Innovative Research Journal of **Clinical Sciences** (IRJCS)
2025; 3(1):1-11
DOI: https://doi.org/10.62497//irjcs.160

Research Article

Antibiotic Resistance Patterns in Urinary Tract Infections: A Two-Year Retrospective study

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Citation: Zainab SH, Bashir M, Qureshi UU, Bashir B, Baig U, Misbah H. Antibiotic Resistance Patterns in Urinary Tract Infections: A Two-Year Retrospective study. Innov Res J Clin Sci. 2025; 2(1):1-11. DOI: https://doi.org/10.62497//irjcs.160. Available at: https://irjpl.org/irjcs/article/view/160.

Article Info
Received: March 11, 2025
Revised: June 06, 2025
Accepted: June 10, 2025

Keywords
Urinary tract infections, antibiotic resistance, *Escherichia coli*, hospital-acquired UTI, community-acquired UTI, antimicrobial susceptibility

Abstract

Introduction: Urinary tract infections (UTIs) are among the most common bacterial infections worldwide, affecting all age groups and both sexes. Increasing antibiotic resistance among uropathogens poses a significant challenge to effective management and increases the risk of treatment failure.

Objective: To determine the antibiotic resistance patterns of uropathogens in culture-positive UTIs and assess associations with patient demographics and type of infection.

Methodology: This two-year retrospective study was conducted at the Department of Microbiology, Abbottabad international medical college (AIMC), Abbottabad, from January 2022 to December 2023. A total of 220 culture-positive UTI cases were included. Patient demographics, type of UTI (community- or hospital-acquired), and uropathogen distribution were recorded. Antibiotic susceptibility was analyzed using standard laboratory methods. Descriptive statistics and Chi-square tests were performed to assess associations between demographics, type of infection, and resistance patterns.

Results: Among 220 cases, the mean age was 37.4 ± 18.6 years, with females comprising 58.2% of the cohort. *Escherichia coli* was the most frequent uropathogen (55%), followed by *Klebsiella pneumoniae* (19.1%) and *Enterococcus spp.* (11.8%). Overall antibiotic resistance was 42.7% with the highest resistance observed against amoxicillin-clavulanate and ceftriaxone. Nitrofurantoin and meropenem retained the highest efficacy. Hospital-acquired UTIs were significantly associated with higher resistance rates ($p < 0.05$). No significant associations were found with age or gender. Temporal trends showed a slight, non-significant increase in resistance over the two-year period.

Conclusion: Antibiotic resistance among UTI pathogens is high, particularly in hospital-acquired infections. Nitrofurantoin and meropenem remain effective treatment options. Continuous local surveillance, rational antibiotic prescribing, and implementation of stewardship programs are essential to reduce the burden of multidrug-resistant UTIs.

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Introduction

Urinary tract infections (UTIs) are among the most prevalent bacterial infections globally, affecting individuals of all ages and both sexes [1]. They constitute a significant percentage of community-acquired and hospital-acquired infections causing a significant effect on patient morbidity, healthcare utilization, and economic burden [2]. According to epidemiological data, the UTIs are especially more prevalent in females due to anatomical and physiological causes such as the shortness of the urethra and the closeness to the anal region which contributes to the bacterial colonization [3]. UTIs are less common in males but tend to be complicated with infections among which prostate involvement and structural abnormalities are common [4].

UTIs are largely bacterial in etiology with Escherichia coli as the most widely occurring causative agent, and Klebsiella spp., Proteus spp., Enterococcus spp., and Pseudomonas aeruginosa being the next most common agents [3]. These pathogens have a wide range of virulence factors that include adhesins, biofilm formation and toxins that contribute to their ability to settle in the urinary tract and avoid the host immune response [5]. UTIs have a clinical spectrum that involves a spectrum of asymptomatic bacteriuria to acute cystitis and life-threating pyelonephritis or urosepsis [6]. The symptoms depend on the age, gender, comorbidities and urinary tract abnormalities, which require early diagnosis and proper treatment [7].

Antibiotic treatment continues to be a pillar of treatment of UTI [8]. Nevertheless, the high and frequent use of antibiotics has caused a terrifying increment in antimicrobial resistance (AMR) in uropathogens [9]. Increasingly reported resistance mechanisms that complicate empirical therapy are the production of extended-spectrum b-lactamases (ESBLs), carbapenemases, efflux pumps and alteration of antibiotic targets sites [10]. The advent of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains has also reduced the treatment possibilities, which has become the primary challenge to practitioners and even healthcare officials [11].

A number of reports have indicated that there are differences in resistance patterns across the globe, depending on geographical location, healthcare facilities, practice of administering antibiotics and patient demographics [12]. Local resistance patterns should be monitored to inform empirical therapy, maximum treatment effects, and then reduce the occurrence of subsequent resistance [13]. Retrospective studies that examine the dynamics of resistance are useful in defining the temporality of resistance, the distribution of certain uropathogens, and profiles of susceptibility, and facilitates clinical as well as policy-level responses [14].

Despite numerous investigations into UTIs and antibiotic resistance, there is a paucity of comprehensive data from many regions on the evolving resistance trends of uropathogens over extended periods. Understanding these patterns is critical for updating empirical treatment guidelines, improving patient outcomes, and combating the global threat of antimicrobial resistance. This study aims to identify antibiotic resistance patterns in urinary tract infections over a two-year period and address the existing gap in longitudinal resistance surveillance in the local population.

Materials and Methods

Study Design and Setting: This retrospective study was carried out at the Department of Microbiology, Abbottabad international medical college (AIMC), Abbottabad. The study examined urine culture reports from patients who presented with UTIs in both outpatient and inpatient settings during the course of two years, from January 2022 to December 2023.

Study Population: The study population included all patients of any age and gender who had a laboratory-confirmed diagnosis of UTI based on positive urine cultures during the study period. For operational purposes, community-acquired UTIs were defined as infections diagnosed within 48 hours of hospital admission in patients without recent hospitalization, catheterization, or antibiotic exposure within the preceding two weeks. Hospital-acquired UTIs were defined as infections that developed after 48 hours of hospital admission or were associated with indwelling urinary catheters, invasive urological procedures, or antibiotic use during the current hospitalization.

Patients with incomplete records, contaminated urine samples, or recurrent UTIs within two weeks of the initial infection were excluded to ensure the reliability of data. In cases where multiple cultures were available for the same patient during the study period, only the first isolate per patient was included to avoid duplication.

Sample Size Calculation: The sample size was calculated using the World Health Organization (WHO) sample size calculator for proportions. Based on a previously published study reporting a 43.5% prevalence of antibiotic resistance among UTI pathogens, a 95% confidence level, and a margin of error of 7%, the minimum required sample size was calculated as 193. To enhance statistical validity and account for possible exclusions, a total of 220 culture-positive UTI cases were included in the final analysis.

Data Collection: Patient records and urine culture reports were retrieved from the laboratory database. Data collected included demographic information (age, gender), type of UTI (community-acquired or hospital-acquired), causative uropathogens, and antibiotic susceptibility patterns. Data extraction was independently verified by two microbiology staff members to ensure accuracy and consistency. Any discrepancies identified during data entry were resolved through cross-checking with the original laboratory records.

Laboratory Methods: Urine samples were processed according to standard microbiological procedures. Midstream clean-catch urine samples or catheterized samples were cultured on Cystine Lactose Electrolyte Deficient (CLED) agar and MacConkey agar. Identification of bacterial isolates was performed using conventional biochemical tests and, when necessary, automated systems. Antimicrobial susceptibility testing (AST) was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar and interpreted according to CLSI M100 (2023) standards. Quality control was ensured by testing ATCC reference strains (*E. coli* 25922, *P. aeruginosa* 27853, and *S. aureus* 25923) with each batch of tests. Extended-spectrum beta-lactamase (ESBL) production was confirmed using the combined disk test, while carbapenem-resistant isolates were screened for carbapenemase production using the Modified Hodge Test (MHT). Intermediate susceptibility results were grouped with resistant isolates for analysis. The antibiotics tested included commonly prescribed agents for UTIs, such as amoxicillin-clavulanate, ceftriaxone, ciprofloxacin, nitrofurantoin, gentamicin, and meropenem. Resistance patterns were categorized as sensitive, intermediate, or resistant.

Data Analysis: Data were analyzed using SPSS version 26.0. The prevalence of bacterial isolates and demographic variables was presented using descriptive statistics. Means and standard deviations were computed for continuous variables, and frequencies and percentages for categorical variables. Comparative analyses between categorical variables, such as patient demographics (age group, gender, and infection type) and antibiotic resistance patterns, were performed using the Chi-square test. Given the retrospective nature of the data and the categorical structure of most variables, the Chi-square test was deemed appropriate for assessing associations without assuming linearity or normal distribution.

Multivariable analysis, such as logistic regression, was considered; however, it was not applied due to limited sample size and incomplete covariate data across all subgroups, which could reduce model reliability. As a result, the findings primarily represent unadjusted associations, and potential confounding factors such as age, gender, and infection type could not be fully controlled. This limitation was acknowledged when interpreting statistical relationships, emphasizing that observed associations do not imply independent causation. A P-value of <0.05 was considered statistically significant. Temporal trends in resistance over the two-year period were also assessed descriptively to identify any emerging resistance patterns.

Results

The study comprised 220 UTI cases that tested positive for culture. The patients ranged in age from 1 to 85 years, with a mean age of 37.4 ± 18.6 years. According to Table 1, 92 cases (41.8%) were male, and 128 cases (58.2%) were female. The majority of infections were community-acquired, with 136 patients (62%) presenting with community-acquired

UTIs, and 84 patients (38%) with hospital-acquired infections. Overall antibiotic resistance was 42.7%, among females 43.0% and 42.4% among males, with no statistically significant association between gender and resistance ($\chi^2 = 0.02$, $p = 0.88$). When stratified by age, resistance rates were 35.3% in patients under 18 years, 42.9% in the 18–40 years group, 50.0% in the 41–60 years group, and 38.9% in those above 60 years, with no significant differences observed ($\chi^2 = 1.47$, $p = 0.69$). In contrast, the type of UTI was significantly associated with antibiotic resistance, as 57.1% of hospital-acquired infections were resistant compared to 33.8% of community-acquired infections ($\chi^2 = 9.12$, $p = 0.003$). These findings indicate that while age and gender did not significantly influence resistance patterns, hospital-acquired UTIs were more likely to be associated with antibiotic-resistant pathogens.

Table 1: Demographics and Chi-square Associations with Antibiotic Resistance

Characteristic	Frequency (n)	Percentage (%)	Antibiotic Resistance (%)	χ^2	p-value
Gender					
Male	92	41.8	39 (42.4%)	0.02	0.88
Female	128	58.2	55 (43.0%)		
Age (years)					
<18	34	15.5	12 (35.3%)	1.47	0.69
18–40	98	44.5	42 (42.9%)		
41–60	52	23.6	26 (50.0%)		
>60	36	16.4	14 (38.9%)		
Type of UTI					
Community-acquired	136	61.8	46 (33.8%)	9.12	0.003*
Hospital-acquired	84	38.2	48 (57.1%)		

Among the 220 culture-positive UTI cases, *Escherichia coli* was the most frequently isolated pathogen, identified in 121 cases (55.0%), followed by *Klebsiella pneumoniae* in 42 cases (19.1%), *Enterococcus spp.* in 26 cases (11.8%), *Pseudomonas aeruginosa* in 18 cases (8.2%), and *Proteus spp.* in 13 cases (5.9%). As Table 2, when stratified by gender, *E. coli* was present in 45 males (46.7%) and 76 females (59.4%), showing a higher prevalence among females, although the difference was not significant statistically ($\chi^2 = 3.47$, $p = 0.062$). *Klebsiella pneumoniae* was isolated in 16 males (17.4%) and 26 females (20.3%) ($\chi^2 = 0.27$, $p = 0.60$), while *Enterococcus spp.* was found in 10 males (10.9%) and 16 females (12.5%) ($\chi^2 = 0.11$, $p = 0.74$). *Pseudomonas aeruginosa* and *Proteus spp.* were detected in 9 males (9.8%) vs. 9 females (7.0%) ($\chi^2 = 0.48$, $p = 0.49$) and 6 males (6.5%) vs. 7 females (5.5%) ($\chi^2 = 0.07$, $p = 0.79$), respectively. These findings indicate that while *E. coli* predominated overall and was more common in females, no statistically significant association between uropathogen type and gender was observed.

Table 2: Distribution of Uropathogens and Chi-square Associations with Gender

Uropathogen	Frequency (n)	Percentage (%)	Male (%)	Female (%)	χ^2	p-value
Escherichia coli	121	55.0	45 (46.7%)	76 (59.4%)	3.47	0.062
Klebsiella pneumoniae	42	19.1	16 (17.4%)	26 (20.3%)	0.27	0.60
Enterococcus spp.	26	11.8	10 (10.9%)	16 (12.5%)	0.11	0.74
Pseudomonas aeruginosa	18	8.2	9 (9.8%)	9 (7.0%)	0.48	0.49
Proteus spp.	13	5.9	6 (6.5%)	7 (5.5%)	0.07	0.79

Analysis of antibiotic resistance among the 220 UTI cases revealed that the highest resistance was observed against amoxicillin-clavulanate, with 119 cases (54.1%) showing resistance, followed by ceftriaxone in 103 cases (46.8%) and ciprofloxacin in 95 cases (43.2%). As shown in Table 3, resistance to gentamicin was noted in 80 cases (36.4%), while nitrofurantoin and meropenem remained the most effective, with resistance observed in only 22 cases (10.0%) and 4 cases (1.8%), respectively. When stratified by gender, resistance patterns were similar between males and females. Specifically, resistance to amoxicillin-clavulanate was seen in 50 males (54.3%) and 69 females (53.9%) ($\chi^2 = 0.003$, $p = 0.96$), ceftriaxone in 41 males (44.6%) and 62 females (48.4%) ($\chi^2 = 0.35$, $p = 0.55$), and ciprofloxacin in 40 males (43.5%) and 55 females (43.0%) ($\chi^2 = 0.001$, $p = 0.98$). Gentamicin resistance was 33 males (35.9%) vs. 47 females (36.7%) ($\chi^2 = 0.01$, $p = 0.91$), nitrofurantoin 11 males (12.0%) vs. 11 females (8.6%) ($\chi^2 = 0.61$, $p = 0.43$), and meropenem 2 males (2.2%) vs. 2 females (1.6%) ($\chi^2 = 0.09$, $p = 0.76$). These results indicate that while resistance was high for commonly used antibiotics, no significant differences were observed between genders.

Table 3: Resistance Patterns with Chi-square Associations for Gender

Antibiotic	Resistant (n, %)	Male Resistant (n, %)	Female Resistant (n, %)	χ^2	p-value
Amoxicillin-clavulanate	119 (54.1%)	50 (54.3%)	69 (53.9%)	0.003	0.96
Ceftriaxone	103 (46.8%)	41 (44.6%)	62 (48.4%)	0.35	0.55
Ciprofloxacin	95 (43.2%)	40 (43.5%)	55 (43.0%)	0.001	0.98
Gentamicin	80 (36.4%)	33 (35.9%)	47 (36.7%)	0.01	0.91
Nitrofurantoin	22 (10.0%)	11 (12.0%)	11 (8.6%)	0.61	0.43
Meropenem	4 (1.8%)	2 (2.2%)	2 (1.6%)	0.09	0.76

Comparison of antibiotic resistance between community- and hospital-acquired UTIs demonstrated significantly higher resistance in hospital-acquired infections for several commonly used antibiotics. As shown in Figure 1, resistance to amoxicillin-clavulanate was observed in 53 hospital-acquired cases (63.1%) compared to 66 community-acquired cases (48.5%) ($\chi^2 = 4.22$, $p = 0.04$). Similarly, ceftriaxone resistance was higher in hospital-acquired UTIs at 54.8% versus 41.9% in community-acquired cases ($\chi^2 = 4.10$, $p = 0.043$), and ciprofloxacin resistance was 58.3% compared to 33.8% ($\chi^2 = 10.72$, $p = 0.001$). Gentamicin also showed a marked difference, with 60.7% resistance in hospital-acquired infections versus 21.3% in community-acquired cases ($\chi^2 = 31.5$, $p < 0.001$). In contrast, resistance to nitrofurantoin and meropenem was low and not significantly different between the two groups (nitrofurantoin: 11.9% vs. 8.8%, $\chi^2 = 0.55$, $p = 0.46$; meropenem: 2.4% vs. 1.5%, $\chi^2 = 0.17$, $p = 0.68$). These findings indicate that hospital-acquired UTIs are significantly more likely to involve antibiotic-resistant pathogens, highlighting the need for careful empiric therapy and antimicrobial stewardship in hospital settings.

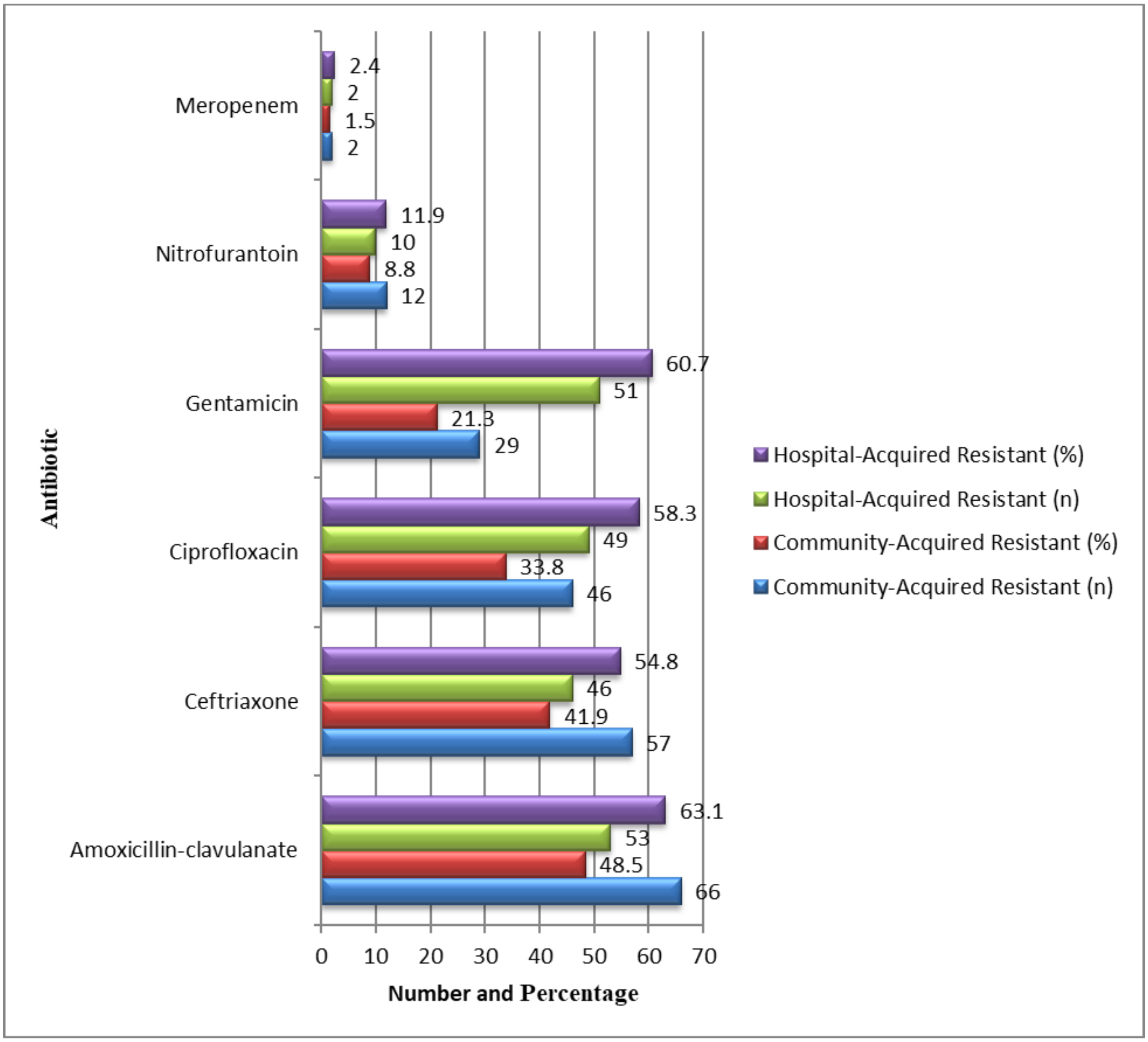

Figure 1: Comparison of antibiotic resistance rates between community- and hospital-acquired UTIs (n=220).

The majority of antibiotics had a minor increase in resistance from 2022 to 2023, according to an analysis of temporal patterns in antibiotic resistance across the two-year study period; however, these changes were not statistically significant. As shown in Figure 2, resistance to amoxicillin-clavulanate increased from 54 cases (49.1%) in 2022 to 65 cases (59.1%) in 2023 ($\chi^2 = 2.19$, $p = 0.14$), ceftriaxone from 46 cases (42.1%) to 57 cases (50.4%) ($\chi^2 = 1.84$, $p = 0.17$), and ciprofloxacin from 39 cases (35.2%) to 56 cases (44.6%) ($\chi^2 = 2.56$, $p = 0.11$). Gentamicin resistance rose from 27 cases (24.5%) to 53 cases (33.6%) ($\chi^2 = 2.07$, $p = 0.15$). Resistance to nitrofurantoin and meropenem remained low, increasing slightly from 9 (8.2%) to 13 cases (11.8%) ($\chi^2 = 0.65$, $p = 0.42$) and 1 (0.9%) to 3 cases (2.7%) ($\chi^2 = 0.91$, $p = 0.34$), respectively. These findings indicate that although there is a trend toward increased resistance over time, the differences were not significant statistically, underscoring the importance of continuous monitoring of antibiotic susceptibility.

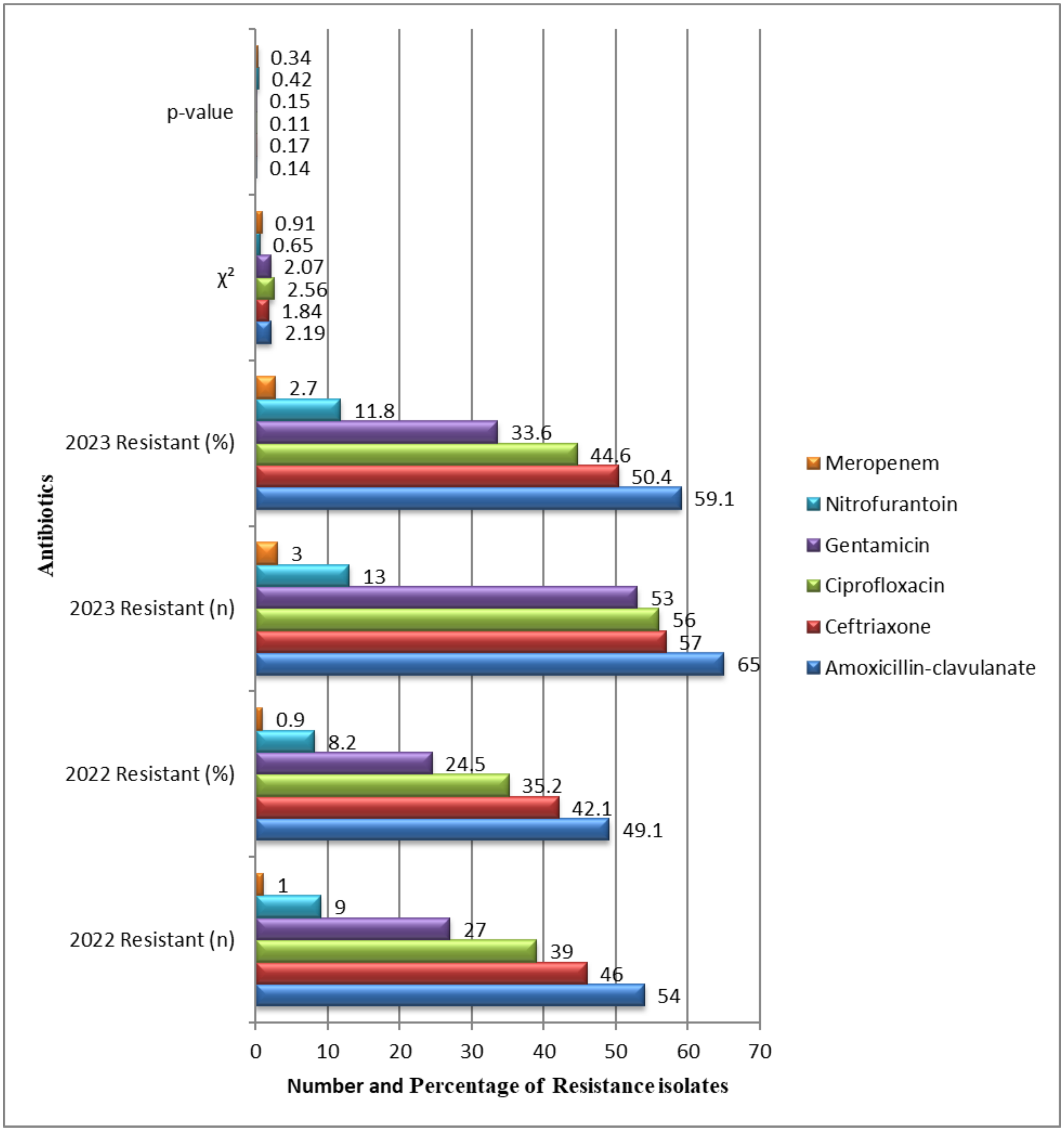

Figure 2: Temporal trends in antibiotic resistance patterns from 2022 to 2023.

Discussion

Escherichia coli was shown to be the most common uropathogen in this two-year retrospective analysis of 220 culture-positive UTI patients, followed by Klebsiella pneumoniae and Enterococcus species. Overall antibiotic resistance was high at 42.7%, with the highest resistance observed for amoxicillin-clavulanate and ceftriaxone. Nitrofurantoin and meropenem retained the highest efficacy. Hospital-acquired UTIs were significantly associated with higher resistance rates compared to community-acquired infections, while age and gender were not significantly associated with resistance. Temporal trends indicated a modest, non-significant increase in resistance over the two-year period.

The predominance of Escherichia coli as a uropathogen aligns with global trends, where it consistently represents the majority of urinary isolates [15]. The high prevalence of Klebsiella pneumoniae and Enterococcus spp. also reflects patterns reported in various regional studies [16]. Overall antibiotic resistance in this study was substantial, particularly against commonly prescribed antibiotics such as amoxicillin-clavulanate and third-generation cephalosporins [17]. This mirrors the growing concern of antibiotic resistance among UTI pathogens worldwide [18].

When compared with recent national surveillance data from Pakistan, our resistance rates to third-generation cephalosporins and fluoroquinolones are within the reported range of 40–70%, while nitrofurantoin continues to show low resistance, supporting its role as an effective first-line agent for uncomplicated UTIs [19]. The observed high resistance among hospital-acquired infections reinforces the need for local antibiogram-guided empirical therapy and emphasizes the importance of antibiotic stewardship programs to minimize unnecessary use of broad-spectrum agents such as cephalosporins and fluoroquinolones [20]. Clinically, these findings suggest that nitrofurantoin should remain preferred for uncomplicated community-acquired infections, while carbapenems should be reserved for confirmed multidrug-resistant cases [21].

Resistance to ciprofloxacin and gentamicin was moderate, indicating reduced efficacy for these commonly used agents, whereas nitrofurantoin and carbapenems maintained strong in vitro activity [19]. The higher resistance observed in hospital-acquired UTIs reflects the impact of prior antibiotic exposure, invasive procedures, and nosocomial transmission, consistent with general findings on hospital-associated infections [20].

Limitations and Future Suggestions: This study has certain limitations. Being retrospective, it depended on existing laboratory records, which may have lacked some clinical details. Its single-center design also limits the generalizability of findings to other settings. Selection bias may have occurred due to the exclusion of recurrent infections and incomplete records, which could have influenced resistance distribution. Furthermore, molecular characterization of resistance mechanisms was not performed, which could have provided insights into specific resistance genes. Future research should involve multicenter data to capture regional variability and incorporate molecular methods to better define resistance determinants. Continuous surveillance of antibiotic susceptibility patterns is essential to guide empirical therapy and mitigate the growing burden of multidrug-resistant UTIs. Strengthening antibiotic stewardship programs and promoting patient education on responsible antibiotic use remain key strategies to curb resistance trends.

Conclusion

This study emphasizes how common antibiotic resistance is among the bacteria that cause urinary tract infections, especially those that are acquired in hospitals. *Escherichia coli* remains the predominant uropathogen, while nitrofurantoin and meropenem retain the highest efficacy. In order to direct successful empirical therapy, the results highlight the necessity of ongoing local observation of resistance patterns and prudent antibiotic use. Implementing antibiotic stewardship programs and promoting awareness of proper antibiotic practices are essential to curb the rising trend of multidrug-resistant UTIs.

Authors' contributions

SHZ: conceptualization and supervision; methodology; investigation; writing—original draft; critical revision of the manuscript; final approval. MB: methodology; data collection; investigation; writing—original draft; critical revision of the manuscript; final approval. UUQ: data collection; data analysis; writing—original draft; critical revision of the manuscript; final approval. BB: data analysis; methodology; critical revision of the manuscript; final approval. UB and HM: data collection; writing—review and editing; critical revision of the manuscript; final approval. All authors contributed to drafting and critically revising the manuscript; approved the final version for submission; and agree to be accountable for all aspects of the work.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors express their gratitude to the staff of the Department of Microbiology, Abbottabad international medical college (AIMC), Abbottabad for their support and cooperation during data collection. We also thank all the participants for their voluntary participation in this study

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