International Journal of Clinical and Biomedical Research
Vol. 11, No. 4 (2026)
pISSN: 2521-0394 · eISSN: 2395-0471

ORIGINAL RESEARCH

A study of Incidence, Risk factors, Bacteriological Profile and Antimicrobial Susceptibility Pattern of Catheter Associated Urinary Tract Infections in the Intensive Care Units of a Tertiary Care Hospital in Rajasthan

Kumari Ritika [1], **Srivastava Preeti** [2], **Fageria Babita K** [3*], **Garg Nitika** [4]

[1] *Third-year MD Microbiology Resident, Jaipur National University Institute for Medical Sciences and Research Centre, Rajasthan, India*
[2] *Professor & HOD, Jaipur National University Institute for Medical Sciences and Research Centre, Rajasthan, India*
[3] *Associate Professor, Jaipur National University Institute for Medical Sciences and Research Centre, Rajasthan, India*
[4] *Assistant Professor, Jaipur National University Institute for Medical Sciences and Research Centre, Rajasthan, India*

*Correspondence: Fageria Babita K <drbebo1290@gmail.com>

ABSTRACT

Background: Catheter-associated urinary tract infection (CAUTI) is among the most common device-associated infections in intensive care units (ICUs), and the pathogens involved are increasingly drug-resistant. This study assessed the incidence, risk factors, bacteriological profile and antimicrobial susceptibility pattern of CAUTI in the ICUs of a tertiary care hospital in Rajasthan, India. **Methods:** A prospective, hospital-based observational study was conducted from June 2024 to May 2025. Consecutive ICU patients with an indwelling urinary catheter for ≥48 hours (n = 207) were followed by daily active surveillance according to CDC NHSN criteria. Urine samples were cultured semi-quantitatively, isolates were identified by standard methods, and antimicrobial susceptibility was tested by Kirby–Bauer disc diffusion (CLSI 2025). Associations between co-morbidities and CAUTI were assessed with the mid-p exact test. **Results:** CAUTI developed in 17 of 207 patients (8.21%); 7046 catheter days were recorded, giving a CAUTI rate of 2.41 per 1000 catheter days. Frequency was highest in the medical ICU (9.9%). *Enterococcus* spp. (58.8%) was the predominant isolate, followed by *Escherichia coli* (29.4%) and *Klebsiella pneumoniae* (11.8%). All isolates were resistant to fluoroquinolones, and Gram-negative isolates were resistant to most cephalosporins and β-lactam/β-lactamase inhibitor combinations. Nitrofurantoin (76%) and fosfomycin (80%) retained the most activity, and all enterococci were susceptible to vancomycin, teicoplanin and linezolid. Type 2 diabetes mellitus was more frequent among patients with CAUTI than among those without (23.5% vs 5.3%; p = 0.022). **Conclusion:** The CAUTI rate was close to the CDC-NHSN benchmark, but antimicrobial resistance was extensive and Enterococcus was the leading pathogen. Continued surveillance, catheter care bundles and antimicrobial stewardship are needed in ICUs.

Keywords: Catheter-associated urinary tract infection; Intensive care units; Enterococcus; Antimicrobial resistance; Healthcare-associated infection

INTRODUCTION

Healthcare-associated infections (HAIs) are one of the leading causes of morbidity and mortality in hospitals globally, especially in various intensive care units (ICUs), with approximately 1.4 million patients worldwide affected at any given time and prevalence rates ranging from 7% to 12% [1, 2]

Urinary tract infections (UTIs) are among the most common healthcare-associated infections accounting for up to 40% of all healthcare-associated infections (HAIs) and around three-quarters of them are associated with indwelling urinary catheters (IUC), while the association is even stronger in ICUs where around 95% of UTIs are related to catheter use [3, 4] Catheter Associated Urinary Tract Infection (CAUTI) is the most common among device associated infections acquired from hospital settings. [5] CDC defines CAUTI as UTI where an IUC was in place for more than two calendar days. [6]

Around 45–79% of critically ill ICU patients undergo urinary catheterization which in itself poses a risk for developing CAUTI. [7] With an in situ IUC, estimated risk of acquiring CAUTI increases by 3–7% with each passing day. [8]

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Acute care hospitals in 2023 documented more than 17,000 CAUTI events occurring over 23 million urinary catheter device-days. [9] The National Healthcare Safety Network (NHSN) reported pooled mean CAUTI rates ranging from 0 to 4.4 per 1000 catheter days across US hospital location types [10]

Escherichia coli is the predominant pathogen causing catheter-associated UTI, followed by other Enterobacterales, non-fermenters and Gram-positive bacteria including Enterococcus. [11] Numerous uropathogens have shown resistance to commonly used antibiotics, making the treatment of Urinary Tract Infections (UTIs) caused by catheter-associated, biofilm-producing, multidrug-resistant (MDR) organisms a particularly difficult challenge in ICUs which is further complicated by risk factors including uncontrolled diabetes, advanced age, immunocompromised status and prolonged hospitalization. [12, 13]

This background underscores the importance of periodically monitoring trends in these infections. Data on CAUTI and its associated factors are not available from this healthcare setting. This study was therefore conducted to determine the incidence, bacteriological profile, risk factors and antimicrobial susceptibility pattern of CAUTI in the ICUs of our tertiary care hospital in eastern Rajasthan.

MATERIALS & METHODS

Study design, setting and duration: A prospective, hospital-based observational study was conducted in the bacteriology laboratory of the Department of Microbiology at Jaipur National University Institute for Medical Sciences and Research Centre (JNUIMSRC), Jaipur, Rajasthan from June 2024 to May 2025, after approval from the Institutional Ethics Committee (Ref. No. [JNUIMSRC/IEC/2024/45], dated [01-03-2024].

Sample size and sampling technique: Sample size was calculated using Cochran's formula taking expected frequency of CAUTI among patients with indwelling urinary catheter as 14.67%, and the margin of error 5% at 95% confidence interval ($n = 1.96^2 \times 0.1467 \times 0.8533 / 0.05^2 = 193$). [6] In total, 207 consecutive patients from different ICUs with an indwelling urinary catheter for ≥48 hours were included in the study after taking written informed consent. In case of children, the consent was obtained from the parents/legal guardians and age-appropriate assent was obtained, wherever applicable.

Inclusion Criteria: Patients of all ages admitted to the Intensive Care Units (ICUs) who were catheterized with an indwelling urinary catheter for ≥48 hours.

Exclusion Criteria:

1. Patients whose urine sample collected at the time of catheterization was culture positive.

2. Patients catheterized prior to admission in ICU.

3. Patients who showed signs and symptoms of UTI within two calendar days of catheterization.

4. Patients with renal anomalies.

5. Patients with condom catheters, suprapubic catheters and percutaneous nephrostomy tubes.

Surveillance of catheterized patients and sample collection:

Site-specific prospective active surveillance was carried out on daily basis in different ICUs and detailed history on each patient fulfilling the inclusion criteria was collected on standardized data collection forms as well as denominator data was also collected daily on denominator reporting form as per CDC NHSN guidelines. [9] Urine samples were obtained aseptically through the catheter sampling port, or when required, by carefully puncturing the catheter tubing using a sterile needle and syringe while following all standard precautions. [14]

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Laboratory Procedure:

Macroscopic examination included color, quantity, presence of blood and turbidity. Microscopic examination of uncentrifuged urine was performed using the wet mount technique and even a few pus cells per high power field (≥1 pus cell per 7 high power fields) were considered indicative of significant pyuria. [15]

Urine samples were immediately cultured by semi-quantitative technique onto HiCrome UTI agar (HiMedia Laboratories, Mumbai, India) using a calibrated loop delivering 1 µL of urine. It was then incubated overnight at 37°C. A colony count of $\geq 10^5$ CFU/ml was considered significant. Presence of three or more types of colonies was reported as mixed growth. Further identification of isolated bacteria was done using Gram staining, colony characteristics and a set of biochemical reactions according to the Gram reaction of the organism. [14]

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method and zones of inhibition were interpreted according to the established breakpoints given by CLSI 2025 guidelines. [16]

CAUTI Case Definition:

CAUTI cases were identified according to the CDC NHSN criteria i.e.Indwelling catheter in place for more than 2 consecutive days; at least one sign or symptom such as fever >38.0 °C, suprapubic tenderness or costovertebral angle pain/ tenderness;and urine culture yielding ≥105 CFU/mL with no more than two species)

Calculation of CAUTI incidence and CAUTI rate: [9]

Cumulative incidence of CAUTI was calculated as percentage of catheterized patients developing CAUTI in study duration.

The CAUTI rate was calculated by dividing the number of CAUTI cases by the number of catheter days and multiplying the result by 1000.

CAUTI RATE = Number of CAUTI cases / Number of urinary catheter days X 1000

Statistical analysis: Data were entered in Microsoft Excel and summarised as frequencies and percentages for qualitative variables and as mean ± standard deviation (range) for quantitative variables. The association between co-morbidities and CAUTI was assessed with the two-tailed mid-p exact test using OpenEpi software (version 3.01). A p-value < 0.05 was considered statistically significant.

RESULTS

Out of the total 207 catheterized patients studied, a total of 17 patients developed CAUTI, accounting for a cumulative incidence of 8.21%. In total, 7046 urinary catheter days were recorded during the study period, yielding an overall CAUTI rate of 2.41 per 1000 catheter days.

The largest group of catheterized patients was aged 60–69 years (41; 19.8%), followed by those aged >69 years (39; 18.8%), while 39 patients (18.8%) were younger than 30 years. Mean age of the patients was 49.33 years (SD = 20.54). CAUTI incidence was highest in the 20–29-year age group (4/19; 21.1%). [Table 1]

Table 1. Age Distribution of Catheterized Patients and CAUTI cases

Age Group (years)	Number Of Catheterized Patients (%)	CAUTI cases (%)
<10	13 (6.3%)	0 (0%)
10-19	7 (3.4%)	1 (14.3%)
20-29	19 (9.2%)	4 (21.1%)
30-39	25 (12.1%)	2 (8.0%)
40-49	26 (12.6%)	0 (0%)

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Age Group (years)	Number Of Catheterized Patients (%)	CAUTI cases (%)
50-59	37 (17.9%)	2 (5.4%)
60-69	41 (19.8%)	4 (9.8%)
>69	39 (18.8%)	4 (10.3%)
Total	207 (100%)	17 (8.21%)
Mean age ±SD	49.33 ± 20.54 years	

Among 17 CAUTI cases, 11 (64.71%) were males, while 6 (35.29%) were females. However, relative frequency of CAUTI was higher in females (6/62; 9.7%) than in males (11/145; 7.6%). [Table 2]

Table 2. Gender-wise distribution of catheterized patients and CAUTI cases

Gender	Number	CAUTI incidence
Male	145 (70.05%)	11 (7.6%)
Female	62 (29.95%)	6 (9.7%)
Total	207 (100%)	17 (8.21%)

The largest proportion of catheterized patients were admitted to the medical ICU (MICU; 91, 44.0%), followed by the respiratory ICU (RICU; 52, 25.1%), surgical ICU (SICU; 34, 16.4%), paediatric ICU (PICU; 16, 7.7%), burn ICU (BICU; 9, 4.3%) and cardiothoracic and vascular surgery ICU (CTVS; 5, 2.4%). CAUTI incidence was highest in the MICU (9/91; 9.9%), followed by the RICU (5/52; 9.6%), PICU (1/16; 6.3%) and SICU (2/34; 5.9%); no CAUTI occurred in the BICU or CTVS unit. [Figure 1]

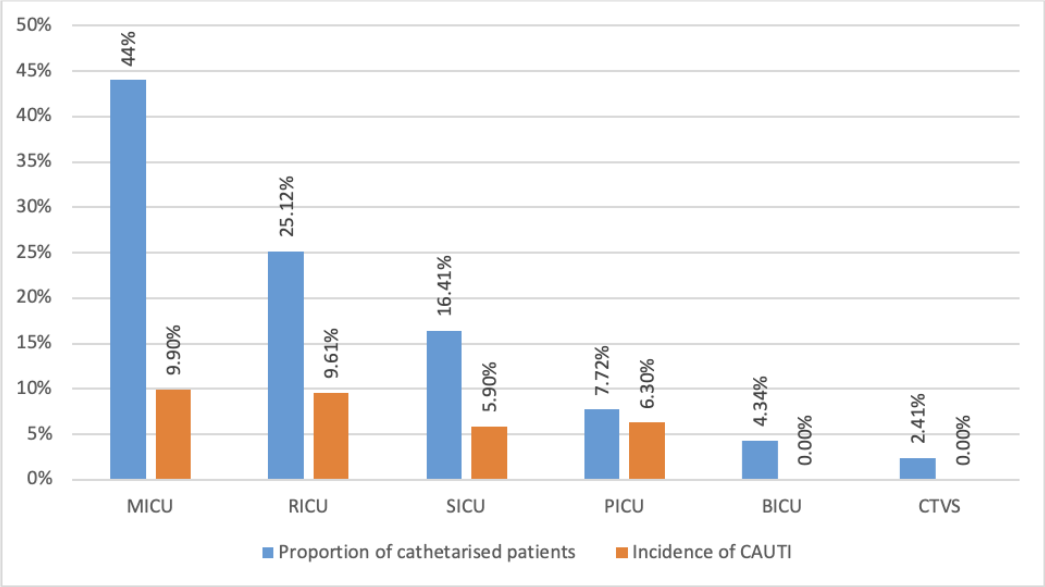


Figure 1. *Proportion of catheterized patients in each ICU and CAUTI INCIDence across ICUs during the study period*

Among 17 CAUTI cases, *Enterococcus* spp. was the predominant pathogen, accounting for 10 isolates (58.8%) followed by *Escherichia coli* with 5 isolates (29.41%) and *Klebsiella pneumoniae* with 2 isolates (11.76%). [Figure 2]

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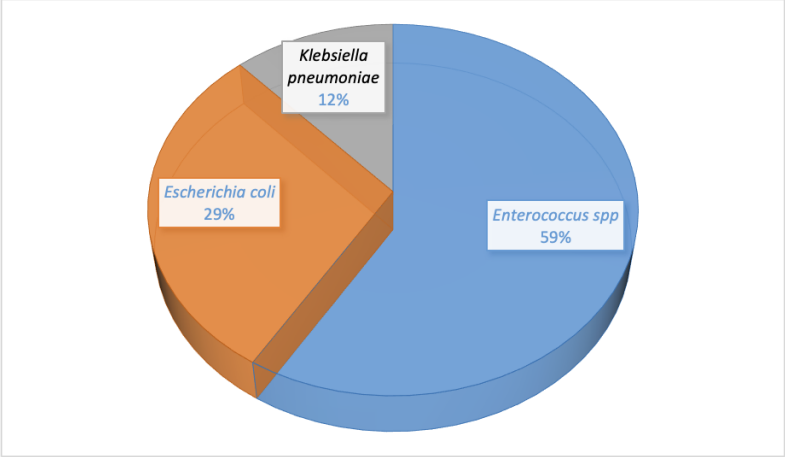


Figure 2. *Distribution of organisms in CAUTI cases*

Each agent was tested against the isolates for which it is clinically relevant (Enterococcus, n = 10; Gram-negative bacilli, n = 7), so denominators differ between agents. The antibiotic susceptibility pattern revealed extensive resistance across multiple drug classes, with only a few agents retaining notable activity. Penicillin and ampicillin showed sensitivity in 20% of isolates (2/10 and 3/15, respectively). Most of the cephalosporins demonstrated poor effectiveness, with cefazolin, cefuroxime, ceftriaxone, cefotaxime and cefepime, showing resistance in all tested Gram-negative isolates, while ceftazidime retained partial activity (29% sensitivity).

Among beta-lactam/beta-lactamase inhibitor (BL/BLI) combinations, amoxicillin/clavulanic acid and piperacillin/tazobactam depicted resistance in 100% isolates while ceftazidime-avibactam showed slight activity (29% sensitivity). Carbapenems showed variable results with 43% isolates being sensitive to meropenem and imipenem each, whereas ertapenem was highly ineffective (14% sensitivity).

All tested isolates were resistant to fluoroquinolones (ciprofloxacin and levofloxacin). Poor susceptibility was noted towards aminoglycosides, with amikacin, gentamicin being active in only 29% isolates while high-level aminoglycosides depicted mixed activity with high-level gentamicin (HLG) showing resistance in 90%, while high-level streptomycin (HLS) retained activity in 80% of the tested enterococcal isolates. Tetracyclines showed moderate activity, with tetracycline being sensitive in 41% and doxycycline in 50% isolates. Among glycopeptides and oxazolidinones, vancomycin, teicoplanin and linezolid demonstrated sensitivity in all Gram-positive isolates (100%). Cotrimoxazole showed limited efficacy being sensitive in 29% isolates. Urinary antibiotics nitrofurantoin and fosfomycin showed moderate to high activity with 76% and 80% sensitive isolates respectively. [Table 3, Figure 3]

Table 3. Overall antibiotic susceptibility pattern of CAUTI isolates (n=17)

Antibiotic	Tested 1	Sensitive	Resistant
Penicillin	10	2(20%)	8(80%)
Ampicillin	15	3(20%)	12(80%)
Cefazolin	7	0%	7(100%)
Cefuroxime	7	0%	7(100%)
Cefotaxime	7	0%	7(100%)
Ceftriaxone	7	0%	7(100%)
Ceftazidime	7	2(29%)	5(71%)
Cefepime	7	0%	7(100%)
Amoxicillin-clavulanic acid	7	0%	7(100%)
Piperacillin-tazobactam	7	0%	7(100%)
Ceftazidime-avibactam	7	2(29%)	5(71%)

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Antibiotic	Tested 1	Sensitive	Resistant
Ertapenem	7	1(14.3%)	6(85.7%)
Imipenem	7	3(43%)	4(57%)
Meropenem	7	3(43%)	4(57%)
Ciprofloxacin	17	0%	17(100%)
Levofloxacin	17	0%	17(100%)
Amikacin	7	2(29%)	5(71%)
Gentamicin	7	2(29%)	5(71%)
Gentamicin (High level)	10	1(10%)	9(90%)
Streptomycin (High level)	10	8(80%)	2(20%)
Tetracycline	17	7(41.1%)	10(58.9%)
Doxycycline	10	5(50%)	5(50%)
Vancomycin	10	10(100%)	0%
Teicoplanin	10	10(100%)	0%
Linezolid	10	10(100%)	0%
Cotrimoxazole	7	2(29%)	5(71%)
Nitrofurantoin	17	13(76.5%)	4(23.5%)
Fosfomycin 2	15	12(80%)	3(20%)

1Number of tested isolates for each antibiotic are mentioned according to the testing panels and established breakpoints given by CLSI, 2025. [Enterococcus spp = 10, E. coli = 5, K. pneumoniae = 2]. 2Enterococcal isolates could not be identified to species level due to lack of necessary biochemical tests, and fosfomycin results were applied to all enterococcal isolates, however, CLSI breakpoints apply to E. faecalis urinary isolates only.

Out of the total 207 patients studied, 46 (22.2%) were identified with co-morbid conditions. The most common co-morbidity was hypertension, observed in 23 patients (11.11%), followed by tuberculosis in 16 patients (7.73%) and type 2 diabetes mellitus in 14 patients (6.76%), while chronic liver disease was noted in 3 patients (1.45%).

Multiple co-morbidities were present in some individuals: 2 (0.97%) patients had both chronic liver disease and hypertension, and 8 (3.86%) patients had both hypertension and type 2 diabetes mellitus.

Among 46 patients with co-morbidities, 7 (15.2%) developed CAUTI, while 10 (6.21%) of the 161 patients without co-morbidities developed CAUTI ($p = 0.071$). There was no statistically significant difference for hypertension, chronic liver diseases and tuberculosis among patients with/without CAUTI. However, type 2 diabetes mellitus was significantly more frequent among patients with CAUTI than among those without CAUTI (4/17, 23.5% vs 10/190, 5.3%; odds ratio ≈ 5.5 [1.53, 20.1], $p = 0.022$). A high odds ratio (OR ≈ 5.9) was also observed with chronic liver disease, but the difference was statistically insignificant (p value= 0.246). [Table 4]

Table 4. Co-morbidities in patients with or without CAUTI

Co-morbidities	Patients with CAUTI (n=17)	Patients without CAUTI (n=190)	p-value (two-tailed mid-p exact test)	Odds Ratio (with 95% CI)
Type 2 Diabetes Mellitus	4 (23.5%)	10 (5.3%)	0.022	5.5 [1.53, 20.1]
Hypertension	1 (5.9%)	22 (11.6%)	0.536	0.48 [0.06, 3.78]
Chronic Liver Disease	1 (5.9%)	2 (1.1%)	0.246	5.9 [0.51, 68.35]
Tuberculosis	1 (5.9%)	15 (7.9%)	0.854	0.73 [0.09, 5.88]

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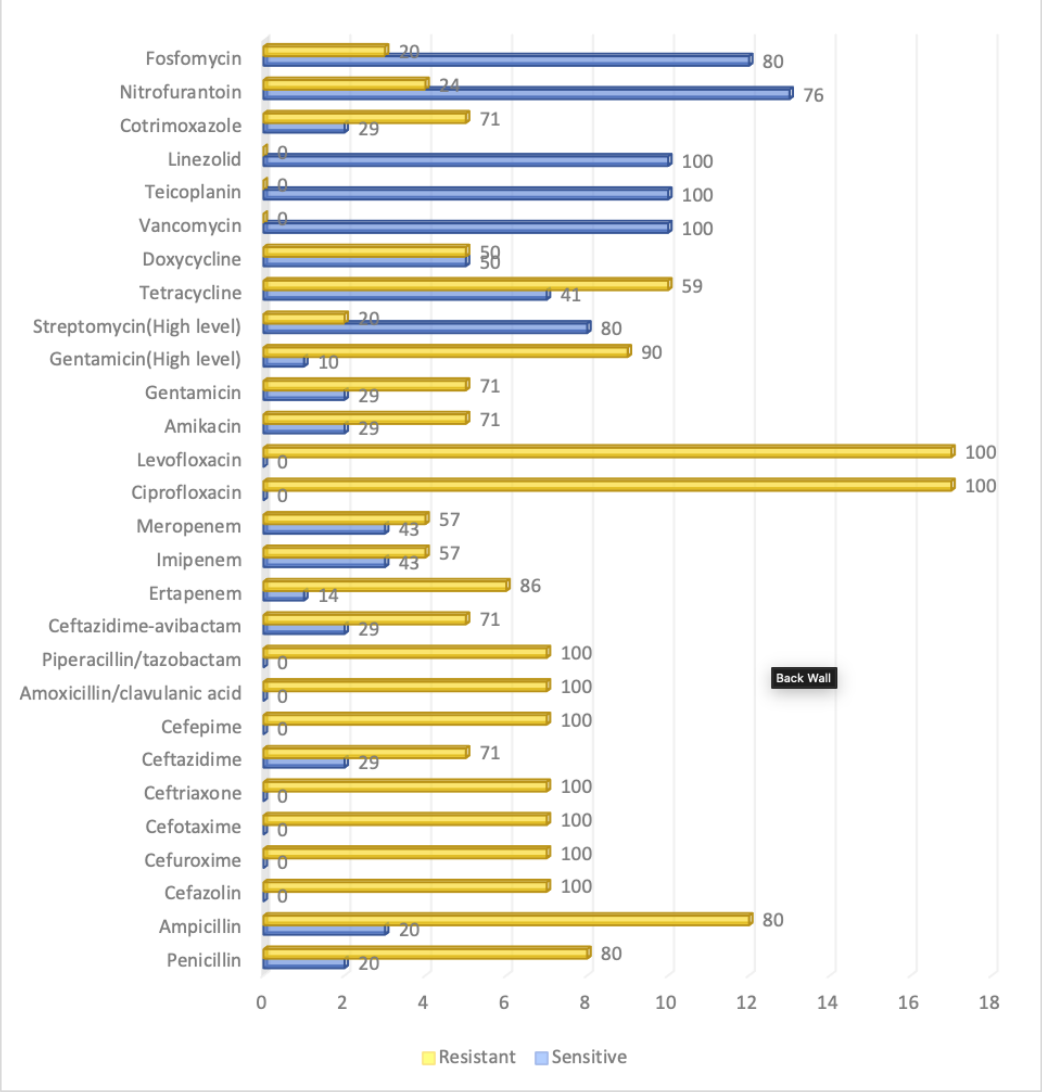


Figure 3. *Antibiotic susceptibility pattern of CAUTI isolates (number of isolates; labels show %)*

DISCUSSION

CAUTI remains an important cause of concern in healthcare settings particularly in ICUs, where its impact is further accentuated by prevailing drug-resistant pathogens and debilitated patient population frequently susceptible to developing these infections. In US hospitals alone, more than 13,000 deaths each year have been estimated to be associated with healthcare-associated UTIs [17]

In the current study, cumulative incidence of CAUTI was found to be 8.21%, maximum being in medical ICU (9.9%), while the CAUTI rate was 2.41 per 1000 catheter days. *Enterococcus species* was the most common isolate among culture positive CAUTI cases. Extensive antimicrobial resistance was recorded across almost all tested drug classes, with the highest overall susceptibility to the urinary agents fosfomycin and nitrofurantoin, while enterococcal isolates additionally depicted complete sensitivity towards glycopeptides and linezolid. Type 2 diabetes mellitus was found to be significantly higher among CAUTI patients than those without CAUTI.

The CAUTI incidence in ICUs of low- and middle-income countries has been reported as 5.5–8.8 per 1000 catheter days, whereas pooled Indian data show a lower rate of 1.60, below both the CDC-NHSN benchmark (2.09) and the INICC benchmark (6.5). Our rate of 2.41 per 1000 catheter days was close to the CDC-NHSN benchmark. [18]

A previous study in a medical ICU recorded a CAUTI prevalence of 14.67%, and other studies have reported higher figures of 26% and 27.8%. [6, 19, 20]

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The reported rate and incidence of CAUTI vary across studies, which is likely due to differences in patient characteristics, duration and frequency of catheterization, adherence to infection prevention practices and healthcare settings. Variations in surveillance methods, diagnostic criteria, study design, local antimicrobial resistance patterns influence the reported rates and incidence. [4] Additionally, institutional resources, healthcare worker compliance with catheter care protocols and regional differences in healthcare infrastructure, can also contribute to the observed variability. [21]

The majority of CAUTI cases (52.94%) and highest incidence in our study were reported from the MICU. This distribution probably reflects the highest proportion of indwelling urinary catheter use in medical ICUs as seen in our study too, where 44% of catheterized patients were from MICU.

Among 17 CAUTI cases, *Enterococcus* spp. was the most common isolated bacteria followed by *E. coli*. *Enterococcus* has also been shown as most common pathogen in CAUTI by few previous studies including a study from Northeast India. [22]

Enterococci have emerged as one of the leading pathogens in CAUTI due to their ability to adhere to and persist on urinary catheters by producing biofilm, as they express endocarditis- and biofilm-associated (Ebp) pili, which bind to fibrinogen deposited on catheters following catheter-induced bladder inflammation. However, *Escherichia coli* has traditionally been the leading cause of all forms of UTI including CAUTI due to its intestinal origin, ability to colonize the periurethral area and form biofilms on catheter surfaces. [23] This has also been documented by a recent Indian study conducted on bacteriological profile of CAUTI. [24]

This varied microbial distribution in CAUTI cases across regions, in our understanding is likely due to variable risk factors among hospitalized patients, previous and present antimicrobial usage and source of infection.

While analyzing the antimicrobial susceptibility pattern obtained in our study, we found that the urinary agents nitrofurantoin and fosfomycin were the most active empirical options in our setting before culture and susceptibility results are available; however, they are suitable only for lower urinary tract infection and not for pyelonephritis or bacteraemia. In addition, if the enterococcal infection is confirmed, glycopeptides and linezolid can be used as all isolates showed susceptibility to these agents. Susceptibility to all other agents was poor, except that most enterococci lacked high-level streptomycin resistance (HLS; 80% susceptible) and half were susceptible to doxycycline. A susceptible HLS screen indicates that streptomycin may act synergistically with a cell-wall-active agent such as ampicillin or vancomycin, not that it can be used alone; streptomycin also requires drug-level monitoring, especially in patients with renal impairment. [25]

A study from South India has reported similar findings with complete susceptibility to glycopeptides, linezolid and nitrofurantoin in Enterococcus, but they showed reduced susceptibility towards nitrofurantoin in Gram-negative bacteria. [26] Similarly, 89.7% sensitivity was observed towards nitrofurantoin in another study. [24] A recent study from USA showed uniformly high sensitivity rates to fosfomycin in both Gram-positive and Gram-negative isolates. [27]

An Indian study showed high resistance rates to cephalosporins and fluoroquinolones similar to our study. This is concerning, as these drugs are usually preferred for treatment of community acquired UTIs, undermining their role in hospital acquired UTIs. [28]

A study from the Middle East observed reduced sensitivity to amikacin and gentamicin [29], while another study from Gujarat, India reported low susceptibility to carbapenems in uropathogenic Enterobacterales causing CAUTI [18], similar to our findings. However, a study from Saudi Arabia observed good sensitivity to both carbapenems and aminoglycosides. [20]

Carbapenems and aminoglycosides are usually prescribed as the initial empirical treatment to critically ill patients in emergency care settings of our hospital, and high resistance rates to these broad-spectrum agents limit their use in such patients.

The high antimicrobial resistance observed in CAUTI patients may be attributed to prolonged hospitalization, biofilm formation and frequent exposure to broad-spectrum antibiotics which leads to colonization by drug-resistant pathogens

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prevailing in hospital environment. The varying resistance patterns across studies likely reflects differences in local pathogens, implementation of antibiotic policies, local antimicrobial prescribing practices and adherence to infection control practices.

While analyzing underlying comorbid conditions among CAUTI cases in our study, only type 2 diabetes mellitus was found to be significantly higher among CAUTI patients than those without it. ($p = 0.022$, OR≈5.5). However, a previous study from Saudi Arabia has identified presence of comorbid conditions, notably diabetes mellitus, hypertension, chronic kidney disease and cardiovascular disease as independent predictors of CAUTI. [20] Another study from Maharashtra, India reported the highest odds of CAUTI in patients with chronic kidney disease, hypertension and diabetes mellitus. [8]

In our study, the association between CAUTI and comorbidities could not be established well, which can be due to lesser number of CAUTI cases which made it difficult to form standard size comparison groups for accurate statistical analysis of risk factors.

Conclusion

Catheter-Associated Urinary Tract Infection (CAUTI) remains a major cause of concern in healthcare settings. In addition to clinical complications, CAUTI imposes a substantial economic burden on patients and healthcare systems including prolonged hospital stays, increased laboratory investigations, higher drug costs, and loss of productive workdays. CAUTI incidence in our setting was similar to many contemporary national studies and lower than a few others, and the CAUTI rate was close to the CDC-NHSN benchmark. This reinforces the role of ongoing surveillance of healthcare associated infections and measures for enhanced adherence to infection control practices being followed at our centre. *Enterococcus spp* was the most common pathogen causing CAUTI, possibly reflecting its persistence in the hospital environment, its ability to form biofilm on catheter surfaces and its intrinsic resistance to many commonly used antibiotics. Extensive drug resistance across many antimicrobial classes in our study highlights the importance of implementing antimicrobial stewardship programs in critical care settings to optimize antibiotic use and improve patient outcomes. Furthermore, appropriate health education, strict adherence to infection control practices, a well-defined antibiotic policy, and proper implementation of catheter care bundles are imperative to prevent CAUTI. Strengthening these measures is the need of the hour to reduce infection rates, curb antimicrobial resistance, and enhance overall quality of care in ICUs.

Strengths and Limitations:

- Site-specific active surveillance was conducted on a daily basis across multiple ICUs using standardized CDC NHSN data collection and denominator forms minimizing underreporting and misclassification.
- This study adds to the evidence of changing microbial profile of hospital acquired UTIs in contrast to those acquired in community where enteric gram-negative bacilli are prevailing.
- This study addressed the need of continuous surveillance of hospital epidemiology and changing antimicrobial resistance patterns.

However,

- The small sample size and single-center design limits the generalizability of the results.
- Because of the small number of CAUTI cases, risk factors could not be analyzed robustly, and a multivariable analysis to identify independent predictors was not possible.
- Testing for minimum inhibitory concentration was not available which is optimal for computing therapeutic index and better selection of definitive antibiotic therapy.

Conflict of Interest- None

Ethical approval: Approved by the Institutional Ethics Committee, JNUIMSRC, Jaipur (Ref. No. JNUIMSRC/IEC/2024/45; dated 01-03-2024. Written informed consent was obtained from all participants or, for minors, from their parents/guardians.

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Funding: None

Author contributions: KR: data collection, laboratory work and drafting; SP: supervision, critical revision and final approval; FBK: data analysis, critical revision of the original draft and final approval ; GN: conception, critical revision and final approval

Acknowledgements: We express our sincere gratitude to hospital administration, ICU and critical care staff, staff of microbiology laboratory and infection control nursing staff for all the cooperation, assistance and infrastructural support provided to carry out this research. Finally, we express our gratitude to all the patients included in this study and their relatives for their cooperation and participation.

Data availability: The data supporting the findings of this study are available from the corresponding author on reasonable request.

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