

Research Article

Prevalence and Antibiotic Resistance Pattern of Urinary Tract Infection in Diabetic Patients in Pakistan

Dr. Muhammad Sohail¹, Dr. Sajid Iqbal², Dr. Muhammad Asif³

¹(MBBS, MS Urology, CHPE), Assistant, Professor of Urology, Department of Urology, University college of Medicine and Dentistry, Lahore.

²(MBBS, MS Urology, CHPE), Assistant Professor, Department of Urology, Rashid Latif Medical College, Lahore.

³(MBBS, MS (Urology), Consultant Urologist, Gujranwala Teaching Hospital, Gujranwala.

Email: ¹doctorsohail7@yahoo.com, ²drsajidiqbal.uro@gmail.com, ³doctorasifmalik@gmail.com

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ABSTRACT

Objective: To determine the prevalence of urinary tract infection (UTI) and pattern of antibiotic resistance among diabetic patients in Pakistan.

Materials and methods: The cross-sectional study was done, which included 320 diabetic patients aged greater than 18 years. Patients with symptomatic or asymptomatic UTI were recruited from UOL Hospital over the interval of eight months. To analyze the urine samples, standard microbiological methods were used. Clinical and Laboratory Standards Institute (CSI) guidelines were taken into account. Statistical significance was checked with logistic regression. Data was analyzed using SPSS and chi-square.

Result: A study of 320 diabetic patients found a high prevalence of urinary tract infections (UTIs), particularly among females (47.5% vs. 19.2% in males; $p < 0.001$) and those with uncontrolled glycemia (48.3% vs. 25.7% in controlled patients; $p < 0.001$). *Escherichia coli* (51.5%) and *Klebsiella pneumoniae* (24.6%) were the dominant uropathogens. Notably, all six ESBL-producing *E. coli* isolates occurred in uncontrolled diabetics ($p = 0.003$). Antimicrobial resistance was high against trimethoprim-sulfamethoxazole (46.8%) and ciprofloxacin (38.2%), while nitrofurantoin (8.5% resistance) and amikacin (4.1%) remained effective, supporting nitrofurantoin as a safer first-line option in this population.

Conclusion: The frequent occurrence of UTIs and high antimicrobial resistance among diabetic patients emphasizes the need for culture-guided antibiotic treatment along with effective glycemic control to manage infections successfully.

Keywords: Diabetes Mellitus, Antimicrobial Resistance, Culture-Guided Antibiotic Therapy, Glycemic Control.

INTRODUCTION

Diabetes mellitus (DM) represents a major global public health challenge and has increasingly become a substantial socio-economic burden, particularly for developing countries.(Zafar et al., 2016) Due to changes in lifestyle, urbanization, and population aging, the prevalence of diabetes has increased significantly in recent decades. In 2017, it was estimated that approximately 451 million individuals worldwide were diabetic and it is suggested that this figure will increase markedly, surpassing 693 million by the year 2045. According to the National Diabetes Survey, nearly 26.3% of the population aged over 19 years has been diagnosed with diabetes, indicating a high prevalence of the disease and highlighting the urgent need for effective prevention, early detection and

comprehensive management strategies.(Basit et al., 2018)

Urinary tract infection (UTI) is one of the most frequently encountered medical conditions across all age groups in individuals with diabetes mellitus. Compared to non-diabetic individuals, patients with diabetes are at a considerably higher risk of developing UTIs.(Abu-Humaidan et al., 2025) Severe infections and their related complications contribute substantially to increased morbidity and mortality in this population(Sewify et al., 2016) Diabetic patients are more prone to UTIs because prolonged hyperglycemia can cause neuropathy, leading to bladder dysfunction, urinary retention, and an increased risk of infection. Treating UTIs increases healthcare costs due to greater medical utilization.(Tebabal et al., 2025)

Diabetic individuals commonly experience bacterial cystitis, with the condition occurring more often in women with diabetes. Compared to healthy women, diabetic women show a higher frequency of both asymptomatic bacteriuria and symptomatic urinary tract infections, along with an increased risk of recurrent episodes and related complications.(Tebabal et al., 2025)Additionally, individuals with diabetes often experience increased urinary urgency and nighttime incontinence, which may be accompanied by painful urination and difficulty in completely emptying the bladder.(Bonadio et al., 2006)

A possible reason for the higher incidence of UTIs in diabetic patients is nerve damage resulting from elevated blood glucose levels which impairs bladder sensation. This leads to prolonged urine retention in the bladder, creating favorable conditions for bacterial growth and increasing the risk of infection. (Geerlings et al., 2000) Moreover, prolonged diabetes can impair blood circulation and weaken host immune defenses, including reduced levels of cytokines such as IL-6 in urine, which results in increasing susceptibility to infections.(Wu et al., 2010)

Although *Escherichia coli* remains the predominant pathogen isolated in urinary tract infections (UTIs) among diabetic patients, research has consistently shown that a wide variety of other aggressive microorganisms also contribute substantially to the infectious burden in this population. (Yeshitela et al., 2012)Studies conducted in diverse clinical settings have reported that, in addition to *E. coli*, organisms such as *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterococcus* species, *Proteus mirabilis*, and even fungal agents are frequently identified in urine cultures from diabetic individuals, underscoring the polymicrobial nature of UTIs in this group.(Assefa et al., 2008)

Escherichia coli is widely recognized as the leading cause of urinary tract infections, frequently accounting for more than half of all positive urine cultures. However, in individuals with diabetes, the diversity of uropathogens is notably greater, with a higher proportion of infections caused by non-*E. coli* organisms. (Aswani et al., 2014)This increased microbial variety is largely influenced by the metabolic and immunological changes associated with diabetes, such as impaired neutrophil function, altered cytokine production, and glycosuria. As a result, a broad spectrum of pathogens,

including other gram-negative bacteria from the *Enterobacteriaceae* family, gram-positive cocci and even fungal species are commonly identified in diabetic UTIs.(Hu et al., 2009)

Studies indicate a strong link between glycemic control and the risk of UTIs in diabetic patients. Those with poor glycemic management, reflected by higher HbA1c levels, experience a higher prevalence of UTIs and are more likely to carry multidrug-resistant organisms, including ESBL-producing strains.(Muller et al., 2005) While the types of pathogens may not vary greatly with glycemic status, inadequate blood sugar control clearly increases infection risk by weakening immune defenses and creating conditions that favor bacterial growth in the urinary tract.(Venmans et al., 2009)

Effective management of UTIs in diabetic patients requires a multiapproach due to the complex interplay between hyperglycemia and infection risk. Maintaining optimal blood glucose levels not only lowers the likelihood of developing infections but also helps prevent the emergence of antibiotic-resistant strains. In addition, routine urine culture and sensitivity testing are crucial to ensure that antibiotic therapy is appropriately targeted, as empirical treatment alone may be insufficient against resistant pathogens. Combining strict glycemic control with regular microbiological monitoring allows clinicians to make informed treatment decisions, ultimately reducing the incidence of recurrent or complicated UTIs and improving outcomes in this vulnerable population.

MATERIAL AND METHODS

Study Population: The study was conducted from April 2025 to November 2025 at the University of Lahore (UOL) Hospital. Out of 320 urine samples analyzed, 130 patients tested positive for urinary tract infection (UTI) and were included in the study. Patient information, including age, gender, and history of urinary frequency, was obtained through the Laboratory Information System (LIS). The data from the LIS was used for research and publication purposes was approved by the Ethical Review Board of UOL Hospital and was performed in accordance with the ethical principles outlined in the Declaration of Helsinki. **Collection and Handling of Urine Samples:** Midstream clean-catch urine specimens were collected from patients using sterile, specialized urine collection containers, with assistance provided by trained laboratory

personnel at UOL Hospital. Prior to collection, each participant received a detailed brochure and verbal instructions on proper midstream urine collection to minimize contamination. For microbiological analysis, 10 µL of each urine sample was inoculated using a calibrated loop onto three types of culture media: Blood Agar, MacConkey Agar, and CLED Agar. All inoculated plates were incubated at 37°C for 24–48 hours to allow for visible microbial growth. Microbial Identification: Urine cultures yielding colony counts greater than 10⁴ CFU/mL were considered positive for UTI. Standard biochemical tests were performed to identify bacterial isolates. If more than two different organisms were isolated from a single sample, the specimen was considered contaminated and excluded from analysis. Plates showing no microbial growth were classified as sterile. For confirmed positive cultures, microbial identification was performed using the automated Microscan system (Walkaway 40 SI, Siemens Healthcare Diagnostics, Sacramento, CA). Gram-negative bacteria were analyzed using NC34 and NC53 panels, while Gram-positive bacteria were processed with PC21 panels (Siemens Healthcare Diagnostics). Further confirmation of both Gram-positive and Gram-negative isolates was carried out using API biochemical kits (API 20E, API Strep, API Staph; bioMérieux, Durham, NC, USA). Quality control was ensured using reference strains, including *Escherichia coli* ATCC 25922, *Klebsiella pneumoniae* ATCC 13883, and *Candida albicans* ATCC 10231 (American Type Culture Collection, Manassas, VA). Antimicrobial Susceptibility Testing: The sensitivity of common uropathogens including *E. coli*, *Klebsiella pneumoniae*, *Enterococcus faecalis*, *Serratia marcescens*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus saprophyticus*, and *Proteus mirabilis* to selected antibiotics was assessed. Antimicrobial susceptibility was determined using the Kirby-

Bauer disk diffusion method in accordance with Clinical Laboratory Standards Institute (CLSI, 2014) guidelines. Fresh bacterial cultures were suspended in 5 mL of sterile saline to prepare inoculums, which were then streaked onto Mueller-Hinton agar plates using sterile cotton swabs. Antibiotic-impregnated disks (Becton Dickinson, Franklin Lakes, NJ, USA) were applied to the plates to assess microbial sensitivity. Data Analysis: All collected data were analyzed using SPSS for Windows. Differences in mean values between UTI groups were evaluated using the nonparametric Mann-Whitney test, while correlations between variables were examined using Spearman's rank correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

RESULTS

This study investigated the prevalence of urinary tract infections (UTIs) and antimicrobial resistance patterns among 320 diabetic patients attending the University of Lahore (UOL) Hospital between April and November 2025. Urine samples were collected via midstream clean-catch technique and analyzed using standardized microbiological and susceptibility testing protocols as per CLSI guidelines. Statistical analyses were performed using SPSS, with a significance threshold set at $p < 0.05$. The findings reveal a substantial UTI burden in this diabetic cohort particularly among females and individuals with poor glycemic control and highlight alarming levels of antimicrobial resistance among common uropathogens.

UTI prevalence was significantly higher among diabetic patients with uncontrolled glycemia ($p < 0.001$). Nearly half (48.3%) of uncontrolled patients tested positive for UTI, compared to only 25.7% in the controlled group, underscoring the critical role of glycemic management in infection risk.

Table 1: Prevalence of UTI by Glycemic Control Status

Glycemic Control	Number of Patients	UTI Positive (n)	Prevalence (%)	p-value
Controlled	109	28	25.7%	<0.001
Uncontrolled	211	102	48.3%	

Females constituted the majority of UTI cases (88.5% of all UTIs), with a significantly higher prevalence than males ($p < 0.001$). This aligns

with known anatomical and physiological risk factors for UTIs in women, exacerbated by diabetes-related urinary dysfunction.

Table 2: Gender Distribution of UTI in Diabetic Patients

Gender	Total Patients (n)	UTI Positive (n)	Prevalence (%)	p-value
Female	242	115	47.5%	<0.001
Male	78	15	19.2%	

E. coli was the predominant uropathogen (51.5%), followed by *K. pneumoniae* (24.6%). Together, they accounted for 76.1% of all isolates. The presence of non-*E. coli* pathogens

including Gram-positive and opportunistic Gram-negative organisms reflects the polymicrobial nature of UTIs in diabetics.

Table 3: Distribution of Uropathogens among UTI-Positive Diabetic Patients

Pathogen	Number of Isolates (n)	Percentage (%)
<i>Escherichia coli</i>	67	51.5
<i>Klebsiella pneumoniae</i>	32	24.6
<i>Enterococcus faecalis</i>	9	6.9
<i>Streptococcus agalactiae</i>	8	6.2
<i>Pseudomonas aeruginosa</i>	5	3.8
<i>Proteus mirabilis</i>	4	3.1
Others (e.g., <i>Serratia</i> , <i>Staph</i>)	5	3.9
Total	130	100.0

All six ESBL-producing *E. coli* isolates were found exclusively in patients with uncontrolled diabetes ($p = 0.003$), indicating a strong link

between hyperglycemia and the carriage of multidrug-resistant organisms.

Table 4: Association between Glycemic Control and ESBL-Producing *E. coli*

Glycemic Control	Total <i>E. coli</i> Isolates (n)	ESBL-Positive (n)	ESBL Prevalence (%)	p-value
Controlled	24	0	0.0%	0.003
Uncontrolled	43	6	14.0%	

High resistance was observed against trimethoprim-sulfamethoxazole (46.8%) and ciprofloxacin (38.2%), both commonly used empirically. In contrast, nitrofurantoin and amikacin showed low resistance (<9%). The difference in resistance between nitrofurantoin

and trimethoprim-sulfamethoxazole was highly significant ($p < 0.001$), supporting nitrofurantoin as a preferred first-line agent especially given amikacin's nephrotoxicity risk in diabetics.

Table 5: Antimicrobial Resistance Patterns of Gram-Negative Uropathogens (*E. coli* And *K. pneumoniae*)

Antibiotic	Resistant Isolates (%)	p-value (vs. most effective drug)
Trimethoprim-sulfamethoxazole	46.8	<0.001
Ciprofloxacin	38.2	0.002
Amoxicillin/clavulanate	12.4	0.07 (NS)
Nitrofurantoin	8.5	Reference
Amikacin	4.1	0.12 (NS)

Diabetic patients found a high prevalence of urinary tract infections (UTIs), particularly among females (47.5% vs. 19.2% in males; $p < 0.001$) and those with uncontrolled glycemia (48.3% vs. 25.7% in controlled patients; $p < 0.001$). *Escherichia coli* (51.5%) and *Klebsiella pneumoniae* (24.6%) were the dominant uropathogens. Notably, all six ESBL-producing

E. coli isolates occurred in uncontrolled diabetics ($p = 0.003$). Antimicrobial resistance was high against trimethoprim-sulfamethoxazole (46.8%) and ciprofloxacin (38.2%), while nitrofurantoin (8.5% resistance) and amikacin (4.1%) remained effective, supporting nitrofurantoin as a safer first-line option in this population.

DISCUSSION

Among the 320 diabetic patients evaluated, 35% tested positive for uropathogens, a prevalence higher than the 20–30% typically reported in diabetic populations. This may be attributed to the long duration of diabetes in most participants (>10 years), as chronic diabetes and its complications, such as neuropathy, increase susceptibility to UTIs regardless of current glycemic control. Notably, 78.2% of UTI cases occurred in patients with uncontrolled glycemia, aligning with studies that demonstrate a higher infection rate in diabetics with poor glucose control compared to non-diabetic individuals.

Consistent with previous research, the majority of UTIs occurred in women (88.5%), confirming the higher prevalence of UTIs among females in both diabetic and non-diabetic populations. (Johnsson et al., 2013b) Interestingly, the distribution of UTIs by gender was similar between patients with controlled and uncontrolled glycemia, suggesting that glycemic control does not significantly affect gender-related susceptibility. (Johnsson et al., 2013a) Age, however, remained an important factor; older patients with uncontrolled glycemia had a higher risk of UTI, whereas in the controlled glycemia group, cases were distributed more evenly across age ranges. (Unnikrishnan et al., 2018)

Microbiological analysis revealed that *E. coli* was the predominant pathogen, followed by *Klebsiella* species, together accounting for 76.2% of UTI cases. These findings are consistent with studies from both diabetic and general populations. (Aggarwal et al., 2019) All six ESBL-producing *E. coli* isolates were identified in patients with uncontrolled glycemia, indicating a possible link between poor glycemic control and multidrug-resistant strains. *Streptococcus agalactiae* represented about 6% of infections in both glycemic groups, a prevalence higher than that reported in other populations, potentially reflecting the impact of obesity and long-term diabetes in this cohort. (Simkhada, 2013)

Antimicrobial susceptibility testing revealed high resistance of Gram-negative bacteria, including *E. coli* and *Klebsiella*, to trimethoprim-sulfamethoxazole (>45%), raising concerns regarding empirical treatment strategies. (Mamuye, 2016) In contrast, amikacin, nitrofurantoin, and amoxicillin/clavulanate demonstrated high

efficacy (>70–96%) against most isolates, though amikacin carries a risk of nephrotoxicity, particularly in diabetic patients with impaired renal function. Overall, nitrofurantoin and amoxicillin/clavulanate appeared to be the most effective first-line options, followed by ciprofloxacin and trimethoprim-sulfamethoxazole. (Khoshnood et al., 2017)

Collectively, the study highlights that uncontrolled glycemia significantly increases UTI prevalence and the risk of resistant infections, while gender distribution and the spectrum of pathogens remain largely unaffected by glycemic status. These findings underscore the need for rigorous glycemic management combined with routine microbiological screening to guide appropriate antibiotic therapy, reduce recurrent infections, and improve clinical outcomes in diabetic patients.

CONCLUSION

The frequent occurrence of UTIs and high antimicrobial resistance among diabetic patients emphasizes the need for culture-guided antibiotic treatment along with effective glycemic control to manage infections successfully.

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