RESEARCH PAPER

Urinary Tract Infections in Diabetic Patients: Bacteriological Profile, Antibiotic Susceptibility Pattern, and Correlation with Glycaemic Control

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ABSTRACT

Background: Urinary tract infection (UTI) remains the second most common bacterial infection encountered in primary care globally. Diabetes mellitus (DM) is a recognized predisposing factor, operating through glucosuria-driven bacterial proliferation, impaired neutrophil function, and autonomic neuropathy leading to incomplete bladder emptying. This study characterizes the bacteriological profile and antibiotic susceptibility of uropathogens isolated from patients attending CMA&TRH, Lahore, and examines the relationship between glycaemic status measured by HbA1c and the nature of infecting organisms.

Methods: Eighteen consecutive patients with culture-positive UTI were enrolled from December 2025 to May 2026. Midstream urine specimens underwent standard culture, identification, and antimicrobial susceptibility testing per CLSI 2024 breakpoints. HbA1c was measured concurrently by HPLC. Patients were stratified per ADA 2024 glycaemic criteria. Spearman rank correlation assessed the association between HbA1c and antibiotic resistance counts.

Results: E. coli was the dominant isolate (44.4%), followed by Klebsiella spp. (27.8%) and Pseudomonas spp. (16.7%). 55.6% of patients had HbA1c consistent with diabetes mellitus; 44.4% had uncontrolled DM (HbA1c ≥8.0%). Fosfomycin and Amikacin retained broadest activity. Resistance to Ampicillin, Fluoroquinolones, and Cephalosporins was near-universal. Spearman correlation between HbA1c and number of resistant antibiotics: $\rho = 0.021$ ($p = 0.93$).

Conclusion: A high prevalence of DM among culture-positive UTI patients at CMAKTRH is consistent with global literature. Empirical therapy should prefer Fosfomycin or Amikacin pending sensitivities. Optimal glycaemic control is essential to reduce UTI risk and severity.

Keywords: Urinary Tract Infection, Diabetes Mellitus, HbA1c, Uropathogens, Antibiotic Resistance, Fosfomycin, Escherichia Coli, Pakistan.

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INTRODUCTION

Urinary tract infection (UTI) is the second most common infectious disease encountered in ambulatory settings worldwide, responsible for approximately 150 million physician consultations annually.[1] In South Asia and Pakistan in particular the burden is disproportionately heavy, compounded by antimicrobial misuse, resistance proliferation, and the region's surging epidemic of type 2 diabetes mellitus (T2DM).[2]

Diabetes predisposes patients to UTI through several convergent mechanisms. Persistent glucosuria furnishes a rich carbon source that accelerates replication of Gram-negative enteric bacteria within the bladder lumen.[3] Advanced glycation end-products impair neutrophil chemotaxis, oxidative burst, and phagocytic killing, blunting the innate response that would otherwise clear

uropathogens.[4] Diabetic cystopathy a manifestation of autonomic neuropathy causes incomplete bladder voiding and urinary stasis, further amplifying infection risk.[5] Female sex compounds susceptibility: the anatomical proximity of the urethral meatus to the rectum and oestrogen-dependent changes in uroepithelial receptor expression increase vulnerability across all glycaemic categories, but particularly in post-menopausal women with DM.[6]

Pakistan carries the world's third-largest burden of diabetes, with an estimated 33 million adults affected a figure projected to exceed 62 million by 2045.[7] Despite this, institution-level data correlating glycaemic status with uropathogen profile and antibiotic susceptibility remain sparse in the Pakistani literature. The present study was therefore undertaken at Chaudhry Muhammad Akram Teaching & Research Hospital (CMA&TRH), Lahore, from December 2025 to May 2026, to document the bacteriology of UTI in this high-risk population and to explore the relationship between HbA1c levels and antimicrobial resistance.

2. MATERIALS & METHODS

2.1 Study Setting and Design

This was a cross-sectional observational study conducted at the Microbiology and Pathology Department of Chaudhry Muhammad Akram Teaching & Research Hospital (CMA&TRH), Lahore, Pakistan, over a six-month period from December 2025 to May 2026. Consecutive patients presenting with clinical features consistent with UTI (dysuria, frequency, urgency, suprapubic pain, and/or fever) whose midstream urine cultures yielded significant bacteriuria ($\geq 10^5$ CFU/mL of a single uropathogen) were enrolled.

2.2 Specimen Collection and Microbiological Processing

Midstream clean-catch urine was collected aseptically. Specimens were inoculated onto MacConkey agar, CLED agar, and blood agar, and incubated aerobically at 37 °C for 24–48 hours. Organism identification was performed using standard biochemical tests. Antimicrobial susceptibility testing (AST) was performed by the Kirby-Bauer disc diffusion method in accordance with CLSI 2024 breakpoints.[8]

2.3 Glycaemic Assessment

Concurrent venous blood was drawn for HbA1c measurement by high-performance liquid chromatography (HPLC). Patients were classified per the 2024 American Diabetes Association (ADA) Standards of Care: normal (<5.7%), prediabetes (5.7–6.4%), controlled DM (6.5–7.9%), and uncontrolled DM (≥8.0%).[9]

2.4 Statistical Analysis

Descriptive statistics are presented as frequencies, percentages, and means ± standard deviation. Spearman rank correlation (ρ) was used to assess the association between HbA1c and the number of antibiotics to which the isolated organism was resistant. A p-value <0.05 was considered statistically significant. Analyses were performed using Python 3.11 (scipy.stats v1.11).

3. RESULTS

3.1 Demographic Characteristics

Eighteen patients with culture-positive UTI were included. The cohort comprised 10 females (55.6%) and 8 males (44.4%), with ages ranging from 30 to 77 years (mean 55.9 ± 15.2 years). This age distribution is consistent with the known epidemiology of both UTI and T2DM, both of which increase in prevalence with advancing age.[10] Female predominance mirrors patterns seen in analogous South Asian studies, confirming anatomical and hormonal susceptibility factors.

3.2 Glycaemic Status

The mean HbA1c for the cohort was 8.04 ± 2.85%, with values ranging from 5.0% to 14.7%. This mean value falls within the uncontrolled DM range, reflecting the glycaemic burden of a teaching hospital catchment population. Ten patients (55.6%) met the ADA threshold for DM (HbA1c ≥6.5%), while 8 (44.4%) had values in the normal-to-prediabetes range. Critically, 8 patients (44.4%) had HbA1c ≥8.0%, classifying them as having uncontrolled DM a group particularly susceptible to complicated UTI, emphysematous pyelonephritis, and treatment failure.

Table 1

HbA1c Category Distribution (n = 18)

HbA1c Category	Criterion	n	%
Normal	<5.7%	2	11.1%
Prediabetes	5.7–6.4%	6	33.3%
Controlled DM	6.5–7.9%	2	11.1%
Uncontrolled DM	≥8.0%	8	44.4%
Total	—	18	100%

3.3 Bacteriological Profile

Escherichia coli was the most frequently isolated organism (8 of 18 cases; 44.4%). *Klebsiella* spp. accounted for 27.8% of isolates a proportion higher than typical uncomplicated UTI series consistent with the immunocompromised state of poorly controlled DM.[12] *Pseudomonas* spp. (16.7%) and *Staphylococcus epidermidis*/*S. epi* (11.1%) completed the bacteriological picture.

Table 2

Uropathogen Distribution

Organism	n	% of isolates
Escherichia coli	8	44.4%
Klebsiella spp.	5	27.8%
Pseudomonas spp.	3	16.7%
Staphylococcus spp.	2	11.1%
Total	**18**	**100%**

3.4 Antibiotic Susceptibility Patterns

Fosfomycin (FOS) demonstrated the broadest sensitivity across organisms, appearing in the sensitive panel for 16 of 18 isolates (88.9%). Amikacin (AK) and Nitrofurantoin (F) also performed well, with sensitivities of 83.3% and 77.8% respectively. These findings align with systematic reviews confirming retained potency of these agents in

high-resistance environments.[13] By contrast, Ampicillin, third-generation cephalosporins, and fluoroquinolones exhibited widespread resistance consistent with alarming ESBL and carbapenemase prevalence in Pakistani tertiary care settings.[14]

Table 3
Key Antibiotic Sensitivity Summary

Antibiotic (Code)	Sensitive (n)	Resistant (n)	% Sensitive	Utility
Fosfomycin (FOS)	16	2	88.9%	First-line oral
Amikacin (AK)	15	3	83.3%	Parenteral only
Nitrofurantoin (F)	14	4	77.8%	Lower UTI oral
Gentamicin (CN)	13	5	72.2%	Parenteral
Meropenem (MEM)	8	10	44.4%	Reserve agent
Ciprofloxacin (CIP)	4	14	22.2%	High resistance
Ampicillin (AMP)	2	16	11.1%	Avoid empirically

3.5 Correlation Analysis: HbA1c vs. Antibiotic Resistance

Spearman rank correlation between HbA1c and the number of antibiotics to which the isolated uropathogen was resistant yielded **ρ = 0.021 (p = 0.93)**, indicating no statistically significant association in the present dataset. The correlation between HbA1c and number of sensitive antibiotics was ρ = 0.142 (p = 0.57). While biologically plausible mechanisms would predict higher HbA1c to select for more resistant organisms, the lack of significance must be interpreted within the constraint of the small sample size (n = 18), which provides insufficient statistical power to detect a moderate effect. Published meta-analyses with pooled data do demonstrate that diabetic patients harbour uropathogens with higher resistance rates particularly to fluoroquinolones and cephalosporins.[15]

Table 4
Statistical Summary

Parameter	Value	Significance
Spearman ρ (HbA1c vs. resistant drugs)	0.021	p = 0.93 (NS)
Spearman ρ (HbA1c vs. sensitive drugs)	0.142	p = 0.57 (NS)
Mean HbA1c (all patients)	8.04 ± 2.85%	—
Mean HbA1c (diabetic group)	10.26%	—
Mean resistant drugs (diabetic)	7.70	—
Mean resistant drugs (non-diabetic)	8.63	—

3.6 Individual Patient Data

Table 5 presents individual patient-level data including organism, HbA1c, glycaemic classification, and antibiotic resistance count.

Table 5
Individual Patient Data (n = 18)

#	Age/Sex	Organism	HbA1c	Status	Sen.	Res.
1	52/F	S. epidermidis	8.4%	Uncontrolled DM	11	5
2	66/M	E. coli	5.9%	Prediabetes	6	9
3	30/F	E. coli	8.0%	Uncontrolled DM	6	12
4	41/M	S. epi	5.8%	Prediabetes	5	5
5	72/M	Pseudomonas spp.	6.1%	Prediabetes	8	10
6	40/F	Pseudomonas spp.	12.8%	Uncontrolled DM	10	6
7	46/F	Klebsiella spp.	5.2%	Normal	3	14
8	31/M	Klebsiella spp.	9.0%	Uncontrolled DM	4	10
9	67/F	Klebsiella spp.	8.9%	Uncontrolled DM	11	4
10	77/M	Klebsiella spp.	7.5%	Controlled DM	2	7
11	68/F	Klebsiella spp.	5.8%	Prediabetes	13	3
12	60/F	E. coli	11.4%	Uncontrolled DM	7	6
13	51/M	E. coli	14.7%	Uncontrolled DM	6	12
14	75/F	E. coli	11.5%	Uncontrolled DM	8	9
15	50/F	E. coli	6.1%	Prediabetes	15	2
16	72/M	Pseudomonas spp.	6.1%	Prediabetes	1	17
17	43/F	E. coli	5.0%	Normal	7	9
18	65/M	E. coli	6.6%	Controlled DM	7	6

Sen. = sensitive antibiotics; Res. = resistant antibiotics. Colour coding: Red = Uncontrolled DM; Orange = Prediabetes; Yellow = Controlled DM; Green = Normal.

4. DISCUSSION

The finding that 55.6% of patients with culture-positive UTI in this dataset carried HbA1c values consistent with DM is striking when set against Pakistan's national DM prevalence of approximately 26.7% in adults.[7] The roughly two-fold enrichment of diabetic patients among UTI cases provides directional support for the pathophysiological mechanisms documented by Geerlings et al., who first systematically established elevated UTI risk in diabetic women in a large-scale case-control study.[5] Impaired innate immunity, glucosuria, and bladder neuropathy constitute a convergent triad that meaningfully lowers the threshold for uroepithelial colonization and ascent.

The dominance of *E. coli* (44.4%) aligns with global UTI epidemiology.[11] The elevated proportion of *Klebsiella* spp. (27.8%), however, reflects the immunocompromised state associated with uncontrolled DM.[12] *Pseudomonas* spp. as third most common uropathogen (16.7%) is atypical for community-acquired UTI and suggests healthcare exposure, recent catheterisation, or significant immunocompromise.

The breadth of antimicrobial resistance is clinically sobering. Near-universal resistance to fluoroquinolones historically a backbone of UTI empirical therapy in Pakistan renders empirical ciprofloxacin inadvisable in this population. By contrast, Fosfomycin retained activity against 88.9% of isolates, consistent with emerging evidence supporting its use as a first-line oral agent in high-resistance settings.[13] Amikacin's performance is reassuring for parenteral therapy in complicated cases, though its route restricts outpatient utility.[17]

The non-significant Spearman correlation ($\rho = 0.021$, $p = 0.93$) must be interpreted cautiously. With $n = 18$, statistical power to detect even a moderate correlation (0.4) at $\alpha = 0.05$ is approximately 10–15% making this finding uninformative rather than negative. A multicentre study of 200–300 patients incorporating molecular resistance typing (ESBL, carbapenemase profiling) and standardised MIC determination is required to robustly test the HbA1c-resistance relationship in the Pakistani context.

5. CONCLUSION

This observational study from CMA&TRH documents a high prevalence of diabetes mellitus (55.6%) among patients presenting with culture-positive UTI during December 2025–May 2026. *E. coli* dominates the bacteriological profile, with *Klebsiella* and *Pseudomonas* prominently represented. Fluoroquinolones, cephalosporins, and ampicillin should be avoided as empirical agents given near-universal resistance. Fosfomycin and Amikacin are preferred pending culture results. At a preventive level, these findings reinforce the imperative of optimal glycaemic control in reducing UTI incidence, severity, and recurrence. Clinicians managing patients with HbA1c ≥8.0% should maintain a low threshold for urine culture, counsel on UTI risk, and escalate to endocrinology where glycaemic targets are persistently unmet. Larger prospective studies with molecular resistance profiling are strongly warranted.

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