



Original Article

Urinary Tract Infection in Children- Epidemiology, Clinical Features, Organisms and Their Antibiotic Susceptibility Pattern

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ABSTRACT

Background: Urinary tract infections (UTIs) are among the most common bacterial infections in children, resulting in significant morbidity if left untreated. Understanding the epidemiology, clinical features, causative organisms, and their antibiotic susceptibility patterns is crucial for effective management.

Objectives: To evaluate the demographic profile, clinical presentation, microbiological spectrum, and antimicrobial susceptibility patterns in pediatric UTIs at SDM Hospital, Dharwad.

Methods: A prospective observational study was conducted from August 2022 to August 2023. Children aged 1 month to 14 years with urine cultures yielding a single pathogen were included. Clinical features, risk factors, and ultrasonography findings were recorded. Urine samples were processed on CLED agar, and isolates were identified using standard microbiological techniques. Antimicrobial susceptibility was tested by the Modified Kirby–Bauer method, following CLSI guidelines.

Results: Among 102 children, 61.8% were male and 55.9% were aged 1–5 years. Fever (59.8%), dysuria (52.9%), and vomiting (42.1%) were common presentations. Upper UTIs accounted for 37.3% of cases and lower UTIs 62.7%. *E. coli* (64.7%) was the predominant pathogen, followed by *Klebsiella pneumoniae* (15.7%) and *Pseudomonas aeruginosa* (9.8%). High resistance was observed to ampicillin, cephalosporins, and cotrimoxazole, while nitrofurantoin, aminoglycosides, and meropenem showed better sensitivity. Gram-positive isolates (*Enterococcus* spp., CONS, MRSA) exhibited variable resistance, with linezolid and vancomycin remaining effective. Fungal UTIs (*Candida tropicalis*) were fully sensitive to all antifungals tested.

Conclusion: Pediatric UTIs in this cohort were largely caused by *E. coli*, with a significant proportion showing multidrug resistance. Culture-guided therapy is essential, and early diagnosis, identification of risk factors, and antimicrobial stewardship are critical to prevent treatment failure and resistance development.

Keywords: Pediatric urinary tract infection, *Escherichia coli*, antibiotic resistance, antimicrobial susceptibility.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common bacterial infections encountered in the pediatric population and represents a significant cause of morbidity, especially in infants and young children. It is estimated that approximately 2–8% of children experience at least one episode of UTI during childhood, with higher prevalence in females after infancy and in males during the neonatal period due to congenital urinary tract anomalies [1,2]. Pediatric UTIs are of particular concern because of their potential to cause renal parenchymal damage, leading to long-term complications such as hypertension, proteinuria, and chronic kidney disease if not diagnosed and treated promptly [3].

The clinical presentation of UTI in children is often nonspecific and varies with age. While older children may present with classical symptoms such as dysuria, urinary frequency, urgency, and suprapubic pain, infants and young children frequently exhibit nonspecific manifestations including fever, vomiting, irritability, poor feeding, and failure to thrive [4].

This variability in presentation often leads to delayed diagnosis, increasing the risk of complications, particularly in cases of upper urinary tract infection (pyelonephritis) [5].

The etiology of pediatric UTIs is predominantly bacterial, with Gram-negative organisms accounting for the majority of infections. *Escherichia coli* remains the most common causative pathogen worldwide, responsible for 60–80% of cases, followed by *Klebsiella pneumoniae*, *Proteus* species, *Enterococcus* species, and non-fermenting Gram-negative bacilli [6,7]. In recent years, there has been a growing concern regarding the emergence of multidrug-resistant organisms, including extended-spectrum β -lactamase (ESBL)–producing and carbapenem-resistant Enterobacteriaceae (CRE), which significantly limit therapeutic options [8].

Antimicrobial resistance (AMR) among uropathogens has become a major global public health challenge, particularly in developing countries where empirical antibiotic therapy is commonly practiced [9]. Inappropriate antibiotic use, lack of antimicrobial stewardship, and easy over-the-counter availability of antibiotics have contributed to rising resistance rates, leading to increased treatment failure, prolonged hospital stays, and higher healthcare costs [10]. Surveillance of local antimicrobial susceptibility patterns is therefore essential to guide empirical therapy and optimize patient outcomes.

Risk factors such as bowel bladder dysfunction, constipation, recurrent diarrhea, congenital anomalies of the urinary tract, and recurrent UTIs play a crucial role in the pathogenesis and recurrence of pediatric UTIs [11,12]. Imaging modalities like ultrasonography help identify structural abnormalities and complications, aiding in risk stratification and long-term management [13].

Given the changing epidemiology of pediatric UTIs and the alarming rise in antimicrobial resistance, there is a pressing need for institution-based studies to evaluate the clinical profile, microbiological spectrum, and antibiotic susceptibility patterns of uropathogens. Such data are vital for formulating evidence-based empirical treatment guidelines and strengthening antimicrobial stewardship practices. The present study was therefore undertaken at a tertiary care teaching hospital in South India to assess the epidemiology, clinical features, causative organisms, and their antimicrobial susceptibility patterns in children with urinary tract infection.

MATERIALS AND METHODS

Study Design

This was a prospective observational study conducted to evaluate the microbiological profile and antimicrobial susceptibility patterns in pediatric urinary tract infections.

Study Setting

The study was carried out at SDM Hospital, Dharwad, a tertiary care teaching hospital catering to both outpatient and inpatient pediatric populations.

Study Period

The study was conducted over a period of one year, from August 2022 to August 2023.

Study Participants

Children aged 1 month to 14 years attending the outpatient department (OPD) or admitted to SDM Hospital, Dharwad, and suspected of having a urinary tract infection were screened for inclusion.

Inclusion Criteria

- Children aged 1 month to 14 years
- Urine culture yielding a single organism with a significant colony count
- Patients attending OPD or admitted to SDM Hospital during the study period

Exclusion Criteria

- Urine cultures showing polymicrobial growth
- Infants aged less than 1 month

Sampling

Sampling Population

A total of 102 children who met the inclusion criteria were enrolled during the study period.

Sample Size Calculation

Sample size was calculated using the formula:

$$N = \frac{Z^2 \times P \times Q}{d^2}$$

Where:

- **P** = Prevalence from previous studies (8%)
- **Q** = 100 – P (92%)
- **d** = allowable error (6%)
- **Z** = 1.96 for 95% confidence interval

The calculated sample size was 82. However, 102 eligible cases were included during the study period.

Sampling Technique

A convenience sampling technique was employed, enrolling all eligible participants who fulfilled the inclusion criteria during the study period.

Ethical Considerations

The study was approved by the Institutional Ethics Committee.

Written informed consent was obtained from parents or legal guardians prior to enrollment.

Study Procedure and Methodology

Collection and Processing of Urine Samples

Urine specimens were collected using appropriate methods based on age and clinical condition, including:

- Clean-catch midstream urine
- Catheterized urine
- Suprapubic aspiration

Samples were processed using the semi-quantitative culture technique, employing a calibrated loop to inoculate urine onto Cystine Lactose Electrolyte Deficient (CLED) agar.

The inoculated plates were incubated at 37°C for 24 hours under aerobic conditions.

Identification of Isolates

Bacterial isolates were identified using standard microbiological techniques, including:

- Colony morphology
- Gram staining
- Catalase and oxidase tests
- In-house biochemical tests as required

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Modified Kirby–Bauer disc diffusion method on Mueller–Hinton agar, following Clinical and Laboratory Standards Institute (CLSI) guidelines.

Interpretation of results was done according to CLSI zone diameter interpretative criteria.

Diagnosis and Follow-up

Diagnosis of urinary tract infection was based on significant colony count on urine culture. Patients were treated according to culture and sensitivity results and subsequently evaluated using appropriate imaging guidelines for further assessment and follow-up.

Data Collection

Data were collected prospectively using a pre-designed proforma after obtaining informed consent. Demographic details, clinical features, laboratory findings, culture results, and antimicrobial susceptibility patterns were recorded.

Definitions

- **Recurrent UTI:** Two episodes of febrile urinary tract infection
- **Bowel bladder dysfunction:** Voiding less than 3 times or more than 8 times per day, voiding holding maneuvers, straining, or poor urinary stream
- **Simple UTI:** UTI with low-grade fever, dysuria, frequency, and urgency, without features of complicated UTI
- **Complicated UTI:** Presence of fever >39°C, systemic toxicity, persistent vomiting, dehydration, or renal angle tenderness
- **Upper UTI:** Infection involving kidneys and ureters (pyelonephritis), presenting with fever, flank pain, vomiting, lethargy, and malaise
- **Lower UTI:** Infection involving bladder and urethra (cystitis), presenting with dysuria, urinary frequency, urgency, and suprapubic pain

Statistical Analysis

Data were entered into Microsoft Excel 2019 and analysed using IBM SPSS version 21.

- Categorical variables were expressed as frequencies and percentages

- Chi-square test was used to assess associations between categorical variables
- A p-value < 0.05 was considered statistically significant

RESULTS AND OBSERVATIONS;

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

Variable	Category	Frequency	Percentage
Age Group	< 1 year	22	21.6
	1–5 years	57	55.9
	> 5 years	23	22.5
Gender	Male	63	61.8
	Female	39	38.2
Total		102	100.0

Table 2: Various and multiple clinical features among study participants

Clinical features	Frequency	Percent
Fever	61	59.8
Vomiting	43	42.1
Dysuria	54	52.9
Urgency	20	19.6
Frequency	23	22.5
Irritability	40	39.2
Flank /back pain	23	22.5
Suprapubic pain	31	30.39
Poor feeding	37	36.3
Signs of dehydration	22	21.5

Distribution of Upper and Lower UTI (n=102)

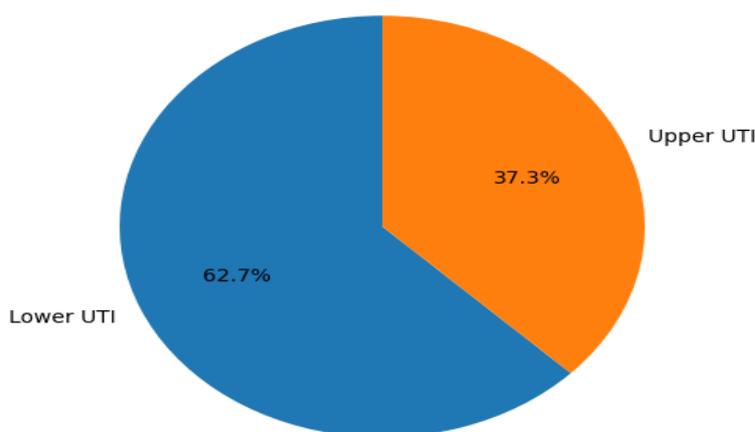


Fig 1: Pie chart showing Upper and lower UTI distribution

Table 3: Distribution of Upper and Lower Urinary Tract Infections Across Different Age Groups and Gender (n = 102)

Type of UTI	Gender	< 1 year n (%)	1–5 years n (%)	> 5 years n (%)	Total n (%)
Upper UTI (n=38)	Male	11 (42.3)	14 (53.8)	1 (3.8)	26 (68.4)
	Female	5 (41.6)	7 (58.3)	0 (0)	12 (31.6)
Lower UTI (n=64)	Male	4 (10.8)	22 (59.5)	11 (29.7)	37 (57.8)
	Female	2 (7.4)	14 (51.8)	11 (40.7)	27 (42.2)

Table 4: Distribution of Risk Factors Among Study Participants Across Different Age Groups (n = 102)

Risk Factor	< 1 year n (%)	1–5 years n (%)	> 5 years n (%)	Total n (%)	p-value
Diarrhoea preceding week	15 (68.2)	18 (31.6)	0 (0.0)	33 (32.4)	0.001
Constipation	2 (9.1)	21 (36.8)	17 (73.9)	40 (39.2)	0.001
Posterior urethral valve (PUV)	3 (13.6)	1 (1.8)	0 (0.0)	4 (3.9)	0.028
Bowel bladder dysfunction (BBD)	0 (0.0)	18 (66.6)	9 (33.3)	27 (26.4)	0.098

Recurrent UTI	9 (40.9)	11 (19.3)	5 (21.7)	25 (24.5)	0.127
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Table 5: Ultrasonography (USG) Findings and Clinical Classification of UTI Among Study Participants (n = 102)

Parameter	Category	Frequency	Percentage
USG Findings	Normal	53	52.0
	Abnormal	33	32.4
	Not done	16	15.7
Abnormal USG Findings(n = 33)	Cystitis	17	51.5
	Hydroureteronephrosis	11	33.3
	Prominent renal pelvis without hydronephrosis	5	15.1
Type of UTI	Complicated UTI	—	—
	Uncomplicated UTI	—	—

Percentages for abnormal USG findings are calculated out of total abnormal scans (n = 33).

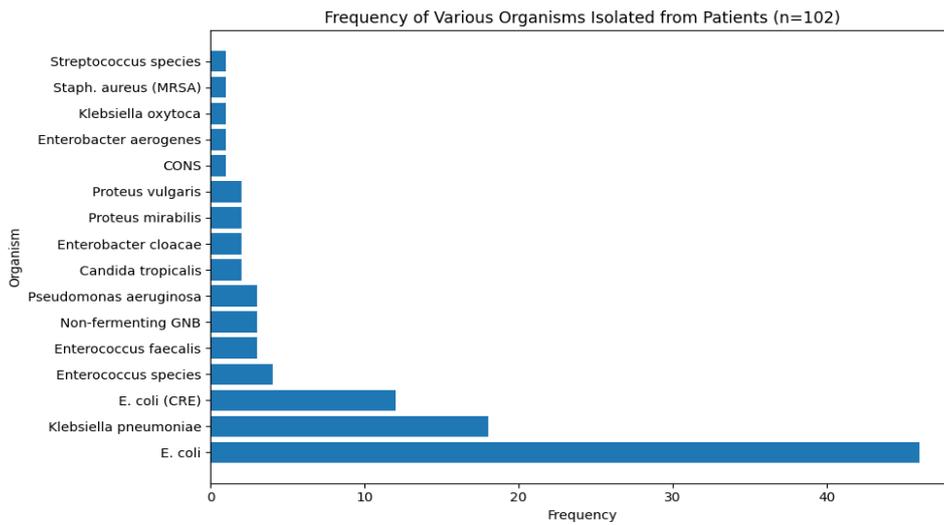


Fig 2: Bar graph showing frequency of various organisms isolated from patients (n = 102)

Chi square = 36.743, P value = 0.185 (NS)

Fig 3 : Multiple bar graph showing frequency of various organism isolated in different age group

Table: 6 Antibiotic Resistance and Sensitivity Patterns of Isolated Organisms (%)

A. Antibiotic Resistance Pattern (%)

Organism	A K	A M P	F E P	F O X	C R O	C I P	S X T	N O R	A M C	C A Z	C T X M	C X M	G E N	N I T	P T Z	C F M	N A	C F	C S T	M E M	C F S	T G C
E. coli	8. 9	95 .6	8 6. 7	68 .9	95 .6	8 2. 2	7 3. 3	87 .7	64 .5	95 .6	97 .8	97 .8	40 .0	4 2. 2	5 7. 8	97 .8	9 7. 8	9 7. 8	6 6. 7	57 .8	6 4. 4	53 .4
E. coli (CRE)	9 2. 3	10 0	1 0 0	10 0	10 0	1 0 0	9 2. 3	10 0	10 0	10 0	10 0	10 0	92 .3	5 3. 8	1 0 0	10 0	1 0 0	1 0 0	5 3. 8	10 0	9 2. 3	38 .5
K. pneu monia e	3 8. 9	94 .4	8 3. 3	66 .7	66 .7	6 6. 7	4 4. 4	50 .0	66 .7	72 .2	10 0	94 .4	33 .3	5 5. 5	5 5. 6	10 0	5 5. 6	1 0 0	6 6. 7	72 .2	6 2. 3	55 .6
Enter ococ cus spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pseud omon as aerugi nosa	0	10 0	0	10 0	10 0	3 3. 3	1 0 0	10 0	10 0	0	10 0	10 0	33 .3	1 0 0	6 6. 7	10 0	1 0 0	1 0 0	3 3. 3	0	0	10 0

B. Antibiotic Sensitivity Pattern (%)

Organism	A K	A M P	F E P	F O X	C R O	C I P	S X T	N O R	A M C	C A Z	C T X	C X M	G E N	N I T	P T Z	C F M	N A	C F	C S T	M E M	C F S	T G C
E. coli	91.1	44.3	13.1	31.4	47.8	17.6	26.7	13.3	35.5	44.2	22.2	60.0	57.8	42.2	42.2	22.2	22.2	33.2	42.2	32.2	35.6	46.6
E. coli (CRE)	77	0	0	0	0	77	0	0	0	0	0	77	46.2	0	0	0	0	0	46.2	0	77	61.5
K. pneumoniae	61.1	56.6	16.7	33.3	33.3	33.3	55.6	50.0	33.3	27.8	0	56.7	66.4	44.5	44.4	0	44.4	0	33.3	27.8	37.7	44.4
Non-fermenting GNB	33.3	0	33.3	0	66.7	66.7	66.7	0	0	33.3	0	66.7	0	0	0	0	0	0	33.3	33.3	33.3	0
Pseudomonas aeruginosa	100	0	100	0	0	66.7	0	0	0	100	0	66.7	0	33.3	0	0	0	0	66.7	100	100	0

Table: 7 Antibiotic Resistance and Sensitivity Patterns of Gram-Positive Isolates (%)

A. Antibiotic Resistance Pattern (%)

Organism	ER Y	GE N	LZ D	PE N	TG C	TE C	CI P	NI T	LE V	TE T	VA N	DA P	CL I	RI F	SX T	OX A	FO X
Enterococcus faecalis	66.7	66.7	0.0	33.3	0.0	0.0	100.0	0.0	100.0	100.0	0.0	0.0	—	—	—	—	—
Enterococcus species	75.0	75.0	0.0	25.0	0.0	0.0	100.0	0.0	100.0	100.0	75.0	100.0	—	—	—	—	—
CONS	100.0	100.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0	100.0	100.0	—	100.0	100.0	100.0	100.0	0.0
Staphylococcus aureus (MRSA)	100.0	100.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	—	100.0	0.0	100.0	100.0	0.0
Streptococcus species	100.0	100.0	0.0	100.0	0.0	0.0	100.0	100.0	100.0	100.0	0.0	—	100.0	100.0	100.0	100.0	100.0

B. Antibiotic Sensitivity Pattern (%)

Organism	ERY	GEN	LZD	PEN	TGC	TEC	CIP	NIT	LEV	TET	VAN	DAP
Enterococcus faecalis	33.3	33.3	100.0	66.7	100.0	100.0	0.0	100.0	0.0	0.0	100.0	100.0
Enterococcus species	25.0	25.0	100.0	75.0	100.0	100.0	0.0	100.0	0.0	0.0	25.0	0.0

Table:8 Antibiotic Sensitivity Patterns of Gram-Positive Isolates (%)

A. Antibiotic Sensitivity Pattern – Panel 1

Organism	Benzyl-Penicillin	Erythromycin	Linezolid	Teicoplanin	Tigecycline	Gentamicin	Ciprofloxacin	Levofloxacin	Nitrofurantoin	Tetracycline
CONS	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0
Staphylococcus aureus (MRSA)	0.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
Streptococcus species	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0

B. Antibiotic Sensitivity Pattern – Panel 2

Organism	Vancomycin	Clindamycin	Rifampicin	Cotrimoxazole	Oxacillin	Cefoxitin
CONS	0.0	0.0	0.0	0.0	0.0	100.0
<i>Staphylococcus aureus</i> (MRSA)	100.0	0.0	100.0	0.0	0.0	100.0
<i>Streptococcus species</i>	100.0	0.0	0.0	0.0	0.0	0.0

Table: 9 Antifungal Susceptibility Pattern in Fungal UTI (%)

C. Antifungal Resistance Pattern

Organism	Amphotericin B	Fluconazole	Voriconazole	Caspofungin	Flucytosine	Micafungin
<i>Candida tropicalis</i>	0.0	0.0	0.0	0.0	0.0	0.0

D. Antifungal Sensitivity Pattern

Organism	Amphotericin B	Fluconazole	Voriconazole	Caspofungin	Flucytosine	Micafungin
<i>Candida tropicalis</i>	100.0	100.0	100.0	100.0	100.0	100.0

DISCUSSION

Urinary tract infection remains a significant cause of morbidity in the pediatric population, and the present prospective observational study provides valuable insights into the epidemiology, clinical presentation, microbiological spectrum, and antimicrobial susceptibility patterns of pediatric UTIs in a tertiary care hospital in South India.

Demographic Profile

In the present study, the majority of cases were observed in children aged 1–5 years (55.9%), followed by those above 5 years (22.5%) and infants below one year (21.6%). Similar age distributions have been reported in previous Indian and international studies, where toddlers and preschool children constituted the most affected age group due to increased exposure, immature immunity, and toilet training–related voiding dysfunctions [14,15]. A male predominance (61.8%) was observed in our study, which contrasts with the female preponderance reported in older children but aligns with findings in infants and young boys where congenital urinary anomalies and uncircumcised status increase susceptibility [16].

Clinical Presentation

Fever was the most common presenting symptom (59.8%), followed by dysuria (52.9%), vomiting (42.1%), irritability (39.2%), and poor feeding (36.3%). These findings are consistent with earlier studies emphasizing that fever remains the most reliable indicator of UTI in young children, while urinary symptoms are more frequently observed in older children [17,18]. The presence of non-specific symptoms such as irritability, vomiting, and poor feeding highlights the diagnostic challenge of pediatric UTIs and reinforces the importance of urine culture in febrile children without an obvious source of infection.

Upper and Lower UTI Distribution

Lower UTIs accounted for 62.7% of cases, while upper UTIs constituted 37.2%, indicating a predominance of cystitis over pyelonephritis. Similar distributions have been reported by Shaikh et al. and Sood et al., who noted that lower UTIs are more common but upper UTIs carry a higher risk of renal scarring and long-term complications [19,20]. Male predominance was more evident in upper UTIs in the younger age group, possibly due to underlying anatomical abnormalities.

Risk Factors

Constipation (39.2%) and bowel bladder dysfunction (26.4%) emerged as significant risk factors, particularly in children above 1 year of age. The strong association between constipation, bladder dysfunction, and UTIs has been well documented, with fecal retention leading to bladder compression, incomplete voiding, and urinary stasis [21]. Diarrhea preceding UTI was significantly associated with infants (<1 year), which may be attributed to perineal contamination and poor hygiene practices [22]. Posterior urethral valve was identified exclusively in male infants, underscoring the importance of evaluating congenital anomalies in recurrent or severe UTIs.

Ultrasonography Findings

Abnormal ultrasonography findings were observed in 32.4% of cases, with cystitis being the most common abnormality followed by hydronephrosis. Comparable rates have been reported in similar hospital-based studies, emphasizing the role of ultrasonography as a non-invasive screening tool for detecting structural abnormalities and guiding further evaluation [23].

Microbiological Profile

Escherichia coli was the predominant uropathogen (45.1%), followed by *Klebsiella pneumoniae* (17.6%) and carbapenem-resistant *E. coli* (11.8%). These findings are consistent with global and Indian literature, where *E. coli*

remains the leading cause of pediatric UTIs due to its virulence factors, including adhesins and biofilm formation [24,25]. The notable proportion of CRE isolates in our study is concerning and reflects the growing burden of antimicrobial resistance in tertiary care settings.

Gram-positive organisms accounted for a smaller proportion of infections, with *Enterococcus* species being the most common among them. Similar trends have been observed in recent studies, suggesting a gradual rise in Gram-positive uropathogens, particularly in hospitalized and catheterized patients [26].

Antimicrobial Resistance Patterns

High resistance rates were observed among Gram-negative isolates to commonly used antibiotics such as ampicillin, ceftriaxone, cefotaxime, ciprofloxacin, and cotrimoxazole. *E. coli* showed resistance exceeding 80% to third-generation cephalosporins and fluoroquinolones, which aligns with reports from other Indian centers [27,28]. The high resistance to oral antibiotics traditionally used for empirical therapy raises serious concerns regarding treatment failures and highlights the need for periodic surveillance.

Carbapenem resistance among *E. coli* (CRE) isolates was alarmingly high, limiting therapeutic options. Similar rising trends of carbapenem resistance have been documented across India, attributed to indiscriminate antibiotic use and lack of robust antimicrobial stewardship programs [29].

Antimicrobial Sensitivity Patterns

Amikacin, gentamicin, nitrofurantoin, piperacillin–tazobactam, and carbapenems demonstrated better sensitivity profiles against most Gram-negative isolates. Nitrofurantoin retained good activity against *E. coli*, supporting its role as a first-line agent for uncomplicated lower UTIs [30]. Gram-positive isolates, particularly *Enterococcus* species, showed excellent sensitivity to linezolid, vancomycin, teicoplanin, and daptomycin, consistent with earlier studies [31].

Fungal UTI

All *Candida tropicalis* isolates demonstrated 100% sensitivity to antifungal agents tested, including amphotericin B, azoles, and echinocandins. This finding is reassuring and comparable with previous pediatric studies, although continued vigilance is necessary due to emerging antifungal resistance reported in other regions [32].

Clinical Implications

The findings of this study emphasize the importance of culture-guided therapy in pediatric UTIs, given the high levels of antimicrobial resistance. Empirical treatment protocols should be revised periodically based on local antibiograms to prevent misuse of broad-spectrum antibiotics and curb the rise of multidrug-resistant organisms.

CONCLUSION

This study demonstrates that pediatric urinary tract infections are predominantly lower UTIs, with *Escherichia coli* as the most common causative organism. A substantial proportion of isolates showed resistance to commonly used empirical antibiotics, indicating a growing burden of antimicrobial resistance. Better sensitivity to nitrofurantoin, aminoglycosides, and higher-end antibiotics highlights the importance of culture-guided therapy. Early diagnosis, identification of underlying risk factors, and adherence to antimicrobial stewardship principles are essential to improve clinical outcomes and prevent the emergence of resistant uropathogens in children.

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