Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Prevalence and Antibiotic Sensitivity Pattern of Uropathogens in Bangladesh: A Multi-Center Retrospective Study

Md Al Hasan Mia
Dhaka Medical College
Tahmid Adeeb
tahmidadeeb14@gmail.com

Rajshahi Medical College
Sayok Chakrabarty
Sylhet MAG Osmani Medical College
Md Jannatul Islam Nabil
Mymensingh Medical College
Kakali Halder
Dhaka Medical College
Sazzad Bin Shahid
Dhaka Medical College

Research Article

Keywords: Urinary tract infection, Antimicrobial resistance, Uropathogen, Bangladesh

Posted Date: July 8th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10142808/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Urinary tract infections are one of the most prevalent diseases worldwide, with a substantial socioeconomic burden, particularly in lower- and middle-income countries, where the rise of antimicrobial resistance further complicates treatment. In Bangladesh, misuse of antibiotics due to widespread availability without prescriptions has been a key contributor to the development of this resistance. Hence, clinicians need to be equipped with knowledge of current resistance patterns to provide effective empirical therapy. This study aimed to evaluate the distribution of uropathogens and their antimicrobial resistance profiles.

Methods

Culture and antimicrobial susceptibility testing data from 9,625 samples collected between July and December 2025 were obtained from the Microbiology departments of Dhaka Medical College, Rajshahi Medical College, and Mymensingh Medical College, in this retrospective cross-sectional study. The samples were cultured on MacConkey agar, Cysteine Lactose Electrolyte Deficient agar, and blood agar; species identification was performed via Gram staining and other standard biochemical tests. The Kirby-Bauer disc diffusion method on Mueller-Hinton agar was utilized for antimicrobial susceptibility testing. Growth positivity, distribution of isolated uropathogens, antibiotic susceptibility and resistance, and resistance classification were assessed using descriptive statistics.

Results

1730 (17.97%) samples were growth-positive, of which 1032 (59.7%) were samples from female patients. Infections were most prevalent in patients belonging to the ≤ 20 years (28.0%) and 40–59 years (27.5%) age groups. Gram-negative uropathogens were most frequently isolated, with Escherichia coli being predominant (42.9% of culture-positive samples), followed by Klebsiella pneumoniae (16.9%). *Escherichia coli* infections were significantly more common in female patients (65.9%), whereas *Pseudomonas aeruginosa* was more prevalent among male patients (62.8%). *E coli* and *K. pneumoniae* showed considerable resistance to co-amoxiclav, co-trimoxazole, ciprofloxacin, and ceftriaxone. Fosfomycin, nitrofurantoin, amikacin, and meropenem were effective antimicrobials against gram-negative uropathogens; for gram-positive pathogens, vancomycin and linezolid were most effective.

Conclusions

Several commonly prescribed antimicrobials were demonstrated to have a considerable loss of susceptibility. This denotes an increased possibility of treatment failures following standard empirical treatment and highlights the need for evidence-based therapy guided by antimicrobial susceptibility testing alongside the development and enforcement of hospital antibiotic policies.

Background

Urinary tract infections (UTIs) affect approximately 150 million people each year worldwide and are the second most common infectious disease in hospitals and communities, after respiratory tract infections [1, 2]. In 2019, the global burden of disease (GBD) reported that 404.61 million people suffered from UTI globally, with 236790 deaths, and 520200 disability-adjusted life-years (DALYs) [3]. Regardless of gender, geography, and age, the total number of incidents and death rates of UTIs has grown significantly from 1990 to 2019. It is primarily attributed to population growth in low- and middle-income countries [3].

UTIs increase socio-economic burden and substantially affect the quality of life of afflicted individuals, being a considerable cause of morbidity in infant boys, the elderly, and females of all ages. Frequent recurrence, pyelonephritis with sepsis, renal damage in young children, pre-term birth, and complications arising from frequent antimicrobial use are serious sequelae of UTIs [4]. A wide range of factors increases the risk of UTIs, including age, gender, diabetes mellitus, pregnancy, introduction of catheters, and kidney transplantation [5].

UTIs are primarily caused by Gram-negative bacteria. The most common causative organism for both uncomplicated and complicated UTIs is the uropathogenic *Escherichia coli* (UPEC), accounting for 80–90% and 30–50% of community-acquired and hospital-acquired UTIs, respectively [6]. Less common organisms include *Proteus mirabilis*, *Klebsiella* spp., *Pseudomonas aeruginosa*, *Enterobacter* spp., and Gram-positive bacteria [7].

Gram-negative uropathogens are becoming an increasing threat to the community due to their ability to acquire genes located on transferable plasmids that code for extended-spectrum β-lactamases (ESBLs) [8]. These enzymes are capable of hydrolyzing third-generation cephalosporins and monobactams [9]. In addition, plasmids encoding ESBLs usually carry other resistance genes against different classes of antibiotics (e.g. aminoglycosides, sulfonamides, and quinolones) [10, 11]. As a result, bacteria that acquire these plasmids become multidrug-resistant.

UTIs impose a significant economic burden in both developed and developing countries. Healthcare expenditure due to increased rate of OPD and emergency room visits, hospitalizations, investigations, and use of antibiotics are responsible for this burden. Antimicrobial resistance (AMR) in uropathogens further increases hospitalization rates and, therefore, associated costs [12].

Antibiotic sensitivity patterns vary globally between different regions, countries, and even within specific areas of a country, owing to different proportions of antibiotic-resistant bacteria. Increased resistance of uropathogens to frequently used antibiotics has been reported in Nepal, India, and Bangladesh [13, 14]. Because of the regional variation in UTI-causing organisms and their changing antibiotic susceptibility over time, it is crucial to study sensitivity patterns

continuously and periodically [15]. Several studies on the antimicrobial susceptibility of uropathogens are available in Bangladesh; however, few were multi-center and we need to know the current pattern. Our study will provide representative data covering several major tertiary hospitals in Bangladesh and will help hospitals prepare and adopt their antibiotic policies.

Methods

Study design

This was a multi-center, cross-sectional retrospective study conducted across three major tertiary care hospitals in Bangladesh: Dhaka Medical College and Hospital(largest tertiary care hospital in Bangladesh), Rajshahi Medical College and Hospital, and Mymensingh Medical College and Hospital. The study analyzed data derived from culture and sensitivity testing of urine samples collected from July to December 2025.

Study population and eligibility criteria

The population of this study comprised both male and female patients presenting to the inpatient and outpatient departments with suspected UTIs. Initially all urine samples with complete demographic and laboratory data were included to analyse the prevalence of positive growth according to age and gender while any duplicate samples from the same patient were excluded. Later on, only samples with positive growth were included and those with negative growth were excluded for further statistical analyses.

Data collection and variables

Retrospective raw data were extracted from the patient records of the microbiology departments at the participating institutions. Then one independent researcher cleaned the raw data and another researcher validated the cleaned data. Variables in the dataset included patient demographics (age and gender), the specific uropathogens isolated from the culture, and the corresponding antimicrobial susceptibility profile for each isolate.

Microbiological procedures and isolate identification

Midstream clean-catch urine samples were collected from the non-catheterized patients, while via aseptic aspiration from the catheter tube for catheterized patients at the respective hospital laboratories. Samples were inoculated onto appropriate culture media including MacConkey agar, Cysteine Lactose Electrolyte Deficient (CLED) agar, and blood agar aerobically at 37°C for 24 h. For clean-catch midstream urine, a bacterial colony count of $\geq 10^5$ colony-forming units (CFU)/mL was considered growth positive, while $\geq 10^4$ CFU/mL for samples derived from a catheter tube. Species identification of the growth-positive samples was done using standard biochemical tests including Gram staining, catalase, coagulase, oxidase, indole, citrate utilization, urease, and triple sugar iron (TSI) agar tests.

Antimicrobial susceptibility testing (AST)

Antimicrobial susceptibility testing of the isolated uropathogens was evaluated using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, with interpretation according to Clinical and Laboratory Standards Institute (CLSI) guidelines, 2024 edition [16]. Antibiotics tested for Gram-negative isolates included Amikacin, Amoxicillin/Clavulanate, Ampicillin, Aztreonam, Cefazolin, Cefepime, Ceftazidime, Ceftriaxone, Ciprofloxacin, Doxycycline, Fosfomycin, Gentamicin, Meropenem, Nitrofurantoin, Piperacillin/Tazobactam, Tetracycline, Tobramycin, and Trimethoprim/Sulfamethoxazole. Antibiotics tested for Gram-positive isolates included Ampicillin, Cefoxitin, Ciprofloxacin, Doxycycline, Fosfomycin, Levofloxacin, Linezolid, Nitrofurantoin, Trimethoprim/Sulfamethoxazole, and Vancomycin.

Classification of antimicrobial resistance

For analyzing the clinical impact and severity of antibiotic resistance, all isolated pathogens were categorized into three resistance classifications: Multidrug-Resistant (MDR), Extensively Drug-Resistant (XDR), and Pandrug-Resistant (PDR). Isolates that were non-susceptible to ≥ 1 agent across ≥ 3 antimicrobial categories were classified as MDR; non-susceptibility to ≥ 1 agent in all but ≤ 2 categories was classified as XDR; and PDR refers to non-susceptibility to all antimicrobial agents listed [17].

Statistical analysis

Descriptive statistical analysis was performed using Statistical Package for the Social Sciences (SPSS). Study participants were divided into four age groups: ≤ 20, 21–39, 40–59 and ≥ 60 years. Growth positivity, distribution of isolated uropathogen, antibiotic susceptibility and resistance, and resistance classification were described using frequencies and percentages. Clinically significant differences were determined applying appropriate statistical methods (Chi-square or Fisher's exact tests). A p-value of < 0.05 was considered statistically significant.

Results

Patient Demographics and Culture Positivity

Among 9625 urine samples, positive bacterial growth was found in 1730 (17.97%) samples. Culture positivity was significantly more prevalent in females than males (19.33% vs 16.29%, p < 0.001) (Table 1A). Individuals aged ≤ 20 years (28.0%) had the highest prevalence of positive cultures, followed by individuals aged 40–59 years (27.5%) (Table 1B).

Table 1
A: Urine Culture Growth Results by Patient Gender

Gender	Total Evaluated	Positive Growth n (%)	Negative/No Growth n (%)	p-value
Male	4285	698 (16.29%)	3587 (83.71%)	< 0.001***
Female	5340	1032 (19.33%)	4308 (80.67%)	
Total	**9625**	**1730 (17.97%)**	**7895 (82.03%)**	
*** p < 0.001				

Table 1
B: Age Distribution of Patients with Positive Urine Cultures

Age Group (years)	Frequency (n)	Percentage (%)
≤ 20	485	28.0%
21–39	370	21.4%
40–59	475	27.5%
≥ 60	400	23.1%
Total	**1730**	**100.0%**

Distribution of Uropathogens

Gram-negative organisms were predominant in this study in comparison to gram-positive organisms (Table 2). *Escherichia coli (E.coli)* being the most frequent pathogen, showed more prevalence in females than males (65.9% vs. 34.1%, p < 0.001). Conversely, the prevalence of *Pseudomonas aeruginosa (P. aeruginosa)* was significantly higher in males than females (62.8% vs. 37.2%, p < 0.001) and highest in patients aged ≥ 60 years (35.2%, p < 0.001). A relatively even distribution was observed for *Klebsiella pneumoniae (K. pneumoniae)* among all age groups and genders. *Proteus mirabilis (P. mirabilis)* infections were highest in individuals aged ≤ 20 years (37.9%, p = 0.004). Other less prevalent gram-negative organisms included *Acinetobacter baumannii(A. baumannii)*, *Citrobacter* spp., *Enterobacter* spp. Among Gram-positive isolates, *Enterococcus* spp. were significantly more prevalent in females (69.3% vs. 30.7%, p = 0.003). Coagulase-negative Staphylococci (CoNS) and *Staphylococcus aureus(S. aureus)*were observed to a lesser extent.

Table 2
Distribution of Bacterial Isolates by Gender and Age Group

Organism Type	Species	Gender		p-value	Age Groups				p-value
		Male *N* (%)	Female *N*(%)		≤ 20 *N*(%)	21–39 *N*(%)	40–59 *N* (%)	≥ 60 *N* (%)	
Gram-negative	*A. baumannii*	24 (47.1%)	27 (52.9%)	0.397	13 (25.5%)	9 (17.6%)	14 (27.5%)	15 (29.4%)	0.714
	Citrobacter spp.	3 (60.0%)	2 (40.0%)	0.659	0 (0.0%)	2 (40.0%)	1 (20.0%)	2 (40.0%)	0.401
	Enterobacter spp.	20 (60.6%)	13 (39.4%)	0.027*	4 (12.1%)	6 (18.2%)	10 (30.3%)	13 (39.4%)	0.067
	E. coli	253 (34.1%)	490 (65.9%)	< 0.001***	208 (28.0%)	163 (21.9%)	225 (30.3%)	147 (19.8%)	0.017*
	K. pneumoniae	126 (43.2%)	166 (56.8%)	0.315	84 (28.8%)	66 (22.6%)	74 (25.3%)	68 (23.3%)	0.829
	P. mirabilis	67 (47.9%)	73 (52.1%)	0.072	53 (37.9%)	21 (15.0%)	27 (19.3%)	39 (27.9%)	0.004**
	P. aeruginosa	125 (62.8%)	74 (37.2%)	< 0.001***	42 (21.1%)	38 (19.1%)	49 (24.6%)	70 (35.2%)	< 0.001***
Gram-positive	CoNS	3 (20.0%)	12 (80.0%)	0.177	3 (20.0%)	4 (26.7%)	4 (26.7%)	4 (26.7%)	0.889
	Enterococcus spp.	66 (30.7%)	149 (69.3%)	0.003**	67 (31.2%)	50 (23.3%)	62 (28.8%)	36 (16.7%)	0.125
	S. aureus	11 (29.7%)	26 (70.3%)	0.246	11 (29.7%)	11 (29.7%)	9 (24.3%)	6 (16.2%)	0.535
Total		698 (40.3%)	1032 (59.7%)	-	485 (28.0%)	370 (21.4%)	475 (27.5%)	400 (23.1%)	-
CoNS: Coagulase-negative Staphylococci. * p < 0.05; ** p < 0.01; *** p < 0.001.									

Susceptibility and Resistance Profiles

Susceptibility and Resistance patterns of gram-negative organisms were shown in Table 3A. Fosfomycin showed notable efficacy against *E. coli* (91.7% susceptible), whereas significant resistance was exhibited against Cefazolin and Ampicillin (92.3% and 84.1% resistance respectively). *Citrobacter* spp. exhibited 100.0% resistance to Nitrofurantoin. *P. mirabilis* demonstrated 100.0% susceptibility to Ampicillin and Trimethoprim/Sulfamethoxazole, but 100.0% resistance to Cefazolin. *P. aeruginosa* was completely (100.0%) susceptible to Tobramycin but substantial resistance was exhibited to Gentamicin and Ceftazidime (67.8% and 60.3% resistance respectively). *K. pneumoniae* showed highest susceptibility to Tobramycin and Fosfomycin (82.5% and 71.2% susceptibility respectively), but significant resistance to Cefazolin and Ceftriaxone (83.2% and 67.5% resistance respectively).

Table 3A: Prevalence of Antibiotic Resistance among Gram-Negative Isolates

Antibiotic	*E. coli* (N=743)	*K. pneumoniae* (N=292)	*P. aeruginosa* (N=199)	*P. mirabilis* (N=140)	*A. baumannii* (N=51)	*Enterobacter* spp. (N=33)	*Citrobacter* spp (N=5)
AMK	S:60.7% I:4.4% R:34.9%	S:51.7% I:4.5% R:43.8%	S:45.7% I:2.0% R:52.3%	S:57.1% I:11.4% R:31.4%	S:58.8% I:0.0% R:41.2%	S:60.6% I:21.2% R:18.2%	S:60.0% I:0.0% R:40.0%
AMC	S:32.2% I:7.8% R:60.0%	S:31.5% I:6.5% R:62.0%	-	S:33.6% I:10.0% R:56.4%	-	-	S:40.0% I:0.0% R:60.0%
AMP	S:14.3% I:1.6% R:84.1%	-	-	-	-	-	-
ATM	S:30.6% I:3.6% R:65.8%	S:46.2% I:2.1% R:51.7%	S:43.7% I:9.0% R:47.2%	S:40.7% I:7.1% R:52.1%	-	-	S:40.0% I:0.0% R:60.0%
CZ	S:7.7% I:0.0% R:92.3%	S:16.8% I:0.0% R:83.2%	-	S:0.0% I:0.0% R:100.0%	-	-	-
FEP	S:27.7% I:7.1% R:65.1%	S:44.5% I:3.8% R:51.7%	S:37.7% I:3.5% R:58.8%	S:66.4% I:0.0% R:33.6%	S:39.2% I:0.0% R:60.8%	-	-
CAZ	S:30.1% I:4.4% R:65.4%	S:35.3% I:3.4% R:61.3%	S:37.7% I:2.0% R:60.3%	S:40.0% I:12.1% R:47.9%	S:27.5% I:3.9% R:68.6%	S:24.2% I:0.0% R:75.8%	S:60.0% I:0.0% R:40.0%
CRO	S:25.7% I:3.0% R:71.3%	S:28.8% I:3.8% R:67.5%	-	S:29.3% I:4.3% R:66.4%	-	S:33.3% I:0.0% R:66.7%	S:60.0% I:0.0% R:40.0%
CIP	S:30.7% I:2.8% R:66.5%	S:31.8% I:5.5% R:62.7%	S:40.2% I:3.5% R:56.3%	S:37.1% I:6.4% R:56.4%	S:37.3% I:0.0% R:62.7%	S:45.5% I:0.0% R:54.5%	S:60.0% I:0.0% R:40.0%
DOX	S:69.4% I:3.6% R:26.9%	S:65.1% I:2.7% R:32.2%	-	-	S:52.9% I:2.0% R:45.1%	S:48.5% I:0.0% R:51.5%	S:40.0% I:0.0% R:60.0%
FOS	S:91.7% I:0.7% R:7.7%	-	-	S:71.4% I:1.4% R:27.1%	-	-	S:80.0% I:0.0% R:20.0%
GEN	S:48.0% I:0.5% R:51.4%	S:38.4% I:0.7% R:61.0%	S:31.2% I:1.0% R:67.8%	S:27.1% I:0.0% R:72.9%	S:54.9% I:3.9% R:41.2%	-	S:40.0% I:0.0% R:60.0%
MEM	S:70.1% I:2.7% R:27.2%	S:59.6% I:4.5% R:36.0%	S:44.2% I:4.0% R:51.8%	S:67.9% I:6.4% R:25.7%	S:41.2% I:3.9% R:54.9%	S:75.8% I:0.0% R:24.2%	S:80.0% I:0.0% R:20.0%
NIT	S:63.1% I:7.3% R:29.6%	S:39.0% I:7.2% R:53.8%	-	-	-	S:39.4% I:0.0% R:60.6%	S:0.0% I:0.0% R:100.0%
TZP	S:56.7% I:5.2% R:38.1%	S:54.8% I:6.8% R:38.4%	S:45.7% I:4.5% R:49.7%	S:69.3% I:1.4% R:29.3%	S:54.9% I:2.0% R:43.1%	S:51.5% I:3.0% R:45.5%	-
TCY	S:37.3% I:2.0% R:60.7%	S:61.0% I:1.4% R:37.7%	-	-	S:43.1% I:13.7% R:43.1%	S:48.5% I:0.0% R:51.5%	-
TOB	S:77.8% I:1.6% R:20.6%	S:82.5% I:4.5% R:13.0%	-	S:66.4% I:0.0% R:33.6%	-	-	-
SXT	S:37.4% I:0.4% R:62.2%	S:34.2% I:0.0% R:65.8%	-	S:42.1% I:2.1% R:55.7%	-	S:21.2% I:0.0% R:78.8%	-

S: Susceptible; I: Intermediate; R: Resistant. AMK: Amikacin; AMC: Amoxicillin/Clavulanate; AMP: Ampicillin; ATM: Aztreonam; CZ: Cefazolin; FEP: Cefepime; CAZ: Ceftazidime; CRO: Ceftriaxone; CIP: Ciprofloxacin; DOX: Doxycycline; FOS: Fosfomycin; GEN: Gentamicin; MEM: Meropenem; NIT: Nitrofurantoin; TZP: Piperacillin/Tazobactam; TCY: Tetracycline; TOB: Tobramycin; SXT: Trimethoprim/Sulfamethoxazole.

Susceptibility and Resistance patterns of gram-positive organisms were shown in Table 3B. Vancomycin and Linezolid were highly effective against *S. aureus* (94.6% and 91.9% susceptible respectively) and *Enterococcus* spp. (87.9% and 88.4% susceptible respectively). High rate of resistance against Ciprofloxacin was exhibited in case of *Enterococcus* spp. (76.7%) and *S. aureus* (70.3%).

Table 3
B: Prevalence of Antibiotic Resistance among Gram-Positive Isolates

Antibiotic	*S. aureus* (N = 37)	*Enterococcus* spp. (N = 215)	CoNS (N = 15)
AMP	-	S:52.6% I:0.9% R:46.5%	-
FOX	S:29.7% I:0.0% R:70.3%	-	S:20.0% I:0.0% R:80.0%
CIP	S:27.0% I:2.7% R:70.3%	S:18.6% I:4.7% R:76.7%	S:26.7% I:6.7% R:66.7%
DOX	S:89.2% I:0.0% R:10.8%	-	S:93.3% I:0.0% R:6.7%
FOS	-	S:78.6% I:5.6% R:15.8%	-
LVX	S:35.1% I:13.5% R:51.4%	S:14.0% I:11.2% R:74.9%	S:40.0% I:13.3% R:46.7%
LNZ	S:91.9% I:2.7% R:5.4%	S:88.4% I:0.9% R:10.7%	S:80.0% I:0.0% R:20.0%
NIT	S:67.6% I:10.8% R:21.6%	S:67.4% I:5.1% R:27.4%	S:46.7% I:6.7% R:46.7%
SXT	S:56.8% I:2.7% R:40.5%	-	S:33.3% I:6.7% R:60.0%
VAN	S:94.6% I:2.7% R:2.7%	S:87.9% I:2.3% R:9.8%	S:86.7% I:0.0% R:13.3%

S: Susceptible; I: Intermediate; R: Resistant. CoNS: Coagulase-negative Staphylococci.

AMP: Ampicillin; FOX: Cefoxitin; CIP: Ciprofloxacin; DOX: Doxycycline; FOS: Fosfomycin; LVX: Levofloxacin; LNZ: Linezolid; NIT: Nitrofurantoin; SXT: Trimethoprim/Sulfamethoxazole; VAN: Vancomycin.

Table 4
A: Classification of Antibiotic Resistance by Age and Gender (Gram-Negative Isolates)

Organism	Category	Total n/N (%)	Gender		p-value	Age Groups				p-value
			Male n/N (%)	Female n/N (%)		≤ 20 n/N (%)	21–39 n/N (%)	40–59 n/N (%)	≥ 60 n/N (%)	
E. coli (N = 743)	MDR	283/743 (38.1%)	117/253 (46.2%)	166/490 (33.9%)	0.001**	42/208 (20.2%)	6/163 (3.7%)	217/225 (96.4%)	18/147 (12.2%)	< 0.001***
	XDR	268/743 (36.1%)	111/253 (43.9%)	157/490 (32.0%)	0.001**	166/208 (79.8%)	0/163 (0.0%)	8/225 (3.6%)	94/147 (63.9%)	< 0.001***
	PDR	35/743 (4.7%)	4/253 (1.6%)	31/490 (6.3%)	0.004**	0/208 (0.0%)	0/163 (0.0%)	0/225 (0.0%)	35/147 (23.8%)	< 0.001***
K. pneumoniae (N = 292)	MDR	92/292 (31.5%)	43/126 (34.1%)	49/166 (29.5%)	0.401	13/84 (15.5%)	6/66 (9.1%)	65/74 (87.8%)	8/68 (11.8%)	< 0.001***
	XDR	101/292 (34.6%)	47/126 (37.3%)	54/166 (32.5%)	0.396	71/84 (84.5%)	0/66 (0.0%)	1/74 (1.4%)	29/68 (42.6%)	< 0.001***
	PDR	31/292 (10.6%)	15/126 (11.9%)	16/166 (9.6%)	0.534	0/84 (0.0%)	0/66 (0.0%)	0/74 (0.0%)	31/68 (45.6%)	< 0.001***
P. aeruginosa (N = 199)	MDR	5/199 (2.5%)	3/125 (2.4%)	2/74 (2.7%)	1.000	0/42 (0.0%)	0/38 (0.0%)	3/49 (6.1%)	2/70 (2.9%)	0.195
	XDR	114/199 (57.3%)	74/125 (59.2%)	40/74 (54.1%)	0.478	42/42 (100.0%)	0/38 (0.0%)	8/49 (16.3%)	64/70 (91.4%)	< 0.001***
	PDR	-	-	-	-	-	-	-	-	-
P. mirabilis (N = 140)	MDR	57/140 (40.7%)	28/67 (41.8%)	29/73 (39.7%)	0.804	44/53 (83.0%)	0/21 (0.0%)	8/27 (29.6%)	5/39 (12.8%)	< 0.001***
	XDR	43/140 (30.7%)	23/67 (34.3%)	20/73 (27.4%)	0.375	9/53 (17.0%)	0/21 (0.0%)	0/27 (0.0%)	34/39 (87.2%)	< 0.001***
	PDR	-	-	-	-	-	-	-	-	-
A. baumannii (N = 51)	MDR	5/51 (9.8%)	2/24 (8.3%)	3/27 (11.1%)	1.000	1/13 (7.7%)	0/9 (0.0%)	4/14 (28.6%)	0/15 (0.0%)	0.041*
	XDR	26/51 (51.0%)	13/24 (54.2%)	13/27 (48.1%)	0.668	12/13 (92.3%)	0/9 (0.0%)	1/14 (7.1%)	13/15 (86.7%)	< 0.001***
	PDR	-	-	-	-	-	-	-	-	-
Enterobacter spp. (N = 33)	MDR	6/33 (18.2%)	2/20 (10.0%)	4/13 (30.8%)	0.182	1/4 (25.0%)	1/6 (16.7%)	4/10 (40.0%)	0/13 (0.0%)	0.101
	XDR	11/33 (33.3%)	7/20 (35.0%)	4/13 (30.8%)	1.000	3/4 (75.0%)	0/6 (0.0%)	2/10 (20.0%)	6/13 (46.2%)	0.048*
	PDR	5/33 (15.2%)	3/20 (15.0%)	2/13 (15.4%)	1.000	0/4 (0.0%)	0/6 (0.0%)	0/10 (0.0%)	5/13 (38.5%)	0.028*

MDR: Multidrug-Resistant; XDR: Extensively Drug-Resistant; PDR: Pandrug-Resistant.

* p < 0.05; ** p < 0.01; *** p < 0.001

Prevalence of MDR, XDR and PDR organisms

Prevalence of MDR *E. coli* was 38.1% and a significantly higher prevalence was observed in males (46.2% vs. 33.9%, p = 0.001) and within the 40–59 years group (96.4%, p < 0.001) (Table 4A). 31.5% of *K. pneumoniae* was MDR, mostly observed in individuals aged 40–59 years (87.8%, p < 0.001). Prevalence of MDR *P. mirabilis* was 40.7%, with a preponderance in individuals aged ≤ 20 years (83.0%, p < 0.001). Prevalences of MDR *S. aureus* and MDR *Enterococcus* spp. were 32.4% and 11.6% respectively mostly prevalent in individuals aged ≤ 20 years (81.8% and 35.8%, p < 0.001).

Isolation of PDR organisms was significantly high in individuals of advanced age. Isolation of PDR *E. coli* (4.7%) was higher in females (6.3% vs. 1.6%, p = 0.004). Notably, 100.0% of PDR *E. coli*, *K. pneumoniae* (10.6% overall PDR), and *Enterobacter* spp. (15.2% overall PDR) were isolated in individuals aged ≥ 60 years (p < 0.001, p < 0.001, and p = 0.028, respectively). In case of *Enterococcus* spp., 16 of 17 PDR strains (7.9% overall PDR) were isolated from individuals aged ≥ 60 (p < 0.001). Furthermore, 100.0% of XDR *P. aeruginosa* strains were isolated from the individuals aged ≤ 20 years and 100.0% of XDR CoNS strains were isolated from the individuals aged ≥ 60 years (Table 4B).

Table 4B: Classification of Antibiotic Resistance by Age and Gender (Gram-Positive Isolates)

Organism	Category	Total n/N (%)	Gender		p-value	Age Groups				p-value
			Malen/N (%)	Female n/N (%)		≤ 20 n/N (%)	21–39 n/N (%)	40–59 n/N (%)	≥60 n/N (%)	
S. aureus (N=37)	MDR	12/37 (32.4%)	5/11 (45.5%)	7/26 (26.9%)	0.443	9/11 (81.8%)	0/11 (0.0%)	1/9 (11.1%)	2/6 (33.3%)	<0.001***
	XDR	4/37 (10.8%)	1/11 (9.1%)	3/26 (11.5%)	1.000	1/11 (9.1%)	0/11 (0.0%)	0/9 (0.0%)	3/6 (50.0%)	0.007**
	PDR	-	-	-	-	-	-	-	-	-
***Enterococcus* spp.** (N=215)	MDR	25/215 (11.6%)	8/66 (12.1%)	17/149 (11.4%)	1.000	24/67 (35.8%)	0/50 (0.0%)	0/62 (0.0%)	1/36 (2.8%)	<0.001***
	XDR	29/215 (13.5%)	15/66 (22.7%)	14/149 (9.4%)	0.016*	13/67 (19.4%)	0/50 (0.0%)	1/62 (1.6%)	15/36 (41.7%)	<0.001***
	PDR	17/215 (7.9%)	2/66 (3.0%)	15/149 (10.1%)	0.101	1/67 (1.5%)	0/50 (0.0%)	0/62 (0.0%)	16/36 (44.4%)	<0.001***
CoNS (N=15)	MDR	7/15 (46.7%)	2/3 (66.7%)	5/12 (41.7%)	0.569	3/3 (100.0%)	0/4 (0.0%)	4/4 (100.0%)	0/4 (0.0%)	0.002**
	XDR	4/15 (26.7%)	0/3 (0.0%)	4/12 (33.3%)	0.516	0/3 (0.0%)	0/4 (0.0%)	0/4 (0.0%)	4/4 (100.0%)	0.002**
	PDR	-	-	-	-	-	-	-	-	-

CoNS: Coagulase-negative Staphylococci. MDR: Multidrug-Resistant; XDR: Extensively Drug-Resistant; PDR: Pandrug-Resistant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Discussion

As a result of this study being multicenter, significant insights into the prevalence of UTI and the antimicrobial resistance pattern of uropathogens across Bangladesh were obtained. Out of 9,625 urine samples from three major tertiary care hospitals, 17.97% yielded positive cultures, which aligns with findings from other contemporary studies conducted in the same setting [18, 19, 20, 21].

A female preponderance (59.7%) was observed among cases of positive culture growth. This trend is also found in other global and regional studies as well, and can mostly be attributed to characteristics of the female urogenital anatomy and ongoing physiological changes associated with aging, such as vaginal epithelium atrophy and lower estrogen levels leading to suppressed vaginal lactobacilli growth [22, 23, 24, 25, 26]. In our study, younger patients (≤ 20 years) constituted the highest proportion of UTI cases (28%), closely followed by patients aged between 40 and 59 (27.5%), contrasting with the findings from previous studies conducted at tertiary care hospitals in Dhaka, which reported a higher incidence in older individuals [18, 27]. This may indicate a demographic shift of the disease and warrants further investigations.

E. coli, being the most frequently isolated uropathogen in this study, constituted 42.9% of all positive cultures. Similar findings are demonstrated in several studies from Bangladesh [18, 22, 27, 28, 29, 30]. Regionally, *E. coli* also emerged as the predominant uropathogen in studies from India, Pakistan, and Nepal [19, 24, 29]. Colonization as normal flora in the gastrointestinal tract provides *E. coli* with close proximity to the urinary tract [31], and, additionally, various cell-surface and secreted virulence factors of uropathogenic *E. coli* enable it to persist in the host urinary tract [21], explaining the high prevalence of *E. coli* in UTIs. Notably, *E. coli* infections were most common in women aged 40–59 years. In an epidemiological study based on 2021 Global Burden of Disease data, He. et al noted a similar pattern, and identified it as a shift in the high-incidence age group for women [26]. *K. pneumoniae* accounted for the second-highest prevalence rate *(*16.9%) after *E. coli*, consistent with several other regional studies that have also identified *K. pneumoniae* as the second most common uropathogen [28, 32, 33]. Other significant organisms included *P. aeruginosa* and *P. mirabilis*, and among gram-positive isolates, *Enterococcus* spp. and *S. aureus*.

The rise in antimicrobial resistance is a global concern. However, substantial disparities in antimicrobial resistance rates exist between developed and lower and middle-income countries (LMICs), with the highest burdens in low-resource settings [34]. This is reflected in the present study, with 68.2% of all isolates demonstrating resistance to multiple antibiotics. Another study in Bangladesh reported that 71.19% of isolates were multidrug-resistant (MDR) [18], and 84.27% were resistant to at least one antibiotic. Similarly, a study from Nepal found that 54% of samples were multidrug-resistant overall, and 84% were resistant to at least one antibiotic [19]. In contrast, in the United States, Ku et al. noted that only 13% were non-susceptible to 3 or more antibiotic classes, whereas 57% of samples from index uncomplicated UTIs were non-susceptible to 1 or more antibiotic classes [35]. This discrepancy can be explained by several factors related to the inappropriate use of antimicrobials that lead to the development and spread of resistant strains. In Bangladesh, the widespread availability of antibiotics as over-the-counter drugs facilitates excessive consumption of antibiotics without a doctor's prescription [36]. In addition, clinicians often rely on clinical judgment to diagnose infections and subsequently prescribe broad-spectrum antibiotics empirically before laboratory results are available [37]. As a result, increased rates of treatment failure and patient morbidity are observed, along with the financial burden of reassessment and retreatment [18]. This underscores the need for greater emphasis on developing policies related to antimicrobial stewardship and for clinicians to be informed about the resistance profiles of uropathogens to improve treatment outcomes.

In our study, we found that 78.9% of *E. coli* were resistant to at least one antimicrobial agent, and 38.1% were MDR. This finding is also evident in a study by Islam et al., in which 74% of *E. coli* isolates were resistant to at least one agent from three or more antibiotic classes [22]. *E. coli* exhibited notable resistance to commonly prescribed oral antimicrobial agents, including ciprofloxacin (66.5%), co-trimoxazole (62.2%), and co-amoxiclav (60%). A systematic review of 21 articles from Bangladesh by Ahmed et al. reported comparable findings, with median resistance rates of 65.2%, 72.2%, and 67.1% for *E. coli* against ciprofloxacin, co-trimoxazole, and co-amoxiclav, respectively [38]. In this scenario, a dependable option may be fosfomycin, which showed the highest efficacy against *E. coli* (91.7%). One study demonstrated similarly high efficacy and noted that fosfomycin remained underutilized in many regions despite it [33]. Thus, minimized selective pressure as a result of limited clinical use could explain its preserved activity. Nitrofurantoin also showed promising efficacy, as 63.1% of isolates were susceptible to the drug. This is probably due to its multi-site intracellular mechanism of action, and it can therefore still be considered as a viable treatment option for uncomplicated lower UTIs [39]. Standard parenteral therapy choices are also severely compromised, evidenced by high ceftriaxone and ceftazidime resistance (71.3% and 65.4%), and resistance to co-amoxiclav and ciprofloxacin, as previously discussed. Resistance to third-generation cephalosporins (3GCs) may be attributed to the high pooled prevalence of ESBL-producing *E. coli* in Bangladesh, as confirmed by a 2023 study by Islam et al. [40]. Irrational use and overreliance on empirical therapy have directly driven the survival and clonal expansion of the CTX-M genotype of ESBL-producing Enterobacteriaceae, routinely resulting in substantially reduced efficacy of third-generation cephalosporins [41]. In Bangladesh, Ahmed et al. documented a median resistance of 59% to ceftriaxone and 65.3% to ceftazidime [38], whereas a study on community-acquired UTIs [22] observed a resistance of 69% to 3GCs. Cefepime, a fourth-generation cephalosporin, also demonstrated a similarly high resistance rate of 65.1%, which is higher than a previously reported rate of 50.51% by a study in Cumilla [37]. Resistance to amikacin for *E. coli* was also substantially higher in the present study (34.9%) compared with previously reported data from tertiary care hospitals in Bangladesh [18, 27, 29]. A possible explanation for this divergence could be the increased reliance on amikacin by regional clinicians, due to the reduced efficacy of parental 3GCs and fluoroquinolones, which has increased selection pressure and led to deteriorated amikacin susceptibility. Nonetheless, amikacin retains considerable therapeutic potential and can be selected for parenteral therapy. Carbapenems, while historically reserved, are increasingly being used as first-line treatment due to the high prevalence of cUTI cases and AMR [28]. The effects of this are evident in our findings: 27.2% of *E. coli* isolates were resistant to meropenem. This is higher than the median resistance of 13.3% calculated by Ahmed et al [38]. Hence, it is recommended to restrict the use of meropenem for routine empirical management and instead reserve it for suspected ESBL-producing and MDR strains or for severe infections.

K. pneumoniae demonstrated notable resistance to co-amoxiclav, co-trimoxazole, ciprofloxacin, ceftriaxone, ceftazidime, and cefepime. Importantly, as with *E. coli*, resistance to meropenem (36.0%) for *K. pneumoniae* was significantly higher than the median reported in the review by Ahmed et al. (7.7%) [38]. Amikacin resistance (43.8%) was comparatively more aligned with the median resistance documented by the same author (37.4%) [38]. Across *E. coli* and *K. pneumoniae* isolates one notable finding was the susceptibility to tobramycin. Parenteral formulations of tobramycin, however, are not commercially available in Bangladesh, leading to increased reliance on amikacin.

P. aeruginosa and *P. mirabilis* accounted for the highest proportions of XDR (57.3%) and MDR (40.7%) strains among all uropathogens in this study. This raises concerns regarding possible treatment failure following empirical therapies in infections caused by these organisms. A study in Dhaka reported considerable resistance to meropenem (44%) among *P. aeruginosa* isolates, which is comparable with our findings (51.8%) [28]. The high resistance is likely due to *P. aeruginosa* strains often being hospital-acquired and possessing multiple mechanisms of drug resistance. Additionally, carbapenem resistant *P. aeruginosa* often harbor aminoglycoside-modifying enzymes that further contribute to their resistance by reducing the efficacy of aminoglycosides such as amikacin [42], which was also evident in our study, as 52.3% of isolates were resistant to amikacin.

High resistance to ciprofloxacin and levofloxacin was observed among gram-positive isolates. However, notable susceptibility to nitrofurantoin and substantial susceptibility to vancomycin and linezolid was observed. Similar efficacy of nitrofurantoin and vancomycin against *Enterococcus* spp. was documented in a multi-center study from India [31]. However, that research did not detect any resistance to linezolid, whereas the present study found a 10.7% resistance rate [31]. Furthermore, Vancomycin was reported to have a median resistance of 0% by local research, but our study showed that some strains were resistant (9.8%) [38]. The higher resistance of vancomycin and linezolid documented in the current study is cause for concern, and further research is required in Bangladesh regarding the resistance of enterococci to these agents. One study on enterococcal infections acknowledged that linezolid showed the best activity against all enterococcal isolates [43], reinforcing the efficacy of linezolid against enterococci across various settings. The susceptibility of *S. aureus* to vancomycin and linezolid is also evident in other regional literature [27, 28, 33]. Hence, for Gram-positive infections, linezolid and vancomycin continue to serve as excellent options for complicated UTIs, and additionally, nitrofurantoin can also be depended upon for uncomplicated lower UTIs.

Conclusions

This study evaluated the antibiotic resistance pattern of uropathogens across three major tertiary care hospitals in Bangladesh. *E. coli* and *K. pneumoniae* were the most prevalent uropathogens, and exhibited notable resistance to co-amoxiclav, co-trimoxazole, ciprofloxacin, third generation cephalosporins, and cefepime. Increased resistance to meropenem was also observed for these organisms compared to several previous studies. *E. coli* isolates were most susceptible to fosfomycin, and *K. pneumoniae* to tobramycin. These findings highlight the limitations of current empirical therapeutic options and imply an urgent need to develop regional guidelines and policies in order to combat rising antimicrobial resistance in Bangladesh.

Limitations

This study was retrospective and relied on clinical records, which did not distinguish between complicated and uncomplicated cases. Data on existing comorbidities could also not be obtained. The absence of these variables limited the study from identifying risk factors. Future prospective multicenter studies should therefore collect data on disease severity and comorbid conditions. Additionally, both inpatient and outpatient data were included, and as

such, the disease burden of either demographic could not be evaluated. Lastly, while this was a multi-center study, the inclusion of more administrative division-level tertiary care hospitals could provide an even more generalizable dataset and improve the usability of the data across the country.

Abbreviations

UTI
Urinary tract infection
GBD
Global burden of disease
DALYs
Disability-adjusted life-years
UPEC
Uropathogenic *Escherichia coli*
ESBLs
Extended-spectrum β-lactamases
OPD
Outpatient department
AMR
Antimicrobial resistance
CLED
Cysteine Lactose Electrolyte Deficient
CFU
Colony-forming units
TSI
Triple sugar iron
AST
Antimicrobial susceptibility testing
CLSI
Clinical and Laboratory Standards Institute
SPSS
Statistical Package for the Social Sciences
MDR
Multidrug-Resistant
XDR
Extensively Drug-Resistant
PDR
Pandrug-Resistant
CoNS
Coagulase-negative Staphylococci

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Institutional Review Board (I.R.B) of Dhaka Medical College, Dhaka, Bangladesh (Ref: Memo No. IRB-DMC/MBBS/Student/2025/03).As the study only involved retrospective analysis of medical records without direct patient exposure, the requirement for informed consent was waived by the Institutional Review Board. The principles of the Declaration of Helsinki were strictly adhered.

Clinical trial

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Funding

No funding was acquired for this study.

Author Contribution

MAHM and TA generated the idea, designed the study, and prepared the initial manuscript. MAHM and TA analyzed the data and made the interpretation. SC and MJIN contributed to data collection and refinement. MAHM, TA, and KH contributed to writing the main manuscript. SBS supervised and edited the manuscript. All authors read and approved the final version of the manuscript.

Acknowledgement

We acknowledge the Microbiology departments of the respective institutions for their help.

Data Availability

The datasets that we used in this study are available upon request from the corresponding author.

References

1. Sahu R, Sahoo RK, Prusty SK, Sahu PK. Urinary Tract Infection and its Management. Syst Reviews Pharm. 2018;10:42–8.
2. Foxman B. Urinary Tract Infection Syndromes: Occurrence, Recurrence, Bacteriology, Risk Factors, and Disease Burden. Infect Dis Clin N Am. 2013;28:1–13.
3. Yang X, Chen H, Zheng Y, Qu S, Wang H, Yi F. Disease burden and long-term trends of urinary tract infections: A worldwide report. Front Public Health. 2022;10(Suppl 4):888205.
4. Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. Nat Rev Microbiol. 2015;13:269–84.
5. Sujith S, Solomon AP, Rayappan JBB. Comprehensive insights into UTIs: from pathophysiology to precision diagnosis and management. Front Cell Infect Microbiol. 2024;14:1402941.
6. Pardeshi P. Prevalence of urinary tract infections and current scenario of antibiotic susceptibility pattern of bacteria causing UTI. Indian J Microbiol Res. 2020;5:334–8.
7. Katongole P, Nalubega F, Florence NC, Asiimwe B, Andia I. Biofilm formation, antimicrobial susceptibility and virulence genes of Uropathogenic Escherichia coli isolated from clinical isolates in Uganda. BMC Infect Dis. 2020;20:453.
8. Bedenić B, Meštrović T. Mechanisms of Resistance in Gram-Negative Urinary Pathogens: From Country-Specific Molecular Insights to Global Clinical Relevance. Diagnostics. 2021;11:800.
9. Mancuso G, Midiri A, Zummo S, Gerace E, Scappatura G, Biondo C. Extended-spectrum beta-lactamase & carbapenemase-producing fermentative Gram-negative bacilli in clinical isolates from a University Hospital in Southern Italy. New Microbiol. 2021;44(4):227–33.
10. Shaikh S, Fatima J, Shakil S, Rizvi SMD, Kamal MA. Antibiotic resistance and extended spectrum beta-lactamases: Types, epidemiology and treatment. Saudi J Biol Sci. 2014;22:90–101.
11. Mancuso G, Midiri A, Gerace E, Biondo C. Bacterial Antibiotic Resistance: The Most Critical Pathogens. Pathogens. 2021;10:1310.
12. François M, Hanslik T, Dervaux B, Le Strat Y, Souty C, Vaux S, et al. The economic burden of urinary tract infections in women visiting general practices in France: a cross-sectional survey. BMC Health Serv Res. 2016;16:365.
13. Warren JW, Abrutyn E, Hebel JR, Johnson JR, Schaeffer AJ, Stamm WE. Guidelines for antimicrobial treatment of uncomplicated acute bacterial cystitis and acute pyelonephritis in women. Infectious Diseases Society of America (IDSA). Clin Infect Dis. 1999;29:745–58.
14. Holloway KA, Rosella L, Henry D. The Impact of WHO Essential Medicines Policies on Inappropriate Use of Antibiotics. PLoS ONE. 2016;11:e0152020.
15. Wagenlehner FME, Bjerklund Johansen TE, Cai T, Koves B, Kranz J, Pilatz A, et al. Epidemiology, definition and treatment of complicated urinary tract infections. Nat Reviews Urol. 2020;17:586–600.
16. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing. 34th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; 2024.
17. Magiorakos A-P, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18:268–81.
18. Chowdhury SS, Tahsin P, Xu Y, Mosaddek ASM, Muhamadali H, Goodacre R. Trends in Antimicrobial Resistance of Uropathogens Isolated from Urinary Tract Infections in a Tertiary Care Hospital in Dhaka, Bangladesh. Antibiotics. 2024;13:925.
19. Shakya S, Edwards J, Gupte HA, Shrestha S, Shakya BM, Parajuli K, et al. High multidrug resistance in urinary tract infections in a tertiary hospital, Kathmandu, Nepal. Public Health Action. 2021;11(Suppl 1):24–31.

20. Khalid F, Aljohani WJ, Akram A, Bukhari A, Khojah OT. Epidemiology and Antimicrobial Resistance of Uropathogens in a Tertiary Care Center in Riyadh, Saudi Arabia: A One-Year Retrospective Analysis. Pathogens. 2025;14:1254.
21. Gebremedhin KB, Amogne W, Alemayehu H, Bopegamage S, Eguale T. The role of uropathogenic Escherichia coli virulence factors in the development of urinary tract infection. J Med Life. 2025;18:701–9.
22. Islam MA, Islam MR, Khan R, Amin MB, Rahman M, Hossain MI, et al. Prevalence, etiology and antibiotic resistance patterns of community-acquired urinary tract infections in Dhaka, Bangladesh. PLoS ONE. 2022;17:e0274423.
23. Czajkowski K, Broś-Konopielko M, Teliga-Czajkowska J. Urinary tract infection in women. Menopause Rev. 2021;20:40–7.
24. Ullah Z, Asghar J, Aziz N, Ullah A, Ashour AA, Felemban MF, et al. Bacterial profiling and antibiotic resistance patterns in urinary tract infections: a microbiological analysis from Dera Isamil Khan, Pakistan. BMC Infect Dis. 2025;25:1151.
25. Nakandi RM, Kakeeto P, Kihumuro RB, Kanyike AM, Nalunkuma R, Lugwana RS, et al. Antibiotic susceptibility patterns of bacterial uropathogens at a private tertiary hospital in Uganda: a retrospective study. BMC Infect Dis. 2025;25:605.
26. He Y, Zhao J, Wang L, Han C, Yan R, Zhu P, et al. Epidemiological trends and predictions of urinary tract infections in the global burden of disease study 2021. Sci Rep. 2025;15:4702.
27. Nahar A, Hasnat S, Akhter H, Begum N. Evaluation of antimicrobial resistance pattern of uropathogens in a tertiary care hospital in Dhaka city, Bangladesh. South East Asia. J Public Health. 2018;7:12–8.
28. Mahjabin S, Rahman R, Munni UR, Mobin ME, Pyash AS, Shoshi HR. Bacterial profile and antibiotic resistance pattern of uropathogens isolated from patients with complicated urinary tract infections in a tertiary care hospital in Dhaka, Bangladesh. BMC Infect Dis. 2025;25:1538.
29. Sanjee SA, Karim ME, Akter T, Parvez MAK, Hossain M, Jannat B, et al. Prevalence and Antibiogram of Bacterial Uropathogens of Urinary Tract Infections from a Tertiary Care Hospital of Bangladesh. J Sci Res. 2017;9:317–28.
30. Rahman S, Ahmed M, Begum A. Occurrence of Urinary Tract Infection in Adolescent and Adult Women of Shanty Town in Dhaka City, Bangladesh. Ethiop J Health Sci. 2014;24:145.
31. Sekito T, Sadahira T, Hirakawa H, Ishii A, Wada K, Araki M. Homology of Escherichia coli isolated from urine and vagina and their antimicrobial susceptibility in postmenopausal women with recurrent cystitis. J Infect Chemother. 2024;30:1081–4.
32. Mohapatra S, Panigrahy R, Tak V, J V S, K C S, Chaudhuri S, et al. Prevalence and resistance pattern of uropathogens from community settings of different regions: an experience from India. Access Microbiol. 2022;4:000321.
33. Kamal AHM, Khatun W, Sultana N, Akter S, Nasrin S, Munir S. Bacterial Profile and Antimicrobial Resistance Patterns in the Pediatric Intensive Care Unit at Rajshahi Medical College Hospital. TAJ: Journal of Teachers Association. 2026;39(2):45–56.
34. Murray CJL, Ikuta K, Dokova K, Sifuentes–Osornio J, Sharara F, Haines–Woodhouse G, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022;399:629–55.
35. Ku JH, Tartof SY, Contreras R, Ackerson BK, Chen LH, Reyes IAC, et al. Antibiotic Resistance of Urinary Tract Infection Recurrences in a Large Integrated US Healthcare System. J Infect Dis. 2024;230:e1344–54.
36. Do NTT, Vu HTL, Nguyen CTK, Punpuing S, Khan WA, Gyapong M, et al. Community-based antibiotic access and use in six low-income and middle-income countries: a mixed-method approach. Lancet Global Health. 2021;9:e610–9.
37. Islam Majumder MM, Rahaman Mahadi A, Ahmed T, Sakib N, Ahmed M, Nazim Uddin M, et al. A Decade of Antibiotic Resistance in E. Coli in Urinary Tract Infections: A Study from a Tertiary Care Hospital in Bangladesh. Med Today. 2025;37:44–51.
38. Ahmed I, Rabbi MB, Sultana S. Antibiotic resistance in Bangladesh: A systematic review. Int J Infect Dis. 2019;80:54–61.
39. Khamari B, Bulagonda EP. Unlocking Nitrofurantoin: Understanding Molecular Mechanisms of Action and Resistance in Enterobacterales. Med Principles Pract. 2024;34:1–17.
40. Islam MS, Rahman AMMT, Hassan J, Rahman MT. Extended-spectrum beta-lactamase in Escherichia coli isolated from humans, animals, and environments in Bangladesh: A One Health perspective systematic review and meta-analysis. One Health. 2023;16:100526.
41. Husna A, Rahman MM, Badruzzaman ATM, Sikder MH, Islam MR, Rahman MT, et al. Extended-Spectrum β-Lactamases (ESBL): Challenges and Opportunities. Biomedicines. 2023;11:2937.
42. Tanriverdi Çayci Y, Cirit OS, Biyik İ, Çinar C, Gür Vural D, Bilgin K, et al. Aminoglycoside-modifying enzymes in carbapenem-resistant Pseudomonas aeruginosa clinical isolates. Mediterr J Infect Microb Antimicrob. 2022;11:37. 10.4274/mjima.galenos.2022.2022.37.
43. Hallgren A. Antimicrobial susceptibility patterns of enterococci in intensive care units in Sweden evaluated by different MIC breakpoint systems. J Antimicrob Chemother. 2001;48:53–62.