JMGCB
ISSN:3032-1085
https://doi.org/10.61796/jmgcb.v1i5.423

The Prevalence of Bacterial Urinary Tract Infections Among School-age Children

Saad M. Hantoosh
PhD. Microbiology/Ministry of Education/Open Educational College/Al-Muthanna Educational Center Al-Muthanna Province, Samawa City , Iraq
saadmuslim85@gmail.com

Received: March 22, 2024; Accepted: Apr 29, 2024; Published: May 20, 2024;

Abstract: Urinary tract infections (UTIs) are the most common and serious bacterial infection in children. The current study aims at identifying the most prevalent symptoms and pathogenic bacteria linked to urinary tract infections in school-aged children in Al-Muthanna Province. Between October 2023 and April 2024, a urine samples were collected from 685 (417 female and 268 male) students across three age groups: 129 (19%) (6-12 years), 240 (35%) (>12-14 years), and 316 (46%) (>14-18 years) with symptoms of urinary tract infection. Female students (345) were significantly more affected by bacterial infections compared to male students (182), χ^2 (df=1, N=685) = 20.2, $p < .001$. In cases of UTI symptom onset, the likelihood of bacterial UTIs is 1.9 times higher for children aged >12-14 and 3.2 times higher for those aged >14-18 compared to children aged 6-12. The prevalence of symptomatic UTIs among schoolchildren increases with age, from 62% to 83.9% across different age groups. Among female students aged 6-18 with UTI symptoms, 82.7% had a bacterial UTI, compared to 67.9% of male students. Over 5% of schoolchildren without bacterial UTI exhibit moderate to marked pyuria. Hematuria percentages were comparable between individuals with and without bacterial UTIs. The average pH tended to be acidic for both groups, with infected individuals having a pH less than six and uninfected individuals having a pH less than seven. Escherichia coli was the predominant infectious followed by Enterococcus faecalis, Enterobacter aerogenes, Klebsiella pneumoniae, Proteus mirabilis and Pseudomonas aeruginosa at rates of 74%, 41%, 33%, 36%, 29% and 19%, respectively. Staphylococcus aureus and Staphylococcus epidermidis occurred at a frequency of 12% and 8%, respectively, while Streptococcus agalactiae occurred at a frequency of 3%.

Keywords: UTI, schoolchildren, urine culture, symptoms

Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections in childhood, affecting around 7.8% of children under 19 years old with urinary symptoms [1, 2]. The prevalence of UTIs in children varies by age, sex, anatomy, hygiene, underlying conditions, circumcision status, race/ethnicity, and environmental factors [3, 4]. In addition to other factors that can influence the prevalence of UTIs in children including: genetics, medical history, immune system, antibiotic use, diet, voiding habits, hydration, use of urinary catheters, exposure to irritants, potty training [2, 5, 6], bladder and bowel dysfunction (BBD), immunodeficiency, neurogenic bladder (NB), diabetes mellites (DM), CAKUT, and urolithiasis [1, 7]. Diagnosing UTIs in children, especially those under

2-3 years old, can be challenging. Fever is the primary indicator in children. Infants and not toilet-trained children may only exhibit fever as a symptom of UTIs, or it may be accompanied by loose stool, irritability, vomiting, failure to thrive, poor feeding, and lethargy. In toilet-trained children, typical urinary symptoms like frequent urination, suprapubic or abdominal pain, loin tenderness, changes in incontinence habits, and dysuria are evident. [2, 8-11]. The infection can affect either the upper urinary tract (pyelonephritis) or the lower urinary tract (cystitis). Distinguishing between pyelonephritis and cystitis based on symptoms and signs, especially in infants and young children, can be difficult [12]. There was a statistically significant increase in both pyelonephritis and cystitis episodes among children from 2000 to 2020 across age groups. In 2020, girls aged 2-4 had the highest cystitis rates (40.3/1000 person-years) and boys aged 10-18 had the lowest rates (2.6/1000 person-years). Girls aged 2-4 also had the highest pyelonephritis rates, especially those under 2 years old [8]. Early detection and treatment of UTIs in children is crucial to avoid complications like kidney damage or repeated infections. Timely identification using urine tests and proper antibiotic therapy are essential for effectively managing UTIs and preventing additional complications [13]. More recent information on the prevalence and symptoms of UTIs is necessary to understand how often UTIs are diagnosed in children. To address this gap, a cross sectional study was conducted to analyze the prevalence and patterns of UTIs in children, in addition to diagnosing the causative bacterial pathogens. The findings from this study are crucial for enhancing our understanding of UTI diagnosis trends in pediatric populations and guiding future healthcare strategies.

Methods

The current study was conducted between October 2023 and April 2024 in Al-Muthanna Province, southern Iraq. This study involved tracking all medical cases of school children who showed symptoms of urinary tract infection (UTI) and were referred to three hospitals, namely: Women's and Children's Hospital in Samawah, Samawah General Hospital, and Al-Khader General Hospital. Urine analysis, including microscopic examination and bacterial culture, was performed on all participants. The criteria for selecting children to participate in the study included several factors: the child had to be accompanied by a parent, referred for analysis by a specialist doctor, showing symptoms of a possible bacterial UTI, and not having taken antibiotics at least 48 hours prior to the analysis. Limited demographic information was collected about each participant, including age, gender, and the type of symptoms that called for a urine analysis. No private data related to the family was collected, such as the number of family members, socioeconomic status, social support, healthcare access, lifestyle factors, and environmental factors. Also, no personal health data was allowed to be collected such as medical history, voiding habits, urinary tract imaging, dietary habits, medical family history, and hygiene practices. The study was approved by the Al-Muthanna General Health Directorate (T/199/2023, date 8 September 2023). Children whose parents or legal guardians did not consent to participate in the study were excluded.

Statistical Analysis:

All raw data were collected, tabulated, and coded in Excel. Statistical analyses were conducted using jamovi (v2.5.3) and MedCalc (v22.023). A Chi-Square Test (x^2) for Proportions Difference was performed to evaluate the statistical differences in UTI proportions between males and females across age groups. Odds Ratio and 95% confidence interval were calculated for urinary tract infections among male and female children in three age groups: 6-12, >12-14, and >14-18. A Chi-Square Test

(x^2) for Proportions Difference was performed to assess the statistical differences in symptoms stratified by gender, infection, and age. $p < 0.05$ was taken as the significance level in the analyses performed.

Results and Discussion

Results

This study involved 685 participants across three age groups: 129 (19%) (6-12 years), 240 (35%) (>12-14 years), and 316 (46%) (>14-18 years). Of these, 61% were female and 39% were male as shown in table 1.

Table 1: The distribution of participants by age and gender

Age (year)	Total Participants	Gender	
		Female n (%)	Male n (%)
6-12	129	56 (43.4)	73 (56.6)
>12-14	240	139 (57.9)	101 (42.1)
>14-18	316	222 (70.3)	94 (29.7)
Total	685	417 (60.9)	268 (39.1)

Among 685 students with symptoms of bacterial UTIs, 527 (77%) students were diagnosed with bacterial infections. Female students (345) were significantly more affected by bacterial infections compared to male students (182), χ^2 (df=1, N=685) = 20.2, $p < .001$. In cases of UTI symptom onset, the likelihood of bacterial UTIs is 1.9 times higher for children aged >12-14 and 3.2 times higher for those aged >14-18 compared to children aged 6-12. Young females (>12-14 years old) have a higher rate of infection compared to males in this age group. However, there was no significant difference in UTIs rates between male and female students in the age groups of 6-12 and >14-18 years as shown in table 2.

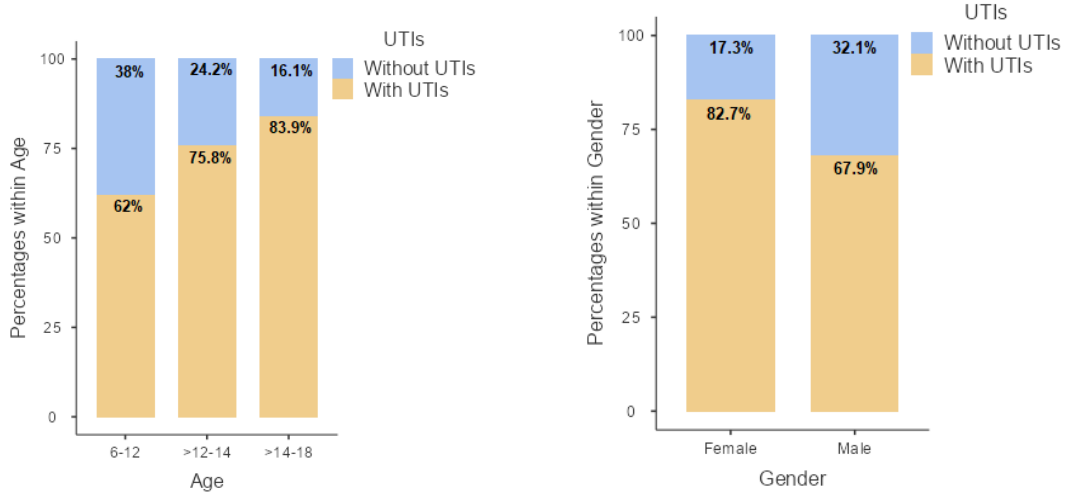
Table 2: The chi-square test for proportions difference and odds ratio of the urinary tract infections between male and female children of three age groups 6-12, >12-14, and >14-18.

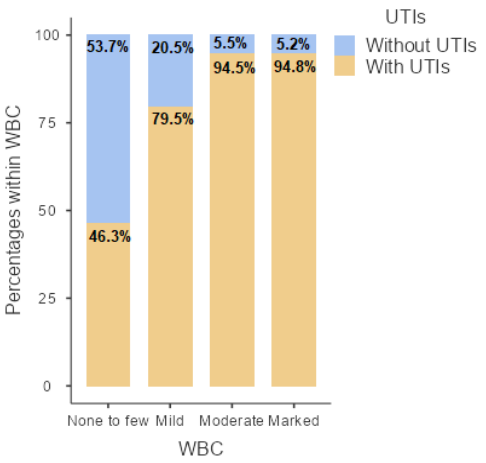
Age	Urinary Tract Infection (UTI)	Gender n (%)		Total	χ^2 Tests		Odds Ratio [95% CI], *p* value
		Female	Male		χ^2	*p*	
6-12	Without UTI	17 (34.7)	32 (65.3)	49	2.44	0.118	Reference category
	With UTI	39 (48.8)	41 (51.2)	80			
	Total	56 (43.4)	73 (56.6)	129			

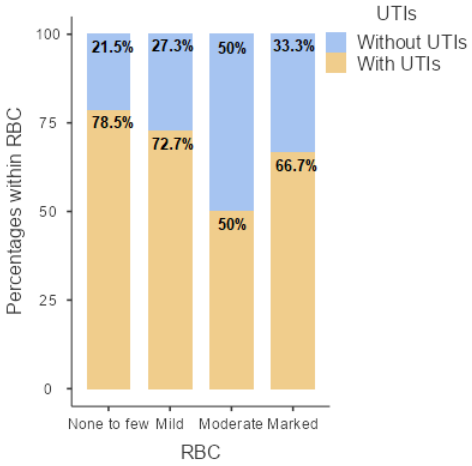
>12-14	Without UTI	24 (41.4)	34 (58.6)	58	8.58	0.003*	1.9 [1.21-3.05], 0.005
	With UTI	115 (63.2)	67 (36.8)	182			
	Total	139 (57.9)	101 (42.1)	240			
>14-18	Without UTI	31 (60.8)	20 (39.2)	51	2.61	0.106	3.18 [1.99-5.06
	With UTI	191 (72.1)	74 (27.9)	265			
	Total	222 (70.3)	94 (29.7)	316			
Total	Without UTI	72 (45.6)	86 (54.4)	158	20.20	< .001*	
	With UTI	345 (65.5)	182 (34.5)	527			
	Total	417 (60.9)	268 (39.1)	685			

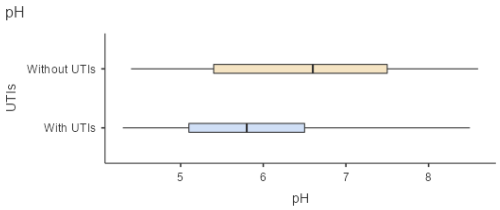
As shown in Figure 1, the prevalence of symptomatic UTIs among schoolchildren increases with age, from 62%, 75.8%, and 83.9% for the age groups of 6–12, >12–14, and >14–18, respectively. The study results revealed that only 82.7% of female students aged 6-18 with UTI symptoms had a bacterial UTI, while the percentage was lower for male students at 67.9% of the same age category. WBC/hpf test revealed that over 5% of schoolchildren without bacterial UTI exhibit moderate to marked pyuria in urine. It was also demonstrated that the percentage of hematuria was comparable between individuals with bacterial UTIs and those without. The average pH tended to be acidic for both individuals with and without bacterial UTIs, but those infected had a pH of less than six, while those uninfected had a pH of less than seven.

Figure 1: The percentages of individuals with and without bacterial urinary tract infection by age, gender, WBC/hpf, RBC/hpf, and urine pH









There were no significant differences in the prevalence of fever, odor, dysuria, loss of appetite, and urinary frequency between males and females, children with and without UTI, or among three age groups 6-12, >12-14, and >14-18 years (Table 3).

Table 3: The chi-square test for proportions difference of participants with and without infection symptoms across gender, infection, and age groups

Symptoms	**Gender n (%)**		**χ^2 Tests χ^2 (*p*)**	**UTI n (%)**		**χ^2 Tests χ^2 (*p*)**	**Age Category n (%)**			**χ^2 Tests χ^2 (*p*)**
	Female	Male		Without	With		**6-12**	**>12-14**	**>14-18**	
Fever	56 (13.4)	47 (17.5)	2.16 (0.142)	25 (15.8)	78 (14.8)	0.0994 (0.753)	26 (20.2)	30 (12.5)	47 (14.9)	3.86 (0.145)
	361 (86.6)	221 (82.5)		133 (84.2)	449 (85.2)		103 (79.8)	210 (87.5)	269 (85.1)	
Odor	330 (79.1)	218 (81.3)	0.496 (0.481)	130 (82.3)	418 (79.3)	0.666 (0.414)	104 (80.6)	195 (81.3)	249 (78.8)	0.551 (0.759)
	87 (20.9)	50 (18.7)		28 (17.7)	109 (20.7)		25 (19.4)	45 (18.8)	67 (21.2)	
Dysuria	129 (30.9)	78 (29.1)	0.259 (0.611)	43 (27.2)	164 (31.1)	0.879 (0.349)	38 (29.5)	70 (29.2)	99 (31.3)	0.346 (0.841)
	288 (69.1)	190 (70.9)		115 (72.8)	363 (68.9)		91 (70.5)	170 (70.8)	217 (68.7)	
Loss of Appetite	370 (88.7)	244 (91)	0.942 (0.332)	145 (91.8)	469 (89)	1.01 (0.315)	113 (87.6)	217 (90.4)	284 (89.9)	0.754 (0.686)
	47 (11.3)	24 (9)		13 (8.2)	58 (11)		16 (12.4)	23 (9.6)	32 (10.1)	
Urinary Frequency	45 (10.8)	38 (14.2)	1.76 (0.185)	22 (13.9)	61 (11.6)	0.630 (0.427)	17 (13.2)	35 (14.6)	31 (9.8)	3.09 (0.214)

	372 (89.2)	230 (85.8)		136 (86.1)	466 (88.4)		112 (86.8)	205 (85.4)	285 (90.2)	

Gray highlighted cells represent participants with symptoms of UTI, white cells represent participants without symptoms of UTI

Bacterial culture results from 685 urine samples found that only 527 tested positive. Escherichia coli was the predominant infectious agent at 74%, followed by Enterococcus faecalis, Enterobacter aerogenes, Klebsiella pneumoniae, Proteus mirabilis and Pseudomonas aeruginosa at rates of 41%, 33%, 36%, 29% and 19%, respectively. The results showed that Staphylococcus aureus and Staphylococcus epidermidis occurred at a frequency of 12% and 8%, respectively, while Streptococcus agalactiae occurred at a frequency of 3%. In addition, 12 urine samples showed polymicrobial growth with positive cultures for Escherichia coli and Enterococcus faecalis.

Discussion

The most common bacterial infection in children is urinary tract infection (UTI). In pediatric patients, this infection can indicate early signs of congenital anomalies of the kidney and urinary tract (CAKUT) or be associated with bladder dysfunctions [14]. The clinical presentation of urinary tract infections in children is very heterogeneous and the symptoms can be quite unclear. Urine culture remains the gold standard for diagnosing a urinary tract infection [15]. The urinary tract is usually bacteria-free, except for the lower urethra. Normally, the periurethral area is harbored by bowel bacteria [16]. UTIs can occur through two routes: hematogenic and ascendant. Hematogenic UTIs are common in newborns, while ascendant UTIs typically occur after the neonatal period. In newborns, UTIs may present as sepsis, with nonspecific symptoms such as anorexia, vomiting, poor sucking, irritability, lethargy, convulsions, pallor, hypothermia, and sometimes jaundice. The ascendant route involves the migration, fixation, and proliferation of uropathogenic bacteria in the urinary tract. These bacteria can reside in the gastrointestinal tract for long periods before spreading to the periurethral area. From there, they ascend the urinary tract against urine flow and establish infection through various mechanisms [19, 18]. In the current study, 685 students with UTI symptoms, 77% diagnosed with bacterial infections. Females (345) more affected than males (182), $\chi^2 = 20.2$, $p < .001$. This indicates that not every student experiencing urinary tract symptoms actually had a bacterial UTI. Viral infection of the bladder or kidney, bladder or kidney stones, interstitial cystitis, sexually transmitted infections (STIs), urinary tract abnormalities (e.g. vesicoureteral reflux (VUR) or urethral strictures), and diabetes can present with similar symptoms to UTIs [2, 9, 19]. Bacterial UTI diagnosis confirmed through urine culture may not always detect bacteria if sample is collected improperly or has low bacterial load (diagnosis limitation) [20]. It's possible that participants with urinary tract symptoms had bacterial UTIs, but they may have also had other infections (coinfection) or conditions contributing to their symptoms [2]. The variation in bacterial UTI percentages (increase or decrease) is often attributed to misdiagnosis. Patients may be incorrectly diagnosed with a bacterial UTI when they are actually suffering from a different condition, and vice versa [21].

The current result suggests age and gender are a key factor in UTI prevalence. Females have a higher likelihood of developing UTIs compared to males because of their anatomy. The proximity of

the urethra to the vagina and rectum in women often leads to the accidental transfer of fecal bacteria into the urinary tract, resulting in frequent UTIs [22, 26]. In the current results, school-age children have higher rates of symptomatic UTIs as they become older: 62%, 75.8%, and 83.9% for the age groups of 6–12, >12–14, and >14–18, respectively. Lower urinary symptoms and risky sexual behavior are key factors linked to UTIs in students. Vigilance and urological care are vital for sexually active individuals. Those prone to UTIs should be advised promptly on preventive measures, including safe sexual practices and hygiene maintenance [23, 24]. When UTI symptoms manifest, children aged 12-14 have a 1.9-fold higher risk of bacterial UTIs, and those aged 14-18 have a 3.2-fold higher risk compared to younger children (6–12 years old). In terms of infection, young females (>12–14 years old) have a higher rate than males in this age group. However, in the age ranges of 6–12 and >14–18 years, there was no apparent difference in the rates of UTIs between male and female students. Female puberty is linked to hormonal changes that can affect the environment in the urinary tract, raising the risk of UTIs by fostering the growth of bacteria [25]. In younger children (6-12 years old), there may be less gender-specific behaviors or activities that increase the risk of UTIs. However, as children reach adolescence (>12-14 years old), factors such as sexual activity or hygiene practices may play a role in the higher rate of UTIs in females [27]. Male and female immune responses differ, especially throughout puberty, which could account for some of the reported variations in UTI incidence [26]. The occurrence of fever, odor, dysuria, appetite loss, and urination did not show significant differences between males and females, children with or without UTI, or among the three age groups (6–12, >12–14, and >14–18 years). UTI symptoms may be nonspecific and have underlying causes beyond the infection itself. Due to this symptom overlap, distinguishing UTIs from other diseases based solely on symptoms can be challenging [28]. Beyond the infection, there may be underlying causes of nonspecific UTI symptoms. It might be challenging to distinguish UTIs from other illnesses based solely on symptoms due to symptom overlap [28]. The results show that Escherichia coli (E. coli) was the predominant bacterial agent in causing urinary tract infections (UTIs) among school-age children, accounting for 74% of cases. This finding is consistent with previous studies, as E. coli is a common pathogen responsible for the majority of UTIs, especially in community settings [2, 8, 9, 23, 29]. Enterococcus faecalis, Enterobacter aerogenes, Klebsiella pneumoniae, Proteus mirabilis, and Pseudomonas aeruginosa were found to be responsible for UTIs, albeit at lower rates. These results align with established UTI-causing pathogens, as these bacteria are frequently linked to UTIs, although their prevalence may differ based on the population and geographic location being studied [30, 31]. Differences in the prevalence of UTI-causing bacteria among school-age children may be influenced by factors such as age, gender, geographical location, and underlying health conditions, as indicated by the varying rates of these bacterial agents. Staphylococcus aureus is a known pathogen that can cause different infections, such as UTIs, although it is not as commonly associated with UTIs as Escherichia coli. In contrast, Staphylococcus epidermidis is a less common cause of UTIs and is more frequently linked to infections from implanted medical devices [32, 33]. The 3% presence of Streptococcus agalactiae is notable. While not common in UTIs, they are pathogens that cause infections in humans. Their appearance in UTIs among school-age children may suggest distinctive sources of infection [5, 34]. Overall, the findings indicate that various bacterial pathogens can play a role in UTIs among school-age children, underscoring the need for thorough diagnostic methods and customized treatment plans depending on the particular pathogens present.

Conclusion

The clinical manifestation of UTIs in children is diverse and symptoms can be unclear, emphasizing the importance of urine culture for diagnosis. Escherichia coli is the predominant bacterial agent causing UTIs in school-age children, followed by other common pathogens such as Enterococcus faecalis, Enterobacter aerogenes, and Klebsiella pneumoniae. The prevalence of UTIs varies with age and gender, with females having a higher likelihood of developing UTIs, especially during puberty. Symptoms of UTIs, including fever, odor, dysuria, loss of appetite, and urinary frequency, did not show significant differences between genders, children with or without UTI, or among different age groups, making it challenging to identify UTIs based on symptoms alone.

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