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Emerging Carbapenem Resistance in *Escherichia coli* and *Klebsiella pneumonia* isolates from a Tertiary Care Hospital in Rajasthan

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Abstract: **Introduction:** Carbapenem-resistant Enterobacterales, especially *Escherichia coli* and *Klebsiella pneumoniae*, are becoming a serious health problem. These bacteria cause many hospital infections and are difficult to treat because they are resistant to strong antibiotics. This leads to increased illness and death. **Materials and Methods:** This was a hospital-based cross-sectional study done over one year at a tertiary care center in Rajasthan. A total of 366 clinical samples were studied. The bacteria were identified and their antibiotic sensitivity was tested using standard laboratory methods. **Results and Discussion:** Out of 366 isolates, 202 (55.2%) were *E. coli* and 164 (44.8%) were *Klebsiella pneumoniae*. Most isolates were obtained from urine, pus, respiratory samples, and blood. Carbapenem resistance was seen in both organisms, but it was higher in *Klebsiella pneumoniae*. Resistance to important antibiotics like imipenem, meropenem, and ertapenem shows the growing problem of drug resistance. Elderly patients were more commonly affected, suggesting age as an important risk factor. Also, more cases were seen in males (66.6%). These findings show that multidrug resistance is increasing and is a major concern in hospitals. **Conclusion:** This study shows a high level of carbapenem resistance among *Escherichia coli* and *Klebsiella pneumoniae*. Regular monitoring, proper infection control, and careful use of antibiotics are very important to control the spread of these resistant bacteria and to protect effective treatments.

Keywords: Enterobacterales, Escherichia coli, Klebsiella pneumonia, Antimicrobial resistance, Multidrug-resistant bacteria, organisms, Antibiotic.

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INTRODUCTION

Escherichia coli and *Klebsiella pneumoniae* are Gram-negative, rod-shaped bacteria belonging to the family *Enterobacteriaceae*. *E. coli* is a normal commensal of the human intestinal tract but is also a common cause of urinary tract infections, bloodstream infections, gastrointestinal infections, and central nervous system infections [1,2]. *K. pneumoniae* is an encapsulated, lactose-fermenting, non-motile bacterium and an important opportunistic pathogen causing pneumonia, sepsis, and urinary tract infections, particularly in hospitalized and immunocompromised patients [3,4]. Both organisms are among the most frequent causes of hospital-acquired infections.

In recent years, *E. coli* and *K. pneumoniae* have demonstrated increasing resistance to multiple classes of antibiotics and are now major contributors to carbapenem-resistant *Enterobacterales* (CRE) [5]. Carbapenems are β-lactam antibiotics and are considered last-resort drugs for the treatment of severe infections caused by multidrug-resistant Gram-negative bacteria [6]. The emergence and rapid spread of carbapenem resistance has therefore become a serious global and national concern.

Carbapenem resistance in these organisms is mainly mediated by the production of carbapenem-hydrolyzing

enzymes known as carbapenemases. These include enzymes such as KPC, NDM, VIM, IMP, and OXA-48-like β-lactamases, which are often encoded on transferable genetic elements, facilitating their rapid dissemination [7,8]. Among these, NDM and OXA-48-like enzymes are commonly reported from the Indian subcontinent. [9,10].

Surveillance studies from India have reported a rising prevalence of carbapenem resistance, particularly among *K. pneumoniae* isolates. According to the Centre for Disease Dynamics, Economics and Policy (CDDEP), nearly 60% of *K. pneumoniae* isolates in India show resistance to carbapenems [11-13] This increasing trend poses a major public health threat due to limited therapeutic options, increased morbidity, mortality, and healthcare costs.

Due to their increasing prevalence, multidrug resistance, and association with severe clinical outcomes, carbapenem-resistant *E. coli* and *K. pneumoniae* have been classified by the World Health Organization as critical priority pathogens [14,15]. Continuous monitoring of antimicrobial resistance patterns is essential to guide empirical therapy and strengthen antimicrobial stewardship and infection control practices.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted in the Department of Microbiology, National Institute of Medical Sciences & Research (NIMS&R), Jaipur, Rajasthan.

Study Period

The study was carried out over a period of one year after obtaining approval from the Institutional Scientific and Ethics Committee.

Ethical Consideration - The study was accredited by the Ethics committee of Nims University Rajasthan, Jaipur (Proposal no. IEC/P-844/2024).

Inclusion Criteria

- Clinical samples including sputum, endotracheal secretions, blood, urine, pus aspirate, cerebrospinal fluid (CSF), body fluids, bronchoalveolar lavage (BAL), and pus swabs.
- Patients of all age groups and both genders, after obtaining informed consent.

Exclusion Criteria

- Samples such as stool and vaginal swabs were excluded from the study.

Specimen Collection and Processing

All clinical specimens were collected aseptically following standard procedures and transported immediately to the microbiology laboratory for further processing.

Microscopy

Direct smears were prepared from the samples and subjected to Gram staining. Microscopic examination was performed to determine the Gram reaction and morphology of the organisms.

Culture and Identification

Specimens were inoculated onto blood agar and MacConkey agar plates and incubated aerobically at 37°C for 18–72 hours. Identification of bacterial isolates was carried out based on colony morphology, Gram staining from colonies, and standard biochemical tests as per conventional microbiological methods.

Preliminary Identification Tests

Preliminary identification of Gram-negative bacilli was performed using catalase test, motility testing by hanging drop method, and string test, where applicable.

Identification of Isolates & Antimicrobial Susceptibility Testing

Identification and Antimicrobial susceptibility testing (AST) of the confirmed *E. coli and K. pneumoniae* isolates was performed using the Vitek® 2 Compact automated system (bioMérieux). The results were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines 2024 and Vitek® 2 manufacturer recommendations.

RESULT

A total of 366 clinical isolates were included in the present study. Among these, 202 (55.2%) isolates were identified as *Escherichia coli*, while 164 (44.8%) isolates were identified as *Klebsiella pneumoniae*. Infections due to both *E. coli* and *Klebsiella pneumoniae* were predominantly observed in elderly patients. Both organisms showed a similar age distribution pattern, the majority were aged between 41-60 years i.e. 114(31.14%) followed by 61-80 years i.e. 101(27.59%), 0-20 years 53(14.48%) and >80 years 13(3.55%). This is suggesting that advanced age is an important risk factor for infections caused by Enterobacteriaceae.

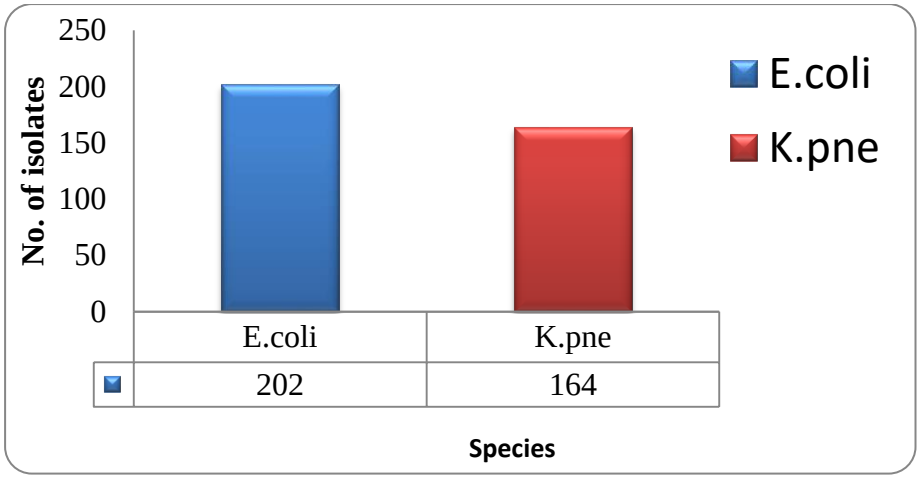

Figure-1: Species wise distribution

Carbapenem resistance

Carbapenem resistance was observed in both *Escherichia coli* and *Klebsiella pneumoniae* isolates, although the extent of resistance varied between the two organisms. Among *E. coli*, resistance was highest to imipenem, with 38 isolates (42.7%) resistant and 51 (57.3%) sensitive. This was followed by meropenem, where 66 isolates (42.0%) were resistant and 91 (58.0%) were sensitive. The lowest resistance was observed with ertapenem, with 36 isolates (34.9%) resistant and 67 (65.1%) sensitive. These findings indicate the emerging presence of carbapenem-resistant *E. coli* in the study population. In comparison, *Klebsiella pneumoniae* demonstrated a markedly higher level of resistance to all tested carbapenems. Resistance to meropenem was the highest, with 121 isolates (79.1%) resistant and only 32 (20.9%) sensitive. Similarly, for imipenem, 53 isolates (75.7%) were resistant and 17 (24.3%) were sensitive. For ertapenem, 47 isolates (70.1%) were resistant and 20 (29.9%) were sensitive. Overall, *Klebsiella pneumoniae* exhibited substantially greater resistance to carbapenems than *E. coli*, highlighting Resistance to one or more carbapenems was frequently observed, highlighting the presence of carbapenem-resistant *Klebsiella pneumoniae (CRKP).*

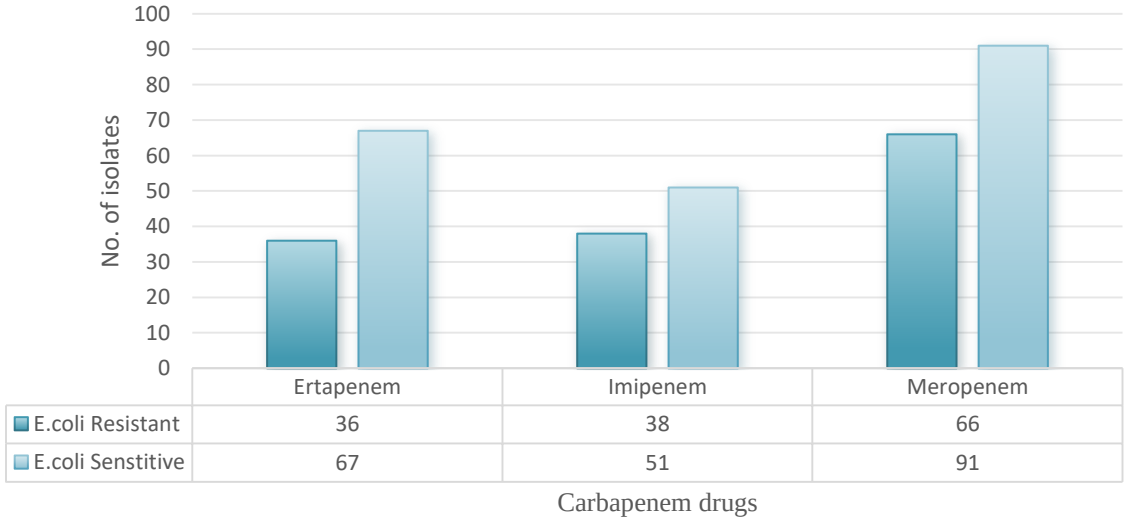

Figure-2: Carbapenem resistance pattern in Escherichia coli

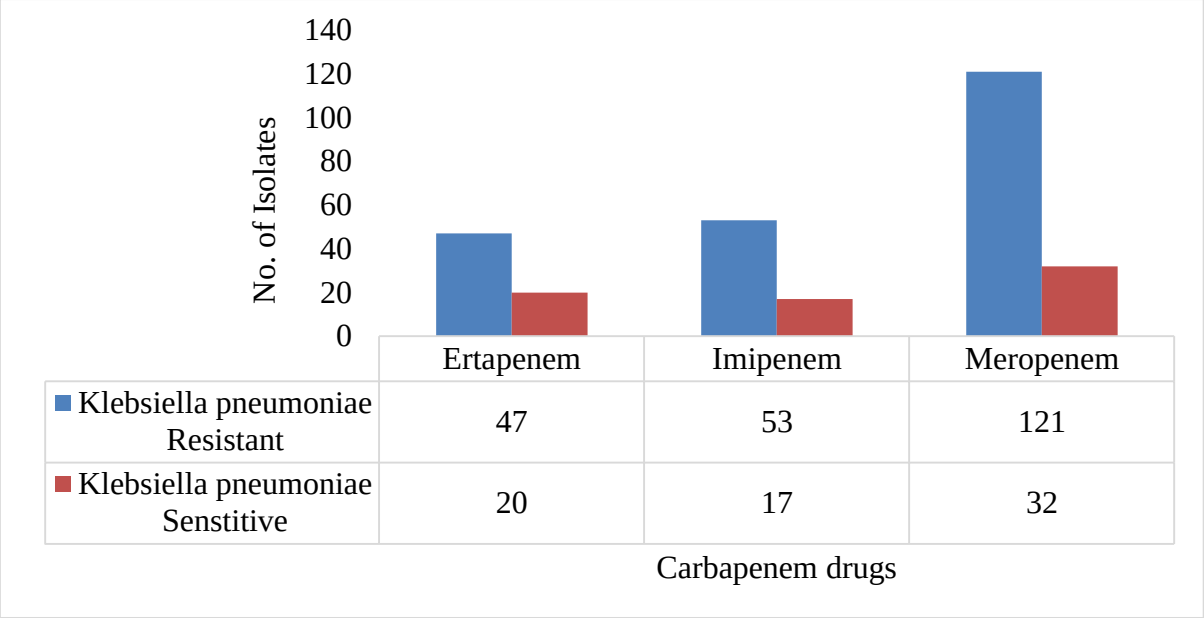

Figure-3: Carbapenem resistance pattern in *Klebsiella pneumoniae*

The present study demonstrates a high prevalence of multidrug resistance among *Escherichia coli* and *Klebsiella pneumoniae*, with alarming levels of carbapenem resistance, particularly in *Klebsiella pneumoniae*. Elderly patients and hospitalized cases constituted the most affected groups."

Table-1: Distribution of *Escherichia coli* and *Klebsiella pneumoniae* Isolates

Organism	Number	Percentage (%)
E. coli	202	55.2
K. pneumoniae	164	44.8
Total	**366**	**100**

A maximum number of isolates were recovered from urine samples, followed by pus/wound swabs, respiratory samples, and blood. *Escherichia coli* was predominantly isolated from pus/swab samples 64 (31.7%) followed by urine 63 (31.1%), blood 40 (19.8%) and respiratory samples (ET & Sputum) 24 (11.8%), whereas *Klebsiella pneumoniae* was more frequently isolated from respiratory samples (ET & Sputum) 50 (30.5%) followed by pus 33 (20.1%) and blood 52 (31.7%), reflecting its association with more severe and hospital-acquired infections.

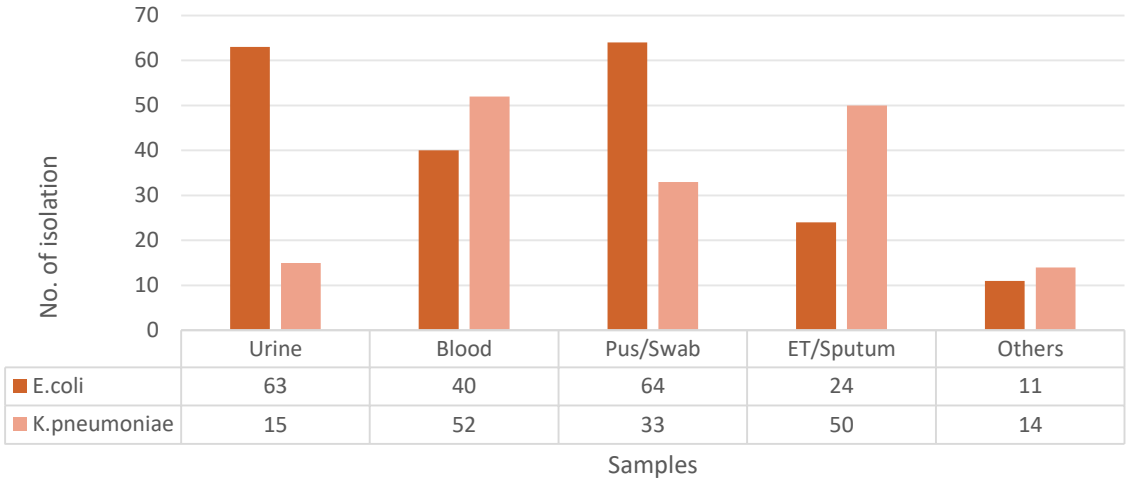

Figure-4: Distribution of carbapenem-resistant isolates among different clinical samples

Both males and females were detected, with a slight predominance of male patients in the study. Among 366 carbapenem-resistant isolates of E. coli and K. pneumononiae, 244 (66.66%) were from male patients whereas 122 (33.33%) from female patients.

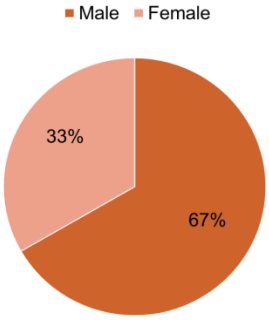

Figure-5(A): Gender wise distribution

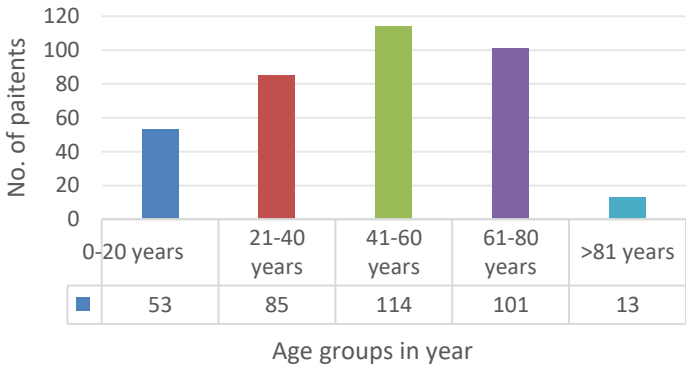

Figure-5(B): Age wise distribution

DISCUSSION

In this study, a large number of infections were caused by *Escherichia coli* and *Klebsiella pneumoniae*. *E. coli* was found more commonly, especially in urine and wound infections, which is similar to other studies [1,11]. On the other hand, *Klebsiella pneumoniae* was more common in respiratory and blood infections, especially in hospitalized patients [3,12]. Srivastava *et al*. (2022) reported a high prevalence (29.35%) of carbapenem-resistant *Escherichia coli* and *Klebsiella pneumoniae* in a tertiary care hospital in rural Uttar Pradesh, with *E. coli* being the predominant isolate. [16] An important finding of this study is that *Klebsiella pneumoniae* showed higher resistance to carbapenem antibiotics compared to *E. coli*. This finding is similar to many studies done in India and other countries, where *Klebsiella* is a major cause of carbapenem-resistant infections [11-13]. The resistance may be due to enzymes like NDM and OXA-48, which can easily spread between bacteria [9,10]. In this study, most infections were seen in elderly patients. This may be because older people often have other diseases, stay longer in hospitals, and receive more antibiotics. These factors increase the risk of infection [4,12]. More cases were seen in males than females, which may be due to higher exposure to risk factors, but more studies are needed to confirm this. The bacteria were found in different types of samples like urine, pus, blood, and respiratory samples. This shows that these organisms can cause many types of infections. The high level of resistance to multiple antibiotics seen in this study is a serious problem and makes treatment difficult [6,13]. Therefore, it is very important to regularly monitor antibiotic resistance, follow strict infection control practices, and use antibiotics carefully. This will help in reducing the spread of resistant bacteria and protect important drugs like carbapenems [14].

CONCLUSION

The study reveals a concerning rise in carbapenem resistance among *Escherichia coli* and *Klebsiella pneumoniae*, particularly in *K. pneumoniae*, in a tertiary care hospital setting. The high prevalence of multidrug-resistant isolates, especially among elderly and hospitalized patients, underscores the growing challenge of antimicrobial resistance. Continuous monitoring of resistance patterns, rational use of antibiotics, and effective infection control strategies are crucial to limit the spread of these pathogens. Strengthening antimicrobial stewardship programs is essential to preserve the effectiveness of last-resort drugs like carbapenems

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Conflict of Interest: The authors declare no conflict of interest.
Source of Fund: None
Ethical Consideration - The study was accredited by the Ethics committee of Nims University Rajasthan, Jaipur (Proposal no. IEC/P-844/2024).

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