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Original Article

Clinical Manifestations, Microbial Agents, and Types of Infection in Children With Urinary Tract Infection

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ABSTRACT

Background and Aim: Urinary Tract Infection (UTI) is common in children. This study aims to evaluate demographic characteristics, etiologies, and clinical presentations of UTI in childhood.

Methods: A cross-sectional retrospective study was conducted to investigate the available data of the children with UTI referred to the nephrology clinic of a tertiary academic children's hospital from September 2002- 2016. Patients aged 0-18 years were included in the study.

Results: A total of 1245 cases, including 1084 girls (87.06%) and 161 boys (12.94%) were included in the study. The age of patients at the first presentation was 35.43±34.94 months. Fever was the most common manifestation (60.1%). The most and least cases of UTI were reported in children aged 2-24 months (49.7%) and over 10 years old (2.9%), respectively. The most common pathogens were E. coli, Klebsiella, Staphylococcus, Enterobacter, Proteus, and Enterococcus species, respectively. The frequency of infection with E. coli in girls was significantly higher than in boys (P=0001), while infection with Staphylococcus and Proteus species was higher in boys (P=0.0001 and 0.002, respectively). The incidence of pyelonephritis decreased with age. Furthermore, febrile UTIs were as common in boys as in girls (P=0.42).

Conclusion: The prevalence of UTI is significantly higher in girls, and the frequency of UTI varies according to age, reaching its peak in the first year of life, and the lowest frequency in children over 10 years of age. Moreover, pyelonephritis is more common in younger children (infants 2-24 months). Gender is a crucial factor in terms of pathogens.

Keywords: Child, Urinary tract infections (UTI), Omit, Sex, Etiology

Introduction

Urinary tract infection (UTI) is one of the most common infections in children. It is crucial to have a clear understanding of the epidemiology, pathology, and etiologies of UTI for diagnostic purposes and therapeutic modalities [1, 2]. The epidemiology of UIT differs according to age, race, gender, and circumcision status [3]. The peak age of UTI is bimodal with two high incidence rates in the first year of life and then at the age of 2-4 years [1]. Considering the impact of age and gender, the

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infection rate is reported to be 6-8% for girls≤12 months. However, this rate declines to 2% after 12 months of life. During the first year of life, circumcised boys with febrile UTI were less affected (2.4%) than the uncircumcised boys (20%) [1, 4].

The UTI rate in the first year of life is higher in boys than girls and after the age of 12 months, the situation changes. For children younger than 14 years, the incidence rate is 1-3% in boys and 3-10% in girls [1, 3, 5, 6]. The clinical manifestations of UTI are related to age because no specific symptom is observed in infancy and childhood. The presentation of UTI may include unexplained fever as the most common feature, sepsis, irritability, poor feeding, anorexia, vomiting, foul-smelling urine, abdominal pain, and failure to thrive. Nonetheless, toddlers and children show more specific signs, including dysuria and frequency...) [1, 2, 7]. Escherichia coli (E. coli) is the most common responsible germ [8, 9]. In addition, numerous organisms, including Enterobacter aerogenes, Klebsiella pneumonia, Proteus mirabilis, Citrobacter, Pseudomonas aeruginosa, Enterococcus, and Serratia species (spp.) have been detected in various surveys [10]. Moreover, diverse viruses, such as adenoviruses, enteroviruses, echoviruses, and coxsackie viruses may cause UTI which often infects the lower urinary tract [11]. Fungi (e.g. Candida spp., Cryptococcus Neoformans, and Aspergillus spp.) are also known as the uncommon causes of UTI [12, 13].

With this background in mind, a comprehensive investigation of the different features of UTI, including clinical manifestations, microbial agents, and types of infection was evaluated in different ages and genders.

Materials and Methods

This retrospective cross-sectional study was conducted to assess the demographic characteristics, etiologies, clinical presentations, and types of UTI (cystitis vs. pyelonephritis). We studied children diagnosed with UTI who were referred to the nephrology clinic of Dr. Sheikh Hospital from September 2002 to September 2016. The recorded medical histories of 1245 patients over 18 years were used.

Eligibility criteria

The inclusion criteria included the diagnosis of UTI and age over 18 years. On the other hand, the exclusion criteria included demonstrating strong symptoms of UTI with a negative urine culture.

Study design

The patient's data were collected using a predesigned checklist. The urine sampling was performed using urinary bags and midstream methods in toilet-less and toilet-trained patients, respectively. The growth of a single organism with a colony-forming unit (CFU)≥10^5 was considered a positive culture and diagnosed as UTI. Regarding the toilet-trained patients with symptomatic UTI (e.g. fever and lower urinary tract symptoms), growth of≥10^4 CFU of a single urinary pathogen was regarded as a positive culture. In the samples obtained via urinary bags, the presence of leukocyturia, in addition to positive urine culture, was necessary for the diagnosis of UTI. Leukocyturia was defined as a white blood cell (WBC) count≥5 (or approximately 25 WBC/L) on a high-power field (HPF) of urinary sediment in a centrifuged urine sample. Three types of infections were determined based on the presence or absence of fever (≥38.5°C) or symptoms of UTI, febrile UTI, cystitis, and asymptomatic bacteriuria (ABU). Recent cases were defined as the presence of an organism with CFU≥10^5 in two consecutive urine specimens without any clinical signs or symptoms of UTI [14].

We aimed to assess the mentioned factors in distinct age and gender groups. Therefore, the patients were divided into five age sub-groups, including≤1 month, 2-24 months, 3-5 years, 6-10 years, and 10-18 years.

Statistical analysis

All data were statistically analyzed utilizing SPSS software v.16. First, the normal distribution of the variables was assessed using the one-sample Kolmogorov-Smirnov test. To describe the quantitative data, we used mean and standard deviation. In addition, the tables and charts were used to present qualitative data. The quantitative and qualitative variables were compared by applying the independent t-test and Chi-Square test, respectively. $P<0.05$ was considered significant for all tests.

Results

First, 1245 patients, including 1084 women and 161 men (female/male ratio of 6.7) patients were included in the study. The age of the subjects at the first presentation varied from 3 days to 214 months (35.43±34.94). The evaluation of circumcision status demonstrated that 70/161 boys (43.48%) were circumcised, 67/161 boys (41.61%) were uncircumcised, and 24 cases (14.91%) were unspecified (the circumcision status was not recorded). Among the recorded samples, 147 subjects

(11.8%) referred to the clinic only once and no more information was available regarding the follow-up. The mean duration of follow-up in the other patients was 17.3±24.33 months.

Age and age subgroup at onset of urinary tract infection (UTI)

The mean age of the patients was 35.59±33.6 months in girls and 31.9±42.83 months in boys. (P=0.18). Figure 1 shows the frequency of the participants based on age. The age of 40 patients (3.2%) was not identified at the first episodes of UTIs. The highest and lowest prevalence of UTI was observed in patients aged 2-24 months and less than 10 years old, respectively. Moreover, the frequency of the two genders was evaluated in the age subgroups. In the first evaluation, the prevalence of infection was assessed in both genders in five pre-determined age subgroups. The results showed that the frequency of affected girls was significantly higher, compared to boys in the age groups of 3-5 and 6-10 years (Table 1) (P=0.001).

After the age of 6 months, UTI occurrence in boys is unusual. Therefore, in the second evaluation, we categorized our patients into two age subgroups of≤6 and>6 months. The findings revealed that 39.7% of boys and 15.6% of girls were under the age of 6 months at the onset of UTI. The frequency of girls in the age group above 6 months was significantly higher than boys (Table 1) (P=0.0001). Afterward, in the third categorization, the patients were categorized into three age subgroups less than 24 months, 3-5 years (toilet training age), and above 5 years. The results in this classification demonstrated that the frequency of girls aged 3-5 years was significantly higher than boys (Table 1) (P=0.007).

The frequency of newly diagnosed UTIs between the ages of 0 to 18 years was evaluated in 1205 patients (The age of 40 cases [3.2%] was not identified at first episodes of UTIs). A sharp decrease in the number of infections was observed in girls between the ages of 1-2 years, so that in the second year of life, newly diagnosed cases reduced by about 50% (Figure 2). This decrease in number between ages 1-2 years was more prominent in boys (more than 80% decrease) (Figure 3). At the age of 6-7 years, the number of newly diagnosed patients reached a steady state, then slowly decreased to reach near zero (ages 12-18 years). Considering all the cases, girls and boys with the identified age at onset of UTIs (1205, 1048 and 157 patients, respectively), the highest frequency was observed in the first year of life (453/1205, 37.6%, 367/1048,35.02%, 86/157, and 54.77%, respectively). The female/male ratio in the first year of life was 4.25. A total of 324/1205 (26.9%) newly diagnosed cases were observed in the toilet training ages (3- 5 years), including 296/1048 girls (28.2%), and 28/157 boys (17.8%).

Clinical manifestation of urinary tract infection (UTI)

The symptoms commonly reported for UTI were collected and categorized based on gender (Table 2). The five most common clinical manifestations in girls were fever (54.33%), dysuria (26.1%), increased voiding frequency (13.2%), abdominal pain (11.07%), and vomiting (8.75%). In boys, they included fever (61.5%), dysuria (19.87%), irritability (12.42%), vomiting (10.5%), and abdominal pain (9.3%). Fever was the most common clinical manifestation in all age subgroups except the age group>10 years (Table 3).

Urinary tract infection (UTI) types

The first episode of UTIs was pyelonephritis in 688 patients (55.26%), 516 (41.44%), and 41 subjects (3.3%) referred with cystitis and asymptomatic bacteriuria (ABU), respectively. Except for 147 (11.8%) patients with lost follow-up, others followed for 17.3±24.33 months. During follow-up, 1802 episodes of UTIs were recorded, 919 (51%) and 883 (49%) episodes were cystitis and pyelonephritis, respectively. Figure 4 illustrates the number of episodes of cystitis and pyelonephritis during follow-up. Of 688 patients first presented as pyelonephritis, recurrent UTIs (febrile or afebrile) were not identified in 13 patients (1.9%).

The assessments demonstrated that during follow-up, 669/1084 girls (61.72%) and 105/161 boys (65.22%) with UTIs had febrile, while 403/1084 (37.18%) and 53/161 (32.92%) had cystitis, respectively. The results indicated that the types of UTIs were not significantly different between genders (P=0.325). In 12 girls (1.1%) and 3 boys (1.86%), both types of infections were reported. Moreover, the frequency of febrile and afebrile infections at the onset of UTIs was evaluated in the different age sub-groups. As shown in Table 4, the rate of febrile infections in the age group of 2-24 months (72.36%) was higher than the number of neonates≤1 month (59%). The lowest incidence of febrile UTI belonged to patients aged over 10 years (28.57%). Febrile vs. afebrile UTIs were significantly more prevalent in the ages of 2- 24 months rather than in other sub-groups (P=0.0001).

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Table 1. Comparing distribution in different age subgroups based on gender

Gender	No. (%)					P[1]
	≤1 month	2-24 months	3-5 years	6-10 years	>10 years	
Female	28(71.8)	510(85.15)	296(91.35)	189(90.85)	26(74.3)	
Male	11(28.2)	89(14.85)	28(8.65)	19(9.15)	9(25.7)	
Female / Male	2.54 / 1	5.73 / 1	10.57 / 1	9.95 / 1	2.88 / 1	0.001
Total cases	39(100)	599(100)	324(100)	208(100)	35(100)	
Gender	**No. (%)**					P
	≤2 years		3-5 years	>5 years		
Female	537(84.3)		297(91.38)	215(88.48)		
Male	100(15.7)		28(8.62)	28(11.52)		0.007
Total number	637(100)		325(100)	243(100)		
Female / Male	5.37 / 1		10.57 / 1	7.67 / 1		
Gender	**No. (%)**					P
	≤6 months		>6 months			
Female	164(72.56)		885(90.4)			
Male	62(27.44)		94(9.6)			0.0001
Total cases	226(100)		979(100)			
Female / Male	2.64 / 1		9.4 / 1			

1. Chi square test was used for analysis.

Frequency of pathogens

Of 1802 episodes of UTIs, the causative pathogens were recorded in 1472 episodes, in the others (330 episodes; 18.3%) pathogens were not clear (just colony count was recorded and the name of pathogens were omitted). The frequency of detected pathogens total and based on gender are summarized in Figures 5 and 6. Acinetobacter, Serratia, Morganella, and Candida which accounted for 1-2 episodes of UTIs were not listed in these Figures. The six main pathogens for UTIs include E. coli, Klebsiella, Staphylococcus, Enterobacter, Proteus, and Enterococcus spp. The most unusual species detected were Acinetobacter (2 episodes; 0.13%) Serratia, Morganella, and Candida (each one episode; 0.06%). Comparing the frequency of the pathogens, infection with *E. coli* species was significantly more prevalent in girls (P=0.001), while infection with Staphylococcus and Proteus species were significantly more common in boys (P=0.0001 and 0.002, respectively) (Table 5).

Excluding one episode of Candida infection, among the 1329 bacterial infection episodes in girls, the most reported agents were *E. coli* (82.4%), Klebsiella (5.95%), Enterobacter (3.08%), Enterococcus (1.95%), and Proteus (1.7%) species. In addition, out of the 142 recorded episodes in boys, the most detected organisms were *E. coli* (61.26%), Staphylococcus (11.26%), Klebsiella (7.04%), Proteus (5.63%), Enterococcus, and Citrobacter (3.5%) species.

Discussion

Young children with fever may have asymptomatic UTI [15]. In addition, the prevalence of UTI varies by age, gender, race, and circumcision status. Clinicians can overcome therapeutic problems and make more reliable case-based decisions by incorporating various demographic and clinical characteristics [3, 16]. The findings of our study regarding *E. coli* as the most common germ

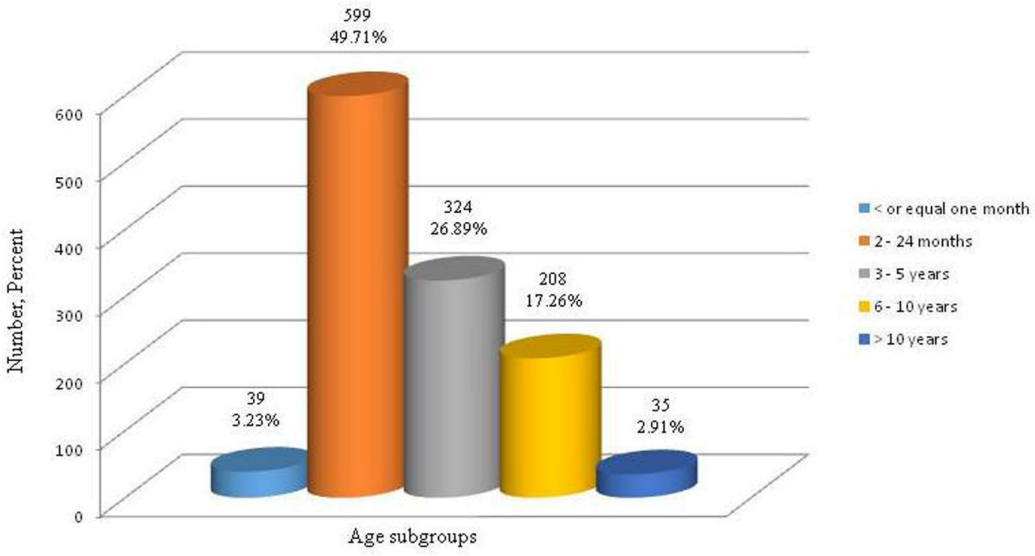

Figure 1. Distribution of patients in main age subgroups

of UTI are consistent with various studies [17-20]. In a survey on children aged≤18 years, the highest prevalence belonged to *E. coli* followed by Enterobacter. In the present study, Enterobacter was replaced by Klebsiella [21]. Mitiku et al. demonstrated that *E. coli* and Klebsiella were the most prevalent agents in patients with UTI. However, the frequency of the microorganisms was different from the current investigation. In their study, the rate of infections with *E. coli* was lower and for Klebsiella was higher than our results (45.9% vs.75.2% for E.coli and 24.3% vs. 6.08% for Klebsiella, respectively) [22].

Thattil et al. conducted a study in India on patients aged 5-55 years to determine the bacteria responsible for UTI. The most frequently detected bacteria were reported as E. coli, Proteus, Klebsiella, Pseudomonas, Staphylococcus aureus, and Enterococcus. According to these authors, the frequency of *E. coli* was lower than the results reported in the western studies (37.4% vs. 80%–85%.) [23], and our series (37.4% vs. 75.2%), respectively. In their series, gram-positive bacteria accounted for 12.9% of infections, which is twice as much as the present study (5.94%). In our series, Staphylococcus, Enterococcus, and Streptococcus species were responsible for 3.4%, 1.97%, and 0.57% of UTIs, respectively. Moreover, we had Enterobacter as one of the main organisms, while it was not reported in the findings of the latter study.

Studies performed by Shrestha et al. and Sorlozano et al. reported Enterococcus spp. as the second most prevalent agent after *E. coli* with a frequency of 22% and 22.4%, respectively [24, 25]. This pathogen was an uncommon germ in our series (1.97% of cases). As shown, the second frequency in the present study belonged to Klebsiella (5.66%), while the two mentioned papers re-

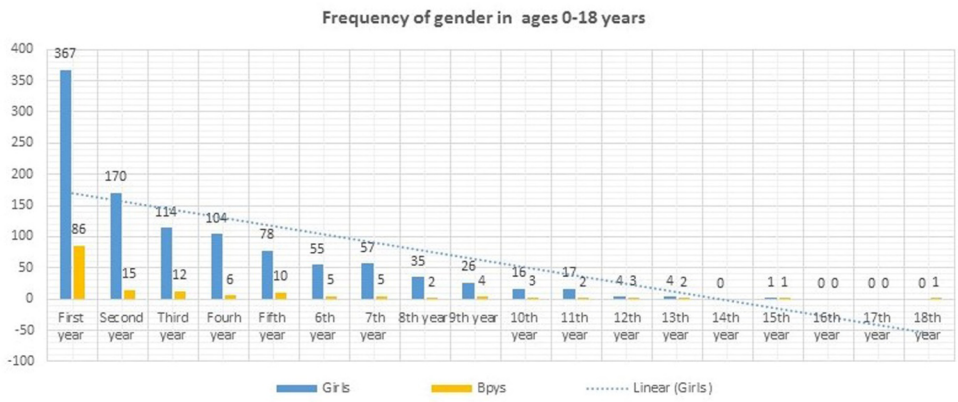

Figure 2. Frequency of gender in ages 0-18 years with trend line for girls

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Table 2. Clinical manifestation based on gender

Clinical Manifestation	No. (%)		
	Boys	Girls	Total Cases
Fever	99(61.5)	589(54.33)	688(55.26)
Dysuria	32(19.87)	283(26.1)	315(25.3)
Increased voiding frequency	5(3.1)	143(13.2)	148(11.9)
Abdominal pain	15(9.3)	120(11.7)	135(10.8)
Vomiting	17(10.5)	95(8.75)	112(9)
Daytime urinary incontinence	6(3.72)	70(6.45)	76(6.1)
Failure to thrive (FTT)	2(1.24)	69(6.35)	71(5.7)
Flank pain	2(1.24)	64(5.9)	66(5.3)
Irritability	20(12.42)	63(5.8)	83(6.7)
Bad smell urine	6(3.72)	57(5.25)	63(5.06)
Nocturnal enuresis	8(4.95)	46(4.25)	54(4.3)
Gross hematuria	12(7.45)	42(3.87)	54(4.3)
Diarrhea	13(8.07)	33(3.04)	46(3.7)
Asymptomatic	8(4.95)	33(3.04)	41(3.3)
Febrile convulsion	6(3.72)	25(2.3)	31(2.5)
Chill	1(0.62)	13(1.2)	14(1.1)
Genital discomfort	0	10(50.92)	10(0.8)
Jaundice	3(1.85)	8(0.73)	11(0.88)
Sepsis like symptoms	4(2.5)	7(0.65)	11(0.88)
Total cases	161(100)	1084(100)	1245(100)

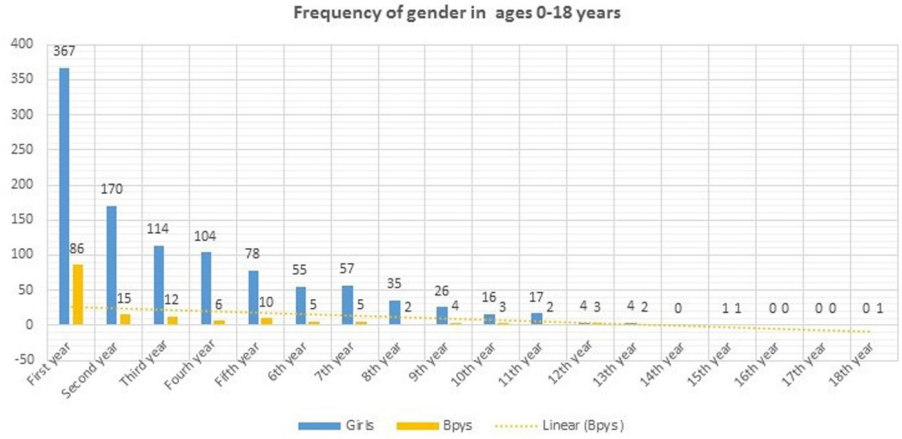

Figure 3. Frequency of gender in ages 0-18 years with trend line for boys

Table 3. Most common clinical manifestations based on age subgroups

Age Subgroup	No. (%)		
	Clinical Manifestation		Total Patients
≤1 month	Fever Jaundice Sepsis like syndromes Dysuria Irritability	16(41.2) 10(28.64) 5(12.82) 4(10.25) 4(10.25)	39(100)
2-24 months	Fever Vomiting Diarrhea Dysuria Bad smell urine	388(64.66) 66(11) 41(6.83) 41(6.83) 32(5.33)	599(100)
3-5 years	Fever Dysuria Increased voiding frequency Abdominal pain Daytime urinary incontinence	177(54.46) 140(43.07) 60(18.46) 37(11.38) 28(8.61)	324(100)
6-10 years	Fever Dysuria Increased voiding frequency Abdominal pain Flank pain	101(48.09) 70(33.33) 45(21.42) 39(18.57) 33(15.71)	208(100)
>10 years	Dysuria Fever Abdominal pain Daytime urinary incontinence Gross hematuria	15(42.85) 13(37.14) 8(22.85) 6(17.14) 6(17.14)	35(100)

ported Klebsiella as the third frequent agent (7% and 6.5%, respectively).

In another survey, Enterococcus was found in infants after Klebsiella [26]. In the study by Wang et al. Enterococcus was the most prevalent agent followed by *E. coli* [27]. The rate of infection with *E. coli* in the present study was higher than the report of these authors. However, Klebsiella was as frequent as the present report. Han et al. [28]. stated the main causes of UTIs in neonates as E. coli, Enterococcus, and Klebsiella. The high number of Enterococcus was related to the age of pa-

Table 4. Comparing frequency of pyelonephritis vs. cystitis by age

Age Subgroups	No. (%)			P[1]
	Pyelonephritis	Cystitis	Total Cases	
≤1 month	23(59)	16(41)	39(100)	0.0001
2-24 months	432(72.3)	165(27.7)	597(100)	
3-5 years	190(59.75)	128(40.25)	318(100)	
6-10 years	104(50.25)	103(49.75)	207(100)	
10-18 years	10(28.5)	25(71.5)	35(100)	
Total cases	759(100)	437(100)	1196[2] (100)	

1. Chi square test was used for analysis.

2. In 49 patients, age or type of UTIs or both were unidentified.

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Table 5. Comparing frequencies of six the most common bacterial pathogens between girls and boys

Pathogen		No. (%)		Number of Total Episodes of Infection	P[1]
		Girls	Boys		
E. coli species	Yes	1095	87	1182	0.001
	No	234	55	289	
Klebsiella species	Yes	79	10	89	0.602
	No	1250	132	1382	
Staphylococcus species	Yes	41	16	57	0.0001
	No	1288	126	1414	
Enterobacter species	Yes	41	4	45	0.86
	No	1288	138	1426	
Proteus species	Yes	23	8	31	0.002
	No	1306	134	1440	
Enterococcus species	Yes	26	5	31	0.217
	No	1303	137	1440	
	Total number	1329	142	1471	

tients. Nevertheless, the other pathogens were reported to be the same as our findings.

Lo et al. [29] provided further evidence in a group of affected children aged <15 years, mostly female. The main pathogen was E. coli, which is the same as our results. They reported Proteus (10.3%) and Staphylococcus saprophyticus (4.1%) after *E. coli* (76.6%). For instance, the frequency of Proteus in their results was five times higher than in the present study. In addition, similar to our study, the prevalence of Proteus spp. in their study was significantly higher in boys than girls. They did not report any difference between genders regarding the prevalence of E. coli. Moreover, in children aged over 10 years old, they reported Staphylococcus as the main responsible pathogen (24.4%). 29 By our findings, Odoki et al. [30] reported Staphylococcus aureus (31.4%) as the second pathogen after *E. coli* (41.9%)

Gondim et al. [31] reported that the prevalence of UTI in women is higher than in men. In their report, affected boys were 2.6 times more than in the present study. Furthermore, the frequency of patients with febrile UTI in the above study was different from our results (39.2% vs. 55.26%, respectively). This variation may be due to the difference between the mean age of patients and the methodology of the two studies. Their enrolled cases included patients diagnosed with overactive bladder.

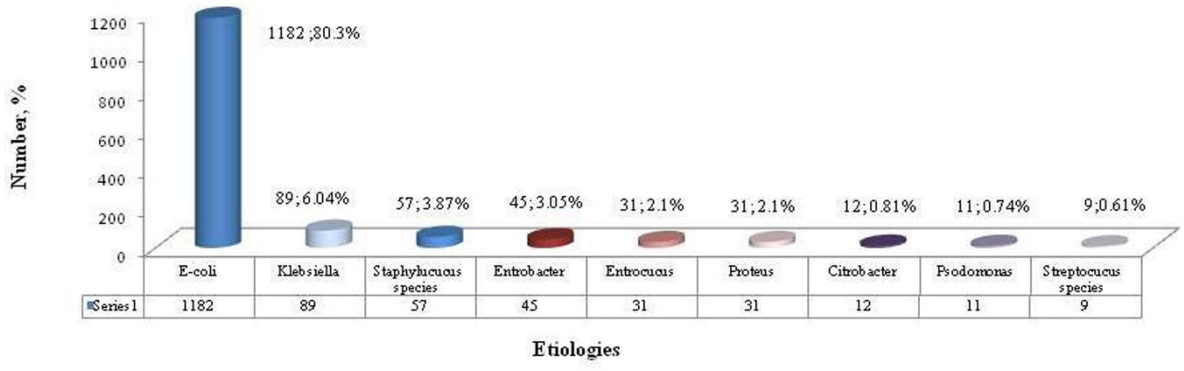

Figure 5. Etiologies of urinary tract infections (UTI) in patients

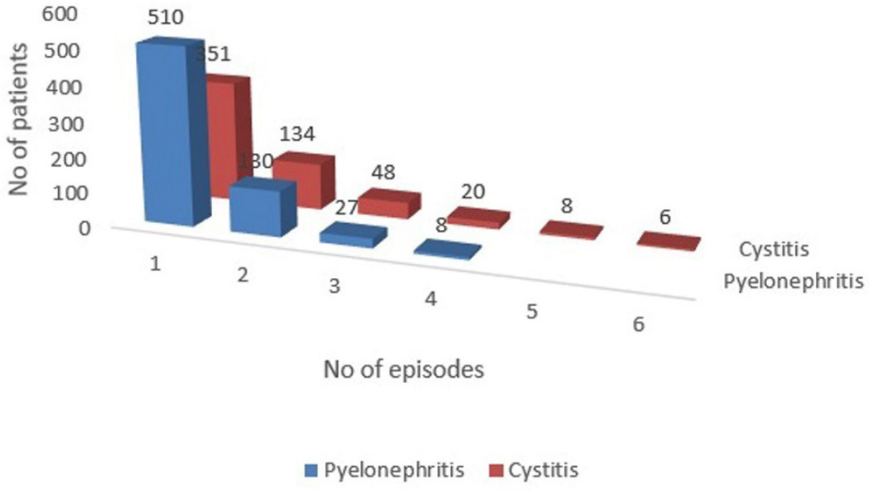

Figure 4. Number of episodes of pyelonephritis and cystitis at follow-up

According to our results, the high prevalence of Proteus mirabilis in male patients was proved by another research [29]. Maglino et al. [32] surveyed a wide range of patients from newborns to 60-year-old patients. They found that age and gender are two crucial factors in the context of UTI etiologies. They reported that the Proteus infection rate is high in children aged≤14 and the prevalence of *E. coli* decreased with age.

Sepsis, irritability, apnea, seizure vomiting, and prolonged jaundice have been reported as the main clinical manifestations of UTI in neonates. During the first two years of life, unexplained fever is the most common symptom. After the age of 2 years, fever, vomiting, and flank pain are common findings. 1 In the current study, fever, jaundice, and sepsis-like syndromes were cardinal manifestations of neonatal UTI. In addition, 63.32% of patients aged≤2 years had fever at the first presentation. Fever, abdominal and flank pain and lower urinary symptoms (dysuria, increased voiding frequency and daytime incontinence) were the main clinical manifestation in the age group>2 years. After the age of 2 years, with increasing age, the frequency of febrile UTIs decreases. However, in children aged>10 years, fever is not an uncommon presentation (37.14%).

A bimodal peak age for UTI has been reported. First, in the first year of life and then at 2-4 years of toilet training age. 1 In the current study, the peak of UTI was in the first year of life. Then the frequency of UTI sharply decreased and reached a plateau state at the age of 6-7 years (school-aged), subsequently declined and reached near zero at the age>14 years.

Conclusion

According to the findings of the present study, UTI is more common in female patients; fever is the most common manifestation in pediatric UTIs. The peak of UTIs is in the first year of life, and it is common for boys

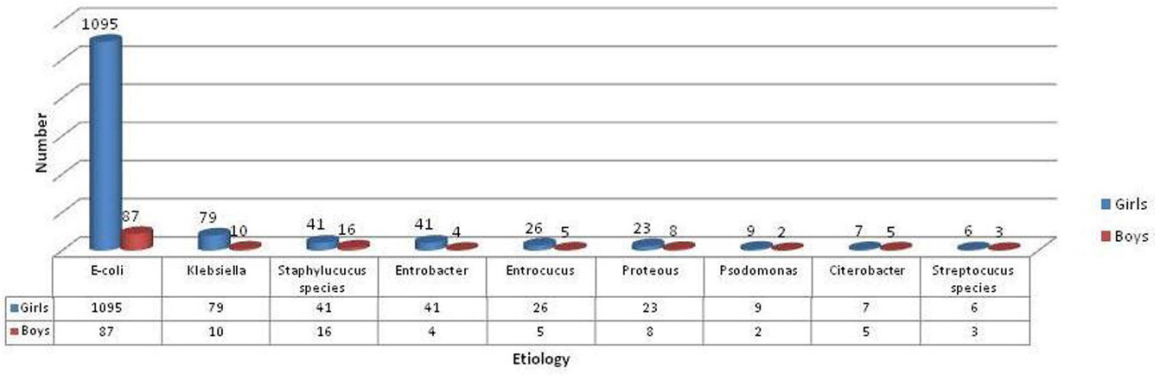

Figure 6. Etiologies of urinary tract infections (UTI) based on gender

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to have UTI after 6 months of age. Majority of pyelonephritis occurred in infants aged 2-24 months and the lowest frequency is in children over 10 years old. The main causative organisms responsible for UTI are E. coli, Klebsiella, Staphylococcus Enterobacter, Proteus, and Enterococcus spp. Furthermore, gender is a vital factor in terms of causative pathogens. For example, *E. coli* frequency was significantly higher in girls, while Proteus and Staphylococcus spp. were more common in boys.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Ethics Committee of Mashhad University of Medical Sciences with the ethics code of IR.MUMS.fm.REC.1396.173.

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Authors' contributions

Conceptualization: Mitra Naseri, Elham Aghatabi. Methodology: Mitra Naseri; Investigation: Elham Aghatabi, Nooshin Tafazoli and Niayesh Tafazoli; Data curation and Software: Nooshin Tafazoli, Niayesh Tafazoli; Original draft preparation: Mitra Naseri, Nooshin Tafazoli, Niayesh Tafazoli. Supervision, project administration funding acquisition formal analysis and final approval: Mitra Naseri.

Conflict of interest

The authors declared no conflict of interest.

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References

[1] Leung AKC, Wong AHC, Leung AAM, Hon KL. Urinary tract infection in children. Recent Pat Inflamm Allergy Drug Discov. 2019; 13(1):2-18. [DOI:10.2174/1872213X13666181228154940] [PMID] [PMCID]

[2] Mishra OP, Abhinay A, Prasad R. Urinary infections in children. Indian J Pediatr. 2013; 80(10):838-43. [DOI:10.1007/s12098-013-1118-4] [PMID]

[3] Shaikh N, Morone NE, Bost JE, Farrell MH. Prevalence of urinary tract infection in childhood: A meta-analysis. Pediatr Infect Dis J. 2008; 27(4):302-8. [DOI:10.1097/INF.0b013e31815e4122] [PMID]

[4] Balighian E, Burke M. Urinary tract infections in children. Pediatr Rev. 2018; 39(1):3-12. [DOI:10.1542/pir.2017-0007] [PMID]

[5] Baumer JH, Jones RW. Urinary tract infection in children, national institute for health and clinical excellence. Arch Dis Child Educ Pract Ed. 2007; 92(6):189-92. [DOI:10.1136/adc.2007.130799] [PMID]

[6] Chang SL, Shortliffe LD. Pediatric urinary tract infections. Pediatr Clin North Am. 2006; 53(3):379-400. [DOI:10.1016/j.pcl.2006.02.011] [PMID]

[7] Robinson JL, Finlay JC, Lang ME, Bortolussi R . Urinary tract infections in infants and children: Diagnosis and management. Paediatr Child Health. 2014; 19(6):315-25. [DOI:10.1093/pch/19.6.315] [PMID] [PMCID]

[8] Korbel L, Howell M, Spencer JD. The clinical diagnosis and management of urinary tract infections in children and adolescents. Paediatr Int Child Health. 2017; 37(4):273-9 [DOI:10.1080/20469047.2017.1382046] [PMID]

[9] Arshad M, Seed PC. Urinary tract infections in the infant. Clin Perinatol. 2015; 42(1):17-28. [DOI:10.1016/j.clp.2014.10.003] [PMID] [PMCID]

[10] Morello W, La Scola C, Alberici I, Montini G. Acute pyelonephritis in children. Pediatr Nephrol. 2016; 31(8):1253-65. [DOI:10.1007/s00467-015-3168-5] [PMID]

[11] Schlager TA. Urinary tract infections in infants and children. Microbiol Spectr. 2016; 4(5):1-7. [DOI:10.1128/microbiolspec.UTI-0022-2016] [PMID]

[12] Desai DJ, Gilbert B, McBride CA. Paediatric urinary tract infections: Diagnosis and treatment. Aust Fam Physician. 2016; 45(8):558-63. [PMID]

[13] Foxman B. The epidemiology of urinary tract infection. Nat Rev Urol. 2010; 7(12):653-60. [DOI:10.1038/nrurol.2010.190] [PMID]

[14] Rubin RH, Shapiro ED, Andriole VT, Davis RJ, Stamm WE. Evaluation of new anti-infective drugs for the treatment of urinary tract infection. Clin Infect Dis. 1992; 15(suppl 1):S216-27. [DOI:10.1093/clind/15.Supplement_1.S216] [PMID]

[15] Zorc JJ, Kiddoo DA, Shaw KN. Diagnosis and management of pediatric urinary tract infections. Clin Microbiol Rev. 2005; 18(2):417-22. [DOI:10.1128/CMR.18.2.417-422.2005] [PMID] [PMCID]

[16] Barber AE, Norton JP, Spivak AM, Mulvey MA. Urinary tract infections: Current and emerging management strategies. Clin Infect Dis. 2013; 57(5):719-24. [DOI:10.1093/cid/cit284] [PMID] [PMCID]

[17] Parajuli NP, Maharjan P, Parajuli H, JoshiG, Paudel D, Sayami S, et al. High rates of multidrug resistance among uropathogenic escherichia coli in children and analyses of ESBL producers from Nepal. Antimicrob Resist Infect Control. 2017; 6:9. [DOI:10.1186/s13756-016-0168-6] [PMID] [PMCID]

[18] Badhan R, Singh DV, Badhan LR, Kaur A. Evaluation of bacteriological profile and antibiotic sensitivity patterns in children with urinary tract infection: A prospective study from a tertiary care center. Indian J Urol. 2016; 32(1):50-6. [DOI:10.4103/0970-1591.173118] [PMID] [PMCID]

[19] Pape L, Gunzer F, Ziesing S, Pape A, Offner G, Ehrich JH. [Bacterial pathogens, resistance patterns and treatment options in community acquired pediatric urinary tract infection (German)]. Klin Padiatr. 2004; 216(2):83-6. [DOI:10.1055/s-2004-823143] [PMID]

[20] Nateghian AR, Parvin M, Rohani P, Tabrizi M. [Incidence and risk factors for gentamicin and ceftriaxone resistant e. coli causing urinary tract infection in children admitted in Hazrat-e-Ali Asghar Hospital (Persian)]. Razo J Med Sci. 2009; 16(66):43-56. [Link]

[21] Heqbalian F, Yousefi Mshouf R. [Determination of frequency of bacterial factors of urinary tract infection and their antibiotic susceptibility patterns in patients under the age of 18 admitted to Ekbatan hospital in Hamedan (Persian)]. Annals of Military and Health Sciences Research. 2005; 3(3):635- -9. [Link]

[22] Mitiku E, Amsalu A, Tadesse BT. Pediatric urinary tract infection as a cause of outpatient clinic visits in southern Ethiopia: A cross sectional study. Ethiop J Health Sci. 2018; 28(2):187-96. [DOI:10.4314/ejhs.v28i2.10] [PMID] [PMCID]

[23] Thattil SJ, Santhosh S. Prevalence of UTI in different age groups in a tertiary care hospital and their antibiogram. Int J Contemp Med Res. 2018; 5(1):1-4. [Link]

[24] Shrestha LB, Baral R, Poudel P, Khanal B. Clinical, etiological and antimicrobial susceptibility profile of pediatric urinary tract infections in a tertiary care hospital of Nepal. BMC Pediatr. 2019; 19(1):36. [DOI:10.1186/s12887-019-1410-1] [PMID] [PMCID]

[25] Sorlózano-Puerto A, Gómez-Luque JM, Luna-Del-Castillo JD, Navarro-Marí JM, Gutiérrez-Fernández J. Etiological and resistance profile of bacteria involved in urinary tract infections in young children. Biomed Res Int. 2017; 2017:4909452. [DOI:10.1155/2017/4909452] [PMID] [PMCID]

[26] Kaur N, Sharma S, Malhotra S, Madan P, Hans C. Urinary tract infection: Aetiology and antimicrobial resistance pattern in infants from a tertiary care hospital in northern India. J Clin Diagn Res. 2014; 8(10):DC01-3. [DOI:10.7860/JCDR/2014/8772.4919] [PMID] [PMCID]

[27] Wang J, He L, Sha J, Zhu H, Huang L, Zhu X, et al. Etiology and antimicrobial resistance patterns in pediatric urinary tract infection. Pediatr Int. 2018; 60(5):418-22. [DOI:10.1111/ped.13526] [PMID]

[28] Han YJ, Yu SL, Tao YZ. [Urinary tract infections in the neonatal intensive care unit: Clinical analysis of 229 cases) Chinese)]. Zhongguo Dang Dai Er Ke Za Zhi. 2012; 14(3):177-80. [PMID]

[29] Lo DS, Shieh HH, Ragazzi SL, Koch VH, Martinez MB, Gilio AE. Community-acquired urinary tract infection: Age and gender-dependent etiology. J Bras Nefrol. 2013; 35(2):93-8. [DOI:10.5935/0101-2800.20130016] [PMID]

[30] Odoki M, Almustapha Aliero A, Tibyangye J, Nyabayo Maniga J, Wampande E, et al. Prevalence of bacterial urinary tract infections and associated factors among patients attending hospitals in Bushenyi district, Uganda. Int J Microbiol. 2019; 2019:4246780. [DOI:10.1155/2019/4246780] [PMID] [PMCID]

[31] Gondim R, Azevedo R, Braga A, Veiga ML, Barroso U. Risk factors for urinary tract infection in children with urinary urgency. Int Braz J Urol. 2018; 44(2):378-83. [DOI:10.1590/s1677-5538.ibju.2017.0434] [PMID] [PMCID]

[32] Magliano E, Grazioli V, Deflorio L, LeuciA L, Mattina R, Romano P, et al. Gender and age-dependent etiology of community-acquired urinary tract infections. Sci World J. 2012; 2012:349597. [DOI:10.1100/2012/349597] [PMID] [PMCID]