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Original Article

Bacteriological profile, antimicrobial susceptibility, and factors associated with urinary tract infection in pregnant women

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Abstract

Introduction: Urinary tract infection (UTI) is a common bacterial complication in pregnancy. The study aimed to estimate the prevalence, risk factors, and bacterial etiology of UTI during pregnancy and determine the efficacy of antimicrobial drugs in treating UTIs.

Methodology: Urine specimens and clinical data were collected from pregnant women who attended primary health centers in Erbil, Iraq. All specimens were cultured on appropriate media and identified by standard microbiological methods. The pregnant women were grouped into symptomatic UTI group, asymptomatic bacteriuria group, and the control group. The agar dilution method was used to determine antimicrobial susceptibility.

Results: Among the 5,042 pregnant women included in this study, significant bacteriuria was found in 625 (12.40%) of the cases, and 198 (31.68%) had symptomatic UTI, of which 43.59% were diagnosed during the third trimester. Out of the 643 bacteria isolated, 33.28% were symptomatic UTI, of which 43.59% developed during the third trimester. There was a significant difference in the bacterial etiology between symptomatic UTI and asymptomatic bacteriuria ($p = 0.002$), as well as between cystitis and pyelonephritis ($p = 0.017$). The most common bacterial species isolated was *Escherichia coli*, which was susceptible to fosfomycin (100%), meropenem (99.45%), and nitrofurantoin (97.8%).

Conclusions: Pregnant women are more likely to develop UTI in the third trimester. *Escherichia coli* is the predominant pathogen. The study suggests the use of fosfomycin, meropenem, and nitrofurantoin for the treatment of UTI. No Gram-positive isolates were resistant to daptomycin.

Key words: UTI; antibiotic resistance; *Escherichia coli*; pregnant; cystitis; pyelonephritis.

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Introduction

Urinary tract infection (UTI) is a common and serious bacterial infection in pregnant women worldwide, leading to costly medical complications [1]. Morphological and physiological changes in the genitourinary tract during pregnancy increase the incidence of UTIs [2]. About 40-50% of women experience UTI during their lifetime, and its incidence has significantly increased globally each year [3,4]. Infection of the urinary tract is caused by different types of microorganisms [5], which depend on where the infection develops along the urinary tract during pregnancy [6]. UTIs have been classified as symptomatic UTIs or asymptomatic bacteriuria (ASB). ASB is defined as the presence of significant bacteria (i.e., the presence of $\geq 10^5$ bacteria/mL of urine) in the absence of symptoms of UTI [7-9].

Screening and treatment of ASB are recommended in pregnant women because if left untreated, it will lead to symptomatic UTI and cause serious risks for both the mother and the fetus [10]. UTIs have been associated with neonatal sepsis and an increased risk of stillbirth. Thus, treatment is important for the mother and child [11,12]. Furthermore, symptomatic UTIs are classified as cystitis and pyelonephritis involving the bladder and kidneys, respectively. Treatment of cystitis and pyelonephritis requires attention to the growing antimicrobial resistance [13]. The patterns of antimicrobial resistance in a wide variety of uropathogenic bacteria can vary over a short period [14], and resistance of uropathogenic bacteria is increasing globally, mainly against commonly used antimicrobials [15]. Therefore, knowledge about antimicrobial resistance patterns is required when selecting antimicrobial agents [16]. Incorrect UTI diagnosis and treatment can result in newborn complications [17].

Appropriate studies involving the treatment of UTIs are required to avoid life-threatening illness and morbidity related to UTI complications in pregnant women [18]. However, in many developing countries, like Iraq, routine urine culture test for pregnant women

is not performed, and antimicrobials are usually prescribed empirically without laboratory urine culture results. Furthermore, current awareness about bacteria causing UTIs and their antibiotic resistance is essential for ensuring successful therapy through periodic evaluation of the antibacterial activity. The goal of this study was to assess the etiologic and antibiotic susceptibility patterns of bacteria isolated from pregnant women with UTIs, and investigate whether UTIs are associated with the third trimester.

Methodology

Study design and patient population

A cross-sectional study was conducted on 5,042 pregnant women attending primary care health centers in Erbil, the capital of Iraq's Kurdistan Region, who were assessed for UTI from October 2018 to February 2022. Exclusion criteria included pregnant women who were below the age of 18 years; refused to participate in the study; were diagnosed with hypertension and/or diabetes mellitus; received antimicrobial treatment within two weeks; had recent hospitalization, catheterization, surgery, or urethral instrumentation in the previous two weeks; were diagnosed with COVID-19; had urologic abnormalities or nephrolithiasis; and had a known serum creatinine level of more than 2.2 mg/d.

Ethical approval

Ethics committee approval was obtained from the Medical Research Ethics Committee of Hawler Medical University, Erbil, Kurdistan Region, Iraq. All pregnant women provided verbal informed consent for participation in the study before specimen collection and authorized the use of their clinical data for subsequent publication. All identifying information about the women was kept confidential.

Data collection

Demographic data, including age, educational level, parity (number of live births), trimester, and medical history, were obtained from the pregnant women. The body mass index (BMI) was calculated by measuring height and weight.

Urine collection and analysis

Clean-catch midstream urine was collected from pregnant women and then cultured. The bacterial culture was performed by streaking 1 µL of urine on MacConkey agar and 5% blood agar plates (Lab M, Lancashire, UK) with a calibrated loop. The plates were incubated at 37 °C for 18–24 hours under aerobic conditions [19]. Plates with mixed cultures were sub-cultured to obtain a pure bacterial culture. Gram staining was performed to identify whether the bacteria were Gram-negative or Gram-positive [20]. The isolated bacteria were identified to genus or species level using the analytical profile index (API) system. The results were interpreted according to the guidelines of the Infectious Diseases Society of America as follows [10]:

(1) Sterile urine: negative urine culture (control group).
(2) Contaminated specimen: urine specimen containing more than two species.
(3) Insignificant bacteriuria: clean-catch urine containing $< 10^5$ colony-forming units (CFU) of bacteria per mL.
(4) Significant bacteriuria: growth of bacteria at $\geq 10^5$ CFU/mL in urine culture, which was sub-classified into two groups [21]:
    a. ASB: significant bacteriuria in the absence of signs or symptoms attributable to an UTI.
    b. Symptomatic UTI: presence of significant bacteriuria with the clinical symptoms of UTI.

Urine specimens that produced insignificant bacteriuria or that were contaminated were excluded from the study.

Identification with API systems

The API system is a method used to identify bacteria based on their biochemical characteristics [22]. The isolated bacterial species were identified using the API system with the API 20E kit for Gram-negative bacteria, the API Staph kit for staphylococci, and the API 20 Strep kit for streptococci and enterococci (bioMérieux, Marcy l'Etoile, France). The tests were performed according to the manufacturer's instructions.

Antimicrobial susceptibility testing

The agar dilution method was performed according to the guidelines of the Clinical Laboratory Standard Institute (CLSI) document M07-A10 to determine antimicrobial susceptibility [23]. Mueller-Hinton agar (Lab M, Lancashire**,** UK) plates were prepared with a doubling concentration of the antimicrobial. The antimicrobials used for Gram-negative and Gram-positive bacteria were ampicillin (AMP), amoxicillin (AMX), cephalexin (LEX), cefuroxime (CXM), ceftriaxone (CRO), cefepime (FEP), meropenem (MEM), azithromycin (AZM), nitrofurantoin (NIT), and fosfomycin (FOF) (Sigma-Aldrich, St. Louis, MO, USA). In addition, daptomycin (DAP) (Sigma-Aldrich)

was used for Gram-positive bacteria. The bacterial suspensions of each bacteria strain were prepared and adjusted to a turbidity equivalent to 0.5 McFarland standard turbidity, and then the bacteria were inoculated on these plates with approximately 10^4 CFU per spot of 5–8 mm in diameter, and the plates were incubated aerobically at 35 ± 2 °C for 16–20 hours. The plates were examined for bacterial growth to determine the minimum inhibitory concentration (MIC), which is the lowest concentration of the antimicrobial that inhibited the growth of the isolate when compared to the growth of the control. The MIC value was compared with the CLSI susceptibility breakpoints [24], and the percentage of antimicrobial susceptibility was determined based on the CLSI breakpoints.

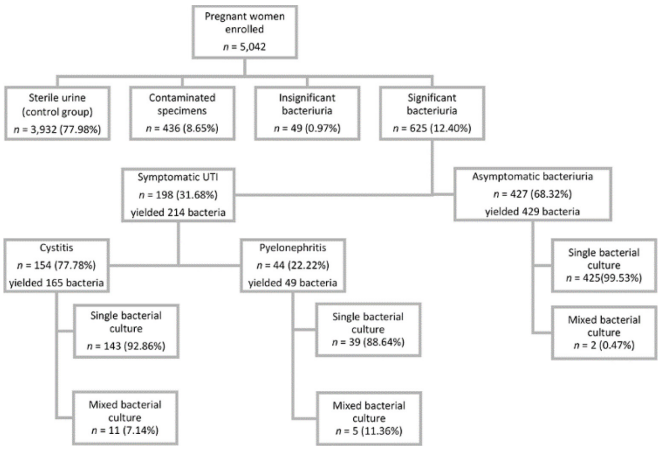
Data analysis

The data were coded and analyzed using SPSS version 25.0 (SPSS, Chicago, IL). The Chi-square test is used to compare categorical variables. A *p* value less than 0.05 was considered a significant association between the variables.

Results

A total of 5,042 pregnant women were examined for UTIs, and 625 (12.40%) were diagnosed with significant bacteriuria. While 3,932 (77.98%) of the urine specimens were sterile (control group), 49 (0.97%) showed insignificant bacteriuria, and 436 (8.65%) of the specimens were contaminated. Furthermore, out of 625 significant bacteriuria, 427 (68.32%) were ASB, yielding 429 bacteria, and 198 (31.68%) were asymptomatic UTI, with 8 of the UTI cultures containing polymicrobial infection. UTIs consisted of 77.78% cystitis and 22.22% pyelonephritis (Figure 1).

Figure 1. Urine culture results of 5,042 pregnant women.



UTI: urinary tract infection.

Table 1 shows the distribution and comparison of the characteristics of symptomatic UTI with ASB and

Table 1. Comparison of the characteristics of symptomatic UTI in pregnant women with asymptomatic bacteriuria and control group.

Characteristics	Symptomatic UTI *n* = 198		Asymptomatic bacteriuria *n* = 427		Control group *n* = 3,932		*p* [a]	*p* [b]
	n	%	*n*	%	*n*	%		
Age (years)								
18-23	54	27.27	90	21.08	767	19.51		
24-29	66	33.33	109	25.53	1676	42.62		
30-35	36	18.18	70	16.39	891	22.66	0.002	0.004
36-41	29	14.65	92	21.55	413	10.5		
42-47	13	6.57	66	15.46	185	4.7		
Educational level								
Illiterate	2	1.01	3	0.70	43	1.09		
Primary (1–8)	29	14.65	37	8.67	574	14.60		
Secondary (9–12)	47	23.74	74	17.33	843	21.44	0.046	0.529
Institute (13-14)	59	29.80	161	37.70	1256	31.94		
University	61	30.81	151	35.36	1204	30.62		
Post-graduate	0	0.00	1	0.23	12	0.31		
Parity								
Nullipara	44	22.22	76	17.80	693	17.62		
Primipara	56	28.28	160	37.47	815	20.73	0.069	0.003
Multipara	98	49.49	191	44.73	2424	61.65		
Trimester								
1st	29	24.79	95	37.85	1404	35.71		
2nd	37	31.62	88	35.06	1175	29.88	< 0.001	0.011
3rd	51	43.59	68	27.09	1353	34.41		
BMI								
Under weight	39	19.70	65	15.22	672	17.09		
Normal	61	30.81	180	42.15	1654	42.07	0.105	0.014
Over weight	69	34.85	131	30.68	1069	27.19		
Obese	29	14.65	51	11.94	537	13.66		

[a] Comparison of symptomatic UTI with asymptomatic bacteriuria using Chi-square test; [b] Comparison of symptomatic UTI with control group using Chi-square test; UTI: urinary tract infection; BMI: body mass index.

Table 2. Bacterial distribution in symptomatic UTI and asymptomatic bacteriuria.

Organism	Symptomatic UTI		Asymptomatic bacteriuria		Total	
	n	%	*n*	%	*n*	%
Escherichia coli	132	61.68	231	53.85	363	56.45
Klebsiella pneumoniae	25	11.68	67	15.62	92	14.31
Proteus mirabilis	23	10.75	26	6.06	49	7.62
Others Enterobacteriaceae [a]	9	4.21	37	8.62	46	7.15
Staphylococcus saprophyticus	7	3.27	12	2.80	19	2.95
Streptococcus agalactiae	7	3.27	5	1.17	12	1.87
Enterococcus faecalis	6	2.80	15	3.50	21	3.27
CoNS [b]	5	2.34	36	8.39	41	6.38
Total	214		429		643	

[a] Others Enterobacteriaceae: *Citrobacter spp*, *Enterobacter spp*, *Klebsiella spp*; [b] Coagulase-negative staphylococci; *p* value = 0.002, between symptomatic UTI and asymptomatic bacteriuria; UTI: urinary tract infection.

control group. During the third trimester, 43.59% of pregnant women had symptomatic UTIs. Statistical differences in age and trimester were observed between symptomatic UTI and the other two groups (ASB and control). The differences in parity ($p = 0.003$) and BMI ($p = 0.014$) were also significant between the symptomatic UTI group and the control group.

Out of the 643 uropathogenic bacteria identified, 214 (33.28%) were isolated from symptomatic UTIs, whereas 429 (66.72%) were obtained from ASB. *E. coli* (56.45%, $n = 363$) was the predominant bacteria, which was responsible for 61.68% of symptomatic UTI and 53.85% of ASB, followed by *K. pneumoniae* (11.68% of symptomatic UTI and 15.62% of ASB) and *P. mirabilis* (7.62% of symptomatic UTI and ASB, 10.75% symptomatic UTI and 6.06% ASB). The difference in bacterial etiology between symptomatic UTI and ASB was statistically significant ($p = 0.002$) (Table 2).

The prevalence of *E. coli* was higher in cystitis (65.45%) than in pyelonephritis (48.98%). *K. pneumoniae* rates were 12.12% and 14.29% in cystitis and pyelonephritis, respectively. The prevalence of *P. mirabilis* in pyelonephritis (16.33%) was higher than in cystitis (7.88%). A significant difference in bacterial etiology was observed between cystitis and pyelonephritis ($p = 0.017$) (Table 3).

E. coli was the major pathogen causing symptomatic UTI and showed a higher level of susceptibility to fosfomycin (100%), meropenem (98.48%), and nitrofurantoin (95.45%), but less susceptibility to azithromycin (34.85%). Moreover, most Gram-negative bacteria isolated from symptomatic UTIs and ASBs were sensitive to meropenem (98.48%), nitrofurantoin (86.18%), and fosfomycin (85.64%). No significant difference was found in the antimicrobial susceptibility profiles between UTI and ASB. The results of the antimicrobial susceptibility pattern of Gram-negative bacteria are shown in Table 4. Gram-positive bacteria showed a high level of susceptibility to daptomycin (100%) and meropenem (95.59%), followed by nitrofurantoin (89.71%), cefuroxime (77.94%), and ceftriaxone (76.47%), but resistance to ampicillin (19.12% sensitive). There was no significant difference in antimicrobial susceptibility patterns between symptomatic UTIs and ASBs (Table 5).

Discussion

Women are predisposed to ASB and symptomatic UTI or pyelonephritis during pregnancy, which can cause significant maternal and fetal morbidity [25]. This study discovered a significant number of ASBs and symptomatic UTIs, which is consistent with previous research [25,26]. ASB predisposes to the development of UTIs [27] and increases the risk of acquiring UTIs due to hormonal and anatomical changes during pregnancy [28]. Furthermore,

Table 3. Distribution of uropathogenic bacteria in cystitis and pyelonephritis.

Uropathogens	Cystitis		Pyelonephritis		Total of symptomatic UTI	
	n	%	*n*	%	*n*	%
Escherichia coli	108	65.45	24	48.98	132	61.68
Klebsiella pneumoniae	20	12.12	7	14.29	27	12.62
Proteus mirabilis	13	7.88	8	16.33	21	9.81
Others Enterobacteriaceae [a]	5	3.03	4	8.16	9	4.21
Staphylococcus saprophyticus	5	3.03	2	4.08	7	3.27
Streptococcus agalactiae	7	4.24	0	0.00	7	3.27
Enterococcus faecalis	2	1.21	4	8.16	6	2.80
CoNS [b]	5	3.03	0	0.00	5	2.34
Total	165		49		214	

[a] Others Enterobacteriaceae: *Citrobacter spp*, *Enterobacter spp*, *Klebsiella spp*; [b] Coagulase-negative staphylococci; *p* value = 0.017, between cystitis and pyelonephritis; UTI: urinary tract infection.

pyelonephritis is most prevalent in late pregnancy [29]. When UTIs were detected and treated early, the complications were reduced [30]. The study also concluded that the majority of UTIs developed during the third trimester. This finding corresponds with another study [31]. UTIs cause adverse pregnancy outcomes, and the identification of uropathogenic bacteria may contribute to the early treatment of pregnant women. Undiagnosed and/or untreated ASB in the first and second trimesters causes cystitis and pyelonephritis in the third trimester. If ASB is left untreated, it may be associated with acute cystitis and pyelonephritis [32]. This emphasizes the significance of screening for ASB and treating symptomatic UTIs with appropriate antimicrobial therapy to reduce the incidence of pyelonephritis and UTI complications during pregnancy [33].

The prevalence of symptomatic UTIs in pregnancy was affected by age, educational level, parity, and BMI compared to ASB or control group. UTIs and ASBs were common in pregnant women of all ages. But some studies have suggested that older age may be associated with a higher risk of bacteriuria and UTIs during pregnancy [34,35], which agrees with our results. The effect of educational level on UTIs in pregnant women is not well established in the current study. This might be attributed to increased awareness about UTI symptoms and prevention measures, as well as high adherence to treatment and follow-up at different educational levels. However, lower levels of education have been associated with a higher prevalence of ASB in other studies [36,37]. The effect of nulliparity on UTIs in pregnant women is not well established. However, the prevalence of UTIs in nulliparous women

Table 4. Antimicrobial sensitivity pattern of 550 Gram-negative bacteria isolated from symptomatic UTI (sUTI) and asymptomatic bacteriuria (ASB).

Gram-negative bacteria	Type	*n*	Antimicrobial agents (% of sensitive)										*p*
			AMP	AMX	LEX	CXM	CRO	FEP	MEM	AZM	NIT	FOF	
Escherichia coli	sUTI	132	38.64	52.27	61.36	66.67	70.45	71.97	98.48	34.85	95.45	100	
	ASB	231	61.04	67.97	71	80.09	85.71	84.85	100	38.53	99.13	100	0.468
	Total	363	52.89	62.26	67.49	75.21	80.17	80.17	99.45	37.19	97.80	100	
Klebsiella	sUTI	25	4	16	60	80	92	92	96	12	32	16	
pneumoniae	ASB	67	20.90	19.40	68.66	94.03	97.01	100	98.51	25.37	38.81	23.88	0.896
	Total	92	16.30	18.48	66.30	90.22	95.65	97.83	97.83	21.74	36.96	21.74	
Proteus mirabilis	sUTI	23	13.04	43.48	65.22	73.91	78.26	65.22	91.30	13.04	91.30	100	
	ASB	26	53.85	69.23	84.62	100	96.15	88.46	100	50	100	100	0.467
	Total	49	34.69	57.14	75.51	87.76	87.76	77.55	95.92	32.65	95.92	100	
Others Ent	sUTI	9	0.00	33.33	44.44	22.22	44.44	33.33	100	0.00	55.56	55.56	
	ASB	37	13.51	35.14	29.73	13.51	21.62	45.95	94.59	8.11	89.19	91.89	0.671
	Total	46	10.87	34.78	32.61	15.22	26.09	43.48	95.65	6.52	82.61	84.78	
Total	sUTI	189	29.10	295.53	38.91	326.36	42.28	321.63	57.21	90.90	176.02	93.17	
	ASB	361	48.20	55.68	67.31	77.29	81.99	83.93	99.17	33.80	86.98	85.04	0.258
	Total	550	41.64	52.18	65.09	73.82	78.91	79.82	98.55	31.64	86.18	85.64	

Ent: Enterobacteriaceae; ND: not done; AMP: ampicillin; AMX: amoxicillin; LEX: cephalexin; CXM: cefuroxime; CRO: ceftriaxone; FEP: cefepime; MEM: meropenem; AZM: azithromycin; NIT: nitrofurantoin; FOF: Fosfomycin; UTI: urinary tract infection.

Table 5. Antimicrobial sensitivity pattern of 68 Gram-positive bacteria isolated from symptomatic UTI (sUTI) and asymptomatic bacteriuria (ASB).

Gram-positive bacteria	Type	*n*	Antimicrobial agents (% of sensitive)											*p*
			AMP	AMX	LEX	CXM	CRO	FEP	MEM	AZM	NIT	FOF	DAP	
Staphylococcus	sUTI	7	14.29	28.57	71.43	71.43	100	0.00	100	28.57	100	ND	100	
saprophyticus	ASB	12	25	58.33	83.33	83.33	83.33	16.67	100	75	100	ND	100	0.938
	Total	19	21.05	47.37	78.95	78.95	89.47	10.53	100	57.89	100	ND	100	
Streptococcus	sUTI	7	71.43	71.43	ND	100	100	100	100	85.71	ND	ND	100	
agalactiae	ASB	5	60	100	ND	100	100	100	100	60	ND	ND	100	0.999
	Total	12	66.67	83.33	ND	100	100	100	100	75	ND	ND	100	
Enterococcus	sUTI	6	0.00	0.00	ND	66.67	66.67	66.67	100	0.00	100	100	100	
Faecalis	ASB	15	13.33	33.33	ND	80	86.67	93.33	100	20	100	100	100	0.910
	Total	21	9.52	23.81	ND	76.19	80.95	85.72	100	14.29	100	100	100	
CoNS	sUTI	5	0.00	40	40	40	40	60	100	0.00	100	ND	100	
	ASB	36	13.89	33.33	61.11	72.22	66.67	80.56	91.67	47.22	94.44	ND	100	0.893
	Total	41	12.20	34.15	58.54	68.29	63.41	78.05	92.68	41.46	95.12	ND	100	
Total	sUTI	68	19.12	42.65	47.06	77.94	76.47	73.53	95.59	47.06	89.71	22.06	100	
	ASB	93	20.43	40.86	41.94	76.34	77.42	68.82	96.77	43.01	84.95	22.58	100	0.999
	Total	68	19.12	42.65	47.06	77.94	76.47	73.53	95.59	47.06	89.71	22.06	100	

CoNS: Coagulase-negative staphylococci; ND: not done; AMP: ampicillin; AMX: amoxicillin; LEX: cephalexin; CXM: cefuroxime; CRO: ceftriaxone; FEP: cefepime; MEM: meropenem; AZM: azithromycin; NIT: nitrofurantoin; FOF: fosfomycin; DAP: daptomycin; UTI: urinary tract infection.

was higher than in ASB and the control group in this study, which may be because the nulliparous women were screened and treated for ASB. Moreover, some studies reported a higher prevalence of UTIs associated with nulliparity [38,39]. Elevated BMI was associated with UTIs, and this result is consistent with other studies [40].

In this study, the most common bacteria isolated from symptomatic UTI and ASB were *E. coli*, which has been reported in other geographical areas with resistance to various antimicrobial agents [41]. Antimicrobial resistance in uropathogenic bacteria is increasing worldwide, especially to the commonly used antimicrobial agents [42]. UTIs caused by *E. coli* pose a therapeutic challenge and are associated with an increased risk of serious complications for the mother and fetus during pregnancy [43]. Antimicrobial resistance of *E. coli* has become an alarming problem in both developed and developing countries because the resistance is increasing faster than the development of antimicrobial agents [44]. Fosfomycin affected all strains of *E. coli* and the majority of the isolated species, but *E. coli* was most likely to be susceptible to fosfomycin, according to the CANWARD surveillance study [45].

Most of the isolates in the current study were susceptible to nitrofurantoin, which is one of the most prescribed antibiotics [46,47]. Therefore, during the first trimester, nitrofurantoin can be used for the prevention and treatment of UTIs. The American College of Obstetricians and Gynecologists recommended that prescribing nitrofurantoin in the first trimester is still appropriate when no other alternative antimicrobial therapies are available [48]. About two-thirds of the uropathogens were susceptible to cephalexin in this study, and it has been recommended as a first-line treatment for UTI in pregnancy by the National Institute for Health and Care Excellence [49]. However, approximately one-third of isolated bacteria were susceptible to ampicillin, which reduced their overall susceptibility to the commonly used form of the antimicrobial agent. The study provides a choice for treatment of UTIs during pregnancy when microbiological results are unavailable, especially in developing countries. A limitation of this study was the lack of testing for extended-spectrum beta-lactamase (ESBL)-producing bacteria.

Conclusions

A significant number of UTIs were reported in pregnant women, and the likelihood was higher during the third trimester. The most common bacterial isolate from UTI and ASB was *E. coli*, and fosfomycin was effective against all strains of this bacterium. The most effective treatment for this infection was meropenem, followed by nitrofurantoin, ceftriaxone, cefepime, and fosfomycin. There was no Gram-positive bacterial resistance to daptomycin. Thus, the efficiency of the antimicrobial drug contributed to the successful treatment of UTIs during pregnancy.

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References

1. Sula I, Alreshidi MA, Alnasr N, Hassaneen AM, Saquib N (2023) Urinary tract infections in the Kingdom of Saudi Arabia, a review. Microorganisms 11: 952. doi: 10.3390/microorganisms11040952.
2. Ansaldi Y, Martinez de Tejada Weber B (2023) Urinary tract infections in pregnancy. Clin Microbiol Infect 29: 1249-1253. doi: 10.1016/j.cmi.2022.08.015.
3. Lelie-van der Zande R, Koster ES, Teichert M, Bouvy ML (2021) Women's self-management skills for prevention and treatment of recurring urinary tract infection. Int J Clin Pract 75: e14289. doi: 10.1111/ijcp.14289.
4. Zeng Z, Zhan J, Zhang K, Chen H, Cheng S (2022) Global, regional, and national burden of urinary tract infections from 1990 to 2019: an analysis of the global burden of disease study 2019. World J Urol 40: 755-763. doi: 10.1007/s00345-021-03913-0.
5. Kalinderi K, Delkos D, Kalinderis M, Athanasiadis A, Kalogiannidis I (2018) Urinary tract infection during pregnancy: current concepts on a common multifaceted problem. J Obstet Gynaecol 38: 448-453. doi: 10.1080/01443615.2017.1370579.
6. Guglietta A (2017) Recurrent urinary tract infections in women: risk factors, etiology, pathogenesis, and prophylaxis. Future Microbiol 12: 239-246. doi: 10.2217/fmb-2016-0145.
7. Mukherjee M, Koley S, Mukherjee S, Basu S, Ghosh B, Chakraborty S (2015) Phylogenetic background of *E. coli* isolated from asymptomatic pregnant women from Kolkata, India. J Infect Dev Ctries 9: 720-724. doi: 10.3855/jidc.5771.
8. Luu T, Albarillo FS (2022) Asymptomatic bacteriuria: prevalence, diagnosis, management, and current antimicrobial stewardship implementations. Am J Med 135: e236-e244. doi: 10.1016/j.amjmed.2022.03.015.
9. Anger J, Lee U, Ackerman AL, Chou R, Chughtai B, Clemens JQ, Hickling D, Kapoor A, Kenton KS, Kaufman MR, Rondanina MA, Stapleton A, Stothers L, Chai TC (2019) Recurrent uncomplicated urinary tract infections in women: AUA/CUA/SUFU guideline. J Urol 202: 282-289. doi: 10.1097/JU.0000000000000296.
10. Nicolle LE, Gupta K, Bradley SF, Colgan R, DeMuri GP, Drekonja D, Eckert LO, Geerlings SE, Köves B, Hooton TM, Juthani-Mehta M, Knight SL, Saint S, Schaeffer AJ, Trautner B, Wullt B, Siemieniuk R (2019) Clinical practice guideline for

the management of asymptomatic bacteriuria: 2019 update by the Infectious Diseases Society of America. Clin Infect Dis 68: e83-e110. doi: 10.1093/cid/ciy1121.
11. Nicolle LE (2006) Asymptomatic bacteriuria: review and discussion of the IDSA guidelines. Int J Antimicrob Agents 28: 42-48. doi: 10.1016/j.ijantimicag.2006.05.010.
12. Bayih WA, Ayalew MY, Chanie ES, Abate BB, Alemayehu SA, Belay DM, Aynalem YA, Sewyew DA, Kebede SD, Demis A, Yitbarek GY, Tassew MA, Birhan BM, Alemu AY (2021) The burden of neonatal sepsis and its association with antenatal urinary tract infection and intra-partum fever among admitted neonates in Ethiopia: a systematic review and meta-analysis. Heliyon 7: e06121. doi: 10.1016/j.heliyon.2021.e06121.
13. Damm TL, Cameron AP (2023) Antimicrobial resistance in urinary tract infections. Curr Bladder Dysfunct Rep 18: 1-9. doi: 10.1007/s11884-022-00674-3.
14. Glover EK, Sheerin NS (2023) Urinary tract infection. Medicine (Baltimore) 51: 239-243. doi: 10.1016/j.mpmed.2023.01.002.
15. Zavala-Cerna MG, Segura-Cobos M, Gonzalez R, Zavala-Trujillo IG, Navarro-Perez SF, Rueda-Cruz JA, Satoscoy-Tovar FA (2020) The clinical significance of high antimicrobial resistance in community-acquired urinary tract infections. Can J Infect Dis Med Microbiol 2020: 2967260. doi: 10.1155/2020/2967260.
16. Kolman KB (2019) Cystitis and pyelonephritis: diagnosis, treatment, and prevention. Prim Care 46: 191-202. doi: 10.1016/j.pop.2019.01.001.
17. Vicar EK, Acquah SEK, Wallana W, Kuugbee ED, Osbutey EK, Aidoo A, Acheampong E, Mensah GI (2023) Urinary tract infection and associated factors among pregnant women receiving antenatal care at a primary health care facility in the northern region of Ghana. Int J Microbiol 2023: 3727265. doi: 10.1155/2023/3727265.
18. Al Khalaf S, Bodunde E, Maher GM, O'Reilly É J, McCarthy FP, O'Shaughnessy MM, O'Neill SM, Khashan AS (2022) Chronic kidney disease and adverse pregnancy outcomes: a systematic review and meta-analysis. Am J Obstet Gynecol 226: 656-670.e632. doi: 10.1016/j.ajog.2021.10.037.
19. Lifshitz E, Kramer L (2000) Outpatient urine culture: does collection technique matter? Arch Intern Med 160: 2537-2540. doi: 10.1001/archinte.160.16.2537.
20. Fenta A, Dagnew M, Eshetie S, Belachew T (2020) Bacterial profile, antibiotic susceptibility pattern and associated risk factors of urinary tract infection among clinically suspected children attending at Felege-Hiwot comprehensive and specialized hospital, Northwest Ethiopia. A prospective study. BMC Infect Dis 20: 673. doi: 10.1186/s12879-020-05402-y.
21. Glaser AP, Schaeffer AJ (2015) Urinary tract infection and bacteriuria in pregnancy. Urol Clin North Am 42: 547-560. doi: 10.1016/j.ucl.2015.05.004.
22. Franco-Duarte R, Černáková L, Kadam S, Kaushik KS, Salehi B, Bevilacqua A, Corbo MR, Antolak H, Dybka-Stępień K, Leszczewicz M, Relison Tintino S, Alexandrino de Souza VC, Sharifi-Rad J, Coutinho HDM, Martins N, Rodrigues CF (2019) Advances in chemical and biological methods to identify microorganisms-from past to present. Microorganisms 7: 130. doi: 10.3390/microorganisms7050130.
23. Clinical and Laboratory Standards Institute (CLSI) (2015) Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically, 10th edition. CLSI supplement. Wayne PA. M07-A10.
24. Clinical and Laboratory Standards Institute (CLSI) (2019) Performance standards for antimicrobial susceptibility testing, 29th edition. CLSI supplement. Wayne PA. M100.
25. Lee AC, Mullany LC, Koffi AK, Rafiqullah I, Khanam R, Folger LV, Rahman M, Mitra DK, Labrique A, Christian P, Uddin J, Ahmed P, Ahmed S, Mahmud A, DasGupta SK, Begum N, Quaiyum MA, Saha SK, Baqui AH (2019) Urinary tract infections in pregnancy in a rural population of Bangladesh: population-based prevalence, risk factors, etiology, and antibiotic resistance. BMC Pregnancy Childbirth 20: 1. doi: 10.1186/s12884-019-2665-0.
26. Nteziyaremye J, Iramiot SJ, Nekaka R, Musaba MW, Wandabwa J, Kisegerwa E, Kiondo P (2020) Asymptomatic bacteriuria among pregnant women attending antenatal care at Mbale Hospital, Eastern Uganda. PLoS One 15: e0230523. doi: 10.1371/journal.pone.0230523.
27. Teh H (2022) A review of the current concepts in canine urinary tract infections. Aust Vet J 100: 56-62. doi: 10.1111/avj.13127.
28. Santos JF, Ribeiro RM, Rossi P, Haddad JM, Guidi HG, Pacetta AM, Pinotti JA (2002) Urinary tract infections in pregnant women. Int Urogynecol J Pelvic Floor Dysfunct 13: 204-209. doi: 10.1007/s192-002-8354-7.
29. Grette K, Cassity S, Holliday N, Rimawi BH (2020) Acute pyelonephritis during pregnancy: a systematic review of the aetiology, timing, and reported adverse perinatal risks during pregnancy. J Obstet Gynaecol 40: 739-748. doi: 10.1080/01443615.2019.1647524.
30. Abou Heidar NF, Degheili JA, Yacoubian AA, Khauli RB (2019) Management of urinary tract infection in women: a practical approach for everyday practice. Urol Ann 11: 339-346. doi: 10.4103/UA.UA_104_19.
31. Easter SR, Cantonwine DE, Zera CA, Lim KH, Parry SI, McElrath TF (2016) Urinary tract infection during pregnancy, angiogenic factor profiles, and risk of preeclampsia. Am J Obstet Gynecol 214: 387.e381-387. doi: 10.1016/j.ajog.2015.09.101.
32. Sheppard M, Ibiebele I, Nippita T, Morris J (2023) Asymptomatic bacteriuria in pregnancy. Aust N Z J Obstet Gynaecol 63: 696-701. doi: 10.1111/ajo.13693.
33. Afoakwa P, Domfeh SA, Afranie BO, Owusu DO, Donkor S, Sakyi KK, Adom RA, Kyeremeh G, Okyere BA, Acheampong E, Amoah B (2018) Asymptomatic bacteriuria and anti-microbial susceptibility patterns among women of reproductive age. A cross-sectional study in primary care, Ghana. Med Sci (Basel) 6: 118. doi: 10.3390/medsci6040118.
34. Hernández-Hernández D, Padilla-Fernández B, Ortega-González MY, Castro-Díaz DM (2022) Recurrent urinary tract infections and asymptomatic bacteriuria in adults. Curr Bladder Dysfunct Rep 17: 1-12. doi: 10.1007/s11884-021-00638-z.
35. Ngong IN, Fru-Cho J, Yung MA, Akoachere JKT (2021) Prevalence, antimicrobial susceptibility pattern and associated risk factors for urinary tract infections in pregnant women attending ANC in some integrated health centers in the Buea Health District. BMC Pregnancy Childbirth 21: 673. doi: 10.1186/s12884-021-04142-4.
36. Tchente Nguefack C, Okalla Ebongue C, Nouwe Chokotheu C, Ebong Ewougo C, Nana Njamen T, Mboudou E (2019) Clinical presentation, risk factors and pathogens involved in bacteriuria of pregnant women attending antenatal clinic of 3 hospitals in a developing country: a cross sectional analytic

study. BMC Pregnancy Childbirth 19: 143. doi: 10.1186/s12884-019-2290-y.
37. Edae M, Teklemariam Z, Weldegebreal F, Abate D (2020) Asymptomatic bacteriuria among pregnant women attending antenatal care at Hiwot Fana Specialized University Hospital, Harar, Eastern Ethiopia: magnitude, associated factors, and antimicrobial susceptibility pattern. Int J Microbiol 2020: 1763931. doi: 10.1155/2020/1763931.
38. Sun M-J, Chen G-D, Chang S-Y, Lin K-C, Chen S-Y (2005) Prevalence of lower urinary tract symptoms during pregnancy in Taiwan. J Formos Med Assoc 104: 185-189.
39. Balachandran L, Jacob L, Al Awadhi R, Yahya LO, Catroon KM, Soundararajan LP, Wani S, Alabadla S, Hussein YA (2022) Urinary tract infection in pregnancy and its effects on maternal and perinatal outcome: a retrospective study. Cureus 14: e21500. doi: 10.7759/cureus.21500.
40. Alhabeeb H, Baradwan S, Kord-Varkaneh H, Tan SC, Low TY, Alomar O, Salem H, Al-Badawi IA, Abu-Zaid A (2021) Association between body mass index and urinary tract infection: a systematic review and meta-analysis of observational cohort studies. Eat Weight Disord 26: 2117-2125. doi: 10.1007/s40519-020-01101-4.
41. Emami A, Javanmardi F, Pirbonyeh N (2020) Antibiotic resistant profile of asymptomatic bacteriuria in pregnant women: a systematic review and meta-analysis. Expert Rev Anti Infect Ther 18: 807-815. doi: 10.1080/14787210.2020.1759420.
42. Bader MS, Loeb M, Brooks AA (2017) An update on the management of urinary tract infections in the era of antimicrobial resistance. Postgrad Med 129: 242-258. doi: 10.1080/00325481.2017.1246055.
43. Szweda H, Jóźwik M (2016) Urinary tract infections during pregnancy - an updated overview. Dev Period Med 20: 263-272.
44. Ahmed SS, Shariq A, Alsalloom AA, Babikir IH, Alhomoud BN (2019) Uropathogens and their antimicrobial resistance patterns: relationship with urinary tract infections. Int J Health Sci (Qassim) 13: 48-55.
45. Karlowsky JA, Baxter MR, Walkty AJ, Lagacé-Wiens PRS, Bay D, Adam HJ, Zhanel GG (2022) In vitro activity of fosfomycin against bacterial pathogens isolated from urine specimens in Canada from 2007 to 2020: CANWARD surveillance study. J Antimicrob Chemother 77: 3035-3038. doi: 10.1093/jac/dkac275.
46. Konwar M, Gogtay NJ, Ravi R, Thatte UM, Bose D (2022) Evaluation of efficacy and safety of fosfomycin versus nitrofurantoin for the treatment of uncomplicated lower urinary tract infection (UTI) in women - a systematic review and meta-analysis. J Chemother 34: 139-148. doi: 10.1080/1120009X.2021.1938949.
47. Khan N, Panda PS, Mehndiratta MM, Sharma S, Rastogi M, Gupta S, Rana N (2020) Antimicrobial therapy for extended spectrum beta lactamase producing uropathogenic *Escherichia coli.* Is fosfomycin a reasonable alternative to nitrofurantoin? 5: 239-241. doi: 10.36348/sjm.2020.v05i05.004.
48. Committee on Obstetric (2017) Committee opinion no. 717: sulfonamides, nitrofurantoin, and risk of birth defects. Obstet Gynecol 130: e150-e152.
49. Chaplin S (2019) Antimicrobial prescribing for urinary tract infections. Prescriber 30: 33-36. doi: 10.1002/psb.1770.

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