e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(6); 2294-2300

Original Research Article

Bacteriological Profile and Antibiotic Susceptibility Pattern in Pediatric Urinary Tract Infection at a Tertiary Care Centre in Western Rajasthan, India: A Prospective Observational Study

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Received: 10-04-2026 / Revised: 15-05-2026 / Accepted: 11-06-2026

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Conflict of interest: Nil

Abstract

Introduction: Urinary tract infection (UTI) is one of the most common bacterial infections in children and may lead to significant morbidity, including renal scarring and chronic kidney disease if not diagnosed and treated promptly. Knowledge of local uropathogen distribution and antimicrobial susceptibility patterns is essential for appropriate empirical therapy.

Aim: To determine the bacteriological profile and antibiotic susceptibility pattern of urinary tract infections among pediatric patients attending a tertiary care centre in Western Rajasthan.

Materials and Methods: This prospective observational study was conducted in the Department of Pediatrics of a tertiary care teaching hospital in Western Rajasthan, India. A total of 250 children aged less than 18 years with clinically suspected UTI were enrolled. Demographic details, clinical features, laboratory investigations, urine microscopy, urine culture, antimicrobial susceptibility testing, and ultrasonography findings were recorded. Urine culture isolates were identified using standard microbiological methods, and antibiotic susceptibility testing was performed according to standard laboratory protocols.

Results: Among 250 enrolled children, females constituted 58% and the most affected age group was 1–5 years (40.4%). Urine culture positivity was observed in 134 (53.6%) cases. Escherichia coli was the predominant uropathogen, accounting for 52.3% of culture-positive isolates, followed by Klebsiella species (11.9%) and Enterococcus species (9.7%). Overall, the highest antimicrobial sensitivity was observed for nitrofurantoin (53.0%), meropenem (38.8%), vancomycin (24.6%), cefotaxime (20.9%), and cotrimoxazole (18.7%). High resistance rates were observed against doxycycline (26.9%), norfloxacin (26.1%), ceftriaxone (21.6%), ampicillin (19.4%), gentamicin (17.2%), and cefepime (17.2%). E. coli demonstrated maximum sensitivity to nitrofurantoin and meropenem.

Conclusion: Escherichia coli was the most common causative organism of pediatric UTI. Nitrofurantoin and meropenem showed the highest antimicrobial activity against commonly isolated uropathogens, whereas substantial resistance was observed to ampicillin, fluoroquinolones, and third-generation cephalosporins. Periodic surveillance of antimicrobial susceptibility patterns is essential for guiding empirical therapy and combating antimicrobial resistance.

Keywords: Pediatric Urinary Tract Infection, Uropathogens, Antibiotic Susceptibility, Escherichia Coli, Antimicrobial Resistance, Nitrofurantoin.

DOI: 10.25258/ijcpr.18.6.361

Introduction

Urinary tract infection (UTI) is one of the most common bacterial infections in children and constitutes a significant cause of morbidity worldwide. It accounts for a considerable proportion of pediatric outpatient visits and hospital admissions, and if not diagnosed and treated promptly, may lead to renal scarring, hypertension, impaired renal function, and chronic kidney disease. [1,2] The prevalence of UTI varies with age and sex. During infancy, UTIs are more common in boys, particularly uncircumcised infants, whereas after the first year of life, girls are affected more frequently because of anatomical predisposition. A meta-analysis by Shaikh et al., reported that approximately 7% of girls and 2% of boys experience at least one episode of UTI during childhood. [3] The clinical presentation of UTI in children is often age-dependent and may range from nonspecific manifestations such as fever, vomiting, irritability, poor feeding, and failure to thrive in infants to dysuria, frequency, urgency, abdominal pain, and flank pain in older children. [2] Accurate diagnosis requires demonstration of significant bacteriuria in an appropriately collected urine specimen, with urine culture remaining the gold standard investigation for confirmation of infection and identification of the causative organism. [1]

Among the various uropathogens, Escherichia coli is consistently reported as the predominant pathogen responsible for pediatric UTIs, followed by Klebsiella species, Proteus species, Enterococcus species, and other Gram-negative bacilli. [4-6] However, the bacteriological profile of UTI may vary across geographical regions and healthcare settings.

The emergence of antimicrobial resistance among urinary pathogens has become a major therapeutic challenge. Increasing resistance to commonly prescribed antibiotics such as ampicillin, cotrimoxazole, fluoroquinolones, and cephalosporins has been reported worldwide, limiting the effectiveness of empirical therapy. 4,7] Regional variations in antimicrobial susceptibility patterns further necessitate periodic surveillance of local uropathogens and their resistance profiles. [5-8]

Knowledge of the prevailing bacteriological spectrum and antimicrobial susceptibility pattern is therefore essential for selecting appropriate empirical therapy, improving treatment outcomes, and preventing the development of resistant strains. Data regarding pediatric UTI from Western Rajasthan are limited. Hence, the present study was undertaken to determine the bacteriological profile and antibiotic susceptibility pattern of urinary tract infections among children attending a tertiary care teaching hospital in Western Rajasthan.

Materials and Methods

Study Design and Participants: This hospital-based prospective observational study was conducted in the Department of Pediatrics, S.P. Medical College and P.B.M. Associated Group of Hospitals, Bikaner, and Rajasthan, India. Children aged 1 month to 14 years admitted with suspected urinary tract infection (UTI) during the study period were screened for eligibility. A total of 250 children fulfilling the study criteria were enrolled consecutively.

Children presenting with urinary symptoms such as dysuria, urgency, frequency, incontinence, hematuria, suprapubic pain, or fever without an identifiable focus were evaluated for UTI. Patients with culture-confirmed UTI were included in the final analysis. Infants younger than one month of age were excluded from the study.

Clinical Evaluation and Sample Collection: A detailed clinical history and physical examination were performed for all enrolled children. Demographic characteristics, presenting complaints, laboratory findings, and radiological investigations were recorded using a predesigned proforma.

Complicated UTI was defined as infection involving the upper urinary tract and was diagnosed in the presence of one or more of the following features: fever >39°C, systemic toxicity, persistent vomiting, dehydration, renal angle tenderness, or elevated serum creatinine. Recurrent UTI was defined as a previous history of one or more documented episodes of UTI.

Laboratory investigations included complete blood count, blood urea, serum creatinine, serum electrolytes, urine microscopy, and urine culture. Blood cultures were obtained in infants whenever clinically indicated to exclude septicemia. Urine microscopy was performed to detect pyuria, hematuria, epithelial cells, casts, and other abnormalities.

Clean-catch midstream urine samples were collected from children older than three years. In infants and younger children, urine specimens were obtained by transurethral bladder catheterization using aseptic precautions.

Ultrasonography of the abdomen was performed in children with significant bacteriuria. Further imaging studies, including micturating cystourethrography, were advised when clinically indicated or when ultrasonographic abnormalities were detected.

Microbiological Processing and Antibiotic Susceptibility Testing: Urine specimens were processed immediately in the microbiology laboratory. Samples were inoculated on MacConkey agar, Nutrient agar, and HiCrome UTI agar using a calibrated loop technique. Significant bacteriuria was defined as growth of a single organism at a concentration of $\geq 10^5$ colony-forming units (CFU)/mL in clean-catch midstream urine samples and $\geq 5\times10^4$ CFU/mL in catheter-obtained specimens.

Bacterial isolates were identified by standard microbiological methods. Antimicrobial susceptibility testing was performed on Mueller-Hinton agar using the Kirby-Bauer disc diffusion method. Extended-spectrum beta-lactamase (ESBL) production was detected by the double-disc synergy test. Interpretation of antimicrobial susceptibility results was carried out according to Clinical and Laboratory Standards Institute (CLSI) recommendations. [9]

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software. Continuous variables were summarized using measures of central tendency and dispersion, whereas categorical variables were expressed as frequencies and percentages. Results were presented using tables and figures. Appropriate statistical tests were applied wherever required, and a p-value <0.05 was considered statistically significant.

Results

A total of 250 children with clinically suspected urinary tract infection (UTI) were enrolled during the study period. Females constituted 145 (58.0%) patients and males 105 (42.0%).

The most commonly affected age group was 1–5 years [101 (40.4%)], followed by 6–10 years [71 (28.4%)], >10 years [43 (17.2%)], and 1 month–1 year [35 (14.0%)]. Urban residents accounted for 141 (56.4%) cases, while 109 (43.6%) belonged to rural areas. The majority of patients belonged to the middle socioeconomic class [74 (29.6%)]. (Table 1)

Table 1: Demographic Characteristics and Culture Positivity of Study Population

	Variable	**Number (%)**
Gender	Male	105 (42.0%)
	Female	145 (58.0%)
Age	Age 1 month–1 year	35 (14%)
	Age 1–5 years	101 (40.4%)
	Age 6-10 years	71 (28.4%)
	>10 years	43 (17.2%)
Area of residence	Rural	109 (43.6%)
	Urban	141 (56.4%)
Socioeconomic Status	Lower	11 (4.4%)
	Lower Middle	57 (22.8%)
	Middle	74 (29.6%)
	Upper Middle	65 (26%)
	Upper	43 (17.2%)

Significant bacteriuria was detected in 134 (53.6%) children, whereas urine cultures were sterile in 116 (46.4%) cases. (Figure 1).

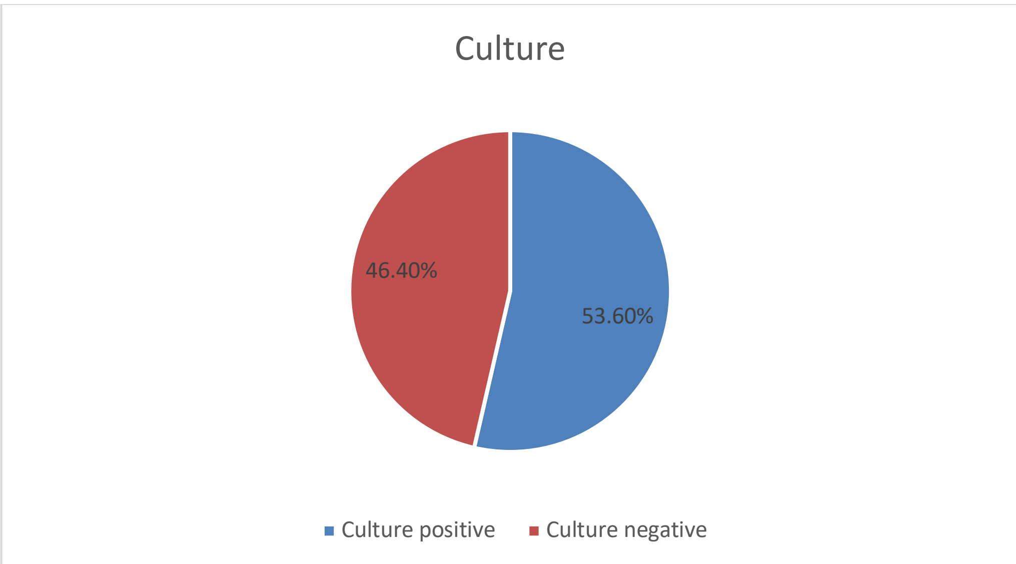

Figure 1: Culture finding in study subjects

Among the microorganisms isolated, Escherichia coli was the predominant pathogen, isolated in 70 (28.0%) cases, followed by Klebsiella species in 16 (6.4%) cases and Enterococcus species in 13 (5.2%) cases. Fungal isolates were identified in 13 (5.2%) children, including Candida albicans and non-albicans Candida species. Mixed growth was observed in six cases (Table 2).

Table 2: Distribution of Uropathogens Isolated from Samples (n=250)

Organism grown	No. of Cases	%
Gram Negative		
E. Coli	70	28.0
Klebsiella	16	6.4
Enterococcus	13	5.2
Acinetobacter	4	1.6
Proteus	1	0.4
Gram Positive		
MRSA	4	1.6
MSSA	3	1.2
CONS	3	1.2
Staphylococcus	1	0.4
Fungal Infection		
Candida albicans	8	3.2
Candida non-albicans	5	2.0
Mixed		
E. Coli & MRSA	1	0.4
E. Coli & Candida Non-albicans	1	0.4
E. Coli&Acinetobacter	1	0.4
E. Coli &Klebsiella	1	0.4
E. Coli &Enterococcus	1	0.4
Klebsiella, Candida	1	0.4
Sterile	116	46.4

Antimicrobial susceptibility testing revealed that nitrofurantoin exhibited the highest sensitivity [71 (53.0%)], followed by meropenem [52 (38.8%)], vancomycin [33 (24.6%)], cefotaxime [28 (20.9%)], and cotrimoxazole [25 (18.7%)]. High resistance rates were observed with doxycycline [36 (26.9%)], norfloxacin [35 (26.1%)], ceftriaxone [29 (21.6%)], ampicillin [26 (19.4%)], gentamicin [23 (17.2%)], and cefepime [23 (17.2%)] (Table 3).

Table 3: Antibiotic sensitivity for common antibiotics

Antibiotics	Sensitive		Resistance	
	No.	%	No.	%
Quinolones				
Ofloxacin	9	6.7	9	6.7
Norfloxacin	5	3.7	35	26.1
Ciprofloxacin	5	3.7	14	10.4
Nalidixic Acid	1	0.7	14	10.4
Penicillin				
Amoxiclav	5	3.7	5	3.7
Pipera+Tazo	12	4.8	4	1.6
Ampicillin	18	13.4	26	19.4
Cephalosporin				
Cefoxitin	0	-	14	10.4
Cephalexin	3	2.2	3	2.2
Cefoperazone	17	12.7	11	8.2
Cefpodoxime	0	-	11	8.2
Cefuroxime	1	0.7	10	7.5
Cefepime	5	3.7	23	17.2
Ceftriaxone	11	8.2	29	21.6
Cefotaxime	28	20.9	18	13.4
Ceftazidime	3	2.2	5	3.7

Overall, Gram-negative organisms constituted the majority of isolates, with Escherichia coli emerging as the predominant uropathogen. Nitrofurantoin and carbapenems demonstrated the highest antimicrobial activity against urinary isolates, whereas considerable resistance was observed against fluoroquinolones, ampicillin, and third-generation cephalosporins.

Table 4: Antibiotic sensitivity (Others)

Antibiotics	Sensitive		Resistance	
	No.	%	No.	%
Aminoglycosides				
Gentamycin	3	2.2	23	17.2
Amikacin	15	11.2	8	6.0
Macrolides				
Clarithromycin	0	-	10	7.5
Azithromycin	12	9.0	13	9.7
Carbapenem				
Meropenem	52	38.8	1	0.7
Imipenem	12	9.0	1	0.7
Polypeptides				
Colistin	9	6.7	11	8.2
Polymyxin B	4	3.0	1	0.7
Nitrofuran Derivatives				
Nitrofurantoin	71	53.0	3	2.2
Tetracycline				
Doxycycline	5	3.7	36	26.9
Lincosamide				
Clindamycin	7	5.2	17	12.7
Monobactam				
Aztreonam	4	3.0	8	6.0
Oxazolidinone				
Linezolid	11	8.2	5	3.7
Cotrimoxazole	25	18.7	19	14.2
Glycopeptide				
Vancomycin	33	24.6	3	2.2

Discussion

Urinary tract infection remains one of the most common bacterial infections in children and constitutes an important cause of morbidity due to its potential long-term complications. Early diagnosis and institution of appropriate antimicrobial therapy are essential to prevent renal damage and recurrent infections. In the present study, the bacteriological profile and antimicrobial susceptibility pattern of pediatric UTI were evaluated among 250 children attending a tertiary care teaching hospital in Western Rajasthan.

Female predominance was observed in the present study, with females accounting for 58.0% of cases. Similar findings have been reported by Sharma et al., Taneja et al., and Badhan et al., who documented a higher prevalence of UTI among female children due to anatomical factors such as a shorter urethra and closer proximity of the urethral opening to the perineum. [5-7] The increased susceptibility of female children to ascending urinary tract infections has been consistently reported in pediatric literature.

The most commonly affected age group in the present study was 1–5 years (40.4%). Similar observations were reported by Singh and Madhup, who found the highest incidence of UTI in preschool-aged children. [10] This age group is particularly vulnerable because of incomplete toilet training, poor perineal hygiene, and increased exposure to environmental pathogens.

In the present study, urine culture positivity was observed in 53.6% of patients. Comparable culture positivity rates have been reported by Sharma et al. and Guidoni et al. in studies evaluating pediatric urinary tract infections. [5,11] Variations in culture positivity among studies may be attributed to differences in patient selection, urine collection techniques, prior antibiotic exposure, and diagnostic criteria used for significant bacteriuria.

Escherichia coli was the predominant uropathogen isolated in the present study, accounting for 52.2% of culture-positive isolates. This finding is consistent with reports by Taneja et al., Badhan et al., Kalantar et al., and Farajnia et al., who also identified E. coli as the leading cause of pediatric UTI. [6,8-12] The predominance of E. coli can be explained by the presence of specific virulence factors, including adhesins, fimbriae, and biofilm-forming capabilities that facilitate colonization of the urinary tract.

Klebsiella species and Enterococcus species were the second and third most common isolates, respectively. Similar bacteriological patterns have been documented in studies from India and other developing countries. [6,7,12] The presence of these organisms emphasizes the need for continuous microbiological surveillance, as their antimicrobial susceptibility profiles often differ from those of E. coli. Analysis of antimicrobial susceptibility patterns revealed that nitrofurantoin demonstrated the highest sensitivity among isolated uropathogens, followed by meropenem and vancomycin. These findings are in agreement with those reported by Kalantar et al. and Farajnia et al., who observed excellent activity of nitrofurantoin against common urinary pathogens. [8,12] Nitrofurantoin achieves high urinary concentrations and has retained activity against many multidrug-resistant urinary isolates, making it a valuable option for the treatment of uncomplicated lower urinary tract infections.

A concerning finding of the present study was the high level of resistance observed against doxycycline, norfloxacin, ceftriaxone, ampicillin, gentamicin, and cefepime. Similar resistance trends have been reported by Akram et al. and Guidoni et al., highlighting the global emergence of antimicrobial resistance among uropathogens. [13,11] Increasing resistance to fluoroquinolones and cephalosporins may be attributed to indiscriminate antibiotic use, self-medication, and widespread empirical prescription practices. These findings underscore the importance of antibiotic stewardship programs and periodic monitoring of local antimicrobial susceptibility patterns.

The findings of the present study have important clinical implications. Knowledge of local bacteriological profiles and resistance patterns can guide empirical antibiotic selection and improve treatment outcomes. Based on the susceptibility profile observed in the present study, nitrofurantoin may be considered an effective first-line option for uncomplicated UTI, whereas empirical use of fluoroquinolones and certain cephalosporins should be undertaken with caution due to high resistance rates.

The strengths of the present study include its prospective design and relatively large sample size. However, being a single-center study, the findings may not be generalizable to all geographic regions.

Multicentric studies involving larger populations are required to provide a broader understanding of antimicrobial resistance trends among pediatric uropathogens in India.

Conclusion

Escherichia coli was the predominant uropathogen causing pediatric urinary tract infection in the present study, followed by Klebsiella and Enterococcus species. Nitrofurantoin showed the highest antimicrobial sensitivity, while considerable resistance was observed against commonly used antibiotics such as norfloxacin, ceftriaxone, and ampicillin. These findings highlight the need for regular monitoring of local antimicrobial susceptibility patterns to guide appropriate empirical therapy and promote rational antibiotic use.

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