Decreasing Central Line–Associated Bloodstream Infections Acquired in the Home Setting Among Pediatric Oncology Patients

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Abstract
Most children receiving cancer treatment require a central venous catheter (CVC), putting them at risk for central line–associated bloodstream infections (CLABSI). As patients are discharged home with a CVC in place, caregivers are expected to maintain the CVC following an in-hospital education session before their first discharge home. Following a review of the literature, the education process was modified to improve the quality of education for caregivers. While the existing step-by-step handbook was reviewed and deemed aligned with best practices, other materials were added for this project: a caregiver skills competency checklist, a handout reviewing oral care and hygiene in the home, and a guide for nurses on what materials to provide families at the time of diagnosis. Additionally, caregivers were required to receive two additional CVC care reinforcement sessions during subsequent admissions to the inpatient units, which involved redemonstrations of skills using the competency checklist. Home-acquired CLABSI in pre- and postintervention groups were compared, and compliance of reinforcement education was measured. Though no statistical significance was found, the odds of experiencing a CLABSI were found to be higher in the preintervention group for mucosal-barrier injury (odds ratio = 2.23; 95% confidence interval [0.43, 22.10]) and laboratory-confirmed bloodstream infections (odds ratio = 4.53; 95% confidence interval [0.59, 203.71]). The clinical significance of reducing home-acquired CLABSI has a positive impact on patient outcomes by decreasing morbidity and mortality, inpatient lengths of stay, and overall health care costs.

Keywords
pediatric oncology, CLABSI, CVC care, home care

Introduction
Most children undergoing cancer treatment require the placement of a central venous catheter (CVC) to accommodate frequent chemotherapy infusions, blood product transfusions, and routine blood draws. A lack of CVC access results in multiple needle sticks for peripheral venous access, placing the patient at risk for local site complications such as infiltration or extravasation. Depending on the specific diagnosis and treatment plan, the CVC may be required for months to years. Therefore, patients are discharged home with the CVC in place. Though a CVC allows patients to receive therapies with greater ease, it places patients at risk for central line–associated bloodstream infections (CLABSI), which can cause life-threatening complications in this immunocompromised population (Secola et al., 2012). CLABSI are categorized by the Centers for Disease Control and Prevention (CDC) as laboratory-confirmed bloodstream infections (LCBI) and mucosal-barrier injury–LCBI (MBI-LCBI). LCBI-CLABSI is the larger category referring to organisms identified in the bloodstream, with no other known possible source of infection. MBI-LCBI, a subset of LCBI-CLABSI, is defined by an organism identified in the bloodstream in neutropenic patients who have experienced damage to their oral or intestinal mucosa (CDC, 2018). MBI-LCBI are caused by gastrointestinal microbiota seeding into the bloodstream and commonly occur in patients receiving chemotherapy or undergoing stem cell transplantation. Identifying CLABSI categories helps
determine potential causative factors and guides interventions to help mitigate infections.

**Background**

While access to national CLABSI data specifically addressing pediatric oncology patients is limited, approximately 250,000 CLABSI are reported in hospitals annually, contributing toward increased morbidity (O’Grady et al., 2011). In addition to placing the patient’s health at risk, CLABSI can be extremely costly and result in unnecessary admissions and increased length of stay, with estimates up to nearly $70,000 per case and a 19- to 21-day length of stay (Goudie et al., 2014; Wilson et al., 2014). Thus, a reduction of overall CLABSI could have a significant impact on pediatric oncology morbidity and mortality with subsequent reductions in health care costs.

At Children’s Hospital Los Angeles (CHLA), 16 patients diagnosed with cancer were admitted from home with a CLABSI in the first two quarters of 2018. Of these infections, 50% were non–MBI-LCBI, and 50% were MBI-LCBI (CHLA, 2018b). To reduce CLABSI, evidence-based guidelines regarding care and maintenance of the CVC must be in place (Secola et al., 2012). At CHLA, evidence-based initiatives have been implemented, which successfully decreased hospital-acquired CLABSI rates, including the reinforcement of CVC care bundle use, development and implementation of a hygiene bundle, and providing extensive staff education regarding best practices. The two inpatient oncology units experienced a 30% decrease in non–MBI-LCBI and a 50% decrease in MBI-LCBI (CHLA, 2018a) in the 2 years following these interventions. While much of the focus has been placed on the reduction of hospital-acquired CLABSI, additional attention must now address interventions that can potentially decrease home-acquired CLABSI to protect patients across the continuum of care. Although patients can acquire a CLABSI from various ambulatory settings, the focus of this project was to improve caregiver skills in the home setting, which refers to any nonhospital setting to which the patient is discharged.

When patients are discharged home, the expectation is that caregivers will provide the same level of CVC care as in the hospital. The current state of discharge planning includes ensuring that parents attend one educational session on CVC care. Parent CVC care education is provided in a class setting by a nurse educator, or one-on-one by the bedside nurse, where caregiver redemonstration of skills is expected. Often due to scheduling conflicts or lack of time, CVC education is combined with other required education, such as new diagnosis oncology education and administration of subcutaneous injections. As the first discharge home after diagnosis can be quite stressful for the family, this is not the ideal time to provide vital information regarding care of the patient’s CVC. Additionally, guidelines for caregiver redemonstration were not standardized among the different written materials. Nurses consistently documented that education was complete prior to discharge; however, there were no data to show the consistency in content or method, which may affect the caregivers’ skill acquisition and comprehension. Rinke, Milstone, et al. (2013) found that patients admitted from home with CLABSI have almost triple the rates of those in inpatient pediatric oncology units, with approximately 13% of these patients requiring admission to the intensive care unit. An evidence-based practice project was completed to identify best practices for CLABSI prevention in the home setting. Utilizing strategies identified in the literature regarding CVC care, CLABSI reduction, and caregiver education, the project focused on improving hospital-based caregiver education with the goal of decreasing home-acquired CLABSI.

**Theoretical Framework**

Prevention of CLABSI is heavily influenced on caregivers’ skill mastery of CVC care and comprehension of infection prevention behaviors. Bandura’s (2012) social cognitive theory describes learning as a social experience dependent on a bidirectional relationship among environment, personal, and cognitive factors, and the person’s behaviors, known as triadic reciprocal determinism. Educators can modify these three determinants to enhance learning experiences while learners can also make changes that will help shape the path of their learning experience (Bandura, 2012). By modifying the current educational program, the social cognitive theory can be applied to the learning needs of caregivers regarding CLABSI prevention in the home setting. Instruction through a standardized class would modify the caregiver’s environment by providing structure and consistency among all educators and would include modeling hands-on CVC care skills. Personal and cognitive factors are addressed by providing the caregiver the right motivation to learn the skills and apply infection prevention initiatives while at home. The caregiver’s behaviors can be enhanced through active redemonstration of skills. When skill mastery is connected directly to the prevention of infection and hospitalization of the child, the caregiver will possess a strong motivation to learn and apply these skills.

**Literature Review**

A thorough literature search was performed to determine best practices for CLABSI reduction in the home care setting and methods of providing caregiver education. The literature search utilized CINAHL, PubMed,
OVID, Cochrane Library, and Web of Science. Evidence related to home CVC care and CLABSI reduction in nonpediatric oncology patients were included if the findings were generalizable to the pediatric oncology population. Additionally, gray literature, such as guidelines from the CDC and the American Academy of Pediatric Dentistry, was included in determining best practices as identified by national organizations.

**CLABSI Prevention**

The importance of CLABSI prevention is well documented in the literature as it can cause significant morbidity and mortality in children with cancer. As the majority of these patients are discharged home with their CVC in place, it is imperative to determine evidence-based interventions to decrease their risk of CLABSI. Rinke et al. (2015) associated nonadherence to the CVC maintenance bundle with acquisition of CLABSI in the home setting, suggesting that caregivers require consistent training and education regarding evidence-based bundles and specific catheter care skills. In an interrupted time-series study, in-depth caregiver training that included quarterly caregiver assessments and redemonstrations significantly reduced ambulatory CLABSI \( (p = .005; \text{Rinke, Bundy, et al., 2013}) \).

In addition to proper CVC care, routine hygiene is an important aspect of CLABSI prevention. Daily bathing decreases skin commensal organisms, minimizing the risk of catheter contamination and bacteremia (Linder et al., 2017). However, bathing needs to be done with proper protection of the CVC to prevent wetting the dressing, as a moist environment can lead to growth of organisms under the dressing (Toscano et al., 2009). This must be properly explained to caregivers in order to prevent catheter contamination. Maintaining oral hygiene is pivotal in CLABSI reduction, and the implementation of a standardized protocol can be an effective strategy to improve patient outcomes (Hogan, 2009).

Proper oral care must become a part of the patient’s daily routine to reduce organisms in the mouth that can seed into the bloodstream, especially if the patient has active oral mucositis. General oral health guidelines include toothbrushing with a soft-bristle toothbrush twice a day, regardless of platelet count, unless there is marked gingival bleeding (American Academy of Pediatric Dentistry, 2018; Padmini & Bai, 2014). The use of a toothbrush, as opposed to gauze or toothettes, is more effective in the removal of biofilm from the teeth (Soga et al., 2011). Furthermore, the use of bland, alcohol-free oral rinses, such as sodium bicarbonate or normal saline, at least twice a day is recommended to remove loose debris and mucous, and to reduce inflammation and xerostomia (Harris et al., 2008; McGuire et al., 2013). Though chlorhexidine oral rinse is an effective agent to decrease bacterial load in the mouth, it has not been shown to reduce bacteremia more significantly than sodium bicarbonate (Choi & Kim, 2012). Decreasing oral mucositis and maintaining the integrity of the mucosa prevents organism translocation into the bloodstream. Furthermore, the unpleasant burning caused by chlorhexidine can make compliance difficult in the pediatric population, thus leaving sodium bicarbonate the preferred rinse to maintain oral hygiene, with normal saline as a secondary option for children who dislike the taste of sodium bicarbonate (McGuire et al., 2013).

**Caregiver Education**

Identifying CLABSI reduction strategies is the first step in successfully protecting patients. As pediatric oncology patients are at higher risk of developing CLABSI at home, providing high-quality education is pivotal in creating optimal learning opportunities for the caregiver. The patient’s caregivers typically provide most CVC care, which includes daily flushing and weekly cap and dressing changes. Caregivers are expected to perform these nursing skills and are taught to do so on diagnosis, while simultaneously attempting to cope with a life-altering situation. A Delphi study showed that 97% of panel experts considered CVC care mandatory prior to a family’s first discharge home (Haugen et al., 2016). Caregivers must be given proper instruction to apply best practices regarding CVC care, but this instruction needs to be performed strategically with evidence-based approaches.

Utilizing evidence to drive the development of caregiver education protocols can enhance the quality and effectiveness of the education. Expert consensus panel recommendations determined principles of patient/family education, emphasizing the importance of maintaining family-centered, interprofessional efforts and that education continue across the continuum of care (Landier et al., 2016). A systematic review investigating caregiver education in pediatric oncology supports these recommendations and identified others, such as providing education in written, verbal, and audio formats, making education anticipatory as caregivers do not yet know what they do not know; consideration for caregiver preferred language and educational level; and creating structured teaching tools (Rodgers, Laing, et al., 2016).

Education needs to be delivered in multiple ways and over time. The consistent theme among evidence addressing caregiver learning is that implementation of standardized educational content, using structured, yet individualized methods, and tiered educational sessions are preferred. Furthermore, the use of checklists and repeat demonstrations has been shown to improve the competence of the caregiver (Drews et al., 2017; Heiser
Rosenberg et al., 2017; Landier et al., 2016; Secola et al., 2012). Incorporating these recommendations into caregiver education programs ensures that best practices guide how parents are taught, thus optimizing their ability to learn.

The emotional state of caregivers must also be addressed, as being stressed, fearful, and overwhelmed can impede the ability to learn (Rodgers, Stegenga, et al., 2016). Anxiety and negative emotions can impede one's ability to achieve self-efficacy and thus impair learning (Bandura, 1977). Caregivers report that, given the emotional stress they are under at the time of diagnosis, they have difficulty comprehending information shared with them by the medical team (Aburn & Gott, 2014). Additionally, the first few weeks at home are the most stressful; however, this improved on their establishment of a routine, with the nurse playing a significant role in enhancing caregiver ability to cope and acquire new knowledge (Aburn & Gott, 2014; Flury et al., 2011). The nurse providing education must acknowledge the emotional state of the caregivers and help them determine ways to incorporate the new expectations of care for their child into their daily lives. Together, they can plan their routine to incorporate CVC care and CLABSI reduction strategies, such as bathing and oral care, into their daily lives.

**Method**

Based on existing literature, the current process of hospital-based caregiver education was modified to create a more effective learning experience for caregivers with the goal of improving their CVC care skills in the home. Following the implementation of these modifications, home-acquired CLABSI data were compared with baseline home-acquired CLABSI data.

**Sample and Setting**

The project took place on two inpatient hematology/oncology units at CHLA with 48 total beds. The learners were caregivers of children diagnosed with cancer who require a CVC for treatment. The caregiver was identified as the person or persons caring for the CVC in the home. Caregivers were recruited on their first inpatient admission once the family participated in a cancer diagnosis conference led by the primary care team. Each child diagnosed with cancer requiring a CVC for treatment was required to have a caregiver receive this education prior to discharge, as this is a hospital requirement. All nurses on the inpatient oncology units were required to provide this education; however, there are also identified nurse educators designated to provide caregiver education on specific days.

**Ethical Considerations**

Institutional review board approval was obtained through CHLA. To maintain the privacy of the patients involved, patient-specific CLABSI data were stored in a password-protected file, and all reported data were aggregated and unidentifiable.

**Intervention**

Following a synthesis of evidence and collaboration with stakeholders, the project interventions were identified. The CVC care guidelines currently in use were in alignment with best practices identified in the literature; therefore, this project focused on improving the methods and quality of education delivery to ensure best practice compliance. Additionally, a fact sheet was developed for caregivers, explicitly addressing the relationship between hygiene, oral care, and CLABSI prevention. All education materials were confirmed to be at a fourth-grade reading level, and were available in English, Spanish, Arabic, and Korean. For other languages, hospital translation and interpretation services were utilized to ensure caregiver understanding. The main changes were the implementation of a competency checklist (Figure 1) during the CVC skills class to standardize competency verification of the caregiver’s skills among all instructors. Additionally, two repeated caregiver redemonstrations were added to the education process and occurred on subsequent admissions. These redemonstrations were evaluated by a nurse utilizing the same competency checklist. This checklist was adapted from the current competency checklist utilized for nurses at CHLA, as the hospital policy and procedure is evidence based. The purpose of these additional redemonstrations was to ensure that the caregivers retained what they learned and to create opportunities for repetition.

**Data Collection**

Baseline CLABSI data were obtained prior to the implementation of the modified guideline intervention. The CHLA Department of Infection Prevention and Control provided a report of all home-acquired CLABSI in oncology patients diagnosed within Quarters 1 and 2 of 2018, including oncology patients admitted directly to the pediatric intensive care unit. Following project implementation in July 2018, home-acquired CLABSI data were obtained for Quarters 3 and 4 of 2018. Only CLABSI identified in patients diagnosed after the intervention implementation date were counted, as using data from patients diagnosed prior to the intervention would obscure the results. Each case of home-acquired CLABSI was classified as either MBI-LCBI or non-MBI-LCBI over
the 6-month time period postimplementation. This classification determined if the infection likely occurred due to breakdown of the mucosa, which could partially be prevented through oral hygiene, or if it was an organism that may have been introduced into the bloodstream on CVC care performed by the caregiver or poor bathing practices.

**Results**

As catheter days were not able to be calculated for patients at home, the data collected relied solely on number of infections in proportion to number of patients diagnosed during each group phase. A Fisher’s exact test was used to test for a significant difference in the proportion
opportunities in which the caregiver redemonstrated skills allowed for two additional reinforcement educational sessions with caregivers forgetting proper technique. This project opportunities for skill redemonstrations, potentially leading one educational session with a nurse with no follow-up prevention strategies. The main goal was for the caregivers to achieve knowledge and skill mastery regarding CVC care and maintenance and infection prevention strategies. The clinical significance of overall decrease of home-acquired CLABSI results in lower morbidity and mortality, less inpatient stays for the patient, and decreased costs (Goudie et al., 2014; O’Grady et al., 2011; Wilson et al., 2014). Amid exceptionally high census on the two units involved in the project, having less patients admitted for CLABSI resulted in more beds being available for other patients requiring chemotherapy treatment or management of other acute complications. Verbal feedback from nurses and caregivers was overall quite positive. Although finding time to provide education was a challenge for the direct care nurse, the nurses expressed acknowledgement of the importance of reinforcement and were motivated to improve caregiver knowledge and skills. Reported verbal feedback from caregivers included appreciation for taking the time to reinforce these challenging skills, allowing for questions to be asked of nurses regarding home care, and validation that they are providing competent care at home.

It is imperative to determine a future plan to sustain this intervention. Collaboration with hospital informaticists has resulted in the plan to create an automatic patient care order that would generate a prompt for the two subsequent inpatient admissions following the initial education.

### Table 1. Analysis of Association Between Intervention Group and CLABSI.

|            | January-June | July-December |
|------------|--------------|---------------|
|            | Infections  | New diagnoses | Infections  | New diagnoses | OR  | 95% CI        | p Value |
| MBI        | 8           | 149           | 2           | 81           | 2.23 | [0.43, 22.10] | .50     |
| Non-MBI    | 8           | 149           | 1           | 81           | 4.52 | [0.59, 203.71] | .17     |

Note. OR = odds ratio, CI = confidence interval, MBI = mucosal-barrier injury.

of patients who experienced a CLABSI between pre- and postintervention groups. Table 1 displays the final results of the project. The odds ratios revealed that the odds of a CLABSI were greater in the preintervention group: 2.23 times greater for MBI-LCBI and 4.52 times greater for non–MBI-LCBI. However, no statistically significant difference was detected at a significance level of .05.

In addition to CLABSI data, intervention compliance was also measured. Throughout project implementation, there were a total of 109 newly diagnosed patients admitted to the inpatient units. All caregivers received the initial education on diagnosis. Sixty-six caregivers (61% of caregivers of newly diagnosed patients) received an initial education session and both subsequent reinforcement sessions. Fifteen caregivers (14% of caregivers of newly diagnosed patients) received initial education session but only one reinforcement session. This resulted in 74% of caregivers of newly diagnosed patients receiving at least one reinforcement education session.

### Discussion

**Implications for Practice**

Having a child diagnosed with cancer is extremely stressful and fear inducing, especially during the first few weeks (Abum & Gott, 2014). Nurses must address this as they prepare to provide education on caring for the child with cancer by engaging the families over time and with multiple educational methods (Rodgers, Stegenga, et al., 2016). This project applied existing evidence of best practices for delivering education to families with a child newly diagnosed with cancer. This included creating multiple educational methods, such as updated written materials; in-person didactic; step-by-step procedures; and repeated opportunities for skill redemonstration utilizing a competency checklist. The main goal was for the caregivers to achieve knowledge and skill mastery regarding CVC care and maintenance and infection prevention strategies.

Prior to implementing this project, caregivers received one educational session with a nurse with no follow-up opportunities for skill redemonstrations, potentially leading to caregivers forgetting proper technique. This project allowed for two additional reinforcement educational opportunities in which the caregiver redemonstrated skills and the nurse assessed their skill mastery using the standardized checklist. If improper skills were demonstrated, the nurse would provide in-the-moment corrective education. Additionally, this project included new written materials to be reviewed with the caregivers regarding oral care and hygiene. For the first time, all educational materials included the rationale for oral care and hygiene, explaining to the caregivers that these interventions could have significant implications for preventing bloodstream infections. Connecting the concepts of oral care and hygiene with bloodstream infection prevention was found to be helpful in facilitating the caregivers’ understanding of the gravity of compliance with these interventions.

Because CLABSI are relatively rare medical events, it is challenging to obtain the very large sample sizes required to detect a statistically significant reduction in CLABSI following a practice change. However, the estimated effects of this intervention suggest that it may be effective in reducing home-acquired CLABSI. Despite a lack of statistical significance, the results of this project had overall positive implications on clinical outcomes. The clinical significance of overall decrease of home-acquired CLABSI results in lower morbidity and mortality, less inpatient stays for the patient, and decreased costs (Goudie et al., 2014; O’Grady et al., 2011; Wilson et al., 2014).
received at diagnosis. This will make the patients more easily identifiable by the nurses, and the process will no longer have to rely on one person reviewing admissions manually.

**Limitations**

Currently, there is no standard of practice for collecting data on home-acquired CLABSI; therefore, there is no mechanism for calculating total outpatient catheter days. For this project, it was not feasible to calculate CLABSI rates that are comparable to inpatient rates, making data analysis more challenging. It is also difficult to determine if the CLABSI was truly home acquired or an event that occurred in an ambulatory visit at the hospital. While this project focused mainly on caregiver education and skill mastery, further work should be done to focus on infection prevention strategies in the hospital-based ambulatory setting.

Additionally, identifying patients was a manual process that involved the project leader reviewing each inpatient chemotherapy admission and determining who required the additional educational reinforcement session. With about 25 to 30 chemotherapy admissions per week and high-acuity patients, there were instances where other job requirements were of higher priority and interfered with patient identification and providing education. As a result, 26% of patients did not receive the project intervention at all, while 14% only received one additional reinforcement session.

**Conclusion**

Home-acquired CLABSI are potentially preventable complications that result in additional inpatient admissions for the child and a variety of unfavorable outcomes. Nurses must provide effective education regarding CVC care and maintenance and engage caregivers in important infection prevention behaviors to decrease the occurrence of CLABSI acquired in the home setting. Though further research should be done to expand the breadth of knowledge regarding this complication, the clinical outcomes of this project suggest that standardizing caregiver education and providing repeated learning opportunities can lead to more competent care in the home, thus potentially decreasing CLABSI.

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**Rachel McClanahan**, DNP, RN, NCSN, is an assistant professor and the acting director of the Southern California CSU DNP Consortium. Dr. McClanahan has 25 years of rich and varied nursing experience, most recently as a school nurse. She earned her MSN from California State University Fullerton and her DNP from the Southern California CSU DNP Consortium.

** Roxanne O’Brien**, PhD, RN, CPHQ, taught at California State University, Fullerton for the last 10 years. The focus of her 29 year career in nursing management in the St. Joseph Health System, the Veterans Affairs Administration, and Kaiser Permanente, Northern California Regional Offices, was on quality, risk management and patient safety. She received both her MSN and PhD from the University of California, San Francisco.

**Paula Murray**, PhD, is a biostatistician in the Institute for Nursing and Interprofessional Research at Children’s Hospital Los Angeles. She obtained her BSc and MSc from the University of Guelph and her PhD in statistics from McMaster University.

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