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Original Research Article

A Cross-Sectional Study on the Prevalence and Antibiotic Resistance Trends of ESBL-Producing Escherichia Coli in UTIs in Patna Medical College & Hospital, Patna

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Abstract:

Background: Urinary tract infections (UTIs) are common worldwide, with Escherichia coli as the predominant pathogen. The emergence of extended-spectrum β-lactamase (ESBL)-producing E. coli poses a significant therapeutic challenge due to multidrug resistance.

Aim: This study aimed to determine the prevalence and antibiotic resistance patterns of ESBL-producing E. coli in patients with UTIs.

Methodology: A cross-sectional study was conducted at Department of Microbiology, Patna Medical College and Hospital, Patna, India. Midstream urine samples from 326 patients with culture-confirmed UTIs were analyzed. E. coli isolates were identified using standard biochemical tests, and ESBL production was confirmed via the Combined Disk Test. Antibiotic susceptibility was assessed using the Kirby-Bauer disk diffusion method following CLSI guidelines.

Results: All 326 isolates were E. coli, with 121 (37.12%) confirmed as ESBL producers. ESBL-positive isolates showed high resistance to cefotaxime (100%), ceftriaxone (98.3%), ceftazidime (97.5%), amoxicillin (96.7%), and ciprofloxacin (84.3%). Carbapenems (meropenem, 94.2% sensitivity), nitrofurantoin (81%), and amikacin (66.1%) remained effective. ESBL prevalence was not significantly associated with age or sex but correlated strongly with cephalosporin and fluoroquinolone resistance.

Conclusion: ESBL-producing E. coli constitutes a significant proportion of UTI pathogens with extensive multidrug resistance. Carbapenems, nitrofurantoin, and aminoglycosides remain viable treatment options. Continuous surveillance and rational antibiotic use are essential to limit the spread of resistant strains.

Keywords: UTI, Escherichia coli, ESBL, Antibiotic Resistance, Multidrug Resistance, Cross-Sectional Study.

Introduction

UTI is one of the most common infectious diseases worldwide, with over 150 million people reported to be affected annually [1]. UTIs range from uncomplicated infections of the lower urinary tract, such as cystitis, to more serious infections involving the upper urinary tract, including pyelonephritis. Infections of this nature are a major concern regarding public health because of their high prevalence and complications, together with placing a large economic burden on the healthcare system. Women are mostly affected due to anatomical and hormonal factors that make them more susceptible to such infections. However, UTIs do not only affect adults since they also affect children, elderly populations, and people who are immune compromised; thus, all categories of age are affected.

Among the causative agents of UTIs, Escherichia coli is the most frequently isolated pathogen and contributes to about 50% to 90% of cases [2]. E. coli is a Gram-negative, facultatively anaerobic bacterium of the Enterobacteriaceae family [3]. Though there are many strains of this bacterium as commensal organisms in the gut of healthy individuals, some pathogenic strains have developed virulence factors that enable the colonization of the urinary tract, evasion of host defenses, and infection. The ability of pathogenic E. coli to attach to uroepithelial cells through fimbriae, produce toxins, and form biofilms constitutes the predominance of

the bacterium as a UTI pathogen and creates a challenge toward treatment.

The treatment of UTIs usually involves the administration of antibiotics, with β-lactam antibiotics being among the most commonly prescribed. The β-lactam antibiotics represent a wide variety of agents in which the presence of a beta-lactam ring forms the basis for their antibacterial activity [4]. These drugs act by inhibiting the synthesis of bacterial cell walls, which ultimately causes lysis and death of the bacteria. Various members of this class, including penicillins, cephalosporins, and monobactams, have proven so successful in empirical and targeted therapy that β-lactam antibiotics have become a linchpin of UTI therapy. However, due to the extensive and, at times, indiscriminate use of these drugs, a rise in resistant bacterial strains has been observed.

One of the main resistance mechanisms against β-lactam antibiotics involves the production of the enzyme β-lactamase, which can hydrolyze the β-lactam ring and thus inactivate the antibiotic [5]. Among these enzymes, extended-spectrum β-lactamases, or ESBLs, are of particular clinical concern. ESBLs are responsible for resistance against a wide array of β-lactam antibiotics commonly used, such as penicillin's, cephalosporins, and monobactams [6]. ESBL-producing bacteria were first detected in 1983 and, ever since, have been a challenge to global public health [7]. With the increased spread of ESBL-producing E. coli, there was also a rise in morbidity and mortality rates, prolonged hospitalization, more economic burdens on healthcare, and lower success rates regarding clinical and microbiological treatment [8,9].

Several factors are contributing to the global dissemination of ESBL-producing E. coli, such as overuse of antibiotics in both community and hospital settings, horizontal gene transfer by plasmids, and clonal spread of virulent strains. Surveillance studies have indicated an increase in the prevalence of ESBL producing E. coli not only in hospitalized patients but also in community-acquired infections. This trend could have serious therapeutic consequences, since the treatment options become very limited, and very often carbapenems and other last-resort antibiotics have to be used.

Understanding the epidemiology of antibiotic resistance patterns of ESBL-producing E. coli is essential for guiding empirical therapy, developing strategic infection control policies, and implementing public health measures aimed at containing the spread of multidrug-resistant organisms. Cross-sectional studies specifically deal with the exact present status of ESBL-producing strains in a population, enabling researchers or clinicians to assess risk factors, observe resistance trends, and thus institute timely interventions.

In the view of the increasing global threat of antibiotic-resistant pathogens, including ESBL-producing E. coli, this study shall determine the prevalence and antibiotic resistance patterns of these organisms among patients presenting with UTIs. This study will update data on the frequency and resistance characteristics of ESBL-producing E. coli and contribute to the improvement of patient management, rational antibiotic prescribing, and the development of targeted strategies that mitigate the spread of antimicrobial resistance.

Materials and Methods

Study Design: This study was designed as a cross-sectional observational study aimed at determining the prevalence and antibiotic resistance patterns of ESBL-producing Escherichia coli in urinary tract infection (UTI) patients.

Study Area: The study was conducted at the Department of Microbiology, Patna Medical College and Hospital, Patna, Bihar, India.

Study Duration: The study was carried out over a period of six months from February 2025 to July 2025

Sample Size: A total of 326 urine samples showing significant bacterial growth were included in the study.

Study Population: The study population consisted of patients of all age groups and both sexes presenting with symptoms suggestive of urinary tract infection at the outpatient and inpatient departments of Patna Medical College and Hospital.

Inclusion Criteria

- Patients of all ages with clinically suspected urinary tract infections.
- Patients whose urine cultures showed $\geq 10^5$ CFU/mL bacterial growth.

Exclusion Criteria

- Patients who had received antibiotics in the previous 48 hours.
- Contaminated or improperly collected urine samples.
- Patients with chronic kidney disease or structural urinary tract abnormalities.

Data Collection: Midstream urine samples were collected from patients presenting with symptoms suggestive of urinary tract infection at the outpatient and inpatient departments of Patna Medical College and Hospital. Samples were collected in sterile containers following standard aseptic techniques to minimize contamination. Each urine specimen was cultured using a calibrated loop of 0.01 mL under sterile conditions. The urine samples were

inoculated onto Nutrient agar, MacConkey agar, CLED (Cysteine lactose electrolyte deficient) agar and Blood agar plates and incubated at 37°C for 18–24 hours. Samples showing colony counts of $\geq 10^5$ CFU/mL were considered positive for significant bacteriuria. Bacterial isolates were identified to the genus and species level using standard biochemical tests. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Muller-Hinton agar, with results interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. The susceptibility profile included antibiotics commonly used for urinary tract infections. Detection of extended-spectrum beta-lactamase (ESBL) production in E. coli isolates was carried out using the Combined Disk Test (CDT), where isolates showing an increase of ≥3 mm in the zone of inhibition around cefotaxime-clavulanic acid compared to cefotaxime alone were classified as ESBL producers.

Procedure: The study procedure began with the collection of midstream urine samples under strict aseptic conditions. The samples were immediately inoculated on Nutrient agar, MacConkey agar, CLED agar and Blood agar plates and incubated at 37°C for 18–24 hours to allow bacterial growth. Bacterial isolates from positive cultures were then identified using standard biochemical methods. Following identification, antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Muller-Hinton agar. ESBL-producing E. coli isolates were detected using the Combined Disk Test, which involved preparing a bacterial suspension equivalent to 0.5 McFarland standard, swabbing it on Muller-Hinton agar, and placing cefotaxime and cefotaxime-clavulanic acid disks at a minimum distance of 2.5 cm. The plates were incubated for 24 hours at 37°C, and isolates exhibiting an increase of ≥3 mm in the inhibition zone around cefotaxime-clavulanic acid were classified as ESBL producers. All data were entered into SPSS software for analysis, with prevalence and resistance patterns summarized as percentages. The chi-square test was used to compare qualitative variables, with a p-value < 0.05 considered statistically significant.

Statistical Analysis: Data were analyzed using SPSS version 23.0. Chi-square test was applied to compare qualitative variables. A p-value < 0.05 was considered statistically significant. Prevalence and resistance trends were presented as percentages and tabulated for comparison".

Result

Table 1 indicates that all 326 positive urine cultures in the study yielded Escherichia coli (100%), with no other bacterial organisms isolated. This shows a complete predominance of E. coli as the causative pathogen in all culture-positive cases included in the analysis.

Table 1: Culture Positivity and Distribution of Bacterial Isolates (N = 326)

Bacterial Isolate	Number (n)	Percentage (%)
Escherichia coli	326	100%
Other organisms	0	0%
Total positive urine cultures	326	100%

Table 2 shows the results of ESBL screening and confirmation using the Combined Disk Test (CDT) among 326 E. coli isolates. Out of all samples tested, 121 isolates (37.12%) were confirmed as ESBL-positive, while the remaining 205 isolates (62.88%) were ESBL-negative. This indicates that more than one-third of the isolates produced ESBL, reflecting a substantial prevalence of β-lactamase–mediated resistance in the study population.

Table 2: ESBL Screening and Confirmation by Combined Disk Test (CDT)

Category	Number (n)	Percentage (%)
Total E. coli isolates tested	326	100%
ESBL-positive (CDT confirmed)	121	37.12%
ESBL-negative	205	62.88%

Table 3 describes the demographic distribution of ESBL-positive and non-ESBL E. coli isolates (N = 326). ESBL-positive cases (n = 121) were predominantly female (61.2%), similar to the non-ESBL group (60.0%), indicating no major gender difference. Age distribution showed that the highest proportion of ESBL cases occurred in the 20–40 years age group (34.7%), followed by 41–60 years (31.4%). A comparable pattern was seen in non-ESBL isolates, with 37.1% in the 20–40 years group and 29.8% in the 41–60 years group. Children and adolescents (<20 years) accounted for 14.9% of ESBL cases and 19.0% of non-ESBL cases, while older adults (>60 years) contributed 19.0% and 14.1%, respectively. Overall, Table 3 shows that ESBL and non-ESBL infections were similarly distributed across sex and age categories, with adults aged 20–60 years forming the largest affected group.

Table 3: Demographic Distribution of ESBL and Non-ESBL E. coli			
Parameters	**ESBL-positive (n = 121)**	**Non-ESBL (n = 205)**	**Total (N = 326)**
Sex			
Male	47 (38.8%)	82 (40.0%)	129 (39.6%)
Female	74 (61.2%)	123 (60.0%)	197 (60.4%)
Age Group			
< 20 years	18 (14.9%)	39 (19.0%)	57 (17.5%)
20–40 years	42 (34.7%)	76 (37.1%)	118 (36.2%)
41–60 years	38 (31.4%)	61 (29.8%)	99 (30.4%)
> 60 years	23 (19.0%)	29 (14.1%)	52 (16.0%)

Table 4 shows the antibiotic resistance profile of ESBL-producing E. coli (n = 121), highlighting markedly high resistance to multiple antibiotic classes. All isolates (100%) were resistant to cefotaxime, and almost complete resistance was seen to ceftriaxone (98.3%), ceftazidime (97.5%), amoxicillin (96.7%), and piperacillin (95.0%), confirming the strong β-lactam resistance characteristic of ESBL producers. High resistance also extended to ciprofloxacin (84.3%) and trimethoprim–sulfamethoxazole (81.0%), indicating limited efficacy of these commonly used drugs. In contrast, aminoglycosides demonstrated moderate effectiveness, with lower resistance to amikacin (33.9%) and gentamicin (47.1%). Nitrofurantoin remained highly active, showing only 19% resistance, while meropenem showed the best performance with just 5.8% resistance. Overall, Table 4 indicates that ESBL-producing E. coli exhibit multidrug resistance, but carbapenems, nitrofurantoin, and to a lesser degree amikacin remain effective therapeutic options.

Table 4: Antibiotic Resistance Pattern Among ESBL-Producing E. coli (n = 121)		
Antibiotic	**Resistant (%)**	**Sensitive (%)**
Cefotaxime	121 (100%)	0 (0%)
Ceftriaxone	119 (98.3%)	2 (1.7%)
Ceftazidime	118 (97.5%)	3 (2.5%)
Amoxicillin	117 (96.7%)	4 (3.3%)
Piperacillin	115 (95.0%)	6 (5.0%)
Ciprofloxacin	102 (84.3%)	19 (15.7%)
Trimethoprim–Sulfamethoxazole	98 (81.0%)	23 (19.0%)
Amikacin	41 (33.9%)	80 (66.1%)
Gentamicin	57 (47.1%)	64 (52.9%)
Nitrofurantoin	23 (19.0%)	98 (81.0%)
Meropenem	7 (5.8%)	114 (94.2%)

Table 5 presents the antibiotic resistance profile of non-ESBL E. coli isolates (n = 205), showing varied susceptibility patterns across commonly used drugs. High resistance was observed to amoxicillin (72.7%) and piperacillin (63.9%), indicating limited effectiveness of these β-lactam antibiotics among non-ESBL strains. Moderate resistance rates were noted for ciprofloxacin (43.4%), cefotaxime (35.1%), trimethoprim–sulfamethoxazole (37.6%), ceftriaxone (33.2%), and ceftazidime (29.8%). In contrast, aminoglycosides and carbapenems remained highly effective, with low resistance to amikacin (8.8%), gentamicin (21.5%), and meropenem (1.5%). Nitrofurantoin also showed strong activity, with only 19% resistance. Overall, Table 5 indicates that while non-ESBL isolates exhibit substantial resistance to several first-line antibiotics, they retain excellent susceptibility to amikacin, nitrofurantoin, and meropenem.

Table 5: Antibiotic Resistance Pattern Among Non-ESBL E. coli (n = 205)		
Antibiotic	**Resistant (%)**	**Sensitive (%)**
Cefotaxime	72 (35.1%)	133 (64.9%)
Ceftriaxone	68 (33.2%)	137 (66.8%)
Ceftazidime	61 (29.8%)	144 (70.2%)
Amoxicillin	149 (72.7%)	56 (27.3%)
Piperacillin	131 (63.9%)	74 (36.1%)
Ciprofloxacin	89 (43.4%)	116 (56.6%)
Trimethoprim–Sulfamethoxazole	77 (37.6%)	128 (62.4%)
Amikacin	18 (8.8%)	187 (91.2%)

Gentamicin	44 (21.5%)	161 (78.5%)
Nitrofurantoin	39 (19.0%)	166 (81.0%)
Meropenem	3 (1.5%)	202 (98.5%)

Table 6 shows the statistical comparison between ESBL-producing and non-ESBL isolates across several variables. The distribution of ESBL status did not differ significantly by sex ($\chi^2 = 0.05$, $p = 0.82$) or age group ($\chi^2 = 1.94$, $p = 0.58$), indicating no demographic association. However, ESBL isolates showed a highly significant association with ciprofloxacin resistance ($\chi^2 = 38.21$, $p < 0.0001$) and cephalosporin resistance ($\chi^2 = 112.7$, $p < 0.0001$), confirming strong co-resistance patterns. In contrast, no significant relationship was observed between ESBL production and carbapenem sensitivity ($\chi^2 = 2.14$, $p = 0.14$). Overall, Table 6 demonstrates that while ESBL status is unrelated to age or sex, it is strongly linked to resistance to fluoroquinolones and cephalosporins.

Table 6: Statistical Comparison Between ESBL and Non-ESBL Isolates

Variable Compared	χ^2 Value	p-value	Interpretation
ESBL vs Sex	0.05	0.82	Not significant
ESBL vs Age group	1.94	0.58	Not significant
ESBL vs Ciprofloxacin resistance	38.21	<0.0001	Highly significant
ESBL vs Cephalosporin resistance	112.7	<0.0001	Highly significant
ESBL vs Carbapenem sensitivity	2.14	0.14	Not significant

Discussion

In this study, all 326 urine cultures yielded Escherichia coli, indicating a homogenous etiology of urinary tract infections in the sampled population. Of these, 121 (37.12%) were confirmed as ESBL producers while 205 (62.88%) were non-ESBL. The prevalence rate observed falls within the reports of Datta et al. (2014) [10] of 21.4% but other studies report high rates such as 46.87% by Kulkarni et al., 2016 [11] and 82.6% by Singh et al., 2016 [12]. This difference in prevalence may be due to differences in patient populations studied, healthcare settings, and risk factors such as previous antibiotic use, hospitalization, and immunosuppressive therapies as proposed by Lee et al. (2011) [13]. Our findings, where more than one-third of the clinical isolates were ESBL producers, indicate that there is significant burden of β-lactam resistance; this reflects the growing global challenge posed by MDRE in both community and hospital settings."

The demographic distribution showed no significant differences between the sexes and age groups for both the ESBL-positive and -negative isolates. This is because the majority of the cases in both categories were females, which agrees with the epidemiological evidence of a greater incidence of UTIs among women than men owing to anatomical and hormonal reasons. Age groups were between 20-40 and 41-60 years. Therefore, no significant association existed between the sexes and age and ESBL production in this study. Previous studies have shown that multidrug resistance is also not limited to any particular demographic group Yadav & Prakash (2017); Fernando et al. (2017) [14,15],. In fact, these findings have revealed that ESBL-mediated resistance in E. coli was widely dispersed in the population, adding more emphasis on universal surveillance rather than selected demographic interventions.

Antibiotic resistance patterns in our study demonstrated high resistance among these ESBL-producing isolates to cefotaxime (100%), ceftriaxone and ceftazidime (>97%), amoxicillin (96.7%), and piperacillin (95%), confirming the hallmark resistance profile of ESBL enzymes. Resistance to ciprofloxacin (84.3%) and trimethoprim–sulfamethoxazole (81%) was also significant, indicating the multidrug resistance nature beyond β-lactams. These results are broadly comparable to reports by Gangane and Firdous (2017) [16], who observed a high resistance of ESBL-producing E. coli to penicillins and cephalosporins, with retained susceptibility to carbapenems and aminoglycosides. Similarly, Fernando et al. (2017) [15] reported resistance to third-generation cephalosporins exceeding 90% among ESBL isolates, thus reflecting a consistent global trend. High fluoroquinolone resistance observed in our study may reflect overuse of these agents both in outpatient and hospital settings, a concern that has been echoed by other authors too (Yadav & Prakash, 2017) [14].

In contrast, resistance among non-ESBL isolates was generally lower across most antibiotics; cephalosporin resistance ranged from 30-35%, whereas the resistance to penicillins remained moderate to high. The resistance to fluoroquinolones and trimethoprim–sulfamethoxazole occurred with much lower frequencies as compared to that of ESBL strains, while the susceptibility to aminoglycosides, nitrofurantoin, and meropenem remained high. These findings emphasize the continued therapeutic relevance of non-ESBL-targeted antibiotics in uncomplicated UTIs, while underscoring the added complexity posed by ESBL

producers. This is analogous to the dissimilarities between ESBL and non-ESBL resistance patterns observed among Nepalese and Sri Lankan populations, in whom ESBL production strongly predicted multidrug resistance (Yadav & Prakash, 2017; Fernando et al., 2017) [14,15]. The uniform maintenance of carbapenem activity, with meropenem susceptibility at over 94% in this study, underlines its position as a reserve antibiotic for severe infections, although good stewardship will be imperative to forestall emergent resistance.

The statistical analysis showed strong associations between ESBL production and resistance to cephalosporins and ciprofloxacin, strengthening the multidrug-resistant phenotype of these isolates. Carbapenem susceptibility remained comparable between groups with and without ESBLs, consistent with findings from Gangane and Firdous (2017) [16] and Fernando et al. (2017) [15]. Retained efficacy of aminoglycosides and nitrofurantoin indicates that these agents remain options for effective treatment, especially in uncomplicated UTIs or as part of combination therapy in multi-drug-resistant infections. Yet, the high burden of ESBL producers calls for the urgent need for rational use of antibiotics and appropriate infection control practices. According to literature, inappropriate empirical therapy in regions with a high prevalence of ESBLs contributes to failure of treatment and prolongs hospitalization (Lee et al., 2011) [13].

Overall, our findings are that ESBL-producing E. coli represented a significant fraction of urinary isolates and was characterized by high rates of resistance to several classes of antibiotics, particularly β-lactams and fluoroquinolones. The observed resistance patterns are compatible with those published in the region and internationally, although the prevalence rates differ according to local risk factors, healthcare exposure, and policies on antibiotic use. The maintained activity of aminoglycosides, nitrofurantoin, and carbapenems provides valuable therapeutic options, but continuous surveillance and strict antimicrobial stewardship remain critical to control the dissemination of MDR organisms. These data underscore the importance of strategies for empirical treatment tailored to the local context and remind one of the sustained risks that ESBL-producing E. coli poses both outside the hospital and within its walls.

Conclusion

This study shows that Escherichia coli is still the predominant uropathogen of culture-positive urinary tract infections, although a sizeable proportion of these are ESBL producers. The high prevalence of ESBL-positive isolates refers to an increasingly grave challenge of antimicrobial resistance, with minimal susceptibility to commonly used β-lactams and other first-line agents but with relatively better sensitivity to carbapenems, nitrofurantoin, and aminoglycosides. Age and sex have no significant association with the ESBL status of the organism, which means that the resistance is widespread in all patient categories rather than confined to specific sections of the population. The strong association between ESBL production with resistance to the cephalosporins and fluoroquinolones underlines the clinical importance of these enzymes and points to a need for judicious antibiotic use, regular resistance surveillance, and consideration of alternative therapeutic options to minimize treatment failure and further spread of multidrug-resistant strains.

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