



Frequency of Bacterial Etiological Factors and Antibiotic Resistance of Infections Caused by Urinary Catheters in Patients in Khorramabad City: A Retrospective Study

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Abstract

Background: The use of urinary catheters is considered one of the most significant factors contributing to urinary tract infections (UTIs), particularly when catheters are used for prolonged periods. Understanding the patterns of catheter-related UTIs and the associated antibiotic resistance is crucial for effective prevention and treatment.

Objectives: This study aimed to investigate the prevalence of bacterial causes and antibiotic resistance in catheter-associated UTIs among patients hospitalized in Khorramabad teaching hospitals during 2022 - 2023.

Methods: This retrospective study analyzed patient records of individuals with urinary catheters in Khorramabad teaching hospitals. A researcher-designed checklist collected data on patient demographics (age and sex), medical history, length of hospital stay, hospital department, bacterial pathogens identified from cultures, and antibiotic resistance profiles. Data analysis was performed using Stata version 16.

Results: The most frequently isolated pathogens in catheter-associated UTIs were *Escherichia coli* (41.20%), *Staphylococcus saprophyticus* (20.80%), and *Klebsiella pneumoniae* (18.40%). Among antibiotics, amoxicillin (59.2%) and ampicillin (53.6%) showed the highest rates of resistance, while imipenem (11.6%) and amikacin (17.6%) exhibited the lowest resistance rates. A statistically significant correlation ($P < 0.05$) was observed between antibiotic resistance to amoxicillin, ampicillin, and imipenem and a history of prior antibiotic use.

Conclusions: The findings suggest that amikacin and imipenem are effective options for initiating empirical therapy for catheter-associated UTIs until antibiogram results become available. Given the importance of emerging antibiotic resistance and the evolving susceptibility patterns of bacterial pathogens, performing antibiogram testing is essential for optimizing treatment outcomes in these infections.

Keywords: Urinary Tract Infections, Urinary Catheterization, Antibacterial Drug Resistance, Antibacterial Agents

1. Background

Urinary tract infections (UTIs) affect over 150 million individuals worldwide annually, making them one of the most prevalent illnesses globally and a significant challenge for healthcare systems (1). Healthcare-associated infections (HAIs) represent a major global health concern, arising from various factors such as

substandard hospital conditions and the use of invasive medical equipment like catheters and probes. Among these, catheter-related infections (CRIs) are particularly common and are associated with increased healthcare costs, prolonged hospital stays, and heightened morbidity and mortality (2, 3). Approximately 15 - 25% of hospitalized patients require urinary catheters (UCs). These devices are utilized in patients with surgical needs or mobility issues to manage urine drainage, urinary

retention, or urinary incontinence, and are used for both male and female patients (4, 5).

According to the centers for disease control and prevention (CDC), catheter-associated urinary tract infections account for approximately 13,000 deaths annually in the United States and contribute to 75% of hospital-acquired infections (6). Studies indicate that 32.2% of HAIs in intensive care units (ICUs) are UTIs, with nearly 80% linked to urinary catheters. This high prevalence is primarily due to the extensive use of catheters in critically ill patients (7-9). A study conducted in Kermanshah reported an incidence of hospital-acquired urinary tract infections (HAUTIs) of approximately 4.5% among ICU patients, with notable variations across hospital wards (10).

Indwelling urinary catheters are the leading cause of catheter-associated UTIs (CAUTIs). The risk of infection increases by 3 - 7% for each day a patient remains catheterized. According to the National Healthcare Safety Network (NHSN) and the CDC, a UTI is defined as an infection caused by a urinary catheter left in place for more than two consecutive days. To meet this definition, the patient must also exhibit at least one of the following symptoms: Fever ($\geq 38.0^{\circ}\text{C}$), suprapubic tenderness, or costovertebral angle pain or soreness (6, 11). The majority of bacteria isolated in CAUTIs are gram-negative bacteria (GNB), including *Escherichia coli*, *Klebsiella* species (e.g., *K. aerogenes*), *Proteus mirabilis*, and *Pseudomonas aeruginosa*. Gram-positive bacteria (GPB), such as *Staphylococcus aureus* and *Enterococcus* species, are also significant pathogens (12-14).

For most CAUTI infections, the patient's own gut microbiota serves as the reservoir for pathogens like *E. coli* and *Klebsiella* spp., while multi-drug-resistant (MDR) strains are often acquired from external sources (15, 16). These superbugs are occasionally transmitted as nosocomial infections, particularly in ICU settings (17). Common antibiotics are typically used to treat UTIs; however, if these infections are not identified and treated promptly, serious complications may arise. These include high blood pressure, kidney failure, uremia, premature birth, and miscarriage in pregnant women. The improper use of antimicrobial medications in treating UTIs has contributed to the spread of antibiotic resistance and the emergence of MDR uropathogens.

Given the shift in the causes of UTIs and the increasing resistance of uropathogens to antibiotics, it is crucial to determine the causative pathogens and conduct drug sensitivity testing. These steps are essential for the effective treatment of UTI patients and have been shown to reduce mortality rates and overall

hospital expenses (18). In most cases, treatment is initiated empirically, as sensitivity and resistance reports typically require at least two days. Therefore, understanding the antibiotic resistance patterns of uropathogenic bacteria is highly beneficial for guiding empirical treatment. Importantly, the pattern of antibiotic resistance varies over time and across regions, making ongoing research on these patterns critical for the effective management of UTI-related infections (19).

2. Objectives

The present study aimed to investigate the frequency of bacterial etiological factors and the antibiotic resistance of infections associated with urinary catheters in patients hospitalized in Khorramabad teaching hospitals during 2022 - 2023.

3. Methods

3.1. Study Design and Data Collection

This retrospective study was conducted on patient records of individuals with urinary catheters admitted to Khorramabad teaching hospitals in 2022 - 2023. The researchers used the census method to examine the patients according to the following criteria: Inclusion criteria: Patients with urinary catheters admitted to Khorramabad teaching hospitals in 2022 who had urine cultures available. Exclusion criteria: (1) Patients with a history of urinary infections before catheter insertion; (2) Immunocompromised patients; (3) individuals under 18 years of age; (4) clinical records missing urine culture results; (5) outpatients, (6) repeat clients or patients. After applying these criteria, 250 individuals were included in the study.

The researchers collected data using a researcher-designed checklist that included information extracted from patient medical records, such as: (1) Demographics: Age and sex; (2) medical history: Previous diseases and conditions; (3) hospitalization details: Number of days hospitalized and the department of admission; (4) microbiological findings: Types of bacteria reported from urine cultures and antibiotic resistance results; (5) clinical details: Antibiotic regimens derived from bacterial culture results and the presence or absence of urinary symptoms.

3.2. Isolation

Between March 2022 and March 2023, records of 250 patients with urinary catheters hospitalized in teaching hospitals in Khorramabad were reviewed. These patients

had urine cultures available for analysis. Midstream urine samples were collected using sterile plastic containers to ensure contamination-free sampling. The collected samples were promptly processed using various laboratory methods, including Gram staining, microbial culture, and antibiotic susceptibility testing.

3.3. Identification of Bacteria

The identification of catheter-associated urinary tract infections (CAUTIs) involved three main laboratory steps:

3.3.1. Sample Collection

A sterile urine sample was collected directly from the catheter to prevent contamination and ensure the accuracy of microbial analysis.

3.3.2. Microbial Culture

The collected samples were cultured on MacConkey agar and blood agar. These media allowed for the identification of bacterial species and differentiation between gram-susceptible and gram-resistant bacteria.

3.3.3. Microscopic Analysis

The urine samples were examined under a microscope to detect the presence of bacteria and white blood cells, confirming infection and providing additional diagnostic information.

3.4. Antibiotic Susceptibility

The antibiotic susceptibility of the isolates was assessed using the Kirby-Bauer disk diffusion method. For this procedure, Müller-Hinton agar plates were prepared, inoculated with the bacterial isolates, and incubated at 37°C for 24 hours. The zones of bacterial inhibition around the antibiotic disks were measured according to the clinical and laboratory standards institute (CLSI) 2013 guidelines. Intermediate susceptibility was classified as resistant for analytical purposes.

Sensitivity testing was conducted on both gram-negative and gram-positive bacterial isolates using 11 antibiotics commonly prescribed for catheter-associated UTIs. These antibiotics included: Ampicillin (30 µg), amoxicillin (25 µg), cefotaxime (30 µg), ceftazidime (30 µg), ceftriaxone (30 µg), imipenem (10 µg), amikacin (30 µg), gentamycin (30 µg), ciprofloxacin (10 µg), nalidixic acid (30 µg), kanamycin (30 µg).

3.5. Statistical Analysis

Data were analyzed using Stata version 16 statistical software. Descriptive statistics, including mean and standard deviation, were calculated for quantitative variables, while frequency and percentage were reported for qualitative variables. Chi-square tests and independent *t*-tests were used to assess associations between variables. Additionally, multivariable logistic regression analysis was performed to examine the relationships between different variables and the prevalence of infections and antibiotic resistance. A significance level of 0.05 was considered for all statistical analyses.

4. Results

4.1. Demographic and Clinical Information of Patients

The average age of the patients in this study was 53.60 ± 10.86 years, with 51.87 ± 12.01 years for men and 54.52 ± 10.12 years for women. The results also indicated that the average duration of hospitalization was 6.32 ± 1.98 days, with 6.20 ± 2.0 days for men and 6.38 ± 1.97 days for women. In terms of gender distribution, 65.20% of the study population were female. Regarding marital status, 81.20% of the patients were married, while 18.80% were single. Clinical records revealed that 18.40% (46 patients) had a positive history of underlying diseases, and 96.40% (241 patients) had a positive history of antibiotic use. The highest proportion of patients, 24.80% (62 patients), were hospitalized in the internal medicine department. Further details on the frequency distribution of clinical characteristics and inpatient department information are summarized in [Table 1](#).

4.2. Identification Bacteria

The results revealed that the most frequently reported pathogen was *E. coli* (41.20%), followed by *Staphylococcus saprophyticus* (20.80%) and *Klebsiella pneumoniae* (18.40%). The pathogens with the lowest frequency were *Citrobacter* and *P. mirabilis*, each accounting for 2% of cases ([Figure 1](#)).

4.3. Antibiotic resistance rate

The results of the study showed that the highest antibiotic resistance was reported to amoxicillin and ampicillin in the studied patients (59.2% and 53.6%, respectively). Also, the lowest antibiotic resistance was reported in the studied patients, respectively, compared to imipenem (11.6%) and then amikacin (17.6%). Other information is given in [Figure 2](#). A chi-square test has been used to check the status of antibiotic resistance according to age and gender. The results of [Table 2](#)

Table 1. Frequency Distribution of Demographic Characteristics of the Studied Patients

Variables and Category	Frequency (%)
Gender	
Male	87 (34.80)
Female	163 (65.20)
Married status	
Married	203 (81.20)
Unmarried	47 (18.80)
History of underlying disease	
Yes	46 (18.40)
No	204 (81.60)
Previous history of antibiotic use	
Yes	241 (96.40)
No	9 (3.60)
Inpatient department	
Emergency	49 (19.60)
Internal	62 (24.80)
Surgery	39 (15.60)
Women	24 (9.60)
Poisoning	1 (0.40)
General	21 (8.40)
Infectious	54 (21.60)
Urinary symptoms	
Yes	216 (86.40)
No	34 (13.60)

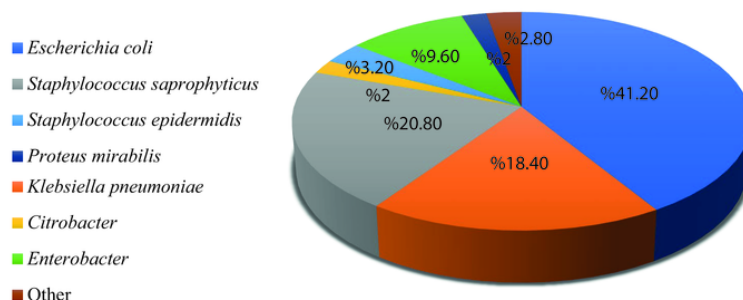


Figure 1. Frequency distribution of the types of pathogens reported from the urine cultures of the studied patients

showed that in people less than 50 years old, the highest resistance was shown by amoxicillin with 71.11% (64 patients) and ampicillin with 68.89% (62 patients). Also, in these people, the lowest antibiotic resistance was observed in Imipenem with 16.67% (15 patients) and amikacin with 24.44% (22 patients). Also, the results showed that people over 50 years old, amoxicillin (52.50%) and ampicillin (45%) showed the highest resistance. Also, in these people, the lowest antibiotic

resistance was observed with imipenem (8.75%) and amikacin with 13.75%. The chi-square test showed that there was no statistically significant relationship between the antibiotic resistance of the studied antibiotics and the age of the patients ($P > 0.05$). Other information is given in Table 2. Based on the results of Table 2, the highest resistance to amoxicillin and ampicillin was observed in women and men, respectively. Also, these people showed the least

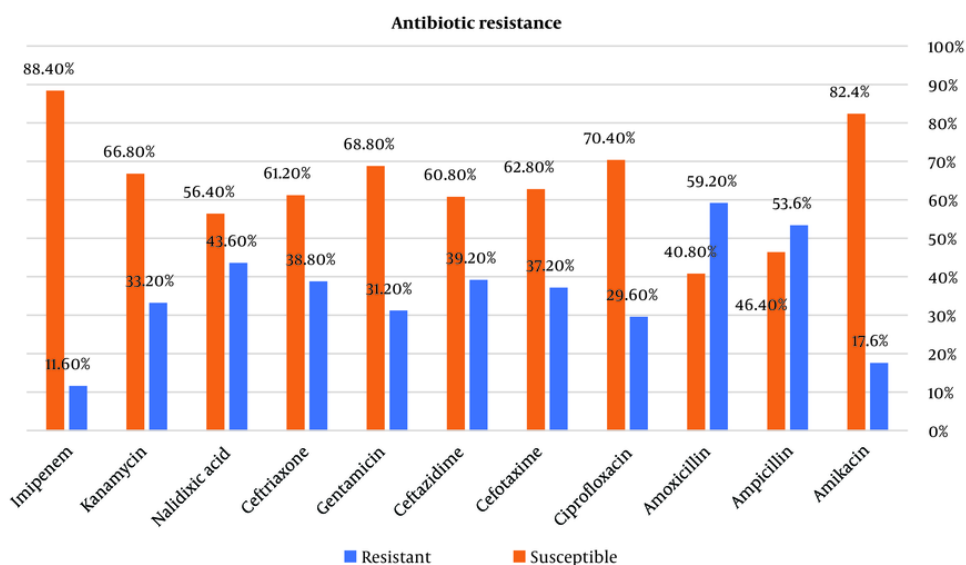


Figure 2. Frequency distribution of antibiotic resistance reported from the urine cultures of the studied patients

resistance to Imipenem and amikacin. According to $P > 0.05$, there was no statistically significant relationship between antibiotic resistance, the ratio of antibiotic types, and the gender of patients.

The results of [Figure 3](#) show that married people showed the highest resistance to amoxicillin and ampicillin with 58.62% and 50.25%, respectively. Also, in single people, ampicillin (68.09%) and amoxicillin (61.70%) showed the highest antibiotic resistance. Based on the chi-square test, no significant relationship was found between marital status and antibiotic resistance ($P > 0.05$). A chi-square test was used to investigate the relationship between antibiotic resistance and antibiotic consumption. The results of the test showed that 59.75% of people who had a history of antibiotic use showed resistance to amoxicillin and 53.53% to ampicillin.

There was a statistically significant relationship between antibiotic resistance to ampicillin and amoxicillin and a previous history of antibiotic use in the patients of the study population ($P < 0.05$). Also, the lowest antibiotic resistance with a previous history of antibiotic use was observed in imipenem with 11.20% and amikacin with 17.43%, and there was a statistically significant relationship between antibiotic resistance to imipenem and previous history of antibiotic use ($P < 0.05$). Other details related to antibiotic resistance in the studied population with a previous history of antibiotic

use can be seen in [Table 3](#). According to the results of [Table 3](#), in people with urinary symptoms, 55.56% (120 people) had resistance to ampicillin, and 59.72% (129 people) had resistance to amoxicillin. Also, 12.50% (27 people) had resistance to imipenem. Based on the chi-square test, there was no statistically significant association between antibiotic resistance and urinary symptoms ($P > 0.05$).

5. Discussion

Considering that many studies have not been conducted to evaluate the results of antibiotic resistance treatment in pathogens in the western region of Iran, the present study was conducted with the aim of investigating the frequency of bacterial etiological factors and antibiotic resistance of infections caused by urinary catheters in patients hospitalized in Khorramabad teaching hospitals in 2022 - 2023. Gender is one of the factors that influence urinary tract infections, according to several studies (20). Similar to the findings of the Mohammadi et al. study (21), women were more likely than men to have urinary infections (65.20%). The majority of the bacteria in the study by Shirvani et al. (22) were also isolated from samples provided by women. The urethra's short length, its close proximity to the anus and vagina, and the warm, humid environment of the perineum may be contributing factors to the rise in infections among women (23, 24).

Table 2. Consensus Table of the Frequency of Antibiotic Resistance Based on Age and Gender in the Studied Patients ^a

Antibiotic Resistance	Age (y)		P-Value ^b	Gender		P-Value ^b
	< 50	> 50		Male	Female	
Amikacin			0.053			0.133
Resistant	22 (24.44)	22 (13.75)		11 (12.64)	33 (20.25)	
Susceptible	68 (75.56)	138 (86.25)		76 (87.36)	130 (79.75)	
Ampicillin			0.098			0.866
Resistant	62 (68.89)	72 (45)		46 (52.87)	88 (53.99)	
Susceptible	28 (31.11)	88 (55)		41 (47.13)	75 (46.01)	
Amoxicillin			0.056			0.686
Resistant	64 (71.11)	84 (52.50)		53 (60.92)	95 (58.28)	
Susceptible	26 (28.89)	76 (47.50)		34 (39.08)	68 (41.72)	
Ciprofloxacin			0.066			0.217
Resistant	33 (36.67)	41 (25.63)		30 (34.48)	44 (26.99)	
Susceptible	57 (63.33)	119 (74.38)		57 (65.52)	119 (73.01)	
Cefotaxime			0.132			0.861
Resistant	39 (43.33)	54 (33.74)		33 (37.93)	60 (36.81)	
Susceptible	51 (56.67)	106 (66.25)		54 (62.07)	103 (63.19)	
Ceftazidime			0.070			0.606
Resistant	42 (46.67)	56 (35)		36 (41.38)	62 (38.04)	
Susceptible	48 (53.33)	104 (65)		51 (58.62)	101 (61.96)	
Gentamicin			0.585			0.595
Resistant	30 (33.33)	48 (30)		29 (33.33)	49 (30.06)	
Susceptible	60 (66.67)	112 (70)		58 (66.67)	114 (69.94)	
Ceftriaxone			0.056			0.735
Resistant	42 (46.67)	55 (34.38)		35 (40.23)	62 (38.04)	
Susceptible	48 (53.33)	105 (65.63)		52 (59.77)	101 (61.96)	
Nalidixic Acid			0.640			0.175
Resistant	41 (45.56)	68 (42.50)		43 (49.43)	66 (40.49)	
Susceptible	49 (54.44)	92 (57.50)		44 (50.57)	97 (59.51)	
Kanamycin			0.383			0.595
Resistant	33 (36.67)	50 (31.25)		27 (31.03)	56 (34.36)	
Susceptible	57 (63.33)	110 (68.75)		60 (68.97)	107 (65.64)	
Imipenem			0.061			0.970
Resistant	15 (16.67)	14 (8.75)		10 (11.49)	19 (11.66)	
Susceptible	75 (83.33)	146 (91.25)		77 (88.51)	144 (88.34)	

^a Values are presented as No. (%).

^b Chi-square test.

In the present study, the most common urinary pathogens in people were *E. coli* (41.20%), *S. saprophyticus* (20.80%), and *K. pneumoniae* (18.40%).

In studies conducted in other parts of Iran and the world, this microorganism is known as the most common cause of urinary tract infection. The prevalence of this bacterium in the study of Mohammed et al. (25), which was conducted on 117 samples in Bahrain, was 49.06%. In the study of Mohammed et al. in 2022, which was conducted on 773 samples in Somalia, *E. coli* was the most common pathogen (26.3%) (1). A study

by Aktaş and Denkaş was conducted in 2020 with the aim of investigating the results of urine culture and antibiotic sensitivity of *E. coli* isolates in Turkey. *E. coli* accounted for 48% of the strains in this study, with *Enterococcus* coming in at 9%, *Staphylococcus coagulase-negative* at 8.3%, and *Klebsiella* at 7.6% (26).

Escherichia coli accounted for 50.6% of the organisms in the Tavanaee Sani and Mehrafarid study conducted in Mashhad. The most frequently occurring organisms were *Candida albicans*, *Pseudomonas aeruginosa*, and *K. pneumoniae*. *Enterococcus* was the most prevalent Gram-

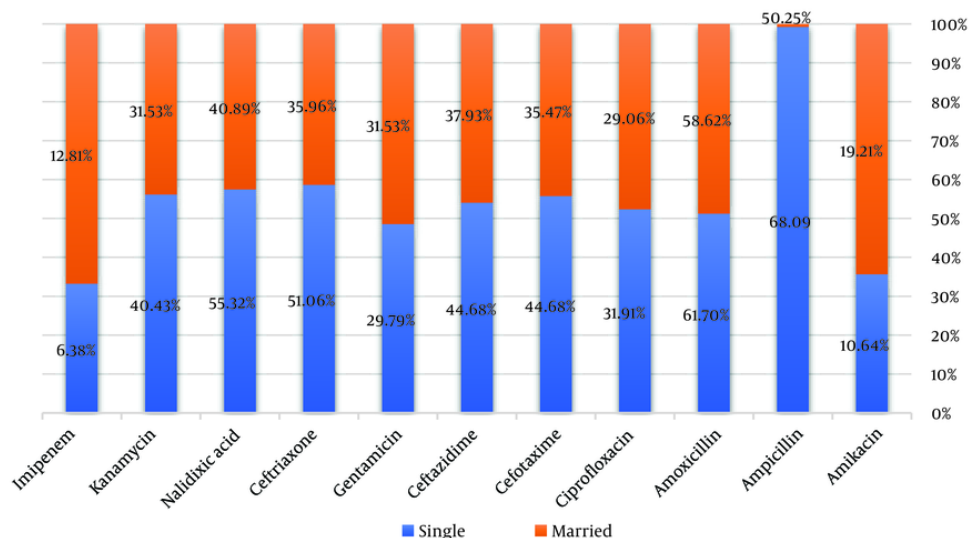


Figure 3. Consensus table of the frequency of antibiotic resistance based on married status in the studied patients

positive organism (27). According to a study conducted in 2020 in Mashhad by Vakilzadeh et al., the most prevalent urinary pathogens in individuals with positive cultures were *E. coli* (60.9%), *K. pneumoniae* (13.9%), and *Enterococcus* (28). The findings of the aforementioned studies demonstrate that urinary pathogen prevalence varies over time and across geographical locations. However, one thing is certain: *E. coli* is the most frequent cause of UTIs in the general population. The prevalence of other pathogens varies amongst studies.

Regardless of the bacterial strains, amoxicillin (59.2%) and ampicillin (53.6%) showed the highest resistance to UTI agents in both sexes in this study, and the findings are consistent with those of Baghani Aval et al. studies in Sabzevar (19) and Abedi et al. in Quemshar (29). Osman (30) also carried out a study in Erbil, Iraq, to look into antibiotic resistance in bacteria that were isolated from urine samples of patients who had urinary tract infections. In the above study, the highest resistance to ampicillin, aztreonam, cefazolin, clindamycin, and tetracycline antibiotics was observed, which was consistent with the findings of the present study in terms of ampicillin resistance (30).

The study's findings about other antibiotics did not agree with ours, and this discrepancy might have been brought about by using different resistance assessment instruments and looking at a different number of antibiotics. For instance, the current study did not look

into resistance to clindamycin, tetracycline, cefazolin, or aztreonam. In this study, the lowest rate of resistance in men and women was related to imipenem (11.6%) and then amikacin (17.6%). The results of the present study were consistent with the results of the study by Mohammadi et al. in Sanandaj (21). Similarly, in the study conducted by Safdari and Ghazvini in Mashhad (31) and the study conducted by Abdollahi and Mehr Azma (32) in Imam Khomeini Hospital, Tehran, the least resistance to imipenem and amikacin was reported. In the Tavanaee Sani and Mehrafarid study in Mashhad, the highest level of sensitivity to the antibiotic amikacin was observed (27).

In the study of Aktaş and Denктаş in 2020, the most effective antibiotics for Harvey *E. coli* included imipenem, meropenem, ertapenem, and amikacin. In terms of sensitivity to imipenem and amikacin, these two studies were consistent. However, in the present study, sensitivity to ciprofloxacin and gentamicin was also high, which was not reported in the above study (26). Considering these similarities regarding the lowest antibiotic resistance compared to amikacin and imipenem, and considering the same drug prescription pattern in different parts of the country, these two drugs can be proposed as the first line of empirical treatment for urinary tract infection. However, among the limitations of using these two drugs, the following can be mentioned: Amikacin may cause decreased kidney function, tinnitus, vertigo, and hearing loss in cases of

Table 3. Consensus Table of the Frequency of Antibiotic Resistance Based on the History of Antibiotic Use in the Studied Patients ^a

Antibiotic Resistance	Antibiotic Use		P-Value ^b	Urinary Symptoms		P-Value ^b
	Yes	No		Yes	No	
Amikacin			0.711			0.148
Resistant	42 (17.43)	199 (82.57)		41 (18.98)	175 (81.02)	
Susceptible	2 (22.22)	7 (77.78)		3 (8.82)	31 (91.18)	
Ampicillin			0.048			0.118
Resistant	129 (53.53)	112 (46.47)		120 (55.56)	96 (44.44)	
Susceptible	5 (55.56)	4 (44.44)		14 (41.18)	20 (58.82)	
Amoxicillin			0.009			0.672
Resistant	144 (59.75)	97 (40.25)		129 (59.72)	87 (40.28)	
Susceptible	4 (44.44)	5 (55.56)		19 (55.88)	15 (44.12)	
Ciprofloxacin			0.803			0.058
Resistant	71 (29.46)	170 (70.54)		69 (31.94)	147 (68.06)	
Susceptible	3 (33.33)	6 (66.67)		5 (14.71)	29 (85.29)	
Cefotaxime			0.807			0.312
Resistant	90 (37.34)	151 (62.66)		83 (38.43)	133 (61.57)	
Susceptible	3 (33.33)	6 (66.67)		10 (29.41)	24 (70.59)	
Ceftazidime			0.713			0.102
Resistant	95 (39.42)	146 (60.58)		89 (41.20)	127 (58.80)	
Susceptible	3 (33.33)	6 (66.67)		9 (26.47)	25 (73.53)	
Gentamicin			0.382			0.151
Resistant	74 (30.71)	167 (69.29)		71 (32.87)	145 (67.13)	
Susceptible	4 (44.44)	5 (55.56)		7 (20.59)	27 (79.41)	
Ceftriaxone			0.732			0.407
Resistant	94 (39)	147 (61)		86 (39.81)	130 (60.19)	
Susceptible	3 (33.33)	6 (66.67)		11 (32.35)	23 (67.65)	
Nalidixic Acid			0.959			0.155
Resistant	105 (43.57))	136 (56.43)		98 (45.37)	118 (54.63)	
Susceptible	4 (44.44)	5 (55.56)		11 (32.35)	23 (67.65)	
Kanamycin			0.993			0.198
Resistant	80 (33.20)	161 (66.80)		75 (34.72)	141 (65.28)	
Susceptible	3 (33.33)	6 (66.67)		8 (23.53)	26 (76.47)	
Imipenem			0.006			0.263
Resistant	27 (11.20)	214 (88.80)		27 (12.50)	189 (87.50)	
Susceptible	2 (22.22)	7 (77.78)		2 (5.88)	32 (94.12)	

^a Values are presented as No. (%).

^b Chi-square test.

improper administration (33). Imipenem can also cause kidney dysfunction and convulsions (34). Therefore, during administration, the maximum and minimum concentrations of the drug should be carefully monitored.

In this study, over 95% of patients had recently used antibiotics, and the findings indicated a statistically significant association between prior antibiotic use and resistance to amoxicillin, ampicillin, and imipenem ($P < 0.05$). This issue may explain why the level of antibiotic resistance in various organisms against the studied

antibiotics was high. It might be possible to prevent the increasing rate of drug resistance with better and more appropriate use of antibiotics. Numerous studies in different parts of the world have shown that the cause and resistance pattern of urinary infections have changed (35). Therefore, identifying the bacterial agents that cause urinary infections and using appropriate and effective antibiotics to eliminate them are practical approaches to dealing with these infections and preventing their consequences. A high prevalence of microbial resistance to common drugs increases treatment costs, as the lack of effectiveness of cheaper,

commonly used drugs often necessitates switching to more expensive alternatives (36). This underscores the importance of making informed decisions regarding treatment.

The large variation in antibiotic resistance levels can be attributed to differences in the use of antibiotics for treating the disease in different regions. It is well-known that inappropriate and excessive use of antibiotics leads to bacterial resistance. Reducing the prescription of certain antibiotics can, in turn, reduce resistance. The high rate of bacterial resistance to antibiotics observed in the present study, as well as in other studies conducted in Iran compared to other countries, can likely be attributed to indiscriminate antibiotic prescriptions and self-administration without a doctor's guidance. To address this issue, measures such as performing microscopic urine examinations and urine cultures, prescribing antibiotics properly based on culture and antibiogram results, and periodically conducting similar research in different times and locations to better understand the epidemiology of urinary infections and the resistance and sensitivity levels of microorganisms to various antibiotics should receive greater attention (37, 38).

The limitations of this study included deficiencies in the clinical and laboratory data of some patients. In certain cases, researchers were unable to access complete and accurate information for specific individuals, leading to their exclusion from the study.

5.1. Conclusions

The majority of bacterial isolates common in catheter-associated urinary tract infections suggest that amikacin and imipenem are appropriate options for initiating empirical therapy until antibiogram results are available. Given the importance of emerging antibiotic resistance and the changing susceptibility and resistance patterns of bacteria, performing antibiogram testing is essential for the effective treatment of these infections.

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Footnotes

Authors' Contribution: B. Y. Y. and A. K. R. designed the study, performed the experiments, and analyzed the data. S. T. Gh. and A. K. R. prepared the figures and tables and wrote the manuscript. S. T. Gh. and A. K. R. critically reviewed the manuscript. M. S. collected the samples. All authors have read and approved the final manuscript.

Conflict of Interests Statement: The authors declare that they have no relevant financial or non-financial interests to disclose.

Data Availability: The data and materials of this article are not publicly available due to ethical considerations but can be obtained from the corresponding author upon reasonable request.

Ethical Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was granted by the Ethics Committee of Lorestan University of Medical Sciences (ID: [IR.LUMS.REC.1401.129](https://doi.org/10.1016/j.jiph.2019.09.009)).

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References

1. Mohammed AH, Sheikh Omar NM, Osman MM, Mohamud HA, Eraslan A, Gur M. Antimicrobial resistance and predisposing factors associated with catheter-associated UTI Caused by uropathogens exhibiting multidrug-resistant patterns: A 3-year retrospective study at a tertiary Hospital in Mogadishu, Somalia. *Trop Med Infect Dis.* 2022;**7**(3). [PubMed ID: 35324589]. [PubMed Central ID: PMC8948891]. <https://doi.org/10.3390/tropicalmed7030042>.
2. Dougnon VT, Sintondji K, Koudokpon CH, Houeto M, Agbankpe AJ, Assogba P, et al. Investigating catheter-related infections in Southern Benin Hospitals: Identification, Susceptibility, and resistance genes of involved bacterial strains. *Microorganisms.* 2023;**11**(3). [PubMed ID: 36985192]. [PubMed Central ID: PMC10057255]. <https://doi.org/10.3390/microorganisms11030617>.
3. Forrester JD, Maggio PM, Tennakoon L. Cost of health care-associated infections in the United States. *J Patient Saf.* 2022;**18**(2):e477-9. [PubMed ID: 33881808]. <https://doi.org/10.1097/PTS.0000000000000845>.
4. Al-Qahtani M, Safan A, Jassim G, Abadla S. Efficacy of anti-microbial catheters in preventing catheter associated urinary tract infections in hospitalized patients: A review on recent updates. *J Infect Public Health.* 2019;**12**(6):760-6. [PubMed ID: 31628048]. <https://doi.org/10.1016/j.jiph.2019.09.009>.
5. Singha P, Locklin J, Handa H. A review of the recent advances in antimicrobial coatings for urinary catheters. *Acta Biomater.* 2017;**50**:20-40. [PubMed ID: 27916738]. [PubMed Central ID: PMC5316300]. <https://doi.org/10.1016/j.actbio.2016.11.070>.
6. Obaid NA, Almarzoky Abuhussain S, Mulibari KK, Alshantqi F, Malibari SA, Althobaiti SS, et al. Antimicrobial-resistant pathogens related to catheter-associated urinary tract infections in intensive care units: A multi-center retrospective study in the Western region of Saudi Arabia. *Clin Epidemiol Global Health.* 2023;**21**. <https://doi.org/10.1016/j.cegh.2023.101291>.

7. Zahraei SM, Eshrati B, Masoumi Asl H, Pezeshki Z. Epidemiology of four main nosocomial infections in Iran during March 2007 - March 2008 based on the findings of a routine surveillance system. *Arch Iran Med*. 2012;15(12):764-6. [PubMed ID: 23199249].
8. Scott BN, Roberts DJ, Robertson HL, Kramer AH, Laupland KB, Ousman SS, et al. Incidence, prevalence, and occurrence rate of infection among adults hospitalized after traumatic brain injury: Study protocol for a systematic review and meta-analysis. *Syst Rev*. 2013;2:68. [PubMed ID: 23971513]. [PubMed Central ID: PMC3765722]. <https://doi.org/10.1186/2046-4053-2-68>.
9. Rahimi M, Farhadi K, Babaei H, Soleymani F. Prevention and management catheter-associated urinary tract infection in intensive care unit. *J Nurs Midwifery Sci*. 2019;6(2). https://doi.org/10.4103/jnms.jnms_47_18.
10. Farhadi K, Rahimi M, Shahmohammadi A. The epidemiology of hospital-acquired urinary tract infections in intensive care units in Kermanshah Hospitals (Iran). *J Kermanshah Univ Med Sci*. 2023;27(3). <https://doi.org/10.5812/jkums-137000>.
11. Centers for Disease Control, Prevention. National Healthcare Safety Network (NHSN) patient safety component manual. Atlanta: CDC. 2018.
12. Jayaprakash C, Sumangala Bai M. A study of bacterial pathogens and their antibiotic susceptibility profile from community-acquired and hospital-acquired urinary tract infections. *J Evol Med Dental Sci*. 2016;5(27):1400-4. <https://doi.org/10.14260/jemds/2016/330>.
13. Bagchi I, Jaitly NK, Thombare VR. Microbiological evaluation of catheter associated urinary tract infection in a tertiary care hospital. *Pakistan J Social Res*. 2015;8(2):23-9.
14. Ndomba ALM, Laisser RM, Silago V, Kidenya BR, Mwangi J, Seni J, et al. Urinary tract infections and associated factors among patients with indwelling urinary catheters attending Bugando Medical Centre a Tertiary Hospital in Northwestern Tanzania. *Microorganisms*. 2022;10(2). [PubMed ID: 35208927]. [PubMed Central ID: PMC8879566]. <https://doi.org/10.3390/microorganisms10020473>.
15. Mahabubul Islam Majumder M, Ahmed T, Ahmed S, Rahman Khan A. Microbiology of catheter associated urinary tract infection. *Microbiology of urinary tract infections - microbial agents and predisposing factors*. London, UK: IntechOpen; 2019. <https://doi.org/10.5772/intechopen.80080>.
16. Juhasz J, Ligeti B, Gajdacs M, Makra N, Ostorhazi E, Farkas FB, et al. Colonization dynamics of multidrug-resistant klebsiella pneumoniae are dictated by microbiota-cluster group behavior over individual antibiotic susceptibility: A metataxonomic analysis. *Antibiotics (Basel)*. 2021;10(3). [PubMed ID: 33800048]. [PubMed Central ID: PMC8001907]. <https://doi.org/10.3390/antibiotics10030268>.
17. Sogaard M, Heide-Jorgensen U, Vandenbroucke JP, Schonheyder HC, Vandenbroucke-Grauls C. Risk factors for extended-spectrum beta-lactamase-producing Escherichia coli urinary tract infection in the community in Denmark: A case-control study. *Clin Microbiol Infect*. 2017;23(12):952-60. [PubMed ID: 28377310]. <https://doi.org/10.1016/j.cmi.2017.03.026>.
18. Hosseinabadi B, Ahani AA, Danesh A. [Frequency and antibiotic resistance pattern of uropathogenic bacteria isolated from urine samples in Kalaleh, North-East Iran]. *JMS Thorbat Univ Med Sci*. 2020;8(1):69-0. FA.
19. Baghani Aval H, Ekrami Toroghi M, Haghighi F, Tabarraie Y. [Common bacterial factors of urinary tract infections and determining their antibiotic resistance in hospitalized and out patients referred to the Vase'ee Hospital in Sabzevar in 2016]. *J Shiraz Univ Med Sci*. 2018;35(5). FA.
20. Genovese C, Davinelli S, Mangano K, Tempera G, Nicolosi D, Corsello S, et al. Effects of a new combination of plant extracts plus d-mannose for the management of uncomplicated recurrent urinary tract infections. *J Chemother*. 2018;30(2):107-14. [PubMed ID: 29078739]. <https://doi.org/10.1080/1120009X.2017.1393587>.
21. Mohammadi S, Ramazanadeh R, Zandi S, Rouhi S, Mohammadi B. [Isolation and antibiotic resistance pattern determination of bacteria causing urinary tract infections in patients referred to Sanandaj's Tohid Hospital, 2013-2014]. *Res J Med Sci*. 2015. FA.
22. Shirvani M, Keramati A, Esmaeli M. Evaluating the pattern of antibiotic resistance of urinary tract infection (UTI)-causing bacteria in the urine culture samples of patients in the infectious ward of Imam Khomeini Hospital, Kermanshah, in Iran from 2016-2018. *African J Urolog*. 2023;29(1). <https://doi.org/10.1186/s12301-023-00364-4>.
23. Rezaei MS, Bagheri-Nesami M, Nikkha A. Catheter-related urinary nosocomial infections in intensive care units: An epidemiologic study in North of Iran. *Caspian J Int Med*. 2017;8(2):76. [PubMed ID: 28702145]. [PubMed Central ID: PMC5494040]. <https://doi.org/10.22088/cjim.8.2.76>.
24. Ghanbari F, Khademi F, Saberianpour S, Shahin M, Ghanbari N, Naderi K, et al. An epidemiological study on the prevalence and antibiotic resistance patterns of bacteria isolated from urinary tract infections in central Iran. *Avicenna J Clin Microbiol Infect*. 2017;4(3):42214. <https://doi.org/10.5812/ajcmi.42214>.
25. Mohammed D, Isa HM, Ali MF. Microbial etiology and antibiotic resistance patterns of urinary tract pathogens in hospitalized infants in Bahrain: A tertiary care center experience. *Cureus*. 2022;14(9). e29236. <https://doi.org/10.7759/cureus.29236>.
26. Aktaş O, Denktaş E. Five-year evaluation of the urine culture results and antimicrobial susceptibility profiles of isolated E. coli strains. *Biomed J Sci Technic Res*. 2020;24(2). <https://doi.org/10.26717/bjstr.2020.24.004029>.
27. Tavanaee Sani A, Mehrafarid S. [Epidemiological study of antibiotic resistant community acquired UTI in patients admitted in Imam Reza hospital in Mashhad during 2019-2020]. *Med J Mashhad Univ Med Sci*. 2022;64(6):4039-48. FA.
28. Vakilezadeh MM, Heidari A, Mehri A, Shirazinia M, Sheybani F, Aryan E, et al. Antimicrobial resistance among community-acquired uropathogens in Mashhad, Iran. *J Environ Public Health*. 2020;2020:3439497. [PubMed ID: 33082791]. [PubMed Central ID: PMC7556082]. <https://doi.org/10.1155/2020/3439497>.
29. Abedi Samakoosh M, Aghaei N, Babamahmodi F, Dawodi AR. [Frequency and pattern of urinary pathogens and their antibiotic resistance in patients with urinary tract infection]. *J Mazandaran Univ Med Sci*. 2015;25(131):155-8. FA.
30. Osman AA. Antibiotic resistance of bacteria isolated in urinary tract infections in Erbil City. *Zanco J Pure Applied Sci*. 2019;31(4). <https://doi.org/10.21271/zjpas.31.4.5>.
31. Safdari S, Ghazvini K. [Antibacterial susceptibility patterns among E. coli isolated from urinary tract infections in Ghaem University hospital, Mashhad]. *Zahedan J Res Med Sci*. 2007;9(3). FA.
32. Abdolahi A, Mehr Azma M. Evaluation of antibiotic susceptibility and resistance pattern of urinary tract infections in Imam Khomeini Hospital, Tehran, Iran. *Pars Jahrom Univ Med Sci*. 2009;7(3):59-66. <https://doi.org/10.29252/jjmj.7.3.59>.
33. Medline Plus. *Amikacin Injection*. 2015. Available from: <https://medlineplus.gov/druginfo/meds/a682661.html>.
34. Cerner M. *Imipenem and cilastatin*. 2015. Available from: <http://www.drugs.com/druginfo/imipenem.html>.
35. Linhares I, Raposo T, Rodrigues A, Almeida A. Frequency and antimicrobial resistance patterns of bacteria implicated in community urinary tract infections: A ten-year surveillance study (2000-2009). *BMC Infect Dis*. 2013;13:19. [PubMed ID: 23327474]. [PubMed Central ID: PMC3556060]. <https://doi.org/10.1186/1471-2334-13-19>.

36. Noor R, Hassan M, Munshi SK, Shams F, Noor AF. Prevalence and antibiogram profile of uropathogens isolated from hospital and community patients with urinary tract infections in Dhaka City. *J Bangladesh Academy Sci.* 2013;**37**(1):57-63. <https://doi.org/10.3329/jbas.v37i1.15681>.
37. Karimi G, Kabir K, Farrokhi B, Abbaszadeh E, Esmaili ED, Khodamoradi F, et al. Prescribing pattern of antibiotics by family physicians in primary health care. *J Pharm Policy Pract.* 2023;**16**(1):11. [PubMed ID: 36658638]. [PubMed Central ID: PMC9854067]. <https://doi.org/10.1186/s40545-023-00515-6>.
38. Dadgostar P. Antimicrobial resistance: Implications and costs. *Infect Drug Resist.* 2019;**12**:3903-10. [PubMed ID: 31908502]. [PubMed Central ID: PMC6929930]. <https://doi.org/10.2147/IDR.S234610>.