ORIGINAL ARTICLE

From Concern to Control: Feedback from a quality improvement project to decrease Central-Line-Associated Bloodstream Infections in a Tertiary Neonatal Intensive Care Unit"

« De l'inquiétude à la maîtrise : Retour d'expérience d'un projet d'amélioration de la qualité pour réduire les bactériémies associées aux cathéters centraux dans une unité néonatale de soins intensifs de 3ème ligne »

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Abstract

Introduction: Infants admitted in Neonatal Intensive Care units (NICU) are frequently exposed to a high risk of contracting a central line-associated bloodstream infection (CLABSI). The study aims to reduce the CLABSI rate in the NICU to reach the Saudi Ministry of Health (MOH) benchmark.
Methods: It is a quality improvement project based on the Plan Do Check Act. This study was conducted in the Neonatal intensive care unit (NICU) at the Prince Sultan Military Medical City. The study was done from February 2023 to July 2023 in NICU. Sixteen evidence-based recommendations were assessed over the project. An assigned team enhanced the regular assessment of central line-related items and supplies.
Results: 38 staff members were selected as 'a vascular access team' for this project. Full compliance with updated recommendations increased from 25% to 56.3%, and overall care bundle compliance improved from 66.07% to 79.12%. The availability of supplies related to central lines improved throughout the CLABSI project. Consequently, the CLABSI rate decreased by 82.3%, from 10.42 (6 CLABSI, 576 central line days; February 2023) to 1.84 (1 CLABSI, 544 central line days; July 2023) CLABSI per 1,000 central line days after six months of quality improvement project implementation.
Conclusions: Reducing the CLABSI rate is achievable by QIP based on updated recommendations to improve the quality of care and outcomes for newborns. However, multiple challenges should be addressed to maintain a low CLABSI rate.

Keywords: Central line-associated bloodstream infections – Quality improvement project – Neonatal intensive care unit

Résumé

Introduction: Les nouveau-nés admis en unité de soins intensifs néonatale (USIN) ont fréquemment un risque élevé de contracter une bactériémie associée aux cathéters centraux (BACC). L'objectif de cette étude était de réduire le taux de BACC en USIN afin d'atteindre le seuil de référence fixé par le ministère de la Santé saoudien (MSS).
Méthodes : Il s'agissait d'un projet d'amélioration de la qualité (PAQ) basé sur le cycle Planifier-Faire-Vérifier-Agir (PDCA). L'étude a été menée à l'USIN de l'hôpital militaire 'Prince Sultan', de février à juillet 2023. Seize recommandations fondées sur des données probantes ont été évaluées. Une équipe dédiée a renforcé l'évaluation régulière des pratiques et des ressources nécessaires associées au cathéters centraux.
Résultats : Trente-huit membres du personnel ont été désignés comme « équipe d'accès vasculaire » pour ce projet. La conformité complète aux nouvelles recommandations est passée de 25 % à 56,3 %, et l'adhésion globale aux protocoles de soins est passée de 66,07 % à 79,12 %. La disponibilité des fournitures s'est également améliorée durant le projet, ce qui a conduit à une diminution du taux de BACC de 82,3 %, passant de 10,42 (6 BACC, 576 jours-cathéter, février 2023) à 1,84 (1 BACC, 544 jours-cathéter, juillet 2023) pour 1 000 jours-cathéter.
Conclusion : La réduction du taux de BACC est réalisable grâce à un PAQ basé sur des recommandations mises à jour, contribuant à améliorer les soins et le pronostic des nouveau-nés. Cependant, plusieurs défis doivent être relevés pour maintenir ce faible taux.

Mots clés: Bactériémie associée aux cathéters centraux – Projet d'amélioration de la qualité – Unité de soins intensifs néonatale.

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What is known

1. Central line-associated bloodstream infections (CLABSIs) are a major cause of morbidity and mortality in neonatal intensive care units (NICUs).

2. Preventing CLABSIs in neonates is particularly challenging due to their fragile skin and immature immune systems.

3. Prior to 2022, there was a lack of clear, evidence-based guidelines specific to CLABSI prevention in neonatal populations.

4. The Society for Healthcare Epidemiology of America (SHEA) and the Centers for Disease Control and Prevention (CDC) published updated recommendations in 2022, addressing key practices.

5. These updates focus on skin antisepsis, dressing change frequency, hub disinfection, and IV set replacement in neonates.

What this article adds

1. This article describes a successful Quality Improvement Project (QIP) that implemented the 2022 SHEA and CDC recommendations in a NICU setting.

2. The project led to a significant reduction in CLABSI rates among neonates.

3. It demonstrates practical strategies for applying updated guidelines in day-to-day NICU practice.

4. The experience highlights the importance of staff education and adherence to standardized protocols.

5. Sharing these results can help other healthcare facilities replicate similar improvements in neonatal patient safety.

Introduction

Infants admitted to neonatal intensive care units (NICUs), whether preterm or term, often require central venous catheters for medications and parenteral nutrition, increasing their risk of central line-associated bloodstream infections (CLABSIs) (1). CLABSI rates in neonates vary significantly between centers due to factors such as prematurity, low birth weight, fragile skin, suboptimal hand hygiene, catheter site, and the number of lumens used (2). Implementing evidence-based bundles and quality improvement (QI) initiatives has proven effective in reducing CLABSI rates, although persistent challenges remain (3,4).

At Prince Sultan Military Medical City (PSMMC), CLABSI care bundles have been implemented since 2013, in accordance with the Ministry of Defense Medical Services (MSD) guidelines derived from CDC's 2011 recommendations (5). Trained infection control practitioners conduct regular audits and provide feedback. Specific interventions are introduced when the CLABSI rate exceeds the historical baseline. Until late 2022, no national benchmark existed for NICU CLABSI rates in Ministry of Health (MOH) hospitals. Hence, our target was to align with the U.S. CDC's National Healthcare Safety Network (NHSN) benchmark (6). In 2017, our institutional policy was updated based on the revised CDC guidance (7), which, despite being comprehensive, was not tailored to neonatal populations. Several unresolved issues persist, particularly for preterm and low-birth-weight infants, due to limited neonatal-specific clinical trials and safety concerns (8,9). In 2022 and 2023, the Society for Healthcare Epidemiology of America (SHEA) and CDC published updated guidelines addressing CLABSI prevention specifically in neonates. These recommendations include practical tools such as the CDC's Targeted Assessment for Prevention strategy and the SHEA practice risk assessment checklist to identify gaps and guide targeted interventions (4,10,11).

During February 2023, a sharp increase in CLABSI cases was observed in PSMMC-NICU, with 6 cases reported and a monthly incidence of 10.42 CLABSI/1,000 central line days, exceeding both the January rate (3.77) and the MOH benchmark (3.74). Most infections occurred in neonates weighing <750 g or >2500 g. The objective of this quality improvement project was to reduce the incidence of CLABSI in our NICU over a six-month period, in line with updated CDC/SHEA recommendations and the national benchmark set by the Ministry of Health.

Methods

The Neonatal intensive care unit at the Prince Sultan Military Medical City is a 96-bed, busy tertiary center with full occupancy. The unit is divided into a Neonatal intensive care unit (NICU), a high-dependency unit (HDU 1), and a high-dependency unit 2 (HDU 2). The HDU1 is equipped to support ventilated babies, babies who need non-invasive respiratory care support, and surgical cases. The HDU 2 provides Level 2 care and has patients with multiple chronic underlying diseases as well as babies who are ready to be discharged home. All patients' rooms are multi-bedded, with almost four incubators/cribs per room. There is no specific procedure room, and the nurse-patient ratio reaches 1:2 to 1:3.

Pre- Intervention Phase

The improvement project team involved representative members from NICU doctors and nurses, infection control, quality, and supply departments. We used quality tools to initiate and implement a Plan-Do-Study-Act (PDSA) strategy. A gap analysis was conducted using a practice risk assessment checklist, including updated standards for CLABSI prevention, published in 2022 (10). A practice risk assessment checklist containing 16 evidence-based recommendations was used to evaluate current practices. A root cause analysis (Fishbone diagram) and driver diagram were developed to identify gaps and plan interventions (Figure 1 & Appendix 1).

Some of the assessed "standards" are part of our care bundle components. They are regularly audited by trained infection control practitioners, and feedback is immediately provided to the involved team with quarterly reports.

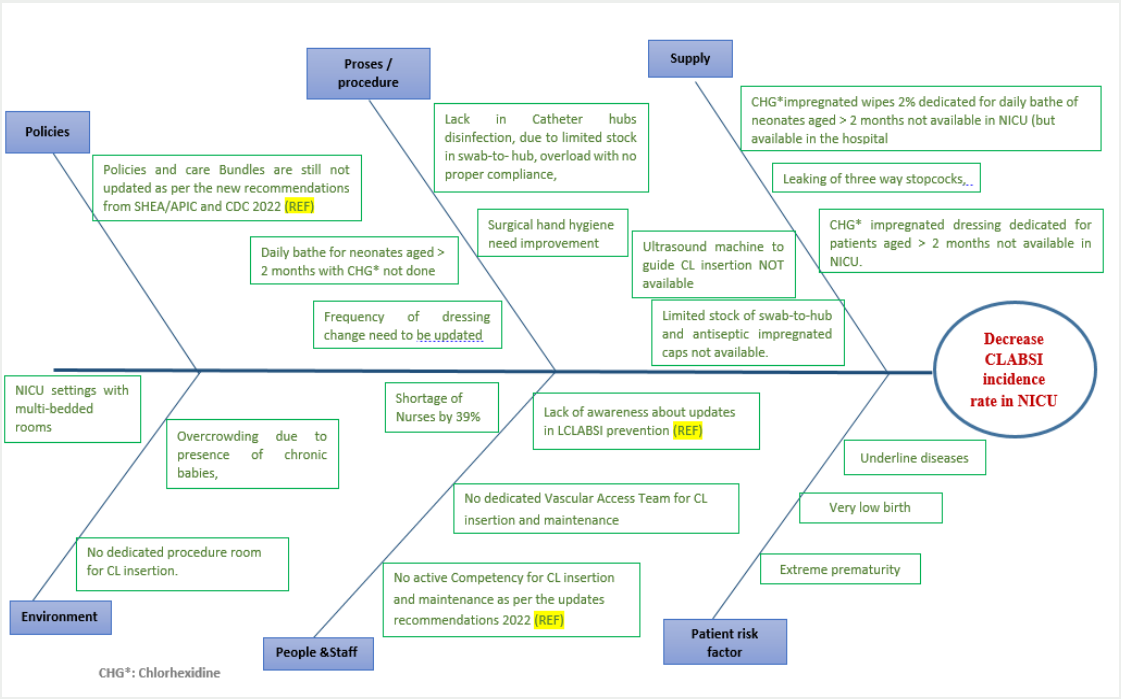

Figure 1. Root causes analysis for CLABSI cases in NICU: Fishbone diagram

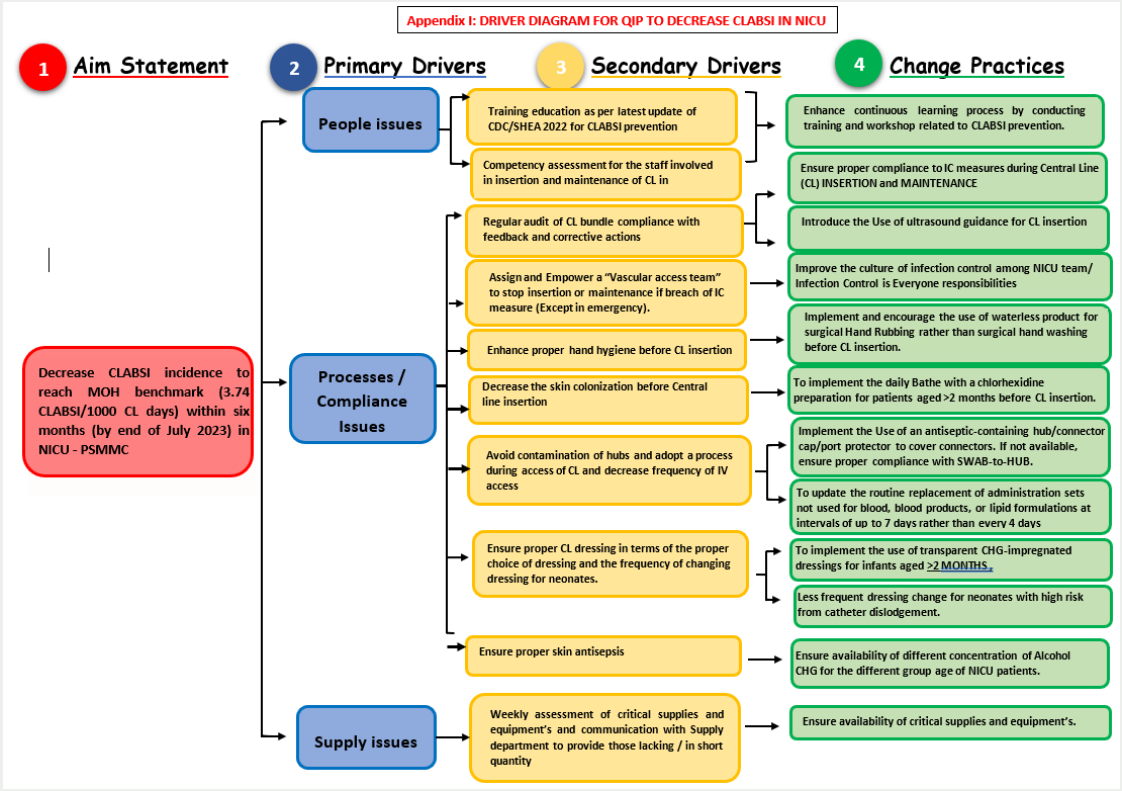

Figure 1. Root causes analysis for CLABSI cases in NICU: Fishbone diagram

Intervention - Phase

Over the project period from February 2023 to July 2023, we conducted continuous in-service training, monitoring for compliance to care bundles, RCA for each CLABSI case, and regular assessment of critical supply needed for CL insertion and maintenance, with immediate feedback and corrective actions. Moreover, the quality team applied, through two (2) cycles, a set of specific interventions targeting the leading causes of increased risk of CLABSI, in addition to the following:

Cycle 1 (February 2023 - March 2023)

Interventions focused on NICU staff training and education regarding updates for CLABSI prevention 4, 10, 11 through several lectures followed by small group workshops and competency assessment. Moreover, the CLABSI prevention policy was updated and disseminated through the electronic PSMMC webpage to be accessible to all.

Cycle 2 (April – May 2023)

Thirty-eight competent staff members, including nurses and doctors, were selected and authorized by NICU nursing, the Head of the NICU, and the IC director to stop any violation of IC measures during central line CL insertion and maintenance. The same selected staff members were dedicated to CL dressing change as per the updated standards. This team was called the 'Vascular Access Team (VAT)'.

Moreover, we introduced chlorhexidine (CHG) impregnated dressings and daily bathing with CHG for full-term neonates aged more than 2 months who are still admitted to the NICU and under strict monitoring for any skin reaction.

During this cycle, awareness activities and campaigns were conducted to enhance compliance with basic infection control measures that may affect CLABSI rate, e.g., proper skin antisepsis and proper disinfection of catheter hubs and ports before line access. Thus, we introduced passive disinfection for hubs and connectors using antiseptic-containing hub/connector cap/port protectors instead of active disinfection based on swabbing the hub.

In addition, to enhance compliance with the proper technique of surgical hand hygiene, mainly in emergency situations for CL insertion, we implemented and trained the VAT on waterless surgical hand rubbing using a hospital-approved chlorhexidine gluconate 1%—ethyl Alcohol 61% hand antiseptic, which is already available at PSMMC operation rooms.

Measures and analysis

For Process Measure(s), we calculated the following:

- Overall Care Bundle compliance rate (%) = Total compliances to all the bundle elements divided by the Total opportunities for CL maintenance.
- Compliance rate per element of a bundle (%) = number of times of compliance with the specific component of the bundle divided by the number of opportunities observed for the same element
- The percentage of compliance with updated standards expressed as fully implemented, not implemented, or partially implemented when the standard required enhanced actions to be considered fully implemented. For example, although NICU doctors are compliant with surgical hand hygiene, we considered that it is necessary to implement surgical hand rubbing with waterless products due to the non-availability of a surgical sink.

We calculated the incidence rate of CLABSI /1000 CL days monthly as follows: the number of events (CLABSI) divided by the total number of central line days. CLABSI surveillance was conducted according to NHSN definition criteria (12).

Members from NICU, angiography, and supply department with infection control and quality members developed and coordinated the project meetings and brainstorming sessions, developed driver diagrams, participated in CLABSI events and RCA sessions mainly conducted by nursing, and documented the project team members agreed-upon actions. The project team met and communicated regularly to evaluate the team's efforts to reduce the CLABSI rate in the NICU and ensure that interventions were effective. During their meetings, the team members reviewed and analyzed the CLABSI events per birth weight categories with compliance rates for CL care bundles and with updates to SHEA/CDC standards to focus their efforts and detect any possible trends. They also reviewed the availability of CL-related supply implement-specific actions.

Data collection and analysis were conducted anonymously using Excel 2016, in line with routine infection control practices, and subsequently imported into SPSS version 20 for further analysis. No specific patient data were recorded, and all interventions implemented followed PSMMC policy and evidence-based practice. The Chi-square test was used to compare compliance and incidence rates before and after the QIP, with a significance threshold of $p < 0.05$.

Results

From March to July 2023, 12141 patient days and 2947 central line days were enrolled and surveilled. Seventy-five percent of NICU physicians and nurses involved in CL insertion and maintenance received specific training and education with competency assessment; 38 staff were empowered and selected as the 'vascular access team.' Full Compliance with SHEA/CDC standards increased from 25 % to 56.3% and essential practices that were not implemented decreased from 31.3% to 6.2% months after QIP implementation (figure 2).

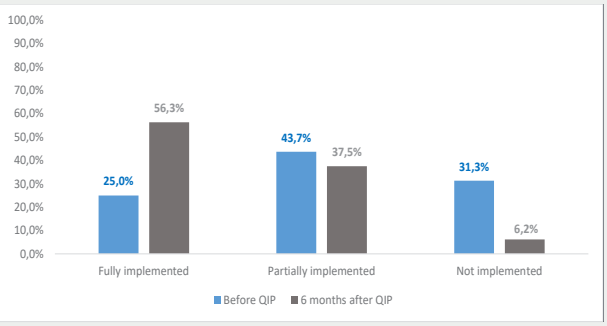

Figure 2. Compliance to "Essential practices" for CLABSI prevention [24] before and after QIP

In fact, in addition to the implementation, for babies older than 2 months, of CHG bathe 2% and CHG dressing, the routine replacement of administration sets not used for blood, blood products, or lipid formulations was updated up to 7 days instead of up to 4 days. Some standards are considered, although their implementation, as partially met and needs enhanced actions to maintain the continuous implementation (Table1).

Table 1. Practice risk assessment check list before and after QIP implementation

Essential practices for CLABSI prevention [4,10,11]	BEFORE QIP IMPLEMEMTATION	AFETR 6 MONTHS OF QIP IMPLEMENTATION
BEFORE CL INSERTION		
Bathe ICU patients >2 months of age with a chlorhexidine preparation on a daily basis	NOT MET, NICU staff not aware about this recommendation	PARTIALLY MET Limited stock of chlorhexidine impregnated wipes and not all staff are compliant..
Education and competency assessment (CLABSI prevention)of HCP involved in insertion, care, and maintenance of CVCs	PARTIALLY MET Competency assessment done based on the non-updated policy	PARTIALLY MET Ongoing several lectures and workshops in small groups to uncover all NICU staff for competency assessment.
Evidence-based list of indications for CVC use to minimize unnecessary CVC placement	FULLY MET	FULLY MET
AT TIME OF CL INSERTION		
Use ultrasound guidance for catheter insertion	NOT MET No Ultrasound Machine Available	NOT MET Request made , still Ultrasound Machine not provided
Use an alcoholic chlorhexidine antiseptic for skin preparation	PARTIALLY MET Different concentrations of alcoholic chlorhexidine are sometimes not available all the time.	FULLY MET Different concentrations of alcoholic chlorhexidine are sufficiently provided
Perform hand hygiene prior to catheter insertion or manipulation	PARTIALLY MET Surgical hand scrubbing done, however the surgical sink not met the required standard and most of CL insertion done in emergency. We plan to introduce, instead, the use of waterless surgical hand rubbing before CL insertion	PARTIALLY MET Waterless surgical hand rubbing implemented, but not all the staff comply with it. More orientation and competency assessment are needed
Use maximum sterile barrier precautions during CVC insertion	PARTIALLY MET Some items are not available all the time. NICU team are barrowing from other areas	PARTIALLY MET Improved, but still need follow up
Use an all-inclusive catheter cart or kit	FULLY MET	FULLY MET
bundle checklist	PARTIALLY MET It should be updated as per the updated standards	FULLY MET (updated)
AFTER CL INSERTION		
Appropriate nurse-to-patient ratio and limit use of float nurses in ICUs	NOT MET, Shortage of staff by	PARTIALLY MET Ratio improved : 1:1 up 1:2 in NICU 1: 2 up 1: 3 in HDU1 1:3 up 1: 4 in HDU2
Use chlorhexidine-containing dressings for CVCs in patients over 2 months of age	NOT MET, NICU staff not aware about this recommendation	FULLY MET
Change transparent dressings	PARTIALLY MET Based on the non-updated policy, non-soiled and damaged dressing is changed every 7 days for all neonates	FULLY MET (update) Dressing not damaged or soiled, is changed less frequently, unless medically indicated, to avoid the risk of CL dislodgment.
Disinfection of catheter hubs, needleless connectors, and injection ports	PARTIALLY MET (based on active disinfection by swabbing the hub, but some staff are not compliant with the proper technique)	PARTIALLY MET Passive disinfection with antiseptic-containing cap implemented but with limited stock
Remove nonessential catheters	FULLY MET	FULLY MET
Routine replacement of administration sets not used for blood, blood products, or lipid formulations at intervals up to 7 days	N NOT MET Based on the non-updated policy, it is changed every 96 hoursMET	FULLY MET
Surveillance for CLABSI	FULLY MET	FULLY MET

- □ Standard Fully Met □ Standard Partially Met □ Standard Not Met

Overall, care bundle compliance for CL maintenance improved from 66.07% to 82.7% (p = 0.002). The low compliance from February until April 2023 was associated mainly with low compliance to swabbing the hubs before accessing the line (Not done, or no respect for the technique), limited supplies, e.g., Total parenteral nutrition administration sets, and the improper frequency for CL dressing change; done weekly based on the previous guideline. However, as per the update for neonates and premature babies, dressing changes should be made less frequently to avoid the risk of CL dislodgment among neonates. During the following

three months, we noticed an improvement for most of the components of the care bundle shown in (figure 3).

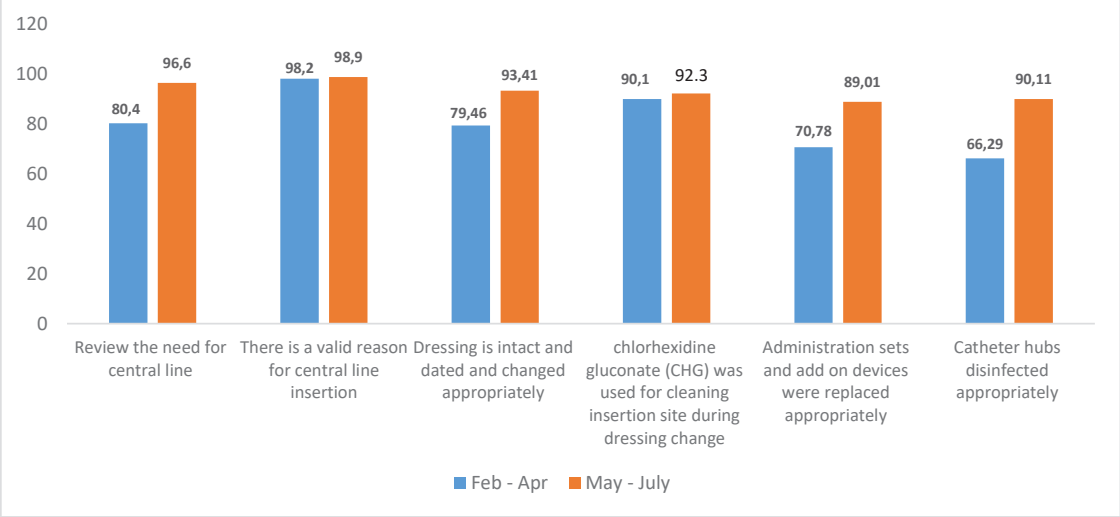

Figure 3. Care bundle compliance for CL maintenance per element from February – July 2023

Moreover, supply availability improved over the CLABSI project period for most CL-related items. Therefore, CLABSI rate decreased significantly by 82.3% from 10.42 (6 CLABSI, 576 CL days; February 2023) to 1.84 (1 CLABSI, 544CL days; July 2023) CLABSI/1000 CL days (p value = 0.048) after 6 months of QIP implementation (figure 4).

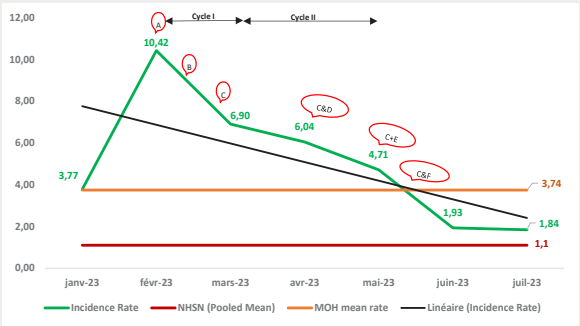

Figure 4. Overall CLABSI incidence rate from January until July 2023

A. CLABSI prevention multi-disciplinary Team created and conducted RCA.

B. Practice risk assessment using updated standards for CLABSI prevention (SHEA 2022).

C. Update CLABSI policy + training educational sessions with competency assessment

D. Assignment of "vascular access team"

E. Introduce the use of chlorhexidine-impregnated dressing and daily bathe with chlorhexidine-impregnated wipes for neonates aged > 2 months

F. Introduce of antiseptic-containing hub/connector cap/port protectors instead of swabbing the hub + infection control Awareness campaign + implementation of waterless surgical hand rubbing before CL insertion

Discussion

QIP can reduce the CLABSI rate to improve the quality of care and outcomes for newborns. In this study, we showed that compliance with SHEA/CDC standards of central line care decreases the CLABSI rate in the NICU.

Infants who are admitted to the neonatal intensive care unit (NICU) usually need central lines for medications and parenteral nutrition. Central line-associated bloodstream infection (CLABSI) is a severe hospital-acquired infection that increases the risk of morbidity and mortality (13). CLABSI results from bacteremia in the presence of a central line that is not attributable to another site in the body, like pneumonia or urinary tract infection (12).

Implementing corrective measures and conducting quality improvement initiatives can reduce CLABSI rates in the NICU (14). Substantial evidence supports effective strategies for preventing CLABSIs in adults and, to a large extent, in older children. However, neonate data are limited due to the diversity of settings and the populations in the NICU (15). The risks of infection vary between different categories of infants admitted to the NICU. Decisions affecting the rate of CLABSI (such as the type and size of central line insertion and timing of catheter removal or replacement) are primarily influenced by factors beyond infection prevention. Considerations like gestational and chronological age, skin maturity, and existing health conditions play a significant role in determining central line usage, with decisions made individually for each patient, balancing risks and benefits.11 However, implementing central line maintenance and insertion bundles has reduced CLABSI rates, but challenges remain (16 – 19). A cross-sectional study analyzed Center for Disease Control and Prevention (CDC) surveillance data from 132 NICUs revealed that CLABSI rates remained steady, with mean rates of 1.56 CLABSIs per 1,000 central venous catheter (CVC) days in very low birth weight infants (VLBW) and 0.72 CLABSIs per 1,000 CVC days. The lack of notable improvements suggests innovative approaches in CLABSI prevention strategies are necessary (14).

A systematic review and meta-analysis on the effectiveness of insertion and maintenance bundles in preventing central line-associated bloodstream infections (CLABSI) revealed a significant reduction in CLABSI rates in adult ICUs, PICUs, and NICUs. The analysis included 14 studies focused on NICU patients, where the CLABSI rate decreased from 8.4 to 2.6 per 1000 catheter days (18). Taking advantage of recently published updates for CLABSI prevention, which could inform the revision

of our PSMMC policy for the year 2024 and adjust our infection control interventions, the infection control team called for a multidisciplinary meeting to initiate a quality improvement project aimed at reducing the CLABSI rate and achieving the MOH benchmark within six months.

Our CLABSI QIP achieved the target within six months with continuous and progressive decrease of CLABSI incidence rate by 82.3% at the end of the QIP associated to an improvement in care bundle compliance rate over the project period. This result highlights the importance of teamwork and good communication among a multidisciplinary team to solve some aggregated factors to solve a problem (14,20).

The VAT assignment in our project greatly enhanced the implementation of infection control measures during CL insertion and maintenance. However, few studies have been performed regarding its impact on CLABSI rates, and SHEA has considered this team as an additional approach to prevent CLABSI (10,21).

The effectiveness of training, education, and compliance with care bundles was previously known in multiple other experiences (20-22). The originality of our project is the involvement of supply members to manage any supply issues related to CL insertion and maintenance as soon as possible and the practice risk assessment conducted in association with RCA to identify which standards were targeted for improvement. The introduction of daily bathing with CHG 2% and the CHG-impregnated dressing for babies older than 2 months, as highly recommended by SHEA (4,10), considering the gestational age and skin integrity seems to participate in the reduction of CLABSI rate by eradication of gram-positive skin commensals (23,24). However, it is unclear whether there is an additional benefit to using a CHG dressing if daily CHG bathing is already established and vice versa. Although life-threatening skin injuries from CHG are rare to appear among older neonates, and most cases have been reported in very young or very preterm infants with very low birth weight, strict monitoring for any skin reaction had been implemented, and no adverse event had been detected over the project period.

The colonization of needless connectors is the cause of 50% of post-insertion catheter-related infections. Breaks in aseptic technique, from failure to disinfect, result in contamination and subsequent biofilm formation within needless connectors and catheters, increasing the potential for infection of central and peripheral catheters (25).

Thus, different recommendations from the Centers for Disease Control (5), the Association for Professionals in Infection Control and Epidemiology (APIC) (26), the Society for Healthcare Epidemiology of America (27), the Agency for Healthcare Research and Quality (28), state that needleless connectors should be consistently and thoroughly disinfected using mechanical friction with 70% alcohol, alcoholic chlorhexidine, or povidone-iodine before each access of an intravascular device with variation in the scrub time required (5 – 60 seconds) for the different guidelines. However, this active disinfection was associated with low compliance among the healthcare providers, as reported by Moureau N.L. (25) and Lee J. (29). It was also revealed through our infection control auditing for the CL maintenance care bundle. The overload may explain this low compliance due to a shortage in the nurse-patient ratio or lack of knowledge affecting the respect of the proper scrub time required or missing the hub scrubbing before accessing the CL. Therefore, to overcome this defect, we implemented a passive hubs disinfection method using alcohol-impregnated port protectors/caps, which has been recently highly recommended and has shown effectiveness in decreasing CLABSI rates in different studies (30,32).

While the CLABSI rate decreased significantly following the QIP implementation, the absence of a control group limits causal inference. Confounding factors such as staffing levels and supply chain variability may have also contributed to the observed improvements.

Conclusion

Reducing the CLABSI rate is achievable to improve the quality of care and outcomes for newborns. Sustaining a low CLABSI rate requires continuous monitoring, staff education, and policy updates. Fortunately, the new guideline published by SHEA in 2023 with updated recommendations for NICU (4) intends to help infection control, and NICU teams have clear answers to specific questions that have been a matter of debate for a long time. Future initiatives may explore the cost-effectiveness of these updated preventives strategies i.e. passive disinfection methods and evaluate long-term outcomes in different NICU settings.

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