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ORIGINAL ARTICLE

Frequency of Urinary Tract Infections and Their Antibacterial Susceptibility among Chronic Kidney Disease Patients Undergoing Hemodialysis

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ABSTRACT

OBJECTIVE: To investigate the prevalence and antibiotic resistance of uropathogenic bacteria among chronic kidney disease (CKD) patients undergoing hemodialysis.

METHODOLOGY: This descriptive, cross-sectional study was conducted at Chandka Medical College, Larkana, from May 2023 to September 2024. Using a convenient sampling technique, the study included 187 patients diagnosed with CKD, aged between 15 and 74 years of both genders, undergoing hemodialysis, including those with stone disease, neurogenic bladder dysfunction, or urinary tract foreign bodies. Patients with a history of urinary tract malignancy, congenital anomaly of the urogenital tract, recent antibiotic use or unwillingness to participate were excluded. Data was collected via a structured questionnaire. Urine samples were cultured on CLED agar, and uropathogenic bacteria were identified using Gram staining and biochemical tests. Antibiotic susceptibility was determined using the Kirby-Bauer method, and data were analyzed with SPSS (24.0).

RESULTS: UTI was identified in 84 (45%) of samples; the most common pathogens were *E. coli* (42.8%), *Klebsiella* spp. (35.7%), and *Proteus spp*. (21.4%). The majority of patients (51.2%) were aged 50–60 years, with no significant difference in UTI occurrence between men and women. Antibacterial susceptibility testing showed that amikacin was the most effective, demonstrating 100% sensitivity for *E. coli* and *Klebsiella spp*. High resistance rates were found for antibiotics such as Ceftazidime, Norfloxacin, and Amoxicillin.

CONCLUSION: This study demonstrated that *E. coli* remained the most common pathogen of UTIs. The study also shows rising antibiotic resistance (AR), underscoring the importance of antibiotic stewardship and regular susceptibility testing to improve antibacterial therapy.

KEYWORDS: Chronic kidney disease, Urinary tract Infections, Uropathogenic bacteria, E. *coli*, Hemodialysis, Antibiotic resistance.

INTRODUCTION

CKD is described as a persistent irreversible derangement of kidney function, along with elevated serum creatinine levels for >3 months or the calculated glomerular filtration rate (GFR) <60 mL/min/1.73m^2. CKD is classified based on staging and grading[1]. The risk factors for the development of CKD consist of diabetes mellitus type 2, glomerulonephritis, hypertension, polycystic kidney diseases, renal vascular diseases, nephrolithiasis and vesicoureteral reflux[2].

CKD patients undergoing hemodialysis are at an increased risk of developing UTIs due to several interrelated factors. CKD is associated with immune system dysfunction, including reduced leukocyte activity and altered cytokine production, which diminishes the body's ability to combat infections effectively[3]. In males with CKD on hemodialysis, additional factors such as prostatic enlargement contribute to urinary stasis, creating a favorable environment for microbial growth and recurrent infections[4].

E. coli, *Klebsiella spp*., *Proteus mirabilis*, *S. saprophyticus*, and *S. aureus* are common uropathogens, with *E. coli* being the most prevalent. While antibiotics are the standard treatment for UTIs, increasing multidrug resistance (MDR) among uropathogens, particularly in CKD patients, complicates therapeutic strategies[5].

METHODOLOGY

This descriptive study was conducted at the Department of Pathology and the Nephrology Department at the Chandka Medical College at Shaheed Mohtarma Benazir Bhutto Medical University in Larkana between May 2023 to September 2024. The institutional review board (IRB) approved the study (Registration No.SMBBMU/OFF ERC/230). The study employed convenient sampling to enrol 187 CKD patients aged 15–74 years, of both genders, undergoing hemodialysis, including individuals with stone disease, neurogenic bladder dysfunction, or urinary tract foreign bodies. Patients with a history of urinary tract malignancy, congenital urogenital anomalies, recent antibiotic use, or those unwilling to participate were excluded. For demographic data, informed consent was obtained from all participants, adhering to ethical research standards.

A 10–30 ml random clean-catch midstream sample was obtained in sterile containers, labeled, and promptly transported to the Microbiology Lab at Chandka Medical College, Larkana, for immediate processing to preserve any uropathogenic bacteria.

Urine specimens were inoculated onto CLED agar using a calibrated 1 µl wire loop for accurate colony counting. Plates were incubated at 37°C for 24–48 hours to promote bacterial growth. After incubation, colonies were visually examined and categorized as significant or non-significant based on colony count. Colonies were identified using morphology, Gram staining, and biochemical tests. Following identification, antibiotic resistance was assessed by the Kirby-Bauer disc diffusion method on Mueller-Hinton Agar, with results interpreted using Clinical Laboratory Standards Institute (CLSI) and zone diameter criteria (2009). Data was analyzed using SPSS (24.0) software**.**

RESULTS

In this study, 187 urine culture samples from CKD patients undergoing HD were investigated. The detection rate for Gram-negative organisms was 84 samples, resulting in a prevalence rate of approximately 45%. The remaining 103 samples, constituting 55%, showed no bacterial growth, underscoring the overall frequency of UTIs within this patient cohort. Among the 84 culture-positive samples, *E.coli* was identified as the most prevalent uropathogen, occurring in 36 cases, which corresponds to a frequency of 42.8%. *Klebsiella spp*. was found in 30 samples, representing a frequency of 35.7%, and Proteus spp. was detected in 18 cases, indicating a frequency of 21.4%.

The study shows a significant concentration of CKD patients aged 50-60 years, accounting for 51.2% (**Table I**) of the sample, highlighting this age group's vulnerability to UTIs. In contrast, younger patients (20-30 years and 30-40 years) represent a smaller percentage of the population.

Table I: Demographic and Comorbidity Profile of Patients with CKD

Category	Subcategory	No. of Patients	Proportion (%)
Age Distribution	20-30 years	9	10.71
	30-40 years	8	9.52
	40-50 years	8	9.52
	50-60 years	43	51.2
	60-70 years	16	19.06
Gender Distribution	Male	39	46.43
	Female	45	53.57
Residence	Rural	62	73
	Urban	22	26
Comorbidities	Diabetes Mellitus	29	34.52
	Hypertensive Disease	23	27.38
	Renal Stones	17	20.24
	Post-partum Hemorrhage	15	17.86

The gender analysis indicates a near-equal distribution of males (46.43%) and females (53.57%) (**Table I)**, with a chi-square test revealing no statistically significant difference in UTI incidence between genders ($p = 0.513$). This suggests that neither gender has an apparent predisposition to UTIs within this patient group.

The findings show a higher prevalence of UTIs among patients from rural areas (73%) compared to urban residents (26%) (**Table I)**. This highlights the potential impact of geographical and environmental factors on UTI incidence in CKD patients.

The data indicate that among patients with diabetes, females experience a higher rate of UTIs than males (**Table I)**. In cases of renal stones, there is a marked male predominance in UTI incidence. Additionally, all female patients with a history of post-partum hemorrhage were diagnosed with UTIs, suggesting a possible link that warrants further investigation.

ABS profiles of *E. coli* isolated from UTIs revealed varying sensitivity. Amikacin showed the highest sensitivity (100%), followed by Fosfomycin (58%), tobramycin (75.8%), and gentamicin

(63.6%). Intermediate susceptibility was observed for cefepime (39.4%) and Ciprofloxacin (29.4%). Several antibiotics, including Norfloxacin, Cefaclor, Amoxicillin, Cephradine, and Cefoperazone, showed low susceptibility, with all isolates resistant to the first four and 72.7% resistant to Cefoperazone. Ceftazidime and Augmentin exhibited resistance rates of 60.6% and 35.7%, respectively, indicating emerging resistance (**Figure I**).

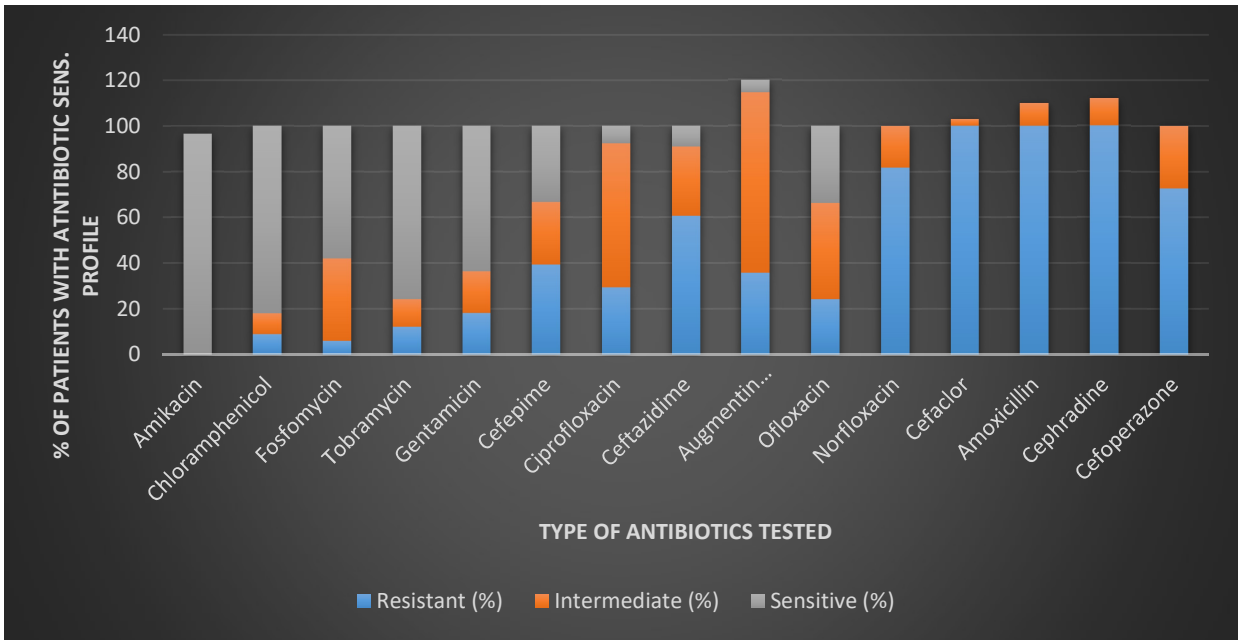

Figure I. Antibacterial sensitivity profile of *E. coli* against different antibiotics

Klebsiella spp. isolates showed complete sensitivity (100%) to Amikacin and Chloramphenicol. Fosfomycin had a moderate sensitivity rate (30%). Intermediate susceptibility was seen for tobramycin, gentamicin, cefepime, and Ciprofloxacin, with rates ranging from 9% (Cefepime) to 16% (Ciprofloxacin). High resistance was observed for Ceftazidime, Norfloxacin, Cefaclor, Amoxicillin, Cephradine, and Cefoperazone, with complete resistance to ceftazidime (100%) (**Figure II**).

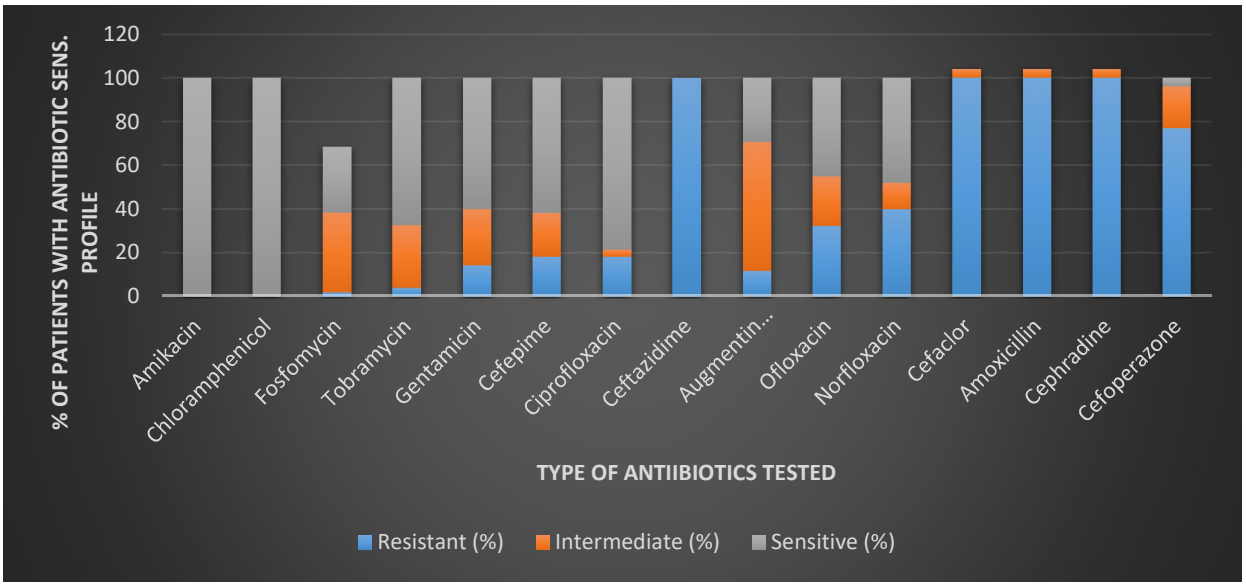

Figure II. Antibacterial sensitivity profile of *Klebsiella spp.* against different antibiotics

Proteus isolates exhibited high susceptibility to amikacin and chloramphenicol (<2% resistance). Fosfomycin showed moderate sensitivity (70%), while tobramycin and gentamicin had sensitivities of 76% and 52.2%, respectively. Intermediate susceptibility was noted for cefepime, Ciprofloxacin, and Augmentin, ranging from 14.8% (Ciprofloxacin) to 33.3% (cefepime). High resistance was found for Norfloxacin, Cefaclor, Amoxicillin, and Cephradine, with complete resistance (100%) (**Figure III**).

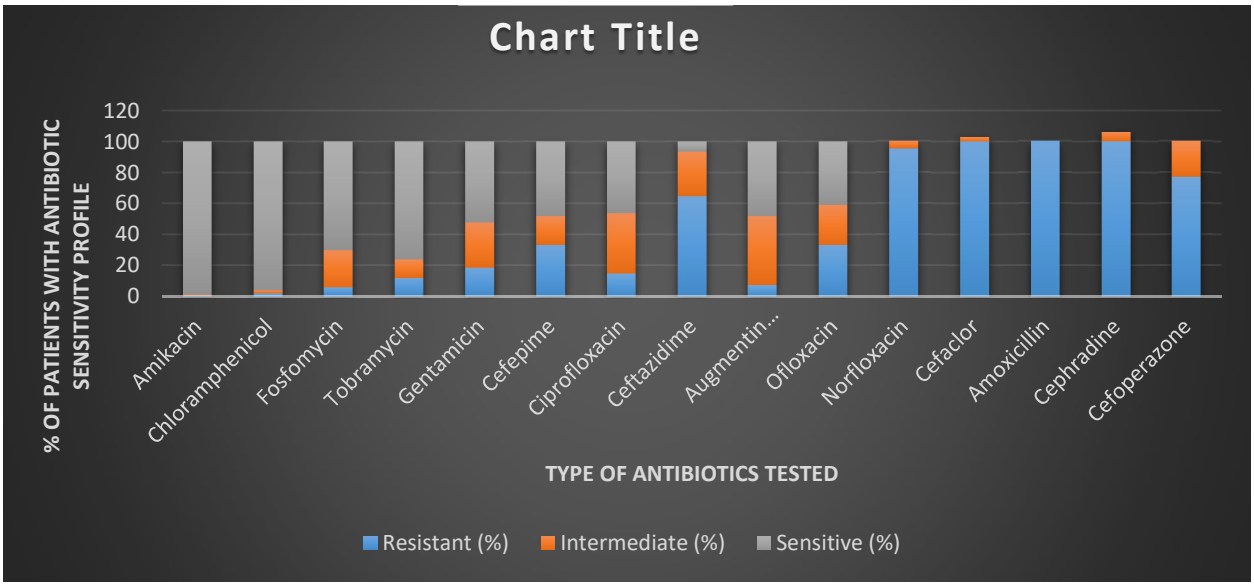

Figure III. Antibacterial sensitivity profile of *Proteus spp*. against various antibiotics

DISCUSSION

UTI is a term applied to a variety of clinical conditions ranging from the asymptomatic presence of bacteria in the urine to severe kidney infection with resultant sepsis[6]. CKD is considered a global public health burden, particularly in low- and middle-income countries[7,8].

The predominance of *E. coli* observed in our cohort aligns with global trends, identifying it as the leading cause of UTIs across various patient populations. Supporting these findings, a recent cross-sectional study conducted among 326 diagnosed CKD patients in the Department of Nephrology at Bangabandhu Sheikh Mujib Medical University reported that 79.4% of bacterial isolates were predominantly Gram-negative[9,10]. *E. coli* also emerged as the predominant pathogen in this study. This finding aligns with existing literature that frequently identifies *E. coli* as the leading cause of UTIs[11].

Demographically, the concentration of UTIs among CKD patients aged 50–60 years highlights the vulnerability of older adults. Older adults with kidney disease are more prone to infections due to weakened immune systems and other health issues common with age[12]. This finding highlights the need for targeted monitoring and preventive strategies in older CKD patients.

The absence of significant gender differences in UTI prevalence in this study supports literature suggesting that, among CKD patients, traditional gender-related anatomical risk differences may be attenuated by overriding factors such as overall health and lifestyle, which might be more influential in determining UTI risk for individuals with kidney disease[13].

Geographic disparities emerged prominently in this study, with a markedly higher prevalence of UTIs among patients residing in rural areas, suggesting barriers to healthcare access in rural areas, which can delay diagnosis and treatment of infections, potentially exacerbating health outcomes[14]. This finding calls for further investigation into the barriers faced by rural CKD patients in accessing timely medical care.

It was observed that diabetes in women was associated with increased UTI risk, while kidney stones were more strongly associated with UTIs in men. These findings align with existing knowledge that the impact of diabetes on increased UTI risk is well-established, as hyperglycemia can impair immune function and facilitate bacterial growth[15]. Furthermore, the complete diagnosis of UTIs in all female patients with a history of post-partum hemorrhage suggests a potential connection that warrants further exploration in future studies.

The antimicrobial susceptibility analysis of *E. coli* isolates revealed a clear gradient of effectiveness across tested agents. Amikacin exhibited complete sensitivity (100%), reaffirming its role as a reliable first-line therapy, consistent with prior studies highlighting its sustained activity even against resistant strains[16]. The moderate susceptibility observed for Fosfomycin, tobramycin, and gentamicin suggests they can still be helpful in some cases. In contrast, Cefepime and Ciprofloxacin had lower susceptibility, reflecting the global rise in resistance to fluoroquinolones and cephalosporins due to mutations in target enzymes and β-lactamase production[18]. These antibiotics are commonly used for treating UTIs, and the relatively low susceptibility rates cause serious concern[17].

Furthermore, several antibiotics, including norfloxacin, cefaclor, amoxicillin, Cephradine, and Cefoperazone, demonstrated low susceptibility, with high resistance rates observed. Ceftazidime and Augmentin also showed significant resistance. This is consistent with studies showing that overuse of these agents in both clinical and community settings has led to the evolution of resistant strains[19]. This indicates a growing challenge in using these antibiotics due to increasing resistance among *E. coli* strains.

The susceptibility profiles of *Klebsiella spp.* Isolates revealed both reassuring and concerning patterns. Amikacin and chloramphenicol demonstrated complete sensitivity (100%), corroborating previous reports of their sustained efficacy against *Klebsiella pneumoniae* infections[21]. However, Fosfomycin showed moderate sensitivity, indicating that these antibiotics may still be viable options in some cases, although their effectiveness can vary based on local resistance patterns. The moderate sensitivity to Fosfomycin is also consistent with other reports, which have noted varying susceptibility rates for this antibiotic among *Klebsiella isolates*[22]. Notably, high resistance rates were observed against several commonly used antibiotics, with ceftazidime showing complete ineffectiveness—an alarming finding given its frequent use for *Klebsiella* infections[23]. These findings highlight the challenges in treating *Klebsiella spp*. Infections with standard antibiotics are due to widespread resistance.

The susceptibility patterns of *Proteus spp.* revealed notable contrasts. Amikacin and chloramphenicol maintained excellent efficacy, with resistance rates below 2%, consistent with prior studies reporting sensitivity exceeding 95%[24,25]. Similar to *E. coli* and *Klebsiella*, Fosfomycin demonstrated moderate sensitivity, suggesting a role in selective cases. Intermediate susceptibility was observed for Cefepime, Ciprofloxacin, and Augmentin, indicating potential but limited use in treatment. High resistance rates were observed for Norfloxacin, Cefaclor, Amoxicillin, and Cephradine, with complete resistance noted in some cases. Studies have consistently shown high resistance rates among *Proteus* isolates to these antibiotics, particularly in healthcare settings where antibiotic use is more prevalent[26, 27]. This underscores the challenge in using these antibiotics effectively against *Proteus spp*[28]. The findings underscore the dynamic nature of AR among uropathogens, necessitating ongoing surveillance and targeted antimicrobial stewardship efforts. Tailored treatment strategies based on local resistance patterns are crucial to optimize therapeutic outcomes and mitigate the spread of resistance in clinical settings.

CONCLUSION

This study shows that UTIs are a common problem for people with kidney disease who are on dialysis. It was found that almost half of the patients studied in this research had a bacterial infection, most often caused by *E. coli*, followed by *Klebsiella and Proteus*. While Amikacin demonstrated continued efficacy, concerning levels of resistance were observed for commonly prescribed antibiotics, including Ceftazidime, Norfloxacin, and Amoxicillin. This resistance complicates the treatment of UTIs in CKD patients, making it imperative for healthcare providers to implement regular ABS testing and adhere to antimicrobial stewardship principles.

Abbreviations: Chronic kidney disease (CKD), Urinary Tract Infections (UTIs) End-stage renal disease (ESRD), Uropathogenic *E. coli (*UPEC), Cysteine-lactose electrolyte deficient (CLED), Mueller-Hinton Agar (MHA), Antibacterial susceptibility (ABS), Confidence Interval (CI), Null hypothesis (HO), Hypertension (HTN), Statistical Package for Social Sciences (SPSS), Post-partum hemorrhage (PPH), Diabetes Mellitus (DM)

Ethical permission: Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan, ERC letter No. SMBBMU/OFF ERC/230.
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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Memon H: Conducted the experiments, collected and analyzed the data, and prepared the initial draft of the manuscript.
Parkash O: Conceptualized the study, supervised the research activities, and reviewed and edited the manuscript.
Gemnani VK: Contributed to the methodology and provided supervision for data collection and analysis.

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