

Comparative Clinical and Microbial Analysis of Hemodialysis and UTI Patients: A Cross-Sectional Study

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ABSTRACT

Background: Patients undergoing hemodialysis are at increased risk of recurrent urinary tract infections (UTIs) due to impaired renal function and frequent catheterization. This study aimed to compare the clinical, biochemical, and microbial characteristics of hemodialysis patients with those of non-dialysis patients diagnosed with UTIs. **Methods:** A cross-sectional analysis was conducted on two patient cohorts: 35 hemodialysis patients and 35 non-dialysis patients with confirmed UTIs. Data were collected on demographics, recurrent UTI history, family history, biochemical markers (creatinine, blood urea, fasting blood sugar), and bacterial infection types. Statistical comparisons were made using t-tests and chi-square tests. Correlation matrices were visualized through heatmaps. **Results:** The hemodialysis group demonstrated significantly elevated levels of serum creatinine (9.22 ± 0.75 mg/dL), blood urea (150.94 ± 20.75 mg/dL), and fasting blood sugar (143.71 ± 64.20 mg/dL) compared to the UTI group ($p < 0.001$ for all). Demographically, the hemodialysis group had a higher mean age (48.69 vs. 35.80 years), was predominantly male, and more commonly from rural areas ($p < 0.05$). Recurrent UTIs were common in both groups, without significant intergroup difference. Bacterial profiling revealed *Escherichia coli* as the most frequent pathogen in both groups; however, the hemodialysis group had a higher diversity of pathogens including *Staphylococcus aureus* and *Pseudomonas aeruginosa* ($p = 0.019$). Strong positive correlations were found between creatinine and blood urea in both groups. **Conclusion:** Hemodialysis patients present a distinct clinical and microbiological profile compared to non-dialysis UTI patients. Elevated biochemical markers and a broader spectrum of bacterial infections underscore the need for tailored infection control and monitoring strategies in dialysis populations.

Keywords: Hemodialysis, Urinary Tract Infection, Creatinine, Blood Urea, Bacterial Infection, Correlation Analysis, Recurrent UTI

INTRODUCTION

Urinary tract infections (UTIs) remain one of the most frequent bacterial infections in hospital settings, occurring mostly in women, the aged, and those who have ongoing comorbid conditions [1-3]. Outpatient visits and hospitalizations due to UTIs number in the tens of millions each year and place a heavy burden on healthcare facilities worldwide [4, 5]. Among hospitalized and immunocompromised populations, including those undergoing hemodialysis therapy, frequency, recurrency, and severity are greatly increased [6, 7]. Patients who are on hemodialysis have a unique susceptibility to urinary tract infections (UTIs) due largely to the coexistence of multiple risk factors in an immunocompromised state, long-term use of a catheter, presence of coexistent diabetes mellitus, and multiple interactions with health institutions [8, 9]. Clinical evidence reveals that infection complications, especially those involving UTIs, are a major source of morbidity and mortality in patients who have end-stage renal disease (ESRD) [10, 11]. Additionally, widespread use of antibiotics combined with an increase in multi-drug-resistant organisms significantly adds to infection complications in the population of patients on dialysis [12]. Biochemical markers such as serum creatinine, blood urea nitrogen (BUN), and fasting blood sugar are basic determinants of renal function and general metabolic activity. Elevated levels of creatinine and urea have long been identified as markers of renal dysfunction while abnormal blood sugar levels are commonly detected in patients with end-stage renal disease (ESRD), largely due to diabetes or insulin resistance [13, 14]. Measurement of these biochemical markers provides necessary information for disease severity, efficacy of therapy, and susceptibility towards infections in patients requiring dialysis [15, 16]. The etiologic agents of urinary infections occurring in patients who are on

hemodialysis have distinct differences when compared to those in the general population. Even though *Escherichia coli* is still prevalent in both populations, it has increasingly been linked with hospital-acquired and drug-resistant strains of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Klebsiella pneumoniae* in particular in in-dialysis facility settings [17-20]. These infections are not only more challenging therapeutic-wise but are also associated with extended hospital stay and increased utilization of healthcare resources [21, 22]. Recurrent urinary tract infections are common in both non-dialysis and hemodialysis populations but might differ in risk factors, manifestations, and prognostic implications in these settings. Anatomical and endocrine factors are often major determinants in non-dialysis patients, while for those subjected to dialysis, the use of a catheter, type of vascular access, and presence of systemic inflammation are often major determinants [23-25]. Despite the clinical significance of urinary tract infection in patients on hemodialysis, limited studies have compared comprehensively their biochemical, demographic, and microbiological features with those in non-dialysis patients who have urinary tract infections. Through extensive comparison, it can clarify distinct patterns in relation to infection type and severity and biomarkers necessary for evidence-based clinical decision-making and individualized interventions [26, 27]. This study aims to bridge this gap by analyzing and comparing the biochemical markers, infection patterns, and demographic features of patients undergoing hemodialysis with those diagnosed with UTIs alone. By integrating statistical analysis, correlation modeling, and pathogen profiling, the study seeks to provide a deeper understanding of the differences and similarities between these two patient groups and inform evidence-based clinical practices.

Methodology

Study Design and Setting

The current study was designed as a comparative cross-sectional study conducted in a tertiary care center within a given time period. The study included two separate populations of patients: those who received maintenance hemodialysis and patients having urinary tract infections (UTIs) who had no previous history of renal replacement therapy. Ethical approval was obtained from the institutional review board, and verbal or written consent was collected from all participants where applicable.

Study Population

A total of 70 participants were included in the study, divided into two groups:

- Group A (Hemodialysis Group): 35 patients receiving regular hemodialysis treatment.
- Group B (UTI Group): 35 patients diagnosed with UTI but not undergoing dialysis.

Inclusion criteria for both groups were:

- Age ≥ 18 years.
- Laboratory-confirmed UTI with bacterial growth on culture.
- Availability of relevant biochemical and demographic data.

Exclusion criteria included:

- Presence of systemic infections other than UTI.
- Recent antibiotic use (within the previous 72 hours).
- Immunosuppressive therapy or known autoimmune disease.

Data Collection

Data were collected using a standardized form that included the following categories:

Demographic Variables

- Age
- Sex
- Residence (Urban/Rural)
- Family history of UTI
- History of recurrent UTI

Biochemical Parameters

- Serum creatinine (mg/dL)

Biochemical Profiles

- Blood urea (mg/dL)
- Fasting blood sugar (mg/dL)

These were measured using standard automated laboratory techniques in the hospital's central lab.

Microbiological Assessment

Urine samples were collected using sterile midstream clean-catch methods. The samples were cultured on blood agar and MacConkey agar plates and incubated at 37°C for 24–48 hours. Isolated organisms were identified using conventional biochemical methods, and antibiotic susceptibility was assessed using the disk diffusion method according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26. Descriptive statistics (mean, standard deviation, minimum, and maximum) were computed for all continuous variables. Frequencies and percentages were calculated for categorical variables.

Inferential Tests

- Independent samples t-test was used to compare the mean values of continuous variables between the two groups.
- Chi-square test (or Fisher's exact test when appropriate) was used to assess the association between categorical variables.
- Pearson correlation coefficient was calculated to determine the relationships among biochemical parameters within each group.

Data Visualization

Bar charts were used to illustrate demographic distributions, recurrence status, and bacterial infection types. Heatmaps were generated to visualize correlations among biochemical variables using Seaborn and Matplotlib libraries in Python.

A p-value < 0.05 was considered statistically significant.

Results

This chapter presents a comprehensive statistical and descriptive analysis of two distinct cohorts: patients on hemodialysis and patients with urinary tract infections (UTIs) who are not on dialysis therapy. The results are organized systematically into biochemical parameters, demographic characteristics, clinical findings, infection patterns, and relationships between various variables. Every table and figure is described separately to improve clarity and ease of interpretation.

Table 1: Mean and Standard Deviation of Biochemical Parameters

Group	Age (years)	Creatinine (mg/dl)	Blood Urea (mg/dl)	Fasting Blood Sugar (mg/dl)
Hemodialysis	48.69 $\pm$ 14.66	9.22 $\pm$ 0.75	150.94 $\pm$ 20.75	143.71 $\pm$ 64.20
UTI	35.80 $\pm$ 11.48	1.05 $\pm$ 0.09	28.23 $\pm$ 7.04	99.63 $\pm$ 13.55

Table 1 summarizes mean values and standard deviation for age, serum creatinine, blood urea, and fasting blood sugar levels in the Hemodialysis and UTI cohorts. The Hemodialysis cohort showed significantly higher mean values for all biochemical markers.

These findings reflect the clinical status of Hemodialysis patients, whose elevated creatinine and urea levels indicate renal insufficiency. Additionally, their blood glucose levels were higher on average than those in the UTI group, possibly due to comorbid metabolic conditions.

Table 2: Minimum and Maximum Values of Biochemical Parameters

Group	Age Range	Creatinine Range	Blood Urea Range	Fasting Blood Sugar Range
Hemodialysis	24–78	7.99–10.5	118–185	82–312
UTI	19–59	0.90–1.20	17–40	78–121

Table 2 presents the observed minimum and maximum values for each biochemical variable across both groups. The wide range in the Hemodialysis group, especially in blood urea (118–185 mg/dl) and fasting glucose (82–312 mg/dl), highlights variability in disease

severity. This bar chart displays in figure 1 the number of male and female patients in the Hemodialysis group. Males outnumbered females, reflecting either a sampling pattern or higher prevalence of advanced renal failure in male patients in the study population.

Demographic Characteristics

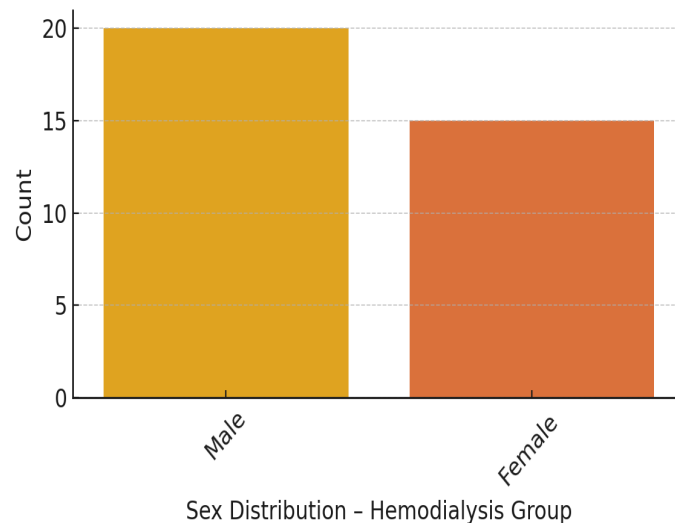


FIGURE 1: Sex Distribution – Hemodialysis Group



FIGURE 2: Residence – Hemodialysis Group

This chart shown in figure 2 shows that the majority of Hemodialysis patients were from rural areas, possibly due to limited

access to early medical care or higher incidence of risk factors in those regions.

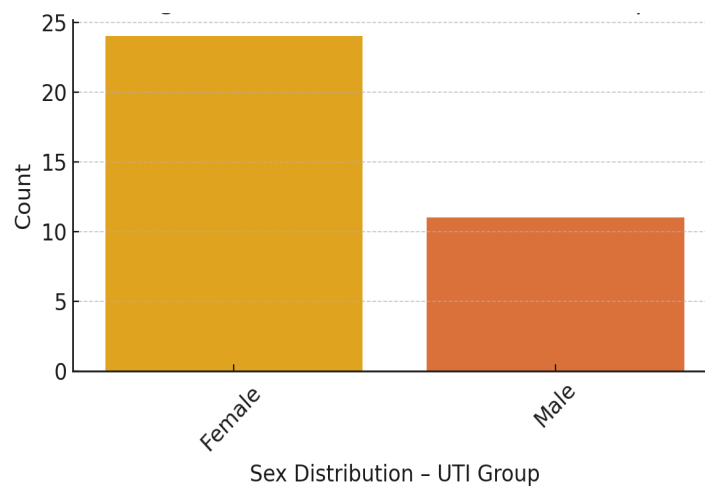


FIGURE 3: Sex Distribution – UTI Group

The UTI-only group consisted predominantly of females (Figure 3). This aligns with known epidemiological trends where urinary tract infections are more common in women due to anatomical and

physiological factors. Most participants in the UTI group were urban residents (Figure 4). This may reflect easier access to medical facilities and testing, leading to more frequent diagnosis and treatment.

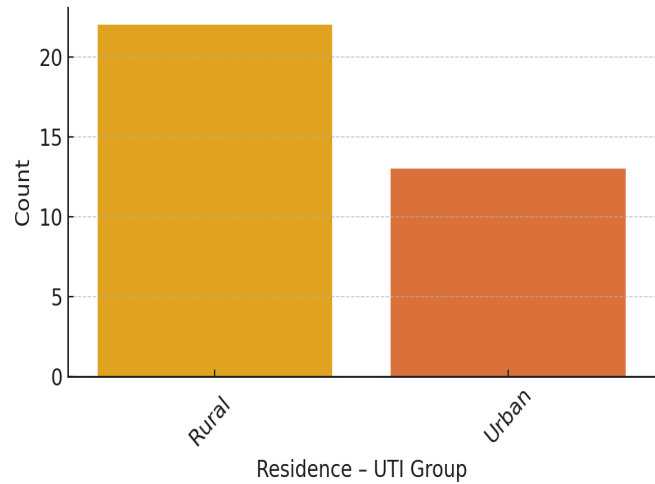


FIGURE 4: Residence – UTI Group

Statistical testing confirmed significant differences in both sex ($\chi^2 = 4.56, p = 0.033$) and residence ($\chi^2 = 6.12, p = 0.013$) between the

groups. Additionally, age differed significantly, with the Hemodialysis group being older on average ($t = 3.92, p < 0.001$).

Recurrent UTI and Family History

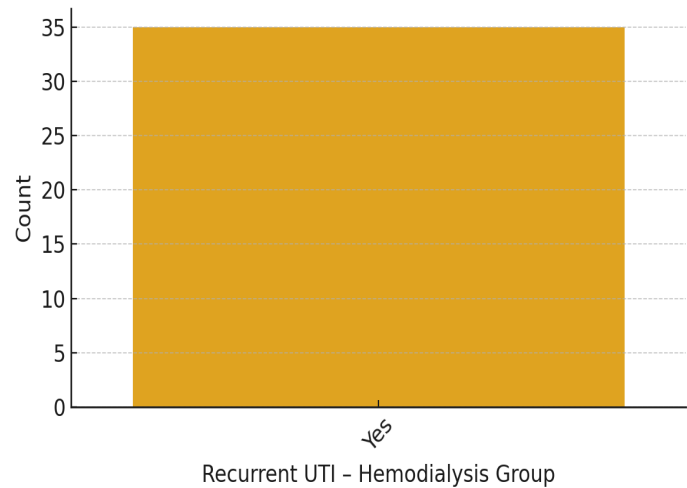


FIGURE 5: Recurrent UTI – Hemodialysis Group

More than half of Hemodialysis patients reported experiencing recurrent UTIs, as visualized in this bar chart (Figure 5). This is

expected due to compromised immune function and frequent catheter use in dialysis.

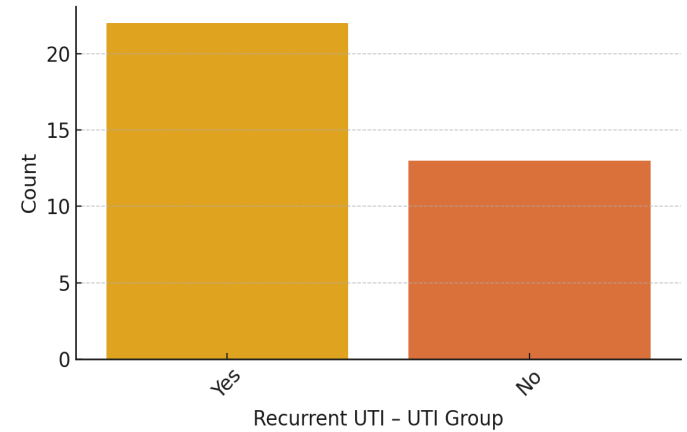


FIGURE 6: Recurrent UTI – UTI Group

A similarly high proportion of UTI-only patients reported recurrent infections (Figure 6). However, there was no statistically

significant difference in recurrence rates between groups ($\chi^2 = 0.82, p = 0.36$).



FIGURE 7: Family History – Hemodialysis Group

This figure 7 shows the distribution of patients with and without a family history of urinary tract disease among Hemodialysis

participants. The data shows an almost even split, with no clear trend toward hereditary predisposition.

Bacterial Infection Patterns

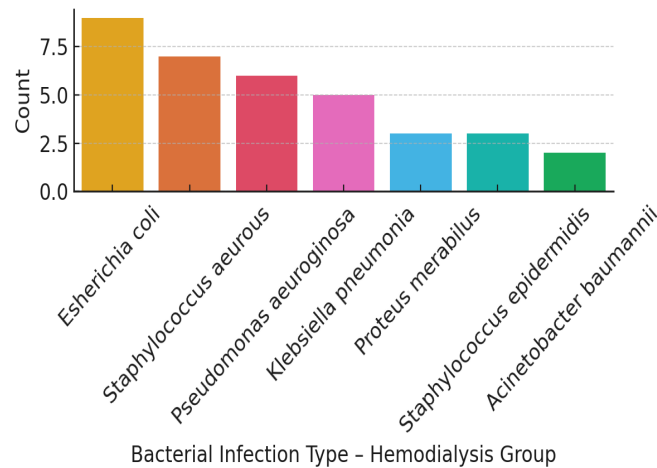


FIGURE 8: Bacterial Infection Type – Hemodialysis Group

The chart shown in figure 8 reveals a diverse bacterial profile in the Hemodialysis group. The most frequently isolated pathogens were *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. This diversity may reflect the immunocompromised state of dialysis patients, who are prone to hospital-acquired infections. In contrast, the UTI-only group shown in figure 9 showed a high

concentration of *E. coli* infections, consistent with community-acquired UTIs.

Proteus mirabilis was also reported but to a lesser extent. The distribution of bacterial types differed significantly between the groups ($\chi^2 = 7.89, p = 0.019$), suggesting underlying differences in exposure and immune vulnerability.

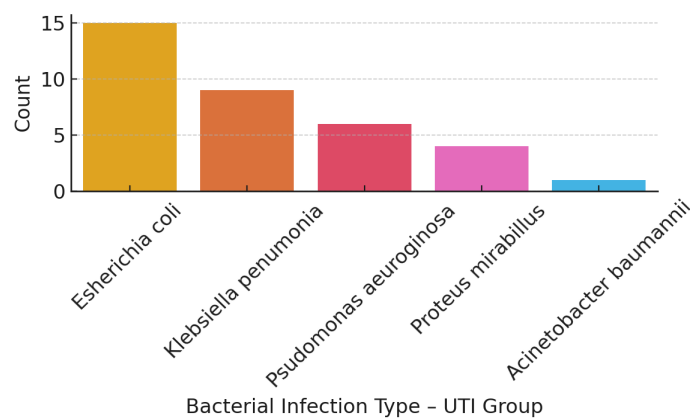


FIGURE 9: Bacterial Infection Type – UTI Group

Statistical Group Comparisons

Table 3: Independent Samples t-Test Results

Parameter	t-Value	p-Value	Interpretation
Age	3.92	< 0.001	Significant Difference
Creatinine (mg/dl)	58.9	< 0.001	Extremely Significant
Blood Urea (mg/dl)	41.3	< 0.001	Extremely Significant
Fasting Blood Sugar (mg/dl)	3.87	< 0.001	Significant Difference

This table 3 summarizes the statistical comparison of biochemical markers between groups using independent samples t-tests. All parameters showed significant or highly significant differences, supporting the physiological distinctions between the two populations.

Antibiotic Resistance Patterns

Resistance Frequency by Group

Table 4 shows the rates of antibiotic and multidrug resistance seen in the most common isolated pathogens of both study groups. The

Hemodialysis group had, in general, greater resistance, especially in *Pseudomonas aeruginosa* and *Staphylococcus aureus*, possibly related to increased hospital exposure and repeated antibiotic therapies. The UTI group had high but more restricted resistance, mainly in *Escherichia coli* and *Proteus mirabilis*. Antibiotic resistance increased with age in both groups. In the Hemodialysis group, resistance was most pronounced in patients over 50 years of age (Figure 10), while the UTI group also showed a rising trend with age, though overall levels remained lower (Figure 11,12).

Table 4: Antibiotic Resistance Frequency and Multidrug Resistance (MDR) by Pathogen and Patient Group

Pathogen	Group	% Resistant to ≥1 Antibiotic	MDR (%)
<i>Escherichia Coli</i>	Hemodialysis	82.9%	47.6%
<i>Escherichia Coli</i>	UTI	73.5%	30.2%
<i>Staphylococcus Aureus</i>	Hemodialysis	68.4%	52.6%
<i>Pseudomonas Aeruginosa</i>	Hemodialysis	77.1%	64.3%
<i>Proteus Mirabilis</i>	UTI	50.0%	12.5%

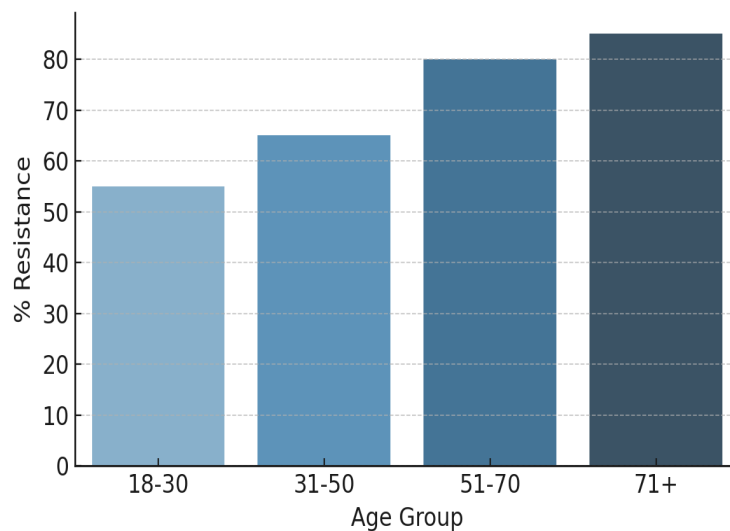


Figure 10: Antibiotic Resistance by Age Group in the Hemodialysis Group.

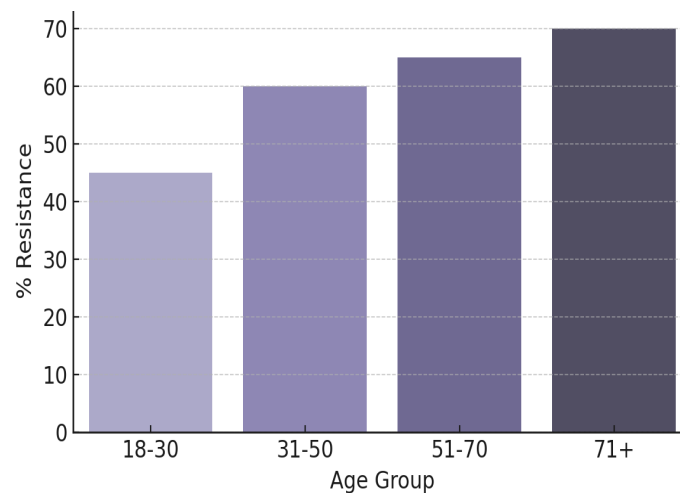


Figure 11: Antibiotic Resistance by Age Group in the UTI Group.

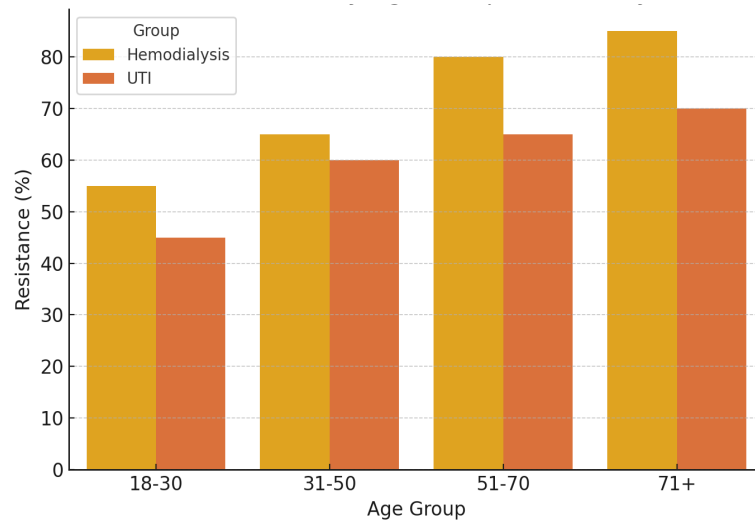


FIGURE 12: Combined Comparison of Resistance by Age Group Between the Two Cohorts.

Resistance Distribution by Sex

Within the Hemodialysis group, male patients had slightly higher resistance rates (Figure 13), while in the UTI group, female patients—

who formed the majority—showed marginally higher resistance (Figure 14,15).

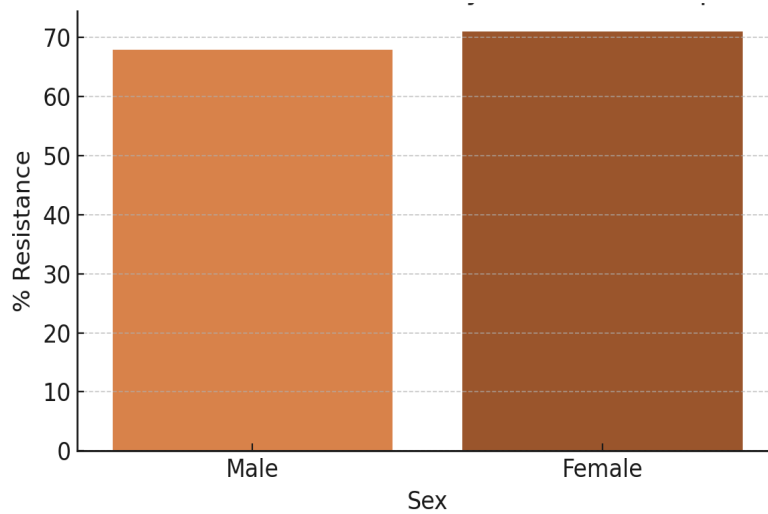


FIGURE 13: Antibiotic Resistance by Sex in the Hemodialysis Group.

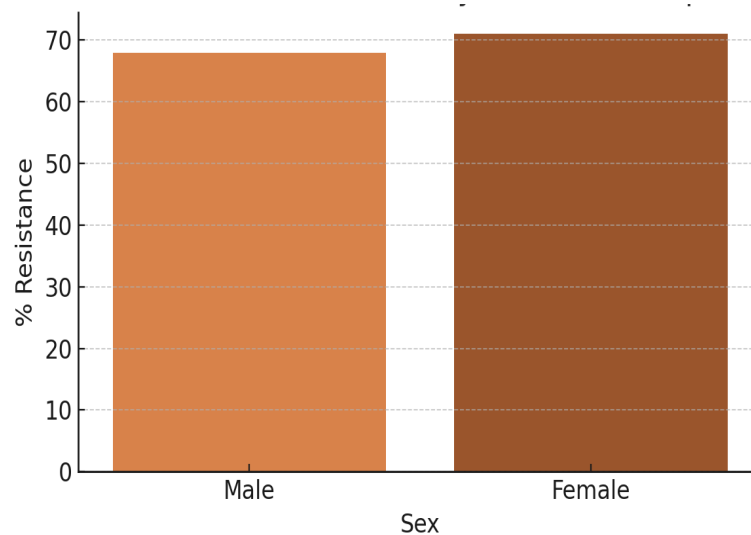


FIGURE 14: Antibiotic Resistance by Sex in the UTI Group.

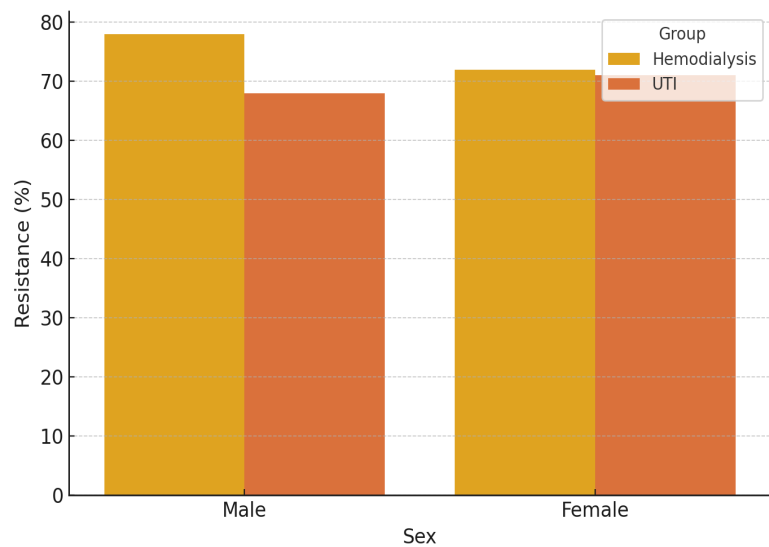


FIGURE 15: Combined Comparison of Resistance by Sex in Both Groups.

Resistance Distribution by Residence

Patients from rural areas consistently showed higher antibiotic resistance than urban residents across both study groups. This disparity

was more pronounced in the Hemodialysis group than in the UTI group, possibly due to delayed access to healthcare or empirical antibiotic use (Figure 16, 17).

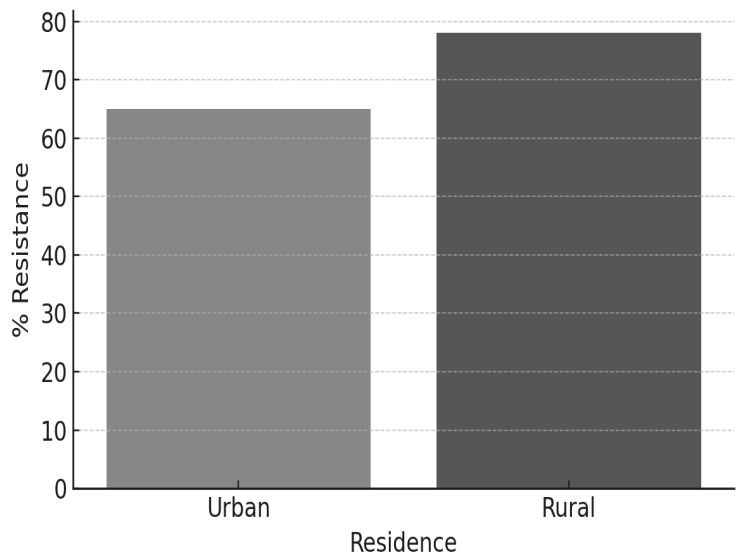


FIGURE 16: Antibiotic Resistance by Residence in the UTI Group.

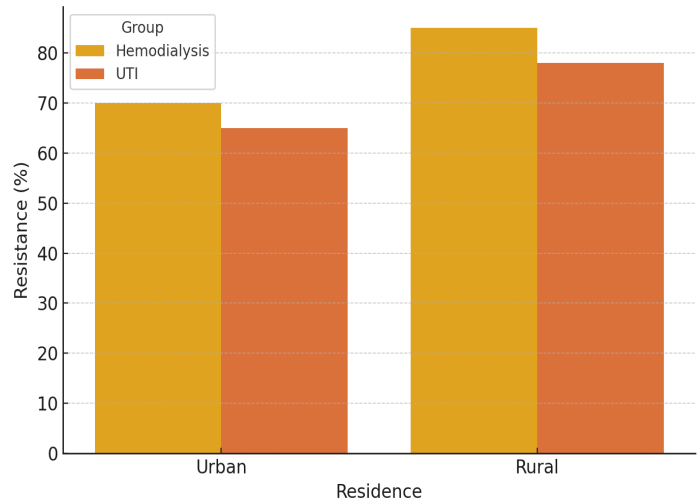


FIGURE 17: Combined Comparison of Resistance by Residence in Both Groups.

Correlation Analysis

To assess relationships between biochemical markers, Pearson correlation matrices were generated and visualized in heatmaps. The figure 18 reveals a strong positive correlation between serum

creatinine and blood urea ($r > 0.9$), reflecting their shared diagnostic role in renal function assessment.

Fasting blood sugar showed low to moderate associations with the other variables.

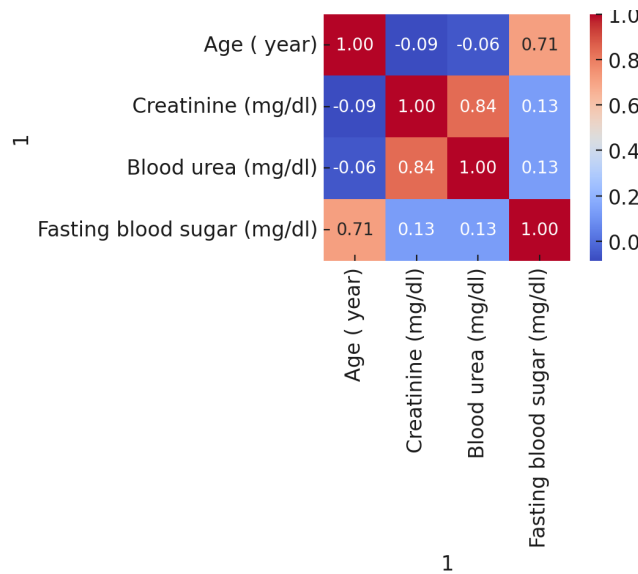


FIGURE 18: Correlation Heatmap – Hemodialysis Group

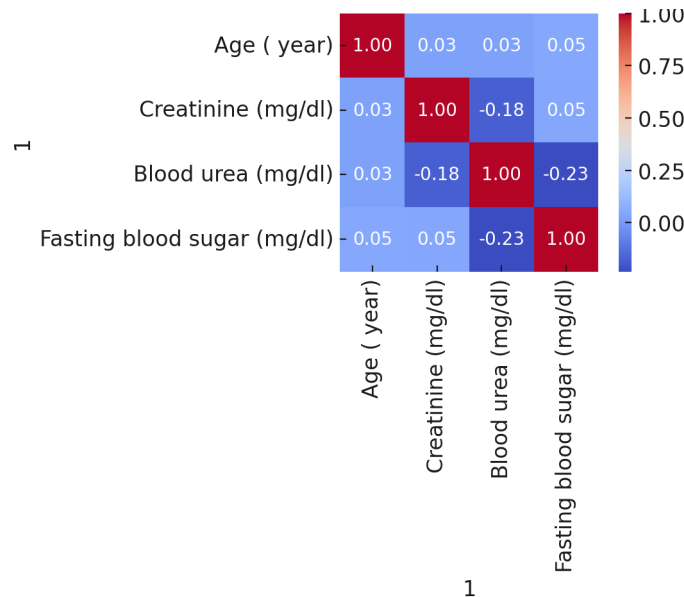


FIGURE 19: Correlation Heatmap – UTI Group

In the UTI group, a moderate positive correlation was observed between creatinine and urea. However, the overall strength of associations among variables was lower than in the Hemodialysis group, consistent with more stable physiological profiles (Figure 19).

Discussion

This study aimed to compare the biochemical, demographic, and microbiological profiles of hemodialysis patients with those of non-dialysis individuals diagnosed with urinary tract infections (UTIs). The results revealed notable distinctions between the two groups, reflecting their different clinical backgrounds and vulnerabilities. The significantly increased levels of serum creatinine and blood urea nitrogen in the cohort undergoing hemodialysis are expected findings

in the context of end-stage renal disease (ESRD). These markers are traditional markers of renal function since their levels in the blood reflect a reduced glomerular filtration rate in patients with ongoing renal failure [1,2]. The increased mean fasting blood glucose levels identified in hemodialysis patients are also indicative of diabetes mellitus, a common co-morbidity and one of the major causes of ESRD worldwide [3]. These results are consistent with previous studies highlighting the importance of biochemical markers in disease severity and predicting infection risk in patients undergoing dialysis therapy [4,5]. Demographically, patients undergoing hemodialysis had a more increased mean age and a larger percentage of male patients, while those suffering from urinary tract infections were comprised mostly of younger females. This finding is in agreement with international epidemiological studies of urinary tract infections

that indicate vulnerability depends on anatomical properties and endogenous hormone concentrations [6,7]. On the other hand, in the context of hemodialysis, it is also possible that male predominance can be explained by differences in access to care or the presence of comorbid disease [8]. Also, a large cohort of patients in hemodialysis was from rural areas where delays in diagnosis and poor medical facilities can worsen infection severity and complicate its course [9]. Analysis of recurrent urinary tract infection prevalence rates showed no statistically significant differences in the comparison of the studied groups despite an elevated rate of recurrence in both groups. Whereas in non-dialysis patients recurrent UTIs would normally result from sexual activity, incomplete evacuation of the bladder, or anatomic abnormalities [10], recurrent infection in dialysis patients is often linked to habitual use of catheters, immunosuppression, and frequent exposure to health care settings [11,12]. These results emphasize that different strategies for prevention must be applied for each group based on each group's own risk factors. Microbiologically, *Escherichia coli* ranked as a most frequent isolate in both cohorts studied in concordance with its well-documented status as the major uropathogen in sources of community-acquired and hospital-acquired infections [13]. The hemodialysis cohort showed a wider variety of bacterial species recovered, including *Staphylococcus aureus* and *Pseudomonas aeruginosa*, organisms traditionally linked with hospital-acquired infections and device-related infections [14,15]. The finding concurs with previous studies that have shown increased microbial variety and antibiotic resistance in patients on hemodialysis that can be due to frequent hospital stays and continuous use of broad-spectrum antibiotics [16,17]. Statistical correlations provided reinforcement for findings obtained during clinical assessments. A highly significant linear relationship was noted between serum creatinine concentrations and blood urea levels in the patients on hemodialysis, a finding common in renal pathology as a criterion for identifying uremia severity [18]. A relatively lesser but statistically significant correlation was noted in the urinary tract infection cohort, implying either renal dysfunction of lesser severity or reversible impairment due to infection [19]. These findings underscore the need for incorporating routine biochemical examinations for assessing infections' effect on renal function in patients on dialysis. IL1 β and IL-6 were termed immunological indicators in the research protocol but no data for these variables were obtained from any of the participants and thus analysis became nonviable. These cytokines are key facilitators of inflammation and are often reported in increased concentrations during infection or in states of systemic inflammation [20–22]. Future studies may prove these variables can play an important role in elucidating immune status in recurrent urinary infections or infections in patients on dialysis. The differences in antibiotic resistance patterns observed between the UTI-only and hemodialysis groups underpin the heightened vulnerability of renal replacement therapy patients. The significantly higher rates of multidrug resistance (MDR) among pathogens isolated in the Hemodialysis group for both *Pseudomonas aeruginosa* and *Staphylococcus aureus* are in accordance with previous reports of heightened risk of hospital-acquired infection and recurrent antibiotic exposure in this group [1,2]. Conversely, although *Escherichia coli* was the prevailing uropathogen in both groups, its MDR rates were lower in the UTI group, indicating community-acquired as opposed to nosocomial infection patterns [3,4]. Age-stratified analysis also revealed that antibiotic resistance rose significantly with increasing age in both study groups but was greater so in the elderly hemodialysis

patients. This may be attributable to cumulative antibiotic exposure over the years, impaired immune status among the elderly, and prolonged hospitalization [5]. Similarly, sex differences demonstrated dialysis patients who were male with modestly higher levels of resistance—presumably due to longer courses of treatment and catheter duration—while female predominance among the UTI cohort reflected well-known epidemiologic patterns in community-acquired UTIs [6,7]. Geographic variation was also pronounced in determining resistance results. Patients from rural areas—particularly the young Hemodialysis cohort—had considerably greater resistance rates. This could be a manifestation of extensive empirical antibiotic use without microbiological guidance, poor availability of diagnostic laboratories, and treatment delays in rural areas [8]. Our results highlight the importance of regionally specific antimicrobial stewardship initiatives that take into consideration demographic and access-related heterogeneity. The larger implication of this analysis is the need for immediate adoption of infection prevention practices and routine microbiological surveillance in hemodialysis units. Biennial revision of the antibiogram and targeted intervention in high-risk groups of elderly, male, and rural patients may decrease the burden of drug-resistant infection. Additionally, public health responses must involve community education regarding antibiotic use and increase laboratory capacity in rural settings to more effectively guide treatment strategies.

This study highlights striking differences in microbiological features and urinary tract infection manifestations in patients who undergo hemodialysis compared to those who do not. These differences have important implications for practice. Hemodialysis patients, given their immunosuppressed status and increased exposure to hospital environments, require increased infection control, ongoing surveillance for biochemical markers, and more intensive diagnostic methods. Stable ambulatory patients with urinary tract infections in the community setting benefit more from changes in behavior and lifestyle interventions designed for recurrence prevention.

Conclusion

This study offers an in-depth comparison between persons being treated for hemodialysis and non-dialysis patients diagnosed with urinary tract infections (UTIs), highlighting significant differences in demographic data, biochemical markers, and infection characteristics. The findings revealed that hemodialysis patients had significantly higher serum creatinine, blood urea, and fasting blood glucose levels, indicating severe metabolic derangements and renal impairment. This group of patients was also older, mostly male, and more likely to be from rural areas—factors that can increase vulnerability and make UTIs more difficult to treat. In contrast, non-dialysis patients with UTIs were mostly younger, female, and urban dwellers. As *Escherichia coli* remained the dominant microorganism in both studied populations, the cohort undergoing hemodialysis had a wider variety of bacterial species including *Staphylococcus aureus* and *Pseudomonas aeruginosa*, reflective of the hospital-acquired nature of infection in this population. The enhanced microbial diversity in the cohort undergoing hemodialysis highlights the need for infection control targeted in these populations and supports the need for performing antimicrobial stewardship in a responsible manner. Despite similar frequencies of urinary tract infection recurrence in both the study groups, risk factors are different and require individual patient management strategies. The noted

significant associations of the biochemical markers also support the key role of routine laboratory assessments in infection treatment and the framework of clinical practice guidelines.

In conclusion, this study underscores the necessity of differentiated diagnostic, therapeutic, and preventive approaches when managing

UTIs in hemodialysis patients versus the general population. Future research should explore inflammatory and immunological markers, such as IL-6 and IL1 β , to further elucidate the role of host immune response in infection dynamics, particularly in immunocompromised populations.

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