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# Near-Zero CLABSI in a Newly Established ICU: A Prospective Quality Improvement Study

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## Abstract

**Aim:** Central venous catheters (CVCs) are essential for patient management in intensive care units (ICUs) but are associated with a significant risk of central line–associated bloodstream infections (CLABSIs). This study aimed to identify deficiencies in CVC care practices, implement targeted interventions, and evaluate subsequent changes in CLABSI rates within a quality improvement framework.

**Methods:** This prospective observational study was conducted in the Internal Medicine Intensive Care Unit (IMICU) of a tertiary-care hospital between January 1, 2023, and February 28, 2024. Surveillance data were collected and analyzed across five consecutive periods. Interventions were implemented sequentially and included staff education, introduction of 2% chlorhexidine gluconate (CHG)-impregnated dressings, and use of CHG wipes.

**Results:** A total of 589 patients (3,819 patient-days) were included. The CLABSI rate decreased from 14.46 to 4.76 per 1000 central line-days following the implementation of interventions, accompanied by a reduction in the standardized infection ratio (SIR) from 1.36 to 0.45. In the final surveillance period, no CLABSI events were observed. These changes occurred despite continued high device utilization.

**Conclusion:** Structured staff education, continuous surveillance, and adherence to evidence-based central line bundles were temporally associated with reduced CLABSI rates in a newly established ICU. These findings should be interpreted within a quality improvement context rather than as evidence of causal effects.

**Keywords:** central line–associated bloodstream infection; quality improvement; intensive care unit; infection prevention; chlorhexidine; surveillance

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## Introduction

Central venous catheters (CVCs) are indispensable in the management of critically ill patients, providing reliable vascular access for the administration of medications, fluids, parenteral nutrition, and hemodynamic monitoring. However, their use is associated with a substantial risk of central line–associated bloodstream infections (CLABSIs), which remain among the most serious healthcare-associated infections in intensive care units (ICUs) [1,2]. CLABSIs are linked to increased morbidity, mortality, prolonged hospital stay, and higher healthcare costs, making their prevention a major priority in modern critical care practice [3].

Over the past decade, significant efforts have been directed toward reducing CLABSI rates through the implementation of evidence-based prevention bundles. These bundles typically include appropriate site selection, maximal sterile barrier precautions, optimal skin antisepsis, and strict adherence to catheter maintenance protocols [4]. Among these measures, chlorhexidine gluconate (CHG) has gained particular attention due to its broad antimicrobial activity and sustained effect on skin colonization. CHG-based interventions, including CHG-alcohol skin antisepsis, CHG-impregnated dressings, and CHG bathing, have been associated with reductions in catheter-related infections in multiple clinical settings [5-8].

Despite well-established guidelines, real-world adherence to central line bundles remains variable, particularly in newly established or resource-limited ICUs. Factors such as inadequate training, variability in clinical practice, and workflow-related challenges may contribute to suboptimal compliance and increased infection risk [9,10]. In this context, quality improvement (QI) initiatives that combine surveillance, feedback, and targeted interventions are increasingly recognized as effective strategies for enhancing adherence to preventive measures and improving patient outcomes.

This study was conducted in a newly established internal medicine ICU where an increase in CLABSI rates had been observed during routine surveillance. The aim of this study was to identify deficiencies in CVC care practices, implement targeted interventions, and evaluate temporal changes in CLABSI rates following these interventions. The study was designed within a quality improvement framework and focuses on describing real-world trends rather than establishing causal relationships.

## Methods

**Study design and setting**

This prospective observational study was conducted in the Internal Medicine Intensive Care Unit (IMICU) of a tertiary-care hospital between January 1, 2023, and February 28, 2024, as part of the Infection Control Committee’s surveillance program. The study population consisted of adult patients aged 18 years and older.

**Data collection and surveillance**

Healthcare-associated infection (HAI) surveillance was actively performed by an infection control nurse responsible for approximately one nurse per 150 hospital beds, using both patient-based and laboratory-based methods. During CLABSI surveillance, the following data were recorded: the number of patients with CVCs, total central line-days, and compliance with central line bundle elements, as defined by the Turkish Ministry of Health and consistent with CDC recommendations for insertion and maintenance practices (9).

**CLABSI definition**

The diagnosis of CLABSI was made jointly by an infectious diseases specialist and an infection control nurse, using the definition of a laboratory-confirmed bloodstream infection occurring in a patient with a central line in place for more than two consecutive calendar days (>48 hours) (10).

**Study procedures and interventions**

Surveillance data were organized into three-month periods, and infection rate calculations and evaluations were performed accordingly. Interventions were implemented sequentially across surveillance periods: education in the first period, CHG-impregnated catheter dressings in the third period, and CHG wipes in the fifth period.

**Outcome measures**

The following indices were calculated for each surveillance period:

Central line utilization ratio (CL-UR) = central line-days / patient-days

CLABSI rate = (number of CLABSI cases / central line-days) × 1000

Standardized infection ratio (SIR) = observed infections / expected infections

Standardized device utilization ratio (SDUR) = observed device-days / expected device-days

The interpretation criteria were defined as follows. An SIR value greater than 1 indicated that observed infections were higher than expected, an SIR value equal to 1 indicated that observed infections were consistent with expected levels, and an SIR value lower than 1 indicated fewer infections than expected. Similarly, an SDUR value greater than 1 indicated higher than expected device utilization, an SDUR value equal to 1 indicated utilization consistent with expected levels, and an SDUR value lower than 1 indicated lower than expected device utilization.

Expected infections were derived from the Turkish national benchmark, and the SIR was calculated using these values as a reference (11). Whenever SIR or SDUR values exceeded 1, an internal investigation was initiated to identify underlying causes and implement corrective measures within the unit.

**Statistical approach**

Given the quality improvement design of the study, the primary focus was on describing temporal trends rather than establishing causal relationships. Descriptive statistics were used to summarize patient characteristics, device utilization, and process indicators across surveillance periods.

In addition, trend analyses were performed to explore changes over time. Linear trend analyses were conducted using regression models, and non-parametric trends were assessed using the Mann–Kendall test, as appropriate. Due to the bundled and sequential implementation of interventions (education, CHG-impregnated dressings, and CHG wipes), attribution of observed effects to individual components was not statistically feasible.

All analyses were interpreted within an exploratory framework, and findings should be considered hypothesis-generating rather than indicative of causal effects.

**Educational intervention**

The educational intervention consisted of approximately 30-minute small-group training sessions delivered separately to physicians and nurses using a standardized, guideline-based presentation covering CVC insertion and post-insertion care. The training was conducted as a single intervention and was not formally repeated during the study period.

**Ethics**

This study was conducted as part of a routine infection control surveillance and quality improvement program. Ethical approval was obtained from the institutional review board (approval number: 2024-TBEK 2024/09-10; 25 September 2024). The requirement for informed consent was waived due to the observational nature of the study and the use of anonymized data. The study was conducted in accordance with the Declaration of Helsinki.

## Results

A total of five surveillance periods were analyzed, spanning from January 2023 to February 2024. Temporal changes in patient burden, device utilization, infection rates, and compliance with central line bundle components are summarized in Table 1, Table 2, and Figure 1.

**Patient Burden and Device Utilization**

The number of patient-days showed minor fluctuations across surveillance periods, ranging from 724 to 787, without a consistent directional trend (Table 1). Similarly, central line-days varied between 389 and 526. The central line utilization ratio (CL-UR) remained relatively stable overall but demonstrated a slight increase in the final period (0.67), compared to earlier periods (range: 0.50–0.57) (Table 1, Figure 1).

Trend analysis indicated a non-significant increase in the number of patients over time ($\beta = 1.40$; $p = 0.880$; Mann-Kendall $\tau = 0.000$, $p = 1.000$). Patient-days showed a non-significant decreasing trend ($\beta = -47.70$; $p = 0.649$; Mann-Kendall $\tau = 0.400$, $p = 0.483$), while central line-days exhibited a non-significant upward trend ($\beta = 21.10$; $p = 0.249$; Mann–Kendall $\tau = 0.400$, $p = 0.483$) (Figure 1).

**CLABSI Rates and Standardized Indicators**

The CLABSI rate per 1000 central line-days demonstrated substantial variability across periods, decreasing from 14.46 in the first period to 4.64 in the second, rising again to 10.28 in the third, and subsequently declining to 4.76 in the fourth period. Notably, no CLABSI events were recorded in the final surveillance period (Table 1, Figure 1).

A decreasing trend in CLABSI incidence was observed over time (β = −1.20), supported by a strong negative Mann-Kendall coefficient (τ = −0.738). However, this trend did not reach statistical significance (linear trend $p = 0.081$; Mann–Kendall $p = 0.077$).

The standardized infection ratio (SIR) followed a similar pattern, decreasing from 1.36 in the first period to 0 in the final period. In contrast, the standardized device utilization ratio (SDUR) showed an increasing trend over time, rising from 1.22 to 1.98, indicating higher-than-expected device use in the later periods (Table 1).

**Table 1.** Temporal Trends in CLABSI Rates and Device Utilization Across Surveillance Periods

| | **January-March 2023** | **April-June 2023** | **July-September 2023** | **October-December 2023** | **January-February 2024** |
|---|---|---|---|---|---|
| **Patient-days** | 724 | 766 | 779 | 763 | 787 |
| **Central line-days** | 415 | 431 | 389 | 420 | 526 |
| **Central Line Utilization Ratio (CL-UR)** | 0.57 | 0.56 | 0.50 | 0.55 | 0.67 |
| **CLABSI rate (per 1000 central line-days)** | 14.46 | 4.64 | 10.28 | 4.76 | 0 |
| **Standardized Infection Ratio (SIR)** | 1.36 | 0.44 | 0.98 | 0.45 | 0 |
| **Standardized Device Utilization Ratio (SDUR)** | 1.22 | 1.22 | 1.10 | 1.21 | 1.98 |

**Abbreviations:** CVC = central venous catheter; CLABSI = central line–associated bloodstream infection; CHG = chlorhexidine gluconate; CL-UR = central line utilization ratio; SIR = standardized infection ratio; SDUR = standardized device utilization ratio.
**Note:** Education was introduced in the first period; CHG-impregnated dressings in the third period; and CHG wipes in the fifth period.

**Compliance with Central Line Bundle Components**

Compliance with infection prevention bundle components was generally high for several key practices (Table 2). Hand hygiene before catheter access remained consistently high (≥97%), reaching 100% in multiple periods. Hand hygiene after catheter access showed slight variability but remained above 90% overall.

Daily assessment of catheter necessity was consistently optimal (100%) in most periods, with a temporary decrease in one period (92.71%). Similarly, hand hygiene before catheter insertion and skin preparation practices maintained near-perfect compliance across all periods.

In contrast, marked variability was observed in certain bundle components. Appropriate disinfection before catheter access decreased substantially in the third and fourth periods (23.42% and 26.92, respectively), before partially recovering in the final period (79.94%). Maximal barrier precautions demonstrated a notable decline over time, reaching 0% in one period before modest recovery.

Appropriate site selection showed consistently low and fluctuating compliance (range: 15.70%-58.39%). The number of dressing changes remained relatively stable across periods (range: 517–579), suggesting consistent catheter maintenance activity (Table 2).

**Overall Trends**

Overall, while patient burden and device utilization remained relatively stable, a clinically meaningful but statistically non-significant reduction in CLABSI rates was observed over time. This reduction coincided with high compliance in several core bundle components but occurred alongside variability in specific practices, particularly disinfection and barrier precautions (Figure 1).

**Table 2.** Compliance with Central Line Bundle Components Across Surveillance Periods

| | January-March 2023 | April-June 2023 | July-September 2023 | October-December 2023 | January-February 2024 |
|---|---|---|---|---|---|
| **Hand hygiene before each catheter access (%)** | 97.06 | 100 | 99.96 | 99.80 | 99.80 |
| **Hand hygiene after each catheter access (%)** | 94.64 | 100 | 90.94 | 99.21 | 100 |
| **Daily assessment of catheter necessity (%)** | 100 | 100 | 100 | 92.71 | 100 |
| **Appropriate disinfection before each catheter access (%)** | 100 | 100 | 23.42 | 26.92 | 79.94 |
| **Hand hygiene immediately before catheter insertion (%)** | 100 | 100 | 100 | 100 | 100 |
| **Appropriate site selection (%)** | 58.39 | 52.66 | 53.50 | 15.70 | 28.71 |
| **Appropriate skin preparation (%)** | 100 | 97.86 | 100 | 100 | 100 |
| **Maximal barrier precautions (%)** | 100 | 88.00 | 47.33 | 0 | 14.76 |
| **Appropriate dressing change (n)** | 579 | 518 | 517 | 559 | 565 |

**Abbreviations:** CVC = central venous catheter; CLABSI = central line–associated bloodstream infection; CHG = chlorhexidine gluconate.
**Note:** Compliance indicators represent process measures and may be influenced by observer and documentation variability.

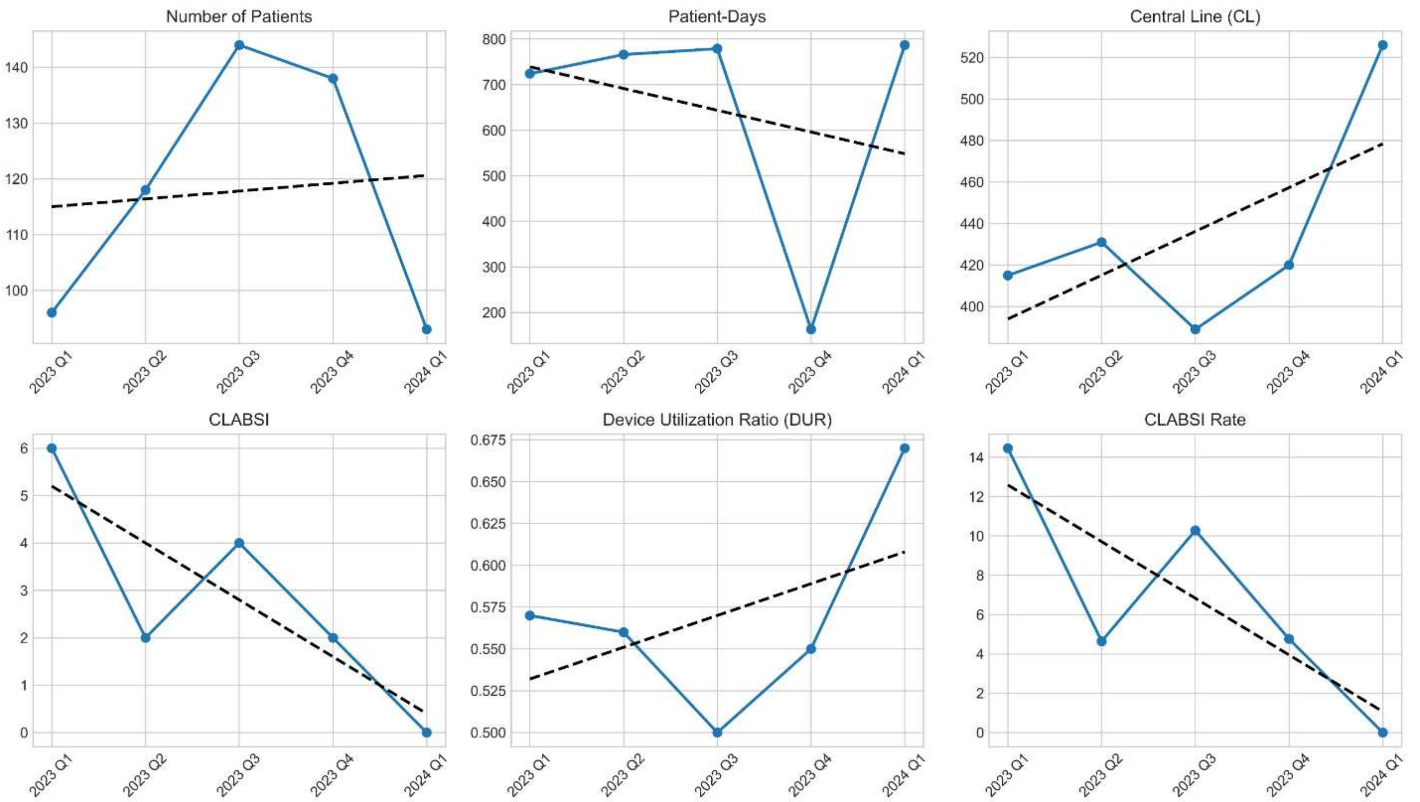


**Figure 1.** Temporal trends in patient burden, central line utilization, and CLABSI incidence across surveillance periods.
A downward pattern in CLABSI incidence is visually evident over time, despite fluctuations in device utilization.

## Discussion

This prospective quality improvement study observed a substantial reduction in CLABSI rates over time following the sequential implementation of targeted interventions, including structured staff education and chlorhexidine-based preventive strategies. The decline from 14.46 per 1000 central line-days to a final surveillance period with no observed CLABSI events, accompanied by a marked reduction in SIR, was temporally associated with these interventions and suggests that coordinated infection control efforts may contribute to meaningful improvements even in newly established ICUs.

Our findings are consistent with a robust body of evidence demonstrating the effectiveness of bundled interventions in reducing CLABSI rates. Evidence-based central line bundles, incorporating maximal sterile barrier precautions, appropriate skin antisepsis, and daily assessment of catheter necessity, have been widely shown to reduce catheter-related infections across diverse clinical settings [1-4]. Landmark quality improvement initiatives have further demonstrated that structured, system-level interventions can achieve rapid and sustained reductions in catheter-related bloodstream infections when implemented with high adherence [11,12]. The magnitude of reduction observed in our study is broadly aligned with these reports, although differences in baseline rates and implementation context should be considered.

Chlorhexidine-based interventions likely contributed to the observed improvements. Both CHG-impregnated dressings and daily CHG bathing have been associated with reduced microbial colonization and bloodstream infection rates [5,8,13]. The sustained antimicrobial activity of chlorhexidine and its effectiveness against skin flora make it a cornerstone of contemporary infection prevention strategies. However, given the bundled and sequential nature of the interventions in this study, it is not possible to determine the relative contribution of each component. This reflects the pragmatic nature of quality improvement initiatives, where multiple strategies are implemented concurrently to achieve maximal clinical impact [4,14].

An important observation is the discordance between process indicators and outcome trends. Despite variability—and in some periods, deterioration—in compliance with key bundle components such as disinfection before catheter access and maximal barrier precautions, CLABSI rates decreased over time. This finding highlights the complex and not strictly linear relationship between process measures and clinical outcomes. It is plausible that high adherence to critical elements, particularly hand hygiene and skin antisepsis, exerted a disproportionately strong protective effect, as previously suggested in infection control research [15]. In addition, improvements in unmeasured factors such as staff awareness, behavioral adaptation, and workflow optimization may have contributed to the observed reductions. This may also reflect measurement bias or differential weighting of bundle components.

The persistence of high device utilization throughout the study period, particularly the increase observed in the final surveillance phase, strengthens the interpretation that reductions in CLABSI rates were not driven by decreased exposure to central lines. This is clinically relevant, as critically ill patients often require prolonged vascular access, and reducing device use is not always feasible. These findings suggest that meaningful reductions in infection rates can be achieved even in high-utilization settings when preventive strategies are consistently applied [16].

The observation of a zero-CLABSI period in the final surveillance phase should be interpreted with caution. While it may reflect the cumulative effect of interventions, it is also susceptible to random variation, particularly in studies with relatively limited sample size. Similar transient zero-infection periods have been described in quality improvement settings and may not necessarily indicate sustained elimination of infection risk [17]. Continued surveillance and reinforcement of infection prevention practices remain essential.

This study has several strengths. It reflects real-world clinical practice in a newly established ICU, incorporates longitudinal surveillance across multiple time periods, and evaluates both outcome and process indicators. The use of standardized metrics such as SIR and SDUR enhances comparability with national benchmarks and supports the validity of the findings. However, several limitations should be acknowledged. First, the single-center design may limit generalizability to other settings with different patient populations and organizational structures. Second, the quality improvement design, with sequential and bundled interventions, precludes attribution of the observed effects to individual components and does not allow for causal inference. Third, compliance data were based on observational and documentation practices and may be subject to reporting bias. In addition, microbiological characteristics of CLABSI episodes were not analyzed in detail, and residual confounding related to patient case-mix and illness severity cannot be excluded. Finally, the relatively short follow-up period limits conclusions regarding the long-term sustainability of the observed reductions, particularly the zero-CLABSI period in the final phase.

In conclusion, a structured quality improvement approach combining staff education, continuous surveillance, and chlorhexidine-based interventions was temporally associated with a substantial reduction in CLABSI rates in a newly established ICU. These findings support the consideration of implementing integrated infection prevention strategies in similar settings, while emphasizing the importance of sustained adherence, ongoing monitoring, and cautious interpretation of short-term zero-infection outcomes. The results should be interpreted within a quality improvement framework and considered exploratory and hypothesis-generating rather than indicative of direct causal effects.

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**Conflict of Interest:** The authors declare that they have no competing interests.

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