An Interprofessional Quality Improvement Project to Reduce Community-Acquired Central Line-Associated Bloodstream Infections in the Pediatric Intestinal Failure Population

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Highlights

- Insufficient evidence exists on prevention of CLABSIs in the ambulatory setting.
- We translated inpatient CLABSI prevention strategies to an ambulatory setting.
- After enhancing our bundle, our average monthly CLABSI rate declined by 66%.
- We sustained a lower CLABSI rate for 24 months (12 fewer infections per year).

Abstract

Aim: Central line-associated bloodstream infections (CLABSIs) result in significant morbidity but are largely preventable. Methods to reduce hospital-acquired CLABSIs are well described, but few recommendations exist for how these practices might translate to patients with central lines in the ambulatory setting. This team sought to reduce the mean monthly community-acquired CLABSI rate by 25% from 11.7 to 8.8 per 1000 community line-days in children with intestinal failure who require home parenteral nutrition within 12 months.
Methods: First, an interprofessional quality improvement team was formed. After baseline data collection, plan-do-study-act cycles began. Tests of change consisted of a central venous catheter (CVC) maintenance bundle. This bundle included a CVC care tote with additional supplies, improved educational materials, and ethanol lock prophylaxis. A control chart was used to display the monthly community-acquired CLABSI rate and observe for special cause variation.
Results: At baseline, the average monthly community-acquired CLABSI rate was 11.7 per 1000 community catheter-days. The home CVC maintenance bundle was implemented, after which there were 5 consecutive

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months with no infections. After enhancements to the care bundle and tote, special cause variation was noted, and the average monthly community-acquired CLABSI rate declined by 66% to 4 per 1000 community catheter-days. Special cause variation was noted at 2 other time points without an identifiable cause.
Conclusion: A lower community-acquired CLABSI rate has been sustained for 24 months and reflects approximately 12 fewer infections per year in this at-risk population.

Keywords: pediatrics, central venous catheters, community-acquired infections, quality improvement

Introduction

Children with intestinal failure (IF) and home parenteral nutrition (PN) dependence present unique challenges to the health care team, families, and community support agencies. These children, residing at home with central venous catheters (CVCs) are especially susceptible to central line-associated blood stream infections (CLABSIs) that greatly impact their care and prognosis. Each incidence of CLABSI requires inpatient admission and increases the risk of complications such as loss of venous access sites, liver failure, antibiotic resistance, sepsis, and death. Additionally, health care cost and length of stay for an inpatient admission for CLABSI is $55,646 (2011 dollars) and 19 days.[1]

Unique factors, such as frequent use of a CVC by nonmedical caregivers and the routine infusion of dextrose-rich solutions, create a high-risk environment for CLABSI in this population. In 2008, Medicare reimbursement for hospital-acquired conditions ceased.[2] In response, many hospitals developed enhanced initiatives, and therefore, robust information exists about effective strategies for reducing CLABSI in the inpatient setting,[3–27] but little guidance is available for the home application of CLABSI prevention bundles.[28,29] This team reviewed current evidence guiding the use of inpatient central line care bundles with the goal of translating these for use in the outpatient setting.

The principal aim of this quality improvement (QI) project was to reduce the mean monthly community-acquired CLABSI (CA-CLABSI) rate by 25% in 12 months through the development and implementation of an enhanced care bundle. Due to unforeseen changes in health care related to the COVID-19 pandemic, the intervention period was extended through May 2022.

Methods

The Pediatric Advanced Nutrition Support (PANS) clinic is affiliated with a large academic medical center in upstate New York with 124 pediatric inpatient beds. The PANS clinic's interprofessional team consists of 1 physician, 2 pediatric nurse practitioners, 3 registered dieticians, 2 nurses, and 1 social worker. The PANS clinic provides support and management for over 1000 children with feeding difficulties ranging from oral aversion to short bowel syndrome and home PN dependence.

This QI initiative began with recognition of the significant number of CA-CLABSIs in this patient population and the formation of the nurse-physician team in March 2019. This team collaborated with the pediatric director of QI, inpatient care coordinator nurses, pediatric vascular access nurses, and the parent of a former home PN-dependent patient. Fishbone and key driver diagrams were created to illustrate possible factors leading to CA-CLABSI (Figures 1 and 2), and a shared mental model was developed for how the team planned to achieve the project aim.

The baseline CA-CLABSI rate was determined using a retrospective chart review. Educational materials and care totes were created through late summer and fall of 2019. Interventions began to reach the patient population in October 2019, and CA-CLABSI data were collected through May 2022. This project was undertaken as a QI initiative, and as per the University of Rochester's Guideline for Determining Human Subject Research, it did not meet the definition of research according to 45CFR 46.

Patients included in the project were children less than 18 years of age with a diagnosis of IF who were managed by the PANS clinic for home PN administered through a CVC. Patients receiving home PN for a diagnosis other than IF were excluded from this project. Between October 2019 and May 2022, 10 patients met the inclusion criteria.

Intervention

After conducting a literature review for best practices for reduction of hospital-acquired CLABSIs, this team implemented a new CA-CLABSI bundle to mirror these. Key elements of the CA-CLABSI bundle include ethanol lock prophylaxis (ELP), CVC care totes (as a method for bundling supplies), use of a central line securement vest, enhanced caregiver education, and standardized hygiene and environment of care recommendations. Evidence supports the efficacy of additional strategies including sterile dressing kits, alcohol impregnated caps, and chlorhexidine impregnated patches.[3–5] These items have been supplied to this population by the homecare infusion pharmacy and therefore were not specifically addressed in this project, though they were in use throughout the baseline and intervention periods.

ELP

ELP has been demonstrated to reduce the incidence of CLABSIs.[6,7,9,12–14,17,19,20,23,26,27] An ELP policy was available at this institution for the inpatient population, and this was reviewed and adapted for home use. Education on administering ELP was completed with parents, and instruction cards were provided including photographic step-by-step instructions for ELP

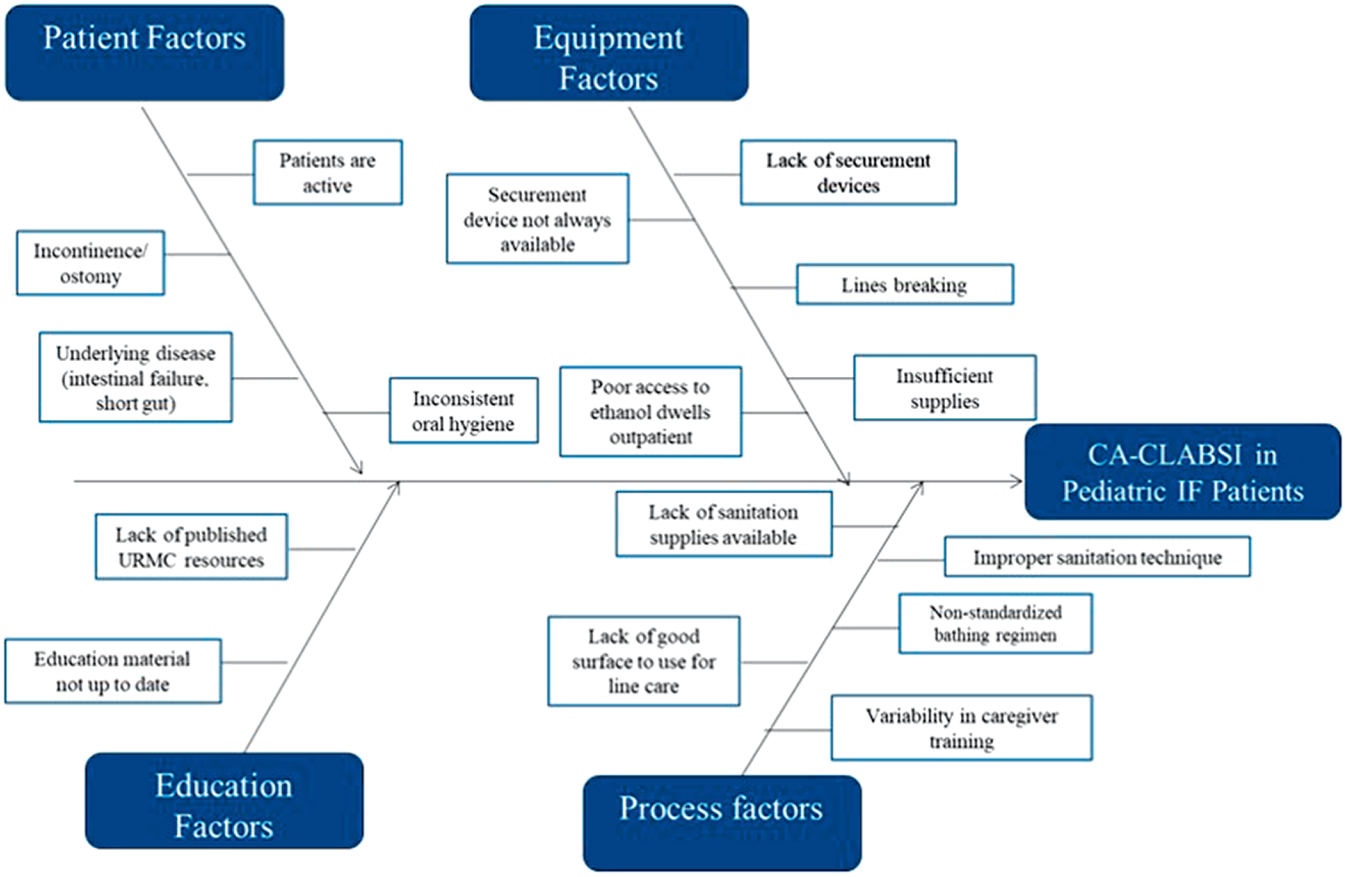

Figure 1. **Fishbone diagram.**

placement and removal. Three patients fell under the inclusion criteria for ELP, and home use was initiated in October of 2019. Between March and June of 2020, outpatient ethanol dwells became unavailable due to national shortages. The last administration of ELP in the outpatient setting was in June of 2020.

CVC Care Totes

The process of bundling supplies in the inpatient setting has been widely accepted as best practice for exemplary CVC care.[3–5,10,11,25] Current inpatient policies and CVC care supplies at this institution were reviewed to identify any inconsistencies between inpatient and outpatient practices. Some supplies that are essential for safe inpatient care were not available in the home. This team purchased these supplies and plastic totes to create a home central line care bundle.

The plastic tote containers provide a designated closed space for the storage of central line care supplies in the home and were assembled to include all supplies that are used inpatient but are not covered by insurance and/or provided by homecare pharmacies (Table). The cost of each care tote was roughly $76 in 2019. Initial supplies were purchased through funds donated by a local homecare supply company. This fund was established before the start of the project with intent to benefit patient care for local children with feeding difficulties. Home use of the central line care totes began in November of 2019.

Central Line Securement

In addition to the CVC care totes, patients were provided with brand-name central line securement vests purchased by the outpatient clinic. Each child with a tunneled CVC received 2 vests with the goal of having 1 to wash and 1 to wear. The vests include a fabric flap for easy access to insertion site while providing an additional barrier. Vests also include clips to secure the external line to prevent line breakage and accidental removal if tubing became tangled and pulled.

The cost of each securement device was roughly $100 in 2019. While unavailable at the start of this project, data from a study completed by St. Pierre-Hetz et al.[30] in 2022 at the Children's Hospital of Pittsburgh have since demonstrated a decrease in line trauma and infections with the use of this central line securement vest.

Caregiver Education Materials

Before this QI project, family education included informal instruction and real-time demonstration provided by inpatient bedside nursing. This was followed by a semiformal knowledge check with inpatient care coordinator nurses. Families did not receive educational materials to refer to once discharged. To support families after discharge, the team developed teaching guides. Each laminated guide includes photographic and written step-by-step instructions for central line care including flushing, needleless access device changes, ELP placement

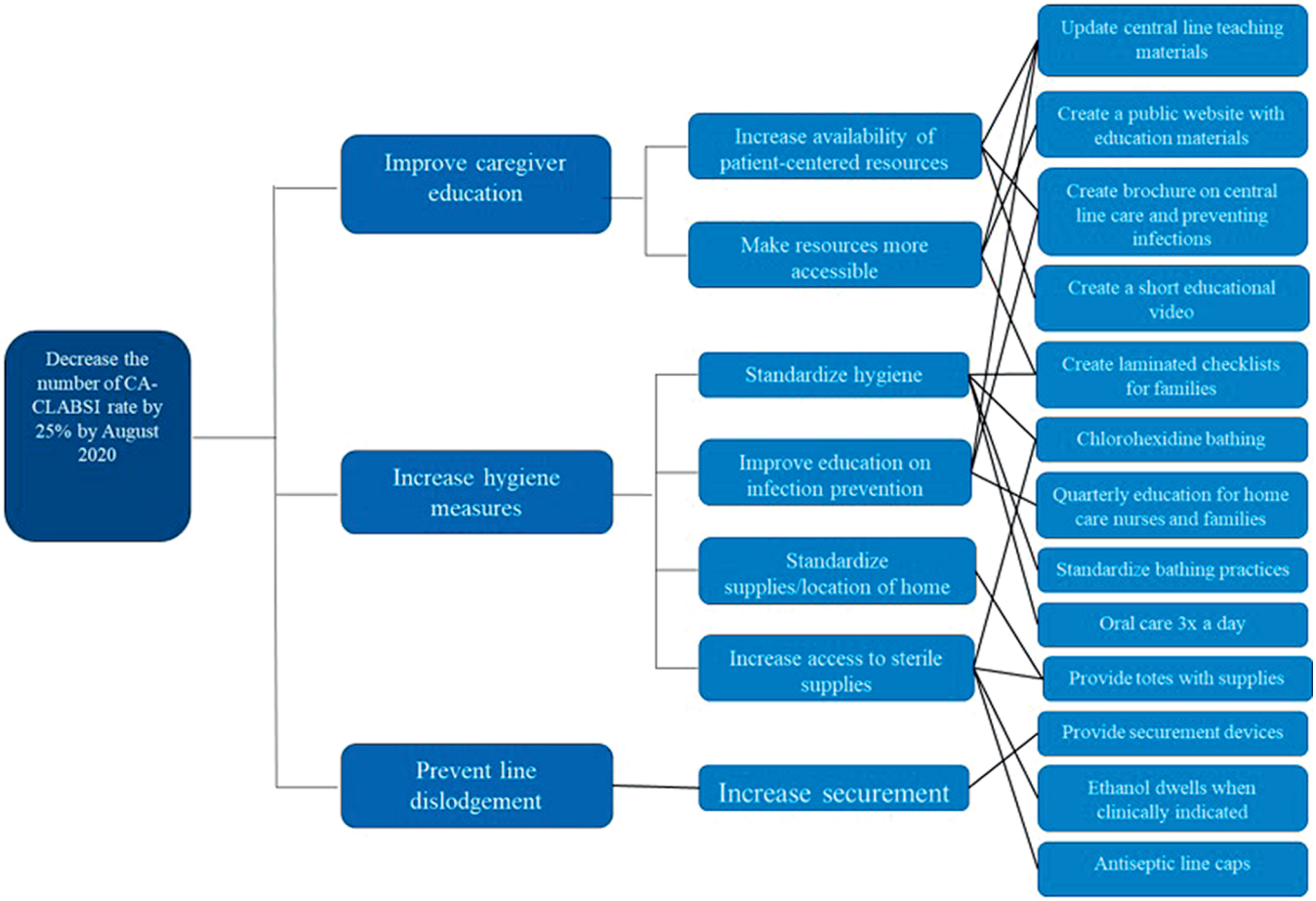

Figure 2. **Key driver diagram.**

and removal, and sterile dressing changes. Guide sheets were attached in a booklet, along with recommendations for hygiene and environment of care, and stored in the CVC care tote. Altounji et al.[31] demonstrated that formalization and reinforcement of caregiver education may be clinically helpful but may not be enough to statistically improve CA-CLABSI rates in their pediatric oncology population. This study suggests that support of caregiver skill and knowledge is important but may be most beneficial as part of a more structured supply CA-CLABSI bundle.

Hygiene Recommendations

Daily chlorhexidine bathing is part of the inpatient CLABSI prevention bundle at this institution. Before this QI project, standardized, specific recommendations for frequency of bathing or use of hygiene products were not provided. Chlorhexidine bathing at home was not standard practice. Chlorhexidine bathing solution and laminated hygiene recommendations were provided to families in the CVC care tote. Recommendations included daily chlorhexidine bathing (unless contraindicated by allergy), twice daily oral care, and environmental recommendations. Plastic wrap and tape were also provided in care totes to protect the central line dressing during bathing to prevent disruption in dressing integrity.

Study of the Interventions

Retrospective chart review of PN-dependent patients managed by the PANS clinic was completed to determine the baseline CA-CLABSI rate. Between July 2018 and September 2019, 20 pediatric patients were overseen by this clinic for management of home PN. Of these patients, 15 had a diagnosis of IF, which is assigned when a patient is unable to absorb sufficient nutrients and fluids to sustain life through enteral means.[32] In this baseline population, the etiology for IF included short bowel syndrome (n = 10) and feeding intolerance related to disordered motility (n = 5).

For this project, CA-CLABSI was defined as any positive blood culture obtained in a community setting (no inpatient stay less than or equal to 3 days before positive blood culture). Community line-days were determined based on the number of days per month that the patient was out of the hospital with a central line in place (excludes day of admission, day of discharge, or any inpatient days). The mean monthly baseline CA-CLABSI rate between July 2018 and September 2019 was 11.7 infections per 1000 community catheter-days. Furthermore, 93% of the total CLABSIs in the pediatric IF patients occurred at home. This is an indicator that improving home CLABSI prevention was needed.

After implementation of the CA-CLABSI bundle, all CLABSI events were identified and tracked manually by the PANS

Table. **Bundled Central Venous Catheter Care Tote Supplies**

Item	Intended Use
Stainless steel tray (13.5″ × 10″, 1 per kit)	Designated surface for CVC care supplies during care task
Disposable disinfectant wipes (1 tub/160 wipes per kit)	Cleaning designated supply surface
Alcohol-based hand sanitizer (1 × 8 fl oz)	Hand hygiene before care task
Clean gloves (size medium, 1 box per kit)	Hand hygiene for nonsterile care tasks
Surgical masks (1 box per kit)	Protective barrier for clean and sterile care tasks
Chlorhexidine soap (1 × 32 oz per kit)	Daily bathing
Plastic wrap (Press'n Seal®, 1 roll per kit)	For CVC dressing protection during bathing
Plastic tape (3M™ Transpore™ Tape, 1 roll per kit)	To secure plastic wrap for bathing

CVC = central venous catheter.

nurse. The monthly CA-CLABSI rate, calculated as the number of infections per 1000 community catheter-days, was displayed on a control chart. Standard control chart rules were used to detect special cause variation. Given the small cohort of patients, all significant patient events were already closely monitored by this team, but CA-CLABSI had not been specifically tracked before this project.

The team also created a patient satisfaction survey and intended to distribute this to families as a second plan-do-study-act cycle in the winter of 2019–2020 to measure satisfaction with the home CLABSI bundle. Unfortunately, the COVID-19 pandemic greatly impacted the team's workflow, and as a result, this was not implemented.

Results

The mean monthly CA-CLABSI rate between October 2019 and May 2022 was 4.0 infections per 1000 community catheter-days (Figure 3). This represents a 66% decrease in the mean monthly CA-CLABSI rate after the distribution of the home CVC maintenance bundle. During the period of baseline data, only 2 nonsequential months passed without a CA-CLABSI. From October 2019 to May 2022, 17 total months passed without any CA-CLABSI, 5 of these months were sequential and occurred during the months of ELP use. No complications or adverse events were identified as a direct result of CLABSI reduction interventions.

The rate of catheter occlusions requiring clinic or hospital-level intervention decreased during this study from 1.9 to 0.3 events per 1000 community catheter-days. No occlusions occurred during the use of ELP. Overall, the rate of catheter breaks/malfunctions decreased from a baseline of 5.1 events to 3.3 events per 1000 community catheter-days. During the 6 months of ELP use, a slight increase occurred from baseline to 5.8 events per 1000 community catheter-days. With the use of central line securement vests, the rate of accidental line removal improved from 2 events to 0.8 events per 1000 community catheter-days (Figure 4).

Discussion

While prevention of hospital-acquired CLABSI has become a national health care priority, the complications of CA-CLABSI are equally significant to the patient and family. Hospital staff routinely receive formal education, annual re-education, adequate supplies, and feedback from inpatient audits regarding CLABSI prevention. While baseline data demonstrated that 93% of CLABSIs for this population were contracted outpatient, before this QI project, the responsibility of preventing these infections in the outpatient setting was unclear. This team has acknowledged that CA-CLABSI prevention is an integral piece of caring for this patient population.

The team reviewed current literature for the methods used in prevention of inpatient CLABSIs. These included the use of chlorhexidine-impregnated dressings,[33] chlorhexidine bathing,[15,16,21] and ethanol dwells.[6,7,9,12–14,17,19,20,22–24,26,27] The team also reviewed articles related to the efficacy of bundling central line care in a variety of inpatient settings.[3,5,10,11,25]

The baseline mean monthly infection rate in this clinic's population was 11.7 infections per 1000 community catheter-days. It is difficult to determine how this rate compares with other institutions managing home PN in the pediatric IF patient, as these data are not currently widely available.

With the introduction of the bundle, the CA-CLABSI rate initially improved significantly. Zero CA-CLABSIs occurred between November 2019 and March of 2020. During the period of ELP use, the median monthly rate was zero. During the remaining project period between June of 2020 and April of 2022, the median CA-CLABSI rate was 4.7 infections per 1000 catheter-days. This suggests that ELP, or a comparable alternative, may be an essential tool in preventing CA-CLABSI.

Available literature has demonstrated inconsistent results regarding the risk of catheter occlusion and fracture related to ELP use. Authors of some studies have found an increase in mechanical complications in central lines with the use of ELP.[34–36] Alternatively, Mezoff et al.[37] demonstrated a reduction in the rates of mechanical complications with the use of ELP.

Due the short duration of ELP use in this study due to availability, it is difficult to determine if the increase in catheter malfunctions during this time is clinically significant. While, in this study, we suggest that an antimicrobial lock may be a crucial tool in CA-CLABSI reduction, more data are needed to determine the most effective option.

When ELP became unavailable, the team submitted a proposal to the Food and Drug Administration (FDA) and institutional

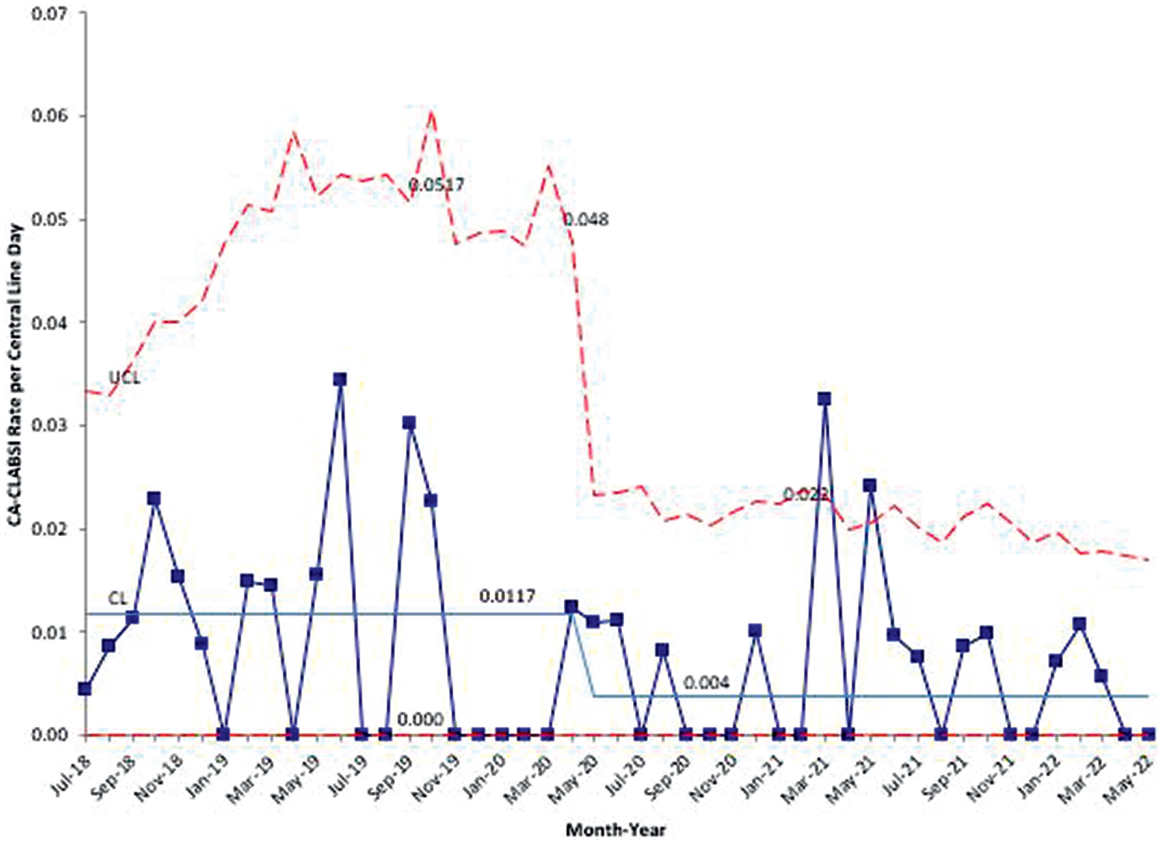

Figure 3. **Community-acquired central line-associated blood stream infection control chart.**

review board (IRB) for single-patient compassionate use for KiteLock™ 4% dwell solution (SterileCare Inc, Markham, Canada). KiteLock was chosen based on studies in which authors demonstrated its efficacy in reducing CLABSI and formation of CVC biofilms.[38–40] The team contacted the manufacturer who agreed to provide an initial small supply without charge. In the spring of 2022, after FDA and IRB approval, KiteLock therapy was initiated for 1 patient who had a significant CLABSI history. After the initial supply, the institution purchased further doses from the manufacturer. Further time and data collection is needed to determine the efficacy of this lock therapy in comparison with ELP.

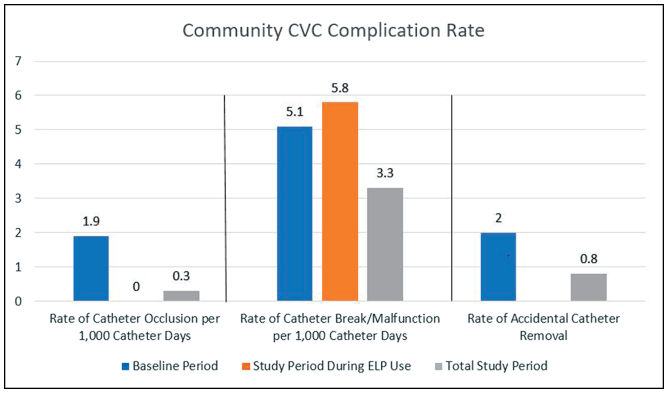

Figure 4. **Community central venous catheter complication rate.**

In discussion with the parent of a former home PN patient, the team identified some challenges unique to routine CVC use in the home. Caregivers reported that they were using any available surface to place central line supplies. Carpeting, wood, and other fabric surfaces may be difficult to clean and present an opportunity for microbial contamination of the CVC. The team addressed this concern by providing a steel tray and cleaning wipes for use as a working surface for central line supplies. Children tend to be more active at home, which may lead to an increased risk of line breaks or removal. Central line securement vests provide an additional layer of securement to support activity.

A challenge in evaluating the efficacy of a home CLABSI bundle is tracking the true usage of the bundle. Inpatient units can complete audits to survey bundle use, but this is not easily achievable at home. While the decrease in CA-CLABSI rate is suggestive of a change in home line care, this project did not include a mechanism to track family adherence to all elements of the bundle.

In the fall of 2022, CA-CLABSI event debriefing was implemented in the days after any positive blood culture. Debriefs included a PANS physician, PANS nurse, vascular access nurse, inpatient care coordinator, and the family to discuss aspects of central line care that were going well at home and areas of concern. The hope is that these debriefs will serve as reinforcement for the use of the home CLABSI bundle tools as well as identify further opportunities for improvement.

Limitations

This QI project had 4 significant limitations. First, given the very specific patient population, the sample size was limited. Second, given the unique population, some limitation exists in the generalizability of the results. Third, tracking the adherence of the maintenance bundle is difficult given its use in the home. The fourth limitation was disruption in the use of ELP due to national shortage.

Conclusions

The CA-CLABSI rate for pediatric IF patients receiving home PN through this clinic decreased after the provision of a home CLABSI prevention bundle. This reduction equates to 12 fewer infections per year. The annual bundle investment is estimated to be around $300 per year for a new patient and around $100 per year for an established patient. As stated above, the estimated health care cost per CLABSI event is $55,646 (2011 dollars).[1] For this clinic's population and the estimated reduction in CA-CLABSI events, the annual cost savings is approximately $667,000.

Patton et al.[41] demonstrated that close collaboration with home health agencies may be an effective addition to the CA-CLABSI bundle. CA-CLABSI events were reduced by 30% through increased awareness, risk screening tools, and formalized tracking involving home health providers. Further inclusion of home health nursing by this clinic may reinforce use of the CA-CLABSI bundle and reveal further areas for improvement.

Statement 4 of the European Society for Clinical Nutrition and Metabolism guideline on home PN indicates a strong consensus that "for a safe [home PN] program, the patient's home environment has to be adequate to safely deliver the therapy proposed."[42] Further exploration is needed to determine what constitutes a safe home environment, measures to improve home safety, and recommendations for care when home safety is a concern.

While this bundle was created with IF patients in mind, any patient with home central line use may benefit from its use. The reduction in CA-CLABSI rate suggests that bundling CVC care may be as successful in the home setting as it is inpatient, and a physician-nurse collaboration appears to be promising for the reduction of CA-CLABSI in the pediatric IF population.

Disclosures

None of the authors have any declarations of interest.

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