ORIGINAL ARTICLE

Impact of Care Bundle Implementation on Incidence of Catheter-associated Urinary Tract Infection: A Comparative Study in the Intensive Care Units of a Tertiary Care Teaching Hospital in South India

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Abstract

Introduction: Implementation of evidence-based infection control practices is the need of the hour for every institute to reduce the device-associated infections, which directly reflects the quality of care. As catheter-associated urinary tract infection (CAUTI) is the most common nosocomial infection, the study was planned to evaluate the impact of the catheter care bundle in reducing CAUTI incidence.

Material and methods: The prospective interventional study before and after the trial study was carried out in adult intensive care units over a period of 9 months (April–June 2017—pre-implementation phase; July–September 2017—training of healthcare worker and implementation of catheter care bundle; October–December 2017—post-implementation phase). Catheter-associated urinary tract infection rates pre- and post-implementation were expressed as incidence rates with Poisson confidence interval.

Results: Statistically significant reduction was found in the incidence of CAUTI (60%—from 10.7 to 4.5 per 1,000 catheter days). The key factors that contributed were significant reduction in device utilization ratio (from 0.71 to 0.56) and average catheter days per patient (from 4.8 to 3.7). This holistic approach has resulted in less incidence of CAUTI even among patients with risk factors and prolonged catheter days. Neuro ICU showed drastic improvement compared to other ICUs due to the poor baseline status of their care practices.

Conclusion: Adherence to all elements of care bundle brought a significant decrease in CAUTI. Implementing care bundle and auditing the adherence to each element should be included as a part of routine hospital infection control committee (HICC) practices.

Clinical significance: Hospital-acquired infection directly reflects on the quality care of the hospital. Bundle care is an "all or none" phenomenon. Adherence to each element will have some influence in reducing CAUTI in terms of reducing the device utilization ratio and average catheter days per patient. Auditing the care bundle adherence is having a positive influence on the outcome.

Keywords: Care bundle, Catheter-associated urinary tract infection, Intensive care unit.

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Introduction

Hospital-acquired infections (HAIs) are the leading cause of morbidity and mortality in healthcare settings throughout the world, especially among the patients admitted in intensive care units (ICUs).[1,2] Apart from increasing the stress, discomfort, pain, and activity restrictions among the patients, HAI also increase the economic burden in the form of prolonged hospital stay, lost work days, and laboratory and drug costs.[3,4] Catheter-associated urinary tract infection (CAUTI) is the most common HAI accounting for 40% of all HAIs and the second most common cause of nosocomial septicemia.[5] According to the Centers for Disease Control and Prevention (CDC), CAUTI increases the morbidity and mortality by 2.8-fold and length of hospitalization by 1–3 days.[6] Approximately 25% of hospitalized patients undergo urinary catheterization, whereas among critically ill ICU patients, it reaches to more than 70%, resulting in >30 million urinary catheter insertions each year.[7] In majority of the cases, use of catheter without proper indication, prolonged catheter days, improper procedural technique, and improper catheter care contribute to the development of CAUTI.[8,9]

About 17–69% of CAUTIs can be prevented if CDC-recommended infection control measures are in place.[10] Educating and training the healthcare personnel and implementing practices for prevention of CAUTI contribute greatly to reduce the incidence of CAUTI.[9] Limited studies have assessed the impact of care practices on reduction of the infections once catheter is inserted.[11–13] But currently there is no defined infection control policy or guideline in India and the need of the hour is implementation of evidence-based infection control practices. So, this study was conducted to evaluate the impact of the catheter care bundle in reducing CAUTI incidence in our set-up.

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Materials and Methods

This prospective interventional study was conducted in our tertiary care center. Medical intensive care unit (MICU), surgical intensive care unit (SICU), neurotrauma intensive care unit (neuro ICU), and cardiothoracic intensive care unit (CTICU) of our hospital were included in this study that spanned over a period of 9 months [April–June 2017—pre-implementation of catheter care bundle; July–September 2017—educating, training of healthcare worker (HCW), and implementation of catheter care bundle; October–December 2017—post-implementation of catheter care bundle]. The study was approved by our institutional ethics committee.

During the pre-implementation phase (April–June 2017), even though care bundle was not introduced, some elements of care bundle were in practice as a part of routine catheter care in our hospital. Full-time infection control nurses (ICNs) were trained by infection control officer to monitor the adherence of each element of bundle care. The bundle care audit reports collected by ICNs were analyzed by hospital infection control team on a monthly basis. ICU-wise adherence and nonadherence to each element of care bundle along with the details of individual staff (nurses and doctors) nonadherence to particular elements were noted cautiously. Surveillance of CAUTI was done as a part of routine activities of the hospital infection control committee (HICC). Following this, hospital healthcare personnel were educated regarding the importance each element of bundle care and training was given as per the need of each ICU. Training of implementation of catheter care bundle (both insertion and maintenance bundle) was conducted in batches for all HCWs including doctors for a period of 3 months (July–September 2017). Pre- and post-training evaluation and objective structured clinical evaluation (OSCE) were done to ensure that every HCW understood the concept. Meeting was held with all HCWs of ICU to address the need and possible difficulties in the implementation in their ICUs. Based on the discussion, availability of resources and staff rotation policies were regularized. Along with this, to motivate the HCWs, it was planned to felicitate the best adherence team with a shield of appreciation.

During the post-implementation phase (October–December 2017), urinary catheter insertion, maintenance, and removal was done based on standard guidelines of our HICC. Adherence to care bundle was ensured and monitored by ICNs using the audit form that was reviewed by infection control team at frequent intervals and surveillance for CAUTI was continued in the same manner as during the pre-implementation period. Surprise audits at various time intervals and by various teams were also carried out to rule out the possible confounding factor like monitoring influence (doing the work perfectly when someone is monitoring).

All catheterized adult patients (both gender) with indwelling urinary catheter (Foley's catheter) admitted in abovementioned ICUs during the study period (excluding training period) were included in the study. Catheterized ICU patients transferred to the general ward were followed up till 2 calendar days (1st day being the day of transfer). Patients only on condom catheter, suprapubic catheter, nephrostomy tube, and patients not consenting were excluded from the study.

CAUTI surveillance was done as per CDC recommendation. CAUTI (CDC definition) is defined as a UTI where an indwelling urinary catheter was in place for more than 2 calendar days on the date of event, with day of device placement being day 1, and an indwelling urinary catheter was in place on the date of event or the day before. If an indwelling urinary catheter was in place for more than 2 calendar days and then removed, the date of event for the CAUTI must be the day of discontinuation or the next day.[10] Study participants were observed for signs and symptoms of UTI, meticulously on a daily basis by ICNs. On clinical suspicion of UTI, the urine sample was collected under aseptic precautions by disinfecting a portion of the catheter tubing with alcohol and aspirating urine with a sterile syringe and needle. The collected sample was sent to the microbiology laboratory within 1 hour of the sample collection.

The urine was inoculated into CLED agar by the semiquantitative method using calibrated 1 µL loop with a diameter of 1.3 mm (Hi media Cat.no: LA023) and incubated at 35–37°C for 24 hours. Growth with colony count of $>10^5$ CFU/mL were included for surveillance. Pathogenic isolates grown were identified to the species level using Gram stain and conventional biochemical identification tests as per our laboratory protocol. Antimicrobial susceptibility testing was done by the Kirby Bauer disc diffusion method as per Clinical and Laboratory Standards Institute (CLSI) 2017 standards. Antibiotic discs were bought from Hi Media Laboratories Pvt. Ltd., Mumbai, India.

Statistical Analysis

Device utilization ratio, average catheter days per patient, and CAUTI rate were calculated using the following formulae:

- Device utilization ratio: No. of indwelling catheter days/no. of patient days
- Average catheter days per patient: No. of indwelling catheter days/no. of patients on catheter
- CAUTI incidence rate: No. of CAUTI/no. of indwelling catheter days × 1000

Catheter-associated urinary tract infection among various gender and age, pathogenic isolates, and the antibiotic sensitivity pattern were expressed as percentage. The CAUTI rates pre- and post-implementation were expressed as incidence rates with Poisson confidence interval and compared for statistically significant differences.

Results

A total of 1,233 patients were included in the study (631 patients—pre-implementation phase and 602 patients—post-implementation phase). The profile of the study participants is given in Table 1 and there was no statistically significant difference in the age, gender, and risk factor profile of the participants included during the pre- and post-implementation period. Most common age group was <50 years, males were more in number than females, and diabetes was the most common risk factor during both the study periods. The clinical diagnosis for which the participants were admitted did not vary significantly except for increased number of cases with gastrointestinal disease during the post-implementation period.

During the pre-implementation phase, overall and ICU-wise data regarding nonadherence to each element of bundle care are represented in Table 2. Documentation of assessment of readiness to remove the catheter (48.4%) and proper indication for catheterization (32.8%) were found to be the most commonly missed out elements.

A total of 32 out of 631 patients and 10 out of 602 patients developed CAUTI during the pre- and post-implementation phases, respectively. Various parameters of CAUTI surveillance during both the study periods are shown in Table 3. There was a statistically

Table 1: Profile of patients admitted in adult ICUs of a tertiary care institute in Southern India pre- (April–June 2017) and post-implementation (October–December 2017) of urinary catheter care bundle ($n = 1233$)

Variables	*Pre-implementation of urinary catheter care bundle (April–June 2017) (n = 631) n (%)*	*Post-implementation of urinary catheter care bundle (October–December 2017) (n = 602) n (%)*	*p value*
Age			0.258
≤50 years	341 (54)	324 (53.8)	
51–64 years	220 (34.9)	228 (37.9)	
65–79 years	65 (10.3)	44 (7.3)	
≥80 years	5 (0.8)	6 (1)	
Gender			0.286
Male	430 (68.1)	393 (65.3)	
Female	201 (31.9)	209 (34.7)	
Diagnostic condition			0.534
Neurological disease and procedure	269 (42.6)	257 (42.7)	
Pulmonary disease	14 (2.2)	5 (0.8)	
Cardiac disease and procedure	190 (30.1)	177 (29.4)	
GIT disease and procedure	30 (4.8)	4 (0.7)	0.001
Kidney disease and procedure	45 (7.2)	52 (8.6)	
Musculoskeletal disease	41 (6.6)	56 (9.3)	
Metabolic disease	12 (1.9)	6 (1)	
Other surgical procedure	24 (3.9)	40 (6.7)	
Poisoning	4 (0.7)	5 (0.8)	
Risk factors			
Diabetic	166 (26.3)	151 (25.1)	0.623
Calculi	14 (2.2)	7 (1.2)	0.225
Stricture	8 (1.3)	2 (0.3)	0.130
Neurogenic bladder	7 (1.1)	2 (0.3)	0.205
Prostatic enlargement	7 (1.1)	1(0.1)	0.088

ICU, intensive care unit

Table 2: Analysis of nonadherence to each bundle care elements among adult ICUs of a tertiary care institute in Southern India, during pre-implementation (April–June 2017) of urinary catheter care bundle ($n = 3003$)—overall and ICU-wise

	ICU (no. of patients on catheter/catheter days)				
	Overall 631/3003	*IMCU—91/484*	*SICU—202/849*	*Neuro ICU—170/1096*	*CTICU—168/574*
Bundle elements	*Not followed n (%)*	*Not followed n (%)*	*Not followed n (%)*	*Not followed n (%)*	*Not followed n (%)*
Proper indication documented	207/631 (32.8)	34/91 (37.4)	69/202 (34.2)	81/170 (47.6)	23/168 (13.7)
Closed drainage system	366 (12.2)	59 (12.2)	87 (10.2)	184 (16.7)	36 (6.3)
Urinary catheter secured/not obstructed	395 (13.2)	72 (14.9)	109 (12.8)	162 (14.8)	52 (9)
Drainage bag above floor and below bladder level	183 (6.1)	42 (8.7)	45 (5.3)	63 (5.7)	33 (5.7)
Hand hygiene	790 (26.3)	158 (32.6)	110 (13)	423 (38.6)	99 (17.2)
Vaginal/meatal care	197 (6.6)	38 (7.8)	37 (4.4)	73 (6.7)	49 (8.5)
Perineal care	889 (29.6)	172 (35.5)	224 (26.4)	396 (36.1)	97 (16.9)
Single-use glove while handling/ emptying	663 (22.1)	102 (21.1)	125 (14.7)	367 (33.5)	69 (12)
No contact b/t jug and bag	270 (9)	63 (13)	61 (7.2)	97 (8.9)	49 (8.5)
Separate jug for collecting	463 (15.4)	88 (18.2)	83 (9.8)	247 (22.5)	45 (7.8)
Assessment of readiness to remove—documented?	1452 (48.4)	226 (46.6)	354 (41.2)	723 (65.9)	149 (26)

significant decrease in the incidence of CAUTI [from the incidence rate of 0.010 with Poisson confidence interval (CI) of 0.007–0.015 during the pre-implementation phase to the incidence rate of 0.004 with Poisson CI of 0.002–0.008 during the post-implementation phase with the incidence ratio of 0.421 with Poisson CI of 0.211–0.839]. Similar to this statistically significant decrease also noted

Table 3: Impact analysis of catheter care bundle among patients admitted in adult ICUs in a tertiary care institute in Southern India, during pre- (April–June 2017) and post-implementation (October–December 2017) of urinary catheter care bundle (n = 1,233)–overall and ICU wise

	Overall		*IMCU*		*SICU*		*Neuro ICU*		*CTICU*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Total no. of patients on urinary catheter	631	602	91	94	202	147	170	190	168	171
Total no. of catheter days[1]	3,003	2,225	484	388	849	564	1,096	868	574	405
Total no. of patient days[2]	4,234	3,996	1,314	1,115	988	914	676	753	1,256	1,213
Device utilization ratio (Poisson confidence interval)*	0.71 (0.684–0.735)	0.56 (0.533–0.580)	0.37	0.34	0.86	0.61	1.62	1.15	0.46	0.33
Average catheter days per patient** (p value =0.001)	4.8	3.7	5.3	4.1	4.2	3.8	6.5	4.5	3.4	2.4
No. of CAUTI	32	10	5	2	8	2	16	5	3	1
CAUTI incidence rate (Poisson confidence interval)***	10.7 (0.007–0.15)	4.5 (0.002–0.008)	10.3	5.1	10.6	3.5	14.6	5.7	5.2	2.4

*Device utilization ratio: no. of indwelling catheter days/no. of patient days
**Average catheter days per patient: No. of indwelling catheter days/no. of patients on catheter, p = 0.001
***CAUTI incidence rate: no. of CAUTI/no. of indwelling catheter days × 1000
[1]Catheter days—number of patients with indwelling urinary catheter collected daily at the same time and summed up for month for that specific location
[2]Patient days—number of patients in the patient care collected daily at the same time and summed up for month for that specific location

in the device utilization ratio [from the incidence rate of 0.709 with Poisson confidence interval (CI) of 0.684–0.735 during the pre- implementation phase to the incidence rate of 0.556 with Poisson CI of 0.533–0.580 during post-implementation phase with the incidence ratio of 0.785 with Poisson CI of 0.743–0.829]. Also there was a statistically significant reduction found in the average catheter days per patient (from 4.8 to 3.7 with the p value −0.001) after care bundle implementation. On analyzing the catheterized patients with risk factors, there was a statistically significant decrease in the incidence of CAUTI during the post-implementation phase even with associated risk factors as shown in Table 4.

Regarding catheter days, there was statistically significant increase in early removal of catheter during the post-implementation period. The percentage of patients in whom the catheter was in place for <5 calendar days has increased from 56.9 to 73.3%. Even among patients in whom catheter was in place for 5–10 or >10 days, there was a statistically significant decrease in incidence of CAUTI (p value = 0.001) during post-implementation as shown in Table 5.

Among patients who developed CAUTI, the most common age group was 65–79 years (43.7% and 70%); gender was male (59.3% and 70%); clinical diagnosis during admission was neurological disease (46.9% and 20%); and associated risk factor was diabetes (78.1% and 100%) during both pre- and post-implementation periods, respectively. *Escherichia coli* was the common organism isolated followed by *Pseudomonas aeruginosa* and all the Gram-negative organisms isolated were sensitive to colistin (Supplementary Tables S1 and S2).

Discussion

Catheter-associated urinary tract infection has become a major global health problem, leading to increased morbidity and mortality in healthcare settings especially in ICUs. As multiple factors like aseptic technique, hand hygiene, catheter care, and duration of catheterization can affect the incidence of CAUTI, a holistic approach becomes mandatory to reduce the incidence of CAUTI.[13]

Since the proportion of catheterized patients will always be comparatively higher in ICUs than wards, adult ICUs were included in the study. Analysis of adherence and nonadherence to each element of care bundle is essential before implementing care bundle in any set-up. Though documentation of assessment of readiness to remove the catheter and proper indication for catheterization (48.4 and 32.8%, respectively) were found to be the most commonly missed out elements, none of the care bundle element was fully adhered.

Our findings are in concordance with the study results of Lai et al., who also reported that among the care bundle elements compliance was lowest for daily review of need of catheter.[14] Since adherence was not to an agreeable level, as a HICC unit we analyzed the root causes for nonadherence. Lack of sufficient knowledge among HCWs, occasional unavailability of handrub/wash, disposable glove, and separate jug were identified and this lacunae was corrected by educating, training, and ensuring availability of all essential things for care bundle implementation.

Before analyzing the impact of care bundle in the post-implementation period, the probable confounding variables including patient number, age, gender, associated risk factors, and diagnostic condition for patients admitted were compared and found to be statistically insignificant except increased number of cases with gastrointestinal disease during the

Table 4: Analysis of risk factor with CAUTI among patients admitted in adult ICUs in a tertiary care institute in Southern India, during pre- (April–June 2017) and post-implementation (October–December 2017) of urinary catheter care bundle (n = 1233)

	Pre-implementation (n = 631)		*Post-implementation (n = 602)*		
Risk factor	*Total number*	*Number of CAUTI (%)*	*Total number*	*Number of CAUTI (%)*	*p value*
Diabetes	166	25 (15.1)	151	10 (6.62%)	0.01
Calculi	14	4 (28.6)	7	–	
Stricture	8	–	2	–	
Neurogenic bladder	7	1 (14.3)	2	–	
Prostatic enlargement	7	79 (100)	1	–	

Table 5: Analysis of catheter days with CAUTI incidence among patients admitted in adult ICUs in a tertiary care institute in Southern India pre- (April–June 2017) and post-implementation (October–December 2017) of urinary catheter care bundle (*n* = 1,233)

	No. of patients on catheter		*Number of CAUTI*		
Catheter days	*Pre-implementation (%)*	*Post-implementation (%)*	*Pre-implementation (%)*	*Post-implementation (%)*	*p value*
<5	359 (56.9)	441 (73.3)	Nil	Nil	0.001
5–10	258 (40.9)	158 (26.2)	20 (7.8)	8 (5.1)	
>10	14 (2.2)	3 (0.5)	12 (85.7)	2 (66.6)	

post-implementation period, which is not known to interfere with inference of the study.

On analyzing the impact of catheter care bundle, the incidence of CAUTI has dropped down by almost 60%, from 10.7 to 4.5 per 1,000 catheter days after implementation of bundle care. These results were found to be statistically significant. Our study findings are concordance with Prakash et al. and Blanck et al., who reported decrease in the CAUTI rate after implementing care bundle by 51.4% (from 4.86 to 2.36 per 1,000 catheter days) and 50% (from 8.4 to 4.3 per 1,000 catheter days), respectively.[12,15] Lesser reduction of 22.7% (3.86–2.98 per 1,000 catheter days) was reported by Lai et al.[14] This may be due to the factor that incidence of CAUTI was already very low even before implementing the catheter care bundle.

Our analysis revealed that the key factor that contributed to this 60% reduction in CAUTI was the decrease in the inappropriate use of catheter, which reflected as statistically significant reduction in the device utilization ratio and average catheter days per patient. The device utilization ratio came down from 0.71 to 0.56. Average catheter days per patient was dropped down from 4.8 to 3.7 with the *p* value of 0.001.

For each day the indwelling urinary catheter remains, the patient has 3–10% increased risk of acquiring CAUTI and risk of bacteriuria reaches nearly 100% if the catheter is in place for 4 weeks.[8] Statistically significant reduction was found on catheter days ($p = 0.006$); in nearly 75% of patients, catheter was removed in less than 5 days as compared to 56.9% in the pre-implementation period. Our study results also highlight that even while the catheter remains for 5–10 or >10 days, CAUTI incidence can be reduced from 7.8 to 5.1% and 85.7 to 66.6%, respectively, if catheter care bundle was properly implemented.

Our study results also depict that ideal catheter care can reduce CAUTI in spite of underlying risk factors as none of the patients with calculi, stricture, neurogenic bladder, or prostatic enlargement developed CAUTI in the post-implementation phase.

Statistically significant reduction of CAUTI found in our study may be due to the intensive education and training given to the HCWs about each element of care bundle and active continuous monitoring carried out by trained ICN on adherence to all steps of bundle care regularly during the post-implementation period. Surveillance and auditing might have had a positive influence on compliance to bundle care in our set-up. The two elements that were found to most commonly missed, i.e., documentation of assessment of readiness to remove the catheter (48.4%) and of proper indication for catheterization (32.8%) in the pre-implementation phase, were corrected in the post-implementation phase. And the holistic approach has resulted in less incidence of CAUTI even among patients with associated risk factors and prolonged catheter days.

Among the ICUs, neuro ICU showed a drastic improvement compared to other ICUs. This might be due to the poor baseline status. Nonpractice of catheter care elements, i.e., documentation of assessment of readiness to remove the catheter (65.9%), proper indication for catheterization (47.6%), hand hygiene (38.6%), perineal care (36.1%), and using disposable glove while emptying or handling urobag (33.5%), was higher compared to other ICUs during the pre-implementation phase and had the highest device utilization ratio (1.62), average catheter days per patient (6.5), and incidence of CAUTI (14.6 per 1,000 catheter days). Hence, proper implementation brought a marked change in neuro ICU.

On further analysis, it was found that no significant difference was found in the pre- and post-implementation phase of CAUTI presentation as CAUTI was most common among the age group of 65–79 years (43.7% and 70%), male gender (59.3% and 70%), and patient admitted for neurological disease (46.9% and 20%) in both pre- and post-implementation phases. Diabetic was the most common risk factor associated with CAUTI (78.1% and 100%) in both phases. In both phases, *E. coli* was the common organism isolated followed by *P. aeruginosa.* All the isolates showed better sensitivity to nitrofurantoin, amikacin, cotrimoxazole, imipenem, and 100% sensitivity to colistin during both phases.

Limitations

The study does not have a true control group. For ethical reasons, standard catheter care could not be withheld for patients, thus eliminating the possibility. This might have led to an underestimation of the impact of the catheter care bundle on CAUTI, since some of the measures in the bundle were practiced during the pre-implementation period as well. Care bundle ideally includes two components—procedural and maintenance bundle. Implementation of the procedural bundle was a challenge in our

set-up as the insertion of the device takes place in varied locations (casualty, operation theater, sometimes in ICUs) of our hospital. The change in the ICU staff structure was minimal during the study period. Since this is unavoidable and was not significant enough to affect the results of the study, the details are not mentioned. Pre- and post-implementation phases of the study were conducted during different seasons of the same year. A holistic approach including insertion bundle along with maintenance bundle will further reduce device-associated infections.

Clinical Significance

Hospital-acquired infections directly reflect on the quality care of the hospital and intervention. Bundle care is an "all or none" phenomenon. Our study results emphasize that even though few elements of care bundle were already in practice, adherence to all elements as a bundle brought a significant decrease in CAUTI. Adherence to each element will have some influence in reducing CAUTI in terms of reducing the device utilization ratio and average catheter days per patient. Auditing the care bundle adherence is having a positive influence in the outcome. Implementing care bundle and auditing the adherence to each element should be included as a part of routine HICC practices.

Research Quality and Ethics Statement

We declare that this scientific work complies with reporting quality, formatting, and reproducibility guidelines set forth by the EQUATOR Network. We also attest that this clinical investigation was determined to evaluate the impact of catheter care bundle in reducing CAUTI incidence in our set-up as there is no defined infection control policy and the need of the hour is implementation of evidence-based infection control practices, require the institutional ethics committee review, and the corresponding protocol was approved by our institute ethical committee (IEC Ref No.: VMCIEC/49/2017). We also certify that we have not plagiarized the contents in this submission and have done a plagiarism check.

Author's Contribution

Raja Sundaramurthy, Geni VG Soundaram have given the concepts and intellectual content. Raja Sundaramurthy, Geni VG Soundaram, Jeyashree Kathiresan designed the study. Raja Sundaramurthy, Geni VG Soundaram, Vithiya Ganesan, Ramesh Arunagiri carried out the literature search. Raja Sundaramurthy, Geni VG Soundaram, Jeyashree Kathiresan, Vithiya Ganesan have collected and analyzed the data. Raja Sundaramurthy, Geni VG Soundaram, Jeyashree Kathiresan, Jhansi Charles carried out the statistical analysis. Raja Sundaramurthy, Geni VG Soundaram done the manuscript preparation. Vithiya Ganesan, Ramesh Arunagiri have done the manuscript editing. Jhansi Charles, Jeyashree Kathiresan carried out the manuscript review.

The manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work and we would also like to state that the manuscript has not been submitted or accepted for publication anywhere.

Ethical Committee Approval

Ethical clearance obtained from Institute Ethical Committee, VMCH&RI, Madurai, Tamil Nadu, India. IEC Ref No.: VMCIEC/49/2017.

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Supplementary Table 1: Profile of patients with CAUTI admitted in adult ICUs of a tertiary care institute in Southern India before (April–June 2017) and after (October–December 2017) implementation of urinary catheter care bundle ($n = 42$)

Variables	*Before implementation of urinary catheter care bundle (April–June 2017) (n = 32) n (%)*	*After implementation of urinary catheter care bundle (September–November 2017) (n = 10) n (%)*
Age		
≤50 years	7 (21.9)	–
51–64 years	9 (28.1)	3 (30)
65–79 years	14 (43.7)	7 (70)
>80 years	2 (6.3)	–
Gender		
Male	19 (59.3)	7 (70)
Female	13 (40.7)	3 (30)
Diagnostic condition		
Neurological disease and procedure	15 (46.9)	2 (20)
Pulmonary disease	–	2 (20)
Cardiac disease and procedure	2 (6.3)	1 (10)
GIT disease and procedure	–	1(10)
Kidney disease and procedure	8 (25)	3 (30)
Musculoskeletal disease	5 (15.6)	–
Metabolic disease	1 (3.1)	1 (10)
Other surgical procedure	1 (3.1)	–
Risk factors		
Diabetic	25 (78.1)	10 (100)
Calculi	4 (12.5)	–
Neurogenic bladder	1 (3.1)	–
Prostatic enlargement	7 (21.9)	–
Organism isolated		
Escherichia coli	15 (46.9)	4 (40)
Pseudomonas aeruginosa	6 (18.7)	4 (40)
Klebsiella pneumoniae	6 (18.7)	1 (10)
Enterobacter species	3 (9.5)	–
Candida species	2 (6.2)	1 (10)

Supplementary Table 2: Antibiotic sensitivity pattern analysis of CAUTI isolates among patients admitted in adult ICUs in a tertiary care institute in Southern India pre- (April–June 2017) and post-implementation (October–December 2017) of urinary catheter care bundle ($n = 42$)

Antibiotic sensitivity pattern (%)—pre-implementation												
Uropathogen (no. of isolate)	CAZ	CTR	CPM	AK	GEN	COT	CIP	OF	NIT	PIT	IMP	CL
Escherichia coli (15)	6.6	6.6	6.6	46.6	20	46.6	0	0	86.6	46.6	60	100
Pseudomonas aeruginosa (6)	0	–	0	0	0	–	0	0	–	16.6	33.3	100
Klebsiella pneumoniae (6)	0	0	0	66.6	33.3	33.3	0	0	50	16.6	33.3	100
Enterobacter spp. (3)	33.3	33.3	33.3	66.6	66.6	33.3	33.3	33.3	66.6	33.3	66.6	100
Antibiotic sensitivity pattern (%)—post-implementation												
Uropathogen (no. of isolate)	CAZ	CTR	CPM	AK	GEN	COT	CIP	OF	NIT	PIT	IMP	CL
Escherichia coli (4)	25	25	25	75	50	50	0	0	75	25	50	100
Pseudomonas aeruginosa (4)	0	–	0	25	25	–	0	0	–	25	75	100
Klebsiella pneumoniae (1)	0	0	0	100	0	100	0	0	100	100	100	100

CAZ, ceftazidime; CTR, ceftriaxone; CPM, cefepime; AK, amikacin; GEN, gentamicin; COT, cotrimoxazole; CIP, ciprofloxacin; OF, ofloxacin; NIT, nitrofurantoin; PIT, Piperacillin-Tazobactum; IMP, imipenem; CL, colistin