


Reducing catheter-associated urinary tract infections in the cardiac intensive care unit with a coordinated strategy and nursing staff empowerment

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ABSTRACT

Background Catheter-associated urinary tract infection (CAUTI) is one of the most common hospital-acquired infections. The use of urinary catheters is associated with several complications and increased mortality and morbidity. At the coronary intensive care unit (CICU) of a tertiary cardiac care facility, the CAUTI rate was 7.6/1000 catheter days in January 2017. In collaboration with the Institute for Healthcare Improvement, we implemented evidence-based practices in the form of bundles based on the value improvement methodology to eliminate CAUTIs in the CICU.

Methods This initiative aimed to reduce the CAUTI rate using a multifaceted approach. The key interventions were empowering front-line nurses for automatic stop orders and ensuring compliance to the catheter insertion and maintenance bundles. We used a model for improvement and tested the changes using small plan-do-study-act cycles. Surveillance methods and CAUTI definitions proposed by the National Healthcare Safety Network were used to monitor the outcomes. Monthly rates of CAUTIs 24 months before the intervention were compared with those 44 months after the intervention using an independent t-test. Statistical significance was set at $p < 0.05$.

Results The rate of CAUTIs dropped from 7.6 per 1000 catheter days in January 2017 to 0 from October 2021 to August 2022. The unit had achieved 280 calendar days free of CAUTI until August 2022.

Conclusions Behavioural changes, including empowerment of nurses and adherence to all elements of the care bundle, led to significant and sustained improvement in reducing the CAUTI rate in the adult CICU.

INTRODUCTION

Healthcare-associated infections (HAIs) constitute an extremely critical issue associated with high rates of mortality and morbidity. HAIs present the most significant challenge for patient safety and can result in extended hospital stays, increased morbidity and mortality, antibiotic overuse and an immense financial burden on the health system.^{1–3} According to the WHO, HAIs are the most common adverse events in

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ One of the most common healthcare-associated infections (HAIs) is catheter-associated urinary tract infection (CAUTI). One of the primary causes is the use of catheters for longer than necessary and the failure to take aseptic precautions. CAUTI can be avoided if evidence-based practices are followed.

WHAT THIS STUDY ADDS

⇒ The study focuses on several strategies for reducing CAUTI in adult intensive care units (ICUs), such as the bundle approach and nursing staff empowerment. It also emphasises the importance of a structured QI approach for evidence integration.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ According to the findings of this study, using a bundle approach and empowering nursing staff has a significant impact on CAUTI rates in adult coronary ICUs. Front-line staff involvement and empowerment, in our experience, also plays an important role in preventing HAIs.

any healthcare system, regardless of existing resources, and account for one million cases per year in the USA alone.^{4,5}

Urinary tract infection (UTI) is defined as an infection that involves any part of the urinary system, including the urethra, bladder, ureters and kidneys. Catheter-associated UTI (CAUTI) is one of the most common types of HAIs reported by the National Healthcare Safety Network (NHSN).⁶ CAUTIs are also probably the most preventable HAIs³; however, despite advances in diagnosis and treatment, CAUTIs continue to be a serious healthcare problem, accounting for up to 40% of hospital infections and 23% of infections in intensive care units (ICUs).^{4,5} CAUTIs have been shown to increase morbidity and mortality by 2.8-fold and the length of hospitalisation by 1–3 days.⁷ The costs associated



with preventable CAUTIs are estimated to range from US\$115 million to US\$1.82 billion annually, and every case of CAUTI costs between US\$1200 and US\$4700.³ In the Australian setting, the costs linked to patients with CAUTI are projected to be two times than those of patients not suffering from CAUTI.⁸

There is an ample evidence demonstrating that CAUTIs can be prevented by avoiding unnecessary catheter use, reducing the duration of catheter use, and following evidence-based practices for insertion and maintenance.⁹ The relevant literature states that adherence to best practices, protocols and checklists to implement care bundles can reduce the CAUTI rate to zero.¹⁰ Therefore, we aimed to reduce the CAUTI rate in an adult coronary ICU (CICU) by using a multifaceted approach with rapid cycle testing.

Operational definition: CAUTIs are defined as follows by the Centers for Disease Control.^{11 12}

1. Use of an indwelling catheter for over 2 consecutive days.
2. Catheter placement on the day of or the day before the event.
3. Two or more symptoms of CAUTI (fever >38.0°C, suprapubic tenderness, costovertebral angle pain or tenderness, urinary urgency, urinary frequency, dysuria).
4. Urine culture with no more than two species of organisms, of which at least one is a bacterium with $\geq 10^5$ CFU/mL

Problem description

At the CICU of a tertiary cardiac care facility, the CAUTI rate was 7.6/1000 catheter days in January 2017, which was significantly higher than the NHSN benchmark. A systematic analysis performed by our team in the CICU to identify the root cause and to implement evidence-based practices revealed gaps in the compliance with the insertion and maintenance bundle elements for CAUTI prevention, and the absence of a mechanism to indicate cases requiring early catheter removal.

To reduce the rate of CAUTIs, we tested and implemented bundled CAUTI prevention tools and measured the effects of their implementation. We predicted that empowering nurses with automatic stop orders for catheter use, targeted education efforts for front-line teams, implementation of standardised checklists and monitoring care bundle compliance will be relatively low-cost and high-yield endeavours that could decrease the incidence of CAUTIs in the CICU setting. Our objective was to design and implement a multidisciplinary quality improvement programme to reduce the CAUTI rate in the CICU.

Exclusion and inclusion criteria

All patients in the CICU with urinary catheters were included, with no exclusions.

Aim statement

To achieve 100 CAUTI-free days in the CICU of a cardiac facility by June 2022.

Objectives

1. To follow evidence-based practices using a multidisciplinary team approach.
2. To improve compliance for care bundles, including bundles for insertion and maintenance of urinary catheters.
3. To empower nursing staff for automatic removal of catheters unless indicated.

Setting

The study was conducted at a tertiary cardiac care facility with 114 inpatients and 28 emergency department beds. The CICU is a 20-bed unit that serves cardiac patients. The CICU patient census is around an average of 400–500 patients per month with an average occupancy rate of 80% and an average length of stay of 1.5 days. The majority of patients are admitted with multiple comorbidities such as diabetes, hypertension, peripheral vascular diseases, neurological disorders, heart failure and dialysis.

METHODS

Interventions

A multidisciplinary team that included nurses, physicians, infection control practitioners and quality improvement professionals was formed to work on this initiative. After brainstorming with the team, gaps in compliance with the care bundle and timely removal of catheters were identified. Team prepared a driver diagram and cause and effect analysis (figures 1 and 2). A three-component model for improvement, which included setting an aim statement, defining measures, and selecting small changes for testing, was used to guide our work. Subsequently, small plan–do–study–act cycles were used to test the changes in ideas.

We enacted an educational module for physicians and nursing staff that aimed to reframe catheter risk and reviewing appropriate indications for catheterisation. The nursing staff was empowered to automatically stop catheter use if there was no clear indication. The tested and implemented changes are described below.

Care bundle implementation

The CAUTI prevention bundle is a care bundle that includes a set of evidence-based measures.^{13–16} Bundles consist of several evidence-based measures with ample supportive literature elements that, when implemented together, have been shown to produce better outcomes and have a greater impact than the isolated implementation of individual measures.¹³ Care bundles have been proven to help create reliable and consistent care systems in hospital settings because they are simple (three to five elements), clear and concise to interpret and implement.¹³

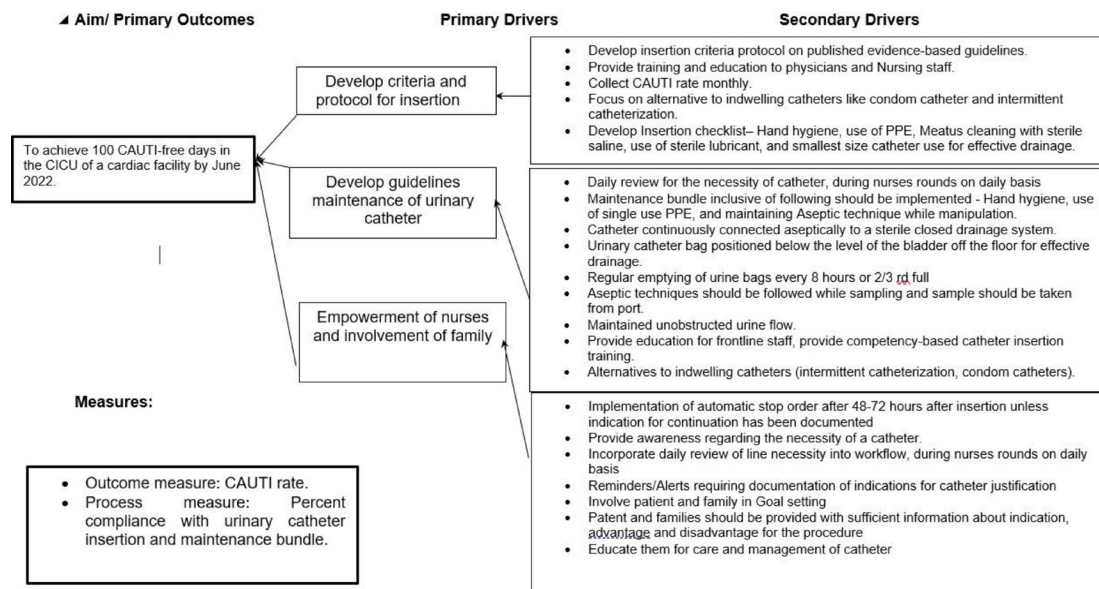


Figure 1 Driver diagram. CAUTI, catheter-associated urinary tract infection; CICU, coronary intensive care unit, PPE, Personal protective equipment.

In preparation for bundle introduction, all bedside nurses were educated about the bundle elements. The components of the care bundles are listed below:

Insertion bundle:

- ▶ Catheters are inserted by skilled, trained staff.
- ▶ Appropriate hand hygiene is practised.
- ▶ Urinary catheters are inserted using aseptic techniques and sterile equipment.
- ▶ Sterile gloves are used when inserting a catheter.
- ▶ Sterile, single-use jelly is employed during catheter insertion.
- ▶ Closed urinary drainage systems are attached.
- ▶ Urinary bags are below the patient’s bladder but do not touch the floor.

- ▶ Catheters are secured to the patient’s thigh after insertion to prevent movement.

- ▶ Hand hygiene is practised after the procedure.¹⁵⁻¹⁷

Maintenance bundle:

- ▶ The need for a urinary catheter is reviewed on a daily basis.
- ▶ Catheters are kept properly secured.
- ▶ Before manipulation, hand hygiene is performed, and personal protective equipment is worn.
- ▶ A continuous closed drainage system is maintained.
- ▶ The drainage bag is positioned below the bladder level and does not touch the floor.
- ▶ The drainage bag is frequently emptied using a separate collection container for each patient.^{17 18}

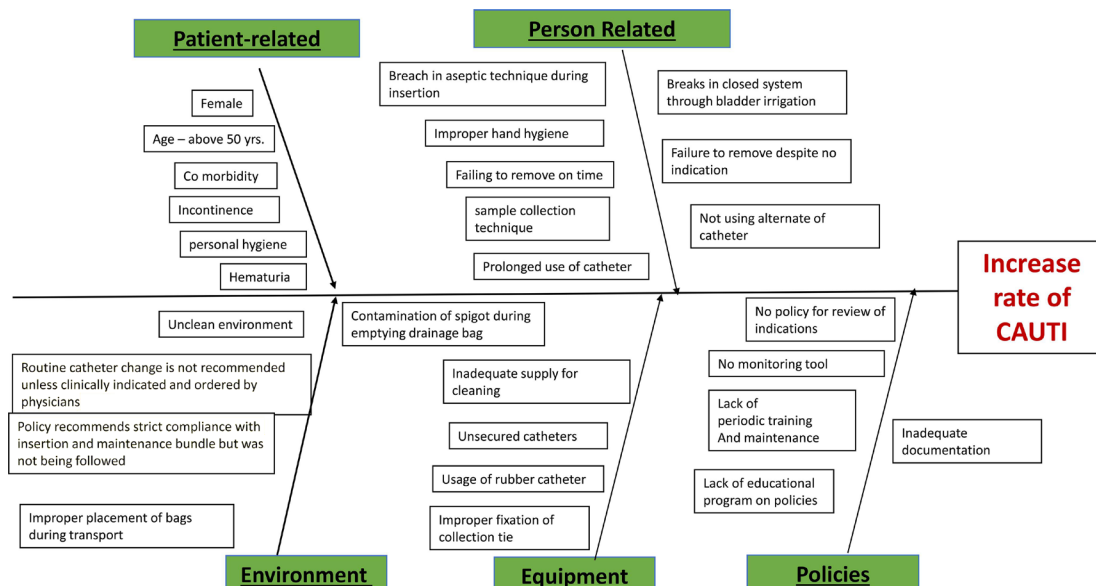


Figure 2 Cause and effect analysis. CAUTI, catheter-associated urinary tract infection.

- ▶ Routine daily meatal hygiene is performed.
- ▶ On procedure completion, Personal protective equipment (PPE) is removed, and hand hygiene is performed.
- ▶ An unobstructed urine flow is maintained.

Monitoring of insertion and maintenance bundle compliance

A CAUTI bundle checklist audit tool was developed and tested in this study based on literature review and evidence based practices.¹⁶ The tool covered both insertion and maintenance elements. It was employed for one nurse and one patient in one shift. Data were collected daily on this audit form, and weekly compliance was calculated by the task force and communicated to the teams. Monitoring was performed by nurses. Since this is an ICU, we have 1:1 care so each nurse is responsible for one patient and he/she is given the task to collect compliance using a paper form. Monitoring takes place daily for the maintenance bundle and during the insertion bundle's insertion time.

The tool was modified based on feedback from nurses before adoption. Bundle compliance was measured using an 'all or nothing' approach, and compliance data were shared with the staff through event calendars and monthly unit meetings.

Implementation of automatic stop orders of the catheter 72 hours after insertion unless indications was documented

In cases requiring an indwelling catheter, the most important strategy is to remove the catheter as soon as possible.¹⁹⁻²¹ To follow this evidence-based practice, automatic stop orders for catheters were implemented in the CICU unless an indication for continuation was documented by the treating physician in the medical records. Nurses were empowered to remove catheters if there was no valid indication to continue catheterisation. Education included evaluation of catheter necessity in daily nursing assessments at the start of every shift, with the requirement of contacting a physician if the criteria are not met. Strategies to reduce catheter days in conjunction with daily reviews were implemented, including automatic stop orders and mandatory renewal orders with documentation of indications and reminders in patient records and daily rounds.

The literature supports the effectiveness of such approaches, since reminders and stop orders have been shown to help reduce catheter duration by 37% and CAUTI rates by 52%.²²

Furthermore, although all consumables were available, there was a need to obtain them in a packaged kit. Therefore, the team came up with the idea of a 'kit' that includes all the essential items required for catheter insertion.

Display of data

To maintain momentum and create a sense of urgency, data including hand hygiene, bundle compliance and CAUTI rates were displayed on the unit quality and

infection control boards, which were easily accessible to the staff.

Study of the interventions

Outcome measures

The CAUTI rate was calculated as follows: number of CAUTIs in the CICU/the number of catheter days in the CICU×1000. Data collection was completed during surveillance performed by infection control practitioners. The catheter days were calculated as the denominator. No cases were excluded in this study, and all patients with catheters in the CICU were included in the analysis.

Process measures

Each element in the bundle was monitored for compliance. Compliance with the use of each of the changes was measured to determine percentage compliance with the bundle as a whole and for each of the bundle elements. Compliance was considered if all elements of the bundles were followed and missing even one component was considered to indicate zero compliance.

Balancing measures

The proportion of catheters that were reinserted within 48 hours of removal.

Statistical analysis

The project outcomes were analysed using standard 'control chart rules' that revealed statistically significant changes in outcomes over time.^{23 24} In addition, compliance data were collected for every element as a process measure. This study analysed CAUTI rates for 24 months before and 44 months after implementing the interventions. Data that did not show a normal distribution were tested using the Shapiro-Wilk test. Monthly rates of CAUTI 24 months before the intervention were compared with those 44 months after the intervention by using the independent t-test. The device utilisation ratio 24 months before the intervention was compared with that 24 months after the intervention by using the Student's independent t-test. Statistical significance was set at $p < 0.05$. An Excel spreadsheet (Microsoft Excel 2016) and SPSS (Statistical package for social science) were used for the analysis.

RESULTS

Implementation of this initiative resulted in the long-term elimination of CAUTIs from the CICU. The monthly rates of CAUTIs 24 months before the intervention were significantly lower than those 44 months after the intervention ($p = 0.02$). The test statistic t was 2.3247, which was not in the 95% region of acceptance: (-2.0258; 2.0258). The SD of the difference, $S' = 0.757$, was used to calculate the statistic. The CAUTI rate per 1000 patient days dropped from 7.6 per 1000 device days in January 2017 to 0 per 1000 device days from October 2021 onwards, which is below the NHSN benchmark of 0.8 (figure 3).

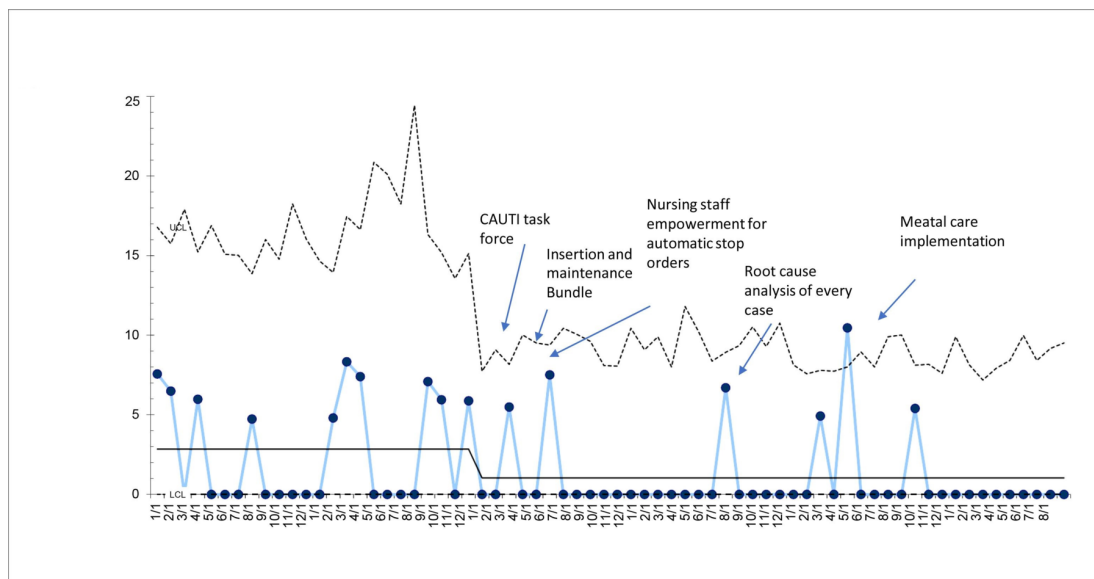


Figure 3 U chart—monthly rate of CAUTI in CICU per 1000 catheter days. CAUTI, catheter-associated urinary tract infection; CICU, coronary intensive care unit.

Compliance with the insertion and maintenance bundles increased from 55% to 65%, respectively, in January 2017 to 100%.

Quarterly data are displayed in figure 4. The control chart displayed in this figure was annotated to show the implementation of some of the changes tested. Attention to the CAUTI prevention bundle appears to have had the greatest impact. The device utilisation ratio in the 24 months preceding the intervention was not significantly different from that 44 months after the intervention ($p=0.0762$). The annual count of CAUTIs reduced from 4 in 2017 and 6 in 2018 to 4 in 2021 and 0 until August 2022. These results have been sustained for more than 3 years, and the improvement has persisted to date.

DISCUSSION

Implementation of the insertion and maintenance bundle of preventive measures resulted in the elimination of CAUTIs from the CICU. The number of CAUTI cases reported in 2017 and 2018 was 4 and 6, respectively. This number reduced to zero from October 2021 onwards. The CAUTI rate per 1000 patient days dropped from 7.6 per 1000 device days in January 2017 to 0 per 1000 device days in August 2022. The two-tailed p value for the difference was <0.05 , which indicated statistical significance.

CAUTIs are considered the most common HAI,⁹ and 65%–70% of CAUTIs are preventable.³ Prevention remains the main strategy in the efforts against CAUTI,

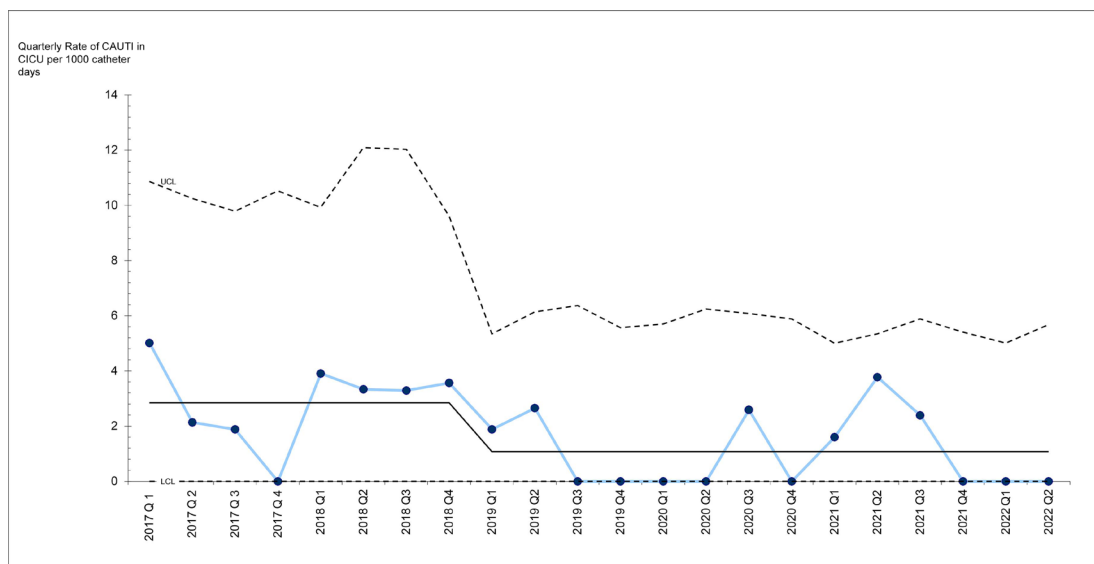


Figure 4 U chart—quarterly rate of CAUTI in CICU per 1000 catheter days. CAUTI, catheter-associated urinary tract infection; CICU, coronary intensive care unit.



and 17%–69% of CAUTIs (or 380 000 infections and 9000 deaths annually) can be prevented with the use of appropriate infection prevention strategies.^{25 26}

A frequent perception among staff, patients and families was that a urinary catheter is a convenient and comfortable option for patients. Therefore, some patients and families request catheterisation rather than experiencing incontinence. One of the most important factors influencing infection is the duration of catheterisation, with the risk of infection increasing by 3%–7% daily.²⁷ The predominant risk factor for CAUTI development is the duration of urinary catheterisation, with an additive 3%–10% risk for each cumulative day of catheterisation.²⁷ A multidisciplinary approach not only allowed us to brainstorm different reasons for the higher rates of CAUTIs in the unit and assess the deficiencies but also yielded new solutions from every aspect of nursing, general medicine and infection control. This included education and awareness regarding the use of catheters among patients and relatives. All interventions were planned and customised based on our patient's needs, which helped us reduce the rate and sustain the improvement for a long time.

Since the bundle consists of several elements that were implemented simultaneously, the intervention with the highest impact could not be definitively determined, but our hypothesis is that effective implementation, monitoring and a multidisciplinary approach led us to this successful outcome. In addition to bundle implementation, regular face-to-face meetings and education sessions that included one-to-one and small classroom sessions proved to be vital in this initiative.

The strengths of this study include its focus on CAUTI prevention in adult CICU settings. Many factors made this initiative a success, including direct observation of catheter insertion site care practices and regular monitoring of bundle compliance. The identification and addressal of training opportunities for the insertion and maintenance bundles, empowerment of nurses to remove the catheter if the indication is not documented, and automatic removal orders within 72 hours of catheter insertion were vital factors influencing the success of this initiative. In addition, a multidisciplinary approach and evidence-based best care practices were implemented, and the positive outcomes have been sustained to date. In addition, this work was led by front-line teams, which gave them the opportunity to apply their quality improvement knowledge to day-to-day practice and to use it for other initiatives in their clinical areas. We recognised the staff with the highest compliance with hand hygiene practices through email and pictures on the notice boards.

Despite these encouraging results, substantial barriers persist in terms of the sustainability of effective CAUTI reduction strategies. First, physicians' awareness of the catheter status remains variable. Up to 28% of catheters are unrecognised by treating physicians, and unrecognised catheters are more likely to be in place for inappropriate indications.²⁸ Our study also showed a lack of understanding of the insertion and maintenance

bundle, which was addressed by vigorous education. Moreover, early removal of catheters faced resistance from patients and their families, which was addressed by front-line staff by educating the patients and families on the disadvantages of prolonged catheter retention.

LIMITATIONS

The main limitation of this study was the inability to differentiate which element from the bundle had the greatest impact on case prevention and determine the impact of each element on CAUTI incidence. Since multiple strategies were implemented simultaneously, we were unable to attribute the results to a single intervention. Moreover, since this was not a randomised control trial and there was no control group, we were unable to assess the effectiveness of each component of the bundled approach.

Several lessons were learnt during this initiative. The involvement of a multidisciplinary team from the beginning of any initiative can have an impact on decision-making and interventions. This approach can facilitate identification of key issues and assist in effective interventions to resolve these issues. Involvement of physician champions for training and educational purposes also played a vital role in this work.

The bundled approach is an effective way to implement change and improve outcomes by promoting teamwork, measuring compliance and providing feedback. In addition, effective implementation of a care bundle requires adaptation of the measures to the local setting, appropriate adherence, ensuring that the measures are suitable for the patient care culture, and monitoring and evaluation to ensure compliance.

CONCLUSIONS

We found that the implementation of a multifaceted intervention in the form of care bundles in the cardiac ICU successfully resulted in a reduction in the rate of catheter-associated infection. Daily physician reminders during rounds paired with extensive education efforts in conjunction with a care bundle and automated 48 hours stop order implementation resulted in a sustained reduction in CAUTIs.

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Contributors PG served as improvement advisor for the work and prepared the initial draft of the manuscript. MT played a significant role in the formulating of change ideas and program implementation as well as served as Guarator. LM, NZ and AFI contributed by implementing change ideas and data collection. MLG, CS and FAM played a key role from infection control point of view. MEH played a significant role in educating physicians. All authors approved the final version of the manuscript.

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Ethics approval Not applicable.

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Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information.

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