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Original Research

To determine the prevalence of Extended-Spectrum Beta-Lactamase (ESBL)-producing Enterobacteriaceae in urinary tract infections (UTIs) among elderly patients

[1]Dr. Ankita Tripathi, [2]Dr. Gaurav Goel

[1]Associate Professor, Department Of Microbiology, Naraina Medical College & Research Centre, Panki, Kanpur - Uttar Pradesh. 208020
[2]Associate Professor, Department Of Microbiology, Naraina Medical College & Research Centre, Panki, Kanpur - Uttar Pradesh. 208020

Corresponding Author:
Dr. Gaurav Goel
Associate Professor, Department Of Microbiology, Naraina Medical College & Research Centre, Panki, Kanpur - Uttar Pradesh. 208020

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Abstract
Aim: The aim of this study was to determine the prevalence of Extended-Spectrum Beta-Lactamase (ESBL)-producing Enterobacteriaceae in urinary tract infections (UTIs) among elderly patients and assess their clinical presentation, antibiotic sensitivity, and resistance patterns.
Materials and Methods: This prospective observational study included 120 elderly patients aged 65 years and above with clinical signs of UTIs. Urine samples were cultured and analyzed for the presence of Enterobacteriaceae species. ESBL production was detected using the combination disc diffusion test, and antibiotic susceptibility was determined by the Kirby-Bauer disc diffusion method.
Results: Out of 120 patients, 37.50% (n=45) were found to have ESBL-producing Enterobacteriaceae, while 62.50% (n=75) had non-ESBL-producing isolates. Escherichia coli was the most prevalent bacterium, accounting for 58.33% (n=70) of the total isolates. Antibiotic resistance was significantly higher in ESBL-producing isolates, with 77.78% resistant to ceftriaxone and 66.67% resistant to ciprofloxacin. Nitrofurantoin showed higher efficacy, with 44.44% of ESBL-producing isolates and 93.33% of non-ESBL isolates being sensitive. Previous antibiotic use was significantly associated with ESBL production ($p<0.001$).
Conclusion: This study reveals a high prevalence of ESBL-producing Enterobacteriaceae in UTIs among elderly patients, with significant resistance to commonly used antibiotics. These findings highlight the need for targeted antibiotic therapies, enhanced infection control measures, and prudent antibiotic use to combat multidrug-resistant infections in this vulnerable population.
Keywords: ESBL-producing Enterobacteriaceae, urinary tract infections, elderly patients, antibiotic resistance, multidrug-resistant bacteria.

Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections affecting elderly patients, leading to significant morbidity and healthcare costs. As the global population ages, the burden of UTIs in older adults is increasing, with complications and recurrences being more prevalent in this population due to multiple predisposing factors. The elderly are particularly vulnerable to UTIs due to a combination of age-related physiological changes, comorbid conditions such as diabetes and hypertension, and an increased likelihood of urinary retention and catheterization. While UTIs can occur at any age, their impact on older adults is often more severe, leading to complications such as bacteremia, sepsis, and even death, particularly in frail individuals with underlying health issues.[1] One of the most concerning developments in the treatment of UTIs is the rising prevalence of antibiotic-resistant bacteria, particularly extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae. These bacteria are capable of breaking down a wide range of beta-lactam antibiotics, including penicillins, cephalosporins, and monobactams, rendering these commonly used

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treatments ineffective. ESBL-producing bacteria, which include species such as *Escherichia coli* and *Klebsiella pneumoniae*, are not only more difficult to treat but are also associated with higher rates of treatment failure, longer hospital stays, and increased healthcare costs.[2] The spread of ESBL-producing Enterobacteriaceae in both community and healthcare settings poses a significant public health challenge, particularly among the elderly. This is because older adults are more likely to be exposed to healthcare environments, where resistant bacteria are more prevalent, and are often subjected to invasive procedures such as catheterization, which increases the risk of infection. Furthermore, the aging immune system is less effective at combating infections, and the frequent use of antibiotics in this population contributes to the selective pressure that drives the emergence of resistant strains.[3]

UTIs in elderly patients often present differently from those in younger populations, making diagnosis and management more complex. While younger individuals typically experience symptoms such as dysuria, frequency, urgency, and suprapubic pain, older adults may present with nonspecific or atypical symptoms, such as confusion, lethargy, or a decline in functional status. These atypical presentations can delay diagnosis, allowing the infection to progress and increasing the likelihood of complications. Additionally, asymptomatic bacteriuria is common in the elderly, and distinguishing between colonization and infection can be challenging, particularly in those with cognitive impairments.[4] The management of UTIs caused by ESBL-producing bacteria is further complicated by the limited treatment options available. Many of the first-line antibiotics commonly used to treat UTIs, such as cephalosporins and fluoroquinolones, are ineffective against ESBL-producing organisms. As a result, clinicians are often forced to rely on more potent antibiotics, such as carbapenems, which are considered the last line of defense against multi-drug resistant organisms. However, the overuse of these antibiotics is contributing to the emergence of carbapenem-resistant Enterobacteriaceae (CRE), further compounding the challenge of treating UTIs in elderly patients.[5] The prevalence of ESBL-producing bacteria varies globally, but studies have consistently shown that the rates are higher in elderly patients, particularly those with frequent hospitalizations, long-term catheter use, or previous antibiotic exposure. In nursing homes and long-term care facilities, where antibiotic use is common and infection control practices may be less stringent, the spread of ESBL-producing bacteria is of particular concern. The overuse and misuse of antibiotics in these settings create an environment conducive to the selection and proliferation of resistant strains.[6] Risk factors for developing UTIs caused by ESBL-producing Enterobacteriaceae in the elderly include advanced age, comorbid conditions (such as diabetes and chronic kidney disease), prolonged hospital stays, and previous antibiotic use. The frequent use of broad-spectrum antibiotics, especially in patients with multiple comorbidities, plays a crucial role in the development of antibiotic resistance. In addition, invasive medical interventions such as catheterization and the use of urinary stents increase the likelihood of bacterial colonization and subsequent infection with resistant strains. Furthermore, recurrent UTIs are common in elderly patients, and each recurrence increases the likelihood of developing an infection caused by a resistant pathogen. In light of the rising prevalence of ESBL-producing Enterobacteriaceae, there is an urgent need to develop more effective strategies for preventing and managing these infections in elderly patients. These strategies include improving diagnostic capabilities to quickly identify resistant pathogens, implementing more stringent infection control measures in healthcare settings, and promoting the judicious use of antibiotics to prevent the further development of resistance. Educating both healthcare providers and patients about the risks associated with antibiotic overuse is also critical in reducing the prevalence of resistant infections.[7] Research into alternative treatments for UTIs, such as the development of new antibiotics or the use of non-antibiotic therapies, is ongoing. However, in the meantime, clinicians must focus on optimizing the use of existing antibiotics through antimicrobial stewardship programs, which aim to ensure that the right antibiotic is used at the right dose for the right duration. These programs are particularly important in long-term care facilities, where the inappropriate use of antibiotics is widespread and the risk of resistant infections is high.

Materials and Methods

This prospective observational study was conducted to determine the prevalence of Extended-Spectrum Beta-Lactamase (ESBL)-producing Enterobacteriaceae in urinary tract infections (UTIs) among elderly patients. The study was performed in a tertiary care hospital over a period of one year, with a total sample size of 120 patients aged 65 years and above. Ethical approval was obtained from the institutional review board, and informed consent was secured from all patients or their legal guardians.

Inclusion Criteria:

Patients aged 65 years and above.

Patients with clinical signs and symptoms suggestive of urinary tract infections, such as dysuria, frequency, urgency, or suprapubic pain.

Positive urine culture with the presence of Enterobacteriaceae species.

Patients who provided informed consent to participate in the study.

Exclusion Criteria:

Patients with known chronic renal disease.

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Patiens with recent antibiotic use (within the last month).

Patients with polymicrobial infections.

Patients who were critically ill or unable to provide consent.

Methodology

Demographic data, including age, gender, and comorbid conditions, were recorded for all patients. Clinical data such as symptoms, history of urinary tract infections, and antibiotic use were documented. Urine samples were collected using aseptic techniques from midstream urine or catheterized samples.

Urine samples were cultured on MacConkey and CLED agar plates and incubated at 37°C for 24-48 hours. Isolated colonies of Enterobacteriaceae were identified using standard microbiological techniques, including biochemical tests such as the oxidase test, indole production, and lactose fermentation.

To detect ESBL production, all Enterobacteriaceae isolates were subjected to the combination disc diffusion test (CDDT) as per Clinical and Laboratory Standards Institute (CLSI) guidelines. The test involved the use of ceftazidime (30 µg) and cefotaxime (30 µg) discs alone and in combination with clavulanic acid (10 µg). A ≥5 mm increase in zone diameter for the combination disc compared to the antibiotic disc alone was considered indicative of ESBL production.

Antibiotic susceptibility of the isolates was determined using the Kirby-Bauer disc diffusion method against commonly used antibiotics such as ceftriaxone, ciprofloxacin, nitrofurantoin, amoxicillin-clavulanate, and others. Results were interpreted based on CLSI guidelines.

Statistical Analysis

Data were entered into SPSS version 25.0 for analysis. Descriptive statistics were used to summarize demographic and clinical characteristics of the study population. The prevalence of ESBL-producing Enterobacteriaceae was expressed as a percentage. Chi-square tests were used to assess the association between demographic factors, clinical features, and ESBL production. A p-value of <0.05 was considered statistically significant.

Results

Table 1: Demographic Profile of Patients (n=120)

The demographic profile of the 120 elderly patients in this study shows that the mean age was 72.4 years (±5.9). Among the patients, 56.67% (n=68) were male, while 43.33% (n=52) were female. The high proportion of males could reflect the increased susceptibility of elderly men to urinary tract infections (UTIs) due to conditions such as benign prostatic hyperplasia. Comorbidities were common in the study population, with 33.33% (n=40) of patients having diabetes and 41.67% (n=50) suffering from hypertension. Additionally, 25% (n=30) of the patients had a history of previous UTIs, indicating a predisposition to recurrent infections, which is a known risk factor for complicated UTIs, especially in the elderly population.

Table 2: Prevalence of ESBL-Producing Enterobacteriaceae

This table highlights the prevalence of Extended-Spectrum Beta-Lactamase (ESBL)-producing Enterobacteriaceae among the 120 elderly patients with UTIs. The findings show that 37.50% (n=45) of the isolates were ESBL producers, while 62.50% (n=75) were non-ESBL-producing isolates. This high prevalence of ESBL-producing bacteria is alarming, as it indicates the widespread presence of drug-resistant pathogens in elderly patients, making treatment more challenging. These findings emphasize the need for careful monitoring of antibiotic resistance patterns in UTI cases, particularly in vulnerable populations like the elderly.

Table 3: Bacterial Isolates from Urinary Tract Infections in Elderly Patients (n=120)

The distribution of bacterial species responsible for UTIs in elderly patients is shown in this table. *Escherichia coli* was the most commonly isolated bacterium, accounting for 58.33% (n=70) of the total isolates, followed by *Klebsiella pneumoniae* at 20.83% (n=25). Other less frequent species included *Proteus mirabilis* (8.33%, n=10), *Enterobacter cloacae* (5.83%, n=7), *Citrobacter freundii* (4.17%, n=5), and *Serratia marcescens* (2.50%, n=3). The predominance of *E. coli* aligns with its well-established role as the leading cause of UTIs, while the presence of *K. pneumoniae* and other less common species highlights the diversity of pathogens contributing to infections in this population.

Table 4: Antibiotic Sensitivity and Resistance in ESBL and Non-ESBL Isolates

This table provides detailed information on the antibiotic sensitivity and resistance patterns of ESBL-producing and non-ESBL-producing isolates.

Ceftriaxone: Only 22.22% (n=10) of ESBL-producing isolates were sensitive to ceftriaxone, with the majority (77.78%, n=35) showing resistance. In contrast, 80% (n=60) of non-ESBL isolates were sensitive, and only 20% (n=15) were resistant. This reflects the common resistance of ESBL producers to third-generation cephalosporins like ceftriaxone.

Ciprofloxacin: The sensitivity to ciprofloxacin was 33.33% (n=15) among ESBL producers, while 66.67% (n=30) were resistant. For non-ESBL isolates, 86.67% (n=65) were sensitive, with only 13.33% (n=10) showing resistance. These findings illustrate the high levels of ciprofloxacin resistance in ESBL-producing bacteria, which limits the use of this antibiotic in treating these infections.

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Nitrofurantoin: Sensitivity to nitrofurantoin was higher among ESBL producers, with 44.44% (n=20) sensitive and 55.56% (n=25) resistant. In the non-ESBL group, 93.33% (n=70) of isolates were sensitive, and only 6.67% (n=5) were resistant, making nitrofurantoin a more effective option for treating non-ESBL UTIs.

Amoxicillin-Clavulanate: Sensitivity was 26.67% (n=12) among ESBL producers and 86.67% (n=65) in non-ESBL isolates. Resistance was much higher in ESBL producers (73.33%, n=33) compared to non-ESBL isolates (13.33%, n=10), underscoring the limited efficacy of this drug against ESBL-producing strains.

Table 5: Clinical Presentation of ESBL and Non-ESBL UTI Cases

The clinical features of UTI in ESBL-positive and ESBL-negative cases were compared.

Dysuria was reported in 66.67% (n=30) of ESBL-positive cases and 60% (n=45) of ESBL-negative cases, with no significant difference (p=0.46).

Frequency/urgency was present in 71.11% (n=32) of ESBL-positive patients and 73.33% (n=55) of ESBL-negative patients, again showing no significant difference (p=0.76).

Suprapubic pain was reported equally in both groups (40%, n=18 in ESBL-positive and 40%, n=30 in ESBL-negative patients).

Table 1: Demographic Profile of Patients (n=120)

Characteristic	Number (n)	Percentage (%)
Mean Age (years)	72.4 ± 5.9	-
Gender		
- Male	68	56.67%
- Female	52	43.33%
Comorbidities		
- Diabetes	40	33.33%
- Hypertension	50	41.67%
- Previous UTI history	30	25%

Table 2: Prevalence of ESBL-Producing Enterobacteriaceae

Outcome	Number (n)	Percentage (%)
Total patients with Enterobacteriaceae	120	100%
ESBL-producing isolates	45	37.50%
Non-ESBL-producing isolates	75	62.50%

Table 3: Bacterial Isolates from Urinary Tract Infections in Elderly Patients (n=120)

Bacterial Species	Number of Isolates (n)	Percentage (%)
Escherichia coli	70	58.33%
Klebsiella pneumoniae	25	20.83%
Proteus mirabilis	10	8.33%
Enterobacter cloacae	7	5.83%
Citrobacter freundii	5	4.17%
Serratia marcescens	3	2.50%

Table 4: Antibiotic Sensitivity and Resistance in ESBL and Non-ESBL Isolates

Antibiotic	ESBL (n=45)		Non-ESBL (n=75)	
	Sensitive (n)	**Sensitive (%)**	**Sensitive (n)**	**Sensitive (%)**
Ceftriaxone	10	22.22%	60	80%
	Resistant (n)	**Resistant (%)**	**Resistant (n)**	**Resistant (%)**
	35	77.78%	15	20%
	Sensitive (n)	**Sensitive (%)**	**Sensitive (n)**	**Sensitive (%)**
Ciprofloxacin	15	33.33%	65	86.67%
	Resistant (n)	**Resistant (%)**	**Resistant (n)**	**Resistant (%)**
	30	66.67%	10	13.33%
	Sensitive (n)	**Sensitive (%)**	**Sensitive (n)**	**Sensitive (%)**
Nitrofurantoin	20	44.44%	70	93.33%
	Resistant (n)	**Resistant (%)**	**Resistant (n)**	**Resistant (%)**
	25	55.56%	5	6.67%
	Sensitive (n)	**Sensitive (%)**	**Sensitive (n)**	**Sensitive (%)**
Amoxicillin-	12	26.67%	65	86.67%

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Clavulanate				
	Resistant (n)	Resistant (%)	Resistant (n)	Resistant (%)
	33	73.33%	10	13.33%

Table 5: Clinical Presentation of ESBL and Non-ESBL UTI Cases

Clinical Feature	ESBL-positive (n=45)	ESBL-negative (n=75)	p-value (Chi-square)
Dysuria	30 (66.67%)	45 (60%)	0.46
Frequency/urgency	32 (71.11%)	55 (73.33%)	0.76
Suprapubic pain	18 (40%)	30 (40%)	1.00
Previous antibiotic use	35 (77.78%)	25 (33.33%)	<0.001*

Discussion

The demographic profile of elderly patients in this study, with a mean age of 72.4 years, reflects the increased vulnerability of this population to urinary tract infections (UTIs). The male predominance (56.67%) aligns with findings from other studies, such as one conducted by Aslan et al. (2020), which observed a similar gender distribution in UTI cases among the elderly, particularly due to conditions like benign prostatic hyperplasia in men, leading to urinary retention and subsequent infections.[8] The prevalence of comorbidities, such as diabetes (33.33%) and hypertension (41.67%), is consistent with research showing that these conditions compromise immune function, making elderly patients more prone to recurrent infections and complications (Stamatiou et al., 2019).[9] The 25% prevalence of prior UTI history in this study underlines the known risk of recurrent infections in elderly patients, as noted in studies by Mody et al. (2019), which emphasize the link between chronic illnesses and recurrent UTIs.[10]

The finding that 37.50% of the bacterial isolates were ESBL producers is notably higher than in many previous studies. For example, a study by Pitout et al. (2021) reported an ESBL prevalence of around 25% among UTI patients in hospital settings, which is still concerning but lower than the 37.50% observed in this cohort.[11] This difference could be attributed to the advanced age of the patients in our study, along with the higher prevalence of comorbidities and previous antibiotic exposure, which are well-established risk factors for the development of resistant infections. The high prevalence of ESBL-producing bacteria underscores the global challenge of managing antibiotic resistance, particularly in elderly and vulnerable populations where antibiotic overuse is common.

As expected, *Escherichia coli* was the predominant pathogen (58.33%) responsible for UTIs in this study, consistent with global data. The findings are comparable to those reported by Flores-Mireles et al. (2020), where *E. coli* accounted for the majority of both community-acquired and hospital-acquired UTIs.[12] Similarly, the 20.83% prevalence of *Klebsiella pneumoniae* in our study matches reports from other studies, such as that by Tumbarello et al. (2021), which highlighted the increasing role of *K. pneumoniae* in nosocomial UTIs, particularly among elderly and immunocompromised patients.[13] The presence of less common species like *Proteus mirabilis* and *Enterobacter cloacae* reflects the diversity of pathogens in elderly UTI patients, as also noted by other researchers, such as Nicolle (2020), who discussed the broader spectrum of bacterial agents involved in UTIs in geriatric populations.[14]

The resistance patterns seen in this study emphasize the clinical challenges posed by ESBL-producing bacteria. For ceftriaxone, 77.78% of ESBL-producing isolates were resistant, which aligns with findings from Rawat and Nair (2019), who reported similar resistance rates in ESBL-producing *E. coli* and *Klebsiella* isolates.[15] The high resistance rate to ciprofloxacin (66.67% in ESBL producers) is also consistent with global trends, where fluoroquinolone resistance has become increasingly problematic. In a study by Sanchez et al. (2020), ESBL-producing *E. coli* isolates showed resistance to ciprofloxacin in over 60% of cases, further limiting treatment options for these infections.[16]

Nitrofurantoin showed better efficacy against both ESBL and non-ESBL isolates, with 44.44% of ESBL-producing bacteria being sensitive to it. This reflects findings from recent studies, such as by Gupta et al. (2021), which demonstrated that nitrofurantoin remains effective against many ESBL-producing uropathogens, particularly in uncomplicated lower UTIs. The higher sensitivity rate in non-ESBL isolates (93.33%) further supports its continued use as a first-line treatment in these cases.[17] The lower sensitivity of ESBL isolates to amoxicillin-clavulanate (26.67%) compared to non-ESBL isolates (86.67%) underscores the need for targeted antibiotic therapy, as beta-lactam/beta-lactamase inhibitors are less effective against ESBL producers, a finding corroborated by other studies like those by Livermore et al. (2020).[18]

The clinical features of UTIs, such as dysuria, frequency, and suprapubic pain, were not significantly different between ESBL-positive and ESBL-negative cases, which is consistent with findings from Banerjee et al. (2019).[19] This suggests that the clinical presentation alone cannot reliably distinguish between infections caused by ESBL-producing and non-ESBL-producing bacteria. However, the significant association between prior antibiotic use and the presence of ESBL-producing bacteria ($p<0.001$) is a

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critical finding. This aligns with other studies, such as those by Paterson and Bonomo (2020), which have documented the strong correlation between antibiotic exposure and the emergence of resistant bacterial strains, particularly in hospital settings where broad-spectrum antibiotics are frequently used.[20]

Conclusion

In conclusion, this study highlights the significant prevalence of ESBL-producing Enterobacteriaceae in urinary tract infections among elderly patients, emphasizing the challenges posed by antibiotic resistance in this vulnerable population. The findings underscore the need for improved diagnostic tools, stricter infection control measures, and judicious use of antibiotics to prevent the spread of resistant pathogens. Given the high rates of comorbidities and previous antibiotic exposure among the elderly, tailored treatment strategies are essential to improve patient outcomes and combat the growing threat of multidrug-resistant infections.

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