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Epidemiological Distribution of Uropathogens in Pediatric Urinary Tract Infections at Women and Children's Teaching Hospital, Al-Muthanna, Iraq

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Abstract

UTI is one of the most common types of bacterial infections in children worldwide, which has made it a leading cause of morbidity among children and an increase in medical costs. The variability of uropathogen profiles is determined by demographic factors, especially age and sex, and knowledge of these trends is crucial to effective antimicrobial stewardship and enhancing the precision of empirical treatment regimens. However, there is still a knowledge gap in terms of the modern, demographically stratified information about the etiology of UTI in children. Proper evaluation of these trends is imperative in making evidence-based decisions on protocols, antimicrobial therapy and interventions on population health. In an effort to aid the formulation of evidence based clinical guidelines, this study was carried out to longitudinal three-year analysis to help determine the relationship between the distribution of bacterial and fungal uropathogens in pediatric UTIs and age and sex.

Keywords: Urinary tract infection; *Escherichia coli*; *Staphylococcus aureus*; *Candida albicans*; Antimicrobial stewardship; Epidemiological surveillance

1. Introduction

1.1. Etiology of Urinary Tract Infections

UTI pathogenesis in children and females is mostly a consequence of the colonization and rapid multiplication of potential pathogenic bacteria in the urinary tract. *Escherichia coli* is the most common etiological agent of UTI and a microorganism, which is usually a part of the gastrointestinal tract and turns into a pathogen when translocated to the urinary system. Besides E. coli studies have also found out that Klebsiella, Proteus and Enterococcus are also important bacterial factors that lead to the development of UTIs [1].

1.2. Pathogenesis in Women

The increased vulnerability of the female population to UTI is mainly explained by certain anatomical and physiological arrangement of the genitourinary tract. The relative shortness of the female urethra and the proximity to the perianal area allow the retrograde passage of commensal enteric bacteria into the urinarytract. Sexual activity is also a risk factor as bacteria may enter into the urethra in a mechanical way [2].

1.3. Pathogenesis in Children

In clinical practice, an important correlation is noticed between the structural malformations of the urinary tract underlying and the occurrence of pediatric UTIs. Vesicoureteral reflux (VUR) is a medical disorder characterized by the retrograde flow of urine in bladder to uterus and kidneys. This mechanism can facilitate the transmission of pathogen

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by reversing the direction of urine flow, thus allowing bacteria in the lower urinary tract to move quickly to the upper urinary tract, increasing the probability of acute pyelonephritis and chronic renal injury. When it comes to pediatric care, a number of behavioral and physiological factors are considered to play a crucial role in the development of UTIs through the facilitation of bacterial colonization and the impairment of bladder functions [3].

Although bacterial pathogens are the main causes of UTI, the clinical literature does not exclude that fungal and viral organisms may sometimes be the etiological agents, but in much less number than the cases of bacterial etiology. A variety of host-related factors, such as impaired immune response, indwelling catheters, anatomical abnormality, and metabolic or endocrine system-wide conditions such as diabetes mellitus are significantly increased in the development of UTI in both female and pediatric cohorts [4].

Proper identification of the causative agent is critical towards the effective therapy interventions and reduced cases of recurrent UTUs. The prophylactic measures of UTIs are multifaceted, with a focus on holistic patient education about hygiene, correction of underlying anatomical anomalies, and judicious and evidence-based use of antimicrobial therapies [5].

1.3.1. Bacterial Pathogens

The bacterial pathogens most frequently identified in UTIs among women and children comprise [6]:

- ***Escherichia coli:*** The majority of simple UTIs are caused by this gram-negative bacillus, which is the most common uropathogen.
- ***Staphylococcus aureus:*** *Staphylococcus aureus* is a prominent opportunistic organism that can cause both short-term and long-term infections, such as UTIs. The accessory gene regulator (Agr), an essential quorum-sensing (QS) system, and the ureABCEFGD gene cluster, which collectively regulate urease production and augment bacterial virulence, largely facilitate the pathogenicity of *S. aureus* [7].
- ***Candida albicans***: Species of the genus Candida have been shown to be a major cause of urinary tract infections (UTIs). Invasive Candida infections are a growing problem in clinical practice because they are linked to high death rates and high healthcare costs [8].

1.3.2. Risk Factors and Predisposing Conditions

There are many host and environmental factors that make people more likely to get UTIs [9]:

- Female sex: a shorter urethra makes it easier for infections to spread.
- Sexual activity: the mechanical transmission of bacteria during sexual activity raises the chance of a UTI.
- Urinary catheterization: the catheter allows microbes to enter and build biofilms.
- Immunocompromise: disorders like diabetes, HIV/AIDS, or chemotherapy make you more likely to get sick.
- Age-related factors: age-specific physiological and behavioral factors play a significant role in the susceptibility to UTIs because they interfere with the normal functioning of the body in clearing pathogens.

1.4. Epidemiology of Urinary Tract Infections

UTIs are a health issue of worldwide concern, and the morbidity rates are especially high in the female and children cohorts. Epidemiological data continuously show that there is a remarkable difference between the lifetime prevalence and frequency of UTIs, and clinical evidence shows that women are affected more than other demographic groups [10].

1.4.1. Female Population

This vast disparity between the UTI rates in the sexes may be largely attributed to certain anatomical and physiological peculiarities of female genitourinary system. Predisposition of the female urinary tract has greatly been attributed to some anatomical factors that lower body natural resistance to the invasion of bacteria. The epidemiological data indicate that the prevalence of symptomatic UTIs among adult women is high during their lifetime, and more than half of adult women report experiencing at least one of the UTI. In addition, there is a recurring tendency of infection amongst a large number of them and that implies that the vulnerability is not a single episode but chronic [11].

1.4.2. Pediatric Population

Urinary tract infections are often diagnosed in pediatric medicine and clinical evidence shows that the rate of incidence is significantly higher in children younger than 24 months. The rate of occurrence of such conditions depends on several factors such as the age of a patient, his/her biological sex and the existence of pre-existing urological disorders. The

presence of a UTI in a baby or a very young child is normally a red flag that can be employed to show the presence of structural abnormalities in the urinary tract and their presence demands a thorough clinical investigation [12].

1.5. Age-Specific Clinical Features

The signs of this disorder depend much on the age of the patient:

1.5.1. Infants and Young children (02 years)

UTIs typically show non-specific or vague symptoms in infants, thus are difficult to detect. Clinical indicators may include irritability, poor feeding, lethargy, fever, vomiting, diarrhea, respiratory distress, or altered levels of consciousness. when an infant develops meningitis, clinical signs may include a bulging fontanelle, persistent or excessive crying, and difficulties with swallowing [13].

1.5.2. Older children and adolescents

For children in this demographic, the clinical presentation of a UTI tends to mirror adult symptoms, frequently involving fever, upper respiratory distress, sore throat, headaches, exhaustion, muscle aches, and various digestive complaints. In the meanwhile, symptoms that are particular to the illness, such as lymphadenopathy in cases of streptococcal pharyngitis or a rash connected to scarlet fever, may be present [14].

1.5.3. Adults

Fever, respiratory symptoms, pharyngitis, headache, exhaustion, myalgia, and gastrointestinal problems are common signs of urinary tract infections in adult patients. Otherwise, adults may also include joint problems, nasal pain, chest pain, and shortness of breath [15].

2. Methods

Positive urine cultures obtained between 2021 and 2023 were the subject of a retrospective observational investigation. Patients were categorised into age groups (0–3, 3–6, 7–10, and 11–15 years) and by sex (Male versus Female). Gram-positive, gram-negative, and fungal pathogens were discovered and classified from bacterial isolates. We used descriptive statistics to summarise categorical variables, and we showed the results as percentages and frequencies [16].

3. Results and Discussion

During the three-year study period, 440 positive urine cultures were evaluated. Of these, 335 were from female patients and 105 were from male patients. This gave an overall female-to-male ratio of 3.2:1. This study presents an analysis of bacterial pathogens identified from positive urine cultures collected between 2021 and 2023 (Tables 1 to 3). Figures 1 and 2 indicate that the data give a full picture of how uropathogens are spread by age and sex.

3.1.1. Bacterial Pathogens in Urine Cultures (2021–2023)

Table 1 Bacterial Pathogens in Positive Urine Cultures by Age and Sex (2021)

Pathogen Type	Pathogen	0–3 yrs (F/M)	3–6 yrs (F/M)	7–10 yrs (F/M)	11–15 yrs (F/M)	Total (F/M)
Gram-negative	*E. coli*	15 / 2	10 / 4	9 / 3	4 / 2	38 / 9
	Pseudomonas	1 / 0	2 / 1	2 / 1	3 / 1	8 / 3
Gram-positive	*Staphylococcus hemolytic*	10 / 3	11 / 1	8 / 2	5 / 3	34 / 9
	Staphylococcus aureus	4 / 3	6 / 2	2 / 1	3 / 1	15 / 7
Fungal	*Candida albicans*	3 / 1	2 / 0	1 / 1	2 / 2	8 / 4

Table 2 Bacterial Pathogens in Positive Urine Cultures by Age and Sex (2022)

Pathogen Type	Pathogen	0–3 yrs (F/M)	3–6 yrs (F/M)	7–10 yrs (F/M)	11–15 yrs (F/M)	Total (F/M)
Gram-negative	*E. coli*	13 / 3	12 / 5	10 / 2	1 / 1	36 / 11
	Pseudomonas	2 / 1	1 / 0	5 / 2	1 / 3	9 / 6
Gram-positive	*Staphylococcus hemolytic*	12 / 4	6 / 2	5 / 2	2 / 1	25 / 9
	Staphylococcus aureus	3 / 1	4 / 1	3 / 3	10 / 2	20 / 7
Fungal	*Candida albicans*	3 / 2	1 / 1	2 / 0	4 / 1	10 / 4

Table 3 Bacterial Pathogens in Positive Urine Cultures by Age and Sex (2023)

Pathogen Type	Pathogen	0–3 yrs (F/M)	3–6 yrs (F/M)	7–10 yrs (F/M)	11–15 yrs (F/M)	Total (F/M)
Gram-negative	*E. coli*	12 / 4	14 / 4	10 / 1	8 / 2	44 / 11
	Pseudomonas	2 / 0	0 / 1	4 / 1	1 / 2	7 / 4
Gram-positive	*Staphylococcus hemolytic*	10 / 2	8 / 2	4 / 1	10 / 2	23 / 7
	Staphylococcus aureus	2 / 0	6 / 2	4 / 2	12 / 4	44 / 8
Fungal	*Candida albicans*	4 / 2	2 / 1	2 / 1	6 / 2	14 / 6

Notes:
F = Female, M = Male
Age groups: 0–3 yrs, 3–6 yrs, 7–10 yrs, 11–15 yrs
Total = cumulative number of isolates per year

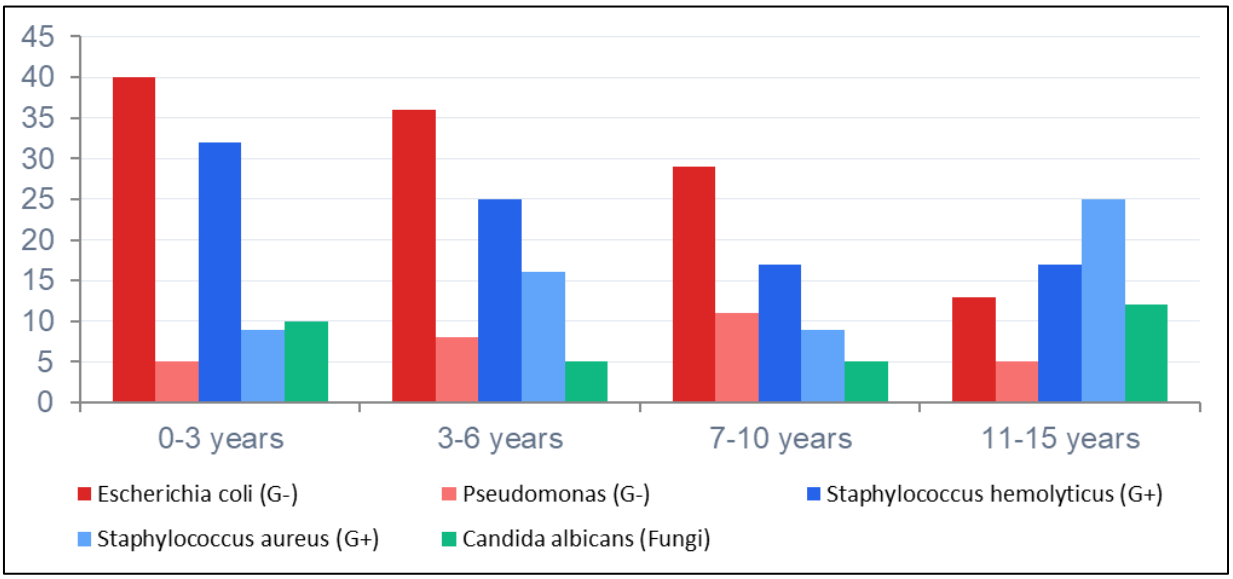

Figure 1 Distribution by Age Group

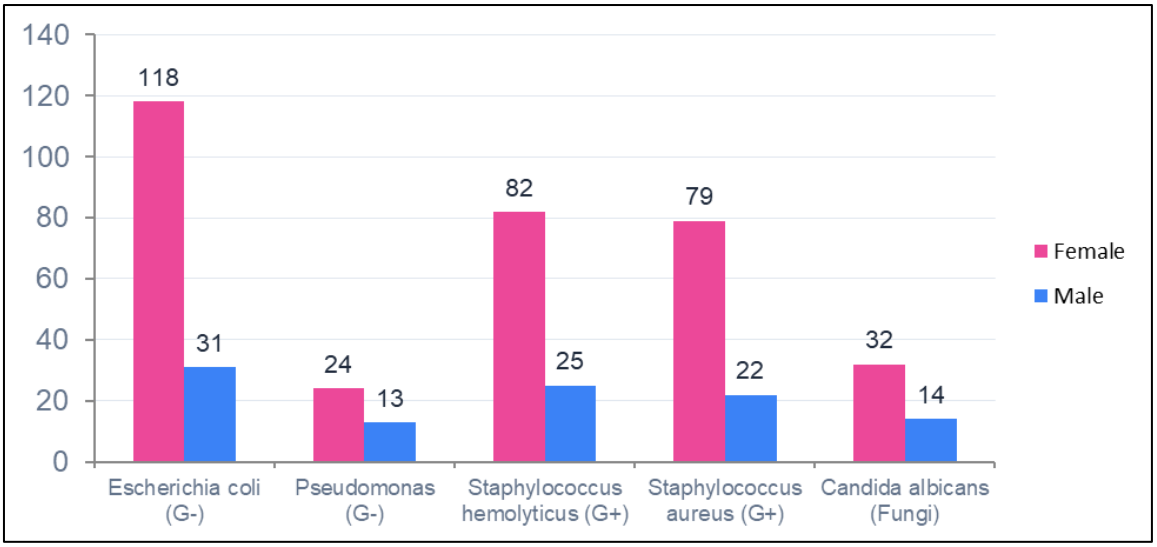

Figure 2 Distribution by Sex

During the three-year study period, *Escherichia coli* was consistently identified as the predominant uropathogen, representing approximately 34–36% of all isolates each year (totaling 118 isolates). It was prevalent among women and small children particularly those aged 0-6. The distribution of *E. coli* per year remained relatively constant, with 47 isolates in 2021 (38 female and 9 males), 36 isolates in 2022 (36 female and 11 male), and 55 isolates in 2023 (44 female and 11 male).

Staphylococcus haemolyticus and *Staphylococcus aureus* accounted about 2530 percent of the cases and so gram-positive bacteria were the second common group to be found. *S. aureus* bore a strong age distribution with the highest prevalence rate increasing with age and peaking in the 1115 age group which presented 26 cases during the study period.

The proportion of infections by *Pseudomonas* species was low (approximately 4.5% or 20 cases in total) and demonstrated a very consistent age distribution and year of study. It has shown an upward trend with time with an increase in cases of fungal uropathogens since 2021 (8 cases) to 2022 (10 cases) and 2023 (14 cases) with *Candida albicans* as a leading cause of fungal infections in pediatric urinary tract infection.

A sex-based analysis showed that women of all ages and with all types of infections had UTIs more often than men. The difference was most clear with *E. coli*, where over 78% of infections were in women.

Recent epidemiological studies, including those by Zhan *et al*. and Shi *et al.* have identified *Escherichia coli* as the most common cause of UTIs across both gender and age groups. The same results were found by Faine et al. and Zagaglia e*t al*. who also found out that uropathogenic *E. coli* is the most prevalent cause of the urinary tract infection [17-20].

Jarsiah *et al*. [21] found that women were more likely to have a positive culture as opposed to males as per the results of this study, which showed that women have a higher likelihood of getting infected with urinary tract infection compared to men. In the experiment conducted by Ramezanzadeh *et al.* [22], the germs were mostly obtained by female samples.

The prevalence of UTIs in women in this study is also in line with the previous studies and is often explained by morphological and physiological factors, including a shorter urethra, the closeness of the urethral orifice to the anus and vagina, and hormonal changes during pregnancy and menopause. These could exacerbate the sensitivity that has been reported with age [23].

The age-specific increase in the prevalence of pathogens, especially the increase in the prevalence of *Escherichia coli* infections in younger individuals, is evidence of the necessity of age-specific diagnostic and treatment strategies. Knowledge of these demographic patterns is crucial to enhancing preventive measures, antibiotic stewardship and treatment in the UTIs [24].

4. Conclusion

The current investigation established that *Escherichia coli* is the primary etiological agent of pediatric urinary tract infections, with a markedly elevated infection rate in females compared to males. Different age groups had different distributions of pathogens, *E. coli* was more common in younger children, whereas *Staphylococcus aureus* was more common in older ones. These findings emphasized the necessity of ongoing epidemiological surveillance to facilitate precise diagnosis, suitable empirical treatment, and efficient antibiotic stewardship.

Compliance with ethical standards

Disclosure of conflict of interest

The author declare that they have no conflict of interest.

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