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Original Article

Diversity of Uropathogens and Ciprofloxacin Resistance Patterns Among Females of Different Age Groups in a Tertiary Care Hospital in Bangladesh

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Abstract

Introduction: *Urinary tract infections (UTIs) are the most common bacterial infections globally, with a particularly high burden among females. Ciprofloxacin has long been a key antimicrobial for empirical UTI treatment, but increasing resistance raises concern, especially in regions with limited surveillance data. This study aimed to investigate the diversity of uropathogens and ciprofloxacin resistance patterns across different age groups of female patients in a tertiary care hospital in Bangladesh.*

Methods: *A retrospective cross-sectional study was conducted from January to December 2022 at the Department of Microbiology, Ad-din Women's Medical College Hospital, Dhaka. Midstream urine samples from the suspected female patients of UTI were cultured and analyzed using standard microbiological techniques. Antimicrobial resistance to ciprofloxacin was evaluated using the Kirby-Bauer disk diffusion technique, and the results were interpreted per the 2020 guidelines of the Clinical and Laboratory Standards Institute.*

Results: *Out of 1930 samples, 323 (16.74%) were ciprofloxacin-sensitive, while 1607 (83.26%) were resistant. Most infections occurred in the 15–49 age group (67.88%).* Escherichia coli *was the most prevalent uropathogen (43.32%), followed by other staphylococci species, specifically coagulase-negative Staphylococci (OSS) (24.61%), and* Enterobacter *spp. (12.54%), and* Klebsiella *spp. (6.58%). Ciprofloxacin resistance was highest among* Enterococci *(96.97%), followed by* Klebsiella *spp. (88.19%) and* E. coli *(85.17%). Resistance was significantly higher in younger age groups ($p < 0.0001$).*

Conclusion: *This study reveals alarmingly high ciprofloxacin resistance rates among uropathogens, particularly in reproductive-age females. The findings underscore the urgent need for local antibiotic stewardship, culture-guided therapy, and age-specific empirical treatment guidelines to combat rising antimicrobial resistance in Bangladesh.*

Keywords: *Urinary Tract Infection, Ciprofloxacin, Bangladesh*

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Introduction

Urinary tract infections (UTIs) are the most common bacterial infections worldwide, affecting millions and straining healthcare systems. Up to 50 times more women than men develop these diseases.[1] Women are more susceptible to bacterial ascent into the urinary stream due to a shorter urethra and physiological factors, such as hormonal changes during the reproductive years and pregnancy.[2,3] Cystitis, the most common form of UTI, is followed by pyelonephritis, silent bacteriuria, and recurring infections.[4] Untreated or poorly managed UTIs can develop into kidney infections or sepsis, emphasising the necessity for prompt treatment.[5]

Most UTIs are caused by uropathogenic *Escherichia coli* (UPEC), which accounts for 75% of uncomplicated and 65% of severe cases.[6] Other important uropathogens include Klebsiella pneumoniae, Proteus spp., Enterobacter spp., *Pseudomonas aeruginosa*, Enterococcus spp., and *Staphylococcus aureus*. However, frequency varies with geography and patient population.[7]

Antimicrobial resistance (AMR) has become a significant issue in UTI management due to the widespread and often indiscriminate use of antibiotics, especially in outpatient settings where empirical therapy is used.[8] Due to its broad-spectrum efficacy against Gram-negative and selective Gram-positive bacteria, ciprofloxacin has been a staple drug of UTI treatment.[9] The increasing resistance pattern of uropathogens to ciprofloxacin, particularly E. coli, has raised concerns about its efficacy as a first-line treatment. South Asian and other studies have found antibiotic resistance rates above 50% due to misuse, self-medication, and selective pressure from frequent prescribing[10]. In resource-limited countries like Bangladesh, where antibiotic regulation and access to healthcare vary, uropathogen ciprofloxacin resistance is poorly understood.

The rise of MDR bacteria, such as ESBL-producing *E. coli* and *K. pneumoniae*, complicates UTI treatment. These resistant bacteria commonly co-resist multiple antibiotic classes, including fluoroquinolones, which limits treatment options and increases the use of carbapenems.[11] MDR isolates pose a public health threat in community-acquired settings, where CA-UTIs account for a large proportion of outpatient visits and antibiotic prescriptions.[12] Thus, local uropathogen diversity and resistance data are crucial for informing empirical therapy, enhancing patient outcomes, and preventing the transmission of AMR, especially in areas with limited surveillance.[13]

Ciprofloxacin's global efficacy reduction has prompted a re-evaluation of its role in UTI therapy. Some investigations have found 96% resistance to UPEC isolates in India, raising questions about its practical use.[14] Local research is needed to validate such suggestions in Bangladesh, where antibiotic availability, prescribing practices, and resistance trends vary.

Despite the widespread use of ciprofloxacin in Bangladesh, age-specific data on resistance are scarce. Age, uropathogen diversity, and ciprofloxacin resistance are understudied in Bangladesh, presenting a crucial knowledge vacuum. The diversity of uropathogens and associated ciprofloxacin resistance patterns in different female age groups must be assessed to optimize empirical therapy and antimicrobial stewardship in tertiary care. This study examined ciprofloxacin resistance in Bangladeshi female UTI patients of various ages.

Material & Methods

Study design

This retrospective cross-sectional study was conducted using stored data from the Department of Microbiology at Ad-din Women's Medical College Hospital, Dhaka, Bangladesh, over a one-year period, from January 2022 to December 2022. The study aimed to assess the diversity of uropathogens and the pattern of ciprofloxacin resistance among them in female patients with urinary tract infections (UTIs), categorized by age group.

Study population

Inclusion criteria: Patients from the specified community who presented to the outpatient department with any of the following symptoms as primary complaints were included in this study. Uncomplicated urinary tract infection (without anatomical or functional abnormalities), cystitis, burning during urination, increased frequency, urgency, pain above the pubic symphysis, patterns presented with asymptomatic bacteriuria in pregnant women, recurrent urinary tract infections, and pattern with unexplained fever were included in this study.

Exclusion criteria: 1) Asymptomatic bacteriuria, 2) Established neurogenic bladder, 3) Obstructive uropathy, 4) Pediatric patients (<18 years) with vesicoureteral reflux, and 5) Those receiving antibiotic prophylaxis.

Data Collection Procedure

Urine samples were collected from female patients of clinically suspected urinary tract infections (UTIs) attending Ad-din Women's Medical College Hospital for diagnosis and treatment from January to December 2022. Midstream clean-catch urine was obtained in sterile containers following standard aseptic procedures. Samples were promptly transported to the Microbiology laboratory and processed. Sociodemographic details and clinical information were recorded using a structured data sheet.

Identification of UTI

UTI was diagnosed based on clinical symptoms and confirmed by microbiological criteria (Urine samples with pus cells over 5/HPF were selected for culture and sensitivity test). Midstream urine samples were cultured on MacConkey agar and Cystine-Lactose Electrolyte-Deficient agar (CLED) using a calibrated loop (0.001 mL) and incubated at 37/ °C for 24 hours. Significant bacteriuria was defined as the growth of ≤10^5 colony-forming units (CFU)/ml. Only samples showing pure, significant growth were considered diagnostic of UTI. Polymicrobial, contaminated, or repeat samples were excluded. Isolates were further characterized by colony morphology, Gram staining, and standard biochemical tests. Patients with positive cultures meeting these criteria were confirmed as having urinary tract infections were included in the study.

Identification of isolates

Bacterial colonies were identified based on standard microbiological and biochemical procedures. Gram-negative isolates were confirmed using Triple Sugar Iron (TSI) slants, Simmons' citrate agar, and MIU (Motility-Indole-Urease) medium. The oxidase test was also performed where applicable. For Gram-positive cocci, catalase and coagulase tests were used to differentiate the species. All biochemical tests were interpreted as per standard diagnostic microbiology guidelines.

Antimicrobial susceptibility testing

Antibiotic susceptibility testing was conducted using the Kirby-Bauer disk diffusion technique on Mueller-Hinton agar (MHA) according to the Clinical and Laboratory Standards Institute (CLSI) 2020 guidelines.[15] Ciprofloxacin (5 µg) discs (Oxoid Ltd., UK) were used to assess the susceptibility pattern. The turbidity of the test inoculum was adjusted to 0.5 McFarland standard before inoculation. Inoculated MHA plates were incubated at 37°C for 24 hours, and zone diameters were measured.

Zone diameter interpretations for ciprofloxacin were made according to organism-specific CLSI 2020 breakpoints[15]:

- For *Enterobacteria*: Resistant ≤21 mm, Intermediate 22–25 mm, Sensitive ≥26 mm
- For *Escherichia coli:* Resistant ≤15 mm, Intermediate 22–25 mm, Sensitive ≥21 mm
- For *Pseudomonas spp.*: Resistant ≤18 mm, Intermediate 19–24 mm, Sensitive ≥25 mm
- For *Staphylococci*, *Acinetobacter spp.*, and *Enterococci spp.*: Resistant ≤15 mm, Intermediate 16–20 mm, Sensitive ≥21 mm

Each isolate's susceptibility profile was recorded as sensitive or resistant. The results were grouped according to bacterial species and age category.

Data analysis

The frequency and percentage distribution of each uropathogen, along with their resistance to ciprofloxacin, were calculated. The association between ciprofloxacin resistance and patient age groups was assessed using the chi-square test. A P-value of less than 0.05 was considered statistically significant. Statistical analysis was conducted using STATA version 15 software.

Ethical considerations

The institutional ethics committee at Ad-din Women's Medical College Hospital approved the research. The study was conducted using data previously stored in the hospital over a specific period from January to December 2022; therefore, consent from the patients was not obtained.

Results:

A total of 1,930 samples were processed from all the attending female patients in the hospital, of which only 16.74% (n=323) were sensitive to the Ciprofloxacin antibiotic. The majority of cases were in individuals aged 15–49 years (67.88%), followed by those aged 0–14 years (19.53%) and ≤50 years (12.59%), suggesting a higher prevalence of urinary tract infections (UTIs) among women of reproductive age. *Escherichia coli* was the most common uropathogen (43.32%), followed by other significant isolates such as OSS (Other Staphylococci, which are coagulase-negative Staphylococci) at 24.61%, Enterobacter (12.54%), and Klebsiella (6.58%). Less common pathogens included Proteus, Enterococci, Acinetobacter, *S. aureus*, and Pseudomonas. Alarmingly, ciprofloxacin resistance was notably high across the board, with 83.26% of isolates showing resistance (Table I).

Table 2 showed a statistically significant association between age category and ciprofloxacin resistance among female UTI patients ($p < 0.0001$). Resistance was most prevalent in the 15–49 years' age group (71.31%), followed by the 0–14 years' age group (19.48%), while the lowest resistance was observed in patients aged 50 years or older (9.21%).

Table I. Distribution of the variables

Variable	Freq.	Percentage
Age		
0-14 years	377	19.53%
15-49 years	1,310	67.88%
>=50 years	243	12.59%
Ciprofloxacin		
Sensitive	323	16.74%
Resistant	1,607	83.26%
Organisms		
E.coli	836	43.32%
OSS (Other Staphylococci which are coagulase-negative Staphylococci)	475	24.61%
Enterobacter	242	12.54%
Klebsiella	127	6.58%
Proteus	74	3.83%
Enterococci	66	3.42%
Acinetobacter	64	3.32%
S. aureus	37	1.92%
Pseudomonas	9	0.47%

Table 2. *Association Between Age Categories and Ciprofloxacin Resistance Pattern Among the Participants*

Age category	Ciprofloxacin		χ^2	P- value
	Sensitive n (%)	Resistant n (%)	[a]103.91	<0.0001
0-14 years	64 (19.81)	313 (19.48)		
15-49 years	164 (50.77)	1146 (71.31)		
>=50 years	95 (29.41)	148 (9.21)		

[a]Pearson chi square test was done

Table 3 highlighted the high ciprofloxacin resistance rate among various uropathogens in the patients. Enterococci showed the highest resistance (96.97%), followed by Klebsiella (88.19%), OSS (87.79%), E. coli (85.17%), Acinetobacter (78.13%), *S. aureus* (72.97%), Proteus (70.27%), Enterobacter (69.01%) and Pseudomonas showed notable resistance (66.67%) (Table 3).

Table 3. Ciprofloxacin Resistance Rates Among Uropathogens

Organism	Ciprofloxacin Resistant n (%)
E. Coli	712 (85.17)
Klebsiella	112 (88.19)
Enterobacter	167 (69.01)
Proteus	52 (70.27)
Pseudomonas	6 (66.67)
Acinetobacter	50 (78.13)
S. aureus	27 (72.97)
OSS (Other Staphylococci which are coagulase-negative Staphylococci)	417 (87.79)
Enterococci	64 (96. 97)

This study also revealed that *E. coli* was the most ciprofloxacin-resistant organism (712 cases), followed by OSS (417) and Enterobacter (167). Resistance was also notable in Klebsiella, Acinetobacter, and Proteus. Fewer resistant cases were observed in S. aureus and Pseudomonas, indicating a wide distribution of resistance among both Gram-negative and Gram-positive uropathogens (Figure 1).

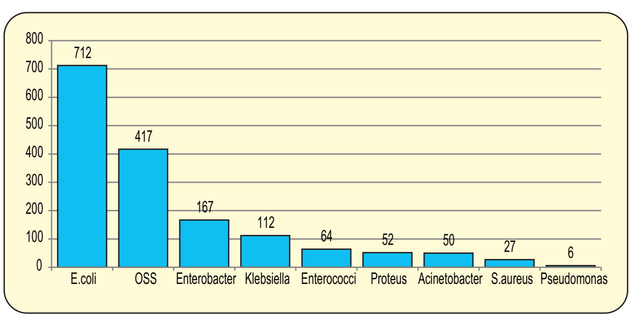

Figure 1: Distribution of Ciprofloxacin-Resistant Bacteria

Discussion

This research investigated the spectrum of uropathogens and analysed ciprofloxacin resistance patterns among females across various age groups at Ad-din Women's Medical College Hospital.

E. coli emerged as the primary uropathogen across all age groups, supporting the results of various national and international studies.[16,17] Azeez et al. (2022) found that E. coli was responsible for 93.55% of urinary tract infections in pediatric patients, 60.24% in adults, and 45.83% in the elderly.[18] Similarly, research by Ahmad et al. in Kashmir revealed a higher prevalence of *E. coli* (53.8%) in urine cultures.[19] Virulence factors such as adhesins, hemolysins, and biofilm-forming capabilities may explain its prevalence in urinary tract colonization.

Klebsiella spp. Constituted the second most prevalent isolate in our findings, corroborating studies conducted in Libya (23.9%) and Iran (28.2%).[20,21] This may stem from the strong biofilm-forming ability of Klebsiella spp., its resistance to antibiotics, and its frequent association with the use of catheters. Furthermore, inadequate infection management and antibiotic misuse may contribute to its increased prevalence.

Other species, including Proteus spp. and Pseudomonas spp., were found in lower quantities; this was supported by a study conducted by Verhaz et al.[22] This study highlighted that while *Pseudomonas aeruginosa* and *Proteus mirabilis* were not the primary isolates (13.8% and 12.9%, respectively), they exhibited markedly high resistance rates to commonly used antibiotics, including ampicillin, gentamicin, and ciprofloxacin, with some resistance levels nearing 100%.[22] This resistance complicates treatment and increases its clinical importance. Nicolle (2002) supports this, indicating that *Proteus mirabilis* and *Pseudomonas aeruginosa* possess intrinsic resistance mechanisms and are commonly found in healthcare settings, posing significant therapeutic challenges for elderly and long-term care populations.[23]

Furthermore, Staphylococcus saprophyticus and Staphylococcus aureus were frequently isolated, particularly in younger women, a finding supported by additional regional studies. Singh et al. reported S. saprophyticus in 8.32%[24] and S. aureus in 6.27%[25] of the isolates. The findings were similar to those reported by Lo et al., who noted a higher prevalence of these infections in symptomatic adolescent females.[26] The heightened prevalence of *S. saprophyticus* and *S. aureus* among younger women may be attributed to hormonal variations, sexual practices, or hygiene habits. These traits likely enhance colonization and infection, as demonstrated in previous studies.[27-29]

Age-specific analysis revealed that the highest prevalence of uropathogenic infections was observed in women aged 20–49 years, aligning with the findings of Chowdhury et al. and Ahmad et al., who reported the majority of cases in women aged 21–30 years.[30] This group may encounter heightened risk due to multiple factors, including sexual activity, use of contraceptive devices, pregnancy, and shorter urethral anatomy. The pediatric and elderly populations demonstrated lower, yet clinically relevant, infection rates,[31] highlighting the need for tailored diagnostic and treatment approaches across the lifespan.

The gender distribution in this study, which consists solely of female patients, aligns with previous research that highlights the prevalence of females in urinary tract infections (UTIs). Turyatunga found that 67% of positive urine cultures were from female patients, while 33% were from male patients. The data reveal anatomical and physiological vulnerabilities in women, such as a shorter urethra and proximity to the anal region, which may facilitate bacterial ascent.

The data revealed a troubling trend of reduced susceptibility to ciprofloxacin, particularly in *E. coli* and Klebsiella spp. The resistance rate of *E. coli* to ciprofloxacin in our study was significantly higher than 85%. Jadoon et al. reported a notable prevalence of ciprofloxacin resistance in *E. coli.*[32] This is concerning, as ciprofloxacin has historically been considered a primary oral medication for treating urinary tract infections.[33] The results suggest that the reduced efficacy of ciprofloxacin can be attributed to indiscriminate use, self-medication, and over-the-counter availability, especially in developing countries.

Comparative analyses reveal geographical variation in ciprofloxacin resistance. Ahmad et al. observed that all isolates demonstrated susceptibility to ofloxacin and over 94% to cefuroxime, indicating the superior efficacy of certain antibiotics across different regions.[34] Sihotang et al. also reported heightened sensitivity to levofloxacin and ofloxacin relative to ciprofloxacin.[35] Chavda et al. noted a fluoroquinolone sensitivity rate of 31.25%, significantly lower than earlier findings, suggesting a consistent rise in resistance.[36] The findings indicate a global trend of reduced fluoroquinolone efficacy, leading to revised guidelines in various countries that recommend against its use in uncomplicated cases, unless supported by data on cultural sensitivity.

Specific patterns correspond with our findings, such as the prevalence of *E. coli* and increased UTI rates in females; however, antibiotic susceptibility varies considerably depending on local prescribing practices and access to healthcare. Arjunan et al. investigated the efficacy of norfloxacin, ciprofloxacin, and gentamicin in rural Tamil Nadu, finding high effectiveness. In contrast, our findings revealed a significantly higher resistance to ciprofloxacin. This highlights the necessity of consistent local monitoring studies to inform empirical treatment protocols. Furthermore, it is essential to recognize that resistance trends evolve. The observed resistance in our study may reflect extended antibiotic exposure over time or the presence of plasmid-mediated resistance genes, such as qnr or aac(6')-Ib-cr, in Enterobacteriaceae, which confer resistance to fluoroquinolones and have been increasingly reported in developing areas.

Limitations of the study:

The study was conducted in a single tertiary care center, which may limit the generalizability of the findings. The study concentrated solely on female patients; hence, the results cannot be generalized to males. Furthermore, resistance patterns to the drugs, other than ciprofloxacin, were not assessed.

Conclusions:

Ciprofloxacin resistance is alarmingly high in uropathogens from female patients of various ages in a Bangladeshi tertiary care hospital. *Escherichia coli* was the most common uropathogen, followed by Klebsiella, Enterobacter, and other bacteria, as observed in regional and global studies. Ciprofloxacin resistance was highest in the reproductive-age cohort, showing a high infection load and suggesting that empirical treatment may no longer be effective. The results indicate the need for improved local empirical treatment guidelines, antibiotic stewardship programs, and public awareness campaigns to reduce antibiotic usage.

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