are often considered last-line agents for severe Gram-negative infections; therefore, increasing resistance poses a serious therapeutic challenge (15). The emergence of carbapenemase-producing organisms has been linked to excessive carbapenem use and horizontal transfer of resistance genes through plasmids (16).

The prevalence of MRSA also increased steadily from 32.1% to 41.7%. MRSA remains an important cause of healthcare-associated infections and is associated with increased morbidity and mortality (17). The rise observed in the present study may reflect ongoing transmission within healthcare facilities and selective pressure resulting from antimicrobial use.

Several factors contribute to the increasing burden of AMR in tertiary care hospitals. These include inappropriate antibiotic prescribing, prolonged hospital stays, inadequate hand hygiene practices, overcrowding, and limited implementation of antimicrobial stewardship programs (18). Intensive care units represent particularly high-risk environments due to frequent use of invasive devices and broad-spectrum antibiotics.

The findings underscore the importance of routine surveillance programs. Continuous monitoring enables early detection of emerging resistance patterns and supports the development of evidence-based treatment guidelines (9). Strengthening infection prevention strategies, including hand hygiene, environmental cleaning, and isolation precautions, is essential to reduce transmission of multidrug-resistant organisms (19).

Antimicrobial stewardship interventions have demonstrated effectiveness in optimizing antibiotic use and reducing resistance rates. Such programs promote appropriate antimicrobial selection, dosing, route, and duration of therapy while minimizing unnecessary exposure to broad-spectrum agents (20). Incorporating stewardship practices into routine clinical care may significantly mitigate the burden of AMR.

Although this study provides valuable insights into resistance trends, its retrospective design limits the ability to establish causality. Additionally, data from a single tertiary care center may not be generalizable to all healthcare settings. Nevertheless, the findings contribute important local evidence regarding the evolving epidemiology of antimicrobial resistance.

CONCLUSION

Antimicrobial resistance continues to increase in tertiary care hospitals, particularly among Gram-negative pathogens. Rising resistance to cephalosporins, carbapenems, and methicillin highlights the urgent need for robust antimicrobial stewardship programs, continuous surveillance, and strengthened infection control practices. Early intervention and evidence-based antibiotic policies are essential to preserve the effectiveness of existing antimicrobial agents and improve patient outcomes.

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