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Original article

Comparative Study of Epidemiology, Sensitivity, and Antimicrobial Resistance of Urinary Tract Infections in Tobruk's Children: A Cross-Sectional Analysis of Under-5 and School-Age Groups

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Abstract
Urinary tract infections (UTIs) are a leading cause of bacterial illness in children, with significant potential for long-term complications. In Libya, particularly in the Tobruk region, there is a critical lack of data on the epidemiology and antimicrobial resistance (AMR) patterns of pediatric UTIs, hindering effective treatment and stewardship efforts. This study aimed to compare the epidemiology, bacterial etiology, and antimicrobial susceptibility profiles of UTIs between preschool-age (PSA, <5 years) and school-age (SA, 5-12 years) children in Tobruk, Libya. A cross-sectional study was conducted on 343 pediatric patients presenting with UTI symptoms. Midstream urine samples were collected and processed using standard microbiological techniques. Bacterial isolates were identified, and antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method against a panel of eight antibiotics. Data were analyzed using descriptive statistics. Of the 343 patients, 61.2% (n=210) were school-aged and 38.8% (n=133) were preschool-aged. Females accounted for 63.8% of cases. A high rate of negative cultures was observed, especially in males. *Escherichia coli* was the predominant pathogen in both age groups, but was significantly more common in females. Antimicrobial susceptibility testing revealed alarmingly high resistance rates to first-line antibiotics: amoxicillin-clavulanate (Augmentin) and cefotaxime were largely ineffective. In contrast, the highest in vitro efficacy was observed for carbapenems (imipenem, 58.9%; meropenem, 60% susceptibility for E. coli) and aminoglycosides (amikacin and gentamicin). Notably, 17.9% of *E. coli* isolates were resistant to trimethoprim-sulfamethoxazole (Septrin). This study reveals a severe burden of antimicrobial resistance in pediatric UTIs in Eastern Libya, with first-line oral therapies showing poor efficacy. There are distinct age and gender disparities in prevalence and etiology. These findings underscore an urgent need to revise local empirical treatment guidelines to favor more effective agents like aminoglycosides and to implement robust antibiotic stewardship and surveillance programs to combat the escalating AMR crisis.
Keywords: Urinary Tract Infections, Preschool-age, School-age, *Escherichia Coli* & Antimicrobial Resistance.

Introduction
Urinary tract infections (UTIs) are among the most common bacterial infections in children, contributing to significant morbidity and potential long-term complications such as renal scarring and hypertension if not properly managed [1]. The incidence and clinical presentation of UTIs vary considerably with age, with preschool-age children (<5 years) being particularly vulnerable due to immature immune systems, incomplete bladder emptying, and hygiene challenges [2]. In contrast, school-age children (5–12 years) exhibit different risk factors, including behavioral patterns and school-related hygiene practices [3].
In Libya, limited data exist on the epidemiology of pediatric UTIs, particularly in regions like Tobruk. Previous studies in North Africa highlight disparities in UTI prevalence, etiology, and antibiotic resistance patterns between age groups [4]. For instance, Escherichia coli remains the predominant pathogen, but resistance to first-line antibiotics like trimethoprim-sulfamethoxazole is rising [5]. Understanding age-specific trends is critical for guiding clinical practice, especially in resource-limited settings where diagnostic and therapeutic options may be constrained.
UTIs represent one of the most frequent bacterial infections in the pediatric population, accounting for approximately 5-14% of febrile illnesses in children under 5 years [6]. The clinical significance of UTIs extends beyond acute morbidity, as recurrent infections in early childhood are strongly associated with renal scarring in 15-40% of cases, potentially leading to hypertension and chronic kidney disease in adulthood [7]. This risk is particularly pronounced in preschool-aged children (<5 years), who exhibit anatomical and immunological vulnerabilities, including shorter urethral length, immature bladder function, and developing immune systems [8].
The epidemiology of pediatric UTIs demonstrates marked variation across age groups. While infants and toddlers (<2 years) frequently present with nonspecific symptoms such as fever and irritability, school-aged children (5-12 years) more commonly exhibit classic urinary symptoms, including dysuria, frequency, and abdominal pain [9]. This diagnostic challenge in younger children often leads to delayed treatment, with studies showing up to 30% of preschool children with UTIs receive incorrect initial diagnoses [10]. Furthermore, emerging evidence suggests that risk factors diverge significantly between age cohorts, with

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uncircumcised male infants <1 year showing the highest incidence (8.7%), while school-aged girls demonstrate a 10-fold increased risk compared to boys [11].
In the North African context, particularly in Libya, the burden of pediatric UTIs remains understudied despite the region's unique environmental and sociocultural factors that may influence infection patterns. A recent hospital-based study from Benghazi reported E. coli as the predominant pathogen (68% of cases), with alarmingly high resistance rates to ampicillin (82%) and cotrimoxazole (65%) [12]. However, no published data exists specifically for Tobruk, where climate conditions, water and sanitation practices, and healthcare access may create distinct epidemiological profiles. This knowledge gap is particularly concerning given Libya's fragmented healthcare system and the WHO's recent report on rising antimicrobial resistance in the Mediterranean region [13]. The clinical management of pediatric UTIs faces additional challenges in resource-limited settings. Current guidelines from the American Academy of Pediatrics [14] recommend urine culture confirmation before treatment, yet in practice, many Libyan healthcare providers must rely on clinical judgment and limited laboratory support. This situation underscores the urgent need for localized data to inform empirical treatment protocols, especially considering that inappropriate antibiotic use in children contributes substantially to resistance development [15].
This comparative study aims to investigate the prevalence, etiological agents, and antimicrobial resistance patterns of UTIs among two critical pediatric populations in Tobruk, Libya: preschool-aged (PSA) children (<5 years) and school-aged (SA) children (5-12 years). By analyzing age-specific differences in clinical presentation, bacterial profiles, and susceptibility patterns, our findings will provide essential evidence to guide age-appropriate empirical antibiotic therapy, inform targeted prevention strategies for high-risk groups, contribute to national antimicrobial stewardship efforts, and establish baseline data for future research in Eastern Libya.

Materials and Methods

Collection of urine samples and transport

Both genders with UTI symptoms were included. Urine samples were collected by sampling the midstream flow. Once collected, specimens of urine were transported to the laboratory without delay, as urine is an excellent culture medium, so that bacteria can reach apparently significant numbers in a short time. So the multiplication of bacteria in the urine should be prevented by storage in a refrigerator at 4°C.

Sample processing

The specimens were collected from outpatients and patients admitted from different wards of the hospital. These were processed for bacterial species identification by standard microbiological procedures and antibiotic sensitivity testing. Specimens were taken from urine and were inoculated on routine culture media like blood agar, cysteine lactose electrolyte deficient (CLED) agar, MacConkey agar, and Sabouraud agar. All plates were then incubated at 37°C aerobically for 24 h. The strains were subjected to biochemical identification tests to identify bacterial species for TSI (Triple Sugar Iron), Gram staining, the motility test, the indole test, and the urea test.

Antibiotic sensitivity test

McFarland Standards is used in the antimicrobial susceptibility testing procedure, where the bacterial suspension is compared to the Standard McFarland before swabbing on Muller Hinton agar. It is a part of quality control to check and adjust the densities of bacterial suspensions that can be used for identification and susceptibility procedures. However, the concentration used for the antimicrobial susceptibility testing and the culture media performance testing is done by 0.5 McFarland standards in the microbiological laboratory. (Stamm WE et al. 2020). The Kirby-Bauer disk diffusion method was performed to determine the antibiotic susceptibility by the standard disk diffusion procedure. Commercially prepared antibiotic discs (Oxoid, UK). (6 mm in diameter) belonging to different groups, the antibiotics Augmentin (30 µg), Cefotaxime (30 µg), Gentamicin (10 µg), Amikacin (30 µg), Nitrofurantoin (300 µg), Septrin (25 µg), Imipenem (10 µg), and Meropenem (10 µg) were used. The zones of inhibition were measured, recorded, and interpreted according to the Clinical Laboratory Standard Institute guidelines. [29] Four to five similar colonies from the overnight growth plate were transferred aseptically into sterile distilled water and vigorously agitated to give a turbidity that matches the 0.5 McFarland standards (approximately 108 cfu/ml). Within 15 min, a sterile cotton swab dipped into the culture suspension was used for inoculating the surface of solidified Mueller-Hinton agar plates. Antibiotic discs were dispensed onto the inoculated plate surface agar and incubated at 37°C for 24 h. The resulting diameters of inhibition zones around the antibiotic discs were measured to the nearest whole mm and interpreted according to protocols standardized for the assay of antibiotic compounds as guided by the National Committee for Clinical Laboratory Standards (NCCLS." The results were categorized as R (resistant) and S (sensitive) [16].

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Statistical analysis
All the collected data was entered into Microsoft Excel and cross-checked for the presence of any errors to maintain its accuracy. Descriptive statistics were applied to calculate proportions and frequencies. Statistical analysis was performed using SPSS software for Windows version 27.

Results
A total of 343 pediatric patients with suspected urinary tract infections (UTIs) were included in this study. Bacterial isolates were successfully detected and cultured from a significant number of cases. The age and gender distribution of the patients is summarized in (Table 1). The cohort comprised 210 (61.2%) school-age children (SA) and 133 (38.8%) preschool-age children (PSA). Females accounted for the majority of cases (n=219, 63.8%), with 136 school-age females and 83 preschool-age females. Males constituted 124 cases (36.2%), comprising 74 school-age males and 50 preschool-age males. The microbiological profile differed notably between age groups and genders, as detailed in (Tables 2 and 3).

Table 1: Gender wise distribution of UTI.

Female (SA)	**Male (SA)**	**Female (PSA)**	**Male (PSA)**	**Total**
136 (39.65%)	74 (21.57%)	83 (24.20%)	50 (14.58%)	343

Table 2: Epidemiology of Females' UTI.

Pathogen	**(PSA)** (n=83)	**(SA)** (n=136)
No growth	56 (67.47%)	92 (67.65%)
E.coli	18 (21.69%)	33 (24.26%)
klebsiella	4 (4.82%)	5 (3.68%)
Proteus	1 (1.20%)	2 (1.47%)
S. saprophticus	2 (2.41%)	2 (1.47%)
Pseudomonas	2 (2.41%)	2 (1.47%)

Table 3: Epidemiology of male UTI.

Pathogen	**(PSA)** (n=50)	**(SA)** (n=74)
No growth	45 (90.00%)	63 (85.14%)
E.coli	3 (6.00%)	3 (4.05%)
klebsiella	1 (2.00%)	2 (2.70%)
Proteus	0 (0.00%)	2 (2.70%)
S.saprophticus	1 (2.00%)	2 (2.70%)
Pseudomonas	0 (0.00%)	2 (2.70%)

The susceptibility and resistance profiles of the identified bacterial isolates are presented in (Tables 4 and 5).

Table 4: Antibiotics used and their susceptibility patterns.

Antibiotic	***E.coli***	**Klebsiella**	**S.saprophticus**	**Pseudomonas**	**Proteus**
Augmentin	20.5%	7.6%	0%	0%	1.2%
Amikacin	33.3%	6.4%	1.2%	0%	1.2%
Cefotaxim	19.2%	0%	0%	0%	0%
Gentamicin	34.6%	7.6%	1.2%	1.2%	2.3%
Nitrofurantoin	8.5%	0%	0%	1.2%	0%
Septrin	9.3%	1.2%	0%	0%	2.3%
Imipenem	58.9%	15.3%	5.12%	8.9%	2.3%
Meropenem	%60	21.7%	5.1%	2.3%	0

Table 5: Antibiotics used and their resistance patterns.

Antibiotic	*E.coli*	Klebsiella	S.saprophticus	Pseudomonas	Proteus
Augmentin	11.5%	8.9%	1.2%	2.5%	0%
Amikacin	1.2%	3.8%	0%	0%	0%
Cefotaxim	20.5%	2.5%	1.2%	0%	2.3%
Gentamicin	6.4%	6.4%	0%	0%	0%
Nitrofurantoin	3.8%	3.8%	1.2%	1.2%	2.1%
Septrin	17.9%	8.9%	1.2%	0%	8.9%
Imipenem	1.2%	1.2%	5%	8.9%	6%

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Discussion

This cross-sectional study provides a critical analysis of the epidemiology, etiological agents, and antimicrobial resistance patterns of urinary tract infections in children from Tobruk, Libya. The findings reveal significant age and gender disparities and a concerning prevalence of antimicrobial resistance and highlight the urgent need for updated local treatment guidelines.

Our data indicate a clear female predominance in pediatric UTIs, with females constituting 63.8% of the studied cohort. This finding is consistent with the well-established global epidemiology of UTIs, where anatomical differences, such as a shorter urethra, and hormonal factors increase susceptibility in females [2]. The higher number of culture-positive cases in school-age females (SA) compared to preschool-age females (PSA) aligns with behavioral risk factors such as school hygiene practices and delayed micturition, as noted in studies from other regions [3]. Conversely, the high rate of negative cultures, particularly in males (45 in PSA and 63 in SA), suggests potential challenges in sample collection, prior antibiotic use, or a high index of clinical suspicion leading to testing in cases of non-bacterial etiology, a common diagnostic dilemma in pediatric practice [10].

Escherichia coli was confirmed as the predominant uropathogen in both age groups and genders in Tobruk, mirroring the etiological profile reported in pediatric populations worldwide [9]. In our study, E. coli accounted for 21.7% of isolates in PSA females and 24.3% in SA females. This is comparable to the findings of El-Mahmoudi et al. [11] in Benghazi, Libya, who reported E. coli as the causative agent in 68% of culture-positive pediatric UTIs. The slightly lower prevalence in our study could be attributed to differences in sample size, patient selection, or the high rate of negative cultures. The isolation of other pathogens like Klebsiella spp., Proteus, and Pseudomonas is also consistent with the microbiological spectrum seen in other North African studies [4].

The most alarming finding of this study is the high prevalence of antimicrobial resistance, which poses a serious threat to effective clinical management. The in vitro susceptibility testing revealed profoundly low efficacy of commonly recommended first-line antibiotics. Augmentin (amoxicillin-clavulanate) and cefotaxime showed poor activity against all major pathogens, especially E. coli. This is a stark contrast to international guidelines, such as those from the American Academy of Pediatrics, which often recommend these agents as empirical choices [14]. Our results are, however, consistent with the escalating resistance crisis in Libya and the wider region. The study from Benghazi reported ampicillin resistance in 82% and cotrimoxazole (Septrin) resistance in 65% of E. coli isolates [11], a trend our data corroborates with a 17.9% resistance rate to Septrin.

The high resistance to first-line oral agents necessitates a shift in empirical treatment strategies. In this context, aminoglycosides like gentamicin and amikacin demonstrated promising in vitro activity, with low resistance rates (6.4% and 1.2% for E. coli, respectively). This makes them a viable option for initial parenteral therapy in severe cases. Most notably, the carbapenem class (imipenem and meropenem) exhibited the highest susceptibility rates, confirming their role as drugs of last resort for multidrug-resistant infections. However, the emergence of resistance even to these agents—most notably an 8.9% resistance in Pseudomonas against imipenem—is a grave warning sign. This echoes the WHO's concerns about the rise of carbapenem-resistant organisms in the Eastern Mediterranean Region [13] and underscores the critical need for robust antimicrobial stewardship programs to preserve their efficacy.

The high rate of culture-negative results, while potentially reflecting true negatives, may also indicate widespread pre-diagnostic antibiotic use, a common practice in many resource-limited settings where antibiotics are often available over the counter [15]. This practice fuels the cycle of resistance, making accurate diagnosis and targeted therapy even more difficult. In female patients, a positive bacterial culture was obtained from 80 cases (44 from the PSA group and 44 from the SA group). E. coli was the predominant pathogen in both age groups, identified in 18 cases (21.7% of PSA females) and 33 cases (24.3% of SA females). This was followed by Klebsiella species. A high number of cultures, particularly from school-age females (n=92), showed no bacterial growth.

In male patients, the rate of culture-positive UTIs was low. Only 11 pathogens were isolated from preschool-age males and 11 from school-age females. E. coli and Klebsiella were the most frequently identified organisms. Most male patients had cultures with no bacterial growth (45 in the PSA group and 63 in the SA group). The carbapenem antibiotics, imipenem and meropenem, demonstrated the highest overall in vitro efficacy. Meropenem showed a 60% susceptibility rate for E. coli and 21.7% for Klebsiella. Imipenem was also highly effective against E. coli (58.9% susceptibility). Among other classes, amikacin and gentamicin were the most effective, with gentamicin showing a 34.6% susceptibility rate for E. coli. Commonly used first-line antibiotics like Augmentin (amoxicillin/clavulanate) and cefotaxime showed notably low susceptibility rates across all pathogens. High resistance rates were observed against Septrin (trimethoprim/sulfamethoxazole), with 17.9% of *E. coli* isolates being resistant. Resistance to cefotaxime was also considerable, particularly for E. coli (20.5%). In contrast, amikacin and gentamicin exhibited low resistance rates (1.2% and 6.4% for E. coli, respectively). Resistance to carbapenems was low but present, most notably for Pseudomonas against imipenem (8.9%) [17].

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Conclusion

This study highlights the significant burden of urinary tract infections among children in Tobruk, Libya, with clear age- and gender-related variations in prevalence and etiology. *E. coli* consistently emerged as the predominant pathogen, affecting females more frequently, particularly in the school-age group. The high proportion of culture-negative cases, especially in males, suggests possible prior antibiotic use, sampling challenges, or non-bacterial etiologies. Antimicrobial susceptibility testing revealed carbapenems (imipenem and meropenem) as the most effective agents, while first-line antibiotics such as Augmentin and cefotaxime demonstrated poor efficacy. Alarmingly, resistance to commonly prescribed antibiotics such as Septrin was widespread, underscoring the escalating threat of antimicrobial resistance in pediatric populations. These findings point out the need for localized surveillance data to guide empirical treatment and inform antibiotic stewardship programs in eastern Libya. Public health efforts should include education on hygiene and responsible antibiotic use, especially for children. Policy support is needed to regulate antibiotic access and ensure the availability of effective treatments. Further multicenter research is recommended to strengthen evidence and guide national protocols.

Conflict of interest

None declared

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References

1. Korbel L, Howell M, Spencer JD. The clinical and economic consequences of untreated urinary tract infections in children. Pediatr Nephrol. 2017;32(1):23-32. doi:10.1007/s00467-016-3412-7
2. Feldman AG, Bauer SB. Diagnosis and management of UTIs in children. Pediatr Rev. 2021;42(3):153-67. doi:10.1542/pir.2020-001610
3. Al-Orifi F, McGillivray D, Tange S, Kramer MS. Urinary tract infection in children: Diagnosis and treatment. BMJ Clin Evid. 2020;2020:0306.
4. Boukhalfa A, Selmani N, Benzerga M, Messaoudi M. Antibiotic resistance trends in pediatric UTIs across North Africa: A systematic review. J Glob Antimicrob Resist. 2022;28:12-9. doi:10.1016/j.jgar.2021.11.009
5. Ben Abda I, Boukhalfa A, Ghenghesh KS, El-Mohammady H. E. coli resistance patterns in Libyan children with UTIs. Libyan J Med. 2021;16(1):1-8. doi:10.1080/19932820.2020.1863556
6. Shaikh N, Hoberman A, Hum SW, et al. UTI prevalence in febrile young children: A meta-analysis. Pediatrics. 2023;151(2):e2022058756. doi:10.1542/peds.2022-058756
7. Paintsil E, Huang Y, Keren R. Long-term renal outcomes of childhood UTIs. Pediatr Nephrol. 2022;37(5):1021-30. doi:10.1007/s00467-021-05254-x
8. Roberts KB. The changing epidemiology of pediatric UTIs. J Pediatric Infect Dis Soc. 2022;11(3):93-8. doi:10.1093/jpids/piab114
9. Leung AKC, Wong AHC, Leung AAM, Hon KL. Urinary tract infection in children. In: Kalra V, editor. Recent Advances in Pediatrics. Vol 39. Springer; 2023:1-24. doi:10.1007/978-981-19-4715-2_1
10. Elsayah K, Atia A, Bkhait N. Antimicrobial resistance pattern of bacteria isolated from patients with urinary tract infection in Tripoli city, Libya. Asian J Pharm Health Sci. 2017;7(4).
11. Naderi A, Kasra-Kermanshahi R, Gharavi S, Fooladi AA, Alitappeh MA, Saffarian P. Study of antagonistic effects of Lactobacillus strains as probiotics on multi drug resistant (MDR) bacteria isolated from urinary tract infections (UTIs). Iran J Basic Med Sci. 2014;17(3):201.
12. El-Mahmoudi H, Ghenghesh KS, El-Mohammady H. Antibiotic resistance in pediatric UTIs in Eastern Libya. Libyan J Med Sci. 2022;6(1):12-8. doi:10.4103/LJMS.LJMS_78_21
13. World Health Organization Regional Office for the Eastern Mediterranean. Antimicrobial resistance surveillance in the Eastern Mediterranean Region: annual report 2022. Cairo: WHO; 2023.
14. American Academy of Pediatrics. Clinical practice guideline for the diagnosis and management of the initial UTI in febrile infants and children 2-24 months. Pediatrics. 2022;150(6):e2022059631. doi:10.1542/peds.2022-059631
15. Gajdács M, Ábrók M, Lázár A, Burián K. The impact of empirical and targeted antibiotic therapy on the emergence of resistance in urinary tract infections. Antibiotics (Basel). 2023;12(2):302. doi:10.3390/antibiotics12020302
16. Jorgensen JH. Methods for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria; approved guideline. 3rd ed. Clinical and Laboratory Standards Institute; 2021.
17. Stamm WE, Norrby SR. Urinary tract infections: disease panorama and challenges. J Infect Dis. 2020;183 Suppl 1:S1-4. doi:10.1086/318844

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