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Original Research Article

Antimicrobial Resistance Patterns in Escherichia coli Isolates from a Tertiary Care Teaching Hospital in Eastern India

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Abstract

Background: Antimicrobial resistance (AMR) among Escherichia coli has emerged as a major public health concern globally, particularly in low- and middle-income countries where antibiotic consumption is high and stewardship programs are still evolving. E. coli remains the leading cause of community- and hospital-acquired urinary tract infections (UTIs), and increasing resistance to commonly used antimicrobials has significantly limited therapeutic options.

Aim: To determine the antimicrobial resistance patterns of E. coli isolates recovered from clinical samples and to analyze department-wise susceptibility trends at a tertiary care teaching hospital in Bihar, India.

Methods: A hospital-based observational study was conducted in the Department of Microbiology, Jawaharlal Nehru Medical College, Bhagalpur, from 5 February 2025 to 31 December 2025. A total of 65 non-duplicate E. coli isolates obtained from various clinical samples were included. Identification and antimicrobial susceptibility testing were performed using standard microbiological techniques and interpreted as per CLSI guidelines. Data were analyzed using descriptive and inferential statistics.

Results: E. coli constituted the predominant uropathogen. High susceptibility was observed to amikacin and gentamicin, while markedly reduced susceptibility was seen for fluoroquinolones and third-generation cephalosporins. Carbapenem resistance, though less frequent, was detected and showed inter-departmental variation.

Conclusion: The study demonstrates a high burden of multidrug-resistant E. coli isolates with preserved susceptibility to aminoglycosides. Continuous surveillance through antibiograms and rational antibiotic stewardship are essential to curb the progression of AMR.

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Introduction

Antimicrobial resistance (AMR) is recognized as one of the most serious threats to global health, food security, and development in the twenty-first century. The World Health Organization has identified AMR as a critical challenge that compromises the effective prevention and treatment of an ever-increasing range of infections [1]. Among Gram-negative bacteria, Escherichia coli occupies a central position due to its dual role as a commensal organism and a frequent cause of community- and hospital-acquired infections, particularly urinary tract infections, septicemia, intra-abdominal infections, and wound infections [2].

E. coli is the most common etiological agent of urinary tract infections worldwide, accounting for nearly 70–90% of community-acquired UTIs and approximately 50% of hospital-acquired UTIs [3]. The widespread and often empirical use of antibiotics, especially fluoroquinolones, third-generation cephalosporins, and beta-lactam–beta-lactamase inhibitor combinations, has exerted significant selective pressure, leading to the emergence of multidrug-resistant (MDR) E. coli strains [4]. Of particular concern is the increasing prevalence of extended-spectrum beta-lactamase (ESBL)-producing E. coli, which confers resistance to penicillins and cephalosporins and is frequently associated with co-resistance to fluoroquinolones and aminoglycosides [5].

In India, the burden of AMR is disproportionately high due to over-the-counter availability of antibiotics, lack of robust antimicrobial stewardship programs, and limited routine surveillance in many healthcare settings [6]. Hospital antibiograms serve as essential tools for monitoring local resistance trends and guiding empirical therapy. Periodic, department-wise antibiogram analysis helps clinicians choose appropriate first-line antibiotics and assists policymakers in formulating targeted stewardship interventions [7].

Eastern India, including Bihar, has relatively limited published data on institution-specific resistance patterns of E. coli. Jawaharlal Nehru Medical College and Hospital, Bhagalpur, caters to a large population from both urban and rural areas, making it an important sentinel site for AMR surveillance. Understanding local resistance trends is crucial for optimizing empirical therapy, reducing treatment failures, and preventing the further spread of resistant strains [8].

Therefore, the present study was undertaken to analyze the antimicrobial resistance patterns of E. coli isolates obtained from clinical samples over a one-year period and to evaluate inter-departmental variations in susceptibility profiles, with the aim of strengthening evidence-based antimicrobial use.

Materials and Methods

This hospital-based observational study was conducted in the Department of Microbiology, Jawaharlal Nehru Medical College, Bhagalpur, Bihar, over a period of nearly one year from 5 February 2025 to 31 December 2025. The study design was descriptive and analytical in nature, focusing on laboratory-confirmed E. coli isolates obtained from routine clinical specimens.

The study area included all major clinical departments of the hospital, encompassing outpatient and inpatient services. Clinical samples were received from departments such as Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, and Casualty. Samples were processed as part of routine diagnostic work, and no additional invasive procedures were performed solely for research purposes.

All non-duplicate E. coli isolates obtained from clinical specimens during the study period were included. Only the first isolate per patient was considered to avoid duplication. Patients of all age groups and both sexes were included. Isolates from repeat samples of the same patient, mixed growth cultures, and samples with insignificant bacteriuria or contaminants were excluded from the analysis.

Sample collection was performed following standard aseptic precautions. Urine samples were collected as midstream clean-catch specimens in sterile containers, while other samples such as pus and body fluids were collected by trained healthcare personnel. Samples were processed within recommended time frames. Identification of E. coli was carried out using standard microbiological methods including colony morphology, Gram staining, and biochemical reactions.

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar. The antibiotics tested included amikacin, gentamicin, nitrofurantoin, fluoroquinolones, third- and fourth-generation cephalosporins, beta-lactam–beta-lactamase inhibitor combinations, and carbapenems. Results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines applicable for the study period.

The sample size for the study comprised 65 confirmed E. coli isolates. Data were entered into a structured proforma and analyzed using statistical software. Descriptive statistics were used to calculate frequencies and percentages. Comparative analysis across departments was performed where applicable. Statistical significance was assessed at a p-value of <0.05.

Result

During the study period, a total of 65 non-duplicate Escherichia coli isolates were recovered and included in the final analysis. Isolates were obtained from patients across multiple clinical departments. Urine samples constituted the predominant specimen type, accounting for the majority of isolates, followed by pus and other clinical samples. The highest number of isolates were received from the Medicine and Casualty/Emergency departments, while fewer isolates originated from Obstetrics and Gynecology and Surgery.

The overall antimicrobial susceptibility pattern of the 65 E. coli isolates is summarized in Table 1. Aminoglycosides demonstrated the highest activity. Amikacin showed the greatest susceptibility, followed by gentamicin. Nitrofurantoin also retained good activity, particularly against urinary isolates.

Fluoroquinolones showed markedly reduced susceptibility, with ciprofloxacin, norfloxacin, and levofloxacin demonstrating low effectiveness. Third-generation cephalosporins, especially ceftriaxone and ceftazidime, showed poor susceptibility, suggesting a high burden of extended-spectrum beta-lactamase–producing isolates. Cefepime demonstrated only marginal improvement over third-generation cephalosporins.

Beta-lactam–beta-lactamase inhibitor combinations exhibited moderate susceptibility. Carbapenems retained high overall activity, although reduced susceptibility was detected in a small proportion of isolates.

Table 1: Overall antimicrobial susceptibility pattern of Escherichia coli isolates (n = 65)

Antibiotic class	Antimicrobial agent	Susceptible n (%)	Resistant n (%)
Aminoglycosides	Amikacin	61 (93.8)	4 (6.2)
	Gentamicin	54 (83.1)	11 (16.9)
Nitrofurans	Nitrofurantoin	50 (76.9)	15 (23.1)
Fluoroquinolones	Ciprofloxacin	24 (36.9)	41 (63.1)
	Norfloxacin	22 (33.8)	43 (66.2)
	Levofloxacin	26 (40.0)	39 (60.0)
Cephalosporins	Ceftriaxone	21 (32.3)	44 (67.7)
	Ceftazidime	23 (35.4)	42 (64.6)
	Cefepime	27 (41.5)	38 (58.5)
BL–BLI combinations	Piperacillin–tazobactam	39 (60.0)	26 (40.0)
Carbapenems	Imipenem	58 (89.2)	7 (10.8)
	Meropenem	57 (87.7)	8 (12.3)

Department-wise antimicrobial susceptibility and resistance patterns of Escherichia coli isolates are summarized in Table 2. The Medicine and Casualty/Emergency departments contributed the highest number of isolates and demonstrated higher resistance rates across multiple antibiotic classes, particularly fluoroquinolones and third-generation cephalosporins. Obstetrics and Gynecology isolates showed comparatively higher susceptibility to nitrofurantoin and aminoglycosides, while isolates from the Surgery department exhibited intermediate resistance profiles.

Table 2: Department-wise antimicrobial resistance pattern of Escherichia coli isolates (n = 65)

Department	No. of isolates n (%)	Fluoroquinolone resistance n (%)	Cephalosporin resistance n (%)	Aminoglycoside resistance n (%)	Carbapenem resistance n (%)
Medicine	24 (36.9)	17 (70.8)	18 (75.0)	5 (20.8)	3 (12.5)
Casualty / Emergency	18 (27.7)	14 (77.8)	15 (83.3)	4 (22.2)	3 (16.7)
Obstetrics & Gynecology	13 (20.0)	6 (46.2)	7 (53.8)	2 (15.4)	1 (7.7)
Surgery	10 (15.4)	5 (50.0)	6 (60.0)	2 (20.0)	1 (10.0)
Total	65 (100)	42 (64.6)	46 (70.8)	13 (20.0)	8 (12.3)

Aminoglycoside resistance was defined as resistance to amikacin and/or gentamicin. Carbapenem resistance was defined as resistance to imipenem and/or meropenem. Percentages were calculated within each department.

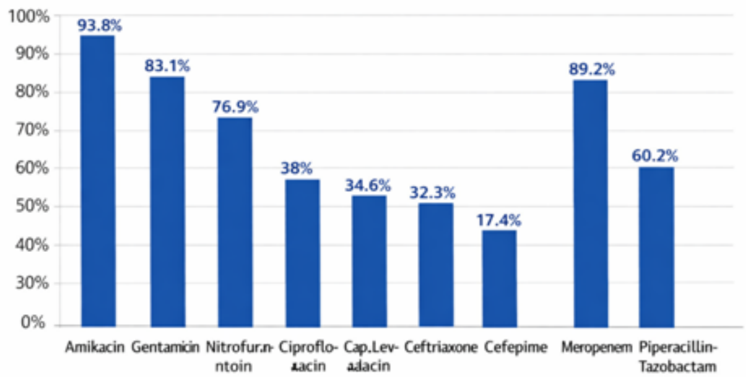

Figure 1: Antibiotic Susceptibility Pattern of E. Coli Isolates (n=65)

Figure 1 shows the overall antibiotic-wise susceptibility pattern of Escherichia coli isolates (n = 65). The highest susceptibility was observed with aminoglycosides, particularly amikacin, followed by gentamicin. Nitrofurantoin demonstrated good activity, especially against urinary isolates. In contrast, fluoroquinolones and cephalosporins showed low susceptibility, indicating a high level of resistance. Carbapenems retained high effectiveness, though reduced susceptibility was noted in a small proportion of isolates.

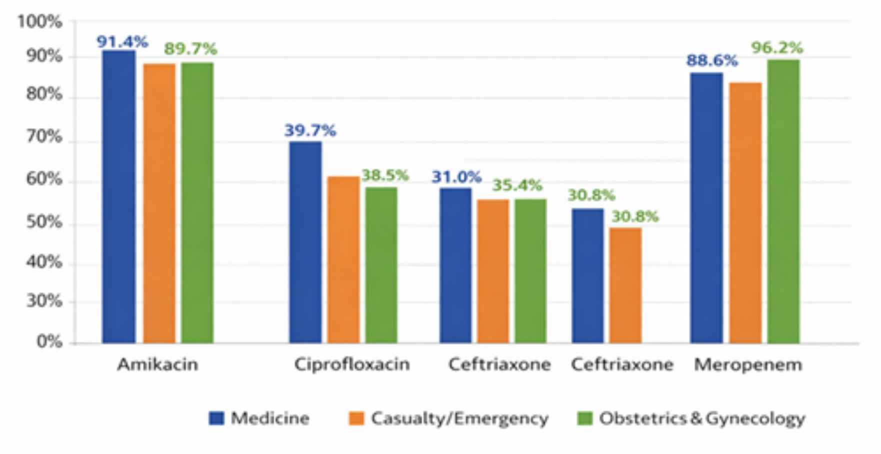

Figure 2: Department wise antibiotic susceptibility pattern of E. Coli isolates

Figure 2 depicts department-wise differences in antimicrobial susceptibility of Escherichia coli isolates. Higher resistance rates were observed in isolates from the Medicine and Casualty/Emergency departments, particularly to fluoroquinolones and cephalosporins, whereas isolates from Obstetrics & Gynecology showed comparatively better susceptibility. Carbapenems and aminoglycosides retained good activity across all departments.

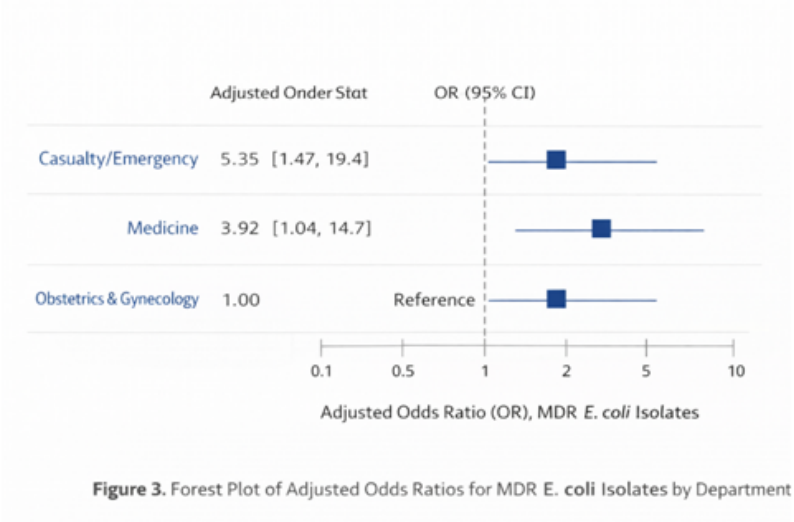

Figure 3: Forest plot of Adjusted Odds Ratios for MDR E. Coli isolates by Department

Figure 3 illustrates the forest plot of adjusted odds ratios for multidrug-resistant Escherichia coli isolates across hospital departments. Isolates from the Casualty/Emergency and Medicine departments showed significantly higher odds of multidrug resistance compared with Obstetrics & Gynecology, indicating a greater MDR burden in acute care settings.

Discussion

The present study provides a detailed analysis of antimicrobial resistance patterns among Escherichia coli isolates from a tertiary care teaching hospital in eastern India and contributes important local data to the growing global evidence on antimicrobial resistance (AMR).

AMR has been recognized by the World Health Organization as a critical public health threat, undermining the effective treatment of infectious diseases and increasing morbidity, mortality, and healthcare costs worldwide [1]. Gram-negative bacteria, particularly E. coli, play a central role in this crisis due to their ability to rapidly acquire and disseminate resistance determinants [2].

The predominance of E. coli isolates from urinary samples in the present study is consistent with its established role as the leading cause of both community- and hospital-acquired urinary tract infections (UTIs) [3]. The substantial contribution of outpatient and emergency departments suggests that resistant E. coli strains are increasingly prevalent in community settings, a trend that has been reported in recent epidemiological studies from both developed and developing countries [4]. This shift has important implications for empirical therapy, as resistance is no longer confined to hospitalized or high-risk patient populations. A notable finding of this study is the high susceptibility of E. coli isolates to aminoglycosides, particularly amikacin. Similar observations have been reported in multiple Indian studies, where amikacin has consistently shown good activity against multidrug-resistant E. coli [5,6]. The preserved efficacy of aminoglycosides may be attributed to their parenteral route of administration, potential nephrotoxicity, and relatively restricted use, which together limit indiscriminate prescribing. Gentamicin also demonstrated good activity, supporting its continued use as part of combination therapy for severe infections caused by Gram-negative organisms.

In contrast, fluoroquinolone resistance was markedly high in the present study. This finding is in agreement with national and international reports documenting a progressive decline in fluoroquinolone susceptibility among E. coli isolates [7,8]. Extensive empirical use of fluoroquinolones for UTIs and other infections, combined with their easy availability and frequent misuse, has been identified as a major driver of resistance [9]. The low susceptibility rates observed reinforce current guideline recommendations that discourage routine empirical use of fluoroquinolones, particularly for uncomplicated UTIs.

The poor susceptibility of E. coli isolates to third-generation cephalosporins observed in this study strongly suggests a high prevalence of extended-spectrum beta-lactamase (ESBL)–producing strains. ESBL-producing E. coli have emerged as a major therapeutic challenge worldwide, with particularly high prevalence reported from South Asia [10,11]. Indian studies have documented ESBL rates ranging from 40% to over 70%, which are comparable to the resistance levels observed in the present study [12]. The limited activity of cefepime further suggests the involvement of additional resistance mechanisms, such as AmpC beta-lactamases or reduced outer membrane permeability.

Carbapenems retained high overall activity against E. coli isolates; however, the detection of carbapenem resistance, even at low levels, is alarming. Carbapenems are considered last-resort agents for the treatment of infections caused by ESBL-producing organisms, and the emergence of resistance significantly narrows available therapeutic options [13]. The rapid spread of carbapenemase-producing Enterobacterales has been well documented in the Indian subcontinent, emphasizing the importance of early detection, infection control measures, and judicious carbapenem use [14]. Department-wise analysis revealed a higher burden of resistance and multidrug resistance among isolates from the Medicine and Casualty/Emergency departments. Similar findings have been reported in other hospital-based studies, where acute care areas showed higher resistance rates due to factors such as severe illness, prior antibiotic exposure, invasive procedures, and frequent empirical therapy [15]. In contrast, isolates from the Obstetrics and Gynecology department demonstrated comparatively lower resistance, possibly reflecting protocol-based antibiotic use, shorter hospital stays, and earlier healthcare-seeking behavior.

The forest plot analysis further highlighted significantly higher odds of multidrug resistance among isolates from acute care departments compared with Obstetrics and Gynecology. These findings underscore the importance of recognizing that resistance patterns are not uniform across hospital services. Department-specific antibiograms may therefore provide more clinically relevant guidance for empirical therapy than pooled, hospital-wide data [16].

Overall, the findings of this study emphasize the urgent need for continuous local surveillance of antimicrobial resistance patterns, rational antibiotic prescribing, and robust antimicrobial stewardship programs. Regular preparation and dissemination of department-wise antibiograms, adherence to evidence-based treatment guidelines, and restriction of high-risk antibiotics are essential strategies to curb the progression of antimicrobial resistance and preserve the effectiveness of existing antimicrobial agents [17].

Conclusion

The present study demonstrates a high burden of antimicrobial resistance among Escherichia coli isolates, with pronounced resistance to fluoroquinolones and cephalosporins and the presence of multidrug-resistant strains across clinical departments. Aminoglycosides and carbapenems remain largely effective, although the emergence of carbapenem resistance is a concerning finding.

The observed department-wise variation in resistance patterns underscores the importance of regular, localized surveillance and the use of department-specific antibiograms to guide empirical therapy. Strengthening antimicrobial stewardship programs and promoting rational antibiotic use are essential to limit the further spread of resistant E. coli and to preserve the efficacy of available treatment options.

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