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ANTIBIOTIC SUSCEPTIBILITY PATTERN OF UROPATHOGENS AMONG CATHETERIZED AND NON-CATHETERIZED HOSPITALIZED PATIENTS AT A TERTIARY CARE CENTRE

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Abstract

Urinary tract infections (UTIs), particularly catheter-associated UTIs (CAUTIs), are major hospital-acquired infections contributing to antimicrobial resistance.To compare uropathogens and antibiotic susceptibility patterns in catheterized and non-catheterized hospitalized patients. A hospital-based comparative study was conducted using urine samples from clinically suspected UTI patients. Isolates were identified by standard microbiological methods, and antimicrobial susceptibility testing was performed using the Kirby–Bauer method**.** In catheterised patients, the predominant isolates were *Escherichia coli* (22%), *Klebsiella pneumoniae* (30%), *Pseudomonas aeruginosa* (9%), *Enterococcus* spp. (22%), *Candida* spp. (7%), Coagulase-negative *Staphylococcus* (4%), *Citrobacter koseri* (2%), *Acinetobacter baumannii* (4%), *Klebsiella oxytoca* (1%), *Enterobacter aerogenes* (1%), and *Proteus* spp. (1%). Among non-catheterised patients, *E. coli* (46%) was most common, followed by *K. pneumoniae* (16%), *Enterococcus*spp. (11%), *Candida* spp. (12%), *P. aeruginosa* (8%), CoNS (3%), *A. baumannii* (1%), *K. oxytoca* (1%), and *Proteus* spp. (1%). Antibiotic susceptibility testing (Amikacin, Piperacillin-Tazobactam, Nitrofurantoin, Ciprofloxacin, Norfloxacin) demonstrated a higher prevalence of multidrug-resistant organisms in the catheterised group. Catheterization is associated with diverse pathogens and increased antimicrobial resistance, highlighting the need for judicious catheter use and local antibiogram-guided therapy.

Keywords: Urinary Tract Infections; Catheter-Associated Urinary Tract Infection; Uropathogens; Antimicrobial Resistance; Antibiotic Susceptibility.

INTRODUCTION

Simple UTI is called if urinary tract does not have an infection in other parts of the body which caused UTI refers to an infection of the urinary tract caused by bacteria that are susceptible to appropriate treatment [1]. This type of infection typically occurs in a non- pregnant, afebrile, and immunocompetent female patient. The presence of pyuria (pus in urine) and/or bacteriuria (bacteria in urine) without any associated symptoms does not constitute a UTI and may not require treatment. For instance, an incidental finding of positive urine culture in an asymptomatic, afebrile, non-pregnant, and immunocompetent female would not be considered a UTI [2]. On the other hand, a complicated UTI (It is a bladder infection in a patient with underlying conditions that increase the risk of serious complications or decrease the effects of treatment) encompasses all UTIs that do not meet the criteria of a simple UTI as described above. This includes infections in immunocompromised patients, males, pregnant individuals, and cases associated with fever, urinary stones, sepsis, urinary

obstruction, catheter use, or those involving the kidneys [3].

The US Centers for Disease Control and Prevention (CDC): National Health Safety Network (NHSN) has a definition of Catheter-Associated Urinary Tract Infection (CAUTI). They consider the presence of a fever, suprapubic tenderness, or costovertebral angle pain, in addition to a colony count exceeding 100,000 with no more than two different organisms as defining criteria for CAUTI.

Catheterized patients typically develop bacteriuria due to colonization and the formation of biofilms. The rate of bacterial colonization ranges from 3% to 10% per day the catheter is in place, resulting in complete bacterial colonization after approximately 30 days. Risk factors associated with this colonization include prolonged Foley catheterization, female gender, advanced age, diabetes, bacterial colonization of the drainage bag, urethral catheterization (compared to suprapubic), and errors in sterile catheter insertion or maintenance [3,4].

UTIs can be caused by a variety of bacteria, both Gram-negative and Gram-positive, as well as fungi. Among these pathogens, Uropathogenic *Escherichia coli* (UPEC) are the predominant cause of UTIs, accounting for 75% of non-complicated UTIs and 65% of complicated UTIs. In cases of complicated UTIs, such as CAUTIs, the most common pathogens following UPEC are *Enterococcus spp. (11%), Klebsiella pneumoniae (8%), Candida spp (7%), Staphylococcus aureus (3%), Proteus mirabilis (2%), Pseudomonas aeruginosa (2%), and Group B Streptococcus (2%)* [5,6].

Antibiotics are considered the primary treatment for CAUTI; however, the inert surface of the catheter often develops biofilms, making it resistant to antibiotic effects.
The use of antibiotics remains essential in treating CAUTIs, but their effectiveness is increasingly challenged by rising rates of antibiotic resistance, which could lead to a post- antibiotic era where common infections may become life-threatening. Clinical antibiotic use, especially when unnecessary or prolonged, significantly contributes to this problem.

Thus, the aim of study is to isolate the uropathogens among catheterized and non-catheterized patients and to study the antibiotic susceptibility pattern of isolated uropathogens among catheterized and non-catheterized patients.

Materials and Methods

The study was conducted at the Microbiology Department over a period of 24 months. This was a cross-sectional study designed to assess the antibiotic susceptibility pattern of uro- pathogens among catheterized and non-catheterized patients hospitalized in a tertiary care center. The study included hospitalized patients aged 18 years and above, who met the inclusion criteria of being catheterized with a Foley's catheter for more than two calendar days. Patients with non-catheterized status were also included. Institutional Ethical clearance was taken number of ethical reference no. R cell,2023/35.

Data Collection: Data were collected through a combination of clinical evaluations, laboratory investigations, and imaging studies. Age, Sex, diagnosis at admission, Functional status (ambulatory or non-ambulatory), Indication for catheterization (e.g., urinary retention, incontinence, altered sensorium), Duration of catheterization, Urine routine/microscopy findings were recorded.

Inclusion Criteria:

1. Hospitalized patients aged 18 years and above.
2. Patients who have been catheterized with a Foley's catheter for more than two calendar days at the time of the event
3. Patients with suspected urinary tract infection (UTI) based on clinical presentation and/or laboratory findings.

Exclusion Criteria:

1. Patients who have not been catheterized or have had a Foley's catheter for less than two calendar days.
2. Patients with a history of urinary tract surgery within the past six months.

For catheterized patients, samples were taken using a sterile disposable syringe after proper cleaning and clamping of the catheter tube. Sampling ports were disinfected with alcohol before sample collection. Clean-catch mid-stream urine samples were collected from non- catheterized patients.

Urine samples underwent wet mount examination to assess the presence of pus cells, epithelial cells, red blood cells (RBCs), cast cells, crystals, fungal hyphae and microorganisms.

Processing the Urine Sample. Semi-quantitative culture of urine samples was performed on 5% sheep blood agar and CLED agar (cystine-lactose-electrolyte-deficient agar) and incubated aerobically at 37°C for 24-48 hours. Sabouraud dextrose agar (SDA) was used for fungal cultures. Antibiotic susceptibility testing was performed using Kirby-Bauer's disk diffusion method on Muller-Hinton Agar as per CLSI guidelines [6].

Isolates were identified based on colony appearance, Gram stain and standard biochemical.

RESULTS

In our study showed the pathogens causing Catheter associated urinary tract infection and non- catheter associated urinary tract infection and their antibiotic susceptibility pattern of 200 Positive urine samples cultured from patients with CAUTI (100) and Non- CAUTI (100) were taken.

The age distribution of patients showed that catheterized patients were predominantly younger, with the highest proportion (38%) in the 20–30 years age group. In contrast, non- catheterized patients were more evenly distributed across age groups, with the highest percentage (22%) in the 61–70 years category. The least represented group in both categories was patients above 70 years, accounting for only 8% in the non-catheterized and 10% in the catheterized groups. Table 1 shows age Distribution of Non-Catheterized and Catheterized Patients

Table 1: Gender Wise Distribution of Non-Catheterized and Catheterized Patients

Sex	Non-Catheterized (n=100)	Catheterized (n=100)
Male	22 (22%)	24 (24%)
Female	78 (78%)	76 (76%)

Female patients comprised the majority in both groups, with 78% in the non-catheterized and 76% in the catheterized patients, whereas male patients accounted for 22% in the non- catheterized and 24% in the catheterized groups (Table 2).

Table 2: Distribution of Patients Across Different Hospital Wards

Ward	Non-Catheterized (n = 100)	Catheterized (n = 100)
Surgery	10 (10.0%)	14 (14.0%)
Medicine	42 (42.0%)	12 (12.0%)
Gynaecology	23 (23.0%)	29 (29.0%)
Intensive Care Unit	23 (23.0%)	42 (42.0%)
Emergency	2 (2.0%)	3 (3.0%)

The distribution across hospital wards showed that non-catheterized patients were mostly in the Medicine ward (42%), while the ICU had the highest percentage (42%) of catheterized patients.

Figure shows the distribution of Gram-positive, Gram-negative, and *Candida* isolates in catheterized and non-catheterized patients. Among non-catheterized patients, Gram-negative organisms were the most prevalent, accounting for 74% (74 cases), followed by Gram- positive organisms at 14% (14 cases), and *Candida* at 12% (12 cases). In catheterized patients, Gram-negative organisms also dominated, comprising 67% (67 cases), with Gram- positive organisms at 26% (26 cases), and *Candida* at 7% (7 cases). Table 3 shows Distribution of organisms on the basis of Gram-stain in catheterized and non-catheterized patients.

Table 3: Distribution of Microorganisms in Non-Catheterized and Catheterized Patients

MICROORGANISM	Non-Catheterized (n=100)	Catheterized (n=100)	z-value	p-value
Escherichia coli (E. coli)	46 (46.0%)	22 (22.0%)	3.70	<0.001
Klebsiella pneumoniae (K. pneumoniae)	16 (16.0%)	30 (30.0%)	2.39	0.017
Enterococcus spp.	11 (11.0%)	22 (22.0%)	2.12	0.034
Pseudomonas spp.	8 (8.0%)	9 (9.0%)	0.25	0.800
Coagulase-negative Staphylococci (CoNS)	3 (3.0%)	4 (4.0%)	0.38	0.700
Acinetobacter spp.	1 (1.0%)	4 (4.0%)	1.37	0.172

Citrobacter koseri	**0 (0.0%)**	**2 (2.0%)**	**1.43**	**0.153**
Enterobacter aerogenes	**1 (1.0%)**	**0 (0.0%)**	**1.01**	**0.315**
Klebsiella oxytoca (K. oxytoca)	**1 (1.0%)**	**0 (0.0%)**	**1.01**	**0.315**
Proteus spp.	**1 (1.0%)**	**0 (0.0%)**	**1.01**	**0.315**

The distribution of microorganisms in non-catheterized and catheterized patients was analyzed using the Gaussian test to assess statistical significance.

Among the isolates, *Escherichia coli* (E. coli) was the most frequently detected organism in both groups; however, it was significantly more prevalent in non-catheterized patients (46.0%) compared to catheterized patients (22.0%), with a z-value of 3.70 and $p < 0.001$, indicating a significant difference.

Conversely, *Klebsiella pneumoniae* (K. pneumoniae) was more commonly found in catheterized patients (30.0%) than in non-catheterized patients (16.0%), with a z-value of 2.39 and $p = 0.017$, also indicating statistical significance. Similarly, *Enterococcus* spp. was significantly higher in catheterized patients (22.0%) than in non-catheterized patients (11.0%) ($z = 2.12$, $p = 0.034$). Other microorganisms, including *Acinetobacter* spp., *Pseudomonas* spp., Coagulase-negative *Staphylococci* (CoNS), *Citrobacter koseri*, *Enterobacter aerogenes*, *Klebsiella oxytoca* (K. oxytoca), *Proteus* spp., and *Candida* spp., did not show significant differences between the two groups ($p > 0.05$). (Table 4,5,6,7)

TABLE 4: Showing Sensitivity profile of Klebsiella spp.:

Antibiotics	**Non-Catheterized (Total = 17)**		**Catheterized (Total = 30)**	
	Sensitive	Intermediate	Sensitive	Intermediate
AK	13 (75%)		14 (46.66%)	
PIT	14 (82.35%)		18 (60%)	
NIT	14 (82.35%)		19 (63.33%)	
CIP	10 (58.82%)		8 (26.6%)	
NX	10 (58.82%)		6 (20%)	
GEN	11 (64.70%)		11 (36.66%)	
DO	14 (82.82%)		23 (76.66%)	
NET	11 (64.70%)		21 (70%)	
TOB	13 (75%)	4 (25%)	18 (60%)	

CPM	9 (52.94%)	8 (47.05%)	7 (23.33%)	
CZ	7 (41.17%)		-	
CTR	9 (52.94%)	8 (47.05%)	4 (13.33%)	
MRP	14 (82.35%)	3 (17.65%)	13 (43.33%)	4 (13.33%)
IMP	14 (82.35%)	3 (17.65%)	7 (23.33%)	5 (16.6%)
CFS	14(82.35%)		16 (53.33%)	

Klebsiella spp. from non-catheterized patients showed higher overall antibiotic sensitivity, notably to NIT, PIT, DO, and MRP (all above 80%). In catheterized patients, sensitivity rates were generally lower, with the highest being for DO (76.66%) and NET (70%), indicating greater resistance in catheter-associated infections. (Table 4)

Table 5: Showing Sensitivity profile of Pseudomonas spp.

Antibiotics	**Non-Catheterized (Total = 8)**		**Catheterized (Total = 9)**	
	Sensitive	**Intermediate**	**Sensitive**	**Intermediate**
PIT	6 (75%)		4 (44.44%)	
CAZ	4 (50%)		4 (44.44%)	
IPM	7 (87.5%)		3 (33.33%)	
GEN	5 (62.5%)		5 (55.55%)	
TOB	5 (62.5%)		3 (33.33%)	
CPM	5 (62.5%)		4 (44.44%)	
NX	5 (62.5%)		3 (33.33%)	
AK	6 (75%)		5 (55.55%)	
DORI	7 (87.5%)		5 (55.55%)	
CFS	6 (75%)		5 (55.55%)	
NIT	6 (75%)		4 (44.44%)	
CIP	5 (62.5%)		2 (21.33%)	
MRP	5 (62.5%)	1 (13%)	5 (55.55%)	

In the case of ***Pseudomonas spp.***, non-catheterized isolates exhibited strong sensitivity to imipenem (87.5%), doripenem (DORI) (87.5%), and amikacin (AK) (75%), indicating their effectiveness in treating such infections. However, catheterized *Pseudomonas* strains showed considerably lower sensitivity to these same drugs, with imipenem dropping to 33.33% and ciprofloxacin (CIP) to just 21.33%. (Table 5)

Table 6: Showing Sensitivity profile of E. coli

Antibiotics	**Non-Catheterized (Total = 46)**		**Catheterized (Total = 22)**	
	Sensitive	Intermediate	Sensitive	Intermediate
AK	41 (89%)		12 (54.54%)	
PIT	42 (91.30%)		14 (63.63%)	
NIT	39 (84.78%)		11 (50%)	
CFS	40 (86.95%)		11 (50%)	
CPM	32 (69.56%)	6 (13.04%)	6 (27.27%)	
CTR	30 (65.21%)	5 (10.86%)	4 (18.18%)	
NET	36 (78.26%)		11 (50%)	
TOB	31 (67.39%)	9 (19.56%)	9 (40.90%)	
AMC	29 (63.04%)	10 (21.73%)	-	
CIP	32 (69.56%)	8 (17.39%)	-	
NX	27 (58.69%)	7 (15.21%)	-	
GEN	40 (86%)		7 (31.81%)	
DO	42 (91.30%)		14 (63.63%)	

For **E. coli**, non-catheterized samples were highly susceptible to most antibiotics, especially PIT (91.3%), doxycycline (DO) (91.3%), and amikacin (AK) (89%), making these suitable choices for empirical therapy. Catheterized E. coli isolates. (Table 6)

Table 7,8,9, 10 are showing sensitivity profile of different species involved in the Catheterized and Non-Cathatheterized patients

Table 7: Showing Sensitivity profile of Proteus spp .

Antibiotics	Sensitivity (S)	Resistance (R)
PIT	100%	AMC
CTR	100%	NIT
CPM	100%	AK
CFS	100%	DO
CIP	100%	
NX	100%	
TGC	100%	
MRP	100%	
GEN	100%	
NET	100%	
TOB	100%	

Note: Highly sensitive to most antibiotics tested, except for resistance noted to AMC, NIT, AK, and DO.

Table 8: Showing Sensitivity profile of Enterobacter aerogenes.

Antibiotics	Sensitivity (S)	Intermediate sensitive
CFS	100%	NIT
CPM	100%	PIT
CTR	100%	CPZ
GEN	100%	
AK	100%	
TOB	100%	
MRP	100%	
IPM	100%	
NX	100%	

Enterobacter aerogenes showed 100% sensitivity to all tested antibiotics including CFS, CPM, CTR, GEN, AK, TOB, MRP, IPM, and NX, indicating excellent antimicrobial response. Intermediate sensitivity was observed to NIT, PIT, and CPZ, suggesting limited resistance.

Table 9: Showing Sensitivity profile of Enterococcus spp. Catheterized and Non- Cathatheterized patients.

S.No	Antibiotic	Catheterized Total-22	Non-Catheterized (Total-11)
1	AMP	11 (100%)	8 (72.72%)
2	NX	7 (31.81%)	5 (45.45%)
3	NIT	16(72.72%)	10 (90.90%)
4	HLG	10 (45.45%)	9 (81.81%)
5	VA	22 (100%)	11 (100%)
6	DO	17(77.27%)	8 (72.72%)
8	CIP	14 (63.63%)	7 (63.63%)
9	TE	16 (72.72%)	6(54.54%)
10	LZ	22(100%)	11(100%)
11	TE	22(100%)	11(100%)
		—	—

Note: Catheter-associated strains showed higher resistance compared to non-Catheterized strains for most antibiotics, especially HLG and NX. However, both groups showed 100% sensitivity to VA,LZ,andTE.

In catheterized patients with Citrobacter koseri, 100% sensitivity was observed to most antibiotics including IMP/MRP, PIT, AK, GEN, CFS, NET, and TOB. Moderate sensitivity (50%) was noted for CIP and NIT, while resistance was observed to AMC and CZ.

Table 10: Distribution of *Candida* Species and Germ Tube Test Results in Catheterized and Non-Catheterized Patients.

	CATHETERIZE D	NON- CATHETERIZED	CATHETERIZED	NON- CATHETERIZE D
GERM TUBE TEST	3	5	4	7
NON-CANDIDA ALBICANS				

	CATHETERIZED	NO. of isolates	NON- CATHETERIZED	No.of isolates
B/C TEST	C. tropicalis	1	C.tropicalis	2
	C.dublinensis	2	C.dublinensis	4
	C.glabrata	1	C.glabrata	1

Among catheterized patients, germ tube test was positive in 3 and 4 cases, while in non- catheterized patients, it was positive in 5 and 7 cases. Non-*Candida albicans* isolates included *C. tropicalis* (1 vs. 2), *C. dubliniensis* (2 vs. 4), and *C. glabrata* (1 each), with *C. dubliniensis* being the most frequent, especially in non-catheterized cases.

DISCUSSION

Age and gender distribution

In the present study, younger adults were disproportionately represented among catheterized patients, with 38% belonging to the 20–30-year age group. In contrast, the non-catheterized group showed its highest representation in the 61–70-year age group (22%). This distribution differs from the pattern commonly described in the literature, where advanced age is recognized as an important risk factor for catheter-associated urinary tract infection (CAUTI). In a prospective multicentre study conducted across 145 intensive care units in nine Latin American countries, increasing age was independently associated with CAUTI, with the risk increasing by approximately 1% for each additional year of age. Female sex, longer hospital stay and a higher urinary-catheter/device-utilization ratio were also independently associated with CAUTI [7].

The relatively high representation of younger adults in the catheterized group in the present study may therefore reflect the clinical characteristics of the study population rather than an intrinsically higher risk of CAUTI in younger individuals. Indications for catheterization, acute urinary retention, trauma, surgery, critical illness and the requirements for close monitoring of urine output may substantially influence catheter utilization independently of age. Current CDC recommendations emphasize that urinary catheters should be inserted only for appropriate indications and removed as soon as they are no longer required, with particular attention to minimizing catheter use and duration in high-risk populations [8,9].

The comparatively lower proportion of elderly catheterized patients in our cohort should therefore not necessarily be interpreted as evidence of lower susceptibility. Rather, it may reflect differences in clinical indications, patient selection, catheter-utilization practices or institutional protocols. Older age remains an established risk factor for adverse outcomes among catheterized patients, and CDC evidence reviews identify advanced age, particularly age above 70 years, among factors associated with increased mortality risk in patients with indwelling urinary catheters [10]. Thus, the age distribution observed in the present study highlights the importance of interpreting CAUTI epidemiology within the specific demographic and clinical context of each institution.

Gender-wise, females predominated in both groups, accounting for 78% of non-catheterized and 76% of catheterized patients. This predominance is consistent with epidemiological observations showing that females frequently constitute a substantial proportion of patients with UTI and CAUTI. The prospective INICC study reported female sex as an independent risk factor for CAUTI, with females demonstrating approximately 28% higher adjusted odds of CAUTI than males [7].

Although females predominated in our study, males constituted a slightly greater proportion of the catheterized group than the non-catheterized group. This finding is clinically relevant because catheter-associated infection is influenced not only by sex but also by catheter duration, underlying urological abnormalities, urinary retention, hospitalization and exposure to antimicrobial therapy. Importantly, the available evidence does not support the conclusion that

catheterized males universally experience more severe CAUTI; rather, sex should be considered together with the underlying clinical indication and other risk factors. Individualized catheter management and avoidance of unnecessary catheterization therefore remain more appropriate strategies than sex-based assumptions regarding infection severity [8,9].

Antimicrobial susceptibility pattern

A marked difference in antimicrobial susceptibility was observed between catheterized and non-catheterized UTI isolates in the present study. Overall, catheter-associated isolates demonstrated lower susceptibility to several commonly tested antimicrobial agents. This observation is consistent with evidence that CAUTIs are frequently associated with a more resistant bacterial population than non-catheter-associated UTIs.

D'Incau et al. [96], in a national surveillance analysis of 27,158 urine cultures, demonstrated important differences in both bacterial distribution and antimicrobial resistance between CAUTI and non-CAUTI isolates. *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Proteus mirabilis* accounted for a large proportion of isolates, while *P. aeruginosa* was significantly more frequent in CAUTI samples. Importantly, *E. coli* isolates from CAUTI samples showed significantly higher resistance to several antimicrobial classes, including third-generation cephalosporins, fluoroquinolones, trimethoprim-sulfamethoxazole and amoxicillin-clavulanate. Increased resistance was also observed among *Klebsiella*, *Proteus* and *Pseudomonas* isolates for selected agents [10].

A separate study of complicated UTIs similarly reported higher proportions of AmpC-producing and carbapenemase-producing organisms among CAUTI patients compared with non-catheter-associated cases [11]. These findings support the present observation that catheterization may be associated with a more complex antimicrobial-resistance profile. The difference is likely multifactorial and may involve prolonged healthcare exposure, prior antimicrobial exposure, repeated instrumentation, colonization and biofilm-associated persistence. However, because the present study was observational, these mechanisms should be considered plausible explanations rather than directly demonstrated causal factors.

***Klebsiella* spp.**

In the present study, *Klebsiella* spp. showed considerably greater susceptibility among non-catheterized isolates to imipenem (82.35%), meropenem (82.35%), piperacillin-tazobactam (82.35%) and nitrofurantoin (82.35%). In contrast, catheterized isolates demonstrated a substantial reduction in susceptibility, with imipenem and meropenem susceptibility falling to 23.33% and 43.33%, respectively.

This pronounced difference is clinically important because *Klebsiella pneumoniae* is a major uropathogen in healthcare-associated infections and is frequently associated with ESBL and carbapenem-resistance mechanisms. In a multicentre Indian surveillance study, carbapenem resistance was particularly prominent among *Klebsiella* urinary isolates, with resistance reported in approximately 76% of *Klebsiella*-associated UTIs in participating tertiary-care hospitals [12]. More recent surveillance has likewise demonstrated substantial resistance among *Klebsiella* isolates, particularly to β-lactams and fluoroquinolones [13].

The markedly reduced carbapenem susceptibility observed in the catheterized group in our study therefore warrants particular attention. Nevertheless, the relatively small number of isolates and the observational nature of the study require cautious interpretation. The retained susceptibility to doxycycline (76.66%) is an interesting finding, but it should not by itself be interpreted as evidence supporting routine empirical use. Antimicrobial selection should instead be based on culture results, local antibiograms, clinical severity and established treatment guidelines.

***Pseudomonas* spp.**

A similar reduction in susceptibility was observed among *Pseudomonas* spp. Non-catheterized isolates showed relatively high susceptibility to imipenem (87.5%), doxycycline (87.5%) and amikacin (75%), whereas catheterized isolates showed substantially lower susceptibility, including 33.33% for imipenem and 21.33% for ciprofloxacin.

These findings are consistent with surveillance studies demonstrating that *Pseudomonas aeruginosa* is

disproportionately represented in CAUTIs and may exhibit increased resistance to several antimicrobial agents. D'Incau et al. reported that *P. aeruginosa* occurred significantly more frequently in CAUTI samples and showed significantly higher resistance to cefepime and piperacillin-tazobactam than isolates from non-CAUTI samples [96]. A recent long-term surveillance study also identified *P. aeruginosa* among the principal CAUTI pathogens and reported substantial multidrug resistance among healthcare-associated isolates [14,15].

The partial activity of last-line agents observed in our study should be interpreted cautiously. The detection of resistance among *Pseudomonas* isolates reinforces the importance of culture-directed therapy and antimicrobial stewardship rather than routine escalation to reserve antibiotics.

Escherichia coli

E. coli was the predominant bacterial isolate in the present study, accounting for 46% of non-catheterized and 22% of catheterized cases. This predominance is consistent with broader UTI literature and surveillance studies identifying *E. coli* as one of the principals uropathogens in both community-associated and healthcare-associated urinary infections [10].

The non-catheterized *E. coli* isolates demonstrated high susceptibility to several agents, including amikacin (>89%), piperacillin-tazobactam (91.3%) and doxycycline (91.3%). In catheterized patients, susceptibility decreased considerably, including amikacin (54.54%), nitrofurantoin (50%) and gentamicin (31.81%). This difference is consistent with the findings of D'Incau et al., who observed significantly greater resistance among CAUTI-associated *E. coli* isolates to multiple antimicrobial classes compared with non-CAUTI isolates, with the exception of nitrofurantoin [10].

The present findings therefore reinforce the importance of distinguishing catheter-associated from non-catheter-associated infections when selecting empirical treatment. The reduced susceptibility observed in catheterized patients suggests that treatment decisions based solely on susceptibility patterns from uncomplicated community-acquired UTI may be inappropriate in catheter-associated infections.

***Proteus* spp.**

Proteus spp. demonstrated susceptibility to several tested antimicrobial agents, although resistance was observed to amoxicillin-clavulanate, nitrofurantoin, amikacin and doxycycline. The presence of *Proteus* in catheterized urinary infections is clinically relevant because *Proteus mirabilis* is a recognized CAUTI-associated pathogen and is frequently associated with catheter encrustation and complicated urinary infection.

D'Incau et al. reported *P. mirabilis* among the principal CAUTI pathogens and identified significantly greater norfloxacin resistance in CAUTI isolates than in non-CAUTI isolates [10]. The susceptibility pattern observed in our study therefore further supports the need for culture-directed treatment and continued local surveillance of *Proteus* resistance.

Enterobacter aerogenes

Enterobacter aerogenes demonstrated relatively good susceptibility to carbapenems and aminoglycosides in the present study, although intermediate susceptibility was observed for nitrofurantoin, ciprofloxacin and netilmicin. Because the number of isolates was limited, these findings should be interpreted cautiously. In addition, organisms historically reported as *Enterobacter aerogenes* are now generally classified as *Klebsiella aerogenes*. This organism possesses inducible AmpC β-lactamase mechanisms and may develop resistance during therapy with certain β-lactam antibiotics.

Accordingly, the apparent susceptibility to individual agents in a small study population should not be extrapolated to empirical treatment recommendations. Continuous institutional surveillance remains essential, particularly for healthcare-associated Gram-negative infections.

***Enterococcus* spp.**

Enterococcal isolates from catheterized patients demonstrated lower susceptibility to several tested agents compared with non-catheterized isolates. High-level gentamicin susceptibility was 45.45% in catheterized isolates compared with 81.81% in non-catheterized isolates, while norfloxacin susceptibility was 31.81% and 45.45%, respectively. However, both groups demonstrated 100% susceptibility to vancomycin, linezolid and teicoplanin.

Enterococci are increasingly recognized among healthcare-associated urinary pathogens, particularly in patients with urinary instrumentation and prolonged hospitalization. The systematic review and meta-analysis of catheter-associated UTI microbiology by recent investigators identified *Enterococcus* spp. among the most frequent bacterial groups associated with CAUTI [16].

Although the complete susceptibility to vancomycin, linezolid and teicoplanin in our isolates is encouraging, these agents should not automatically be regarded as first-line therapy for enterococcal UTI. Their use should be reserved for appropriate clinical indications and guided by susceptibility testing, infection severity and antimicrobial-stewardship principles.

Citrobacter koseri

Only two *Citrobacter koseri* isolates were identified in the present study. Both showed susceptibility to carbapenems and colistin, while reduced susceptibility was observed for ciprofloxacin and piperacillin-tazobactam. Because of the very small sample size, no definitive conclusions regarding the resistance profile of *C. koseri* can be drawn. Nevertheless, the finding illustrates the importance of species-level identification and individualized susceptibility testing, particularly for less frequently encountered Gram-negative uropathogens.

Candida species

Candida growth was detected in 7 catheterized and 12 non-catheterized patients. Germ-tube testing identified *Candida albicans* in 3 catheterized and 5 non-catheterized samples. Among the non-*albicans Candida* isolates, biochemical testing, including sugar assimilation, urease testing, inverted Durham's tube testing and sugar fermentation, identified *C. tropicalis*, *C. dubliniensis* and *C. glabrata* in the catheterized group, while *C. tropicalis*, *C. dubliniensis* and *C. glabrata* were also detected among non-catheterized patients.

In both groups, *C. dubliniensis* was the most frequently identified non-*albicans Candida* species, followed by *C. tropicalis*, whereas *C. albicans* was identified by germ-tube testing. The predominance of non-*albicans Candida* observed in the present study is noteworthy because candiduria in hospitalized and catheterized patients is frequently associated with non-*albicans Candida* species. An Indian study of catheterized ICU patients reported non-*albicans Candida* species as the predominant group, accounting for 71.4% of isolates [17].

The detection of Candida in urine, however, requires careful clinical interpretation because candiduria may represent colonization rather than symptomatic Candida UTI, particularly in patients with indwelling urinary catheters. The IDSA guideline emphasizes that asymptomatic candiduria commonly reflects colonization and recommends elimination of predisposing factors, particularly removal of an indwelling urinary catheter when feasible, rather than routine antifungal treatment [18].

Therefore, the Candida findings in the present study should be interpreted primarily as a microbiological observation unless corresponding clinical evidence of Candida UTI was documented. Species-level identification remains valuable because Candida species differ in their antifungal susceptibility profiles, and emerging evidence continues to demonstrate the importance of species identification and susceptibility testing in symptomatic candiduria [19].

Overall interpretation

Taken together, the present findings demonstrate important differences between catheterized and non-catheterized urinary infections with respect to demographic distribution, pathogen profile and antimicrobial susceptibility. The predominance of *E. coli*, together with the presence of *Klebsiella*, *Pseudomonas*, *Proteus* and *Enterococcus*, is broadly consistent with contemporary CAUTI surveillance literature [11].

The generally lower antimicrobial susceptibility observed among catheter-associated isolates is particularly important. D'Incau et al. demonstrated that CAUTI-associated pathogens were more frequently resistant to commonly used empirical antibiotics than non-CAUTI pathogens, supporting the use of urine culture and susceptibility testing before or during treatment whenever clinically appropriate [96]. Similar findings have been reported in complicated UTI populations, where CAUTI was associated with higher frequencies of AmpC-producing and carbapenemase-producing organisms [11].

The findings also emphasize that antimicrobial susceptibility patterns are institution-specific. Thus, the relatively high activity of amikacin, piperacillin-tazobactam or doxycycline against selected isolates in the present study should not be interpreted as a universal recommendation for empirical therapy. Instead, these results should contribute to the development of a local antibiogram and periodically updated empirical treatment protocols.

Finally, the findings support a comprehensive CAUTI-prevention strategy based on appropriate catheter indication, aseptic insertion, proper catheter maintenance, regular assessment of continued need and prompt removal when the catheter is no longer clinically indicated. Current CDC recommendations specifically emphasize minimizing both catheter utilization and duration of catheterization [9,10]. In combination with antimicrobial stewardship, microbiological surveillance and institution-specific antibiograms, these measures can help reduce unnecessary antimicrobial exposure and limit the selection and transmission of resistant uropathogens.

CONCLUSIONS

Urinary tract infections (UTIs) remain a major public health concern, particularly among women. This study identified Escherichia coli, Klebsiella pneumoniae, and Staphylococcus aureus as the predominant pathogens responsible for UTIs. A concerning observation was the widespread resistance of these isolates to commonly prescribed antibiotics, underscoring the urgent need for routine antimicrobial surveillance and monitoring to improve patient management and treatment outcomes. The findings strongly advocate for judicious catheter use, strict infection control practices, and evidence-based antibiotic stewardship programs.

STATEMENTS AND DECLARATIONS

AI Statement: No AI tools are used in this article.

Ethical Standards: All the ethical Research standards were followed while writing this Research Article.

Conflict of Interest: The authors state that they do not have any conflict of interest.

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