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Antibiotic Resistance Patterns in Pediatric and Adult Urinary Tract Infections

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Abstract

Antimicrobial resistance in urinary tract infections (UTIs) poses a major challenge to effective treatment across age groups. This cross-sectional study examined resistance patterns in 240 patients (120 pediatric, age 1–17; 120 adult, age 18–75) presenting with culture-confirmed UTIs. Escherichia coli was isolated in 75% of pediatric and 68% of adult cases, with Klebsiella pneumoniae accounting for the remainder. Resistance to ampicillin was markedly elevated in both cohorts (pediatric: 78%; adult: 71%; $p = 0.21$). Pediatric isolates demonstrated higher trimethoprim-sulfamethoxazole resistance (65% vs. 52%, $p = 0.04$), whereas adult isolates exhibited greater ciprofloxacin resistance (adult: 62%; pediatric: 28%; $p < 0.001$). Nitrofurantoin retained high efficacy across both groups (>85% susceptibility). Multivariate logistic regression, adjusted for gender and inpatient status, confirmed adult age as an independent predictor of fluoroquinolone resistance (OR = 3.4; 95% CI 1.9–6.1; $p < 0.001$). These findings reveal divergent resistance profiles between pediatric and adult UTIs, with significant implications for age-specific empirical therapy. The study underscores the need for periodic surveillance and targeted antibiotic stewardship.

Keywords: urinary tract infection; antibiotic resistance; pediatrics

Introduction

Urinary tract infections (UTIs) are common bacterial infections affecting individuals across all age groups, with a rising global burden compounded by increasing antimicrobial resistance[1]. In both pediatric and adult populations, UTIs are frequently caused by Gram-negative pathogens—predominantly Escherichia coli and Klebsiella pneumoniae[2]. Empirical therapy has traditionally relied on first-line antibiotics such as ampicillin, trimethoprim-sulfamethoxazole (TMP-SMX), fluoroquinolones, and nitrofurantoin[3]. However, recent surveillance data (2022–2025) report escalating resistance to numerous antimicrobials, undermining treatment efficacy and prompting concerns about therapeutic failures[4].

Age-specific factors may contribute to differential resistance patterns. Pediatric patients often receive TMP-SMX for prophylaxis or treatment, potentially driving resistance[5]. Conversely, adults—particularly those with recurrent UTIs or hospital exposure—may have higher exposure to fluoroquinolones, fostering resistance development[6]. Despite these insights, comparative studies evaluating resistance across pediatric and adult populations within a single framework remain limited[7].

Local antibiograms often guide empiric therapy, but such profiles frequently amalgamate adult and pediatric data, obscuring age-specific trends and possibly leading to suboptimal prescribing[8]. Recognizing distinct resistance patterns is critical; fluoroquinolones, for instance, are contraindicated in children due to toxicity concerns, whereas nitrofurantoin is favored in pediatric UTIs given its efficacy and safety[9]. Adult prescribing trends—with higher fluoroquinolone usage—may necessitate alternative empiric options[10].

Surveillance studies from 2023–2024 observed persistent ampicillin resistance (>70%) in pediatric UTIs and increasing adult resistance to ciprofloxacin (>60%)[11]. Yet, differences in TMP-SMX resistance across age groups have not been thoroughly explored within the same patient population[12].

This cross-sectional study aimed to compare antibiotic resistance patterns in pediatric versus adult UTIs, focusing on common uropathogens and clinically relevant antibiotics. By stratifying data and utilizing robust statistical analysis with adjustment for confounders, the study provides actionable insights to refine age-appropriate empirical therapy and inform stewardship strategies[13],[41],[15].

Methodology

A cross-sectional observational study was conducted at Bolan medical college, enrolling 240 patients with culture-confirmed UTIs. Sample size determination via Epi Info® version 7 considered an anticipated ciprofloxacin resistance difference of 20% between pediatric and adult groups, $\alpha = 0.05$, 80% power, and SD assumption yielding 110 per group; sample size was increased to 120 per cohort to account for dropouts. Patients were stratified into pediatric (aged 1–17 years) and adult (18–75 years) cohorts. Inclusion criteria comprised symptomatic UTI supported by $\geq 10^5$ CFU/mL bacterial growth. Exclusions included recent hospitalization (<30 days), current antibiotic therapy, known urinary tract anomalies, pregnancy, or immunocompromised status. Verbal informed consent (and assent where applicable) was obtained under IRB-approved protocol. Demographic and clinical data—such as age, sex, inpatient versus outpatient status, prior UTI history—were documented. Mid-stream or catheter-collected urine samples underwent standard plating, and identification of E. coli and Klebsiella spp. was performed using biochemical or automated methods. Antimicrobial susceptibility testing was conducted via Kirby-Bauer disc diffusion per Clinical & Laboratory Standards Institute guidelines, evaluating ampicillin, TMP-SMX, ciprofloxacin, nitrofurantoin, and ceftriaxone. Quality control strains were used to ensure reliability. Data normality was checked via Shapiro-Wilk test. Resistance rates between age cohorts were compared using chi-square or Fisher's exact tests. Multivariate logistic regression models were fitted to assess predictors of resistance—including age group, gender, and inpatient status—with odds ratios and 95% confidence intervals. Analyses were conducted using SPSS® v25.0, with $p < 0.05$ denoting statistical significance.

Results

Table 1. Demographic Characteristics of Study Population

Variable	Pediatric (n=120)	Adult (n=120)	p-value
Age (years)	9.4 ± 4.2	45.8 ± 15.2	–
Female, n (%)	88 (73%)	82 (68%)	0.39
Inpatients, n (%)	52 (43%)	58 (48%)	0.47
Recurrent UTI, n (%)	26 (22%)	41 (34%)	0.02

This table demonstrates comparable sex distribution and inpatient status, with adults showing significantly higher recurrent UTI frequency.

Table 2. Antibiotic Resistance Rates by Age Group (%)

Antibiotic	Pediatric Resistant (%)	Adult Resistant (%)	p-value
Ampicillin	78	71	0.21
TMP-SMX	65	52	0.04
Ciprofloxacin	28	62	<0.001
Nitrofurantoin	12	8	0.32
Ceftriaxone	34	41	0.18

Children had significantly higher TMP-SMX resistance, while adults showed much higher ciprofloxacin resistance.

Table 3. Multivariate Logistic Regression Predicting Antibiotic Resistance

Antibiotic	Predictor	Adjusted OR (95% CI)	p-value
Ciprofloxacin	Adult cohort	3.4 (1.9–6.1)	<0.001
TMP-SMX	Pediatric cohort	1.8 (1.1–3.0)	0.02
Inpatient status	Any resistance	1.5 (1.0–2.3)	0.04

Analysis confirms adult age independently predicts ciprofloxacin resistance, and pediatric age predicts TMP-SMX resistance.

Discussion

This study highlights marked differences in urinary pathogen resistance profiles between pediatric and adult patients. Elevated TMP-SMX resistance in children (65%) mirrors findings from recent pediatric surveillance reporting rates between 60–70%, likely driven by widespread prophylactic use[16]. Conversely, the significantly higher fluoroquinolone resistance in adults (62%) reflects adult prescribing practices and corroborates current national data showing rates above 55% in middle-agedpopulations[17].

Ampicillin resistance remained high across both cohorts (>70%), consistent with global trends reflecting this antibiotic's diminished utility in UTI management[18]. Nitrofurantoin retained robust susceptibility (>85%), reaffirming its role as a reliable first-line therapy in both pediatric and adult lowerUTIs[19].

The logistic regression confirmed adult age as an independent risk factor for fluoroquinolone resistance (OR 3.4), consistent with prior reports identifying age-related antimicrobial exposure as a determinant of resistance[20]. In pediatric patients, the elevated TMP-SMX resistance (OR 1.8) underscores the need to reevaluate its empirical use, particularly in recurrent cases or prophylaxis[21].

Recurrent infection history, more common in adults, contributed modestly to resistance risk, reflecting pathogen exposure and selective pressure[22]. Inpatient status modestly increased overall resistance risk, highlighting hospital-associated factors such as cross-transmission and broader antibioticusage[23].

These findings support age-tailored empirical therapy: nitrofurantoin remains optimal for both groups; TMP-SMX should be used with caution in pediatrics where resistance is high. Empiric fluoroquinolone use in adults demands reconsideration given resistance rates exceeding 60%[24]. Study strengths include parallel analysis across age groups and rigorous susceptibility testing. However, the cross-sectional design limits causal inference, and single-center data may reduce generalizability[25]. Future longitudinal surveillance and multicenter studies will enhance external validity and monitor temporal trends[26]. Implementing age-specific antibiograms and stewardship interventions could optimize UTI management. Coupling such initiatives with outpatient stewardship programs may reduce unnecessary TMP-SMX or fluoroquinolone use[27]. Further research into rapid point-of-care susceptibility testing for UTIs could support timely, targeted therapy[28]. In conclusion, this study underscores the importance of recognizing age-based resistance differences to guide empiric therapy in UTIs. Future strategies should prioritize tailored empirical guidelines and continuous surveillance to combat rising antimicrobial resistance[29]-[30].

Conclusion

Pediatric and adult UTI pathogens exhibit distinct antibiotic resistance patterns, with children demonstrating higher TMP-SMX resistance and adults showing increased fluoroquinolone resistance. These findings underscore the necessity for age-specific empirical antibiotic guidelines and reinforce the value of updated resistance surveillance. Future multicenter and longitudinal studies are warranted to refine therapeutic strategies and stewardship efforts.

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