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Assessment of Bacterial Uropathogens and their Antibiotic Susceptibility in Rural Healthcare Facilities, Jamalpur, Bangladesh

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ABSTRACT: Urinary tract infections (UTIs) are common in Bangladesh and increasingly complicated by antibiotic resistance. This study aimed to identify uropathogens and their antibiotic susceptibility patterns in patients at a tertiary care center in Jamalpur. A six-month cross-sectional study analyzed 282 urine samples from suspected UTI cases. Bacterial identification followed standard microbiological methods, and antibiotic sensitivity was determined using the Kirby-Bauer disk diffusion method per CLSI guidelines. Out of 282 urine samples, 54 (19.1%) showed significant bacterial growth, while 228 (80.9%) had no significant growth. Gram-negative bacteria comprised 83.4% of the isolates, with *Escherichia coli* (66.7%) being the most prevalent, followed by *Klebsiella spp.* (11.1%), *Pseudomonas spp.*, (3.7%), and *Acinetobacter* spp. (1.9%). Among Gram-positive organisms, *Enterococcus faecalis* (9.3%) and *Staphylococcus aureus* (5.6%) were predominant. Females accounted for 74.1% of positive cases, with the highest prevalence in patients over 49 years of age. High resistance was observed to commonly used antibiotics such as ceftriaxone (81.5%) and chloramphenicol (94.4%), whereas meropenem (96.3%) and netilmicin (85.2%) showed the highest sensitivity.

KEYWORDS: Urinary tract infection, antimicrobial resistance, uropathogens, antibiotic susceptibility.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections globally, affecting individuals across all age groups and representing a significant burden on healthcare systems. It is estimated that 50–60% of women experience at least one UTI during their lifetime, with recurrent episodes frequently reported (Ahmed *et al*., 2009 and Abedin *et al*.,2020).

While both Gram-negative and Gram-positive bacteria are implicated, *Escherichia coli* remains the predominant uropathogen, accounting for 70–95% of community-acquired and approximately 50% of hospital-acquired UTIs (Abedin *et al.*,2022a). Other organisms, such as *Klebsiella pneumoniae, Pseudomonas aeruginosa, Enterococcus faecalis*, and *Staphylococcus aureus*, contribute to infection in specific clinical contexts (Abedin *et al.*,2022b).

The treatment of UTIs is becoming increasingly challenging due to the rise in antimicrobial resistance (AMR), particularly among Gram-negative uropathogens. Resistance to commonly prescribed antibiotics—including ampicillin, fluoroquinolones, and third-generation cephalosporins—has been documented worldwide, primarily driven by the emergence of extended-spectrum β-lactamase (ESBL)–producing Enterobacteriaceae (Mia *et al*.,2022). While carbapenems, such as meropenem and imipenem, have retained efficacy against many resistant strains, the emergence of carbapenem-resistant organisms poses a critical threat to effective therapy (Abedin *et al*., 2023).

In resource-limited settings like rural Bangladesh, data on local resistance patterns remain sparse. Consequently, clinicians often rely on empirical treatments without microbiological confirmation, potentially exacerbating resistance trends. This study was conducted to evaluate the prevalence of bacterial uropathogens and their antibiotic susceptibility patterns in a tertiary care facility in Jamalpur. The findings aim to support evidence-based treatment protocols and contribute to the development of regional antimicrobial stewardship strategies.

The majority of UTIs are caused by bacteria, with Gram-negative organisms predominating. Our data demonstrates this pattern, with Gram-negative bacteria accounting for 92.59% of identified pathogens (50/54 cases) compared to 7.41% Gram-positive organisms (4/54 cases). Among Gram-negative isolates, *Escherichia coli* was the most prevalent (66.7% of all positive cases), followed by *Klebsiella pneumoniae* (11.1%), *Pseudomonas aeruginosa* (3.7%), and *Acinetobacter spp.* (1.9%). Among Gram-positive organisms, *Staphylococcus aureus* (5.6%) and *Streptococcus spp.* (1.9%) were identified. *E. coli's* dominance as a uropathogen is well-documented, typically accounting for 70-95% of community-acquired and 50% of hospital-acquired UTIs (Abedin *et al*.,2020). This organism possesses numerous virulence factors that facilitate urinary tract colonization, including adhesins (type 1 fimbriae, P fimbriae), toxins (hemolysin, cytotoxic necrotizing factor), and mechanisms for iron acquisition (siderophores) (Abedin *et al*.,2022a). Klebsiella species, the second most common Gram-negative pathogens in our study, are particularly associated with healthcare-associated UTIs and frequently exhibit multidrug resistance (Paczosa *et al.*,2016).

Gram-positive organisms, though less common overall, play important roles in specific clinical scenarios. *Enterococcus faecalis* (9.3% in our data) is a frequent cause of hospital-acquired UTIs, particularly in catheterized patients and those with structural abnormalities of the urinary tract. *Staphylococcus aureus* UTIs often indicate hematogenous spread from distant foci and are associated with bacteremia and renal abscess formation (Fisher et al.,2009)

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional study was conducted over a six-month period, from January to June 2023, at Zia Health Complex, a prominent diagnostic center in Jamalpur, Bangladesh.

Study Population: Urine samples were collected from 282 patients of various age groups and both sexes who presented with clinical symptoms suggestive of urinary tract infection (UTI). Inclusion criteria consisted of patients with complaints such as dysuria, frequency, urgency, suprapubic discomfort, or fever. Exclusion criteria included patients on recent antibiotic therapy or with known chronic urinary disorders.

Sample Collection and Processing: Clean catch midstream urine specimens were collected from aseptically in sterile containers following proper instructions after obtaining consent. The samples were promptly transported to the microbiology laboratory for culture and analysis.

Bacterial Isolation and Identification: Urine samples were cultured using calibrated loops (0.001 mL) on MacConkey agar, Blood agar, and Chromogenic agar plates. The plates were incubated aerobically at 37°C for 24–48 hours. Significant bacteriuria was defined as colony counts $\geq 10^5$ CFU/mL. Isolates were identified based on colony morphology, Gram staining, and standard biochemical tests.

Antimicrobial Susceptibility Testing: The antibiotic susceptibility of bacterial isolates was determined using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. Antibiotics tested included Amoxyclav (30 µg), Amikacin (30 µg), Aztreonam (30 µg), Ceftazidime (30 µg), Cefuroxime (30 µg), Cefotaxime (30 µg), Ceftriaxone (30 µg), Chloramphenicol (30 µg), Ciprofloxacin (5 µg), Co-trimoxazole (25 µg), Imipenem (10 µg), Meropenem (10 µg), Mecillinam (10 µg), Nalidixic Acid (30 µg), Netilmicin (50 µg), and Nitrofurantoin (300 µg). Interpretation of results was based on Clinical and Laboratory Standards Institute (CLSI) guidelines [30].

DATA ANALYSIS

Descriptive statistics were used to analyze the prevalence of bacterial isolates and their susceptibility profiles. Frequencies and percentages were calculated to express organism distribution and resistance patterns. Graphs and tables were used to represent demographic distribution, infection rates, and antimicrobial susceptibility trends.

RESULTS

Out of 282 urine samples collected from clinically suspected UTI patients who fulfilled the inclusion criteria over 6 months, 54 samples (19.1%) showed significant bacterial growth, while 228 samples (80.9%) had no growth within 24-48 hours after incubation at 37°C. (Table 1).

An antibiotic sensitivity test was performed by the disc diffusion method (Kirby-Bauer's technique) using commercially available discs (Biomaxima, Poland), namely Amoxyclave (30 µg), Amikacin (30 µg), Aztreonam (30 µg), Ceftazidime (30 µg), Cefuroxime (30 µg), Cefotaxime (30 µg), Chloramphenicol (30 µg), Ciprofloxacin (5 µg), Mecillinam (10 µg), Meropenem (10 µg), Imipenem (10 µg), Nalidixic Acid (30 µg), Netilmicin (50 µg), Co-trimoxazole (25 µg), Ceftriaxone (30 µg), Nitrofurantoin (300 µg) and the results were recorded following the instructions of the manufacturer.

AGE AND SEX DISTRIBUTION

Among the 54 culture-positive cases, 40 were female (74.1%) and 14 were male (25.9%). The highest proportion of positive cases was observed in patients aged >49 years (25 cases; 46.3%). Younger age groups (0–36 years) consisted exclusively of female patients (Table-2).

Table 1: Distribution of Culture Results

Culture Results	Sample (n)	Percentage (%)
No Growth	228	80.9
Positive cases	54	19.1
Total Sample	282	100.0

Table-2: Bacterial growth positive rate in urine sample collected in various ages and sex.

	Sex			
	Female		Male	
Age wise group (Years)	n	%	n	%
0-12	6	11.1	0	0.0
13-24	4	7.4	0	0.0
25-36	16	29.6	0	0.0
37-48	3	5.6	0	0.0
>49	11	20.4	14	25.9

Table 3: Distribution pattern of Bacterial Isolates of UTI infection (n=54)

Isolation Group	Bacterial isolates	Total No.	Percentage
Gram Negative Bacterial isolates (n-45, 83.3%)	*E. coli*	36	66.7
	Klebsiella pneumoniae	6	11.1
	Pseudomonas aeruginosa	2	3.7
	Acinetobacter spp.	1	1.9
Gram Positive Bacterial isolates (n-9, 16.7%)	*Enterococcus faecalis*	5	9.3
	Staphylococcus aureus	3	5.6
	Streptococcus spp.	1	1.9
	Total isolates	54	100

DISTRIBUTION OF ISOLATES

Of the 54 bacterial isolates, Gram-negative organisms accounted for 83.3% (n=45), while Gram-positive organisms represented 16.7% (n=9). *Escherichia coli* was the most frequent pathogen 66.7% (n=36;), followed by *Klebsiella pneumoniae* 11.1% (n=6;), *Pseudomonas aeruginosa* 3.7% (n=2;), and *Acinetobacter spp.* 1.9% (n=1;). Among Gram-positive isolates, *Enterococcus faecalis* accounted for 9.3% (n=5;), *Staphylococcus aureus* for 5.6% (n=3;), and *Streptococcus spp.* 1.9% (n=1;) (Table 3).

Table 4: Overall Antimicrobial Susceptibility Profiling of Bacterial Isolates

Name of Antibiotics	Codes	Disk concentration	Sensitive S		Intermediate IS		Resistance R	
			n	%	n	%	n	%
Amoxyclave	AMC	30 µg	23	42.6	13	24.1	18	33.3
Amikacin	AK	30 µg	31	57.4	12	22.2	7	13.0
Aztreonam	ATM	30 µg	13	24.1	4	7.4	37	68.5
Ceftazidime	CAZ	30 µg	13	24.1	17	31.5	20	37.0
Cefuroxime	CXM	30 µg	8	14.8	7	13.0	35	64.8
Cefotaxime	CTX	30 µg	12	22.2	11	20.4	27	50.0
Chloramphenicol	CH	30 µg	0	0.0	3	5.6	51	94.4
Ciprofloxacin	CIP	5 µg	32	59.3	4	7.4	17	31.5
Mecillinam	MEC	10 µg	31	57.4	4	7.4	19	35.2
Meropenem	MEM	10 µg	52	96.3	0	0.0	2	3.7
Imipenem	IPM	10 µg	36	66.7	5	9.3	13	24.1
Nalidixic Acid	NA	30 µg	6	11.1	6	11.1	38	70.4
Netilmicin	NET	50 µg	46	85.2	3	5.6	1	1.9
Co-trimoxazole	SXT	25 µg	36	66.7	1	1.9	17	31.5
Ceftriaxone	CRO	30 µg	2	3.7	8	14.8	44	81.5
Nitrofurantoin	F	300 µg	29	53.7	18	33.3	3	5.6

ANTIBIOTIC SUSCEPTIBILITY PROFILES

Antimicrobial susceptibility testing revealed that the majority of isolates exhibited resistance to several commonly used antibiotics. Highest overall sensitivity was observed for Meropenem (96.3%), Netilmicin (85.2%), Co-trimoxazole (66.7%), Ciprofloxacin (59.3%), Mecillinam (57.4%) High resistance rates were seen with Chloramphenicol (94.4%), Ceftriaxone (81.5%), Nalidixic acid (70.4%), Aztreonam (68.5%) (Table 4).

PATHOGEN-SPECIFIC SUSCEPTIBILITY

E. coli (n=36) was found to be most sensitive to Meropenem, Netilmicin, Nitrofurantoin (97.2%). The highest intermediate sensitivity was shown to Amikacin (69.4%) and Mecillinam (66.7%). The highest resistance was shown to Chloramphenicol (100%), Ceftriaxone, Nalidixic acid (80.6%).

Klebsiella pneumoniae was the second most frequent bacteria 11.1% (n=6). It was fully sensitive to Meropenem, Imipenem, and Co-trimoxazole, and showed highest resistance to Chloramphenicol (83.3%) and Aztreonam, Ceftazidime (50.0%).

Enterococcus faecalis (n=5) was the third most frequent bacteria in this study. It was completely sensitive to Amoxyclav, Ciprofloxacin, Meropenem (80.0%), Imipenem, Netilmicin, Co-trimoxazole and Nitrofurantoin (60.0%). It showed the highest intermediate resistance to Nitrofurantoin (40.0%) and the highest resistance to Aztreonam, Nalidixic Acid (100.0%), Amikacin, Cefuroxime, Chloramphenicol, Mecillinam and Ceftriaxone (80.0%), Ceftazidime, Cefotaxime (60.0%). (Figure 2)

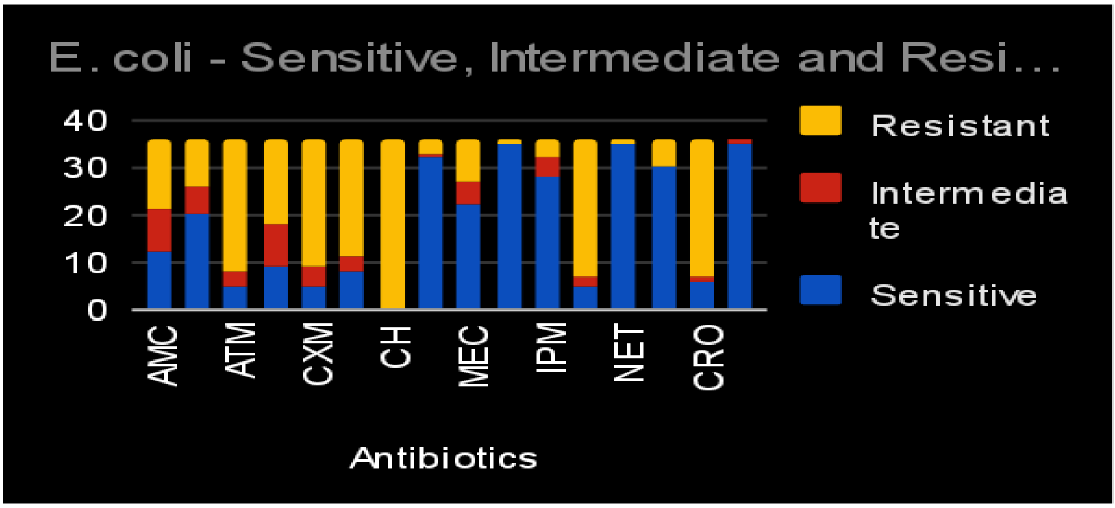

Figure 2: ***E. coli*** **- Sensitive, Intermediate Resistance, and Resistance chart**

DISCUSSION

The overall **culture positivity rate** was 19.1%, consistent with regional studies reporting positivity rates between 15–25% among symptomatic patients. A clear **female predominance (74.1%)** was observed, attributable to anatomical and hormonal predispositions such as a shorter urethra, closer proximity to the anal region, and hormonal influences that facilitate ascending infections (Abedin et al., 2020 and Abedin et al.,2022a). Interestingly, infections in younger age groups (0–36 years) were exclusively female, whereas male infections were more frequent in those aged >49 years, likely due to age-related factors such as **benign prostatic hyperplasia** and **urinary stasis** (Glover et al.,2016).

Gram-negative bacteria accounted for 83.3% of isolates, aligning with global data on UTI etiology (Kumburu *et al.*, 2017). *Escherichia coli* was the most prevalent pathogen (66.7%), consistent with its well-established dominance in UTIs, supported by virulence factors including P fimbriae, hemolysins, and siderophore-mediated iron acquisition (Johnson, 1991). Other Gram-negative isolates included *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter spp.*, commonly implicated in healthcare-associated UTIs and known for MDR profiles (Abedin *et al.*,2023). Among Gram-positive pathogens, *Enterococcus faecalis* and *Staphylococcus aureus* were frequently detected, often associated with catheter-associated UTIs and structural abnormalities (Hooton et al,2009).

A critical concern is the **alarming resistance rates** among uropathogens to commonly prescribed antibiotics. Over 80% of *E. coli* isolates were resistant to **ceftriaxone, cefuroxime, and nalidixic acid**, strongly suggestive of **extended-spectrum β-lactamase (ESBL)** production (Paterson et al,2009).. Although phenotypic confirmation was not performed, the resistance profile strongly supports its presence, corroborated by findings in similar South Asian settings (Dash et al,2012).

Meropenem exhibited the highest sensitivity (96.3%), followed by **netilmicin (85.2%)**, **nitrofurantoin**, and **amikacin**, supporting their role in the empirical treatment of complicated UTIs [Abedin et al.,2020]. Nevertheless, the increasing reliance on carbapenems is concerning, as it may fuel the emergence of **carbapenem-resistant Enterobacteriaceae (CRE)**, emphasizing the need for **strict antimicrobial stewardship** (Mia et al.,2022).

Nitrofurantoin showed excellent efficacy against *E. coli* (97.2%), making it a suitable first-line option for uncomplicated lower UTIs, particularly in outpatient settings (Abedin et al.,2022b). Conversely, resistance to **chloramphenicol (94.4%)** and **ceftriaxone (81.5%)** was widespread, a worrying trend given their frequent empirical use in rural areas without microbiological confirmation [Abedin et al., 2022a.]. Despite relatively preserved susceptibility to carbapenems and aminoglycosides, **continued surveillance and localized antibiogram updates** are essential for guiding effective empirical therapy and slowing resistance development.

LIMITATIONS

This study has several limitations. First, phenotypic or molecular testing for ESBLs, AmpC β-lactamases, or carbapenemases was not performed, which would have provided a more comprehensive resistance profile. Second, the sample size of Gram-positive isolates was relatively small, limiting conclusions for these organisms. Third, clinical outcomes following antibiotic treatment were not recorded.

CONCLUSION

This study highlights the high prevalence of Escherichia coli as the primary uropathogen in UTIs, along with significant resistance to commonly prescribed antibiotics such as ceftriaxone, aztreonam, and chloramphenicol. Gram-negative organisms, particularly *E. coli,* dominated the infection spectrum, and resistance patterns suggest the likely presence of ESBL-producing strains. The retained sensitivity of meropenem, netilmicin, and nitrofurantoin emphasizes their role in empirical therapy, particularly in settings with limited diagnostic facilities. The findings underscore the need for routine culture and sensitivity testing before initiating antibiotic therapy, particularly in recurrent or complicated UTIs. To combat rising antimicrobial resistance, it is imperative to implement local antibiogram-guided prescribing practices, enhance stewardship programs, and invest in laboratory capacity-building in rural health centers.

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CONFLICTS OF INTEREST

The authors of this paper state that they have no conflicts of interest with relation to its publication.

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