

Catheter-Associated Urinary Tract Infections and Bundle Care Compliance: A One-Year Surveillance Study in a Tertiary Care Hospital

Shaik Naseema¹, Anam Pradeep Reddy², Penmetcha Uma³

¹Associate Professor, Department of Microbiology, NRI Medical College, Chinakakani, Guntur, Andhra Pradesh, India,

²Assistant Professor, Department of Microbiology, Mamatha Medical College, Khammam, Andhra Pradesh, India,

³Head of the Department, Department of Microbiology, NRI Medical College, Chinakakani, Guntur, Andhra Pradesh, India

Corresponding Author: Dr. Shaik Naseema

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ABSTRACT

Introduction: Common and preventable catheter-associated urinary tract infections (CAUTI) increase hospital stays, costs, and patient morbidity. To study the incidence of CAUTI, patient characteristics, microbiological profile, risk factors and compliance to catheter care bundle in an Indian tertiary care hospital over a period of 1 year.

Material and Methods: This retrospective descriptive study was conducted from January to December 2025 in a 900 bedded tertiary care teaching hospital in Guntur, Andhra Pradesh, India. All indwelling urinary catheter and laboratory-confirmed CAUTI patients were included. CAUTI rates per 1,000 catheter-days were calculated using the CDC/NHSN definitions. Descriptive statistics were used to analyse demographic information, risk factors, microbiology and adherence to catheter care bundle.

Results: Urinary catheterizations were performed on 5,679 patients, for a total of 28,397 catheter days (5.0 days/patient). There were 33 laboratory-confirmed CAUTIs in this group (1.16 per 1000 catheter-days; 95% CI: 0.76–1.56). The mean age was 62.3 years and 54.5% were male. The most common CAUTI risk factors were diabetes (30.3%), multiple comorbidities (24.2%), and postoperative status (18.2%). The most common bacteria causing CAUTI were *E. coli* (36.4%) and *Klebsiella* spp. (27.3%). The device utilization ratio (DUR) for urinary catheters was 55.6%. The biggest gap in the insertion bundle was defective documentation (16.7%). The largest maintenance bundle gap was below the bladder position (4.4% catheter days).

Conclusions: Despite quality improvement efforts, CAUTI remains one of the most common nosocomial infections in Indian tertiary care hospitals at 1.16 per 1000 catheter days. Patients over 70 and diabetics are more likely to have CAUTIs. Better documentation, patient education and placement of a drainage bag can reduce rates. Continuous monitoring of preventive programs and trends is needed.

Keywords: Catheter-associated urinary tract infection, CAUTI, surveillance, risk factors, microbiology, bundle compliance, India

INTRODUCTION

The problem is that HAIs continue to be one of the major and ongoing problems of patient safety in medical practice. CAUTI is also one of the HAI problems that is extremely difficult to manage, especially in the ICU setting because many critically ill patients require invasive devices. Although urinary catheterization may seem like a relatively simple process, the widespread use of this method combined with extended durations of indwelling catheters necessary for critical illness creates an ideal environment for microbial colonization and subsequent infection. [1,2]

The clinical and economic impact of CAUTI is significant. Patients who acquire these infections have longer hospitalizations, unnecessary antimicrobial therapy and a significantly increased cost of health care. More importantly, there is the downstream risk of secondary bloodstream infections, which can turn a preventable complication into a life-threatening event. [3] The pathogenesis of CAUTI is complex and multifactorial. When the closed drainage system is broken or aseptic technique is violated, microorganisms can ascend externally along the catheter from periurethral flora or enter through the internal lumen. Critically, the risk of infection increases proportionally with the duration of catheterization—a sobering reality for patients who require prolonged intensive care. [4] The good news about CAUTIs is that they can be prevented. There is a substantial base of scientific evidence to support that adherence to best practice techniques (such as correct placement technique, proper maintenance and timely removal of unnecessary urinary catheters) can greatly reduce the occurrence of CAUTI. One of the most effective methods to reduce DAI has been through implementation of "Care Bundles," or groups of interventions. These interventions are designed to work in conjunction with each other. A typical CAUTI prevention bundle would include: the appropriate determination whether an indication exists

for a catheter, sterile insertion of the catheter, maintaining a closed drainage system, performing daily catheter care, and ongoing review of whether the catheter remains necessary. [5]

Multiple studies at multiple healthcare institutions have found that bundles reduce CAUTI rates. Soundaram et al. found a 56% decline in ICU patients in South India and Huang et al. found a 52% decline in all tertiary hospital patients in China. [6,7] Bundles with real-time feedback have dropped over 60% recently. [8] Bundles appear to promote sustainable infection control changes. Another issue is that many QI projects achieve immediate results that are lost when staff turnover or issue attention decreases. Successful bundle implementation requires more than just adding new bundles to an institution. The organization must foster a culture of quality improvement and develop and maintain effective surveillance systems to monitor bundle compliance. Fast-paced clinical environments make it difficult to develop such systems and cultures. [9]

Although the National Accreditation Board for Hospitals and Healthcare Providers (NABH) in India has developed guidelines that contain many elements required to establish robust systems for controlling healthcare associated infection (HAI), including monitoring for HAI, bundles and ongoing quality improvement; NABH accreditation also requires hospitals to have processes in place for continuous monitoring of outcomes and processes as part of their quality improvement efforts. [10] This provides a framework and support for preventing CAUTI; however, the literature reflects a lack of studies from India using a combination of rigorous outcome monitoring and process evaluation over time. The majority of reports are of short-term intervention(s) without an in-depth assessment of why they were successful or unsuccessful. [11]

The purpose of this study was to document the epidemiology, patient demographics, microbiological profile and risk factors

associated with CAUTI that occurred in tertiary care hospital during a 1-year period. The results provide important baseline information on which targeted preventive measures and improved patient outcomes can be based.

MATERIALS & METHODS

Study Design and Setting

This retrospective descriptive study was conducted at NRI General and Super Specialty Hospital. It is a 900-bed tertiary care teaching hospital located in Guntur, Andhra Pradesh, India. The study was performed for 12 months (January-December 2025). The Institutional Ethics Committee of NRIAS approved the study protocol (Approval No. IEC 2025 F014).

Study Population

All adult patients (≥ 18 years) who had an indwelling urinary catheter for >48 h and developed laboratory-confirmed CAUTI were included in the study. CAUTI diagnosis was based on standardized surveillance definitions of the Centers for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN).^[12] Patients with catheters in place for <24 hours, those with pre-existing urinary tract infections, and cultures yielding > 2 organisms (suggesting contamination) were excluded. Cultures yielding exclusively fungal organisms were also excluded.

Data Collection

Data were obtained through Infection Prevention and Control (IPC) Department records; Medical Charts; and Microbiology Reports. The data that were collected include: Patient Age; Gender; Duration of Catheterization; Hospital Length of Stay; Comorbidities (Diabetes Mellitus; Hypertension; Immunosuppressed Status; Chronic Liver Disease; Pulmonary Tuberculosis; Organ Transplant); Laboratory Culture Results; and Compliance with Catheter Care Bundle.

CAUTI Rate Calculation

The CAUTI rate was defined as the number of laboratory-confirmed CAUTIs per 1000 catheter days.^[12] Catheter-days were recorded on a daily basis by nursing Staff, and verified by the IPC team.

Device Utilization Ratio (DUR)

The DUR for urinary catheters is defined as the total number of catheter days, divided by the total number of patient days. This ratio is then converted to a percentage. This represents the total percent of time patients had their urinary catheters in place, allowing for better understanding of CAUTI rates.

Microbiological Methods

Urine samples obtained via aseptic catheter sampling port procedures were delivered to the laboratory for semi-quantitative culture preparation. The urine samples were cultured using a calibrated loop on blood agar and MacConkey agar and incubated at $35-37^{\circ}\text{C}$ for 18–24 h. Bacteriuria was considered significant when a single microorganism had a count in excess of 10^5 CFU/mL; alternatively, when a clinical symptom consistent with an infection occurred and there was a count of $\geq 10^4$ CFU/mL. A microbial ID was completed utilizing the automated VITEK 2 Compact System (bioMérieux, France), as well as antimicrobial susceptibility testing based on CLSI guidelines.^[13]

Catheter Care Bundle

The catheter care bundles in this study were developed from the NABH accreditation criteria for hospitals; and APSIC's infection control guidelines^[5] as they relate to urinary catheter care. The contents of insertion bundle were as follows suitable clinical indication, proper use of hand sanitizer, sterile gloves on the hands of healthcare workers, aseptic non-touch technique for handling equipment during catheterization, adequate cleansing of the urethral opening, correct catheter size, utilization of a closed drainage system, and proper catheter fixation. Similarly, the maintenance bundle consisted of:

maintenance of a closed drainage system, free-flowing urine, placement of the drainage bag below bladder level, daily cleaning of the meatus, separate collection containers for the urine drainage bags for each patient, daily assessments of patient needs, and education provided to both the patients and their caregivers.

Bundle Compliance Analysis

Two audit methodologies were employed to assess bundle compliance. The first methodology involved auditing the components of the insertion bundle at the time that catheters were inserted into individual patients by the IPC team; thus, there were 5,679 insertion opportunities. The second methodology involved conducting once-daily audits of all maintenance bundle components among all catheterized patients by the IPC team; thus, there were 28,397 catheter-day audit opportunities. Two breach rate calculations were made separately for each bundle type based on the respective denominators. For example, for insertion bundle breaches, the denominator utilized was the total number of catheterizations, whereas for maintenance bundle breaches, the denominator used was the total number of days those catheters remained in place.

Statistical Analysis

Descriptive statistical analysis was applied to the data collected in this study.

Frequencies and percentages were determined for nominal or ordinal variables. Mean values along with standard deviations were determined for interval or ratio scale variables. Rates of CAUTIs were expressed as events per 1000 catheter-days with associated 95% CI. All analyses were completed using Microsoft Excel

RESULT

Study Population and CAUTI Incidence

During the 12-month evaluation period (January–December 2025), 5679 patients had urinary catheters inserted, resulting in 28,397 catheter-days, with an average catheter duration of 5.0 days. Thirty-three confirmed laboratory CAUTI cases occurred during this time, providing an incidence rate of 1.16 per 1000 catheter-days (95% CI: 0.76–1.56) for the entire study period. Rates varied monthly ranging from 0.49 per 1000 catheter-days to 1.62 per 1000 catheter-days. The highest rate was observed in June (1.62) and the lowest rate in December (0.49).

Device Utilization Ratio (DUR)

Total adult patient days for the ICU and wards were 51,106 and total adult catheter days were 28,397. This data demonstrates a urinary catheter utilization ratio (DUR) of 55.6%. Therefore, urinary catheters were used on approximately 56% of all adult patient days. The monthly DUR varied between 44.2% and 64.9% (see Table 1).

Table 1: Monthly CAUTI Rates and Device Utilization Ratio (January–December 2025)

Month	Patient days	Catheter days	CAUTI cases	CAUTI rate	DUR (%)
January	4368	2619	3	1.15	59.9
February	4553	2489	4	1.61	54.7
March	4897	2818	4	1.42	57.5
April	4319	2802	3	1.07	64.9
May	4956	2772	3	1.08	55.9
June	4563	2468	4	1.62	54.1
July	4726	2565	4	1.56	54.3
August	4363	2488	2	0.80	57.0
September	3859	1706	1	0.59	44.2
October	3833	1779	2	1.12	46.4
November	3076	1850	2	1.08	60.1
December	3593	2041	1	0.49	56.8
Total	51106	28397	33	1.16	55.6

Note: DUR = (Catheter-days ÷ Patient-days) × 100. Catheterized patients calculated as Catheter-days ÷ 5 days mean duration = 5,679 patients.

Patient Demographics and Risk Factors

The mean age was 62.3 ± 15.4 years (mean $\pm$ standard deviation) in 33 patients with CAUTI. The majority of cases were in the age group of >70 years (48.5%, $n=16$) followed by 51-70 years (27.3%, $n=9$), 31-50 years (15.2%, $n=5$), and 18-30 years (9.1%, $n=3$). Males comprised 54.5% ($n=18$) with a male: female ratio of 1.2:1.

Diabetes mellitus was the most common risk factor in 30.3% ($n=10$) of patients followed by multiple comorbidities in 24.2% ($n=8$), post-surgery in 18.2% ($n=6$), neurological deficits in 18.2% ($n=6$) and chronic kidney disease in 9.1% ($n=3$).

Microbiological Profile

Beginning with *E. coli* being the dominant causative agent at 36.4% ($n = 12$) in this cohort of patients experiencing CAUTIs, it is important to note that *Klebsiella* spp. were also prevalent at 27.3 % ($n = 9$) as well as *Pseudomonas aeruginosa* at 15.2 % ($n =$

5), *Staphylococcus aureus* at 12.1% ($n = 4$), and *Acinetobacter* spp. at 9.1% ($n = 3$).

Catheter Care Bundle Compliance

Bundle compliance for catheter insertion was evaluated using data from 5,679 catheter insertions. The documentation portion of the catheter care bundle had the highest number of breaches during catheter insertion at 16.7% ($n = 948$) followed by an aseptic technique breach at 5.6 % ($n = 318$). Bundle compliance for catheter maintenance was evaluated based on data from 28,397 catheter days. As such, bag position below the bladder was the greatest number of breaches at catheter maintenance at 4.4 % ($n = 1259$) followed by breaches related to closed drainage systems at 2.8 % ($n = 790$); patient/ family education at 2.8 % ($n = 790$); evaluation of necessity every day at 2.8 % ($n = 790$); aseptic technique at 1.7 % ($n = 471$); and monitoring of signs at 1.1 % ($n = 318$) as can be seen in Table 2.

Table 2: Catheter Care Bundle Compliance

Bundle component	Followed n (%)	Not followed n (%)
Insertion bundle		
Indication	5679 (100)	0 (0)
Aseptic technique	5361 (94.4)	318 (5.6)
Catheter secured	5679 (100)	0 (0)
Documentation	4731(83.3)	948 (16.7)
Maintenance bundle		
Aseptic technique	27926 (98.3)	471 (1.7)
Closed drainage	27607 (97.2)	790 (2.8)
Signs monitored	28079 (98.9)	318 (1.1)
Bag below bladder	27138 (95.6)	1259 (4.4)
Daily necessity assessment	27607 (97.2)	790 (2.8)
Patient/Family education	27607(97.2)	790 (2.8)

Note: Insertion bundle compliance was assessed at the time of catheter insertion. Maintenance bundle compliance was assessed through once-daily audits across all catheterized patients. Breach counts represent actual observations

DISCUSSION

This one-year observational study is the first to provide a detailed report on the prevalence of CAUTI within a large Indian tertiary care facility. It covered 5,679 patients who received a urinary catheter for a total of 28,397 catheter days and 51,106 patient days during this time period. This resulted in a urinary catheter utilization ratio (DUR) of 55.6%. Therefore, urinary

catheters were utilized in almost 56% of each day where there was at least one patient present. A total of 33 confirmed laboratory CAUTIs occurred among these patients, which resulted in a total incidence of 1.16 per 1000 catheter-days (95% C I: 0.76 – 1.56).

The 1.16 per 1000 catheter-days of CAUTI rate, we measured in our study shows a favourable relationship with other known

benchmarks. Our rate fell short of the Indian Pooled Average of 2.4 and the INICC Benchmark of 2.91; however, it was greater than the NABH 6th Edition Target of <1.0 [10,14,15], indicating that while our hospital's infection control practices have improved over the national average, there remains opportunity for additional growth. In similar fashion, Soundaram et al. demonstrated a comparative pre-implementation rate of 1.25 per 1000 catheter-days prior to implementing their bundle and ultimately decreasing their rate to 0.55 post-implementation, illustrating that there is potential for further reduction. [6] Prakash et al. reported a range of 1.5 to 2.5 per 1000 catheter-days within a tertiary teaching institution; this is significantly greater than our observed rate. [14] Therefore, these positive comparisons support the fact that our current infection prevention strategies are effective.

The DUR in our study was 55.6%, which was comparable to the DUR reported by Soundaram et al. and Kashyap et al. in Delhi ICUs before intervention: 0.71 (71%) and 0.99 (99%), respectively. [3,6] The high DUR reflects the high proportion of patient-days requiring catheterization in a tertiary care setting.

The high proportion of our study population (>70 years: 48.5%) is similar to other Indian studies. [6,16] Results show that older adults are particularly vulnerable to CAUTI, probably due to the aging of the immune system and the higher prevalence of comorbidities such as diabetes and hypertension, in addition to longer hospital stays. Male preponderance was 54.5% which is comparable to other Indian studies. This could be explained by higher rates of catheterization of male patients due to diseases such as benign prostatic hyperplasia and urine retention. [6,17] The most frequently reported risk factors in the literature are diabetes mellitus (30.3%) and multiple comorbidities (24.2%). [18] The presence of multiple comorbidities reflects the complexity of CAUTI etiology. Neurological deficits (18.2%) are also a risk

factor that requires increased monitoring. The high percentage of post-surgical patients (18.2%) indicates the need for perioperative catheter care. [18]

The most frequent pathogens were *Escherichia coli* (36.4%), followed by *Klebsiella* spp. (27.3%), which is in line with global monitoring studies that identified Gram-negative bacteria as the main reason for CAUTI infections. [19] In contrast to Soundaram et al. reporting an incidence rate of *E. coli* in 64% of their cases, we found a much lower frequency and a greater diversity of microbial organisms, such as *Pseudomonas aeruginosa* (15.2%), *Staphylococcus aureus* (12.1%), and *Acinetobacter* spp. (9.1%). [6]

Quality improvement for the insertion bundle was based on 5,679 catheter insertions, in which documentation represented the most frequent breach at 16.7% (n = 948), and quality improvement for maintenance bundles was evaluated over 28,397 catheter days, with improper placement of the urinary drainage bag below the level of the bladder representing the most common breach at 4.4% (n = 1259), followed by failure to use closed drainage systems (2.8%), lack of patient/family education (2.8%), and daily necessity assessments (2.8%). Improperly placed urinary drainage bags may cause retrograde flow of urine potentially resulting in an increased risk of bacterial colonization and infection [20], similar to the documented breaches with respect to documentation. Documentation gaps represent one of many barriers to maintaining consistency with bundle implementation. [21] Therefore, quality improvement initiatives should be directed toward improving staff knowledge related to proper placement of the urinary drainage bag, establishing structured documentation processes, providing adequate education to patients and their families, and conducting regular assessments for catheter necessity.

Despite training our staff in CAUTI prevention bundles and catheter care, CAUTI still occurs in our hospital. This

ongoing event highlights multifactorial etiology of CAUTI pathogenesis and the difficulty in preventing CAUTI in a busy tertiary care setting.

Limitations

This study has several limitations that should be considered when interpreting the results. Retrospective records may have been less complete than prospectively collected data, introducing information bias. To reduce bias, medical records and microbiology reports were used to validate all data using CDC/NHSN definitions. ^[12] This was a single-center study in a tertiary care teaching hospital and may not be generalizable to other health care settings. We did not evaluate CAUTI-related hospitalizations, ICU admissions or mortality. Bundle compliance was assessed by daily and at-insertion audits of maintenance and insertion components. Daily audits are more detailed than once-per-patient audits, but the Hawthorne effect may cause healthcare workers to behave differently when observed. Maintenance bundle compliance may vary across shifts, but our audit design did not capture this. Despite these limitations, our baseline CAUTI epidemiology data in Indian tertiary care is useful.

Clinical Implications

Our results have clinical applications. The high DUR of 55.6% indicates that catheters were used in a significant percentage of patient days, requiring daily catheter necessity reviews. Individual bundle breaches, such as bag placement below bladder (4.4% of catheter-days) and documentation (16.7% of insertions), can be targeted for quality improvement. The most frequent maintenance error was placement of the bag below the bladder (4.4% of catheter-days) indicating that structured training programs on drainage bag positioning should be a priority to prevent retrograde flow of urine and bacterial colonization [20]. The 16.7% rate of errors in documentation for insertion ^[21] suggests

that standardized checklists and electronic systems for documentation may improve the documentation of catheter care. Deficiencies in patient/family education and daily necessity assessment (2.8% of catheter-days each) suggest that formal educational programs and daily necessity rounds may help reduce unnecessary catheter days. Monitoring may be intensified in high-risk patients (diabetics, those over 70 with multiple comorbidities) to decrease CAUTI rates. CAUTI rate was high in post-surgical patients (18.2%), indicating that perioperative catheter management may prevent CAUTI.

Recommendations

Hospitals need to train medical staff on the correct placement of urine collection bags, sterile drainage, and documentation of observations. We also believe that catheter insertion/maintenance checklists and guidelines should be standardized in hospitals. Another proposal is to educate patients and families about catheters. We also want to assess the need for daily catheterization for each patient and follow up with high-risk patients, (elderly, diabetic...etc). Finally, we recommend regular audits with immediate feedback to clinical staff regarding compliance and additional research on systemic measures, such as electronic reminders for catheters and computer-based data recording.

CONCLUSION

We followed catheter-associated urinary tract infections in 5679 catheterized patients in our hospital for 1 year. These patients had 33 CAUTIs, for a rate of 1.16 per 1,000 catheter-days. The DUR of our hospital was 55.6%. This indicates high usage of catheters. Our CAUTI rate was below the national average and INICC benchmark, indicating effective control of urinary catheter infection. In this study 48.5 % of the patients were over 70 years of age and 30.3 % had diabetes and were thus at risk. Specific prevention is needed in these vulnerable groups. The most common

pathogen was *Escherichia coli* (36.4%) followed by *Klebsiella* species (27.3%). The most common errors, at 16.7%, were insertion bundle assessment documentation errors. Drainage bag position resulted in violations of the maintenance bundle for 4.4% of catheter days. Future quality improvement efforts should include education for staff and patients regarding catheter placement, drainage bag placement, and sterile maintenance of urinary catheters, suggest the authors of this study. Review each patient's need for a urinary catheter on a regular basis. Regular evaluations and audits of best practices are required to maintain improvements in catheter care in India

Declaration by Authors

Authors' contribution: First author has conceptualized the study, compiled and curated the data, formal analysis, data analysis and drafted the manuscript. second author reviewed and editing and our HOD supervised the manuscript.

Ethical Approval: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee (IEC) of NRIMC (Approval no: IEC 2025 F014).

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