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Incidence of Urinary Tract Infections, Etiological Agents, and Antibiotic Susceptibility Among Pregnant and Non-Pregnant Women in Amedi Region, Iraq

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ABSTRACT: Urinary tract infection is a bacterial infection caused by bacteria from the digestive tract entering the urinary tract. It is more prevalent in women and remains the most common bacterial infection in humans. The study aimed to assess the prevalence of urinary tract infections (UTIs) in pregnant women, identify and diagnose uropathogenic bacteria, and examine the antibiotic susceptibility of the isolated bacteria. A total of 283 urine specimens were collected from pregnant and non-pregnant females of different ages who visited Amedi hospital between October 2020 and January 2021. The samples were cultured and incubated on Blood agar and MacConkey agar plates for 24 hours at 37°C. Bacterial isolates were identified and their antibiotic sensitivity was assessed using the Vitek-2 method. The study found a total UTI rate of 42.4% (120/283), with higher rates in pregnant patients (58.3%) compared to non-pregnant patients (41.7%). Among 120 positive urine cultures, bacterial isolates were identified in 92.5% (111/120), with Gram-positive bacteria being more prevalent (51.4%) than Gram-negative (48.6%). The most common Gram-negative bacteria was *Escherichia coli* (29.7%), while Gram-positive bacteria included *Enterococcus faecalis*, *Staphylococcus haemolyticus*, and *Streptococcus agalactiae* (each 12.6%; 14/111). The rate of fungal positive cultures (Candida spp.) was 7.5%. Gram-negative isolates showed high sensitivity to tigecycline (99.0%) and ertapenem (80.6%), but low sensitivity to ampicillin (2.7%) and cefuroxime (16.1%). Gram-positive isolates were highly sensitive to linezolid (98.7%) and tigecycline (98.5%). The findings of this study are valuable for understanding the nature of urinary tract infections (UTIs) and guiding appropriate treatment, leading to a reduction in the misuse of antibiotics.

Keywords: Urinary tract infection; Pregnancy; Antibiogram; Uropathogenic bacteria; Iraq.

مدى انتشار التهابات المسالك البولية والعوامل المسببة لها والحساسية للمضادات الحيوية بين النساء الحوامل وغير الحوامل في منطقة العمادية – العراق

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الملخص: التهاب المسالك البولية هو عدوى بكتيرية تسببها البكتيريا التي تنتقل من الجهاز الهضمي إلى المسالك البولية. هي أكثر شيوعًا لدى النساء وتبقى العدوى البكتيرية الأكثر شيوعًا بين البشر. هدفت الدراسة إلى تقييم انتشار التهابات المسالك البولية (UTIs) لدى النساء الحوامل، وتحديد وتشخيص البكتيريا المسببة للمرض في المسالك البولية، وفحص حساسية البكتيريا المعزولة تجاه المضادات الحيوية. تم جمع 283 عينة بول من نساء حوامل وغير حوامل

من أعمار مختلفة زرن مستشفى العمادية بين أكتوبر 2020 ويناير 2021. تم زراعة العينات وتحضينها على أطباق آجار الدم وآجار مككونكي لمدة 24 ساعة عند 37 درجة مئوية. تم تحديد عزلات البكتيريا وتقييم حساسيتهن للمضادات الحيوية باستخدام طريقة Vitek-2. وجدت الدراسة معدل إجمالي لالتهابات المسالك البولية بنسبة 42.4% (283/120)، مع معدلات أعلى بين المرضى الحوامل (58.3%) مقارنة بالمرضى غير الحوامل (41.7%). من بين 120 مزرعة بول إيجابية، تم تحديد عزلات بكتيرية في 92.5% (120/111)، حيث كانت البكتيريا موجبة الجرام أكثر شيوعًا (51.4%) من البكتيريا سالبة الجرام (48.6%). كانت البكتيريا سالبة الجرام الأكثر شيوعًا هي الإشريكية القولونية (29.7%)، بينما كانت البكتيريا موجبة الجرام تشمل المكورات المعوية البرازية، المكورات العنقودية الدموية، والمكورات العقدية القاطعة للدر (كل منها 12.6%; 111/14). كان معدل المزارع الإيجابية الفطرية (فطر المبيضات) 7.5%. أظهرت العزلات سالبة الجرام حساسية عالية تجاه تيجيسيكلين (99.0%) و إرتابينيم(80.6%) ، ولكن حساسية منخفضة تجاه أمبيسيلين (2.7%) و سيفوروكسيم (16.1%). كانت العزلات موجبة الجرام شديدة الحساسية تجاه لاينزوليد (98.7%) و تيجيسيكلين (98.5%). تعتبر نتائج هذه الدراسة ذات قيمة لفهم طبيعة التهابات المسالك البولية (UTIs) وتوجيه العلاج المناسب، مما يؤدي إلى تقليل الاستخدام السئ للمضادات الحيوية.

الكلمات المفتاحية: عدوى المسالك البولية، الحمل، مخطط المضَادات الحيوية، البكتيريا المرضية في المسالك البولية و العراق

1. Introduction

Urinary tract infections (UTI) are caused by bacteria in the urinary tract. They are normally caused by microbes in the digestive tract that increase the opening of the urethra and begin to multiply to trigger infection [1]. This is mostly due to the short urethra and invasion of the peri-urethral region by gastrointestinal tract pathogens. Pathogens move from the peri-urethral region to colonize the urinary bladder or kidneys [2]. Women between 16 and 35 years old are more susceptible, with about 25% experiencing recurrent infections within six months [3, 4]. Asymptomatic bacteriuria is usually transient among reproductive-age women and does not require antibiotic therapy [5]. UTIs are among the most common diseases during pregnancy, especially in developing countries [6]. UTI risk during pregnancy is influenced by humoral and immunological changes typical of normal pregnancy [7]. Studies show that females are more susceptible to UTIs than males, with over a third of women experiencing at least one UTI episode in their lifetime [8]. This higher vulnerability in women can be attributed to physiological differences in the urinary tracts; females have thinner urethras, with a length of 3-4 cm, compared to males with a urethral length of up to 20 cm [9]. Symptomatic urinary tract infections (UTIs) can be classified into lower UTIs (acute cystitis) and upper tract infections (acute pyelonephritis) [10]. Pregnant women with a history of UTIs are at an increased risk of developing UTIs during pregnancy. Other risk factors for UTIs during pregnancy include age, lack of prenatal care, UTI disorders, inadequate fluid intake, sickle cell syndrome, anemia, and diabetes mellitus [11]. The etiological agents of UTIs are primarily bacteria. Additionally, fungi, particularly Candida species, and viruses like adenovirus can infrequently cause UTIs [12]. The bacterial species responsible for UTIs during pregnancy are similar to those in non-pregnant patients, with *E. coli* causing 80-90% of cases. Also, *Proteus mirabilis* and *Klebsiella pneumonia* are common species. The less common causes of UTI are group-B streptococci and *Staphylococcus saprophyticus* [13-15]. For many decades, the primary treatment for urinary tract infections (UTIs) was trimethoprim-sulfamethoxazole (TMP-SMX) or trimethoprim alone. Cephalosporins are also used to treat UTIs, especially in pregnant women. However, they are not recommended for empirical therapy due to relatively high levels of resistance and reduced effectiveness, especially in short-term treatments [16]. The aim of the study was to determine the prevalence of UTIs in pregnant women in Duhok province, Kurdistan region, Iraq. Also, to isolate and diagnose uropathogenic bacteria and Candida isolates. Additionally, to investigate the antibiogram of the bacterial isolates towards different antibiotics.

2. Materials and methods

2.1 Study setting and design

The research was conducted at Amedi Hospital, Duhok Governorate, Iraq during the period from October 2020 to January 2021. A total of 283 urine samples were taken from pregnant and non-pregnant females of different age groups (ranged between 18 and 70 years; table 1) who visited Amedi hospital in various places. Face-to-face details about age, employment, living environment, number of children, history of urinary tract infection, and awareness of UTI were obtained. Interviews were conducted with the outdoor patients who came to this hospital for free regular check-ups and medicines.

2.2 Collection, examination and culturing of urine specimens

From each patient, 5 mL of midstream urine sample was collected in a sterile container. The collected samples were cultured and incubated on a Blood agar and a MacConkey agar plate at 37 °C for 24 hours. Urine specimens (5 mL) were placed in clean, dry 15-milliliter centrifuge tubes and centrifuged for five minutes at 3000 rpm. One drop of the resulting sediment was then transferred to a labelled glass slide, coated with another glass slide, and examined under a light microscope at 10X and 40X magnifications. During urine analysis, low power is used to search for crystals, casts, squamous cells, and other larger elements. For visualizing and identifying cells, crystals, and microorganisms, high-power magnification is employed. Cell types are quantified by counting the number of each kind found per high-power field. The urine samples were cultured on the Blood agar and MacConkey agar; the plates were incubated at 37 °C for 18-24 hours, after which the colonies were diagnosed morphologically depending on their morphological characteristics, in terms of shape, size, and color [17].

2.3 Identification of bacterial isolates

2.3.1 The VITEK-2 compact system (bioMerieux, France) was used to identify the isolates.

Inoculum preparation.

The process starts with a Gram stain to select the suitable testing card. Several colonies from clear cultures were transferred to a plastic test tube containing 3 mL of sterile saline solution using a sterile swab. Based on the system's instructions, the suspension was adjusted to a McFarland turbidity standard of 0.50 - 0.63 [18].

Inoculation: The identification process involves using cards with 43 biochemical experiments to evaluate carbon source utilization, enzymatic activity, and resistance to antibiotics. Bacterial suspensions are introduced to the cards through an integrated vacuum system, with final results available within approximately eight hours. The inoculation suspension is forced into microchannels, filling all test wells. The filled cassette is then manually inserted into the vacuum chamber station, and air was reintroduced into the station [19].

Card sealing and incubation: Before being loaded into the carousel incubator, inoculation cards were passed through a machine that shut off the transfer tube and sealed the card. All card types were cultured in the incubator at a temperature of 35.5°C ± 1.0°C. Throughout the entire incubation period, each card was taken to the optical system for reaction readings and data were collected every 15 minutes. A Gram-negative card (GNC) was used to identify the 135 most important non-fermenting and fermentative bacilli species. A Gram-positive card (GPC) was used to identify 115 species of Gram-positive non-spore bacteria, mainly cocci [19].

2.3.2 Bacterial morphological examination

One pure colony was taken from each growth present on the primary culture media initially. The isolates were diagnosed based on morphological features, including colony size, color, and edge. Next, the characteristics of the cells were studied under a microscope after staining with the Gram stain, which included examining the cell shapes, and the information was collected. Subsequently, the isolates were diagnosed according to the guidelines provided by Macfaddin [20].

2.4 Antimicrobial susceptibility testing

The VITEK-2 compact system was used for antibiotic susceptibility testing, employing an AST card following the manufacturer's guidelines. The VITEK-2 AST sensitivity card is specifically designed for in-vitro testing in clinical laboratories to determine the sensitivity of clinically significant bacteria to antimicrobial drugs [21]. The inoculum was prepared by adding 200µL of culture solution from the 0.5 McFarland culture into a fresh 3mL sterile saline solution, resulting in a final turbidity of $8x10^6$ CFU/mL in the filling chamber. The VITEK-2 System automatically processes the antibiotic sensitivity cards until MICs are generated. The VITEK-2 compact system then utilizes an inner database of probable phenotypic combinations for microbe-antibacterial agents to adjust MICs or clinical categories as necessary. In this system, several antimicrobial groups were used to examine the antibacterial sensitivity of the isolated bacteria Table (5).

2.5 Identification of Candida isolates

The identification of Candida isolates involved using special techniques on culture media and conducting microscopic examination. Blood agar was used to cultivate the isolates, and pure Candida colonies were selected after incubation at 37°C for 24-48 hours. The colonies were then assessed for their shape, size, color, and consistency. Further identification was done using Gram stain to recognize Candida spp, and lactophenol cotton blue was used to stain the Candida, which was then observed under a microscope at 40x and 100x magnification with oil immersion.

2.6 Data analysis

The statistics were analyzed using the Statistical Package for the Social Sciences program version 22 (SPSS). Cross-tabulation of frequencies and relevant statistical tests, such as the Chi-square test, were conducted to determine significance, which was defined as a *P*-value of less than 0.05.

3. Results

The UTIs were screened from 283 women, including 135 (47.7%) pregnant women and 148 (52.3%) non-pregnant women. The total rate of UTIs among all enrolled patients was 42.4% (120/283). Pregnant patients had a higher rate of 58.3% (70/120), while non-pregnant patients had a rate of 41.7% (50/120). The difference between pregnant and non-pregnant patients was significant ($P = 0.002$). Regarding the gestational period, UTIs were higher in the first trimester at 62.9% (22/35) compared to the second and third trimesters of pregnancy at 53.6% (30/56) and 40.9% (18/44), respectively. However, these differences were not significant ($P = 0.051$). The ages of participants ranged between 18 and 70 years and were divided into 5 age groups (Table 1). The highest occurrence rate (37.5%) was found in the age group of 25-34 years, followed by the 18-24 age group (27.5%). The age group of 57-70 years recorded the lowest rate of infection (7.5%). The *P* value (0.284) indicated that there were no significant differences among pregnant women based on their ages. Furthermore, a high rate of infection was observed in those with no children (21.7%), followed by those with one child (19.2%), with significant differences (P = 0.031). In terms of education, no significant differences were observed (P = 0.132). According to occupation, the majority of the infections (72.5%) were among housewives (P = 0.001).

Table 1. UTI Rates in Different Age Groups and Demographic Factors among Pregnant Women.

		culture results		*P* value
		Positive UTI	Negative UTI	
		N (%)	N (%)	
Number of children	0	34(28.3)	32(19.6)	0.031
	1	23(19.2)	27(16.6)	
	2	26(21.7)	33(20.2)	
	3	20(16.7)	42(25.8)	
	≥4	17(14.1)	29(17.8)	
	Total	120(100)	148(100)	
Education level	illiterate	28(23.3)	23(14.1)	0.132
	primary school	39(32.5)	61(37.4)	
	secondary school	34(28.3)	46(28.2)	
	university & above	19(15.8)	33(20.2)	
	Total	120(100)	148(100)	
Occupational status	Employed	33(27.5)	78(47.9)	0.001
	Housewife	87(72.5)	85(52.1)	
	Total	120(100)	148(100)	
Age	18-24	33(27.5)	36(22.1)	0.284
	25-34	45(37.5)	58(35.5)	
	35-45	21(17.5)	36(22.1)	
	46-56	12(10)	21(12.3)	
	57-70	9(7.5)	12(7.3)	
	Total	120(100)	148(100)	

Table 2. Association between the medical history of women with UTI.

		Pregnant status				Total	*P* value
		Pregnant		Non-pregnant			
		Positive UTI	Negative UTI	Positive UTI	Negative UTI		
		N (%)	N (%)	N (%)	N (%)		
History of miscarriage	No	60(23.5)	60(23.5)	45(17.7)	90(35.3)	255	0.209
	Yes	10(35.7)	5(17.9)	5(17.9)	8(28.5)	28	
Antibiotic uses	No	69(27.6)	56(22.4)	49(19.6)	76(30.4)	250	0.001
	Yes	1(3.0)	9(27.3)	1(3.0)	22(66.7)	33	
Symptoms of a UTI	No	45(23.7)	51(26.8)	26(13.7)	68(35.8)	190	0.001
	Yes	25(26.9)	14(15.1)	24(25.8)	30(32.2)	93	
History of previous UTI	No	31(14.3)	65(30.1)	31(14.3)	89(41.3)	216	0.001
	Yes	39(58.2)	0	19(28.4)	9(13.4)	67	
History of diabetes	No	62(24.5)	60(23.7)	41(16.2)	90(35.6)	253	0.095
	Yes	8(26.7)	5(16.7)	9(30)	8(26.6)	30	

The data showed that UTI prevalence in pregnant women was 35.7%, compared to 17.9% in non-pregnant women with a history of miscarriage. However, the *P* value (0.209) indicated no significant differences. Both pregnant and non-pregnant women who used antibiotics had a UTI ratio of 3.0%. Additionally, UTIs were more common in females with UTI symptoms, with ratios of 26.9% in pregnant and 25.8% in non-pregnant females, with no significant differences. Regarding the previous history of UTIs, pregnant females had a 58.2% UTI ratio, and non-pregnant females had 28.4%, with significant differences ($P = 0.001$). In regard to the history of diabetes, the frequency of UTI in pregnant women was 26.7% and 30% in non-pregnant women, with no significant differences ($P = 0.095$) (Table 2). The positive urine culture ratio among all participants was 42.4% (120/283), while the rate of fungal positive culture was 7.5% (9/120) (Candida spp.). Among 120 positive urine culture specimens, the bacterial isolates were 92.5% (111/120). The highest infection by Gram-negative bacteria was by *E. coli* at 29.7% (33/111). *E. coli* was the most frequent Gram-negative pathogen among pregnant (40.7%) and non-pregnant (20.4%) women (Table 3).

The highest infection by Gram-positive bacteria was by *Enterococcus faecalis* and *Streptococcus agalactiae* with an equal ratio of 12.6% (14/111). In pregnant women the most frequent Gram-positive pathogen bacteria was *Streptococcus agalactiae* 14.0 %. While amongst the non-pregnant women, the most frequent Gram-positive pathogen bacteria was *E. faecalis* 10.5% (Table 4). The result of the current study showed that the prevalence of Gram-positive bacteria 51.4% (57/111) was higher as compared with Gram-negative bacteria 48.6% (54/111).

The antibiotic susceptibility profile for the isolates was varied (Table 5). Gram-negative bacteria were highly sensitive to tigecycline (99.0%) followed by ertapenem (80.6%) and less sensitive to ampicillin (2.7%), and cefuroxime (16.1%). While Gram-positive isolates exhibited high sensitivity to linezolid (98.7), followed by tigecycline (98.5%) Table 6.

Table 3. The types and percentages of Gram-negative isolates according to pregnancies.

Strain spp (No)	Pregnant	Non-pregnant
E. coli (33)	22(40.7)	11(20.4)
Klebsiella pneumoniae (7)	3(5.5)	4(7.4)
Proteus mirabilis (5)	3(5.5)	2(3.7)
Morganella morganii (3)	2(3.7)	1(1.9)
Acinetobacter baumannii (3)	3(5.5)	0
Pseudomonas aeruginosa (1)	0	1(1.9)
Serratia liquefaciens (1)	0	1(1.9)
Myroides spp (1)	0	1(1.9)
Total Gram-negative	54	

Table 4. The types and percentages of Gram-positive isolates according to pregnancies.

Strain spp	Pregnant	Non-pregnant
Enterococcus faecalis (14)	6(10.5)	8(14.0)
Staphylococcus aureus (2)	1(1.8)	1(1.8)
Staphylococcus haemolyticus (14)	10(17.5)	4(7.0)
Staphylococcus epidermids (10)	4(7.0)	6(10.5)
Staphylococcus simulans (1)	1(1.8)	0
Staphylococcus pseudintermedius (1)	1(1.8)	0
Staphylococcus hominis (1)	0	1(1.8)
Streptococcus agalactiae (14)	8(14.0)	6(10.5)
Total Gram-positive	57	

Table 5. Antibiotic susceptibility profile of gram-negative bacteria.

		Microorganism							
		E. coli	*Klebsiella pneumoniae*	*Proteus mirabilis*	*Morganella morganii*	*Acinetobacter baumannii*	*Pseudomonas aeruginosa*	*Serratia liquefaciens*	Myroides *spp*
		(33)	**(7)**	**(5)**	**(3)**	**(3)**	**(1)**	**(1)**	**(1)**
Amoxicillin	S	40	0	50	0	0	0	0	0
	R	60	100	50	100	0	100	0	0
Ampicillin	S	16.1	0	0	0	0	0	0	0
	R	83.9	100	100	100	100	100	0	0
Ertapenem	S	100	83.3	100	100	0	0	100	0
	R	0	16.7	0	0	0	100	0	0
Meropenem	S	100	85.7	100	100	0	0	100	100
	R	0	14.3	0	0	100	100	0	0
Cefuroxime	S	25.8	66.7	20	0	0	0	0	0
	R	74.2	33.3	80	100	100	100	100	0
Piperacillin-Tazobactam	S	77.4	83.3	80	100	0	100	100	100
	R	22.6	16.7	20	0	100	0	0	0
Cefoxitin	S	77.8	66.7	100	0	0	0	0	0
	R	22.2	33.3	0	100	100	0	100	0
Ceftriaxone	S	31.3	66.7	20	50	0	0	0	0
	R	68.8	33.3	80	50	100	100	100	0
Amikacin	S	92.9	83.3	100	66.7	0	100	100	0
	R	7.1	16.7	0	33.3	0	0	0	100
Gentamycin	S	66.7	57.1	20	100	33.3	100	100	0
	R	33.3	42.9	80	0	66.7	0	0	100
Ciprofloxacin	S	43.8	71.4	60	33.3	0	100	0	0
	R	56.3	28.6	40	66.7	100	0	100	100
Tigecycline	S	100	100	0	0	100	0	0	0
	R	0	0	0	0	0	0	0	0
Sulfamethoxazole	S	42.4	42.9	40	33.3	33.3	0	0	0
	R	57.6	57.1	60	66.7	66.7	100	100	100

Table 6. Antibiotic susceptibility profile of gram-positive isolates.

		Microorganism							
		Enterococcus faecalis	*Staphylococcus aureus*	*Staphylococcus haemolyticus*	*Staphylococcus epidermids*	*Staphylococcus simulans*	*Staphylococcus pseudintermedius*	*Staphylococcus hominis*	*Streptococcus agalactiae*
		(14)	(2)	(14)	(10)	(1)	(1)	(1)	(14)
Ampicillin	S	64.3	0	0	0	0	0	0	100
	R	35.7	0	0	0	0	0	0	100
Benzylpenicillin	S	83.3	0	0	0	0	0	0	100
	R	16.7	100	100	100	100	0	0	0
Gentamycin	S	0	100	58.3	60	100	100	100	0
	R	0	0	41.7	40	0	0	0	0
Ciprofloxacin	S	69.2	100	70	40	100	0	100	0

	R	30.8	0	30	60	0	100	0	0
Erythromycin	S	0	0	0	28.6	0	0	0	22.2
	R	100	100	100	71.4	0	100	100	77.8
Clindamycin	S	0	0	7.7	70	0	100	0	0
	R	0	100	92.3	30	100	0	100	100
Linezolid	S	90.9	100	100	100	100	100	0	100
	R	9.1	0	0	0	0	0	0	0
Vancomycin	S	30.8	50	14.3	70	100	100	0	87.5
	R	69.2	50	85.7	30	0	0	100	12.5
Tigecycline	S	90.9	100	100	100	100	0	0	100
	R	9.1	0	0	0	0	0	0	0
Tetracycline	S	0	0	50	30	0	0	100	7.1
	R	100	100	50	70	100	100	0	92.9
Sulfameth-oxazole	S	0	100	76.9	80	100	100	100	100
	R	100	0	23.1	20	0	0	0	0

4. Discussion

Urinary tract infection (UTI) continues to be the main bacterial infection in humans. Every year, approximately 150 million people around the world are affected [22]. In the present study, the prevalence of UTIs among patients was 42.4% (120/283). A higher rate of UTIs was recorded among pregnant patients, with a rate of 58.3% (70/120), while in non-pregnant individuals, it was 41.7% (50/120). Moreover, the rate of UTIs was higher in the first trimester (62.8%) compared to the second and third trimesters of pregnancy, which had rates of 53.6% and 40.9%, respectively. These results were similar to those of researchers in other countries with small variations, which may be due to differences in the environment, group social activities, and personal hygiene and education standards. In several studies conducted in Iraq, similarly, high rates of UTI infection have been recorded. For example, Almukhtar [23] reported a higher ratio of UTIs among pregnant women (43.0%) compared to non-pregnant women (33.4%), and the lowest rates were observed in unmarried women, at 24.6%. Al-Jawadi [24] in Mosul demonstrated that the percentage of positive UTIs in pregnant women was 47.4%.

On the other hand, pregnant women in their third trimester of pregnancy were more vulnerable to microbial infections compared to the first two trimesters. The current results are in contrast with those of Al-Mamoryi and Al-Salman [25], who recorded a higher rate of UTI during the second trimester. Al-Jawadi [24] in Mosul demonstrated that the ratio of positive UTIs in the third trimester of pregnancy was 53.0%, compared to ratios of 30% and 44.0% in the first two trimesters, respectively. Similarly, in Kirkuk, Almukhtar [23] studied UTI and reported a higher percentage of UTIs in the 3rd trimester of pregnancy, with a ratio of 39.6%.

Pregnant women are more susceptible to UTIs due to a variety of biological and hormonal alterations, the difficulty of personal hygiene, and an extended abdomen [5]. The risk of UTIs in pregnant women increases, reaching its peak at 4-5 months [26]. During pregnancy, many physical, structural, and individual factors contribute to this issue. Increased urinary stasis leads to higher bladder volume, urethral dilatation, and decreased bladder tone. Furthermore, there is a physiological rise in plasma volume, which lowers urine concentration, resulting in up to 70% of pregnant women developing glycosuria, promoting bacterial growth [6].

With regards to pregnancy, the study showed that the rate of UTIs was significantly higher ($p<0.05$) among pregnant (58.3%) as compared with non-pregnant (41.7%). According to the monthly difference of the rates of infection among tested urine samples, the infection rate was high in November (30.8%), in contrast, the lowest rate was recorded in October with a rate (18.3%).

The study found that the rate of UTIs was significantly higher ($p<0.05$) among pregnant women (58.3%) compared to non-pregnant women (41.7%). Regarding demographic characteristics. The age range of 25-34 years had the highest occurrence rate of UTIs at 37.5% and the lowest rate of infection, 7.5%, was observed in the age group of 57-70 years. Comparable studies conducted in Iraq and other countries also showed higher UTI rates among the age group of 25-34 years. Al-Barzinji *et al.* [27] in Erbil demonstrated that the highest percentage of infection, 44.44%, was found in females aged between 20-39 years. Similarly, a study reported by Joni [28] in Baghdad showed a high prevalence of UTI, 47.5%, in diabetic females within the 26-35 years age group. The increased frequency of UTIs in the age group of 20-39 years could be attributed to the frequency of sexual intercourse (Hu, 2004). This age group is typically the most sexually active in the population, and certain sexual behaviors and contraceptive methods can predispose women to UTIs. Women in this age range are more sexually active, which may contribute to their higher susceptibility to UTIs [29].

The study observed a high rate of infection in women with no children followed by those with one child. However, there were no significant differences found in this study regarding the number of children and UTI incidence. It is worth noting that these results do not align with the findings of Al-Mamoryi and Al-Salman [25], who demonstrated that the incidence rate of UTI was higher among women with multiple births. These discrepancies in findings may be attributed to the fact that these studies were conducted in different locations, suggesting that regional variations and other factors may play a role in the association between parity and UTI incidence.

The study revealed that the majority of UTI infections (32.5%) was among people who had completed only primary school education, which is consistent with similar studies conducted in Baghdad and Kirkuk by Ali and Sajem [30] and Almukhtar [23], respectively. The research found that there were no significant differences in the occurrence of UTI among different education levels, as indicated.

The study revealed that housewives constituted the majority of UTI infections. Similar research conducted in Iraq and other regions also reported higher UTI rates among housewives. Almukhtar [23] in Kirkuk found the highest rate of UTIs at 65.9% among housewives. Additionally, Al-Jawadi [24] in Mosul reported a high frequency of UTI infections, 91.8%, among housewives. One possible explanation for this trend could be that employed women might face conflicts with their jobs, which could hinder their ability to attend health units for antenatal treatment as frequently as they would prefer.

The prevalence of UTIs was higher in both pregnant and non-pregnant females with a history of miscarriage. Previous studies by Ali *et al.* [31] in Kirkuk demonstrated that the frequency of UTIs increased with the number of miscarriages, with rates of 20.68% for one-baby miscarriage and 27.58% for two-baby miscarriages. Miscarriage is a major contributing factor to UTIs during pregnancy. The pressure of labor weakens women's resistance defenses, leading to significant blood loss and creating an ideal environment for bacteria. These bacteria can then ascend to the urethra, bladder, or kidney, causing cystitis or pyelonephritis [32].

The present study found that UTIs are more common in females who had symptoms of a UTI and had a previous UTI. This result is in contrast to the findings of Ali *et al.* [31] in Kirkuk, which reported a higher percentage of 72.4% for symptomatic UTIs. Also, the study found that 62.0% of women had a previous history of UTIs, while a lower rate of 37.1% was reported by Ali and Sajem [30] in Baghdad. Additionally, it was found that the frequency of UTIs in pregnant women was 26.7% and 30% in non-pregnant women with a history of diabetes. In contrast, other studies conducted in Iraq by Al-majedy [33] Mohan (2015) reported higher prevalence rates of UTIs in diabetic patients, with percentages of 50.7% and 35% respectively.

The prevalence of Gram-positive bacteria (51.4%) was higher compared to Gram-negative bacteria (48.6%) in the study. This result was consistent with other findings in the region [34], but it contradicted the research by other studies [35, 36]. The difference in the prevalence of Gram-positive and Gram-negative bacteria in the study can be attributed to geographical variations and the misuse of antibiotics, leading to the emergence of multi-drug resistant bacteria, which influences the distribution of bacterial types [15, 37-39].

In this study, *E. coli* was identified as the most predominant infectious UTI isolate, while *P. aeruginosa*, *S. liquefaciens*, and *Myroides spp*. were less commonly detected. These findings are consistent with similar studies that also reported *E. coli* as the most prevalent infectious UTI isolate [40-42].

Among the Gram-positive isolates in the study, *E. faecalis* and *S. agalactiae* were the most prevalent, while *S. simulans*, *S. pseudintermedius*, and *S. hominis* were less commonly detected. These findings are in agreement with similar studies conducted in Duhok. Assafi *et al.* [34] reported that *S. haemolyticus*, *E. faecalis*, and *S. agalactiae* were highly prevalent. Naqid *et al.* [35] in Duhok demonstrated that the most prevalent Gram-positive bacteria were *S. haemolyticus*, followed by *E. faecalis*.

The current study reported the presence of Candida spp., fungi that cause UTIs, with a rate of 7.5% (9/120). This finding is consistent with a study by Ali *et al.* [43] in Duhok, which found an incidence rate of *C. albicans* of 4.4%. However, Al-Berfkani *et al.* [44] recorded a higher rate of *C. albicans* in females at 17.0%, and Ali *et al.* [31] in Kirkuk reported an infection rate of *C. albicans* at 3.44%.

The antibiotic susceptibility profile among the examined isolates was diverse. Gram-negative bacteria were highly susceptible to tigecycline (99.0%) and ertapenem (80.6%), but less susceptible to ampicillin (2.7%) and cefuroxime (16.1%). On the other hand, Gram-positive isolates exhibited high sensitivity to linezolid (98.7%) and tigecycline (98.5%), but lower sensitivity to erythromycin (92.7%). These findings align with a study by [34] in Duhok, which demonstrated that Gram-negative isolates were susceptible to carbapenems and aminoglycosides but heavily resistant to cefuroxime. Gram-positive bacteria in that study were susceptible to linezolid, vancomycin, tigecycline, and nitrofurans, while resistant to erythromycin and tetracycline. Another study by [40] in Duhok reported that most Gram-negative bacteria were resistant to cefepime, ceftriaxone, aztreonam, and ampicillin, but ertapenem and imipenem were effective against 95% of them. The majority of Gram-positive bacteria showed high resistance to gentamicin, benzylpenicillin, oxacillin, and erythromycin, while being highly sensitive to linezolid, tigecycline, and nitrofurantoin.

The high resistance of bacterial isolates to beta-lactam antibiotics may be attributed to the production of beta-lactamase enzymes encoded by genes present in either the bacterial chromosome, plasmids, or transposons [45]. Bacterial resistance to this group of antibiotics can result from three mechanisms: modifying the target site of the antibiotics, reducing permeability, and producing enzymes that inhibit them. The increase in the number of bacterial isolates resistant to beta-lactam antibiotics could be due to the use of under-treatment doses, leading to the spontaneous emergence of mutant isolates [46].

In the present study, *Serratia liquefaciens* showed resistance to several antibiotics like cefuroxime, cefoxitin, ceftriaxone, ciprofloxacin, and sulfamethoxazole, but was sensitive to ertapenem, meropenem, piperacillin-tazobactam, amikacin, and gentamycin, which is consistent with previous results by Stock *et al.* [47]. *Myroides* spp. in this study demonstrated total sensitivity to piperacillin-tazobactam and meropenem, aligning with previous findings by Elantamilan *et al.* [48] who reported that *Myroides* spp. were only susceptible to piperacillin-tazobactam. However, treating *Myroides* spp. infection is challenging, as most species are resistant to β-lactams like aztreonam and carbapenems, and exhibit variable resistance to aminoglycosides, quinolones, and sulfamethoxazole [49, 50]. *Staphylococcus* spp. exhibited high resistance to benzylpenicillin, erythromycin, and tetracycline. They were, however, susceptible to gentamycin, linezolid, and tigecycline. These findings are consistent with several studies conducted in the region [40, 51, 52].

5. Conclusion

Prompt treatment for UTIs is crucial for pregnant women to avoid the risk of premature delivery, but certain antibiotics may not be safe during pregnancy. Choosing appropriate treatment considers factors such as drug effectiveness, pregnancy stage, maternal health, and potential fetal impact. UTI prevalence is higher in pregnant patients, with E. coli being the most common bacterium, followed by *Staphylococcus* spp. Bacteria showed sensitivity to tigecycline, linezolid, and ertapenem, but resistance to ampicillin, cefuroxime, and erythromycin. In order to address the rising challenge of antibiotic resistance and promote effective management of UTIs, individuals with urinary tract infections should undergo culture examination and antimicrobial susceptibility testing to tailor treatment and minimize the emergence of resistant bacteria. Also, avoiding random administration of antibiotics by individuals without proper medical guidance. Furthermore, encourage every patient to complete the entire antibiotic course to effectively treat infections and reduce the high rate of antibiotic resistance.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgment

Not applicable.

Ethical statement

Ethical approval for the study was obtained from the Directorate of General Health Amedi/ Research Ethics Committee. All patients were informed about the study's objectives and asked to provide informed consent by signing a consent form. They were assured that all the information they shared would be kept completely confidential.

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