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Research Article

Prevalence of Carbapenem Resistant Enterobacterales at a Tertiary Care Hospital

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ABSTRACT
Background: Carbapenem-resistant Enterobacterales (CRE) have emerged as a major public health concern owing to their increasing prevalence, limited therapeutic options, and association with high morbidity and mortality. The rapid dissemination of carbapenemase-producing organisms has significantly challenged the management of healthcare-associated infections worldwide.
Aim: To determine the prevalence of Carbapenem-resistant Enterobacterales among clinical isolates obtained from patients attending a tertiary care hospital.
Materials and Methods: A prospective observational study was conducted in the Department of Microbiology of a tertiary care hospital from July 2023 to December 2023. Clinical specimens including urine, pus, swabs, blood, sputum, cerebrospinal fluid, pleural fluid, and other body fluids received for culture and antimicrobial susceptibility testing were included. Enterobacterales were isolated and identified using conventional microbiological methods. Antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.
Results: A total of 306 Enterobacterales isolates were recovered during the study period, of which 133 (43.5%) were carbapenem-resistant. *Escherichia coli* was the predominant organism isolated (162/306) followed by *Klebsiella pneumoniae* (48/306). CRE were most commonly seen in *Escherichia coli* (74 isolates, 45.6%), most frequently isolated from urine specimens (59%) and hospitalized patients (48%). Among the carbapenem-resistant isolates, more resistance towards Imipenem was observed compared to Meropenem.
Conclusion: The high proportion of CRE observed in the present study highlights the growing burden of antimicrobial resistance in tertiary healthcare settings. Continuous microbiological surveillance, strict infection prevention measures, and implementation of antimicrobial stewardship programmes are essential to limit the emergence and spread of CRE.

Keywords: Carbapenem-Resistant Enterobacterales, Antimicrobial Resistance, Infection Prevention.

INTRODUCTION

Antimicrobial resistance (AMR) is recognized as one of the most important global public health threats of the twenty-first century. The increasing emergence of multidrug-resistant Gram-negative bacteria has significantly reduced the effectiveness of commonly used antimicrobial agents and has become a major challenge for clinicians and microbiologists worldwide.[1,2]

Among Gram-negative pathogens, members of the order Enterobacterales are responsible for a wide spectrum of community-acquired and healthcare-associated infections, including urinary tract infections, bloodstream infections, lower respiratory tract infections, intra-abdominal infections, wound infections, and neonatal sepsis.[3] The most frequently isolated organisms include *Escherichia coli, Klebsiella pneumoniae, Enterobacter species, Citrobacter species, Proteus* species, *Morganella morganii,* and *Serratia* species.[4]

Carbapenems, including imipenem, meropenem, doripenem, and ertapenem, have long been regarded as the drugs of choice for treating infections caused by extended-spectrum β-lactamase (ESBL)-producing Enterobacterales because of their broad antimicrobial spectrum and stability against most β-lactamases.[3] However, indiscriminate use of these antibiotics has resulted in the emergence of carbapenem-resistant

Enterobacterales (CRE), which now constitute one of the World Health Organization's priority pathogens requiring urgent attention.[1]

Resistance to carbapenems is mediated through several mechanisms, including production of carbapenemase enzymes such as New Delhi metallo-β-lactamase (NDM), Klebsiella pneumoniae carbapenemase (KPC), OXA-48-like enzymes, Verona integron-encoded metallo-β-lactamase (VIM), and imipenemase (IMP). Other mechanisms include porin loss combined with overproduction of AmpC or extended-spectrum β-lactamases and activation of efflux pumps.[5,6]

Patients infected with CRE often experience prolonged hospital stay, delayed initiation of effective antimicrobial therapy, increased healthcare expenditure, and higher mortality rates than those infected with carbapenem-susceptible organisms.[7] In addition, CRE possess a remarkable ability to disseminate within healthcare facilities through person-to-person transmission and contaminated hospital environments, making infection prevention and control measures critically important.[8]

The prevalence of CRE varies considerably across different geographical regions and healthcare institutions owing to differences in antibiotic prescribing practices, infection prevention strategies, laboratory detection methods, and local epidemiology.[9] Recent Indian studies have reported a substantial increase in carbapenem resistance among Enterobacterales, particularly among isolates recovered from intensive care units and hospitalized patients, emphasizing the need for continuous surveillance and antimicrobial stewardship programmes.[10–13]

Determination of the local prevalence and distribution of CRE is essential for guiding empirical antimicrobial therapy, monitoring resistance trends, formulating institutional antibiotic policies, and strengthening infection control practices. Hospital-based surveillance studies also contribute valuable epidemiological data for regional and national antimicrobial resistance programmes.[14]

Therefore, the present prospective observational study was undertaken to determine the prevalence of carbapenem-resistant Enterobacterales among clinical isolates recovered from patients attending a tertiary care hospital and to describe their distribution according to specimen type, bacterial species, patient location, and carbapenem susceptibility pattern.

Aim

To determine the prevalence of carbapenem-resistant Enterobacterales (CRE) among clinical isolates obtained from patients attending a tertiary care hospital.

Objectives

- To isolate and identify Enterobacterales from various clinical specimens received in the Department of Microbiology.
- To determine the proportion of CRE among various clinical isolates.
- To analyze the distribution of CRE according to bacterial species and clinical specimen.
- To determine the distribution of CRE among outpatient (OPD) and inpatient (IPD) populations.
- To evaluate the susceptibility pattern of CRE isolates to carbapenem antibiotics.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted in the Department of Microbiology of a tertiary care teaching hospital.

Study Duration

The study was carried out over a period of six months from July 2023 to December 2023.

Study Population

The study included patients attending both the outpatient and inpatient departments whose clinical specimens were received in the microbiology laboratory for bacterial culture and antimicrobial susceptibility testing.

Sample Size

A total of 306 Enterobacterales isolates recovered from various clinical specimens during the study period were included in the analysis.

Inclusion Criteria

- Clinical specimens received for bacteriological culture and susceptibility testing during the study period.
- Isolates belonging to the order Enterobacterales.

Exclusion Criteria

- Duplicate isolates from the same patient.
- Contaminated or improperly collected specimens.
- Non-Enterobacterales isolates.

Isolation and Identification of Isolates

Clinical specimens received from patients were processed using standard microbiological procedures. Specimens were inoculated onto appropriate culture media, including blood agar and MacConkey agar, and incubated aerobically at 35–37°C for 18–24 hours. Suspected Enterobacterales isolates were

identified based on colony morphology, Gram staining, motility, and standard biochemical reactions.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method using Mueller–Hinton agar. A 0.5 McFarland bacterial suspension was prepared from fresh cultures, inoculated onto Mueller–Hinton agar, and appropriate antibiotic discs were applied. After incubation at 35–37°C for 16–18 hours, inhibition zones were measured and interpreted according to CLSI M100, 35th edition. [2]

Isolates showing resistance to one or more tested carbapenems, such as imipenem, meropenem or ertapenem, according to the applicable CLSI criteria were classified as carbapenem-resistant Enterobacterales (CRE).

Appropriate reference strains were used for quality control of culture and antimicrobial susceptibility testing.

Data Collection

The following variables were recorded for each isolate:

- Age and sex of the patient
- Patient location (OPD/IPD)
- Type of clinical specimen
- Bacterial isolate
- Carbapenem susceptibility status
- Results of antimicrobial susceptibility testing

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software and results were expressed as frequencies and percentages. Descriptive statistics were used to determine the prevalence and distribution of CRE among different bacterial species, specimen types, and patient categories

RESULT

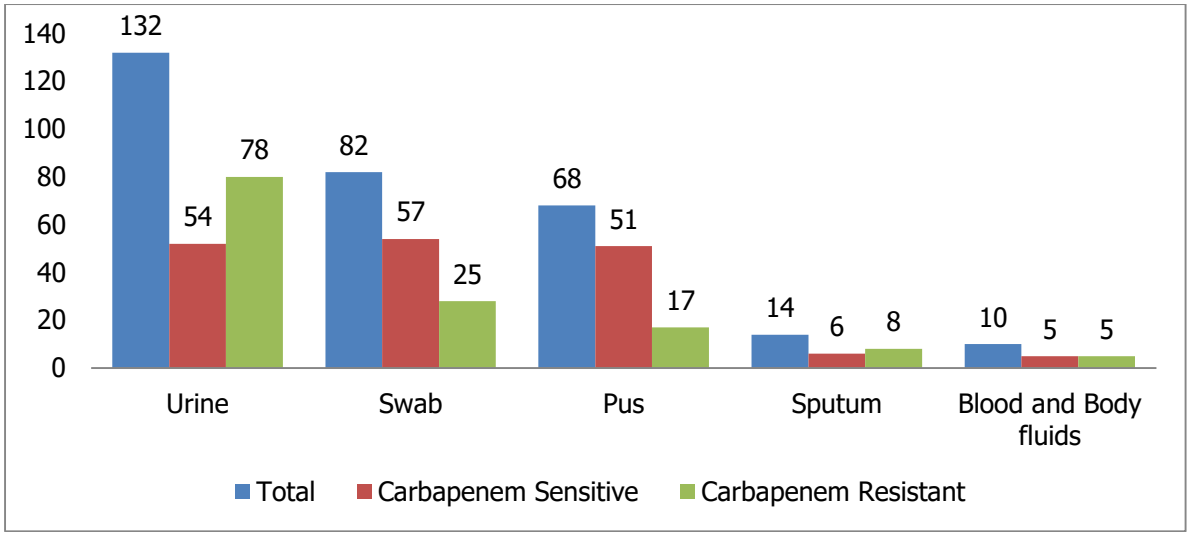
During the study period a total of 306 Enterobacterales isolates were recovered from various clinical specimens like urine, pus, swab, blood, CSF, pleural fluid and others received in the Department of Microbiology. Among these, 133 (43.5%) isolates were identified as CRE, whereas 173 (56.5%) isolates were susceptible to carbapenem antibiotics.

Escherichia coli was the predominant isolate, accounting for 162 (52.9%) of all Enterobacterales isolates, followed by *Klebsiella pneumoniae* (48; 15.7%) and Klebsiella oxytoca (36; 11.8%). Among the carbapenem-resistant isolates, *E. coli* contributed the highest proportion (74/162 isolates; 45.6%), followed by *K. pneumoniae* (21/48isolates; 43.7%) and *K. oxytoca* (15 /36 isolates; 41.6%).

Table 1. Organism-Wise Distribution of Enterobacterales and Carbapenem Susceptibility Pattern

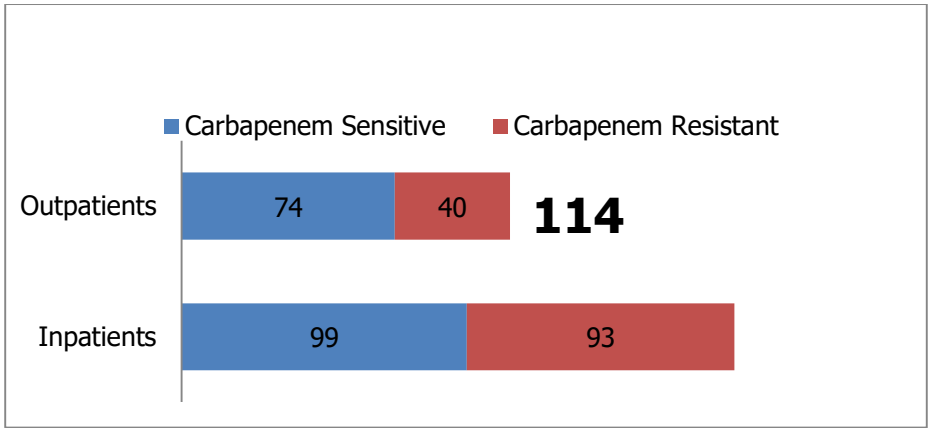
S.no	Organisms	Total isolates	Carbapenem Sensitive isolates	Carbapenem Resistant isolates
1	Escherichia coli	162 (52.9%)	88	74
2	Klebsiella pneumoniae	48 (15.7%)	27	21
3	Klebsiella oxytoca	36 (11.8%)	21	15
4	Citrobacter freudii	24 (7.8%)	12	12
5	Citrobacter koseri	22 (7.1%)	14	8
6	Proteus mirabilis	10 (3.2%)	8	2
7	Proteus vulgaris	4 (1.3%)	3	1
Total		306 (100%)	173 (56.5%)	133 (43.5%)

Urine specimens accounted for the largest proportion of CRE isolates. Of the 132 urinary isolates, 78 (59%) were Carbapenem resistant. Swab specimens shows 25 CRE isolates, followed by pus (17 isolates) and sputum (8 isolates). Five CRE isolates were recovered from blood and body fluids.



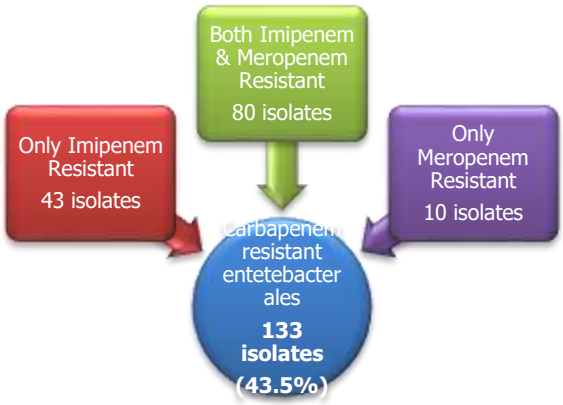
Graph 1. Specimen-Wise Distribution of Carbapenem-Resistant Enterobacterales

Among 306 Enterobacterales isolated, 192 were obtained from inpatients and 114 from outpatients. Of these, 133 (43.4%) were carbapenem-resistant Enterobacterales. Among the 133 CRE isolates, 93/192 (48%) were recovered from inpatient samples compared with 40/114 (35%) from Outpatient samples. This indicates a higher burden of carbapenem resistance among hospitalized individuals.



Graph 2. Distribution of CRE According To Patient Location

Among the 133 CRE isolates, 80 (60%) were resistant to both imipenem and meropenem while 43 isolates (32%) demonstrated resistance only to imipenem and 10 isolates (8%) were resistant only to meropenem.



Graph 3. Distribution of CRE among Carbapenems.

Summary of Findings

Overall, carbapenem resistance was identified in 43.5% of Enterobacterales isolates during the study period. *Escherichia coli* was the predominant organism isolated and also accounted for the largest proportion of CRE. Urine was the most common clinical specimen yielding CRE, and the majority of resistant isolates were recovered from hospitalized patients. Resistance to imipenem was more frequent than resistance to meropenem among the CRE isolates. These findings demonstrate a substantial burden of carbapenem resistance in Enterobacterales isolated from patients attending the tertiary care hospital.

DISCUSSION

Carbapenem-resistant Enterobacterales (CRE) have emerged as one of the most important antimicrobial-resistant pathogens worldwide and represent a major challenge for healthcare systems because of limited treatment options, prolonged hospitalization, increased healthcare costs, and higher mortality rates.[1,2] Continuous surveillance of CRE is essential to monitor resistance trends, guide empirical antimicrobial therapy, and strengthen antimicrobial stewardship and infection prevention strategies.[3]

In the present study, the overall prevalence of carbapenem-resistant Enterobacterales at a tertiary care hospital was 43.5% (133/306). This prevalence is considerably high and indicates a substantial burden of carbapenem resistance in our tertiary care hospital. Similar observations have been reported from tertiary care centres across India, although the reported prevalence varies depending on geographical location, patient population, infection control practices, and laboratory methods used for detection.[4–6]

Shafi et al. reported a CRE prevalence of 33.9% in a tertiary care hospital in North India, which was lower than that observed in the present study. The higher prevalence in our hospital may be attributed to differences in antimicrobial prescribing practices, referral of critically ill patients, prolonged hospitalization, and selective antibiotic pressure.

Escherichia coli was the predominant organism isolated in our study, accounting for 162 (52.9%) of all Enterobacterales isolates, of which 74 isolates (45.6%) were carbapenem resistant. This finding is consistent with the epidemiology of urinary tract infections, where *Escherichia coli* remains the leading pathogen. Several Indian studies have similarly reported *Escherichia coli* and *Klebsiella pneumoniae* as the most frequently isolated Enterobacterales species associated with carbapenem resistance. [4,7]

Klebsiella pneumoniae was the second most common CRE isolate in our study. This organism is recognized as one of the principal reservoirs of carbapenemase genes, particularly NDM, OXA-48-like, and KPC enzymes, which facilitate rapid dissemination of resistance within healthcare settings.[2,8] The increasing prevalence of carbapenem-resistant *Klebsiella* species is particularly concerning because these organisms are associated with outbreaks in intensive care units and high mortality among critically ill patients.[9]

Urine specimens accounted for the highest proportion of carbapenem-resistant isolates in the present study. This observation is expected because urinary tract infections constitute one of the commonest bacterial infections encountered in routine clinical practice, particularly among hospitalized patients and those with urinary catheterization or recurrent antibiotic exposure.[10] Similar findings have been reported in several Indian studies where urine was the predominant specimen yielding CRE isolates.[7]

An important finding of the present study was that 48% of CRE isolates were recovered from hospitalized patients, indicating that carbapenem resistance is more common among inpatients than outpatients. Hospitalization exposes patients to invasive procedures, prolonged antimicrobial therapy, indwelling medical devices, and repeated contact with healthcare environments, all of which increase the risk of acquisition and transmission of multidrug-resistant organisms.[2,11] This finding emphasizes the importance of strict adherence to infection prevention measures, including hand hygiene, contact precautions, environmental cleaning, and active surveillance of high-risk patients.

The carbapenem susceptibility profile demonstrated a higher proportion of resistance to imipenem than meropenem among CRE isolates. Differences in resistance rates between individual carbapenems have also been documented in previous studies and may reflect local antimicrobial prescribing practices and differences in resistance mechanisms.[12] Although phenotypic susceptibility testing remains the cornerstone for routine laboratory detection of CRE,

molecular characterization of carbapenemase genes would provide valuable epidemiological information and should be considered in future studies.

The emergence and dissemination of carbapenem-resistant Enterobacterales have important therapeutic implications. Treatment options are often limited to agents such as polymyxins, tigecycline, fosfomycin, aminoglycosides, or newer β-lactam/β-lactamase inhibitor combinations, depending on the susceptibility profile.[3,13] Judicious use of these agents is essential to prevent the emergence of further resistance.

The high prevalence of CRE observed in this study underscores the urgent need for strengthening antimicrobial stewardship programmes in tertiary care hospitals. Rational antibiotic prescribing, routine surveillance of antimicrobial resistance, implementation of evidence-based infection prevention practices, and regular education of healthcare workers remain the key strategies for limiting the spread of CRE.[1,3,14]

Strengths of the Study

The present study provides institution-specific epidemiological data on carbapenem-resistant Enterobacterales obtained from a variety of clinical specimens in both outpatient and inpatient settings. Such surveillance data are valuable for developing local antibiograms, guiding empirical therapy, and formulating hospital antibiotic policies.

Limitations

The study was conducted at a single tertiary care centre over a relatively short duration of six months. Molecular characterization of carbapenemase genes, minimum inhibitory concentration (MIC) testing, and evaluation of clinical risk factors for CRE acquisition were not performed. Therefore, the underlying mechanisms of carbapenem resistance and patient-related predictors could not be assessed. Future multicentre studies incorporating molecular techniques are recommended to better understand the epidemiology and transmission dynamics of carbapenem-resistant Enterobacterales.

CONCLUSION

The present study demonstrated a high prevalence (43.5%) of carbapenem-resistant Enterobacterales among clinical isolates in a tertiary care hospital. *Escherichia coli* was the predominant CRE isolate, with urine being the most common specimen source and hospitalized patients contributing the majority of cases. These findings highlight the growing burden of carbapenem resistance and reinforce the need for continuous microbiological surveillance, robust infection prevention and control measures, antimicrobial stewardship programmes, and timely laboratory detection to prevent the further spread of these multidrug-resistant pathogens.

Declaration by Authors

Ethical considerations: The study was conducted in the Department of Microbiology among the routine samples received for culture and sensitivity. Permission to conduct the study was obtained from the Head of the department. Patient confidentiality was maintainted throughout the study.

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Conflict of Interest: The authors declare no conflict of interest.

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