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Research Article

Antimicrobial Resistance Patterns of Uropathogens Isolated from Patients with Urinary Tract Infections in a Tertiary Care Hospital

Dr Seema Sahu MBBS MD
Assistant Professor, Shri shankaracharya Institute Of Medical Sciences, junwani Bhilai Chattisgarh.
Email: dr.seemasahu0111@gmail.com
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ABSTRACT

Background: Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and represent a major cause of morbidity and antimicrobial use. The increasing prevalence of antimicrobial resistance among uropathogens has become a significant challenge in the effective management of UTIs, necessitating continuous surveillance of local resistance patterns.

Objective: To determine the spectrum of uropathogens and evaluate their antimicrobial resistance patterns among patients with urinary tract infections attending a tertiary care hospital.

Materials and Methods: A hospital-based cross-sectional study was conducted on 110 culture-positive urine samples obtained from patients clinically suspected of having UTIs. Urine specimens were processed using standard microbiological techniques for isolation and identification of bacterial pathogens. Demographic characteristics, bacterial isolates, antimicrobial resistance profiles, and multidrug resistance patterns were analyzed.

Results: Of the 110 patients included in the study, females constituted 65.5% of cases, while males accounted for 34.5%. The highest proportion of infections was observed in the 21–40 years age group (36.4%). Escherichia coliwas the predominant uropathogen, accounting for 52.7% of isolates, followed by Klebsiellapneumoniae (19.1%) and Enterococcus faecalis (10.0%).

Conclusion: Escherichia coliremains the predominant causative agent of urinary tract infections. High resistance rates to commonly prescribed antibiotics such as ampicillin, ciprofloxacin, and ceftriaxone highlight the growing burden of antimicrobial resistance.

Keywords: Urinary Tract Infection; Uropathogens; Antimicrobial Resistance; Multidrug Resistance; Escherichia Coli; Antibiotic Susceptibility.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections encountered in clinical practice and represent a significant public health concern worldwide. They affect individuals of all age groups, with a particularly high prevalence among women, elderly individuals, pregnant women, diabetic patients, and those with urinary tract abnormalities. UTIs account for a substantial proportion of outpatient visits, hospital admissions, and antimicrobial prescriptions, thereby contributing considerably to healthcare expenditures and patient morbidity [1]. The clinical spectrum of UTIs ranges from uncomplicated cystitis to severe pyelonephritis, urosepsis, and recurrent infections, which may lead to long-term renal complications if inadequately treated [2].

The etiological agents responsible for UTIs are predominantly Gram-negative bacteria, although Gram-positive organisms and fungi may also be implicated. Among the bacterial pathogens, Escherichia coli remains the most frequently isolated uropathogen, accounting for the majority of community-acquired and hospital-acquired infections. Other commonly encountered organisms include Klebsiellapneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Enterococcus faecalis, and Staphylococcus saprophyticus [3]. The distribution of uropathogens may vary according to geographical location, healthcare setting, patient demographics, and underlying comorbidities. Consequently, continuous surveillance of local pathogen profiles is essential for effective management of UTIs.

Antimicrobial therapy remains the cornerstone of UTI treatment. However, the increasing emergence and spread of antimicrobial resistance (AMR) among uropathogens have become a major challenge to clinicians worldwide [4]. The widespread and often inappropriate use of antibiotics in human medicine, veterinary practice, and agriculture has accelerated the development of resistant bacterial strains. As a result, many previously effective antibiotics are losing their therapeutic efficacy, leading to treatment failures, prolonged hospital stays, increased healthcare costs, and elevated mortality rates [5]. The World Health Organization has recognized antimicrobial resistance as one of the greatest threats to global health, food security, and development in the twenty-first century [6].

Particularly concerning is the increasing prevalence of multidrug-resistant (MDR) uropathogens, including extended-spectrum β-lactamase (ESBL)-producing Enterobacterales and carbapenem-resistant organisms. These resistant strains significantly limit treatment options and often necessitate the use of more expensive or toxic antimicrobial agents [7]. Resistance to commonly prescribed antibiotics such as ampicillin, trimethoprim-sulfamethoxazole, fluoroquinolones, and third-generation cephalosporins has been reported in numerous studies across different regions of the world [8]. Furthermore, antimicrobial susceptibility patterns vary substantially between institutions and geographic regions, emphasizing the importance of local antibiograms for guiding empirical therapy [9].

Tertiary care hospitals often serve as referral centers for complicated infections and patients with multiple comorbidities, making them important reservoirs for resistant microorganisms. Regular monitoring of antimicrobial resistance patterns in these settings provides valuable information for clinicians, microbiologists, infection control teams, and policymakers. Such surveillance assists in optimizing empirical antibiotic selection, developing antimicrobial stewardship programs, reducing the spread of resistant pathogens, and improving patient outcomes [10].

Understanding the current resistance trends among uropathogens is therefore essential for evidence-based clinical decision-making. Knowledge of local susceptibility profiles can help minimize inappropriate antibiotic use and contribute to the containment of antimicrobial resistance. In this context, the present study aims to evaluate the antimicrobial resistance patterns of uropathogens isolated from patients with urinary tract infections in a tertiary care hospital. The findings are expected to provide important epidemiological data regarding prevalent uropathogens and their susceptibility profiles, thereby supporting the rational use of antimicrobial agents and strengthening institutional infection control strategies.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted in the Department of Microbiology at ___Shri shankaracharya hospital __________, a tertiary care teaching hospital located in ___Bhilai(Chattisgarh _)_________. The study was carried out over a period of __January 2025_________ to __february __2026_________. The primary objective was to determine the antimicrobial resistance patterns of uropathogens isolated from patients diagnosed with urinary tract infections (UTIs).

Study Population and Sample Size

A total of 110 consecutive urine samples yielding significant bacterial growth were included in the study. Samples were obtained from patients clinically suspected of having UTIs and attending outpatient departments, inpatient wards, and intensive care units during the study period. Only culture-positive urine specimens demonstrating significant bacteriuria were included for microbiological analysis.

Inclusion and Exclusion Criteria

Patients of all age groups and both sexes with clinically suspected UTI and positive urine culture results were included in the study. Duplicate isolates obtained from the same patient during the study period were excluded to avoid overrepresentation of resistance patterns. Samples showing mixed growth suggestive of contamination and specimens with incomplete clinical or laboratory records were also excluded.

Specimen Collection and Processing

Midstream clean-catch urine specimens were collected in sterile, wide-mouthed containers following standard aseptic procedures. For catheterized patients, urine samples were collected aseptically from the sampling port. Specimens were transported promptly to the microbiology laboratory and processed within two hours of collection.

Urine samples were cultured using a calibrated loop technique on Cysteine Lactose Electrolyte Deficient (CLED) agar and MacConkey agar. The inoculated plates were incubated aerobically at 35–37°C for 18–24 hours. Significant bacteriuria was defined as bacterial growth of ≥10^5 colony-forming units (CFU)/mL. Bacterial isolates were identified using colony morphology, Gram staining characteristics, and standard biochemical tests.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI) guidelines. Antibiotics tested included ampicillin, amoxicillin-clavulanic acid, ceftriaxone, cefotaxime, ceftazidime, ciprofloxacin, norfloxacin, nitrofurantoin, gentamicin, amikacin, piperacillin-tazobactam, and meropenem, depending on the bacterial species isolated.

After incubation, inhibition zone diameters were measured and interpreted as susceptible, intermediate, or resistant according to current CLSI breakpoints. Multidrug resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories.

Quality Control

Quality assurance procedures were maintained throughout the study. Standard reference strains, including Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 25923, were used for quality control of culture media and antimicrobial susceptibility testing.

Data Collection and Statistical Analysis

Demographic and microbiological data were recorded using a structured data collection form. Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Antimicrobial resistance patterns were presented descriptively. Associations between categorical variables were analyzed using the Chi-square test or Fisher's exact test where appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 110 culture-positive urine samples from patients with clinically suspected urinary tract infections were analyzed. Females constituted the majority of cases (65.5%), and the most affected age group was 21–40 years (36.4%). Escherichia coliwas the predominant uropathogen isolated, followed by Klebsiellapneumoniae and Enterococcus faecalis. High resistance rates were observed against ampicillin and fluoroquinolones, whereas nitrofurantoin, amikacin, and meropenem demonstrated comparatively better antimicrobial activity.

Table 1. Demographic Characteristics of Patients with Culture-Positive UTI (n = 110)

Variable	Frequency (N)	Percentage (%)
Gender		
Male	38	34.5
Female	72	65.5
Age Group (Years)		
≤20	18	16.4
21–40	40	36.4
41–60	31	28.2
>60	21	19.1

Table 1 Among the 110 patients included in the study, females constituted the majority of cases, accounting for 72 (65.5%) patients, whereas males represented 38 (34.5%) patients. Analysis of age distribution revealed that the highest proportion of urinary tract infections occurred in the 21–40 years age group, comprising 40 (36.4%) patients. This was followed by the 41–60 years age group with 31 (28.2%) patients, patients older than 60 years with 21 (19.1%) cases, and those aged 20 years or younger with 18 (16.4%) cases. These findings indicate a higher burden of UTIs among young and middle-aged adults, particularly females.

Table 2. Distribution of Uropathogens Isolated from Urine Samples (n = 110)

Organism	Frequency (N)	Percentage (%)
Escherichia Coli	58	52.7
Klebsiellapneumoniae	21	19.1

Enterococcus Faecalis	11	10.0
Pseudomonas Aeruginosa	8	7.3
Proteus Mirabilis	7	6.4
Staphylococcus Saprophyticus	5	4.5
Total	**110**	**100**

Table 2 A total of 110 bacterial isolates were recovered from culture-positive urine specimens. Escherichia coliwas the most frequently isolated pathogen, accounting for 58 (52.7%) isolates. Klebsiellapneumoniae was the second most common organism with 21 (19.1%) isolates, followed by Enterococcus faecalis with 11 (10.0%) isolates. Other pathogens identified included Pseudomonas aeruginosa[8 (7.3%)], Proteus mirabilis[7 (6.4%)], and Staphylococcus saprophyticus[5 (4.5%)]. The predominance of E. coli confirms its established role as the principal etiological agent of urinary tract infections.

Table 3. Antimicrobial Resistance Pattern among Major Uropathogens

Antibiotic	E. Coli (%)	K. Pneumoniae (%)	E. Faecalis (%)
Ampicillin	79.3	85.7	72.7
Ciprofloxacin	63.8	66.7	54.5
Ceftriaxone	58.6	61.9	NA
Gentamicin	27.6	33.3	18.2
Nitrofurantoin	15.5	23.8	9.1
Amikacin	10.3	14.3	9.1
Meropenem	3.4	4.8	NA

Table 3 Antimicrobial susceptibility testing demonstrated varying resistance patterns among the predominant uropathogens. E. coli exhibited the highest resistance to ampicillin (79.3%), followed by ciprofloxacin (63.8%) and ceftriaxone (58.6%). Similarly, K. pneumoniae showed marked resistance to ampicillin (85.7%), ciprofloxacin (66.7%), and ceftriaxone (61.9%). Among Enterococcus faecalis isolates, resistance was highest against ampicillin (72.7%) and ciprofloxacin (54.5%). Conversely, lower resistance rates were observed against nitrofurantoin, amikacin, and meropenem across the major pathogens. Meropenem demonstrated the greatest effectiveness, with resistance rates below 5% among Gram-negative isolates.

Table 4. Overall Resistance Profile of Uropathogens (n = 110)

Antibiotic	Resistant Isolates (N)	Resistance (%)
Ampicillin	88	80.0
Ciprofloxacin	70	63.6
Ceftriaxone	61	55.5
Gentamicin	33	30.0
Nitrofurantoin	18	16.4
Amikacin	12	10.9
Meropenem	4	3.6

Table 4 Evaluation of the overall antimicrobial resistance profile revealed that ampicillin was the least effective antibiotic, with 88 (80.0%) isolates demonstrating resistance. High resistance was also observed against ciprofloxacin [70 (63.6%)] and ceftriaxone [61 (55.5%)]. Moderate resistance was noted for gentamicin [33 (30.0%)]. In contrast, resistance to nitrofurantoin[18 (16.4%)] and amikacin[12 (10.9%)] remained relatively low. Meropenem exhibited the lowest resistance rate, with only 4 (3.6%) resistant isolates. These findings suggest that carbapenems and aminoglycosides remain highly effective against most urinary pathogens, whereas

resistance to commonly prescribed first-line antibiotics is substantial.

Table 5. Distribution of Multidrug-Resistant (MDR) Uropathogens

Organism	MDR Isolates (N)	MDR Percentage (%)
E. Coli (N=58)	24	41.4
K. Pneumoniae (N=21)	11	52.4
E. Faecalis (N=11)	3	27.3
P. Aeruginosa (N=8)	4	50.0
P. Mirabilis (N=7)	2	28.6
S. Saprophyticus (N=5)	1	20.0
Total	**45**	**40.9**

Table 5 Among the 110 bacterial isolates, 45 (40.9%) were identified as multidrug resistant. The highest prevalence of multidrug resistance was observed among Klebsiellapneumoniae, where 11 of 21 isolates (52.4%) exhibited MDR characteristics. Pseudomonas aeruginosa also demonstrated a high MDR rate of 50.0%. Among Escherichia coli, 24 of 58 isolates (41.4%) were multidrug resistant. Lower MDR frequencies were observed in Proteus mirabilis (28.6%), Enterococcus faecalis (27.3%), and Staphylococcus saprophyticus (20.0%). The substantial proportion of MDR organisms highlights the growing challenge of antimicrobial resistance in urinary tract infections and emphasizes the need for continuous surveillance and antimicrobial stewardship programs.

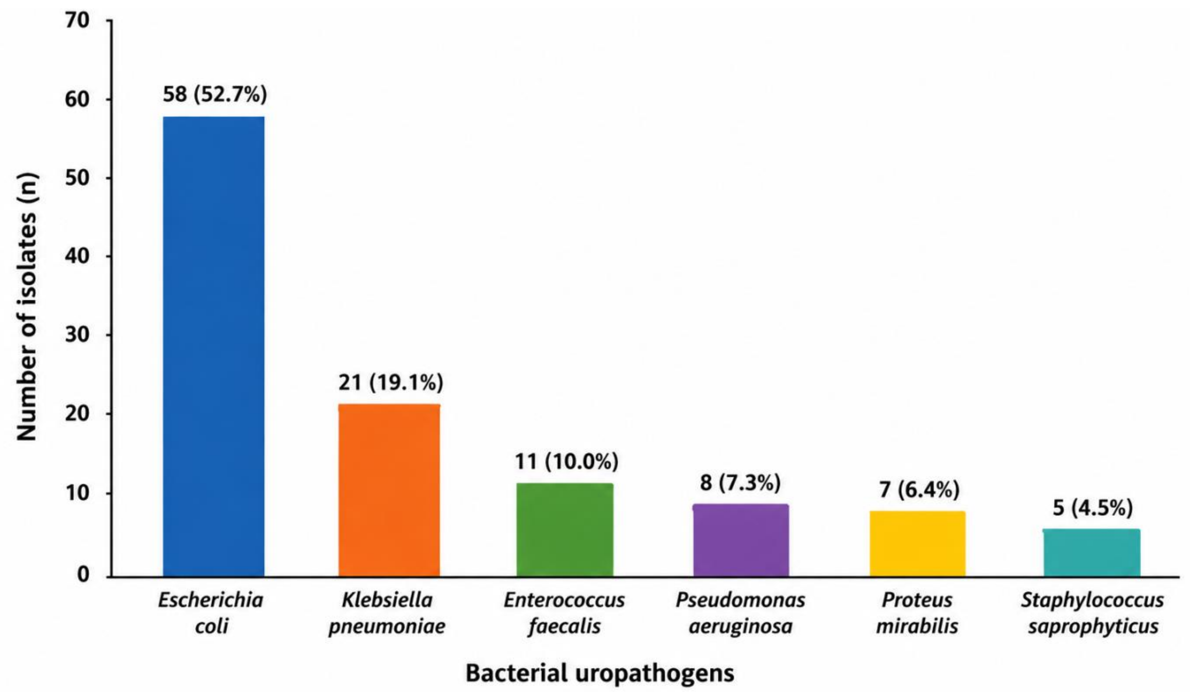

Figure 1. Frequency distribution of bacterial uropathogens isolated from urine cultures

Figure 1 illustrates the distribution of bacterial uropathogens isolated from 110 culture-positive urine samples. Escherichia coliwas the predominant pathogen, accounting for 58 (52.7%) isolates, followed by Klebsiellapneumoniae with 21 (19.1%) isolates. Enterococcus faecalis represented 11 (10.0%) isolates, while Pseudomonas aeruginosa and Proteus mirabilis accounted for 8 (7.3%) and 7 (6.4%) isolates, respectively. Staphylococcus saprophyticus was the least frequently isolated organism, comprising 5 (4.5%) isolates. The findings demonstrate the overwhelming predominance of E. coli as the principal causative agent of urinary tract infections, with Gram-negative bacteria constituting the majority of isolates recovered in the present study. The distribution pattern observed highlights the importance of targeting predominant uropathogens when formulating empirical antimicrobial therapy and local infection control strategies.

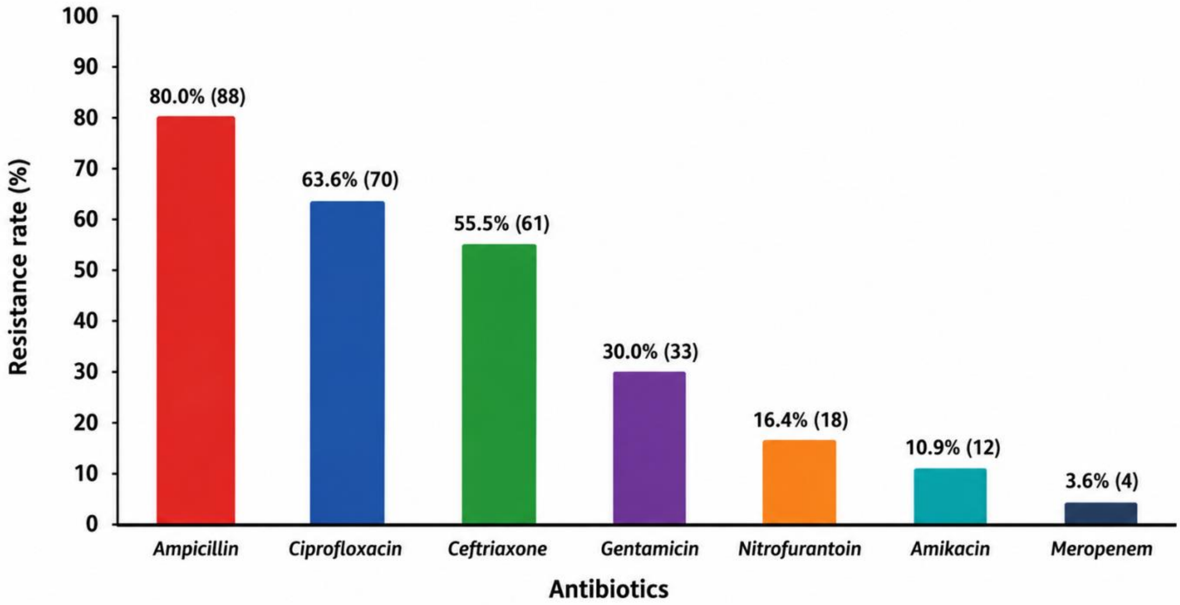

Figure 2. Overall antimicrobial resistance rates of uropathogens against commonly prescribed antibiotics

Figure 2 depicts the overall antimicrobial resistance profile of uropathogens isolated from patients with urinary tract infections. The highest resistance rate was observed against ampicillin, with 88 (80.0%) isolates demonstrating resistance, indicating its limited effectiveness for empirical treatment. High resistance was also noted for ciprofloxacin [70 (63.6%)] and ceftriaxone [61 (55.5%)], suggesting a substantial decline in susceptibility to commonly prescribed fluoroquinolones and cephalosporins. Moderate resistance was observed against gentamicin, with 33 (30.0%) resistant isolates. In contrast, lower resistance rates were recorded for nitrofurantoin [18 (16.4%)] and amikacin [12 (10.9%)], indicating relatively preserved antimicrobial activity. Meropenem exhibited the lowest resistance rate, with only 4 (3.6%) resistant isolates, highlighting its continued effectiveness against most uropathogens.

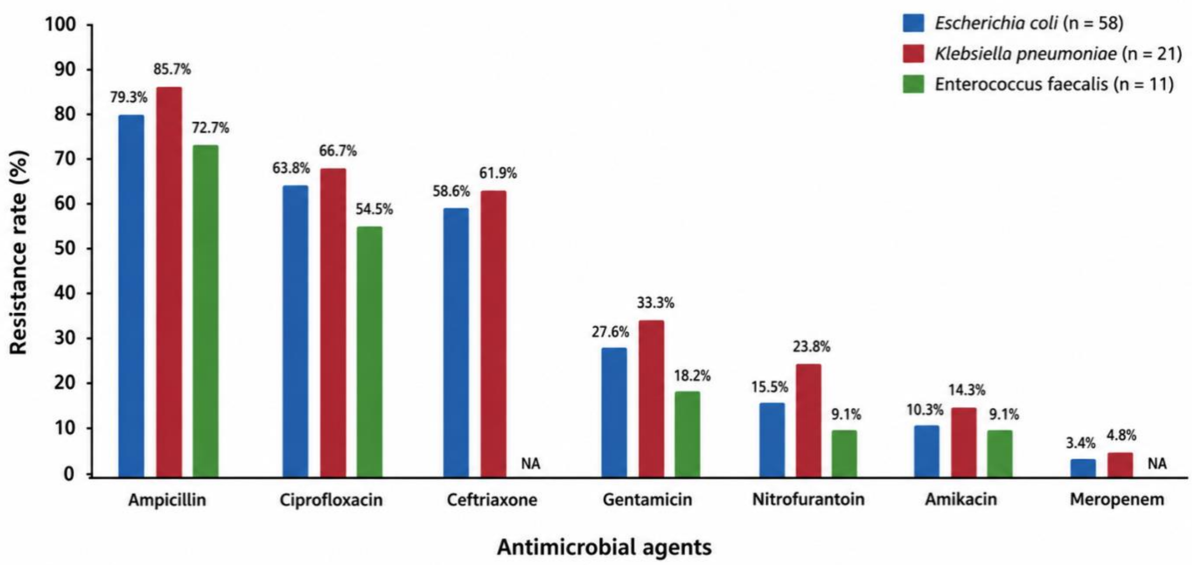

Figure 3. Comparative resistance pattern of Escherichia coli, Klebsiellapneumoniae, and Enterococcus faecalis against major antimicrobial agents

Figure 3 compares the antimicrobial resistance profiles of the three most frequently isolated uropathogens, namely Escherichia coli, Klebsiellapneumoniae, and Enterococcus faecalis. All three organisms demonstrated high resistance rates to ampicillin, with the highest resistance observed in K. pneumoniae (85.7%), followed by E. coli (79.3%) and E. faecalis (72.7%). Similarly, considerable resistance to ciprofloxacin was noted among K. pneumoniae (66.7%), E. coli (63.8%), and E. faecalis (54.5%). Resistance to ceftriaxone was also substantial among Gram-negative isolates, affecting 61.9% of K. pneumoniae and 58.6% of E. coli isolates.

DISCUSSION

Urinary tract infections (UTIs) remain one of the most frequently encountered bacterial infections worldwide and continue to pose a significant therapeutic challenge because of the increasing prevalence of antimicrobial resistance. In the present study, females constituted 65.5% of culture-positive UTI cases, indicating a marked female predominance. This observation is consistent with the well-established epidemiology of UTIs, wherein women are disproportionately affected because of anatomical and physiological factors, including a shorter urethra, proximity of the urethral opening to the anal region, hormonal influences, and increased susceptibility associated with sexual activity and pregnancy. Similar findings have been reported by Medina and Castillo-Pino [11] and Tandogdu and Wagenlehner [12], who described women as the population most vulnerable to urinary tract infections globally.

Analysis of age distribution revealed that the highest proportion of infections occurred in the 21–40-year age group (36.4%), followed by individuals aged 41–60 years (28.2%). The predominance of UTIs among young and middle-aged adults may be attributed to increased sexual activity, pregnancy-related physiological changes, occupational stress, and lifestyle factors. Previous epidemiological investigations have likewise demonstrated a greater incidence of UTIs among reproductive-age women and middle-aged adults [13,14]. The lower prevalence observed in younger individuals may reflect reduced exposure to recognized risk factors, whereas elderly patients often present with complicated infections associated with underlying comorbidities and urinary tract abnormalities.

Regarding bacterial etiology, Escherichia coli was identified as the predominant uropathogen, accounting for 52.7% of all isolates. This finding is consistent with numerous surveillance studies that have established E. coli as the principal causative agent of both community-acquired and healthcare-associated UTIs [15,16]. The predominance of E. coli is largely attributable to the presence of virulence factors such as adhesins, fimbriae, hemolysins, and biofilm-forming capabilities that facilitate colonization and persistence within the urinary tract [17]. Klebsiellapneumoniae represented the second most common pathogen (19.1%), followed by Enterococcus faecalis (10.0%). Similar pathogen distributions have been documented across various geographic regions, emphasizing the continued dominance of Enterobacterales in urinary tract infections [18].

One of the most important findings of the present study was the high level of antimicrobial resistance observed among uropathogens. Ampicillin exhibited the highest overall resistance rate (80.0%), with resistance exceeding 70% among the major pathogens. Comparable resistance rates have been reported in several international studies, reflecting the widespread dissemination of β-lactam resistance mechanisms among urinary pathogens [19,20]. Extensive use of ampicillin over several decades has contributed substantially to selective pressure and the emergence of resistant strains, thereby limiting its usefulness as an empirical therapeutic option.

Resistance to ciprofloxacin (63.6%) was also notably high. Fluoroquinolones have historically been among the most commonly prescribed agents for UTIs because of their favorable pharmacokinetic properties and broad-spectrum activity. However, increasing resistance to this class has been reported worldwide and is largely attributed to chromosomal mutations and plasmid-mediated resistance mechanisms [21]. Similar resistance patterns have been documented in multicenter surveillance studies, suggesting that empirical use of fluoroquinolones should be reconsidered in regions with high resistance prevalence [22].

Ceftriaxone resistance was observed in 55.5% of isolates, indicating a substantial burden of resistance to third-generation cephalosporins. This trend is concerning because cephalosporins are frequently used for the treatment of complicated urinary tract infections. The increasing prevalence of extended-spectrum β-lactamase (ESBL)-producing Enterobacterales has significantly reduced the effectiveness of cephalosporins and contributed to therapeutic failures [23]. The high resistance rates identified in the present study underscore the necessity of routine susceptibility testing before initiating antimicrobial therapy whenever feasible.

In contrast, relatively low resistance rates were observed for nitrofurantoin (16.4%), amikacin (10.9%), and meropenem (3.6%). Nitrofurantoin remains an effective first-line agent for uncomplicated UTIs because of its unique mechanism of action and limited propensity for resistance development [24]. Likewise, amikacin demonstrated excellent activity against the majority of isolates, consistent with previous reports highlighting its effectiveness against multidrug-resistant Gram-negative pathogens [25]. Meropenem exhibited the lowest resistance rate among all tested antibiotics, reflecting its continued efficacy against resistant uropathogens. Nevertheless, carbapenems should be reserved for severe or complicated infections to minimize the emergence of carbapenem-resistant organisms and preserve their clinical utility [26].

Another notable finding was the high prevalence of multidrug-resistant (MDR) isolates, which accounted for 40.9% of all uropathogens. MDR organisms were particularly common among Klebsiellapneumoniae and Pseudomonas aeruginosa. Similar MDR rates have been reported in recent surveillance studies, highlighting the growing global burden of antimicrobial resistance in urinary pathogens [27,28]. The emergence of MDR bacteria significantly restricts therapeutic options, increases healthcare costs, prolongs hospitalization, and contributes to poorer clinical outcomes. These findings emphasize the importance of antimicrobial stewardship programs, infection prevention measures, and continuous monitoring of local resistance trends.

Overall, the findings of the present study demonstrate that E. coli remains the predominant uropathogen causing UTIs, while resistance to commonly prescribed antibiotics such as ampicillin, ciprofloxacin, and ceftriaxone has reached alarming levels. The preserved activity of nitrofurantoin, amikacin, and meropenem provides valuable guidance for empirical treatment strategies. Continuous surveillance of antimicrobial susceptibility patterns is essential to support evidence-based prescribing practices and mitigate the further spread of multidrug-resistant uropathogens.

CONCLUSION

The present study demonstrated that urinary tract infections remain a significant clinical problem, with females constituting the majority of affected patients and young to middle-aged adults representing the most commonly affected age group. Escherichia coliwas identified as the predominant uropathogen, followed by Klebsiellapneumoniae and Enterococcus faecalis, confirming the continued dominance of these organisms in urinary tract infections.A concerning level of antimicrobial resistance was observed among the isolated uropathogens, particularly against commonly prescribed antibiotics such as ampicillin, ciprofloxacin, and ceftriaxone. In contrast, nitrofurantoin, amikacin, and meropenem retained good antimicrobial activity and demonstrated low resistance rates, suggesting their continued effectiveness in the treatment of urinary tract infections. Furthermore, the high prevalence of multidrug-resistant isolates highlights the growing challenge posed by antimicrobial resistance in routine clinical practice.

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