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Original Research Article

Prevalence and Antimicrobial Resistance Patterns of Escherichia Coli Isolated from Urine Samples of Urinary Tract Infection Patients: Six-Months Study

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Abstract:

Background: Urinary tract infections (UTIs) are among the most common bacterial infections, predominantly caused by Escherichia coli. Rising antimicrobial resistance has reduced the effectiveness of empirical therapy and necessitates local surveillance.

Aim: To determine the prevalence and antimicrobial resistance pattern of Escherichia coli isolated from urine samples of UTI patients over six months.

Methodology: A retrospective cross-sectional study was conducted in the Department of Microbiology, Darbhanga Medical College and Hospital, Bihar, India. A total of 490 urine samples from clinically suspected UTI patients were processed by standard culture methods. Significant isolates were identified using biochemical tests and antibiotic susceptibility testing was performed by Kirby–Bauer disc diffusion as per CLSI guidelines.

Results: Females constituted 68.16% cases, with maximum incidence in 41–60 years (35.92%). E. coli was the predominant pathogen (63.67%). High sensitivity was observed to meropenem (86.54%), nitrofurantoin (78.85%), imipenem (75.64%), and amikacin (75%). Marked resistance occurred against ampicillin (96.15%), cephalosporins (57–73%), and fluoroquinolones (~59%). Multidrug resistance was seen in 53.85% isolates and 11.54% were extensively drug-resistant.

Conclusion: E. coli remains the leading uropathogen with high multidrug resistance, limiting empirical therapy; culture-guided treatment and antimicrobial stewardship are essential.

Keywords: Urinary Tract Infection, Escherichia Coli, Antimicrobial Resistance, Multidrug Resistance, Carbapenems, Nitrofurantoin.

Introduction

Urinary tract infection (UTI) happens when microbes enter the urinary system and cause inflammation. The infection can affect any part of the tract, the urethra (urethritis), bladder (cystitis), ureters, or kidneys (pyelonephritis). It begins when microorganisms manage to bypass the body's natural defenses and multiply inside the urinary tract. UTIs are among the most common bacterial infections worldwide and can occur at any age, from newborns to older adults [1]. Because they lead to many clinic visits, emergency consultations, and hospital admissions, they also create a significant medical and financial burden.

Most UTIs are caused by bacteria. Gram-negative organisms make up the majority, and Escherichia coli is the most common cause. Other bacteria include Klebsiella species (10%), Proteus species (5–10%), and Pseudomonas species (2–5%). Gram-positive organisms such as Group B Streptococcus and Staphylococcus species may also cause infection, especially in certain high-risk groups [2]. Among all of them, E. coli remains the leading pathogen in both community and hospital infections, responsible for about 60–70% of cases [3]. Its success comes from special features; adhesins, pili, hemolysins, and biofilm formation, which help it attach to and survive inside the urinary tract.

Typical symptoms include burning during urination, frequent urination, urgency, lower abdominal discomfort, and fever. Yet many infections cause no symptoms at all. This silent form is common in pregnant women, elderly people, and catheterized patients. Even without symptoms, asymptomatic bacteriuria must be taken seriously because it can progress to serious problems such as kidney infection, renal scarring, or septicemia if untreated [4]. For this reason, early detection and proper treatment are important in both symptomatic and asymptomatic cases.

Research consistently shows that Gram-negative bacteria dominate urine cultures from UTI patients [5]. Around 95% of UTIs are bacterial, and E. coli accounts for most of them [6]. Which organism appears depends on several factors; age, sex, pregnancy, sexual activity, catheter use, urinary tract abnormalities, weakened immunity, and previous antibiotic use. Women are especially vulnerable because their urethra is shorter and closer to the anal region, making it easier for bacteria to travel upward.

Correctly identifying the causative organism and its antibiotic sensitivity is essential for treatment. Doctors often start therapy before culture results are available, so they rely on knowledge of common local bacteria and resistance patterns to choose medicines wisely [7]. Without this information, inappropriate antibiotic use can lead to persistent infection, recurrence, and complications.

In recent years, antimicrobial resistance has become a major global health concern. Many studies reports rising resistance in E. coli to commonly used drugs such as beta-lactams, fluoroquinolones, and cotrimoxazole. Particularly worrying is multidrug resistance (MDR), defined as resistance to at least one drug in three or more antibiotic groups [8]. MDR E. coli infections are difficult to treat because they limit available options and may require expensive or toxic alternatives.

The impact goes beyond treatment difficulty. Resistant UTIs are linked to longer hospital stays, higher medical costs, greater illness severity, and increased mortality. This problem is even more serious in developing countries, where healthcare resources are limited and antibiotic misuse is widespread [9,10]. Easy over-the-counter access, incomplete treatment courses, and lack of stewardship programs all speed up the spread of resistant bacteria.

Therefore, continuous monitoring of antibiotic sensitivity patterns is essential for effective infection control. Resistance levels vary between regions due to differences in prescribing habits, infection control practices, and local microbial environments. Region-specific data are needed to guide treatment guidelines and slow further resistance.

Because E. coli is the most common urinary pathogen and resistance is increasing, regular tracking of its resistance pattern is crucial. Knowing local trends helps clinicians choose appropriate empirical therapy, reduces treatment failure, and supports antibiotic stewardship. Hence, the present study aims to determine the prevalence of Escherichia coli in patients with urinary tract infection and to evaluate its antimicrobial resistance pattern over a six-month period.

Methodology

Study Design: This study was a retrospective cross-sectional laboratory-based study conducted to determine the prevalence and antimicrobial resistance patterns of Escherichia coli isolated from urine samples of patients suspected of urinary tract infection (UTI).

Study Area: The study was carried out in the Department of Microbiology, Darbhanga Medical College and Hospital (DMCH), Laheriasarai, Darbhanga, Bihar, India from April 2025 to September 2025

Study Duration: The study was conducted over a period of six months.

Sample Size: A total of 490 urine samples received in the microbiology laboratory from clinically suspected UTI patients were included in the study.

Study Population: The study population comprised patients of all age groups and both sexes attending outpatient departments and admitted wards of Darbhanga Medical College and Hospital (DMCH), Laheriasarai, Darbhanga, Bihar, India, with clinical suspicion of urinary tract infection (UTI). Patients presented with symptoms such as dysuria, urinary frequency, urgency, suprapubic discomfort, loin pain, and fever associated with urinary complaints. A total of 490 urine samples received in the Department of Microbiology during the six-months study period were included and analyzed for bacteriological profile and antimicrobial resistance pattern of Escherichia coli.

Sample Collection: Patients were instructed to provide early morning clean-catch midstream urine specimens. Approximately 10–20 mL of urine was collected in sterile, wide-mouthed, leak-proof containers. Each specimen container was appropriately labeled with patient identification number, age, sex, and time of collection. The samples were transported to the microbiology laboratory within one hour of collection. In case of delay, samples were refrigerated at 4°C and processed within 24 hours to prevent bacterial overgrowth or contamination.

Laboratory Processing: Each urine sample was centrifuged at 2000 rpm for 5 minutes and the sediment was examined microscopically for pus cells, red blood cells, bacteria, and casts. Using a calibrated loop (0.001 mL), urine was inoculated on Cystine Lactose Electrolyte Deficient (CLED) agar, MacConkey agar, and nutrient agar plates and incubated aerobically at 37°C for 18–24 hours. Significant bacteriuria was defined as colony growth $\geq 10^5$ CFU/mL. Presumptive Escherichia coli colonies were identified based on colony morphology, Gram staining showing Gram-negative bacilli, and standard biochemical reactions including indole positivity, methyl red positivity, citrate negativity, urease negativity, motility positivity, and acid/acid reaction on triple sugar iron agar without hydrogen sulfide production.

Antimicrobial Susceptibility Testing: Antibiotic susceptibility testing of confirmed E. coli isolates was performed using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar. The antibiotics tested included amikacin, amoxicillin-clavulanate, ampicillin, cefepime, cefixime, ceftazidime, ceftriaxone, cefuroxime, ciprofloxacin, cotrimoxazole, gentamicin, imipenem, levofloxacin, meropenem, nitrofurantoin, piperacillin-tazobactam, and tetracycline. After incubation at 37°C for 18–24 hours, the diameter of inhibition zones was measured and interpreted as sensitive, intermediate, or resistant according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Inclusion Criteria

- Patients clinically suspected of UTI
- Both indoor and outdoor patients
- All age groups and both sexes
- Samples showing significant bacteriuria

Exclusion Criteria

- Improperly collected urine samples
- Contaminated samples (mixed growth)
- Patients on antibiotic therapy within last 48 hours
- Repeated samples from same patient during study period

Procedure

All urine samples received in the microbiology laboratory during the study period were processed according to standard microbiological procedures. Microscopy was performed followed by culture on appropriate media. Isolates showing significant bacteriuria were identified by biochemical tests. Confirmed Escherichia coli isolates were subjected to antimicrobial susceptibility testing. The laboratory findings along with patient demographic details were recorded systematically and compiled for analysis to determine prevalence and resistance patterns.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The prevalence of Escherichia coli was calculated as the proportion of total culture-positive isolates. Association between demographic variables and antimicrobial resistance patterns was analyzed using the Chi-square test, and a p-value of less than 0.05 was considered statistically significant."

Result

Table 1 shows the age- and gender-wise distribution of 490 UTI-positive patients. The highest proportion of cases occurred in the 41–60 years age group (176; 35.92%), followed by 21–40 years (142; 28.98%), >60 years (114; 23.26%), and ≤20 years (58; 11.84%). Gender distribution revealed a clear female predominance with 334 females (68.16%) compared to 156 males (31.84%). Overall, the table indicates that UTIs were most common among middle-aged adults and occurred more frequently in females.

Table 1: Age & Gender-wise distribution of UTI positive patients (N = 490)

Age group (years)	Frequency (n)	Percentage (%)
≤20	58	11.84
21–40	142	28.98
41–60	176	35.92
>60	114	23.26
Gender		
Male	156	31.84
Female	334	68.16
Total	**490**	**100**

Table 2 presents the distribution of organisms isolated from 490 urine samples. Escherichia coli was the predominant pathogen accounting for 312 cases (63.67%), followed by Klebsiella pneumoniae 66 (13.47%) and Pseudomonas aeruginosa 36 (7.35%). Other isolates included Proteus mirabilis 28 (5.71%), Enterococcus faecalis 22 (4.49%), Staphylococcus saprophyticus 18 (3.67%), and Staphylococcus aureus 8 (1.63%). Overall, the table shows a clear predominance of Gram-negative bacilli, particularly E. coli, as the major cause of urinary tract infections.

Table 2: Distribution of organisms isolated from urine samples (N = 490)		
Bacterial pathogens	**Frequency (n)**	**Percentage (%)**
Escherichia coli	312	63.67
Klebsiella pneumoniae	66	13.47
Pseudomonas aeruginosa	36	7.35
Proteus mirabilis	28	5.71
Enterococcus faecalis	22	4.49
Staphylococcus saprophyticus	18	3.67
Staphylococcus aureus	8	1.63
Total	**490**	**100**

Table 3 shows the antibiotic susceptibility pattern of 312 Escherichia coli isolates. The highest sensitivity was observed with meropenem (270, 86.54%), followed by nitrofurantoin (246, 78.85%), imipenem (236, 75.64%), and amikacin (234, 75.00%), indicating good efficacy of carbapenems and some aminoglycosides. Moderate sensitivity was seen with piperacillin-tazobactam (69.87%) and gentamicin (60.26%), while cotrimoxazole showed nearly equal sensitivity and resistance (47.44% vs 45.51%). High resistance was noted against commonly used β-lactams such as ampicillin (96.15%), cefuroxime (73.08%), cefixime and ceftazidime (61.54% each), ceftriaxone (57.69%), and fluoroquinolones like ciprofloxacin (59.62%) and levofloxacin (58.97%). Overall, the table indicates extensive resistance to cephalosporins and fluoroquinolones, while carbapenems and nitrofurantoin remain the most effective drugs.

Table 3: Antibiotic susceptibility pattern of Escherichia coli isolates (n = 312)				
Antibiotics	**Concentration (µg)**	**Sensitive n (%)**	**Intermediate n (%)**	**Resistant n (%)**
Amikacin	30	234 (75.00)	25 (8.01)	53 (16.99)
Amoxiclav	30	128 (41.03)	18 (5.77)	166 (53.20)
Ampicillin	30	12 (3.85)	0 (0.00)	300 (96.15)
Cefepime	30	108 (34.62)	20 (6.41)	184 (58.97)
Cefixime	30	96 (30.77)	24 (7.69)	192 (61.54)
Ceftazidime	30	104 (33.33)	16 (5.13)	192 (61.54)
Ceftriaxone	30	112 (35.90)	20 (6.41)	180 (57.69)
Cefuroxime	30	74 (23.72)	10 (3.21)	228 (73.08)
Ciprofloxacin	5	96 (30.77)	30 (9.62)	186 (59.62)
Cotrimoxazole	25	148 (47.44)	22 (7.05)	142 (45.51)
Gentamicin	10	188 (60.26)	18 (5.77)	106 (33.97)
Imipenem	10	236 (75.64)	10 (3.21)	66 (21.15)
Levofloxacin	5	108 (34.62)	20 (6.41)	184 (58.97)
Meropenem	10	270 (86.54)	6 (1.92)	36 (11.54)
Nitrofurantoin	30	246 (78.85)	12 (3.85)	54 (17.31)
Piperacillin+Tazobactam	4.5	218 (69.87)	14 (4.49)	80 (25.64)
Tetracycline	30	132 (42.31)	18 (5.77)	162 (51.92)

Table 4 illustrates the multidrug resistance (MDR) pattern among 312 E. coli isolates. More than half of the isolates were MDR (168, 53.85%), indicating resistance to multiple antibiotic classes, while 108 (34.62%) were non-MDR. Additionally, 36 isolates (11.54%) were extensively drug-resistant (XDR), representing the most severe resistance category. Overall, the findings demonstrate a high burden of antimicrobial resistance with nearly two-thirds of isolates showing advanced resistance (MDR/XDR).

Table 4: Multidrug resistance (MDR) pattern of E. coli isolates (n = 312)		
Resistance category	**Frequency (n)**	**Percentage (%)**
Non-MDR	108	34.62
MDR	168	53.85
XDR	36	11.54
Total	**312**	**100**

Discussion

In this study, most culture-positive cases were seen in people aged 41–60 years (35.92%), followed by those between 21–40 years (28.98%). Only 11.84% of patients were 20 years or younger. Earlier research has shown a similar pattern, where middle-aged and older adults formed the largest group of

UTI patients; especially those aged 51–60 years in one report (56.67%) (Shah et al., 2005). Shah (2002) [11] also noted that uropathogens were isolated more often in people above 40 years. The higher risk with age may be linked to urinary retention, diabetes, enlarged prostate, and repeated hospital exposure. However, some community studies found a slightly younger peak age, probably because sexually active women in reproductive age groups experience UTIs more often (Dimitrov et al., 2004) [12]. This suggests that social and demographic factors influence disease patterns. The fairly large elderly group in our study (23.26%) further supports the role of associated illnesses in increasing infection risk".

A clear female predominance was found: 68.16% females versus 31.84% males. This matches earlier observations that women are more vulnerable due to a shorter urethra and its closeness to the perineal region (Shah et al., 2005) [13]. Several hospital-based studies also reported female proportions between 60–75% (Dimitrov et al., 2004; Sabir et al., 2014) [12,14]. Pregnancy, hormonal changes, and sexual activity increase the risk further in women, while infections in men are often linked to structural problems and tend to be complicated. The similarity between our findings and previous reports confirms the well-known epidemiology of UTIs.

Escherichia coli was the most common organism in our study, isolated in 63.67% of cases. Although high, this is slightly lower than studies reporting 70–80% isolation (Singh et al., 2012; Dimitrov et al., 2004) [15,12]. The difference may be due to hospital-associated infections and catheter use, where other Gram-negative bacteria appear more often. Klebsiella pneumoniae (13.47%), Pseudomonas aeruginosa (7.35%), and Proteus mirabilis (5.71%) followed E. coli, matching global UTI patterns (Pitout, 2012) [16]. The dominance of E. coli comes from its virulence traits; adhesins, fimbriae, and toxin production, which help it attach to urinary epithelium (Wiles et al., 2008; Ulett et al., 2013) [17,18]. Researchers have also emphasized its genetic adaptability, allowing it to acquire resistance genes and survive in the urinary tract.

In antibiotic testing, the isolates showed the highest sensitivity to meropenem (86.54%), nitrofurantoin (78.85%), imipenem (75.64%), and amikacin (75.00%). Similar results have been reported, with 80–90% sensitivity to carbapenems and about 70–80% to nitrofurantoin and aminoglycosides (Akhtar et al., 2016) [19]. This suggests carbapenems remain reliable against resistant uropathogens. Piperacillin-tazobactam sensitivity (69.87%) was also close to earlier reports of around 70% effectiveness (Pitout, 2012) [16]. On the other hand, gentamicin and cotrimoxazole showed only moderate activity in our study, unlike older reports that showed better results, likely reflecting rising resistance over time (Khan et al., 2002) [20].

Strong resistance was seen against commonly used oral antibiotics. Ampicillin resistance reached 96.15%, similar to nearly 100% resistance reported earlier (Sabir et al., 2014) [14]. Cephalosporins such as cefuroxime (73.08%), cefixime (61.54%), and ceftazidime (61.54%) also showed high resistance, consistent with global findings related to extended-spectrum β-lactamase production (Pitout, 2012) [16]. Fluoroquinolone resistance was about 59%, comparable to earlier rates of 60–70% (Hillier et al., 2007) [21]. This decline in effectiveness likely reflects frequent empirical use in outpatient treatment. These trends indicate a shift away from traditional oral therapy toward drugs like nitrofurantoin for uncomplicated UTIs.

Multidrug resistance was notably high: 53.85% MDR and 11.54% XDR isolates. Increasing MDR has been described worldwide and linked to improper antibiotic use and gene transfer among bacteria (Belay et al., 2007) [22]. The presence of ESBL production further complicates treatment and reduces available options (Pitout, 2012) [16]. Previous studies also connected prior antibiotic exposure with resistant UTI pathogens (Hillier et al., 2007) [21]. Our results support the idea that resistance builds up over time due to incomplete treatment and easy access to antibiotics.

Overall, this study shows patterns similar to earlier regional and international reports; female predominance, E. coli dominance, high carbapenem sensitivity, and strong resistance to beta-lactams and fluoroquinolones. Small differences in percentages may reflect variations in prescribing habits, healthcare practices, and antibiotic use in the community. Continuous monitoring and culture-guided therapy are therefore essential to reduce treatment failure and slow antimicrobial resistance.

Conclusion

This six-month study shows that urinary tract infections occurred more often in females and mainly affected middle-aged and older adults. Escherichia coli was the primary pathogen in both community and hospital infections. The antibiotic profile revealed widespread resistance to commonly used oral drugs: especially penicillins, cephalosporins, and fluoroquinolones; making empirical treatment with these agents less reliable. Better effectiveness was seen with carbapenems, nitrofurantoin, aminoglycosides, and β-lactam/β-lactamase inhibitor combinations. A large proportion of isolates were multidrug resistant, and some were extensively resistant, highlighting the growing limitation of treatment options. These findings underline the need for routine culture-based diagnosis, regular resistance surveillance, and strict antibiotic stewardship programs to guide proper therapy and limit the spread of antimicrobial resistance in urinary pathogens.

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