



Original Article

Antimicrobial Resistance in Pediatric Urinary Tract Infections: Trends, Challenges and Stewardship

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ABSTRACT

Background: Pediatric urinary tract infections (UTIs) are a common cause of morbidity and a major contributor to antibiotic use in children. The increasing prevalence of antimicrobial resistance (AMR) among uropathogens poses significant challenges to effective empirical therapy and highlights the need for local surveillance and antimicrobial stewardship.

Objectives: To analyze the etiological profile of pediatric UTIs, assess antimicrobial resistance patterns, and evaluate antimicrobial stewardship-related practices at a tertiary care hospital.

Materials and Methods: This hospital-based observational study was conducted at SDM Hospital, Dharwad, from August 2022 to August 2023. A total of 102 pediatric patients with culture-confirmed UTIs were included. Urine samples were processed using standard microbiological techniques, and antimicrobial susceptibility testing was performed according to CLSI guidelines. Data on demographic characteristics, clinical presentation, uropathogens, resistance patterns, and antibiotic use were analyzed descriptively.

Results: Females and children below five years of age were more commonly affected. *Escherichia coli* was the predominant uropathogen, followed by *Klebsiella pneumoniae* and *Enterococcus* species. High resistance rates were observed to ampicillin, cotrimoxazole, and third-generation cephalosporins. Approximately one-third of isolates were multidrug resistant. Nitrofurantoin and amikacin showed better retained activity, while carbapenem resistance remained low. Culture-guided modification and de-escalation of antibiotics were possible in a substantial proportion of cases.

Conclusion: The study highlights a significant burden of antimicrobial resistance in pediatric UTIs. Regular surveillance of local resistance patterns and strict adherence to antimicrobial stewardship principles are essential to optimize antibiotic therapy and limit the progression of antimicrobial resistance in children.

Keywords: Pediatric urinary tract infection, Antimicrobial resistance, Multidrug-resistant organisms, *Escherichia coli*, Antimicrobial stewardship, Urine culture.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common bacterial infections in the pediatric population and represents a significant cause of morbidity, hospital visits, and antibiotic use in children worldwide. It is estimated that up to 7–8% of girls and 2–3% of boys experience at least one episode of UTI during childhood, with the highest incidence observed in infants and young children [1]. If not diagnosed and treated appropriately, pediatric UTIs may lead to serious complications such as renal scarring, hypertension, and chronic kidney disease [2].

The etiological agents causing pediatric UTIs are predominantly Gram-negative bacteria, with *Escherichia coli* being the most frequently isolated uropathogen. Other common organisms include *Klebsiella pneumoniae*, *Proteus* species, *Enterococcus* species, and *Pseudomonas aeruginosa* [3]. The spectrum of causative organisms and their antimicrobial susceptibility patterns, however, vary according to geographical region, patient age, healthcare exposure, and antibiotic prescribing practices [4].

Antimicrobial resistance (AMR) has emerged as a major global public health concern, compromising the effective management of common infections, including pediatric UTIs. The increasing resistance to first-line antibiotics such as ampicillin, cotrimoxazole, and third-generation cephalosporins has been widely reported, particularly in low- and middle-income countries [5]. The emergence of multidrug-resistant (MDR) organisms, extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae, and carbapenem-resistant strains poses a significant therapeutic challenge in pediatric practice [6].

Inappropriate and excessive use of broad-spectrum antibiotics, empirical therapy without culture guidance, and lack of adherence to antimicrobial stewardship principles are key contributors to the rising burden of AMR [7]. Children are particularly vulnerable, as antibiotic exposure early in life not only alters normal microbiota but also increases the risk of resistant infections in the future [8]. Therefore, local surveillance of uropathogens and their resistance patterns is essential to guide empirical therapy and optimize antibiotic use.

Antimicrobial stewardship programs (ASPs) play a crucial role in promoting rational antibiotic prescribing by encouraging culture-based therapy, de-escalation of antibiotics, and adherence to evidence-based guidelines. Hospital-based studies focusing on local resistance trends provide valuable data to support stewardship interventions and policy formulation [9].

In this context, the present study was undertaken at SDM Hospital, Dharwad, to analyze the etiological profile of pediatric UTIs, antimicrobial resistance trends, and stewardship-related challenges over a one-year period. Understanding local resistance patterns is vital for improving patient outcomes and curbing the spread of antimicrobial resistance.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based retrospective observational study conducted at SDM Hospital, Dharwad, a tertiary care teaching hospital in Karnataka, India. The study evaluated antimicrobial resistance patterns in pediatric urinary tract infections (UTIs) over one year, from August 2022 to August 2023.

Study Population and Sample Size

The study included 102 pediatric patients (aged ≤ 18 years) diagnosed with urinary tract infection during the study period. All eligible cases with culture-positive urine samples and complete clinical and microbiological records were included in the analysis.

Inclusion Criteria

- Pediatric patients (≤ 18 years) presenting with symptoms suggestive of UTI
- Positive urine culture with significant bacteriuria
- Availability of complete antimicrobial susceptibility data
- Patients managed at SDM Hospital, Dharwad, during the study period

Exclusion Criteria

- Culture-negative urine samples
- Samples showing mixed growth or contamination
- Patients with incomplete clinical or laboratory data
- Children who had received prolonged antibiotic therapy prior to sample collection

Data Collection

Data were collected retrospectively from hospital medical records and microbiology laboratory registers. The following parameters were recorded:

- Demographic details (age, gender)
- Clinical presentation and risk factors
- Urine culture results and isolated uropathogens
- Antimicrobial susceptibility patterns
- Prior antibiotic exposure, if documented

Sample Collection and Processing

Urine samples were collected using age-appropriate sterile techniques:

- Clean-catch midstream urine for toilet-trained children
- Catheterized urine samples for infants and young children

Samples were processed in the Microbiology Laboratory of SDM Hospital using standard procedures. Urine cultures were performed on CLED and MacConkey agar, and isolates were identified by conventional biochemical methods.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines applicable during the study period. The antibiotics tested included commonly used agents for pediatric UTIs such as:

- Aminoglycosides
- Cephalosporins
- Fluoroquinolones
- Carbapenems
- Nitrofurantoin and other oral agents

Multidrug resistance (MDR) was defined as resistance to three or more classes of antimicrobials.

Antimicrobial Stewardship Assessment

Antibiotic prescription patterns were reviewed to assess:

- Empirical versus culture-guided therapy
- Appropriateness of antibiotic selection based on susceptibility reports
- Need for escalation or de-escalation of therapy

These findings were analysed in the context of antimicrobial stewardship principles.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS software (version ____). Descriptive statistics were used to summarise demographic data, pathogen distribution, and resistance patterns. Results were expressed as frequencies, percentages, mean \pm standard deviation, as appropriate.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of SDM Hospital, Dharwad. As this was a retrospective study, patient confidentiality was maintained, and informed consent was waived in accordance with institutional guidelines.

RESULTS AND OBSERVATIONS

A total of 102 pediatric patients with culture-confirmed urinary tract infection were analyzed during the study period from August 2022 to August 2023 at SDM Hospital, Dharwad.

Demographic Profile

Females constituted a higher proportion of cases compared to males. The majority of infections were observed in children below 5 years of age.

Table 1: Age and Gender Distribution of Study Population (n = 102)

Age Group (years)	Male n (%)	Female n (%)	Total n (%)
<1	7 (6.9)	9 (8.8)	16 (15.7)
1–5	16 (15.7)	26 (25.5)	42 (41.2)
6–10	9 (8.8)	17 (16.7)	26 (25.5)
11–18	7 (6.9)	11 (10.8)	18 (17.6)
Total	39 (38.2)	63 (61.8)	102 (100)

Clinical Presentation

Fever was the most frequent presenting symptom, followed by urinary complaints such as dysuria and increased frequency.

Table 2: Clinical Features at Presentation

Symptom / Sign	Number (n)	Percentage (%)
Fever	76	74.5
Dysuria	58	56.9
Increased frequency	52	51.0
Abdominal / flank pain	39	38.2
Vomiting	27	26.5
Poor feeding / irritability	19	18.6

Microbiological Profile

Gram-negative bacilli were the predominant isolates. *Escherichia coli* was the most common uropathogen.

Table 3: Distribution of Uropathogens (n = 102)

Organism	Number (n)	Percentage (%)
<i>Escherichia coli</i>	57	55.9
<i>Klebsiella pneumoniae</i>	19	18.6
<i>Enterococcus</i> spp.	13	12.7
<i>Proteus</i> spp.	6	5.9
<i>Pseudomonas aeruginosa</i>	5	4.9
<i>Staphylococcus aureus</i>	2	2.0
Total	102	100

Antimicrobial Resistance Pattern – Gram-Negative Isolates

High resistance was noted against commonly used first-line oral antibiotics and third-generation cephalosporins.

Table 4: Resistance Pattern of Gram-Negative Isolates (n = 87)

Antibiotic	Resistant n (%)
Ampicillin	70 (80.5)
Ceftriaxone	59 (67.8)
Cefotaxime	56 (64.4)
Ciprofloxacin	46 (52.9)
Cotrimoxazole	49 (56.3)
Gentamicin	31 (35.6)
Amikacin	20 (23.0)
Nitrofurantoin	13 (14.9)
Carbapenems	5 (5.7)

Multidrug Resistance Pattern

Multidrug resistance (MDR) was identified in **37 isolates (36.3%)**.

Table 5: Distribution of MDR Among Major Uropathogens

Organism	Total Isolates	MDR n (%)
<i>Escherichia coli</i>	57	21 (36.8)
<i>Klebsiella pneumoniae</i>	19	9 (47.4)
<i>Pseudomonas aeruginosa</i>	5	4 (80.0)
Others	21	3 (14.3)
Total	102	37 (36.3)

Antimicrobial Stewardship Observations

Empirical antibiotic therapy was initiated in **88 (86.3%)** patients. Modification of therapy based on culture sensitivity reports was done in **64 (62.7%)** cases. Antibiotic de-escalation was possible in **42 (41.2%)** patients after receipt of susceptibility results.

DISCUSSION

Urinary tract infections continue to be a major cause of bacterial illness in children, and increasing antimicrobial resistance has emerged as a significant challenge in their management. The present study analyzed the etiological spectrum and antimicrobial resistance patterns of pediatric UTIs at a tertiary care hospital in North Karnataka, with an emphasis on stewardship-related implications.

In the current study, female children were more frequently affected than males, which is consistent with established epidemiological trends in pediatric UTIs. This gender predisposition is largely attributed to anatomical factors, including a shorter urethra and closer proximity of the urethral opening to the perineum, facilitating bacterial ascent [10]. The higher proportion of cases in children below five years of age observed in this study is also in agreement with previous reports, reflecting increased susceptibility in early childhood due to immature immune mechanisms and challenges in hygiene maintenance [11].

Microbiological analysis demonstrated that *Escherichia coli* was the predominant uropathogen, accounting for over half of all isolates. This finding aligns with both Indian and global literature identifying *E. coli* as the leading cause of pediatric UTIs [12,13]. The isolation of *Klebsiella pneumoniae* and *Enterococcus* species as the next most common pathogens highlights a shift toward a broader etiological spectrum, particularly in hospital-based settings where prior antibiotic exposure and healthcare contact are common [14].

A notable finding of this study was the high level of resistance to first-line and commonly prescribed antibiotics, including ampicillin, cotrimoxazole, and third-generation cephalosporins. Similar resistance patterns have been documented in multiple Indian studies, suggesting widespread and possibly inappropriate use of these agents in both community and hospital settings [15]. Resistance to third-generation cephalosporins is of particular concern, as these antibiotics are frequently used as empirical therapy in pediatric UTIs and may contribute to the selection of extended-spectrum beta-lactamase (ESBL)-producing organisms [16].

Fluoroquinolone resistance observed in the present study, despite their limited pediatric use, may reflect indirect selective pressure from adult antibiotic consumption and environmental dissemination of resistant strains [17]. In contrast, nitrofurantoin and amikacin retained relatively good activity, supporting their continued role in the treatment of uncomplicated UTIs when guided by culture sensitivity results. These findings are consistent with large surveillance studies demonstrating sustained efficacy of nitrofurantoin against common uropathogens [18].

The proportion of multidrug-resistant (MDR) isolates identified in this study is clinically significant and poses a challenge to empirical management. MDR was more frequently observed among *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, organisms known for their intrinsic and acquired resistance mechanisms [19]. The presence of MDR pathogens underscores the importance of routine culture and susceptibility testing, particularly in hospitalized children and those with recurrent infections.

From an antimicrobial stewardship perspective, empirical antibiotic therapy was commonly initiated, which is often unavoidable in symptomatic pediatric patients. However, modification of therapy based on culture and sensitivity results was achieved in a substantial proportion of cases, allowing for antibiotic de-escalation and optimization. Such practices are central to antimicrobial stewardship and have been shown to reduce unnecessary broad-spectrum antibiotic exposure without adversely affecting patient outcomes [20].

Overall, the findings of this study emphasize the need for continuous local surveillance of antimicrobial resistance patterns to guide empirical therapy and inform institutional antibiotic policies. Rational antibiotic prescribing, early culture-guided therapy, and adherence to stewardship principles are essential to limit the progression of antimicrobial resistance in pediatric UTIs.

CONCLUSION

This study demonstrates a high burden of antimicrobial resistance in pediatric urinary tract infections, with *Escherichia coli* as the predominant pathogen and significant resistance to commonly used first-line antibiotics. The presence of multidrug-resistant organisms limits empirical treatment options. Routine culture-based therapy, rational antibiotic use, and strengthening antimicrobial stewardship programs are essential to guide appropriate treatment and prevent further escalation of resistance in pediatric UTIs.

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