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Original Research Article

Evaluation of Antimicrobial Susceptibility Patterns to Oral Fluoroquinolones among Uropathogens Isolated from the Paediatric Population in Eastern India: A Cross-Sectional Analysis

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Abstract

Background: Urinary tract infections (UTIs) are among the most frequent bacterial infections affecting children and constitute a major cause of emergency department visits, outpatient management, and hospitalization. Antimicrobial resistance among commonly isolated uropathogens has become a significant public health challenge, limiting therapeutic options and complicating empirical management. Fluoroquinolones, including ciprofloxacin and levofloxacin, are widely used oral antibiotics due to their broad antimicrobial coverage, excellent urinary penetration, and favourable pharmacokinetic properties. However, regional variability in antimicrobial resistance significantly influences treatment outcomes.

Objective: To determine the magnitude of culture-positive paediatric urinary tract infections in a tertiary care hospital in Eastern India and to evaluate and compare antimicrobial susceptibility to ciprofloxacin and levofloxacin among isolated uropathogens.

Materials and Methods: A descriptive cross-sectional study was conducted over nine months from October 2023 to June 2024, involving 268 culture-confirmed paediatric UTI cases. Urine samples were collected using sterile midstream clean-catch technique and processed using standard microbiological procedures. Identification and antimicrobial susceptibility testing were performed according to Clinical and Laboratory Standards Institute (CLSI 2023) guidelines using the Kirby–Bauer disk diffusion technique. Statistical evaluation was performed using chi-square analysis.

Results: The mean age of participants was 6.1 years, with female predominance (male:female = 1:1.3). *Escherichia coli* was the most frequently isolated organism (47%), followed by *Klebsiella pneumoniae* (19%), *Proteus mirabilis* (12%), *Enterococcus faecalis* (9%), *Staphylococcus aureus* (7%), and *Staphylococcus saprophyticus* (6%). Levofloxacin demonstrated significantly higher susceptibility (61%) compared with ciprofloxacin (32%). Nitrofurantoin exhibited the highest susceptibility (71%) among tested antibiotics ($p< 0.05$).

Conclusion: Levofloxacin remains a comparatively effective oral therapeutic option for uncomplicated paediatric urinary tract infections in this region. Ongoing antimicrobial stewardship and regional susceptibility monitoring are essential to prevent further escalation of resistance.

Keywords: Paediatric UTI, Antimicrobial resistance, Fluoroquinolones, Ciprofloxacin, Levofloxacin, Uropathogens, Eastern India.

Introduction

Urinary tract infections are one of the most common bacterial infections affecting children worldwide and are associated with considerable clinical burden. Globally, the incidence of paediatric UTI is estimated to be approximately 7–8% in girls and 2% in boys under seven years of age. UTIs frequently occur due to colonisation and subsequent ascent of pathogenic bacteria into the urinary tract, resulting in inflammation and symptomatic illness. Paediatric UTIs can cause significant morbidity and may lead to renal parenchymal damage, scarring, recurrent infection, hypertension, and chronic kidney disease if inadequately treated.[1] The clinical presentation of paediatric UTIs varies widely, ranging from mild lower urinary tract symptoms such as dysuria, frequency, and suprapubic discomfort to severe upper tract involvement accompanied by high

fever, flank pain, vomiting, and systemic manifestations. Children below five years often present with nonspecific symptoms, making early diagnosis and laboratory support essential.[2] In India, socioeconomic disparities, limited access to clean water and sanitation, and self-medication practices contribute to increasing incidence and delayed intervention.

*Escherichia coli*remains the predominant uropathogen responsible for both community-acquired and hospital-acquired paediatric UTIs. Other common organisms include *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis*, and *Staphylococcus* species. Antimicrobial resistance trends among these pathogens have shown significant regional variability. [3,4,5] Several studies have reported increasing resistance to commonly used drugs such as cotrimoxazole, fluoroquinolones, and third-generation cephalosporins, attributed to widespread empirical prescription and lack of judicious antibiotic policies. [6]

Fluoroquinolones are broad-spectrum antibiotics with excellent activity against Gram-negative and selected Gram-positive organisms. Their high oral bioavailability, ability to attain therapeutic urinary concentrations, and relatively convenient dosing make them effective agents in treating urinary infections. Ciprofloxacin is traditionally used, while levofloxacin, a more recent fluoroquinolone, offers enhanced pharmacokinetic and pharmacodynamic advantages. However, emerging resistance threatens their reliability.[7,8]

In this context, regular local surveillance of antimicrobial susceptibility patterns remains essential to guide clinical decisions and update institutional antibiograms.[9] Limited published data from Eastern India specifically evaluating fluoroquinolone susceptibility in paediatric UTI populations necessitate research.

Materials and Methods

Study Design and Setting: This descriptive cross-sectional study was conducted in the Department of Microbiology at a tertiary care teaching hospital in Eastern India. The study was carried out over a period of nine months, from October 2023 to June 2024**.** Ethical approval was obtained from the Institutional Ethics Committee prior to commencement of the study, and written informed consent was taken from the parents or legal guardians of all participating children.

Study Population: The study included 268 paediatric patients aged 1 to 15 years presenting with clinically suspected urinary tract infection. All patients were evaluated by paediatricians and referred to the microbiology laboratory for urine culture and sensitivity. Inclusion criteria consisted of symptomatic UTI cases confirmed with significant bacteriuria. Patients with chronic renal disease, congenital urinary tract anomalies under active surgical management, or catheter-associated infections were excluded to avoid confounding.

Sample Collection: Clean-catch midstream urine samples were collected in sterile wide-mouth containers after appropriate instruction regarding genital cleansing. In infants, sterile urine collection bags were used. Samples were transported to the laboratory within one hour of collection, and when delay was unavoidable, specimens were refrigerated at 4°C for up to two hours.

Laboratory Processing: Urine samples were inoculated on MacConkey agar, blood agar, and nutrient agar plates using a calibrated 0.001 mL inoculating loop through the semi-quantitative streak technique. Plates were incubated aerobically at 37°C for 24 hours. Growth of $\geq 10^5$ colony-forming units (CFU) per millilitre of a single organism was considered significant. Colony morphology, Gram staining, motility testing, and standard biochemical identification tests were employed to identify isolates.

Antimicrobial Susceptibility Testing: Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, in accordance with the 2023 Clinical and Laboratory Standards Institute (CLSI) guidelines. The panel of antibiotics tested included ciprofloxacin (5 µg), levofloxacin (5 µg), and nitrofurantoin (300 µg), with inhibition zone diameters measured and interpreted as sensitive, intermediate, or resistant based on CLSI charts. Quality control for the assay was validated using the *Escherichia coli* ATCC 25922 reference strain.

Data Collection and Statistical Analysis: Data were entered in Microsoft Excel and analysed using SPSS Version 26. Descriptive statistics were expressed as frequencies and percentages. Comparative evaluation of ciprofloxacin and levofloxacin susceptibility was performed using the Chi-square test, with $p < 0.05$ considered statistically significant.

Outcome Parameters: The primary outcome measures included the prevalence of culture-positive paediatric urinary tract infections, the distribution of bacterial isolates, and the evaluation of antimicrobial susceptibility patterns specifically regarding ciprofloxacin and levofloxacin.

Results

A total of 268 culture-positive paediatric urinary tract infection cases were included in the study. The mean age of patients was 6.1 years (range 1–15 years), with the majority belonging to the younger age group. Females (56%, n = 151) were more

commonly affected than males (44%, n = 117), giving a male:female ratio of 1 : 1.3.

Age-wise Distribution: The highest incidence of UTI was observed among children aged 4–6 years (27%), followed by 7–9 years (24%), 1–3 years (22%), 10–12 years (17%), and the lowest incidence in 13–15 years (10%). Overall, 73% of cases occurred among children below 10 years of age. (Figure 1)

Gender Distribution: Out of 268 children, 151 cases (56%) were female and 117 (44%) were male, indicating that UTIs are more prevalent among females, although the difference was not statistically significant ($p > 0.05$). (Figure 2)

Bacterial Isolates: *Escherichia coli* was the most frequently isolated organism, accounting for 126 cases (47%), followed by *Klebsiella pneumoniae* (n = 51, 19%), *Proteus mirabilis* (n = 32, 12%), *Enterococcus faecalis* (n = 24, 9%), *Staphylococcus aureus* (n = 19, 7%), and *Staphylococcus saprophyticus* (n = 16, 6%); collectively, Gram-negative bacilli comprised 78% of the isolates, whereas Gram-positive cocci represented 22%. (Figure 3)

Antimicrobial Susceptibility Pattern: Antibiotic susceptibility testing revealed variable resistance patterns across the isolates. Nitrofurantoin demonstrated the highest overall in vitro efficacy with a susceptibility rate of 71%, followed by levofloxacin (61%) and ciprofloxacin (32%). Statistical analysis confirmed a significant difference in susceptibility between the two fluoroquinolones ($p < 0.05$), with levofloxacin demonstrating superior sensitivity compared to ciprofloxacin. In terms of species-specific distribution, *Escherichia coli* isolates exhibited 65% sensitivity to levofloxacin compared to 35% for ciprofloxacin. Similarly, *Klebsiella pneumoniae* isolates showed 54% sensitivity to levofloxacin versus only 22% to ciprofloxacin, reinforcing the statistically significant performance gap between the two agents.

Discussion

The present study provides updated data on antimicrobial susceptibility trends among paediatric uropathogens in Eastern India and highlights the increasing burden of antimicrobial resistance affecting fluoroquinolone utilisation. The observed female predominance aligns with established findings that girls have a significantly higher predisposition to UTIs due to anatomical and physiological factors such as shorter urethral length, proximity to the anal opening, and higher rates of perineal contamination.[10] In the current study, 73% of all cases occurred below 10 years of age, which further supports the vulnerability of younger children resulting from developing immune systems and hygiene-related behavioural patterns.[11,12]

Consistent with international and national epidemiological trends, Escherichia coli was the most prevalent uropathogen, accounting for 47% of culture-positive isolates. This finding is comparable to the reports of Chakraborty et al. and Banerjee et al. from Eastern India, which identified *E. coli* as the dominant causative organism among paediatric UTI cases.[13,14] The second most common organism in this study, *Klebsiella pneumoniae* (19%), is clinically important given its association with multidrug resistance mediated by extended-spectrum β-lactamase production.

The emerging challenge of fluoroquinolone resistance remains a major public health concern worldwide. Widespread empirical prescription, self-medication practices, and availability of antibiotics without prescription contribute to selective pressure and resistance escalation. In this study, ciprofloxacin demonstrated low susceptibility (32%), supporting recent literature indicating declining efficacy of older fluoroquinolones. [15-21] In contrast, levofloxacin showed significantly higher susceptibility (61%), making it a comparatively acceptable therapeutic option for paediatric UTIs in the studied population. (Figure-4)

These findings corroborate the conclusions of Cao et al. who demonstrated superior efficacy of levofloxacin compared with ciprofloxacin in systematic meta-analysis.[22] However, conflicting observations exist, such as the Ghanaian study by Afriyie et al., which showed greater sensitivity to ciprofloxacin than levofloxacin in their region, indicating that geographic variation in resistance is substantial and region-specific antibiotic policies remain essential.[23] Nitrofurantoin demonstrated the highest overall susceptibility (71%), reaffirming its recommended role as a first-line treatment for uncomplicated lower UTIs.[24,25] However, its limited tissue penetration restricts its usefulness in suspected pyelonephritis.[24,26] Despite concerns surrounding paediatric use of fluoroquinolones due to potential musculoskeletal adverse effects, controlled evidence suggests that cautious use is justified when no safer alternatives exist — especially in the context of increasing resistance to commonly used agents such as cotrimoxazole and cephalosporins.[27,28,29,30]

Strengths & Limitations of the Study: The primary strength of this study lies in the evaluation of a significant sample size of 268 paediatric cases using standardized CLSI methodology, providing critical local data on fluoroquinolone efficacy. Nevertheless, the study is limited by its single-centre nature, which restricts generalizability.

Furthermore, the analysis was confined to phenotypic disk diffusion testing without minimum inhibitory concentration (MIC) determination or molecular characterization of resistance mechanisms. The study design also lacked clinical follow-up, precluding the correlation of laboratory sensitivity patterns with therapeutic outcomes.

Recommendations: Future research should include multicentric, longitudinal surveillance to monitor evolving resistance patterns and molecular mechanisms. Antibiotic stewardship practices must be strengthened through clinician education, prescription regulation, and community awareness.

Conclusion

Escherichia coli remains the primary causative agent of paediatric UTIs in Eastern India, followed by *Klebsiella pneumoniae*. Levofloxacin demonstrated significantly greater sensitivity than ciprofloxacin and therefore may be considered a more reliable oral therapeutic agent when nitrofurantoin is unsuitable.

The findings support the need for continuous antibiotic susceptibility monitoring, rational prescribing, and strict implementation of regional antibiograms to minimise antimicrobial resistance trends.

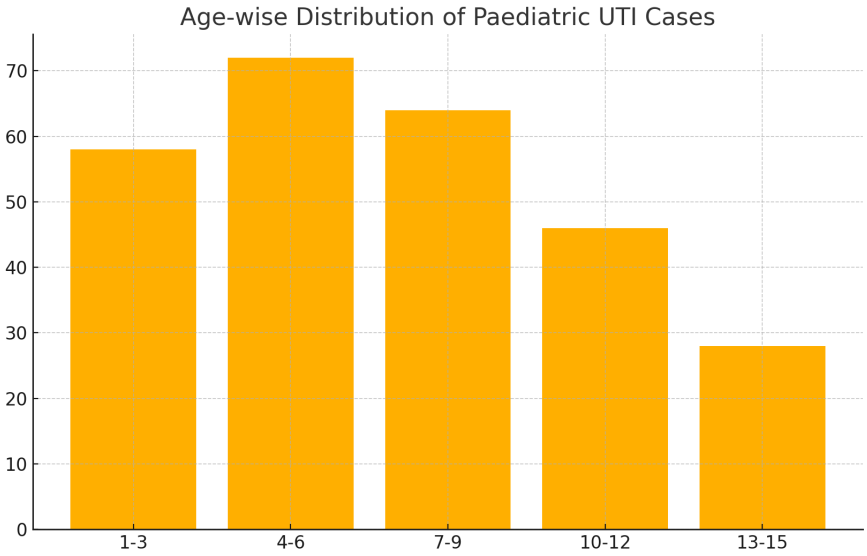

Figure 1: Age-wise distribution of UTI cases

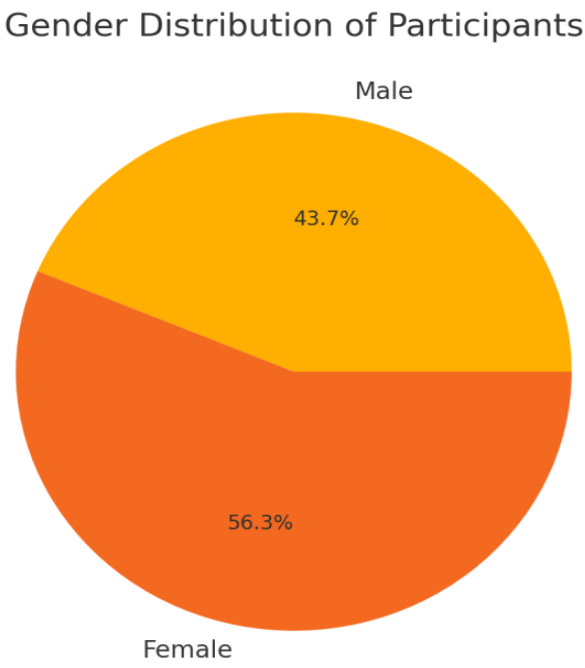

Figure 2: Gender distribution of participants

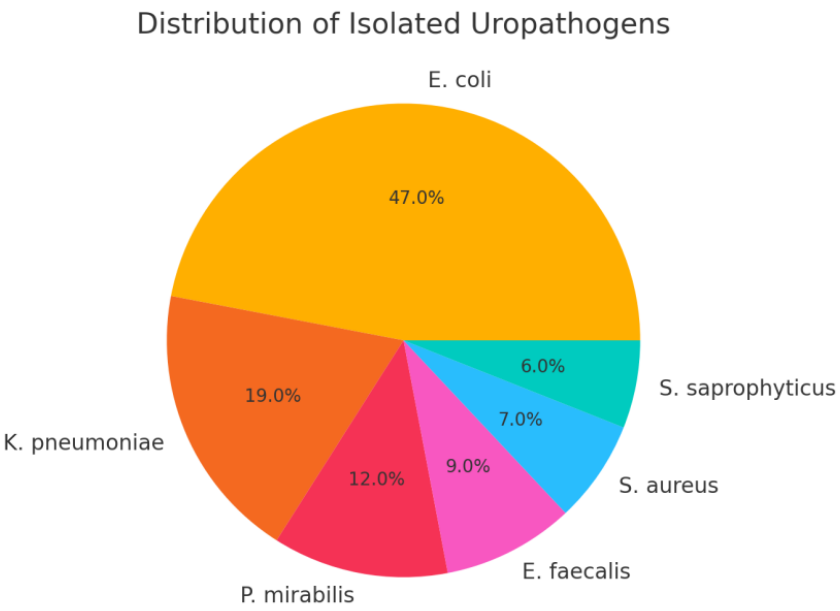

Figure 3: Distribution of isolated uropathogens

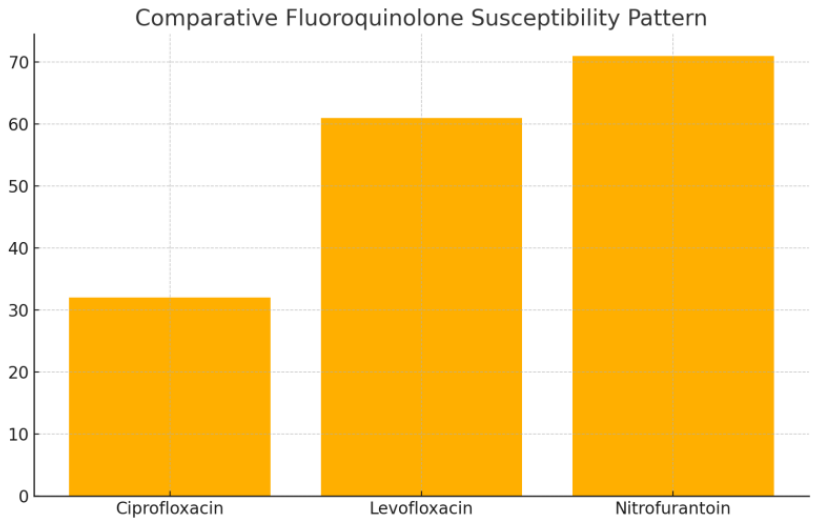

Figure 4: Comparative fluoroquinolone susceptibility pattern

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