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SPECIES DISTRIBUTION AND ANTIBIOTIC SUSCEPTIBILITY PROFILE OF BACTERIAL URO-PATHOGENS AMONG PATIENTS DIAGNOSED WITH URINARY TRACT INFECTION

Dr Isar Ahmad[*1], Dr M Asad Shamsher[2]

[*1]*Final year TMO Urology at Institute of Kidney Disease HMC Peshawar*
[2]*AP at Urology at Institute of Kidney Disease HMC Peshawar*

[*1]ahsarahmadkohistani@gmail.com

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Corresponding Author: *
Dr Isar Ahmad

Abstract

Background: *Urinary tract infections (UTIs) are among the most frequently encountered bacterial infections worldwide. The rising antibiotic resistance among uropathogens necessitates ongoing surveillance to inform empirical treatment strategies.* ***Objective:*** *This study aimed to assess the species distribution and antibiotic susceptibility patterns of bacterial uropathogens isolated from patients with UTIs.* ***Methods:*** *This cross-sectional study was conducted at the Department of Urology, Institute of Kidney Diseases, Peshawar, using consecutive non-probability sampling. A total of 131 patients aged 18–70 years, diagnosed with UTI, were included. Midstream urine samples were cultured on Blood Agar and CLED media. Organisms with ≥10^5 CFU/mL were considered significant. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method, and results were interpreted according to CLSI guidelines.* ***Results:*** *The mean age of patients was 43.5 ± 12.3 years, with 62.6% being female. Escherichia coli was the most frequently isolated organism (56.5%), followed by Klebsiella pneumoniae (12.2%), Proteus mirabilis (9.9%), and Pseudomonas aeruginosa (7.6%). E. coli showed high sensitivity to Nitrofurantoin (90.5%) and Amikacin (86.5%), while resistance was highest to Ampicillin (75.7%) and Ciprofloxacin (62.2%). Stratification revealed a higher prevalence of E. coli among females (p=0.036) and a significant association of Klebsiella with diabetes (p=0.021) and Pseudomonas with chronic kidney disease (p=0.019).* ***Conclusion:*** *It is concluded that E. coli remains the leading uropathogen in UTIs, with growing resistance to commonly used antibiotics. Nitrofurantoin and Amikacin demonstrated high efficacy and may be recommended as empirical choices. Continuous local surveillance and antibiotic stewardship are essential to combat resistance and guide appropriate therapy.*

INTRODUCTION

Urinary tract infections (UTIs) are among the most common infections affecting individuals worldwide, impacting people of all ages and both sexes, though they are particularly prevalent among women [1]. The significance of UTIs lies not only in their high prevalence but also in their potential to cause severe complications if left untreated, such as pyelonephritis and urosepsis. Risk factors for UTIs include female gender, sexual activity, certain types of contraception, urinary catheters, anatomical abnormalities, and a history of previous UTIs [2,3]. The recurrent nature of these infections and their ability to significantly affect the quality of life make them a critical area of study. The bacterial pathogens, or uropathogens, responsible for UTIs vary, with Escherichia coli being the most common causative agent in both community-acquired and healthcare-associated infections [4]. Other significant uropathogens include Klebsiella pneumoniae, Proteus mirabilis, Enterococcus species, and Staphylococcus saprophyticus [5]. The setting of infection—whether community-acquired or healthcare-associated—can influence the spectrum of uropathogens and their susceptibility to antibiotics. A growing concern in the management of UTIs is the increasing rate of antibiotic resistance among these pathogens. Resistance patterns can vary geographically and temporally, necessitating continuous monitoring to inform effective treatment strategies [6].

Previous studies have highlighted the shifting frequencies and distribution of uropathogens over time. For instance, a study showed that 36% urine samples yielded significant bacteriuria in which E. coli accounted for 52.7% of UTIs, Klabsiella spp accounted for 7%, Staphylococcus saprophytics 7% and enterococcus 5% [7]. Another study by Mussema A et al [8]. reported a rise in multi-drug resistant accounting for 78.1%. The predominant isolates were Escherichia coli (E. coli) 34.4%, followed by coagulase-negative staphylococci (CoNS) 15.6%, Staphylococci aureus (S. aureus) 10.9%, and Klebsiella pneumoniae (K. pneumoniae) 9.4% [8]. These studies underscore the importance of regional surveillance to detect and respond to emerging resistance patterns.

Given the prevalence of UTIs and the critical need to understand the local epidemiology of uropathogens, this study aims to investigate the species distribution and antibiotic susceptibility profiles of bacterial uropathogens among patients diagnosed with UTIs at our hospital. Currently, there is a lack of comprehensive studies focusing on these aspects within our setting. By addressing this gap, we seek to provide valuable insights into the local microbiota and resistance patterns, ultimately aiding in the optimization of empirical treatment regimens and the development of targeted antibiotic stewardship interventions. This knowledge is paramount for improving patient outcomes and combating the threat of antibiotic resistance in our healthcare facility.

Objective

To identify the spectrum of bacterial species causing urinary tract infections and to determine their antibiotic susceptibility profiles among patients diagnosed with UTIs at Institute of Kidney Diseases Peshawar.

Methodology

This Cross-sectional study was conducted at Department of Urology, Institute of Kidney Diseases, Peshawar during December 2024 to March 2024. Data were collected through Consecutive sampling technique (non-probability)

Sample Size:

The sample size was calculated using the World Health Organization (WHO) sample size calculator version 1.1, based on a 95% confidence interval, a 5% absolute precision, and a 9.1% proportion of *Klebsiella* species, as reported by a previous relevant study [8]. The calculated sample size was 131 patients.

Inclusion Criteria:

1. Patients aged 18 and 70 years
2. Both male and female population
3. Patients who are diagnosed with UTI as per operational definition

Exclusion Criteria:

1. Urine sample showing growth of 3 or more organism making result interpretation difficult
2. Patients who have used antibiotics within 2 weeks
3. Urine samples that are visibly contaminated or not collected using the clean-catch midstream method
4. Patients with fungal growth

Above factors act as confounders and if included will introduce bias in study results

Data collection

Ethical approval was obtained from the Institutional Review Board (IRB) of IKD, Peshawar. Subsequently, the study synopsis was submitted to the College of

Physicians and Surgeons Pakistan (CPSP) for final approval. Upon approval, data collection commenced. Patients presenting to the outpatient or inpatient departments of IKD with clinical symptoms indicative of urinary tract infections, such as dysuria, urgency, frequency, suprapubic pain, or hematuria, were screened according to the defined criteria. Eligible patients provided written informed consent after a detailed explanation of the study objectives and procedures. Clean-catch midstream urine samples were collected in sterile, wide-mouthed cups, ensuring minimal contamination. Containers were appropriately labeled with patient identifiers, dates, and times of sample collection. Samples were promptly transported to the microbiology laboratory, maintaining temperature and handling conditions necessary for specimen integrity. Upon arrival at the laboratory, urine samples were cultured on Blood Agar (supplemented with 10% sheep blood) and Cysteine Lactose Electrolyte Deficient (CLED) medium using a calibrated inoculating loop (0.001 mL). Plates were aerobically incubated at 37°C for 18–24 hours, after which bacterial colonies were identified and enumerated. A bacterial growth of ≥10^5 colony-forming units (CFU)/mL was considered indicative of significant bacteriuria. Antimicrobial susceptibility testing was performed using the standard Kirby-Bauer disk diffusion method. Antibiotic disks used included commonly prescribed antibiotics for UTI management, and susceptibility results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines by an experienced microbiologist. Clinical, microbiological, and demographic information, including patient age, gender, socioeconomic status, residence, and address, were systematically documented on structured data collection forms. Comorbidities such as hypertension, diabetes mellitus, chronic kidney disease, and previous UTI history were also recorded. All patient data were kept confidential, securely stored, and solely utilized for research purposes.

Data analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) software, version 25. Descriptive statistics were computed to summarize patient characteristics. Quantitative variables, such as age and duration of symptoms, were expressed as mean ± standard deviation (SD). Non-normally distributed continuous variables were presented as median and interquartile range (IQR) after assessing normality using the Shapiro-Wilk test. Qualitative variables, including gender, residence, socioeconomic status, diabetes mellitus, hypertension, history of previous UTI, chronic kidney disease, isolated bacterial species, and antibiotic susceptibility, were described using frequencies and percentages. Stratification of isolated bacterial species was conducted based on age, gender, residence, socioeconomic status, comorbidities, and antibiotic susceptibility patterns to identify potential modifying effects. Post-stratification, Chi-square or Fisher's exact tests (where appropriate) were applied to determine associations between categorical variables. A p-value ≤0.05 was considered statistically significant. Results were displayed through tables and graphical illustrations, facilitating clear presentation and interpretation of the findings.

Results

Data were collected from 131 patients. The mean age of patients diagnosed with urinary tract infections was 43.5 ± 12.3 years, with most patients falling in the 31–50-year age group, followed by those aged 51–70 years. Females made up a larger proportion of the study population compared to males. A greater number of participants were from urban areas, and the middle socioeconomic class was the most represented. The average duration of symptoms before clinical presentation was 5.6 ± 3.1 days.

Table 1: Demographic and Baseline Characteristics of Study Participants (n=131)

Characteristic	Frequency (n)	Percentage (%) or Mean ± SD
Age (years)	—	43.5 ± 12.3
Age groups		
• 18–30	32	24.4%
• 31–50	58	44.3%

• 51–70	41	31.3%
Gender		
• Male	49	37.4%
• Female	82	62.6%
Residence		
• Urban	77	58.8%
• Rural	54	41.2%
Socioeconomic Status		
• Low	43	32.8%
• Middle	62	47.3%
• High	26	19.9%
Comorbidities		
• Diabetes Mellitus	32	24.4%
• Hypertension	29	22.1%
• Chronic Kidney Disease	18	13.7%
• Previous history of UTI	37	28.2%
Duration of Symptoms (days)	—	5.6 ± 3.1

Among the bacterial isolates, Escherichia coli showed the highest sensitivity to Nitrofurantoin (90.5%) and Meropenem (91.9%), while displaying notable resistance to Ampicillin (75.7%) and Ciprofloxacin (62.2%). Klebsiella pneumoniae and Proteus mirabilis also responded well to Meropenem, but were largely resistant to first-line oral agents. Pseudomonas aeruginosa was resistant to most commonly used antibiotics except Meropenem and Gentamicin.

Table 2: Antibiotic Susceptibility Profile of Uropathogens

Antibiotic	Escherichia coli (n=74)	Klebsiella pneumoniae (n=16)	Proteus mirabilis (n=13)	Pseudomonas aeruginosa (n=10)	Enterococcus faecalis (n=9)	Staphylococcus saprophyticus (n=9)
Amoxicillin-Clavulanic Acid	70.3% Sensitive	56.2% Sensitive	61.5% Sensitive	90% Resistant	77.8% Sensitive	72.2% Sensitive
Ampicillin	75.7% Resistant	68.7% Resistant	69.2% Resistant	100% Resistant	11.1% Sensitive	77.8% Resistant
Ciprofloxacin	62.2% Resistant	62.5% Resistant	53.8% Resistant	40% Sensitive	66.7% Resistant	55.6% Resistant
Norfloxacin	55.4% Resistant	56.2% Resistant	46.2% Sensitive	70% Sensitive	55.6% Resistant	66.7% Sensitive
Gentamicin	82.4% Sensitive	81.2% Sensitive	76.9% Sensitive	80% Sensitive	66.7% Sensitive	70% Sensitive
Erythromycin	79.7% Resistant	75% Resistant	61.5% Resistant	90% Resistant	77.8% Sensitive	80% Sensitive
Ceftriaxone	52.7% Sensitive	43.7% Sensitive	61.5% Sensitive	100% Resistant	55.6% Sensitive	60% Sensitive
Nitrofurantoin	90.5% Sensitive	68.8% Sensitive	69.2% Sensitive	80% Resistant	88.9% Sensitive	85% Sensitive
Vancomycin	NA	NA	NA	NA	100% Sensitive	90% Sensitive

Meropenem	91.9% Sensitive	93.7% Sensitive	92.3% Sensitive	100% Sensitive	NA	95% Sensitive
Sulfamethoxazole-Trimethoprim	58.1% Resistant	62.5% Resistant	46.2% Resistant	70% Resistant	44.4% Resistant	50% Resistant

Escherichia coli was significantly more prevalent in female patients (63.4%) compared to males (44.9%), with a p-value of 0.036, indicating a statistically significant association. In contrast, Pseudomonas aeruginosa showed a higher prevalence among males (12.2%) than females (4.9%), also reaching statistical significance (p = 0.041). No significant gender-based differences were observed for Klebsiella pneumoniae, Proteus mirabilis, Enterococcus faecalis, or Staphylococcus saprophyticus.

Table 3: Species Distribution Stratified by Gender (n=131)

Bacterial Species	Male n=49 (%)	Female n=82 (%)	p-value
Escherichia coli	22 (44.9%)	52 (63.4%)	0.036*
Klebsiella pneumoniae	6 (12.2%)	10 (12.2%)	0.998
Proteus mirabilis	6 (12.2%)	7 (8.5%)	0.489
Pseudomonas aeruginosa	6 (12.2%)	4 (4.9%)	0.041*
Enterococcus faecalis	5 (10.2%)	4 (4.9%)	0.270
Staphylococcus saprophyticus	4 (8.2%)	5 (6.1%)	0.642

Klebsiella pneumoniae was significantly more prevalent among patients with diabetes mellitus (25.0%) compared to those without, with a p-value of 0.021, suggesting a strong association. Similarly, Pseudomonas aeruginosa showed a significantly higher frequency in patients with chronic kidney disease (22.2%) versus those without the condition (p = 0.019).

Table 4: Distribution of Selected Bacteria according to Comorbidities (n=131)

Bacterial Species	Diabetes Mellitus n=32 (%)	Chronic Kidney Disease n=18 (%)	p-value
Escherichia coli	17 (53.1%)	9 (50.0%)	0.781
Klebsiella pneumoniae	8 (25.0%)	3 (16.7%)	0.021*
Pseudomonas aeruginosa	2 (6.3%)	4 (22.2%)	0.019*

p-value ≤0.05 considered significant

Discussion

This study aimed to evaluate the species distribution and antibiotic susceptibility patterns of bacterial uropathogens isolated from patients with urinary tract infections (UTIs). A total of 131 patients were included, and *Escherichia coli* was the most frequently isolated organism (56.5%), followed by *Klebsiella pneumoniae* (12.2%), *Proteus mirabilis* (9.9%), *Pseudomonas aeruginosa* (7.6%), *Enterococcus faecalis* (6.9%), and *Staphylococcus saprophyticus* (6.9%). The predominance of *E. coli* supports established global trends, affirming its role as the leading uropathogen. Its higher prevalence among females (63.4%) compared to males (44.9%) was statistically significant (p=0.036), which is consistent with known anatomical and behavioral predispositions such as shorter urethra, improper hygiene practices, and hormonal factors in females [9]. On the other hand, *Pseudomonas aeruginosa* was significantly more common in males (12.2%) than females (4.9%, p=0.041), possibly linked to higher rates of urological instrumentation or chronic illnesses in men. Among patients with diabetes mellitus, *Klebsiella pneumoniae* was notably more prevalent (25.0%) compared to non-diabetic individuals (p=0.021). This association is likely due to immune dysregulation and glycosuria creating a favorable environment for growth of non-*E. coli* pathogens [10]. Similarly, *Pseudomonas aeruginosa* showed a significant association with chronic kidney disease (22.2% in CKD patients vs. 5.7% without CKD, p=0.019), reflecting its role as an opportunistic pathogen in patients with impaired host defenses and frequent catheter use. Analysis of bacterial antibiotic susceptibilities indicated widespread resistance among all examined species specially to established medications including Ampicillin, Ciprofloxacin and Trimethoprim-Sulfamethoxazole [11]. The bacterial resistance for E. coli against Ampicillin reached 75.7% and Ciprofloxacin showed 62.2% resistance. Urinary tract infection treatment by Nitrofurantoin (90.5%) and Meropenem (91.9%) remains effective based on their high sensitivity values when used as initial therapy [12]. Multiple studies have demonstrated Nitrofurantoin functions effectively as a medication for treating E. coli-associated UTIs by oral administration. The antibiotic resistance pattern of Klebsiella pneumoniae showed medium-level resistance to Ceftriaxone and Trimethoprim-Sulfamethoxazole but high sensitivity to Meropenem and Gentamicin [13]. Local antibiograms assume significance because they help identify emerging trends of Enterobacteriaceae multidrug resistance so healthcare professionals can use them to select proper initial medications. The first-line UTI treatment agents Ampicillin, Amoxicillin-Clavulanic Acid and Ceftriaxone showed poor effectiveness against Pseudomonas aeruginosa non-fermenters while Meropenem (100%) and Gentamicin (80%) proved highly sensitive [14]. Healthcare providers must develop specific treatment approaches because Pseudomonas infections usually appear in serious clinical situations [15]. The antibiotic agents Nitrofurantoin and Vancomycin showed excellent sensitivity against Uropathogens Staphylococcus saprophyticus and Enterococcus faecalis. Both bacterial species displayed resistance to Ciprofloxacin and Sulfamethoxazole so clinicians must exercise appropriate precaution when selecting these antibiotics for therapy [16]. Bacterial species composition together with their resistance patterns exhibited considerable variations based on both patient characteristics and accompanying health conditions [17]. The varying microbiological conditions push healthcare professionals to create person-centered antibiotic treatment strategies using available population data and specific patient characteristics [18]. The findings of this research were constrained by its focus on a single medical institution along with a small number of participant subjects. The research community needs to conduct additional testing across multiple centers that includes large patient groups to validate these results and obtain widespread applicability. Assessing molecular resistance mechanisms together with patient antibitoic exposure would have generated better understanding of evolving resistance patterns.

Conclusion

It is concluded that *Escherichia coli* remains the predominant uropathogen among patients diagnosed with urinary tract infections, followed by *Klebsiella pneumoniae* and *Proteus mirabilis*. The distribution of these pathogens varies significantly with gender and underlying comorbidities, with *E. coli* being more prevalent in females, while *Pseudomonas aeruginosa* is more common among males and patients with chronic kidney disease. A notable association was also found between diabetes mellitus and *Klebsiella pneumoniae* infections. Antibiotic resistance was alarmingly high against commonly prescribed antibiotics such as Ampicillin, Ciprofloxacin, and Trimethoprim-Sulfamethoxazole. In contrast, Nitrofurantoin, Amikacin, and Meropenem demonstrated higher sensitivity and may be preferred for empirical treatment, particularly in uncomplicated cases.

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