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ORIGINAL PAPER

Incidence and pattern of antimicrobial resistance of main bacterial isolates from patients with community-acquired urinary tract infections in North of Iraq

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Summary

Introduction: *Urinary tract infections (UTIs) are among the most common bacterial infections, with Escherichia coli as the leading cause. Increasing antimicrobial resistance has reduced the effectiveness of standard empirical treatments, making continuous monitoring essential. This study evaluated the bacterial causes of community-acquired UTIs and their resistance patterns to commonly used antibiotics.*

Methods: *A descriptive cross-sectional study was conducted from November 2023 to July 2025 on patients presenting with symptoms of community-acquired UTI. Demographic and clinical data were collected with a structured form, and urine samples were subjected to culture and antimicrobial susceptibility testing. Patients with recent hospitalization, urinary procedures, catheterization, anatomical abnormalities, or pregnancy were excluded. Data were analyzed using SPSS v22, applying descriptive and comparative statistics with significance set at* $p < 0.05$.

Results: *Among 453 patients, 509 culture-positive samples were identified; 82% were female. Gram-negative organisms dominated (69.2%), with E. coli as the most frequent pathogen (44.4%). High resistance rates were observed to ampicillin, trimethoprim, and nalidixic acid. In contrast, carbapenem resistance remained low, and nitrofurantoin retained good activity. Staphylococcus haemolyticus showed the highest overall resistance burden. Older age, male sex, and comorbidities such as diabetes, renal insufficiency, and hypertension were significantly associated with increased antimicrobial resistance.*

Conclusions: *Community-acquired UTI pathogens in Sulaimani showed high resistance to widely used oral antibiotics, while carbapenems and nitrofurantoin remained effective. Higher resistance was especially noted among older adults, men, and patients with diabetes or renal disease. These findings highlight the need for improved empirical therapy and ongoing resistance surveillance.*

KEY WORDS: *Urinary tract infection; Antimicrobial resistance; Community-acquired infections; Escherichia coli; Bacterial pathogens.*

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INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide, affecting all age groups and both sexes, though they occur far more frequently in women. Nearly half of all women experience at least one episode during their lifetime, yet UTIs also pose a substantial burden on men, children, and the elderly, creating significant pressure on healthcare systems (1).

Clinically, UTIs are classified as uncomplicated or complicated depending on anatomical or functional urinary abnormalities and the presence of comorbidities. While bacteriuria may occur without symptoms, symptomatic cases typically present with dysuria, urgency, frequency, or suprapubic discomfort, with fever or flank pain in more severe disease. Beyond physical symptoms, UTIs contribute to notable psychological and socioeconomic consequences, including recurrent medical visits and reduced productivity (3).

Multiple risk factors increase susceptibility, such as female sex, advanced age, sexual activity, pregnancy, menopause, urinary tract anomalies, diabetes mellitus, and renal impairment. Accurate diagnosis relies on urinalysis, urine culture, and antimicrobial susceptibility testing, which guide targeted therapy (5, 6).

Escherichia coli (E. coli) remains the predominant uropathogen in both uncomplicated and complicated infections, followed by other Gram-negative bacteria including Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, and Enterobacter species. Gram-positive organisms, particularly *Enterococcus faecalis* (E. faecalis) and coagulase-negative Staphylococcus species, account for roughly 15-30% of community-acquired cases (8). Identifying these patterns is essential for selecting appropriate empirical therapy.

The rise of antimicrobial resistance (AMR) among uropathogens has become a major global public health concern. Misuse and overuse of antibiotics – especially broad-spectrum agents have accelerated the emergence of multidrug-resistant strains, limiting treatment options and complicating infection control, particularly in low-resource settings (10). Resistance rates vary widely across regions, underscoring the need for localized surveillance of

pathogen distribution and antibiotic susceptibility (11). In Iraq, including the Kurdistan Region, antibiotic resistance continues to escalate both in hospitals and within the community. Easy over-the-counter access to antibiotics and routine empirical treatment of UTIs contribute significantly to this trend. As a result, infections that were once easily treated now frequently require culture-guided therapy due to widespread multidrug resistance (12). Current IDSA guidelines recommend trimethoprim-sulfamethoxazole, nitrofurantoin, or fosfomycin as first-line therapy for uncomplicated UTIs, while fluoroquinolones and β-lactams are reserved for complicated or recurrent cases (13). This study aimed to assess the prevalence of key bacterial pathogens causing community-acquired UTIs in Sulaimani City, Iraq, and to evaluate their antibiotic resistance patterns. The results will help inform evidence-based treatment decisions, reduce unnecessary antibiotic use, and guide appropriate prescribing practices in the region.

Methods

Study design

This research was designed as a descriptive cross-sectional observational study conducted over a twenty-month period (November 2023 to July 2025). Urine samples were collected from patients presenting with symptoms of community-acquired urinary tract infection.

Demographic and clinical information, including comorbidities, was obtained at the time of presentation or through follow-up contact when necessary to complete missing data.

Data collection

Patients who presented with signs and symptoms suggestive of urinary tract infection were referred for urine culture and *antimicrobial susceptibility testing* (AST). Data collected for each patient included age, sex, urine culture results, bacterial identification, antimicrobial susceptibility pattern, and clinical comorbidities such as diabetes mellitus, hypertension, renal insufficiency and malignancy. The information was obtained using a structured questionnaire linked to the laboratory records.

Eligibility criteria

All male and female patients of any age presenting with clinical features consistent with community-acquired urinary tract infection were included, while those with recent hospitalization, urinary tract instrumentation or urethral catheterization, known anatomical or functional urinary tract abnormalities, or pregnancy were excluded.

Data entry and analysis

All data were entered and analyzed using IBM SPSS Statistics version 22 and Microsoft Excel. Descriptive statistics were used to calculate frequencies and percentages of bacterial isolates and their resistance rates. The average resistance rate for each bacterial species was computed as the mean percentage of *resistant* (R) isolates across all antibiotics tested. Associations between antimicrobial resistance and demographic or clinical characteristics (such as age, gender, and comorbidities) were evaluated using the chi-square or Fisher's exact test for categorical variables and Welch's t-test or Mann-Whitney U test for continuous variables, as appropriate. A p-value of < 0.05 was considered statistically significant.

Results

A total of 509 culture-positive urine samples were obtained from 453 patients with community-acquired urinary tract infections. Females constituted 82% of cases, while males accounted for 18%. Gram-negative organisms predominated, comprising 69.2% (n = 352) of isolates, whereas Gram-positive organisms represented 30.8% (n = 157). E. coli was the most frequently isolated uropathogen (44.4%), followed by Staphylococcus haemolyticus (12.8%), E. faecalis (10.8%), and Klebsiella pneumoniae (10.8%). Polymicrobial growth was identified in 4.1% of cultures, most commonly involving combinations of E. coli with E. faecalis or S. haemolyticus (Table 1).

Overall antibiotic resistance rates among all isolates were highest for ampicillin (71.3%), trimethoprim (64.7%), and nalidixic acid (62.8%). In contrast, carbapenem resistance remained low, with resistance rates of 2.4% for meropenem and 4.0% for imipenem. Nitrofurantoin also demonstrated relatively preserved activity, with an overall resistance rate of 17.5% (Table 2).

Antibiotic resistance stratified by age group demonstrated a progressive increase in resistance with advancing age ($p = 0.026$). Patients aged 61-85 years exhibited the highest resistance rates across multiple antibiotics, including ampicillin, nalidixic acid, ciprofloxacin, and nitrofurantoin, whereas carbapenem resistance remained low across all age groups (Table 3).

Comparison of resistance patterns by antibiotic class revealed high resistance to β-lactams, fluoroquinolones, and trimethoprim/sulfonamides, whereas carbapenems and nitrofurantoin demonstrated the lowest overall resistance rates (Table 4).

Species-level resistance was evaluated by calculating the average resistance rate for each bacterial species, defined as the mean proportion of tested antibiotics to which isolates were resistant. Among Gram-positive organisms, Staphylococcus haemolyticus demonstrated the highest

Table 1.
Prevalence of bacterial strains and their resistance rate.

Bacteria	Count	Resistance rate (%)
Escherichia coli	226	44.7
Staphylococcus haemolyticus	65	68.4
Enterococcus faecalis	55	33.9
Klebsiella pneumoniae	55	51.2
Proteus mirabilis	15	47.5
Pseudomonas aeruginosa	10	49.6
Acinetobacter baumannii	8	58.1
Burkholderia cepacia	4	55.3
Corynebacterium urealyticum	4	37
Staphylococcus aureus	3	62.8

Table 2.
Antibiotic resistance rates for all isolates.

Antibiotic	Resistance rate (%)
Ampicillin	71.3
Trimethoprim	64.7
Nalidixic Acid	62.8
Ceftriaxone	58.9
Cefdinir	58
Cefotaxime	55.9
Cefazolin	54.6
Cefixime	52.9
Ciprofloxacin	45.9
Amoxicillin-Clavulanate	42.1
Fosfomycin	41.1
Norfloxacin	39.6
Levofloxacin	39.4
Cefepime	38.8
Tobramycin	34.3
Gentamicin	25.9
Nitrofurantoin	17.5
Piperacillin-Tazobactam	10.1
Colistin	9.5
Imipenem	4
Meropenem	2.4

Table 3.
Antibiotic resistance by age group.

Antibiotics	0-18	19-40	41-60	61-85
Amoxicillin-Clavulanate	36.84	36.94	46.99	48.19
Ampicillin	79.03	61.86	75	77.78
Cefazolin	52.83	43.02	55.74	78.57
Ciprofloxacin	32.84	37.89	52.43	57.84
Nalidixic Acid	45.95	54.67	72.73	74.14
Fosfomycin	61.7	40.78	33.78	35
Imipenem	3.64	1.65	3.23	8
Meropenem	1.79	0.95	0	6.74
Nitrofurantoin	20	11.73	15.79	25.94

Table 4.
Antibiotic effectiveness according to their classes.

Drug class	Example agent	Average resistance
Carbapenems	Meropenem, Imipenem	2-4
Nitrofurantoin	Nitrofurantoin	9
Fosfomycin	Fosfomycin	41
Beta-lactams (Non-ESBL)	Amoxicillin-Clavulanate, Ampicillin, Cefazolin	60-80
Cephalosporin (3rd generation)	Ceftriaxone, Cefotaxime	65-70
Fluoroquinolones	Ciprofloxacin, Nalidixic acid	60-70
Trimethoprim/Sulfonamides	Trimethoprim, TMP-SMX	65

Table 5.
Antibiotic effectiveness according to their classes.

Bacterial species	% of total isolates	Average resistance (%)
Staphylococcus haemolyticus	12.8	68.4
Enterococcus faecalis	10.8	33.9
Corynebacterium urealyticum	0.8	55.3
Staphylococcus aureus	0.6	62.8

Table 6.
Antimicrobial susceptibility profile of common gram-negative bacteria isolated from urinary tract infection.

Bacterial species	% of total isolates	Average resistance (%)
Escherichia coli	44.4	44.7
Klebsiella pneumoniae	10.8	51.2
Proteus mirabilis	2.9	47.5
Pseudomonas aeruginosa	2	49.6
Acinobacter baumannii	1.6	58.1
Burkholderia cepacia	0.8	55.3

Table 7.
Multidrug resistance (MDR) levels in common bacterial isolates.

Species	% of MDR ≥ 3 classes	% MDR ≥ 5 classes
Escherichia coli	64.4	19.1
Staphylococcus haemolyticus	60	12.3
Enterococcus faecalis	32.7	0
Klebsiella pneumoniae	56.4	34.5

average resistance rate (68.4%), while E. faecalis showed a substantially lower resistance burden (33.9%) (Table 5). Among Gram-negative bacteria, Klebsiella pneumoniae exhibited a higher average resistance rate (51.2%) compared with E. coli (44.7%). Non-fermenting organisms, including Pseudomonas aeruginosa and Acinetobacter baumannii, demonstrated the highest overall resistance profiles among Gram-negative isolates (Table 6).

Analysis of multidrug resistance patterns revealed that more than half of all isolates were resistant to three or more antibiotic classes. High rates of multidrug resistance (MDR ≥ 3 classes) were observed in E. coli (64.4%), Staphylococcus haemolyticus (60.0%), and Klebsiella pneumoniae (56.4%), while high-level MDR (≥ 5 classes) was most frequently observed in K. pneumoniae (34.5%) (Table 7).

The overall resistance was higher among male patients compared with females (p = 0.001). Among patients with comorbidities, diabetes mellitus (p = 0.0035), renal insufficiency (p = 0.041), and hypertension (p = 0.033) were significantly associated with increased resistance load,

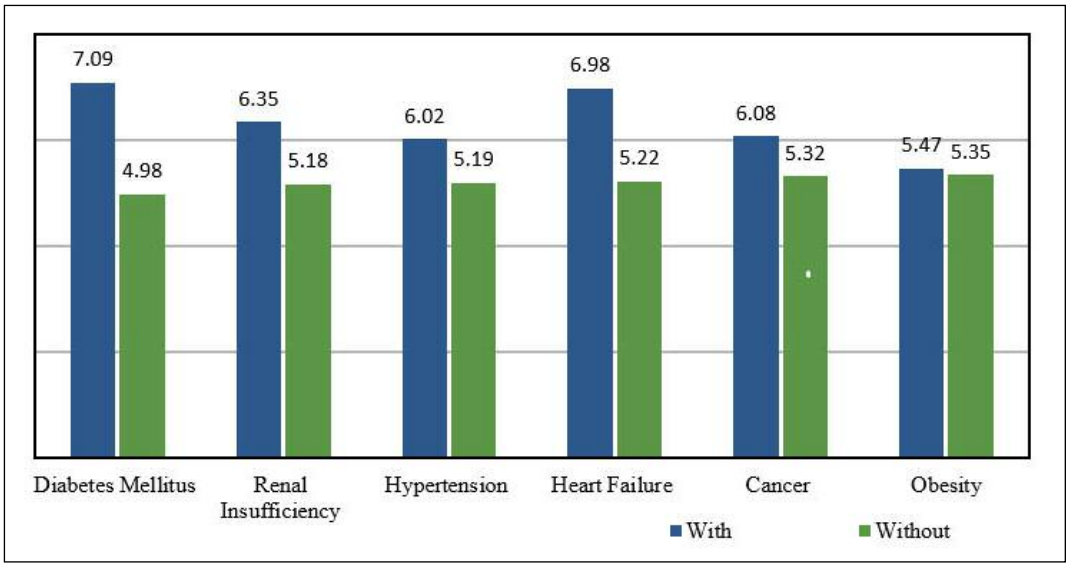

Figure 1. *Comparison of average number of resistant strains with risk factors.*

whereas no significant associations were observed for heart failure, malignancy, or obesity (Figure 1).

Discussion

This research offers significant insights into the trends of antibiotic resistance in community-acquired UTIs. It constitutes one of the most thorough regional evaluations to date and serves as a crucial reference for formulating local antibiotic stewardship programs and empirical treatment procedures.

The majority of cases were female, aligning with global epidemiological statistics that demonstrate a significantly greater prevalence of UTIs in women, attributable to shorter urethral length, proximity to the perineum, and hormonal effects on mucosal immunity (2, 5). The observed gender predominance in several worldwide research studies underscores the necessity of prioritizing preventative interventions, public education, and hygiene awareness for women, especially those with recurring infections.

From a public health standpoint, these findings highlight the significance of localized surveillance systems in informing antibiotic policies and clinical management strategies. This study establishes baseline resistance data for the population, providing the necessary information for developing region-specific empirical therapy guidelines to combat the increasing challenge of antimicrobial resistance in Iraq.

E. coli was recognized as the predominant uropathogen, consistent with its reported global prevalence in community-acquired urinary tract infections (2, 5). The detected resistance in E. coli highlights increasing difficulties in managing community infections with conventional first-line treatments. Elevated resistance to ampicillin, trimethoprim, and nalidixic acid emphasizes the diminishing effectiveness of these frequently administered antibiotics.

In addition to E. coli, several commonly isolated bacteria, including Klebsiella pneumoniae and Staphylococcus haemolyticus, have shown significant multidrug resistance, rendering them major factors in the failure of empirical UTI treatment. The data indicate that both Gram-negative and Gram-positive bacteria are significantly contributing to resistance within the community, highlighting the necessity for regular regional surveillance and enhanced antibiotic stewardship programs to maintain the efficacy of empirical therapy over time.

The significant resistance noted to β-lactam antibiotics in E. coli and Klebsiella pneumoniae isolates in this investigation strongly indicates the existence of *extended-spectrum β-lactamase* (ESBL)-producing bacteria. Resistance to β-lactams and cephalosporins indicates the declining effectiveness of these drugs in the empirical management of urinary tract infections. These findings underscore the therapeutic significance of identifying ESBL producers in community environments, as they can inactivate the majority of β-lactam antibiotics, including penicillins and cephalosporins. Notwithstanding this, almost all ESBL-suspected isolates showed significant susceptibility to carbapenems, hence affirming the ongoing efficacy of this class for complex infections.

This pattern highlights an immediate necessity to reassess local antibiotic prescribing practices, restrict unwarranted use of broad-spectrum β-lactams, and adopt revised empirical treatment guidelines aligned with the microbiological profile of Sulaimani. Enhancing antimicrobial stewardship, together with consistent laboratory monitoring of ESBL prevalence, is essential to avert the continued spread of these resistant bacteria.

A statistically significant correlation was seen between patient age and antibiotic resistance, with resistance levels markedly rising in older people ($p = 0.026$). This discovery corresponds with earlier global studies indicating that increasing age correlates with elevated rates of multidrug-resistant illnesses (7, 8). The increased resistance noted in older individuals can be ascribed to various age-related variables, such as recurrent antibiotic exposure, chronic comorbidities, frequent healthcare interactions, and immunological deterioration, all of which facilitate the selection and survival of resistant microorganisms.

From a clinical perspective, these findings underscore the necessity of factoring in patient age when determining

empirical therapy. Older persons may necessitate more extensive initial coverage or culture-guided treatment modifications, but younger, otherwise healthy individuals can frequently be treated with narrower-spectrum antibiotics. Integrating age-related resistance patterns into empirical treatment guidelines will improve therapeutic accuracy and minimize unnecessary antibiotic utilization in this population.

A notable disparity in antibiotic resistance was detected between male and female patients. Resistance was much greater in males than in females ($p < 0.001$). This disparity signifies that urine pathogens obtained from male patients exhibited, on average, resistance to a higher quantity of antibiotics. This gap may be attributed to biological and clinical reasons, such as the higher incidence of severe UTIs in males, delayed healthcare seeking, and increased past antibiotic exposure. Moreover, anatomical disparities and the increased probability of structural or functional urinary anomalies in men may influence these resistance patterns (9, 10).

These findings underscore the significance of factoring in patient gender when establishing empirical therapy. Broader-spectrum antibiotics or early culture testing may be more suitable for males, while empirical administration of first-line drugs may be reasonable for otherwise healthy females with simple infections.

A notable correlation was identified between antibiotic resistance and specific comorbidities, especially diabetes mellitus and renal insufficiency ($p = 0.0035$ and $p = 0.041$, respectively). The findings align with global research suggesting that metabolic and renal dysfunctions heighten vulnerability to multidrug-resistant infections (10, 12-14). The fundamental mechanisms probably involve modified antibiotic pharmacokinetics, compromised immune responses, and recurrent healthcare exposure, all of which facilitate the colonization and maintenance of resistant microbes.

Conversely, other concomitant conditions – such as hypertension, heart failure, cancer, and obesity – did not have statistically significant impacts on overall resistance levels. It is crucial to acknowledge the impact of diabetes and renal impairment while determining empiric therapy and antibiotic dosage. High-risk patients may benefit from expanded initial coverage and more rigorous culture-based monitoring to avert treatment failure and the emergence of resistant strains.

This study from Sulaimani City, Iraq, highlights the critical necessity for focused antibiotic stewardship and region-specific treatment strategies to address the escalating issue of antimicrobial resistance in community-acquired urinary tract infections. The results unequivocally indicate that both Gram-negative and Gram-positive uropathogens significantly contribute to resistance, with particularly elevated levels observed in Staphylococcus haemolyticus, Klebsiella pneumoniae, and E. coli.

Moreover, resistance was significantly affected by patient demographics, particularly advanced age and male sex, in addition to clinical comorbidities such as diabetes and renal insufficiency.

Incorporating these aspects into treatment decision-making is crucial for enhancing clinical outcomes and mitigating the further spread of resistance. The data produced from this study establish a solid evidence base for regional empirical treatment guidelines, highlighting the sustained efficacy of carbapenems and nitrofurantoin while indicating the restricted value of first-line β-lactams and fluoroquinolones. Continuous monitoring, clinician training, and public awareness initiatives are essential elements of a thorough stewardship framework that can maintain antibiotic effectiveness and protect community health in the Kurdistan Region and beyond (15-20).

Conclusions

This study demonstrates significant antimicrobial resistance among key uropathogens causing community-acquired UTIs in Sulaimani, with limited effectiveness of commonly used oral antibiotics. Carbapenems and nitrofurantoin remain the most reliable options, while resistance is notably higher in older adults, males, and patients with diabetes or renal impairment. Despite its limitations, the study provides valuable local data to guide empirical therapy and underscores the need for continued resistance surveillance and strengthened antimicrobial stewardship.

Declarations

Ethical approval and consent for participate: *This study was conducted in accordance with international ethical standards, including the principles of the 2008 Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the College of Medicine, University of Sulaimani, Iraq (Approval No. 58). Confidentiality of all participants was strictly maintained, and verbal informed consent was obtained from every patient prior to inclusion in the study.*

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Use of Artificial Intelligence Tools: *Artificial intelligence assistance (ChatGPT, OpenAI, 2025 version) was utilized for language refinement, data interpretation support, and structural editing of the manuscript. All interpretations and final conclusions were verified independently by the authors to ensure accuracy and scientific integrity.*

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