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Bacterial detection and antibiotic resistance pattern of urinary tract infections among Iraqi patients: A cross-sectional study

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ABSTRACT

Urinary tract infection (UTI) refers to a spectrum of clinical illnesses, including asymptomatic cases. UTIs are inflammatory disorders induced by bacteria that have multiplied excessively inside the urinary system. The study objective the most prevalent bacterial pathogens causing urinary tract infections among patients and to evaluate the patterns of antimicrobial resistance. A cross-sectional study was conducted at Al-Hussain Teaching Hospital, Karbala, Iraq. A total of 230 urine samples were collected from patients with suspected urinary tract infections, including 188 females and 42 males. The participants were categorized into four age groups (≤ 20 , 21–30, 31–40, and ≥ 40 years). Pathogen distribution and antimicrobial susceptibility were evaluated across all age groups. *Escherichia coli* were the most frequently isolated pathogen, accounting for 42.2% of the total bacterial isolates, followed by *Staphylococcus aureus* (33.0%). *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* represented 15.7% and 9.1% of the isolates, respectively. *Escherichia coli* were the predominant uropathogen, particularly in females, with distribution influenced by gender and urine pH. Susceptibility testing showed variable resistance, while Gentamicin, Imipenem, and Nitrofurantoin were the most effective agents. The findings emphasize the significance of using local resistance surveillance as a means of directing empirical treatment.

Keywords: Antibiotics, Bacterial infection, Antibiotic resistance pattern, *E. coli*, UTI

INTRODUCTION

Recently, the problem of antibiotic resistance has become a concern for health authorities, especially after the emergence of diseases caused by various pathogens that are resistant to antibiotics. Initial estimates indicate that approximately 4 million people contract urinary tract infections annually, and this number is likely to increase, making this type of infection the most common (Mahjabin *et al.*, 2025). Urinary tract infections (UTIs) affect both genders and cause complications ranging from short-term to long-term outcomes. Short-term complications include dysuria, hematuria, foul-smelling urine, lower abdominal pain, and a general feeling of fatigue and malaise. In chronic cases, UTIs may lead to renal scarring. Women are more susceptible to this type of infection than men due to several anatomical and physiological factors. The most significant of these is the shorter urethra in females. Additionally, the close proximity of the urethral opening to the anus plays an important role. All of these factors substantially contribute to the increased risk of infection (Mihankhah *et al.*, 2017). Clinically, urinary tract infections (UTIs) can be classified according to the anatomical site of infection into pyelonephritis, urethritis, and cystitis. It is noteworthy that urinary tract disorders may be acquired either in community settings or within hospitals (nosocomial infections) (Alzahrani *et al.*, 2021).

The causes of urinary tract infections vary depending on several factors, including the time period of the infection, the geographical area, and the age of the patient. The most common cause, accounting for up to 90% of cases, is *Escherichia coli*, followed closely by *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Staphylococcus* spp, *Klebsiella* spp, *Enterococcus* spp, and *Serratia* spp, in varying order of prevalence (Sula *et al.*, 2023). UTIs are generally classified into simple and complicated. The presence of partial or complete obstruction in the urinary tract is considered a complicated infection, whereas uncomplicated infections are more common, occur more frequently, and are

typically amenable to treatment (Edlin *et al.*, 2013, Sargiary *et al.*, 2016).

Approximately one hundred and fifty million UTI cases are diagnosed annually worldwide, resulting in a minimum of \$6 billion in healthcare expenses. The empirical selection of antibiotics for UTI treatment is facilitated by susceptibility data from local microbiological facilities. However, these data are restricted to problematic UTIs due to the rarity of sending uncomplicated UTI specimens to laboratories (Flores-Mireles *et al.*, 2015). As a result, UTIs are currently managed through empirical methods, especially in country and rural circumstances where urine culture is not available, leading to antibiotic abuse. The increased occurrence of medication resistance among uropathogens is a major public health problem, necessitating ongoing antibiotic susceptibility (AS) testing for organisms that cause UTI (Gharavi *et al.*, 2021). Antimicrobial susceptibility patterns of UTI pathogens vary by time and region; therefore, continuous local surveillance is essential to maintain accurate and current epidemiological data (Duan *et al.*, 2021).

The study aimed to identify the most common bacterial pathogens causing urinary tract infections among the studied patients, and evaluate antimicrobial resistance patterns.

MATERIALS AND METHODS

Study design

All patients meeting the inclusion criteria were recruited using a census sample strategy. The eligibility criteria for this study were: (1) a confirmed diagnosis of UTI in 2025, (2) a validated urine culture and antibiogram, and (3) an age of 20 years or older. A retrospective cross-sectional study was performed from March to July 2025 at Imam Al-Hussain Medical City in Karbala, Iraq. The study comprised 230 clinical samples (188 females and 42 men) from patients aged between 20 and 40 years. The samples were categorized into four age brackets: ≤20, 21–30, 31–40, and ≥40 years. The examined

age groups were assessed to ascertain the distribution of pathogenic agents and to conduct antibiotic susceptibility tests for the principal identified pathogens.

Sample collection and culture

The UTI culturing method was carried out in accordance with the hospital's Department of within 2 hours. 10 microliters of urine with a calibrated loop were streaked onto a Columbia Clinical Laboratory standard operating procedures (SOPs). Briefly, clean catch midstream urine was collected from patients suspected of having UTIs, and the samples were forwarded to a clinical microbiology laboratory blood agar plate (OXOID, Thermo Fisher Scientific) (OXOID), which was then incubated aerobically at 35 degrees Celsius for 24-48 hours in a 5% CO₂ atmosphere. The number of colonies was counted.

Antibiotic susceptibility test

The VITEK 2 Compact automated system (bioMérieux, France) was used to conduct the bacterial identification and antibiotic susceptibility testing (Bitew *et al.*, 2017). The minimum inhibitory concentration (MIC) was determined for a variety of antibiotics, including Amoxicillin + Clavulanic acid (AMC), Amikacin (AMK), Cefotaxime (CTX), Vancomycin (VAN), Gentamicin (GEN), Imipenem (IPM), Aztreonam (ATM), Nitrofurantoin (NIT), Cefoxitin (FOX), Clindamycin (CLI), and Ceftazidime (CAZ). 5-10 well-isolated colonies were selected from each sample for antimicrobial susceptibility testing. The results were interpreted in accordance with the Clinical Laboratory Standards Institute (CLSI) guidelines (M100, 28th edition, 2018).

Statistical analysis

Data were summarized in tables and analyzed using descriptive statistics, including means and frequency distributions. Statistical analysis was performed using IBM SPSS version 23 (IBM Corp., Armonk, NY, USA). Associations between categorical variables were assessed using the chi-square test.

RESULTS

In accordance with entered data, the distribution of the major isolates demonstrated that *E. coli* were the most frequently examined organisms, represented 42.2% of the total isolates, followed closely by *Staphylococcus aureus* (33%). In contrast, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*. Were 15.7%, 9.1% respectively (Fig. 1).

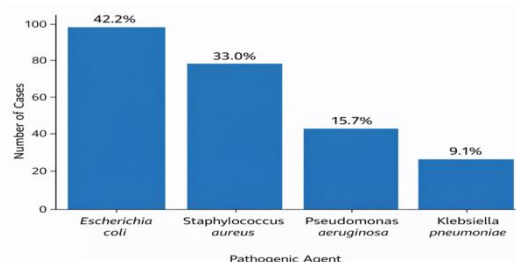


Fig. 1. Frequency distribution of major bacterial isolates identified in the study population

The distribution of the study population across age categories showed that individuals aged 21–30 years constituted the largest proportion of the total sample, followed by those in the 31–40 years' age group. In contrast, participants aged ≤20 years and ≥40 years accounted for smaller proportions of the study population. The distribution was further stratified by gender, as illustrated in Fig. 2.

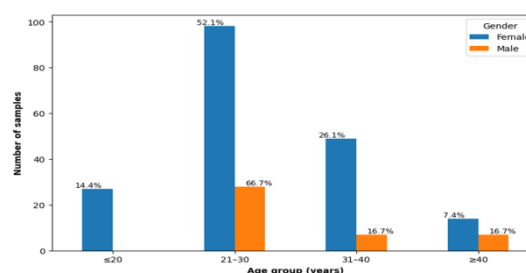


Fig. 2. Gender distribution across age groups among the study population (n = 230)

A Chi-square test revealed a statistically significant association between gender and pathogenic agents ($\chi^2 = 16.66$, $df = 3$, $p = 0.00083$), indicating that the distribution of bacterial pathogens differs significantly between males and females (Table 1). A significant association was observed between

reaction) PH) results and pathogenic agents, with acidic reactions predominating among most isolates ($\chi^2 = 24.48$, $df = 3$, $p < 0.001$) (Table 2).

Antimicrobial susceptibility patterns demonstrated variable distributions among the studied bacterial genera depending on the antibiotic tested. Chi-square analysis revealed statistically significant differences in susceptibility profiles for gentamicin, imipenem, and nitrofurantoin ($p < 0.05$), indicating heterogeneous

patterns of sensitivity and resistance among bacterial genera for these agents. In contrast, amikacin, aztreonem, amoxicillin–clavulanic acid, cefotaxime, cefoxitin, ceftazidime, clindamycin, and vancomycin did not show statistically significant differences in susceptibility patterns across bacterial genera ($P \geq 0.05$). Overall, the distribution of sensitive and resistant isolates varied among antibiotics, reflecting differences in antimicrobial activity across the studied bacterial genera (Table 3).

Table 1. Association between bacterial isolates and gender in the study population

Bacterial pathogens	Female (188)	Male (42)	Total (230)	Female (%)	Male (%)	P-value
<i>E. coli</i>	83	14	97	85.6%	14.4%	P < 0.001
<i>Staphylococcus aureus</i>	55	21	76	72.4%	27.6%	
<i>Pseudomonas aeruginosa</i>	36	0	36	100%	-	
<i>Klebsiella pneumoniae</i>	14	7	21	66.7%	33.3%	

Table 2. Association between urine pH and distribution of bacterial pathogens among patients

Pathogenic Agent	Acidic (216)	Acidic (%)	Alkaline (14)	Alkaline (%)	Total (230)	P-value
<i>E. coli</i>	97	100.0%	0	-	97	P < 0.001
<i>Staphylococcus aureus</i>	63	82.9%	13	17.1%	76	
<i>Pseudomonas aeruginosa</i>	35	97.2%	1	2.8%	36	
<i>Klebsiella pneumoniae</i>	21	100.0%	0	-	21	

Table 3. Association between bacterial isolates and antimicrobial susceptibility profiles among UTI patients

Antibiotics	Bacterial isolates				P-value
	<i>E. coli</i>	<i>Staphylococcus aureus</i>	<i>Pseudomonas aeruginosa</i>	<i>Klebsiella pneumoniae</i>	
Amikacin	91(S) 39.6%/ 6(R) 2.6%	72(S) 31.3%/ 4(R) 1.7%	36(S) 15.7%/ 0(R) 0.0%	19(S) 8.3%/ 2(R) 0.9%	P ≥ 0.05
Aztreonem	34(S) 14.8%/ 63(R) 27.4%	29(S) 12.6%/ 47(R) 20.4%	17(S) 7.4%/ 19(R) 8.3%	6(S) 2.6%/ 15(R) 6.5%	P ≥ 0.05
Amox + clav	7(S) 3.0%/ 90(R) 39.1%	0(S) 0.0%/ 76(R) 33.0%	3(S) 1.3%/ 33(R) 14.3%	0(S) 0.0%/ 21(R) 9.1%	P ≥ 0.05
Cefotaxime	79(S) 34.3%/ 18(R) 7.8%	61(S) 26.5%/ 15(R) 6.5%	27(S) 11.7%/ 9(R) 3.9%	17(S) 7.4%/ 4(R) 1.7%	P ≥ 0.05
Cefoxitin	49(S) 21.3%/ 48(R) 20.9%	34(S) 14.8%/ 42(R) 18.3%	15(S) 6.5%/ 21(R) 9.1%	11(S) 4.8%/ 10(R) 4.3%	P ≥ 0.05
Ceftazidime	31(S) 13.5%/ 65(R) 28.3%	22(S) 9.6%/ 53(R) 23.0%	10(S) 4.3%/ 26(R) 11.3%	5(S) 2.2%/ 16(R) 7.0%	P ≥ 0.05
Clindamycin	1(S) 0.4% / 96(R) 41.7%	0(S) 0.0%/ 76(R) 33.0%	0(S) 0.0%/ 36(R) 15.7%	0(S) 0.0%/ 21(R) 9.1%	P ≥ 0.05
Gentamicin	96(S) 41.7%/ 1(R) 0.4%	61(S) 26.5%/ 15(R) 6.5%	26(S) 11.3%/ 10(R) 4.3%	21(S) 9.1%/ 0(R) 0.0%	P < 0.05*
Imipenem	93(S) 40.4%/ 4(R) 1.7%	62(S) 27.0%/ 14(R) 6.1%	33(S) 14.3%/ 3(R) 1.3%	21(S) 9.1%/ 0(R) 0.0%	P < 0.05*
Nitrofurantoin	97(S) 42.2%/ 0(R) 0.0%	53(S) 23.0%/ 23(R) 10.0%	21(S) 9.1%/ 15(R) 6.5%	8(S) 3.5%/ 13(R) 5.7%	P < 0.05*
Vancomycin	36(S) 15.7%/ 61(R) 26.5%	31(S) 13.5%/ 45(R) 19.6%	21(S) 9.1%/ 15(R) 6.5%	7(S) 3.0%/ 14(R) 6.1%	P ≥ 0.05

DISCUSSION

UTI is the third most prevalent category of infection in human medicine worldwide, UTIs can affect both outpatients and hospitalized patients, especially those with immunosuppression (Bruxvoort *et al.*, 2020). *Escherichia coli* (*E. coli*) is the predominant pathogen responsible for 80%–90% of community-acquired UTIs. However, other bacteria, such as *Klebsiella* spp., *Staphylococcus* spp. can also contribute to UTIs (Gnimatin *et al.*, 2022).

Our study revealed heterogeneous findings regarding urinary tract infections among study samples across different age groups. The present study demonstrated that *Escherichia coli* were the predominant uropathogen, representing 42.2% of the total bacterial isolates. This finding is consistent with numerous previous studies, which have also identified *E. coli* as the leading causative agent of urinary tract infections and reported that Gram-negative bacteria predominate over Gram-positive organisms in patients with UTIs (Wanja *et al.*, 2021). The predominance of *E. coli* may be attributed to its role as a normal inhabitant of the human intestinal microbiota, providing a continuous source for ascending urinary tract colonization. In addition, this organism possesses several well-recognized virulence factors, including adhesins, fimbriae, and other surface structures that facilitate attachment to uroepithelial cells, thereby enhancing its ability to establish infection (Govindarajan and Kandaswamy, 2022). These characteristics, together with its increasing capacity to develop antimicrobial resistance, explain its continued predominance as the principal uropathogen across different geographical regions (Aal-Aaboda and Al-Notazy, 2018).

The present study demonstrated that individuals aged 21–30 years exhibited the highest prevalence of urinary tract infections. This finding is consistent with previous studies in India and China, which have similarly reported that young adults and individuals of reproductive age represent the

population at greatest risk for UTIs (Mavi *et al.*, 2024). The increased prevalence in this age group may be attributed to greater exposure to established risk factors, including increased sexual activity, occupational and social interactions, and other behavioral factors that facilitate bacterial colonization of the urinary tract. Furthermore, anatomical and physiological factors, together with behavioral and environmental influences, may contribute to the increased susceptibility to UTIs in this age group (Zhan *et al.*, 2024). In contrast to the present study, study conducted in Kirkuk City, north of Iraq in 2024 reported that the highest prevalence of UTIs occurred among individuals aged 42–51 years, while the 21–32-year age group ranked second.

This discrepancy may be attributed to differences in the study population, healthcare setting, inclusion criteria, and demographic characteristics between the two studies (Mohammed and Saleh, 2024).

The distribution of bacterial pathogens demonstrated a statistically significant association between patient gender and the isolated organisms ($P < 0.001$). Results from our study reveal that female participants were more likely to be affected by UTI than their male counterparts. This higher prevalence in females can be attributed to anatomical and hormonal factors predisposing them to UTIs, the finding of our study agree with (Hu *et al.*, 2004).

Escherichia coli was the most frequently identified pathogen in both genders, with a greater prevalence among females (85.6%), our finding agree with study conducted in Pakistan and Nepal have also identified *E. coli* as the most commonly detected uropathogen (Khatoon *et al.*, 2023). In the present study, *Pseudomonas aeruginosa* was isolated exclusively from female patients. This observation is supported by previous reports identifying *P. aeruginosa* as an important uropathogen among women with UTIs. The predominance observed in the current study may reflect the characteristics of

the study population and differences in healthcare exposure, previous antibiotic use, urinary catheterization, or other predisposing clinical factors rather than a sex-specific distribution these finding agree with (El Hussein *et al.*, 2004).

A high significant association between pathogenic agents and urine reaction PH, ($P < 0.001$). Most bacterial isolates were recovered from acidic urine samples, with *Escherichia coli* and *Klebsiella pneumoniae* isolated exclusively from acidic urine, while *Pseudomonas aeruginosa* was also predominantly detected in acidic urine. These findings are consistent with (Herrera-Espejo *et al.*, 2024). Demonstrating that acidic urine enhances the pathogenicity of uropathogenic *E. coli* and *K. pneumoniae* by promoting bacterial adhesion, invasion, biofilm formation, and persistence within the urinary tract. Furthermore, urinary pH may influence both bacterial colonization and antimicrobial activity, thereby affecting the composition of uropathogens recovered from patients with urinary tract infections.

However, the antimicrobial susceptibility testing of the pathogenic bacterial species included in this study revealed considerable variability in response patterns. The results demonstrated differences ranging from susceptibility in certain bacterial pathogens to resistance in others. The present study demonstrated statistically significant differences in the susceptibility patterns of bacterial isolates to Gentamicin, Imipenem, and Nitrofurantoin ($P < 0.05$), indicating that the effectiveness of these antimicrobial agents varied among the isolated uropathogens, our findings in line with study conducted in Pakistan showed high susceptibility to imipenem (100%), nitrofurantoin (78.2%) and gentamicin (58.1%) respectively (Khan *et al.*, 2023). In another previous study conducted in Argentina found Gram-negative bacteria had a 98.1% susceptibility to amikacin, unlike our study found amikacin was effective against many bacterial isolates but not show a statistically significant (Villar *et al.*, 2014).

CONCLUSION

This study highlights *Escherichia coli* as the predominant uropathogen, particularly among female patients, with variations in pathogen distribution associated with gender and urine pH. Antimicrobial susceptibility testing demonstrated variable resistance patterns, while Gentamicin, Imipenem, and Nitrofurantoin showed higher effectiveness against the majority of isolates. These findings emphasize the value of local antimicrobial surveillance in guiding appropriate empirical treatment.

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