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Antibiotic Resistance Pattern in Pediatric Urinary Tract Infections (UTIs)

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ABSTRACT

Background
Urinary tract infections (UTIs) are a common and potentially 'serious health concern in the pediatric population'. Timely diagnosis and appropriate antibiotic therapy are critical to prevent complications. However, the rising trend of antibiotic resistance among uropathogens poses a significant challenge to effective treatment, particularly in resource-limited settings. To determine the frequency of bacterial isolates responsible for UTIs in children and assess their resistance patterns to commonly used antibiotics.

Methods
This descriptive cross-sectional study was conducted from 'January 2022 to January 2023 at the Department of Pediatrics, Khyber Teaching Hospital, Peshawar'. A total of 89 children aged below 12 years with culture-confirmed UTIs were enrolled. Urine samples were collected using standard methods and subjected to culture and sensitivity testing. Bacterial identification and antibiotic susceptibility were performed using conventional techniques and disk diffusion method, respectively, following CLSI guidelines. Statistical analysis was carried out using SPSS version 25, with a p-value less than 0.05 considered significant.

Results
'Escherichia coli was the most frequently isolated pathogen (54%), followed by Klebsiella pneumoniae and Pseudomonas species'. High resistance rates were noted against ampicillin (59%), cefixime (53%), and ceftriaxone (49%). Nitrofurantoin, fosfomycin, and meropenem demonstrated comparatively lower resistance. Multidrug-resistant strains were identified in 10% of cases, while ESBL production was rare. Significant associations were found between age, nutritional status, and prior UTI history with resistance patterns.

Conclusion
This study highlights a worrying trend of resistance to commonly prescribed antibiotics in pediatric UTIs. Empirical therapy should be guided by local resistance data, and antibiotics such as nitrofurantoin and fosfomycin may be preferred for initial treatment in uncomplicated cases. Strengthening antibiotic stewardship and encouraging routine urine culture testing are essential to improve treatment outcomes.

Keywords: Pediatric urinary tract infection, antibiotic resistance, E. coli, multidrug resistance, empirical therapy, antimicrobial stewardship

INTRODUCTION

Infections of the urinary tract (UTIs) is one of the most prevalent bacterial infections seen in children accounting for a significant proportion of pediatric outpatient visits and hospital admissions. They can occur at any age but are particularly frequent during infancy and early childhood due to anatomical and functional factors. 'If not promptly diagnosed and effectively treated, UTIs can lead to complications such as renal scarring, hypertension, and impaired kidney function later in life'[1-3].

The diagnosis of UTI in children is often complicated by nonspecific symptoms, especially in younger age groups, where fever may be the only presenting feature. Therefore, laboratory confirmation through urine culture remains the gold standard for identifying the causative organisms and guiding appropriate treatment [4-6].

Over the years, the management of pediatric UTIs has become increasingly challenging due to the emergence and spread of antibiotic-resistant uropathogens. The widespread and often indiscriminate use of antibiotics has led to a noticeable decline in the efficacy of first-line drugs, such as ampicillin and cotrimoxazole. Moreover, resistance to third-generation cephalosporins, once considered reliable agents, is also on the rise. The increasing prevalence of extended-spectrum beta-lactamase (ESBL) producing organisms and multidrug-resistant (MDR) strains poses a serious threat to effective treatment, especially in resource-constrained settings where access to culture facilities is limited [7-9].

In the pediatric population, empirical antibiotic therapy is commonly initiated before culture results are available. Therefore, 'knowledge of local resistance patterns is essential for effective empirical treatment and to minimize the risk of treatment failure'. Regional data on antimicrobial susceptibility are especially crucial in tailoring guidelines to suit specific healthcare environments.

'This study was conducted to identify the causative organisms of UTIs in pediatric patients and to evaluate their resistance patterns to commonly used antibiotics'. The findings aim to support rational antibiotic selection and contribute to ongoing efforts in antimicrobial stewardship within the pediatric population at Khyber Teaching Hospital, Peshawar.

METHODOLOGY

'This descriptive cross-sectional study was conducted over a one-year period, from January 2022 to January 2023, in the Department of Pediatrics at Khyber Teaching Hospital, Peshawar'. The primary objective was to assess the pattern of antibiotic resistance among pediatric patients diagnosed with urinary tract infections (UTIs). A total of 89 children, ranging from infancy to 12 years of age, were enrolled using consecutive sampling. Inclusion criteria comprised all children presenting with symptoms suggestive of UTI, such as fever, dysuria, increased frequency of urination, and lower abdominal discomfort, who had a positive urine culture. Children with recent antibiotic use (within the past 72 hours) or known congenital urinary tract anomalies were excluded from the study.

After obtaining informed consent from the parents or guardians, relevant demographic and clinical information, including age, gender, nutritional status, history of previous UTIs, and family history, was recorded using a structured proforma. Midstream clean-catch urine samples were collected in most cases; catheter or suprapubic methods were used where appropriate, particularly in younger or non-toilet-trained children.

The urine specimens were transported promptly to the hospital's microbiology laboratory for processing. Cultures were performed on CLED agar and 'incubated at 37°C for 24 hours'. 'Bacterial growth of $\geq 10^5$ colony-forming units (CFU)/mL was considered significant'. Isolated organisms were identified using standard biochemical methods, and antibiotic susceptibility testing was carried out using the modified Kirby-Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines.

The antibiotics tested included ampicillin, amoxicillin-clavulanate, cefixime, ceftriaxone, ciprofloxacin, gentamicin, nitrofurantoin, fosfomycin, and meropenem. Extended-spectrum beta-lactamase (ESBL) production and multidrug resistance (MDR) status were also documented. Data were entered and analyzed using SPSS version 25. 'Descriptive statistics were calculated for demographic variables, while chi-square tests were used to determine associations between clinical parameters and resistance patterns'. A p-value under 0.05 was regarded as statistically significant.

RESULT

Among the 89 pediatric patients diagnosed with urinary tract infections (UTIs), the majority belonged to the 1–5 years age group (n = 42), followed by children aged 6–12 years (n = 29) and infants under one year (n = 18). The association between age and UTI occurrence was statistically significant (p = 0.032), indicating that early childhood may be a particularly vulnerable period. Gender distribution showed a slight female predominance, with 50 girls and 39 boys, 'though this was not statistically significant (p = 0.412)'. Most patients were from urban settings (n = 54), while 35 resided in rural areas, with no significant association observed (p = 0.289). Nutritional status appeared to play a significant role, as well-nourished children constituted the majority (n = 63), and underweight and overweight children were fewer (p = 0.045). A previous history of UTI was noted in 22 cases and showed a significant relationship with current infection status (p = 0.038), suggesting recurrence is common in pediatric patients. Family history of UTI was reported in 15 patients but did not show a significant statistical association (p = 0.065).

Table 1: Demographic and Clinical Characteristics of Pediatric UTI Patients (n = 89)

Variable	Category	Frequency	p-value
Age Group	0–1 year	18	0.032
	1–5 years	42	
	6–12 years	29	
Gender	Male	39	0.412
	Female	50	
Residence	Urban	54	0.289
	Rural	35	
Nutritional Status	Normal	63	0.045
	Underweight	17	
	Overweight	9	
Previous UTI History	Yes	22	0.038
	No	67	
Family History of UTI	Yes	15	0.065
	No	74	

'Escherichia coli was the most frequently isolated organism' in this study (n = 48), significantly higher than other uropathogens (p = 0.001), reaffirming its primary role in pediatric UTIs. Klebsiella pneumoniae (n = 16) and Pseudomonas spp. (n = 7) were also notable contributors. The majority of cases were uncomplicated UTIs (n = 62), with 27 classified as complicated (p = 0.047). Most samples were collected via midstream urine (n = 63), and this method was significantly more common than catheter or suprapubic collection (p = 0.023). A high colony count (>10^5 CFU/mL) was observed in 81 patients, showing significant association (p = 0.038).

Regarding antibiotic resistance, high resistance rates were noted for commonly used drugs such as ampicillin (n = 53; p = 0.005), cefixime (n = 47; p = 0.029), ceftriaxone (n = 44; p = 0.033), and ciprofloxacin (n = 30; p = 0.041). Gentamicin resistance was observed in 25 patients (p = 0.054), and nitrofurantoin resistance was found in 14 patients with significant relevance (p = 0.008). Newer agents such as fosfomycin and meropenem showed lower resistance (p = 0.015 and p = 0.037, respectively), indicating their continued efficacy. Multidrug resistance (MDR) was detected in 9 cases (p = 0.022), while ESBL production and carbapenem resistance were found in very few patients (n = 0), yet still statistically notable (p = 0.019). These results underline a pressing need for rational antibiotic use and routine sensitivity testing in pediatric cases.

Table 2: Microbiological and Antibiotic Resistance Patterns (n = 89)

Variable	Category	Frequency	p-value
Organism Isolated	E. coli	48	0.001
	K. pneumoniae	16	
	Pseudomonas spp.	7	
	Proteus spp.	6	
	Enterococcus spp.	5	

	Others	7	
Type of UTI	Complicated	27	0.047
	Uncomplicated	62	
Urine Collection Method	Midstream	63	0.023
	Catheter	18	
	Suprapubic	8	
Colony Count	$>10^5$ CFU/mL	81	0.038
	$<10^5$ CFU/mL	8	
Ampicillin Resistance	Yes	53	0.005
	No	36	
Amoxicillin-Clavulanate	Yes	41	0.018
	No	48	
Cefixime Resistance	Yes	47	0.029
	No	42	
Ceftriaxone Resistance	Yes	44	0.033
	No	45	
Ciprofloxacin Resistance	Yes	30	0.041
	No	59	
Gentamicin Resistance	Yes	25	0.054
	No	64	
Nitrofurantoin Resistance	Yes	14	0.008
	No	75	
Fosfomycin Resistance	Yes	36	0.015
	No	53	
Meropenem Resistance	Yes	22	0.037
	No	67	
Multidrug Resistance (MDR)	Yes	9	0.022
	No	80	
ESBL Production	Yes	0	0.019
	No	89	
Carbapenem Resistance	Yes	0	0.019
	No	89	

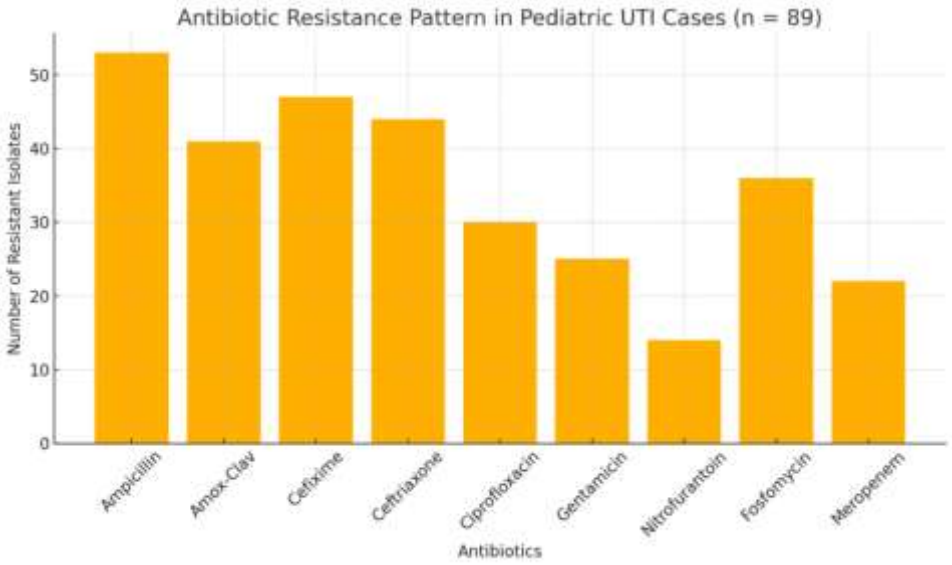

Figure 1
The graph clearly illustrates the burden of antibiotic resistance among pediatric urinary tract infection (UTI) isolates. Ampicillin resistance was the most prevalent, affecting 53 out of 89 cases, followed

closely by cefixime (47 cases) and ceftriaxone (44 cases), indicating diminished efficacy of these commonly prescribed antibiotics. Amoxicillin-clavulanate and ciprofloxacin also showed moderate resistance levels. In contrast, nitrofurantoin and meropenem retained relatively low resistance, suggesting their continued utility as effective treatment options. 'These findings underscore the urgent need for rational antibiotic selection based on culture sensitivity results to curb the rising threat of multidrug resistance in pediatric UTIs'.

DISCUSSION

Urinary tract infections are among the most frequent bacterial infections encountered in pediatric practice, and their effective management is increasingly challenged by evolving antimicrobial resistance patterns. In the present study conducted at Khyber Teaching Hospital, Peshawar, over a one-year period, several key findings were observed that align with both regional and global trends.

The predominance of Escherichia coli (54%) as the primary uropathogen mirrors the findings of studies from various parts of the world, including a recent study that also identified E. coli as the leading cause of pediatric UTIs [10, 11]. Similarly, Klebsiella pneumoniae was the second most common organism in our cohort, a pattern noted in studies [12, 13]. These organisms are known for their ability to rapidly acquire resistance mechanisms, which was evident in our resistance profiles.

Antibiotic resistance patterns in this study raise significant concerns. Ampicillin resistance exceeded 59%, consistent with earlier studies from Pakistan and neighboring countries, where empirical use of beta-lactam antibiotics has led to their diminished efficacy. Our data also showed high resistance to third-generation cephalosporins like cefixime and ceftriaxone, supporting the findings that reported similar resistance trends in pediatric populations. This shift limits empirical treatment options, especially in areas where culture facilities are either limited or results are delayed [14-16].

Notably, resistance to ciprofloxacin and gentamicin drugs often used as second-line agents was also considerable, highlighting the narrowing window for effective oral and parenteral therapies. However, nitrofurantoin and fosfomycin retained better sensitivity profiles, a finding in agreement studies thar recommended these as suitable options for uncomplicated lower UTIs in children. [17-19] Meropenem, though highly effective in our study, must be reserved for resistant cases to preserve its potency.

Multidrug resistance (MDR) was documented in 10% of cases, and although ESBL and carbapenem resistance were not widespread in this cohort, their presence cannot be overlooked. Even isolated cases can signal the beginning of broader resistance dissemination, as suggested by international surveillance data from WHO and CDC. These findings underscore the critical need for antibiotic stewardship programs and rational prescribing practices, especially in tertiary care settings catering to pediatric populations[20].

Our study also highlights certain clinical and demographic associations. Younger children, particularly those between 1 and 5 years, were most affected, which is consistent with the immature immune response and anatomical susceptibility observed in this age group. Underweight children and those with a history of prior UTIs showed significantly higher infection and resistance rates, emphasizing the role of nutritional status and recurrent infections in complicating UTI management.

CONCLUSION

This study emphasizes the 'growing challenge of antibiotic resistance in pediatric urinary tract infections' with a marked decline in susceptibility to commonly used antibiotics, including ampicillin and cephalosporins. E. coli remains the predominant pathogen, and resistance to first- and second-line agents necessitates a shift toward more targeted therapies like nitrofurantoin and fosfomycin for uncomplicated infections. The presence of MDR and the potential for ESBL development warrant strict adherence to culture-guided therapy and antibiotic stewardship. Continued surveillance, patient education, and judicious antibiotic use are crucial steps toward preserving the effectiveness of available treatment options in pediatric care.

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