A Quality Improvement Project to Decrease CLABSIs in Non-ICU Settings

Jill Engel, DNP, ACNP, NEA-BC, FAANP; Britt M. Meyer, PhD, RN, CRNI, VA-BC, NE-BC;
Gloria Alston McNeil, DNP, MA, MBA, RN, NE-BC, NEA-BC, CENP;
Tammi Hicks, DNP, RN, CEN, NE-BC; Kalpana Bhandari, MPH; Daniel Hatch, PhD;
Bradi B. Granger, PhD, RN, FAHA, FAAN;
Staci S. Reynolds, PhD, RN, ACNS-BC, CCRN, CNRN, SCRN, CPHQ

Background and Objectives: Central line–associated bloodstream infections (CLABSIs) are a common, preventable healthcare–associated infection. In our 3-hospital health system, CLABSI rates in non-intensive care unit (ICU) settings were above the internal target rate of zero. A robust quality improvement (QI) project to reduce non-ICU CLABSIs was undertaken by a team of Doctor of Nursing Practice (DNP)-prepared nurse leaders enrolled in a post-DNP Quality Implementation Scholars program and 2 QI experts. Based on a review of the literature and local root cause analyses, the QI team implemented the evidence-based practice of using 2% chlorhexidine gluconate (CHG) cloths for daily bathing for non-ICU patients with a central line. **Methods:** A pre-post-design was used for this QI study. CHG bathing was implemented using multifaceted educational strategies that included an e-learning module, printed educational materials, educational outreach, engagement of unit-based CLABSI champions, and an electronic reminder in the electronic health record. Generalized linear mixed-effects models were used to assess the change in CLABSI rates before and after implementation of CHG bathing. CLABSI rates were also tracked using statistical process control (SPC) charts to monitor stability over time. CHG bathing documentation compliance was audited as a process measure. These audit data were provided to unit-based leadership (nurse managers and clinical team leaders) on a monthly basis. A Qualtrics survey was also disseminated to nursing leadership to evaluate their satisfaction with the CHG bathing implementation processes. **Results:** Thirty-four non-ICU settings participated in the QI study, including general medical/surgical units and specialty areas (oncology, neurosciences, cardiac, orthopedic, and pediatrics). While the change in CLABSI rates after the intervention was not statistically significant ($b = -0.35$, $P = .15$), there was a clinically significant CLABSI rate reduction of 22.8%. Monitoring the SPC charts demonstrated that CLABSI rates remained stable after the intervention at all 3 hospitals as well as the health system. CHG bathing documentation compliance increased system-wide from 77% (January 2020) to 94% (February 2021). Overall, nurse leaders were satisfied with the CHG bathing implementation process. **Conclusions:** To sustain this practice change in non-ICU settings, booster sessions will be completed at least on an annual basis. This study provides further support for using CHG cloths for daily patient bathing in the non-ICU setting.

Key words: chlorhexidine gluconate (CHG) cloths, evidence-based practice, infection, nursing, quality improvement

Central line–associated bloodstream infections (CLABSIs) are one of the most common healthcare–associated infections. These preventable infections are a source of morbidity and mortality in the hospital setting, adding approximately $48 000 in additional costs per event and contributing an extra 10.4 days in the hospital.[1-3] Further, CLABSIs are a publicly reportable quality metric that impacts reputation rankings and can lead to financial penalties.[4,5]

Our 3-hospital health system in the southeastern United States consists of a large university hospital and 2 community hospitals. CLABSI rates in non-intensive care unit (ICU) settings were 0.70 CLABSIs per 1000 central line days for the system (CLABSI rates for university hospital: 0.74; Community Hospital A: 0.44; Community Hospital B: 0.60). Our health system had recently instituted a "Commit to Zero" campaign for preventable harms—the system rate failed to achieve the internal CLABSI target rate of 0. A root cause analysis was completed on each non-ICU CLABSI event to identify potential opportunities for improvement. Minimal opportunities were found as standard CLABSI prevention insertion and maintenance bundle compliance was high. A robust quality improvement (QI) study was launched to address the cause(s) of the important issue of non-ICU CLABSIs.

Author Affiliations: Duke University Health System, Durham, North Carolina (Drs Engel and Granger); Duke University Hospital, Durham, North Carolina (Drs Meyer and Reynolds and Ms Bhandari); Duke Regional Hospital, Durham, North Carolina (Dr McNeil); Duke Raleigh Hospital, Raleigh, North Carolina (Dr Hicks); and Duke University School of Nursing, Durham, North Carolina (Drs Hatch, Granger, and Reynolds).

Correspondence: Staci S. Reynolds, PhD, RN, ACNS-BC, CCRN, CNRN, SCRN, CPHQ, Associate Professor, Duke University School of Nursing, 307 Trent Dr, Durham, NC 27710 (Staci.reynolds@duke.edu).

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The QI team, which included 4 Doctor of Nursing Practice (DNP)-prepared nurse leaders and 2 QI mentors, led this study as part of a post-DNP Quality Implementation Scholars program. Details of this program, including the curriculum and program evaluation data, have been previously described by Reynolds and colleagues.[6]

The QI team began by searching the literature to identify additional evidence-based CLABSI prevention practices. Articles were critiqued with the level and quality of evidence assessed by the QI team. A recent level 1, high-quality cluster randomized trial by Huang and colleagues[7] found that daily bathing with prepackaged 2% chlorhexidine gluconate (CHG) cloths reduced CLABSIs in non-ICU settings in patients with a central line. This study enrolled 53 hospitals and 194 non-ICU areas, of which 27 hospitals and 104 units, including over 183 000 patients, were enrolled in the intervention group with patients receiving daily CHG bathing. Post hoc analyses found that patients in the intervention group who had indwelling medical devices had a 32% greater reduction in all-cause bacteremia and a 37% reduction in methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococcus compared with those in the control group.[7] Whereas the post hoc analyses showed significant improvements for patients with a medical device, the authors noted that the trial was not designed or powered for this evaluation. However, similar findings have been replicated in other high-quality studies, with other articles consistently noting an improvement in CLABSI rates after implementing CHG bathing.[8,9] Additionally, CHG cloths for daily bathing were already instituted in our health system's ICU settings, and showed significant reductions in ICU CLABSI rates.[10] Given the evidence supporting use of CHG cloths, as well as support from hospital leadership, the purpose of this QI study was to implement daily 2% CHG bathing in non-ICU patients with a central line.

METHODS

A pre-/post-design was used to evaluate the impact of daily 2% CHG bathing on non-ICU CLABSI rates. Baseline CLABSI rates were collected from January 2018 to December 2019. Daily 2% CHG bathing in non-ICU settings began on January 6, 2020; post-implementation data were measured from January 2020 to February 2021. A total of 34 non-ICUs, with a baseline average of 182 central line days per month per unit, participated in the study. See Table 1 for an overview of each hospital's number of non-ICU settings, beds, and average central line days. Patient populations varied among the non-ICUs, including medical, surgical, cardiac, neuroscience, oncology, and pediatric specialties. Due to the variation in unit type, some non-ICUs (ie, cardiac and oncology) had patient populations at higher risk for CLABSI, including those who were immunocompromised and with higher utilization of central lines.

The Promoting Action on Research Implementation in Health Services (PARIHS) framework was used as a guide for this study.[11] This framework postulates that successful implementation of evidence-based practices is a function of the relationship and strength of the evidence, context, and facilitation.[11] As such, we attempted to account for each of these constructs prior to implementation by ensuring appropriate measures were in place. For this QI study, we had *evidence* for the practice change, a *context* that had robust leadership support, and a comprehensive plan to *facilitate* implementation of the practice change. This QI

Table 1. Number of Non-ICU Settings and Beds, and Average Number of Central Line Days Per Month for Each Hospital and the System

				Average Central Line Days/Month, n (SD)	
Type of Hospital	Non-ICU Settings, n	Type of Non-ICUs: n	Non-ICU Beds, n (Range/Unit)	Baseline (January 2018 to December 2019)	Post-implementation (January 2020 to February 2021)
University	23	General medical/surgical: 9 Cardiac: 6 Pediatric: 3 Oncology: 3 Neuroscience: 2 Orthopedic: 1	623 (12-32)	5031 (353)	4878 (498)
Community A	6	General medical: 2 General surgical: 1 Cardiac: 1 Neuro/ortho: 1 Oncology: 1	197 (26-36)	558 (79)	543 (89)
Community B	5	General medical/ surgical: 4 Neuroscience: 1	163 (9-45)	603 (143)	713 (164)
System (total)	34		983 (9-45)	6192 (434)	6134 (501)

Abbreviation: ICU, intensive care unit.

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study was deemed exempt as QI by the university's institutional review board.

Measures

Outcome measure: CLABSI rates

CLABSI rates, defined as the number of CLABSIs per 1000 central line days, were measured on a monthly basis per standard National Healthcare Safety Network[12] criteria and provided by the hospital's infection prevention departments. Generalized linear mixed-effects (GLME) models were used to evaluate the change in pre- (January 2018 to December 2019) to post-CLABSI (January 2020 to February 2021) rates. Per the hospital's quality management department, CLABSI rates were also tracked using statistical process control (SPC) charts to monitor stability.

Process measure: CHG bathing treatment documentation compliance

To measure compliance with daily 2% CHG bath treatments, documentation from the electronic health record (EHR) was audited for those patients meeting criteria for receiving a CHG bath. Several times each month, a sample of patient charts was audited on each unit by the unit-based CLABSI champion and members of the QI team. Unit-based CLABSI champions are staff nurses who have attended additional training to learn about CLABSI prevention, and serve as local resources, change agents, and role models for nursing staff. Data were entered into The Joint Commission (TJC) Resources Portal, an online data repository. Documentation compliance from this audit data was regularly disseminated to unit leadership and champions via email and during daily huddles, and through various leadership meetings.

Satisfaction With implementation

We further sought to evaluate nursing leadership satisfaction with the CHG bathing implementation process. An 11-item Qualtrics survey was developed by the authors, with guidance taken from Proctor and colleague's implementation outcomes.[13] The survey was sent to nursing leaders from the 34 non-ICU settings 3 months after implementation. Eight questions asked participants to rate their satisfaction with various aspects of the implementation plan on a 5-point Likert scale (1 = extremely dissatisfied, 5 = extremely satisfied). They were also asked to rate their agreement with the adoption, value, and long-term sustainability of the CHG bathing treatment initiative. Three open-ended, free-text questions asked leaders to discuss the strengths, weaknesses, and opportunities of the QI implementation process. The survey remained open for 2 weeks at the beginning of March 2020.

Procedures

In collaboration with infection prevention, a comprehensive informational presentation was created by the QI team that outlined the study rationale, patient benefits, and frequently asked questions about the 2% CHG bathing treatment protocol. Using a standardized approach, the QI team presented the proposed study to stakeholder groups across the system, including clinical and operational leaders, and nursing staff. The QI team also developed a multifaceted education plan, which included: (1) an e-learning module with an assessment test, (2) printed educational materials, (3) educational outreach, (4) engagement of unit-based CLABSI champions, and (5) an EHR reminder. Education for the daily 2% CHG bathing process followed the protocol published by the Agency for Healthcare Research and Quality (AHRQ), which includes cleaning over transparent central line dressings and up to 6 inches of the catheter and tubing in addition to bathing the full body below the jawline.[14]

The e-learning module included background on the evidence supporting 2% CHG bathing and a short video; nurses and nursing assistants (NAs) completed the module before the study began. The term "CHG bath *treatment*" was adopted to raise awareness of the importance of the protocol.[15,16] Upon completion of the module, a knowledge assessment was provided utilizing a case study with a required passing score of 80%. This module was added to nursing and NA's orientation pathways to hardwire the protocol for new hires. Automated reports were disseminated to local leaders to track staff completion.

Printed educational materials provided an overview of the evidence and rationale for CHG bathing treatments, and a diagram of the appropriate bathing process as found in the AHRQ protocol.[14] The QI team attended local unit huddles across the system for bidirectional information sharing and gathering. Additionally, the QI team partnered with the infection prevention teams to provide logistical support for product allocation and warming devices.

The QI team engaged the CLABSI champions at their monthly meetings. They provided demonstrations of the bathing protocol, scripting for staff, patients, and families about the bathing process, and further assessed barriers and facilitators to the standard work. Electronic reminders for the daily CHG bath treatment were also built into the EHR creating a worklist task for nurses and NAs.

Continuous improvement

Standardized education was provided to all 34 units. Each unit has a unique culture and they were encouraged to operationalize the intervention based on their unit's context and patient population. For example, to integrate and sustain the practice change, many units tailored their daily huddle boards, nursing and NA report sheets, and charge nurse-rounding processes to include CHG bathing. Following implementation, and in conjunction with the Commit to Zero campaign, CHG bathing treatments were a regular agenda item presented at entity-specific leadership meetings, CLABSI champion meetings, and during daily huddles. Monthly CLABSI rates and CHG bathing documentation compliance were shared at these venues and feedback was sought to improve the process. Minor modifications were made to the printed educational materials,

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EHR options, and information shared during educational outreach and huddles based on suggestions or clarification needed from leadership and direct care nurses. For example, an update was made to the printed educational materials providing staff with direction and scripting for what to do if a patient refused their CHG bath treatment. Also, the timing of when the EHR worklist task was changed after implementation to better fit with the nurse's workflow.

RESULTS

Daily 2% CHG bathing treatments in non-ICU settings for patients with a central line went live on January 6, 2020. The university hospital had the largest number of non-ICU areas (n = 23 units) and average central line days per month (4878) in the post-implementation period (January 2020 to February 2021). The 2 community hospitals had 5 to 6 non-ICU areas, with an average of 543 and 713 non-ICU central line days per month (Table 1).

Outcome measure: CLABSI rates

A GLME model was used to assess the effect of the intervention on CLABSI rates. In this, CLABSI rates in the various hospital units were regressed on the fixed effect of intervention, defined as 0 during the pre-implementation period (January 2018 to December 2019) and 1 during the post-implementation period (January 2020 to February 2021). Because this intervention is confounded by time, we also included the fixed effect of time, in months. To account for clustering within hospital units, a random intercept was included. Among all hospital units, time (in months) was not significant ($b = 0.009$, $P = .37$), and the change in CLABSI rates before and after the intervention was not statistically significant ($b = -0.35$, $P = .15$).

Additionally, SPC charts were used to monitor stability of CLABSI rates over time. Consistent with QI methodology,[17] baseline data (January 2018 to December 2019) contained at least 20 data points prior to the intervention. The mean CLABSI rate in this baseline period for the health system was 0.70. After CHG bathing was implemented, the mean and control limits were revised using January 2020 to February 2021 data. The mean system-wide CLABSI rate decreased to 0.54, a 22.8% reduction (Figure 1A). Community Hospital A and the university hospital saw reductions in their mean CLABSI rate from the baseline to post-implementation period (41% and 28% reductions, respectively) (Figures 1B and 1C). Hospital B saw a 29% increase in CLABSI rates after implementation (Figure 1D). In review of the SPC charts, CLABSI rates remained stable for all hospitals after the intervention.

Process measure: CHG bathing treatment documentation compliance

CHG bathing treatment documentation compliance was measured beginning in January 2020. Over the course of 14 months, a total of 6798 patient records were audited. In January 2020, system-wide CHG bathing documentation compliance was 77%; compliance increased by 17.1 points to 94.1% in February 2021 (Figure 2). For the first year post-implementation (January to December 2020), the compliance goal was set by the hospital at 90%, similar to other infection prevention compliance measures. As the overall health system consistently met this goal from September to December 2020, the compliance goal was increased to 95% starting in January 2021.

Satisfaction with implementation

A total of 68 nurse leaders completed the Qualtrics survey. Most were from the university hospital (n = 33). Participants had a variety of leadership roles, including clinical team leaders (n = 31), nurse managers (n = 21), Clinical Operations Director (n = 2), Associate Vice President (n = 1), and other roles (n = 5). Results of the survey can be found in Table 2. Most leaders were satisfied with the overall implementation of CHG bathing treatments. The highest rated component was the education provided during the rollout, as it included the rationale (or "why") for the importance of daily CHG bathing treatments. Nurse leaders also highly ranked their agreement with the adoption, value, and long-term sustainability of the CHG bathing initiative. Narrative strengths included the benefits to patient outcomes, feedback provided on CHG documentation compliance, and the logistical assistance provided by the QI team with acquiring warmers and CHG cloths. One nurse leader stated, "[A strength was that] education included the 'why' behind the initiative, so that staff better understood the importance of daily CHG bathing. Also, the QI team took the workload off of the local teams." Weaknesses included the quick implementation plan and lack of staff buy-in of the new process. One leader commented, "I feel we did not have enough time to provide training/education to staff before go-live, which can reduce staff's buy-in of the practice change."

DISCUSSION

Outcome measure: CLABSI rates

An overall 22.8% reduction in system-wide CLABSI rates after implementing the CHG bathing treatment protocol in non-ICU settings was achieved, with Community Hospital A and the university hospital seeing the largest reductions. The university hospital had the largest number of non-ICU settings (23 units), the highest number of central lines, and therefore had the greatest opportunity for reduction. Other studies have shown similar results, with reductions in CLABSIs after implementation of CHG bathing.[7,18,19] Whereas most studies have found a reduction in CLABSIs in the ICU setting,[10,19,20] this QI study adds to the body of knowledge supporting the use of CHG bathing to decrease CLABSI rates specifically in the non-ICU population for patients with central lines.

Community Hospital B unfortunately saw an increase in CLABSI rates after implementation of CHG

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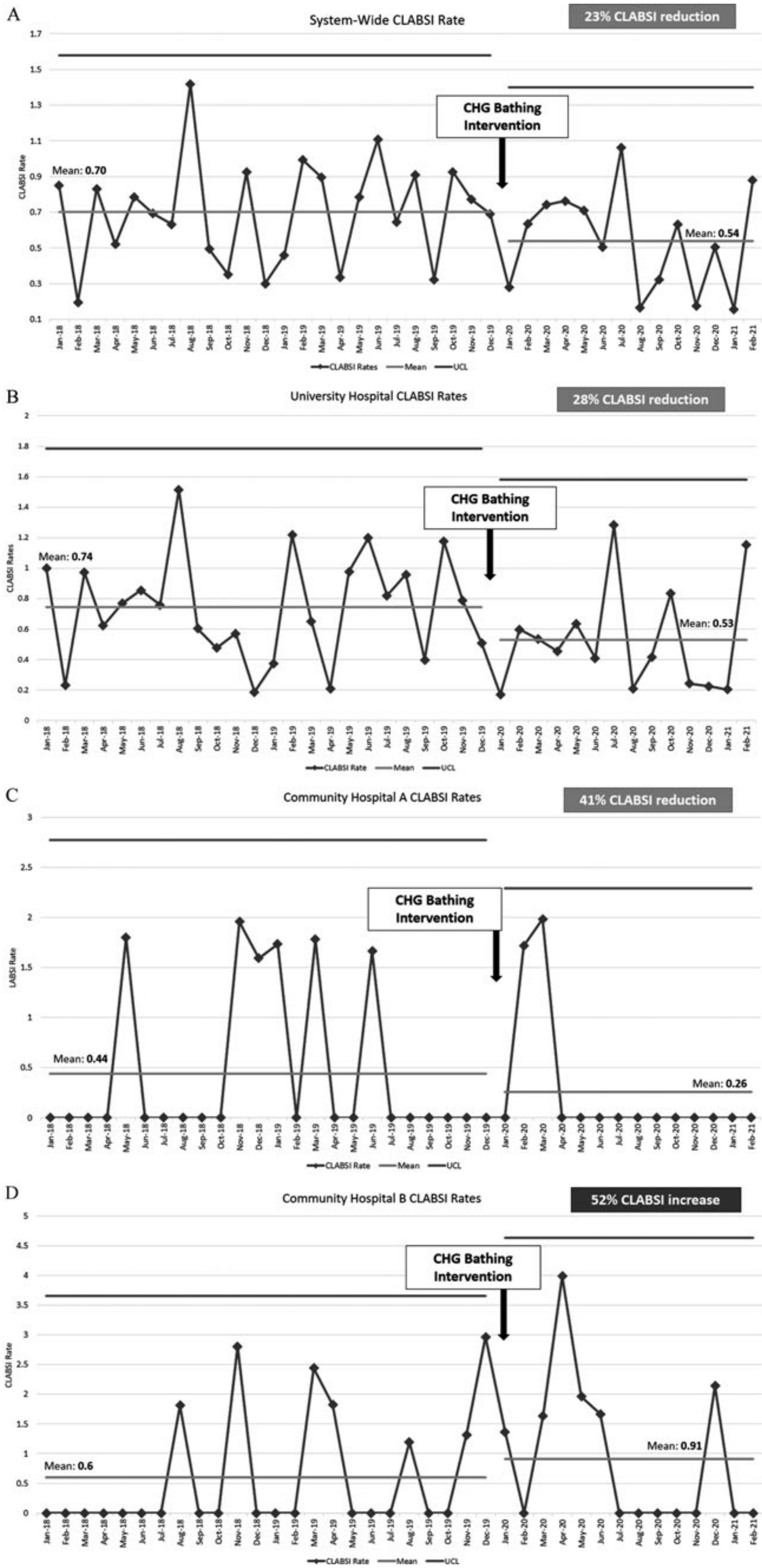

Figure 1. Statistical process control charts of CLABSI rates. (A) System-wide CLABSI rates. (B) University Hospital CLABSI rates. (C) Community Hospital A CLABSI rates. (D) Community Hospital B CLABSI rates. CLABSI indicates central line–associated bloodstream infection; UCL, upper control limit.

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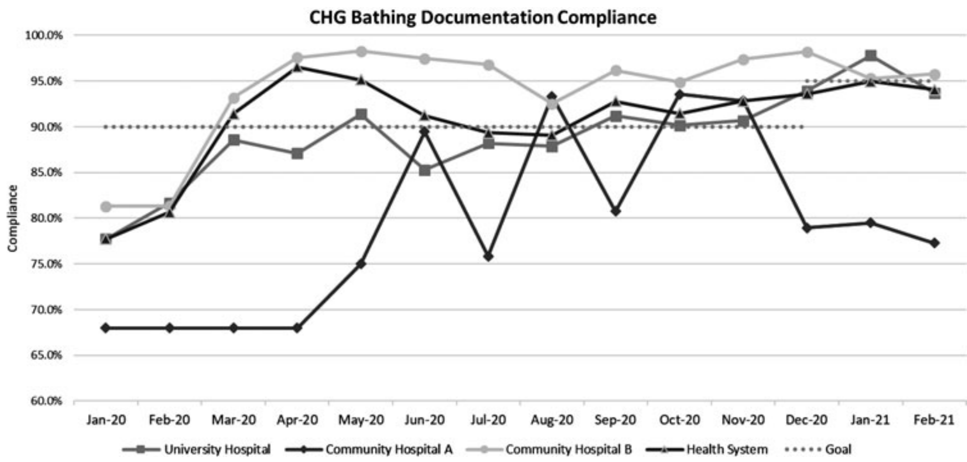

Figure 2. Non-ICU CHG bathing documentation compliance. CHG indicates chlorhexidine gluconate; ICU, intensive care unit.

bathing from March to June 2020, at the height of the COVID-19 pandemic. The community hospital may have admitted patients with higher acuity. Fakih and colleagues[21] found that the COVID-19 pandemic was associated with substantial increases in CLABSI rates in hospitals. It is important to note that, whereas this hospital saw an overall increase in CLABSI rates post-implementation, they did have a 5-month stretch (July to November 2020) with zero CLABSIs, as noted in Figure 1D.

In addition to the important clinical outcomes achieved in this QI study, there are sizeable financial implications of implementing CHG bathing. The average cost of a CLABSI event is $48 000.[2] The reduction in CLABSIs noted throughout our health system was associated with an annual cost aversion of approximately $768 000. However, CHG cloths cost approximately $5.25 more than nonmedicated pre-packaged cloths, adding an approximate annual additional cost of $387 600 to hospital expenses. Accounting for the increased cost of CHG cloths, the health system still realized a cost aversion of $380 400.

Even though CHG cloths are more expensive than nonmedicated cloths, the ultimate benefits to patient safety and CLABSI cost aversion are substantial. With an estimated increase in length of stay associated with CLABSI of 10.4 days per event, the impact for the health system on bed days was approximately 166.4 days.[3] Similar to the savings realized in our study, Huang and colleagues[22] also noted that implementing daily CHG bathing treatments may save hospitals an estimated $171 000. Reagan and colleagues[23] also found that improving daily CHG compliance could save over $800 000 from infection reduction.

Process measure: CHG bathing treatment documentation compliance

CHG bath treatment documentation compliance improved over the course of the 14 months following implementation of the intervention. Many other studies have also evaluated CHG bathing compliance through EHR documentation audits and have found similar improvements after education.[18,24,25] In addition to conducting documentation audits, leaders

Table 2. Nursing Leadership Satisfaction and Agreement With CHG Bathing Implementation

Question	Mean (SD) n = 60	Two-Top-Box Responses n = 60
Education provided (e-learning module, printed educational materials)	4.02 (0.76)	85%
Logistics (warmer acquisition, cloth ordering)	3.98 (0.96)	78%
EHR worklist task	3.71 (0.94)	62%
Audit and feedback provided on CHG documentation compliance	3.75 (0.99)	73%
Overall CHG bathing rollout	3.62 (1.07)	67%
CHG bathing has been well adopted on my unit/area	3.98 (0.85)	82%
This initiative is valuable to my unit/area	4.27 (0.75)	85%
This initiative will be sustainable long term	4.12 (0.86)	78%

Abbreviations: CHG, chlorhexidine gluconate; EHR, electronic health record.

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were provided feedback on a regular basis on their unit's documentation compliance. Literature shows that this type of audit and feedback strategy is helpful in improving compliance with evidence-based practices.[26-29]

Documentation audits provide a relatively simple process metric to measure compliance with CHG bathing; however, documentation may not always reflect nursing practice. Community Hospital B had the highest CHG bathing documentation compliance, yet saw an *increase* in CLABSI rates. In contrast, Community Hospital A had lower CHG bathing documentation compliance (average of 79.2% after implementation) than the other hospitals, but showed the largest hospital-wide reduction of CLABSIs.

Documentation audits may not provide the most accurate measure of compliance with the practice change. Other process metrics may be helpful to further capture CHG bathing treatment compliance, such as observation of the bathing process or measuring the usage of CHG bath cloth packages.[24] Through mathematical modeling, Reagan and colleagues[23] completed an analysis noting that improving compliance with daily CHG bathing can result in 20 averted infections. Future CHG bathing treatment studies should consider monitoring compliance with other types of process metrics, not just documentation audits. They should also provide feedback on compliance to individual units and leaders.

Satisfaction with implementation

Most nurse leaders were satisfied with the overall implementation plan and processes. Previous evaluation research has reported on bedside nurses' experience with implementation process.[30] However, there is a paucity of evidence on nurse leaders' experience and satisfaction with implementation processes of CHG bathing at a system level. Reynolds and colleagues[31] conducted a qualitative study evaluating the impact of a CHG bathing implementation science study on nurse leaders' competencies. Findings showed that being a part of an implementation science study and associated processes was a positive experience and allowed leaders to promote the use of evidence-based infection prevention practices.[31] In a review of the literature, we did not find other studies evaluating nurse leaders' experience and satisfaction with implementation of other evidence-based practices.

Based on the leaders' feedback, they appreciated the hands-on approach of the QI team in assisting with education and the necessary logistics with implementing a large, system-wide study. However, as CLABSI prevention was a major focus for the hospital, the CHG bath treatment practice was implemented quickly. Several nursing leaders identified this as a weakness of the study, which could have contributed to suboptimal staff buy-in of the practice change. Further, CLABSI champions were used as local change agents to engage staff, yet lack of staff buy-in was a noted weakness. Per the PARIHS framework, we attempted to have a strong *facilitation* plan prior to the rollout of the initiative. The CLABSI champions were provided with resources; however, it may have been helpful for the QI team to provide additional tools and/or superusers to better support the practice change from a *facilitation* standpoint. For future implementation initiatives, it may be beneficial for studies to consider evaluating implementation processes from a leadership perspective to identify strengths and opportunities.

Limitations

This QI study has several limitations. First, this study was initially implemented on October 1, 2019. Two days after implementation, the CHG bath cloth manufacturer announced a nation-wide backorder of the cloths, forcing the QI study to suddenly stop. This abrupt pause may have negatively affected the robust implementation plan, as education was completed in September/October 2019, yet CHG bathing treatments were not officially (re)implemented until January 2020. Further, much of the post-implementation period coincided with the COVID-19 pandemic. With many competing priorities, CHG bathing treatments may have had lower priority for the staff and this could have affected compliance with the CHG bath treatment protocol. Finally, this study was conducted across a single health system in the southeastern United States, which may limit generalizability.

CONCLUSIONS

Findings of this QI study support daily bathing with pre-packaged 2% CHG bath cloths in non-ICU settings to reduce CLABSI, although the finding was not statistically significant. Booster sessions will be implemented during annual skills revalidation and as needed to sustain this practice change. CLABSI champions, as well as nurses participating in a new health system evidence-based practice fellowship, will be mentored by QI experts to maintain the gains made from this QI study.

CHG bathing, a nurse-led intervention, can reduce CLABSIs in the non-ICU setting. Other health care systems may seek to implement CHG bathing in this patient population. In addition to the main outcome of CLABSI rate reduction, other measures, such a CHG bathing documentation compliance and staff or leadership satisfaction, should be measured.

REFERENCES

1. Centers for Disease Control and Prevention. Central Line-Associated Bloodstream Infections. https://arpsp.cdc.gov/profile/infections/CLABSI. Published 2021.
2. Bysshe T, Gao Y, Heaney-Huls K, et al. *Estimating the Additional Hospital Inpatient Cost and Mortality Associated With Selected Hospital-Acquired Conditions.* Rockville, MD: Agency for Healthcare Research and Quality; 2017:75.
3. Jia H, Li L, Li W, et al. Impact of healthcare-associated infections on length of stay: a study in 68 hospitals in China. *Biomed Res Int.* 2019;2019:e2590563. doi:10.1155/2019/2590563.
4. The Leapfrog Group. Hospital-Acquired Conditions. https://www.leapfroggroup.org/ratings-reports/hospital-acquired-conditions. Published March 15, 2016. Accessed August 24, 2020.

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5. Sankaran R, Sukul D, Nuliyalu U, et al. Changes in hospital safety following penalties in the US Hospital Acquired Condition Reduction Program: retrospective cohort study. *BMJ*. 2019;366:l4109. doi:10.1136/bmj.l4109.
6. Reynolds SS, Howard V, Uzarski D, et al. An innovative DNP post-doctorate program to improve quality improvement and implementation science skills. *J Prof Nurs*. 2021;37(1):48-52. doi:10.1016/j.profnurs.2020.12.005.
7. Huang SS, Septimus E, Kleinman K, et al. Chlorhexidine versus routine bathing to prevent multidrug-resistant organisms and all-cause bloodstream infections in general medical and surgical units (ABATE Infection trial): a cluster-randomised trial. *Lancet North Am Ed*. 2019;393(10177):1205-1215. doi:10.1016/S0140-6736(18)32593-5.
8. Tien K-L, Sheng W-H, Shieh S-C, et al. Chlorhexidine bathing to prevent central line–associated bloodstream infections in hematology units: a prospective, controlled cohort study. *Clin Infect Dis*. 2020;71(3):556-563. doi:10.1093/cid/ciz874.
9. Giri VK, Kegerreis KG, Ren Y, et al. Chlorhexidine gluconate bathing reduces the incidence of bloodstream infections in adults undergoing inpatient hematopoietic cell transplantation. *Transplant Cell Ther*. 2021;27(3):262.e1-262.e11. doi:10.1016/j.jtct.2021.01.004.
10. Reynolds SS, Woltz P, Keating E, et al. Results of the CHlorhexidine Gluconate Bathing Implementation Intervention to Improve Evidence-Based Nursing Practices for Central Line Associated Bloodstream Infection Prevention Study (CHanGing BathS): a stepped wedge cluster randomized trial. *Implement Sci*. 2021; 16(1):45.
11. Rycroft-Malone J. The PARIHS framework—a framework for guiding the implementation of evidence-based practice. *J Nurs Care Qual*. 2004;19(4):297-304.
12. National Healthcare Safety Network ACH Surveillance for BSI (CLABSI). https://www.cdc.gov/nhsn/acute-care-hospital/clabsi/index.html. Published December 13, 2019. Accessed March 31, 2020.
13. Proctor E, Silmere H, Raghavan R, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Adm Policy Ment Health*. 2011; 38(2):65-76. doi:10.1007/s10488-010-0319-7.
14. Agency for Healthcare Research and Quality. Universal ICU Decolonization: An Enhanced Protocol. https://www.ahrq.gov/sites/default/files/publications/files/universalicu.pdf. Published 2013. Accessed March 31, 2020.
15. Vanhoozer G, Lovern BS I, Masroor N, et al. Chlorhexidine gluconate bathing: patient perceptions, practices, and barriers at a tertiary care center. *Am J Infect Control*. 2019;47(3):349-350. doi:10.1016/j.ajic.2018.08.002.
16. Caya T, Knobloch MJ, Musuuza J, Wilhelmson E, Safdar N. Patient perceptions of chlorhexidine bathing: a pilot study using the health belief model. *Am J Infect Control*. 2019;47(1):18-22. doi:10.1016/j.ajic.2018.07.010.
17. Provost LP, Murray SK. The Health Care Data Guide: Learning from Data for Improvement. San Francisco, CA: Jossey-Bass; 2011.
18. Reynolds SS, Sova C, McNalty B, Lambert S, Granger B. Implementation strategies to improve evidence-based bathing practices in a neuro ICU: *J Nurs Care Qual*. 2019;34(2):133-138. doi:10.1097/NCQ.0000000000000347.
19. Dicks KV, Lofgren E, Lewis SS, Moehring RW, Sexton DJ, Anderson DJ. A multicenter pragmatic interrupted time series analysis of chlorhexidine gluconate bathing in community hospital intensive care units. *Infect Control Hosp Epidemiol*. 2016;37(7): 791-797. doi:10.1017/ice.2016.23.
20. Huang SS, Septimus E, Kleinman K, et al. Targeted versus universal decolonization to prevent ICU infection. *N Engl J Med*. 2013; 368(24):2255-2265. doi:10.1056/NEJMoa1207290.
21. Fakih MG, Bufalino A, Sturm L, et al. Coronavirus disease 2019 (COVID-19) pandemic, central-line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI): the urgent need to refocus on hardwiring prevention efforts. *Infect Control Hosp Epidemiol*. 2022;43(1):26-31. doi:10.1017/ice.2021.70.
22. Huang SS, Septimus E, Avery TR, et al. Cost Savings of universal decolonization to prevent intensive care unit infection: implications of the REDUCE MRSA trial. *Infect Control Hosp Epidemiol*. 2014;35(S3):S23-S31. doi:10.1086/677819.
23. Reagan KA, Chan DM, Vanhoozer G, et al. You get back what you give: Decreased hospital infections with improvement in CHG bathing, a mathematical modeling and cost analysis. *Am J Infect Control*. 2019;47(12):1471-1473. doi:10.1016/j.ajic.2019.07.003.
24. Caya T, Musuuza J, Yanke E, et al. Using a systems engineering initiative for patient safety to evaluate a hospital-wide daily chlorhexidine bathing intervention. *J Nurs Care Qual*. 2015;30(4): 337-344. doi:10.1097/NCQ.0000000000000129.
25. Kettelhut V, Van Schooneveld T, McClay J, Fruhling A, Dempsey K. The utility of electronic health record-based hygiene notes for chlorhexidine bathing practice evaluation. *J Infect Prev*. 2017; 18(2):72-77. doi:10.1177/1757177416667288.
26. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. 2012;(6):CD000259. doi:10.1002/14651858.CD000259.pub3.
27. Chan WV, Pearson TA, Bennett GC, et al. ACC/AHA special report: clinical practice guideline implementation strategies: a summary of systematic reviews by the NHLBI Implementation Science Work Group: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*. 2017;135(9):e122-e137. doi:10.1161/CIR.0000000000000481.
28. Colquhoun HL, Carroll K, Eva KW, et al. Advancing the literature on designing audit and feedback interventions: identifying theory-informed hypotheses. *Implement Sci*. 2017;12(1):117. doi:10.1186/s13012-017-0646-0.
29. Reynolds S. Using audit and feedback to improve compliance with evidence-based practices. *Am Nurse*. 2020;15(10):16-19.
30. Reynolds SS, McLennon SM, Ebright PR, Murray LL, Bakas T. Program evaluation of neuroscience competency programs to implement evidence-based practices. *J Eval Clin Pract*. 2017;23(1): 149-155. doi:10.1111/jep.12654.
31. Reynolds SS, Woltz P, Neff J, Elliott J, Granger BB. Impact of an implementation science study on nursing leader's competencies: a qualitative study [published online ahead of print August 30, 2021]. *Nurse Leader*. doi:10.1016/j.mnl.2021.08.001.

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Brief Report

Reducing central line-associated bloodstream infection (CLABSI) rates with cognitive science-based training

Jessica Lowery PhD, CIC, FAPIC [a,*], Matthew Jensen Hays PhD [b], Andrea Burch MS, RN NEA-BC [a], Debra Behr DNP, RN, CCRN-K [a], Steven Brown MD, FACR [a], Elise Kearney RN, BSN, VA-BC [a], Deborah Senseney DNP, RN, RN-BC [a], Sky Arce MSN, RN, PCCN-K [a]

[a] *Lutheran Medical Center, Wheat Ridge, CO*
[b] *Amplifire, Boulder, CO*

Key Words:
CLABSI reduction
Clinical Improvement
Cognitive-based learning
Healthcare-associated infections

There have been many tactics throughout the years aimed at reducing central line-associated bloodstream infections (CLABSI) in the healthcare setting. To reduce CLABSI rates at this facility, we employed cognitive science-based online training directed at nursing departments. Following implementation, we found significant reductions in CLABSI rates that were sustained for a minimum of 9 months. These results demonstrate that this learning methodology can be used to help decrease CLABSI and potentially other health care-associated infections.
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The average healthcare-associated central line-associated bloodstream infection (CLABSI) costs $48,108.[1] A CLABSI increases patient mortality by 12%- 25%.[2] Additionally, with the COVID-19 pandemic beginning in 2020, there was shown to be a significant increase in many hospital-associated infections, including CLABSIs.[3]

One strategy to reduce CLABSI is to increase staff, but this can be financially and operationally burdensome. While there are multiple other strategies for reducing CLABSI,[4] one alternative is to strategically place smart cards and standards-based signage near patient beds. The goal of these external memory aids is to reduce the burden on the caregivers' brains.

The present intervention, using training to introduce or reinforce concepts and procedures that support safe and effective central line placement and maintenance, was designed to strengthen those caregiver's brains. The training was delivered by an online e-learning platform designed to accommodate how people learn, remember, and forget.[5] The system presents questions and collects responses, then algorithmically determines whether and when to provide corrective feedback. Other algorithms in the training determine whether, when, and how to revisit material; learning is not complete until the platform has determined that all content has been mastered.

The purpose of this investigation was to determine the extent to which cognitive science-based online training can affect CLABSI rates.

METHODS

The participants were 541 registered nurses (RNs) at one hospital in the mountain west region of the United States of America. The participants included RNs that worked in various units, including the Emergency Department, Critical Care, Medical-Surgical, and Behavioral Health.

On July 5, 2020, the participants were assigned one CLABSI prevention training module containing 27 learning objectives. The assignment was delivered via the hospital's learner management system (LMS), which is the source of all online training that the participants receive. The training included important CLABSI prevention tactics with a focus on optimal maintenance of the central line.

The training module was announced via message in the LMS system, which was accompanied by a direct email from the Chief Nursing Officer that conveyed the importance of the training. The study participation window closed on September 3, 2020. A total of 536

* Address correspondence to Jessica Lowery, PhD, CIC, FAPIC Lutheran Medical Center, 8300 W 38th Ave, Wheat Ridge, CO 80033.

E-mail address: jessica.lowery@sclhealth.org (J. Lowery).

Conflict of Interest: Matthew Jensen Hays, PhD, is an employee of Amplifire, the software platform used to deliver the training. He is salaried; there is no direct monetary benefit to him from the work described or the publication thereof.

This quality improvement project was determined exempt from human subjects review by the systems' Institutional Review Board.

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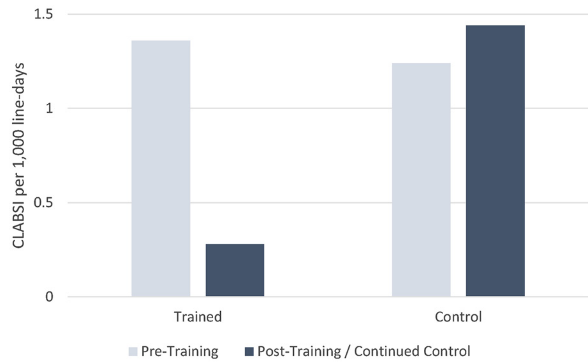

Fig 1. CLABSI per 1,000 line-days at the trained and control locations in the pre-training and post-training periods.

participants (99%) completed the training. The median training duration was 22.82 minutes (IQR: 16.56-33.85).

CLABSI incidences and line-days were evaluated using a pre-test post-test design with the seven other hospitals in the same health care system, where no training had been conducted, serving as a control group. The pre-training period was defined as November 2019 through June 2020. The training was conducted from July 2020 through September 2020, with the post-training period as of October 2020 through July 2021.

RESULTS

At the trained location, the pre-training period comprised 6,642 line-days. During that period, there were 9 CLABSI, yielding a rate of 1.36 CLABSI per 1,000 line-days. The post-training period comprised 7,180 line-days. During that period, there were 2 CLABSI, yielding a rate of 0.28 CLABSI per 1,000 line-days. Fig 1 depicts this 79% reduction in the CLABSI rate. A chi-squared test (with Yates's continuity correction) indicated that the pre-versus-post-training difference in CLABSI rates was statistically significant: $\chi^2 = 3.76$, $P = .05$.

At the control locations, the pre-training period comprised 23,306 line-days. During that period, there were 29 CLABSI, yielding a rate of 1.24 CLABSI per 1,000 line-days. The post-training period comprised 29,906 line-days. During that period, there were 43 CLABSI, yielding a rate of 1.44 CLABSI per 1,000 line-days. As expected, a chi-squared test indicated that there was no effect of training at the untrained control locations: $\chi^2 = 0.36$, $P = .55$.

Finally, a chi-squared test (with Yates's continuity correction) indicated that CLABSI rates in the trained and control groups were statistically significantly different in the post-training period: $\chi^2 = 5.49$, $P = .02$.

DISCUSSION

These data indicate that cognitive-science-based training can measurably impact CLABSI rates. The adaptive learning platform we used was able to modify and improve caregiver behavior in a way that substantially reduced the CLABSI rate.

The influence of training was durable, with a sustained absence of CLABSI for the first eight months post-training; the first CLABSI did not occur until June 2021. In contrast, in the pre-training period, the trained location never experienced a 3-month period without at least one CLABSI.

This finding is yet more notable given the dates during which these data were collected. Throughout this health system, several post-training months had proportional and substantial spikes in COVID hospitalizations. The increase in CLABSIs can be seen in the control group in Fig 1, and mirrors a nationwide trend, specifically a 46%-47% increase in CLABSI during Q3 and Q4 of 2020.[3]

More generally, the pandemic and the significant increase in COVID patients resulted in a greater proportion of high-acuity patients, with concomitantly higher risks of infection and other negative outcomes, including increased mortality risk in some cases. This COVID hospitalization increase was seen in all hospitals in this healthcare system, both the trained locations and the control groups. This change in patient population also increased the burden on the health care system's staff; compared to typical patients, COVID patients require significantly more attention over a longer period of time.[6] Multiple staff members faced burn-out and the changes in staffing related to increased patient load and new nurses that were unfamiliar with hospital protocols may have also led to these increases in CLABSI rates around the country.[6]

Nevertheless, the beneficial effects of the present intervention continued to manifest. Despite the burden felt by the health care workers, there was a high completion rate of the program. This can be attributed to the continued support and promotion of the training from Senior Leadership, indicating that the nursing staff understood and supported this initiative towards patient safety.

Without the training, we would have expected approximately ten CLABSI during the post-training period at the trained location – eight more than were observed. With a CLABSI mortality rate of 12%- 25%,[2] the training in this pilot program is estimated to have saved one to two lives. This illustrates the benefits of this cognitive-science-based training program on patient safety and infection prevention.

References

1. Agency for Healthcare Research and Quality. *Estimating the Additional Hospital Inpatient Cost and Mortality Associated With Selected Hospital-Acquired Conditions*. 2017. Accessed December 1, 2021. ahrq.gov/hai/pfp/haccost2017.html.
2. Centers for Disease Control and Prevention (CDC). Vital signs: central line-associated blood stream infections–United States, 2001, 2008, and 2009. *MMWR Morb Mortal Wkly Rep*. 2011;60:243–248.
3. Weiner-Lastinger LM, Pattabiraman V, Konnor RY, et al. The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: A summary of data reported to the National Healthcare Safety Network. *Infect Control Hosp Epidemiol*. 2022;43:12–25.
4. Yokoe DS, Anderson DJ, Berenholtz SM, et al. A compendium of strategies to prevent healthcare-associated infections in acute care hospitals: 2014 updates. *Infect Control Hosp Epidemiol*. 2014;35(S2):S21–S31.
5. Hays MJ, Glick AR, Lane HC. Leveraging cognitive science and artificial intelligence to save lives. *International Conference on Artificial Intelligence in Education*. Springer, Cham; 2019386–391.
6. Fakih MG, Bufalino A, Sturm L, et al. Coronavirus disease 2019 (COVID-19) pandemic, central-line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI): The urgent need to refocus on hardwiring prevention efforts. *Infect Control Hosp Epidemiol*. 2022;43:26–31.

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Original Article

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Reduction of central line-associated bloodstream infections in a large acute care hospital in Midwest United States following implementation of a comprehensive central line insertion and maintenance bundle

Abraham E Wei[1], Ronald J Markert[1], Christopher Connelly[2] and Hari Polenakovik[3]

Abstract

Background: Central line-associated bloodstream infection (CLABSI) is a preventable medical condition that results in increased patient morbidity and mortality. We describe the impact of various quality improvement interventions on the incidence of CLABSI in an 848-bed community teaching hospital from 1 January 2013 to 31 December 2017.

Aim: To reduce CLABSI rates after implementation of a comprehensive central line insertion and maintenance bundle.

Methods: A comprehensive bundle of interventions was implemented incorporating the standard US Centers for Disease Control and Prevention bundle with additional measures such as root-cause analysis of all CLABSI cases, use of passive disinfection caps on vascular access ports, standardisation of weekly central venous catheter (CVC) site dressing changes, and use of antithrombotic and antimicrobial-coated CVCs with fewer lumens. A retrospective study evaluated CLABSI rates and time of CLABSI onset after CVC placement in both intensive care unit (ICU) and non-ICU settings.

Results: The annual number of CLABSI cases declined 68% (34 to 11 patients) from 2013 to 2017. There was a 30% decline in CVC days from years 2014 to 2017. Over the same period, CLABSI cases per 1000 CVC days decreased from 0.624 to 0.362: a 42% decline.

Conclusion: Following the implementation of a comprehensive bundle of interventions for CVC insertion and maintenance, we found a reduction in rates of CLABSI.

Keywords

Central line-associated bloodstream infection, hospital-acquired infection, central venous catheter

Date received: 20 May 2020; accepted: 1 February 2021

Introduction

Central line-associated bloodstream infection (CLABSI) is a preventable medical condition that results in increased patient morbidity and mortality as well as increased medical costs. Among all types of healthcare-associated infections, CLABSIs have the highest mortality rate ranging from 12 to 25% (CDC, 2011). The cost per CLABSI averages US$70,696 with a range of US$40,412 to US$100,980 (AHRQ, 2012).

[1]Department of Internal Medicine, Wright State University Boonshoft School of Medicine, USA
[2]Department of Clinical Analytics, Miami Valley Hospital, USA
[3]Division of Infectious Diseases, Wright State University Boonshoft School of Medicine, USA

Corresponding author:
Abraham E Wei, Department of Internal Medicine, Wright State University Boonshoft School of Medicine, 128 East Apple Street, Dayton, OH 45409, USA.
Email: abraham.wei@wright.edu

The US Centers for Disease Control and Prevention (CDC) estimated that an average of 30,100 cases of CLABSI occurred annually from 2008 to 2013 in intensive care units (ICUs) and non-ICUs of acute care facilities in the USA. CLABSI rates decreased 46% during that five-year period (CDC, 2020), and the latest national study found a 9% decrease from 2017 to 2018 (CDC, 2018). While significant improvements in reducing CLABSIs have been achieved over the years, there remains thousands of CLABSI cases each year.

Some of the reduction in CLABSI rates can be attributed to the application of central line bundles (CDC, 2011), which are a set of interventions that should be implemented to prevent infection. Common components of bundles include hand hygiene (HH), skin antisepsis, use of maximal sterile barriers during central venous catheter (CVC) insertion and prompt removal of unnecessary lines. The CDC has recommended its bundle of interventions, and medical facilities have implemented their own modified CLABSI bundles. In our 848-bed hospital we instituted additions to our CLABSI bundle from January 2013 to December 2017. Our multidisciplinary approach involved collaboration among medical providers (physicians and physician extenders), nurses and infection prevention staff. Retrospective analysis evaluated the impact of these quality improvement interventions on CLABSI rates.

Methods

Both ICU and non-ICU CLABSI cases in our hospital's adult patient population from 1 January 2013 to 31 December 2017 were included in the study. Positive blood cultures with organisms on the CDC's National Healthcare Safety Network blood stream infection eligible organism list (CDC, 2020) that occurred in patients with a CVC were flagged and sent to infection prevention staff for investigation. Cases in the study met the CDC definition of CLABSI if the following criteria were met: (a) presence of a central line that intravascularly terminates at or close to the heart or in one of the great vessels; (b) central line in place for greater than two consecutive days following first access and in an inpatient location during current admission up until the day after removal from the body or patient discharge, whichever comes first; (c) no reported site-specific infection at another body site that has seeded the bloodstream. Cases were excluded if the patient was less than 18 years of age or a consulted infectious disease specialist deemed the source of infection to be definitely from somewhere other than a central line. Equivocal cases were included as CLABSI cases. The study protocol was approved by the Institutional Review Board at our institution (IRB No.: 06549).

Our CLABSI bundle included the main interventions listed in the CDC bundle checklist and additional measures listed in Table 1. Various methods were implemented to minimise the use of CVCs. To decrease the use of CVCs for venous access in difficult venepuncture cases, nurses were trained to put in peripheral venous lines via use of a vein finder. In addition, there was ongoing education of the medical staff on limiting the use of CVCs for routine blood draws. Medical providers ordering peripherally inserted central catheters (PICCs) were prompted with an order menu to specify a reason for ordering a CVC and to consider ordering a midline instead.

When a CLABSI event was identified, root-cause analysis (RCA) was completed promptly. If appropriate, re-education on CLABSI prevention was provided for medical staff involved in the event. An RCA established that triple lumen PICCs led to more venous thrombus formation and CLABSIs. Therefore, we started using Best Practice Advisory alerts within our electronic medical record system to encourage providers to order a catheter with fewer lumens when ordering a PICC. At around the same time, we advised the hospital logistics service to purchase and medical providers to use antithrombotic and antimicrobial-coated CVCs instead of standard poly-urethane CVCs as the former were shown to decrease CLABSI rates (Hockenhull et al, 2009; Long and Coulthard, 2006). PICC team feedback revealed antimicrobial-coated catheters were more slippery and difficult to handle compared to antithrombotic catheters (Angiodynamics BioFlo catheters); consequently, the latter was used. All non-PICC CVCs had antimicrobial coating; chlorhexidine-silver sulfadiazine-impregnated catheters (Arrowg+ard Blue Plus CVC) were used.

Curos™ port protectors were utilised to eliminate the need for nurses to scrub access ports for disinfection prior to use. This intervention was implemented after several RCAs showed that nursing staff were unable to consistently adhere to scrubbing of the catheter hub with isopropyl alcohol for the full 15 s in the setting of CLABSI cases that occurred $>$ 7 days after insertion. RCA also showed that a CLABSI was more likely to occur if the CVC site dressing had not been changed timely (by 7 days). Therefore, weekly CVC site dressing changes were implemented. They were scheduled for the same day of the week to increase standardisation and quality.

To reduce the incidence of blood culture contamination, nurses and phlebotomists were regularly educated not to draw blood cultures from CVCs unless explicitly stated. Computer screensavers were also implemented reminding the medical staff not to draw blood cultures from CVCs, as well as encouraging removal of CVCs when no longer needed. Data on the HH compliance rates and product-use metrics showed no significant change during the study period. Specifically, no intervention was done to improve the HH compliance rates during this study period.

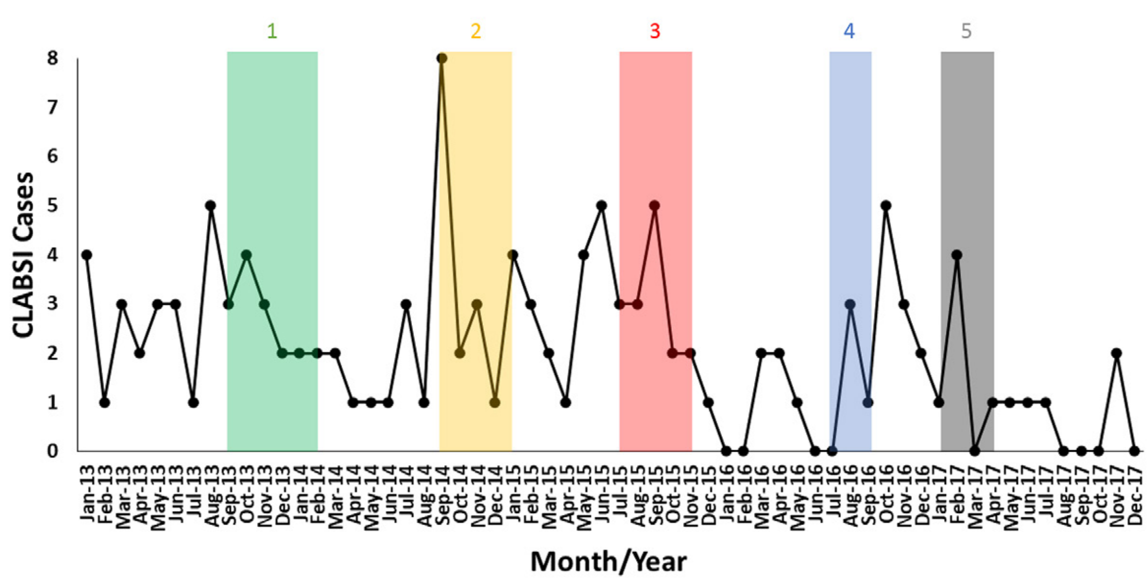
Figure 1 shows the time periods when various interventions were put in place and then continued indefinitely. Weekly unit-based RCA and medical staff education

Table 1. Components of the CLABSI bundle.

Insertion
• Hand hygiene before CVC insertion • Adhere to aseptic technique • Use maximal sterile barrier precautions • Avoid femoral site in obese patients • *Use of antimicrobial-coated non-PICC CVCs* • *Antithrombotic PICCs* • *Use of CVCs with fewer lumens* • *Reduced use of CVCs (Use midline catheters, if feasible)*
Maintenance
• Hand hygiene when handling CVCs • Use only sterile devices to access CVCs • Immediately replace dressings that are wet, soiled, or dislodged • Standardised weekly CVC site dressing changes • *Daily chlorhexidine bath for all patients with CVCs (including non-ICU patients)* • *Addition of Curos™ passive disinfection caps on vascular access ports*
Other
• Daily audits assessing need for CVCs • Educating healthcare personnel on proper insertion and maintenance of CVCs • *Root-cause analysis and re-education for each CLABSI case* • *Avoidance of blood culture draws from CVCs*

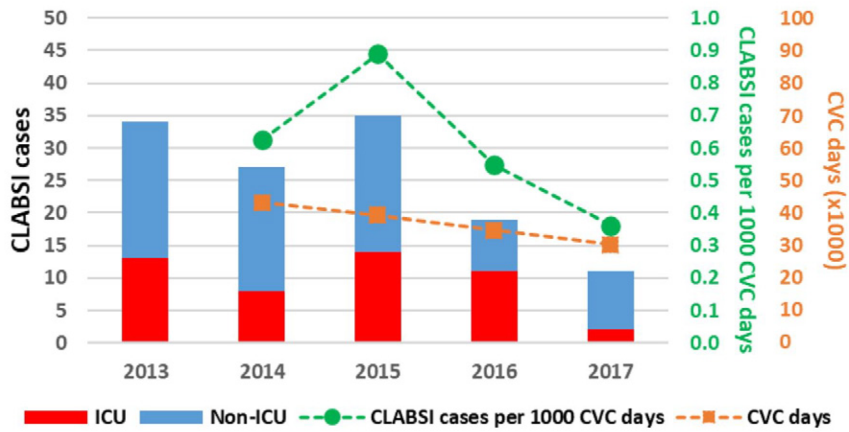
Italicised components are additional interventions not part of the CDC's CLABSI bundle.
CLABSI, central line-associated blood stream infection; CVC: central venous catheter; ICU, intensive care unit; PICC: peripherally inserted central catheter.

Figure 1. Monthly CLABSI cases and time periods for full implementation of various interventions. Interventions include: (1) using lower lumen PICCs, antithrombotic PICCs and antimicrobial-coated non-PICC CVCs; (2) weekly CVC site dressing change and peripheral venous line insertion training; (3) using Curos™ passive disinfection caps on CVC access sites; (4) using midlines instead of CVCs if feasible; (5) all patients with CVCs receive daily chlorhexidine gluconate baths.



CLABSI, central line-associated blood stream infection; CVC: central venous catheter; PICC: peripherally inserted central catheter.

Figure 2. CLABSI cases and CVC days from 2013 to 2017.



CLABSI, central line-associated blood stream infection; CVC: central venous catheter; ICU, intensive care unit.

(including use of screensavers) were implemented around 2013 and continued indefinitely. However, the content of the screensavers changed periodically and reflected the outcomes of RCA.

Yearly CLABSI rates per 1000 CVC days were examined using MedCalc® comparison of two rates (Sahai and Khurshid, 1996). Time of CLABSI onset after catheter placement was analysed according to year, ICU v. non-ICU settings, and catheters with different number of lumens. Time to CLABSI onset was investigated with the Mann–Whitney Test using IBM SPSS Statistics 25.0 (IBM, Armonk, NY). We also analysed the microbial aetiologies of CLABSI cases. A tally of each microbial aetiology was completed according to year of infection and whether it occurred in an ICU or non-ICU setting.

Results

During the study period 126 CLABSI cases were identified. Infectious disease specialists excluded two cases in 2013, five annually from 2014 to 2016 and three in 2017. The number of CLABSI cases per year in both ICU and non-ICU settings is shown in Figure 2. There was a 67.6% decline in number of CLABSI cases from 34 to 11 patients between 2013 and 2017.

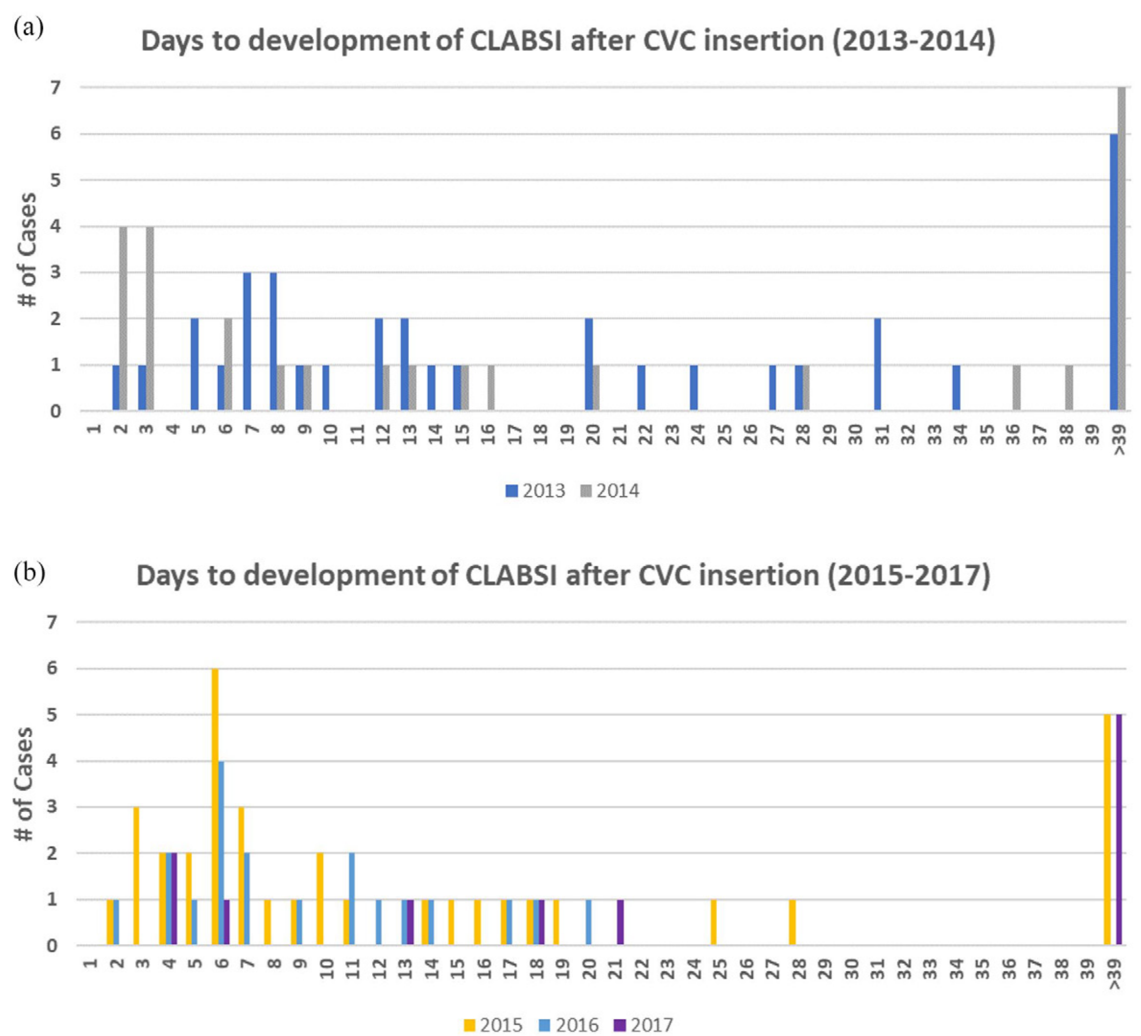
CVC days decreased from 43,240 in 2014 to 30,361 in 2017, a decline of 4293 CVC days per year and a total reduction of 29.8% (Figure 2). Data for 2013 were not available in the medical records system. The decrease in CVC days was likely due to lower utilisation of CVCs after training nursing staff to insert peripheral venous lines via a vein finder and encouraging medical providers to order midlines instead of CVCs when feasible. CLABSI cases per 1000 CVC days decreased 42% from 0.624 to 0.362 from 2014 to 2017 ($p = 0.12$) (Figure 2). There was a 59% decline from 2015 to 2017, from 0.889 CLABSI cases per 1000 CVC days to 0.362 per 1000 CVC days ($p = 0.007$). Device utilisation ratio (i.e. number of central line days divided by number of patient days) from 2014 to 2017 was 0.210, 0.179, 0.172 and 0.162, respectively.

The number of cases by time of CLABSI onset after catheter placement is shown in Figure 3. When separating cases by time of CLABSI onset (< 7 days v. $\geqslant 7$ days), the yearly results were: 5 v. 29 (2013); 10 v. 17 (2014); 14 v. 21 (2015); 8 v. 11 (2016); and 3 v. 8 (2017). The mean time of CLABSI onset in the ICU and non-ICU setting was 9.04 (SD 6.98) days and 55.27 (SD 144.31) days ($p < 0.001$). When excluding cases with time of CLABSI onset > 60 days, the mean time of CLABSI onset for ICU cases remained the same while non-ICU cases decreased to 14.05 (SD 9.09) days ($p = 0.006$).

Mean time of CLABSI onset for CVCs with two lumens v. CVCs with three lumens was 31.47 (SD 67.48) days and 11.88 (SD 12.49) days ($p = 0.11$). Excluding cases with CLABSI onset after 60 days of CVC insertion, time to CLABSI onset was 13.97 (SD 11.90) days and 9.84 (SD 7.02) days ($p = 0.17$). For the 78 two-lumen CVCs, 55 (71%) were PICCs and 52 (67%) were in the ICU. For the 26 three-lumen CVCs, two (8%) were PICCs and 12 (46%) were in the ICU. Only three cases utilised four-lumen CVCs, and all were non-PICC CVCs and in the ICU. Their time of CLABSI onset after catheter insertion was 4 (SD 2) days.

Supplementary appendix 1 lists the CLABSI cases by microbial aetiology. Some CLABSI cases had more than one pathogen. The percent of cases caused by *Staphylococcus epidermidis* from 2013 to 2017 were 15, 27, 35, 9 and 8%, respectively; for *Enterococcus* spp.: 20, 8, 8, 3, 0; for *Klebsiella* spp.: 15, 10, 8, 5, 0%; and for Candida and other yeast: 10, 13, 13, 5, 3%. ICU and non-ICU did not differ significantly in incidence of specific pathogens.

Figure 3. Central line-associated blood stream infection time of onset after central venous catheter placement for (a) 2013–2014 and (b) 2015–2017.



Discussion

CLABSI cases decreased after our bundle of interventions was instituted. Much of the reduction may have been due to CVC management, that is minimising unneeded CVC insertions and promptly removing unnecessary CVCs. Our addition of interventions beyond those recommended by the CDC may have led to one of the lowest CLABSI rates (0.36 per 1000 CVC days) reported in the literature to date. Salm et al (2018) and Ong et al (2011) reported modestly lower CLABSI rates, 0.2 and 0.3 per 1000 CVC days, respectively. Others have reported CLABSI rates ranging from 0.50 to 10 per 1000 CVC days (Han et al, 2010; Patel et al, 2018; Son et al, 2012). The CDC reported the average US rate to be 1.65 and 1.14 CLABSI per 1000 CVC days in the ICU and inpatient wards, respectively (CDC, 2011). However, most recent data showed substantial progress in reduction of CLABSI rates has been achieved across the US hospital over the past decade with the incidence decreasing from 1.6 cases per 1000 CVC days in 2009 to 0.9 cases per 1000 CVC days in 2018 (Nkwata et al, 2020).

In our study, CLABSI cases decreased as years advanced except for 2015. The increase in CLABSI cases in 2015 cannot be explained by greater CVC utilisation since CVC days decreased from the year prior. Chart review of providers who inserted CVCs leading to a CLABSI event that year did not find any repeat cases. RCA revealed that a possible explanation is that chlorhexidine gluconate (CHG) biopatch protective disks were replaced by Tegaderm CHG intravenous securement dressings in early 2015 due to cost concerns. Nursing staff reported having initial difficulty removing the old Tegaderm CHG dressing because the gel pad would stick to the CVCs and partially pull the catheter out of the insertion site. RCA revealed that at times the nursing staff would try to push the CVCs back into their original position, likely introducing infection into the CVC insertion site. In response, the nursing staff were re-educated and two-person dressing change teams were deployed to better handle the CVC site dressing changes. Fewer complications were reported afterwards.

Many of our interventions were rolled out simultaneously over an extended period in an effort to further decrease CLABSI rates; therefore, it was difficult to associate specific interventions with a change in CLABSI rate for a yearly time period. Review of the CLABSI cases occurring soon after CVC insertion and seven days or later suggests both insertion and maintenance aspects of the bundle of interventions played a role in decreasing CLABSI cases. Usually, development of CLABSI soon after catheter insertion suggests an extraluminal source of infection due to inadequate skin antisepsis, whereas delayed CLABSI development is a failure of maintenance interventions such as intraluminal colonisation from access port contamination (Chopra, 2020; Ryder, 2006).

The use of antithrombotic and antimicrobial-coated CVCs may have contributed to the decrease in CLABSI rates. After full implementation of these interventions by February 2014, CLABSI cases decreased from 34 in 2013 to 27 in 2014. Further analysis showed that CLABSI cases with onset $\geqslant$ 7 days declined notably from 29 to 17 during this period, suggesting that the use of antithrombotic and antimicrobial-coated CVCs may have decreased intraluminal colonisation. We used Angiodynamics BioFlo antithrombotic PICCs, which yield low thrombosis and infection rates (McDiarmid et al, 2017). Other antithrombotic CVCs, such as those with heparin-coating, also reduce the incidence of catheter-related thrombosis and infection, problems that can interact synergistically (Long and Coulthard, 2006). It is likely that thrombus and fibrin sheath development provide a *nidus* for growth of bacteria, and, in turn, infection can cause an inflammatory response activating the local coagulation system (Ibeas-Lopez, 2015). Antimicrobial-coated CVCs are also effective in preventing bloodstream infections, especially amongst patients in ICUs and with specific comorbidities such as burns or neutropenia (Hockenhull et al, 2009; Ibeas-Lopez, 2005; Lai et al, 2016). These studies and our current investigation suggest that antithrombotic and/or antimicrobial-coated CVCs be included as part of the standard CLABSI bundle of interventions. Chlorhexidine-silver sulfadiazine, rifampin–minocycline, silver–platinum–carbon are some of the more commonly used antimicrobial coating options.

We found an increase in time to CLABSI onset when using CVCs with fewer lumens. This finding held even when excluding cases where the time to onset of CLABSI was greater than 60 days, in a group that included tunnelled catheters. Thus, our use of CVCs with fewer lumens may have helped to reduce the number of CLABSI cases by delaying onset of infection before CVCs were removed at the end of usage. Although the difference in time to CLABSI onset between the groups was not statistically significant, had the sample size been larger, we may have been able to claim otherwise. Chopra et al also found that CVCs with fewer lumens were associated with decreased rates of infection and later onset (Chopra et al, 2014). Others have shown that larger CVCs with more lumens risk intimal vessel injury with activation of coagulation cascade leading to increased incidence of thrombosis (Evans et al, 2010; Wall et al, 2016) and associated infection (Dezfulian et al, 2003; Templeton et al, 2008). However, in our study this relationship may not be clear-cut since many of our CLABSI cases with two-lumen CVCs also had greater utilisation of PICCs when compared to CLABSI cases with three- and four-lumen CVCs.

Similar to previous studies, our use of alcohol-impregnated port protectors (e.g. Curos™ caps) likely helped decrease our CLABSI rates (Danielson et al, 2014; Merrill et al, 2014; Sumner et al, 2013; Sweet et al, 2012). After this intervention was implemented, CLABSI cases decreased decidedly in 2016. The considerable drop for CLABSI cases with onset $\geqslant$ 7 days suggests decreased intraluminal colonisation with the use of Curos™ caps. Traditional disinfection of intravenous access ports entails scrubbing the top and sides of catheter hubs with chlorhexidine and alcohol for 15 s and then waiting for the hub to dry before port access. The technical demands and time requirements of traditional disinfection make it difficult to obtain completely successful implementation in the long term. The passive disinfection of Curos™ caps eliminates the "scrub the hub" requirement and decreases the chance of operator error.

After institution of daily CHG baths for patients with CVCs in early 2017, rates of CLABSI declined from 19 in 2016 to 11 in 2017. The number of CLABSI cases with onset $<$7 days suggests decreased extraluminal colonisation attributable to the daily CHG baths. Prior studies found significant decreases in CLABSI rates with this intervention (Climo et al, 2013; Bleasdale et al, 2007).

In 2017 there continued to be a handful of CLABSI cases from CVCs in place greater than 39 days (Figure 3(b)). RCA showed one case to be due to a PICC left in place unnecessarily for 40 days. The other four cases were due to a tunnelled haemodialysis (HD) catheter and three port-a-catheters; three of these cases grew *Staphylococcus aureus*. RCAs of these cases disclosed irregularity in the routine CVC dressing changes. Typically, the port-a-catheters and HD catheter dressing changes were not done by the unit nursing staff, but by a specialised IV therapy team and HD/plasmapheresis staff, respectively. Subsequently, an improved communication plan was developed between these services and the unit nursing staff to ensure timely dressing changes for these types of CVCs.

This study has several limitations. First, this investigation was conducted at a single institution. Thus, our findings may not be generalisable to other hospitals. Nevertheless, we believe that hospital practice philosophies are similar, and implementation of interventions can be applied successfully in diverse medical systems. Second, many of our interventions were implemented simultaneously, making it difficult to attribute improvement in CLABSI rates to any single intervention. However, the goal of our study was to evaluate the effectiveness of our bundle of interventions in changing CLABSI rates.

Conclusions

After implementation of a comprehensive bundle of interventions for CVC insertion and maintenance, CLABSI rates decreased. A multidisciplinary approach with additional measures such as the use of antithrombotic or antimicrobial-coated CVCs with fewer lumens resulted in CLABSI rates lower than or comparable to earlier reports. Our findings support the use of a comprehensive bundle of interventions to reduce the incidence of this preventable hospital-acquired infection that has high morbidity and mortality.

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ORCID iD

Abraham E Wei https://orcid.org/0000-0003-3192-2975

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References

AHRQ (2012) Eliminating CLABSI, A National Patient Safety Imperative. Available at: www.ahrq.gov/sites/default/files/publications/files/clabsifinal.pdf (accessed 5 May 2020).

Bleasdale SC, Trick WE, Gonzales IM, Lyles RD, Hayden MK and Weinstein RA (2007) Effectiveness of chlorhexidine bathing to reduce catheter-associated bloodstream infections in medical intensive care unit patients. *Archives of Internal Medicine* 167(19): 2073–2079.

CDC (2011) Vital signs: central line-associated bloodstream infection – United States, 2001, 2008, and 2009. *Morbidity and Mortality Weekly Report* 60(8): 243–248.

CDC (2018) Current HAI Progress Report, 2018 National and State Healthcare-Associated Infections Progress Report. Available at: www.cdc.gov/hai/data/portal/progress-report.html (accessed 5 May 2020).

CDC (2020) Bloodstream Infection Event (Central Line-Associated Bloodstream Infection and Non-central Line Associated Bloodstream Infection). Available at: www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf (accessed 5 May 2020).

Chopra V, Ratz D, Kuhn L, Lopus T, Chenoweth C and Krein S (2014) PICC-associated bloodstream infections: prevalence, patterns, and predictors. *American Journal of Medicine* 127(4): 319–328.

Chopra V (2020) Central line-associated bloodstream infection (CLABSI): An introduction. Available at: www.cdc.gov/infectioncontrol/pdf/strive/CLABSI101-508.pdf (accessed 5 May 2020).

Climo MW, Yokoe DS, Warren DK, Perl TM, Bolon M, Herwaldt LA, Weinstein RA, Sepkowitz KA, Jernigan JA, Sanogo K and Wong ES (2013) Daily chlorhexidine bathing-effect on healthcare-associated BSI and MDRO acquisition. *New England Journal of Medicine* 368(6): 533–542.

Danielson B, Williamson S, Kaur G and Johnson N (2014) A significant decline in central line-associated blood stream infections using alcohol-impregnated port protectors at a large non-profit acute hospital. *American Journal of Infection Control* 42(6): S16.

Dezfulian C, Lavelle J, Nallamothu BK, Kaufman SR and Saint S (2003) Rates of infection for single-lumen versus multilumen central venous catheters: a meta-analysis. *Critical Care Medicine* 31(9): 2385–2390.

Evans RS, Sharp JH, Linford LH, Lloyd JF, Tripp JS, Jones JP, Woller SC, Stevens SM, Elliott CG and Weaver LK (2010) Risk of symptomatic DVT associated with peripherally inserted central catheters. *Chest* 138(4): 803–810.

Han Z, Liang SY and Marschall J (2010) Current strategies for the prevention and management of central line-associated bloodstream infections. *Infection and Drug Resistance* 3: 147–163.

Hockenhull JC, Dwan KM, Smith GW, Gamble CL, Boland A, Walley TJ and Dickson RC (2009) The clinical effectiveness of central venous catheters treated with anti-infective agents in preventing catheter-related bloodstream infections: a systematic review. *Critical Care Medicine* 37(2): 702–712.

Ibeas-Lopez J (2015) New technology: heparin and antimicrobial-coated catheters. *Journal of Vascular Access* 16(Suppl 9): S48–S53.

Nkwata A, Soe M, Li Q, Godfrey-Johnson D, Edwards J and Dudeck M (2020) Incidence trends of central-line-associated bloodstream infections in acute-care hospitals, NHSN, 2009–2018. *Infection Control & Hospital Epidemiology* 41(S1): S294–S295.

Lai NM, Chaiyakunapruk N, Lai NA, O'Riordan E, Pau WS and Saint S (2016) Catheter impregnation, coating or bonding for reducing central venous catheter-related infections in adults. *Cochrane Database Systematic Reviews* 3(3): CD007878.

Long DA and Coulthard MG (2006) Effect of heparin-bonded central venous catheters on the incidence of catheter-related thrombosis and infection in children and adults. *Anaesthesia and Intensive Care* 34(4):481–484.

McDiarmid S, Scrivens N, Carrier M, Sabri E, Toye B, Heubsch L and Fergusson D (2017) Outcomes in a nurse-led peripherally inserted central catheter program: a retrospective cohort study. *CMAJ Open* 5(3); E535–E539.

Merrill KC, Sumner S, Linfold L, Taylor C and Macintosh C (2014) Impact of universal disinfectant cap implementation on central line-associated bloodstream infections. *American Journal of Infection Control* 42(12): 1274–1277.

Ong A, Dysert K, Herbert C, Laux L, Granato J, Crawford J, Rodriguez A and Cortes V (2011) Trends in central line-associated bloodstream infections in a trauma-surgical intensive care unit. *Archives of Surgery* 146(3): 302–307.

Patel PK, Gupta A, Vaughn VM, Mann JD, Ameling JM and Meddings J (2018) Review of strategies to reduce central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) in adult ICUs. *Journal of Hospital Medicine* 13: 105–116.

Ryder M (2006) Evidence-based practice in the management of vascular access devices for home parenteral nutrition therapy. *Journal of Parenteral and Enteral Nutrition* 30(Suppl 1): S82–S93, S98–S99.

Sahai H and Khurshid A (1996) *Statistics in Epidemiology: Methods, techniques, and applications*. Boca Raton, FL: CRC Press.

Salm F, Schwab F, Behnke M, Brunkhorst FM, Scherag A, Geffers C and Gastmeier P (2018) Nudge to better care – blood cultures and catheter-related bloodstream infections in Germany at two points in time (2006, 2015). *Antimicrobial Resistance and Infection Control* 7: 141.

Son CH, Daniels TL, Eagan JA, Edmond MB, Fishman NO, Fraser TG, Kamboj M, Maragakis LL, Mehta SA, Perl TM, Phillips MS, Price CS, Talbot TR, Wilson SJ and Sepkowitz KA (2012) Central line-associated bloodstream infection surveillance outside the intensive care unit: a multicenter survey. *Infection Control & Hospital Epidemiology* 33(9): 869–874.

Sumner S, Merrill KC, Linford L and Taylor C (2013) Decreasing CLABSI rates and cost following implementation of a disinfectant cap in a tertiary care hospital. *American Journal of Infection Control* 41(6): S37.

Sweet MA, Cumpston A, Briggs F, Craig M and Hamadani M (2012) Impact of alcohol-impregnated port protectors and needless neutral pressure connectors on central line-associated bloodstream infections and contamination of blood cultures in an inpatient oncology unit. *American Journal of Infection Control* 40(10): 931–934.

Templeton A, Schlegel M, Fleisch F, Rettenmund G, Schobi B, Henz S and Eich G (2008) Multilumen central venous catheters increase risk for catheter-related bloodstream infection: prospective surveillance study. *Infection* 36(4): 322–327.

Wall C, Moore J and Thachil J (2016) Catheter-related thrombosis: a practical approach. *Journal of Intensive Care Society* 17(2): 160–167.

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Major Article

Using the Comprehensive Unit-based Safety Program model for sustained reduction in hospital infections

Kristen Miller DrPh, MSPH [a,*], Carol Briody MT (ASCP), CIC [b], Donna Casey BSN, MA, RN, FABC, NE-BC [c], Jill K. Kane BSN, RN, CCRN [d], Dannette Mitchell MSN, APRN, ACNS-BC, CCRN [e], Badrish Patel MD [d], Carol Ritter MSN, RN, CCRN, CNML [d], Maureen Seckel APN, MSN, ACNS-BC, CCNS, FCCM [d], Sandy Wakai MSN, RN, CCRN [f], Marci Drees MD, MS [a,b]

[a] *Value Institute, Christiana Care Health System, Newark, DE*
[b] *Infection Prevention, Christiana Care Health System, Newark, DE*
[c] *Patient Care Services, Cardiovascular and Critical Care, Christiana Care Health System, Newark, DE*
[d] *Medical ICU, Christiana Care Health System, Newark, DE*
[e] *Medical ICU, Wilmington Hospital, Wilmington, DE*
[f] *Joint Replace Center, Wilmington Hospital, Wilmington, DE*

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Comprehensive Unit–based Safety Program
catheter infections
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safety culture

Background: Prompted by the high number of central line–associated bloodstream infections (CLABSIs), our institution joined the national On the CUSP: Stop BSI initiative. We not only report the significant impact that the Comprehensive Unit-based Safety Program (CUSP) had in reducing CLABSI, but also report catheter-associated urinary tract infections (CAUTIs) and ventilator-associated pneumonia (VAP) in 2 intensive care units (ICUs).

Methods: At our community-based academic health care system, 2 ICUs implemented CUSP tools and developed local interventions to reduce CLABSI and other safety problems. We measured CLABSI, CAUTI, and VAP during baseline, the CUSP period, and a post-CUSP period.

Results: CLABSIs decreased from 3.9 per 1,000 catheter days at baseline to 1.2 during the CUSP period to 0.6 during the post-CUSP period (rate ratio, 0.16; 95% confidence interval [CI], 0.07-0.35). CAUTIs decreased from 2.4 per 1,000 patient days to 1.2 during the post-CUSP period (rate ratio, 0.4; 95% CI, 0.24-0.65). VAP rate decreased from 2.7 per 1,000 ventilator days to 1.6 during the CUSP and post-CUSP periods (rate ratio, 0.58; 95% CI, 0.30-1.10). Device utilization decreased significantly in both ICUs.

Conclusions: Implementation of CUSP was associated with significant decreases in CLABSI, CAUTI, and VAP. The CUSP model, allowing for implementation of evidence-based practices and engagement of frontline staff, creates sustainable improvements that reach far beyond the initial targeted problem.

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For over a decade, the Comprehensive Unit-based Safety Program (CUSP) model, a multifaceted approach to patient safety, has empowered units to take action by aligning culture change and quality improvement models.[1] Implementation of this model has resulted in a dramatic and sustained decrease in central line–associated bloodstream infection (CLABSI) rates, with sustained improvements.[2,3] Among health care–associated infections, CLABSI was initially the major focus of CUSP because of high morbidity and mortality,[4,5] excess cost,[6-8] and a greater understanding of evidence-based prevention measures compared with other types of infections. However, the CUSP model can, and is intended to, be applied to any patient safety issue. CUSP is sufficiently structured to provide a strategy for health care organizations to improve culture and learn from mistakes, but is flexible enough for units to focus on risks that they perceive as most important, given their context. Subsequent evaluations of CUSP demonstrate improved safety and teamwork climate,[9] decreased nursing turnover, and decreases in other health care–associated infections.[10-12]

Since the initial project describing CUSP success with CLABSI, the CUSP model has been applied in intensive care units (ICUs) to reduce

* Address correspondence to: Kristen Miller, DrPh, MSPH, Value Institute, Christiana Care Health System, John H. Ammon Medical Education Center, 4755 Ogletown-Stanton Rd, 2nd FL, Office 2E61C, Newark, DE 19718.

E-mail address: Krmiller@christianacare.org (K. Miller).

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infections nationwide, initially focusing on CLABSI but then expanding to develop and implement interventions to reduce catheter-associated urinary tract infection (CAUTI)[13] and, most recently, ventilator-associated pneumonia (VAP) and other complications of mechanical ventilation.[14] In each of these initiatives, there is a well-described distinction between the technical work (ie, evidence-based practices to decrease infections) and adaptive work (ie, change in culture, communication, teamwork, and other practices necessary to sustain behavior change and infection reduction). Implementation of CUSP demonstrated that most CLABSI are preventable through consistent application of evidence-based practices, and these reductions can be sustained over extended periods of time.[3]

Based on the prior success of CUSP implementation, the Agency of Healthcare Research and Quality funded the On the CUSP: Stop BSI initiative and challenged state hospital associations nationally to reduce CLABSI rates to <1 per 1,000 central line days, and in 2009, the U.S. Department of Health and Human Services set a national goal for a 50% reduction in CLABSI by 2013.[3] The On the CUSP: Stop BSI initiative was implemented in sequential groups of state hospital associations who were tasked with enrolling at least 15 hospitals in their state to participate in the collaborative. In 2010, cohort 4 of CUSP was launched statewide in Delaware, with full participation in 100% of acute care hospitals (n = 8) and a total of 14 CUSP unit teams.[15]

Christiana Care Health System (CCHS) joined the On the CUSP: Stop BSI initiative, prompted in part by high CLABSI rates in one ICU in particular, in addition to implementing other complementary systemwide initiatives. Despite significant improvement compared with 2004-2005, CLABSI rates at CCHS had increased beginning in mid-2009. This study describes the impact of CUSP implementation in 2 CCHS ICUs, the Wilmington intensive care unit (WICU) and the Christiana Hospital medical intensive care unit (MICU), that participated in the On the CUSP: Stop BSI initiative.

METHODS

Setting

CCHS, headquartered in Wilmington, Delaware, is one of the country's largest health care providers, ranking 22nd in the nation for hospital admissions with >53,000 annually. A not-for-profit, nonsectarian community-based academic health system, CCHS includes 2 major teaching hospitals with >1,100 patient beds and 5 adult ICUs. CCHS is the major health care provider in Delaware, with approximately 50% of the hospitalizations statewide and 90% of the adult non–Veterans Affairs hospitalizations in the county. CCHS is 1 of 8 Delaware hospitals that participated in the On the CUSP: Stop BSI initiative.

The WICU, a 9-bed closed unit at the smaller Wilmington Hospital, provides services to a diverse mix of adult medical and surgical patients. The WICU is unique as the only ICU on the Wilmington Hospital campus. The MICU, a 22-bed closed unit located at Christiana Hospital, cares for medical critical care patients. Case mix data for 2015 (MICU: 2.698, WICU: 2.389) and top diagnoses (eg, septicemia or severe sepsis; respiratory system diagnosis with ventilator support) indicate the 2 units are similar in patient acuity. The health care provider team for both units consists of intensivists on site, resident coverage, and critical care physician assistants, along with a tele-ICU model allowing remote critical care nursing and physician supervision. The WICU and MICU share intensivists that rotate on a weekly basis, 2 of which are medical directors for the units, and physician assistants that rotate on a regular basis. There is no crossover for nursing management and staff. In addition to the delivery of expert patient care, critical care coverage extends outside the boundaries of these units, including response to code blues and rapid responses throughout the campus. The units participate in a medical critical care leadership group which is a collaborative of the 2 units to work on major goals that would be the same for each unit.

CUSP development

Leadership and physician engagement were key components in CUSP development. Enrollment in the On the CUSP: Stop BSI initiative required CCHS leadership support and stakeholder engagement, including support from the chief executive officer. The infection prevention department oversaw program participation and worked with senior leadership to identify an executive champion for each participating ICU. At the onset of the project, each unit formed their CUSP team, including a team leader, physician champion, executive champion, nurse manager, infection preventionist, and a multidisciplinary team of nurses, nurse educators, respiratory therapists, and vascular access nurses. As needed, team members from other departments (eg, emergency department, hemodialysis, respiratory) were invited to be members. To take full advantage of the transdisciplinary nature of CUSP, CCHS engaged a variety of stakeholders to implement evidence-based practices, including information technology, the virtual education and simulation training center, clinical engineering, logistics, and environmental services.

CCHS participated in the On the CUSP: Stop BSI initiative from July 2010-June 2012. The CUSP framework is comprised of 5 steps: train staff in the science of safety; engage staff to identify defects; senior executive partnership and patient safety rounds; continue to learn from defects; and implement tools to improve teamwork and communication. The specific goals of CUSP implementation at CCHS were to work toward eliminating CLABSI, aiming for a target of zero CLABSI per 1,000 central line days, to improve the culture of safety by 50% based on the Agency of Healthcare Research and Quality Hospital Survey on Patient Safety Culture, and to learn from all defects. The CUSP teams underwent the initial On the CUSP: Stop BSI Web-based immersion program to learn the science of safety, CUSP principles and tools, and CLABSI prevention and conducted a baseline culture of safety survey and staff safety assessment.

Interventions

The CUSP teams implemented many efforts to help set the expectation of zero CLABSI, including but not limited to, CUSP training and the technical strategies endorsed by On the CUSP: Stop BSI. These initiatives may be grouped into distinct categories: culture change, learning from experience, observation, evidence-based practice, and education (Fig 1). Units participated in monthly meetings to review current practice, discuss evidence-based practice for infection prevention and strategies for implementation, and perform gap analysis at a unit level. This interdisciplinary gathering provided opportunities to investigate each defect using an internally developed CLABSI investigation tool to conduct a root cause analysis of any identified CLABSI. All infections were reported at CUSP monthly meetings, and each defect was thoroughly investigated. The resulting actions were foundational (actions that depend on staff to remember their training or remember what is written in policy), including education, training, and demonstration; intermediate (actions somewhat dependent on staff remembering to do the right thing, but they provide tools to help staff to remember or to promote clear communication), including electronic checklists; and strong (actions that do not depend on staff to remember to do the right thing; the action may not totally eliminate the vulnerability but provide very strong controls), including a central line cart and nurse in room for every line insertion and executive unit rounding. Unit-level gap analysis and investigations of any CLABSIs revealed line maintenance as the primary opportunity for eliminating CLABSI. The team undertook

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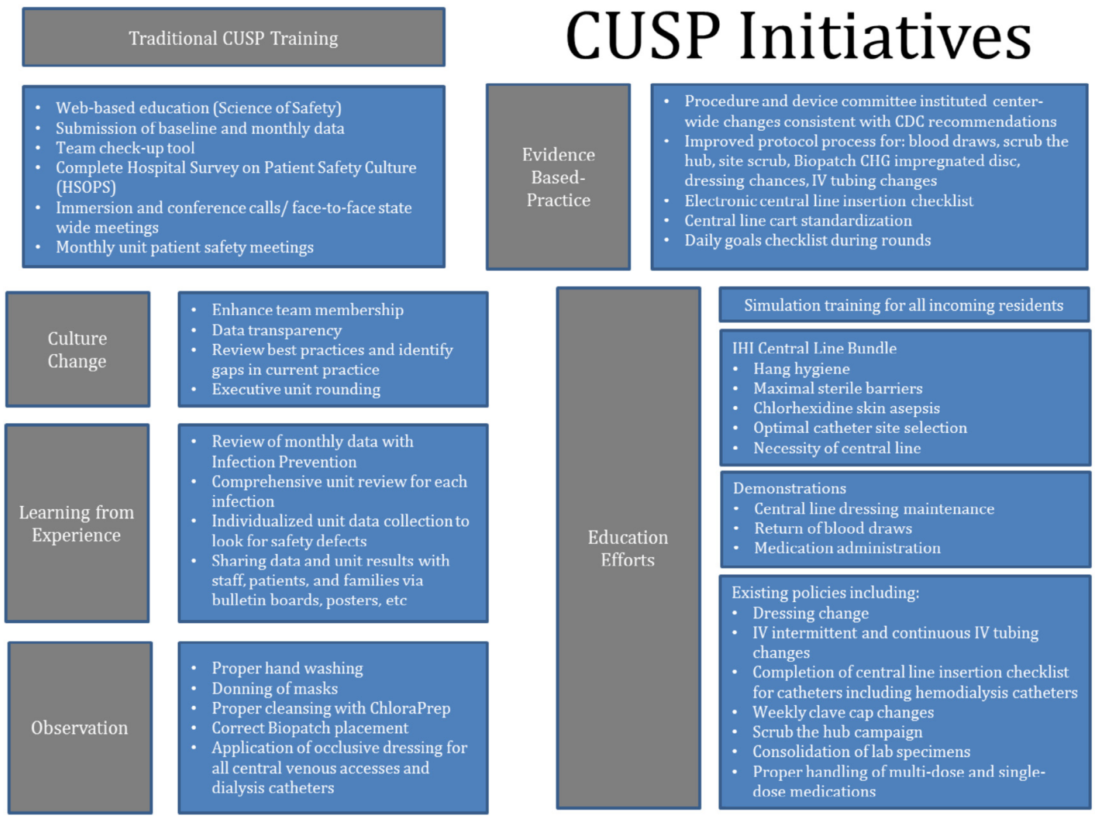

Fig 1. Initiatives implemented during the CUSP period. *CDC*, Centers for Disease Control and Prevention; *CHG*, chlorhexidine gluconate; *CUSP*, Comprehensive Unit-based Safety Program; *IHI*, Institute for Healthcare Improvement; *IV*, intravenous.

standard of care and culture modifications to adopt evidence-based practices related to insertion and maintenance.

Two systemwide initiatives, in particular, required multidisciplinary efforts that were facilitated via the CUSP teams: a central line checklist and inclusion of nurses in the placement process. All teams put forth major effort to implement a central line insertion checklist to require an independent observer to ensure that all nonemergent central lines were placed under full sterile conditions (and to empower the observer to halt the procedure if necessary). The CCHS's infection prevention department had previously developed a paper-based central line insertion checklist that was fairly detailed but infrequently completed. Given On the CUSP: Stop BSI's focus, the device and procedure-related infection task force (a subcommittee of the infection prevention committee) worked with the CUSP teams and information technology to rapidly develop a simpler electronic version (implemented in October 2010). More importantly, the CUSP teams worked together to ensure that nurses were notified when central lines were about to be placed so they could be present; and nurses were empowered to stop the procedure if any aspect of the checklist was overlooked. Based on another On the CUSP: Stop BSI recommendation, task force members, ICU staff, and logistics staff sought to improve the central line placement process by developing standardized carts specific to the insertion needs. An iterative process was used with staff in each unit to determine the optimal supplies needed.

Several other technology solutions were piloted and ultimately adopted by CCHS systemwide during the CUSP period, via the ICU CUSP teams. The first was BioPatch (Ethicon, Johnson & Johnson, Somerville, NJ), a chlorhexidine gluconate–impregnated disk that surrounds the central line exit site, limiting bacterial growth and reducing infections.[16,17] Because the CUSP teams noted that many infections were occurring later, therefore suggesting maintenance issues, Site-Scrub (CR Bard, Murray Hill, NJ) was adopted to improve nurses' ability to effectively scrub the hub prior to accessing every central line.[18] The successful implementation of each of these technologies was heavily dependent on the CUSP teams' input and feedback.

In addition to these 2 initiatives, the units focused on improving culture. In our experience, CLABSI reduction requires a change in culture among interprofessional staff. We educated staff regarding current evidence-based recommendations for CLABSI prevention and engaged them in efforts to adapt CUSP based on local needs and to develop sustainable interventions. For example, units developed a multidisciplinary daily rounding tool to identify central line utilization and management practices. Between 2009 and 2010, the units introduced a performance improvement monitoring process that helped track progress of actionable items identified as impacting patient safety. Examples of actionable items include assessing central lines for dressing change information and intactness, labeling of intravenous catheters and intravenous tubing, and hand hygiene. Every staff member assumed responsibility for monitoring adherence with an evidence-based recommendation, shared responsibility and authority to coach colleagues if they identified opportunities to improve. This approach led to a unit-level culture of accountability and ownership of outcomes (both positive and negative). Although the units' initial focus was on CLABSI prevention, over time the CUSP teams evolved a CUSP-like approach to other infection types, including CAUTI, and other safety issues in their units.

Similar to discussions of each CLABSI, the teams held discussions regarding CAUTI incidents at monthly meetings, and with the help of the infection prevention team, investigated each infection

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and developed interventions to assist with barriers. Every nurse was provided education on cleaning the patient prior to catheter insertion and every 8-hours. Additionally, the team reinforced the use of leg straps and early removal and assessed the need when the order was written. These specific project items became part of the performance improvement monitoring process. VAP has been addressed consistently in the critical care setting, including data collection, monitoring, and daily round discussion. The units ensured that specific project items, such as elevation, teeth brushing, and oral suctioning, were included in the same discussion as other harm prevention measures.

Data collection

CCHS has been a participant in the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) since 1995, and each ICU had a certified infection preventionist who determined CLABSI or CAUTI infection rates using NHSN definitions and began reporting back to the units in real time (or at least weekly) of any potential or confirmed infections in the unit. In addition to infection investigations, trends of the weekly monitoring (including central line checklist completion, weekly Clave cap changes (ICU Medical Inc, San Clemente, CA), proper BioPatch placement, and occlusiveness of dressing) were visually presented on a unit surveillance board at the CUSP monthly meetings. The data collection snapshot provided opportunities for education and improvement. Specific to On the CUSP: Stop BSI data collection, infection preventionists collected central line days, patient days, and number of CLABSIs observed and submitted to the On the CUSP: Stop BSI National Database.

For the current report, we combined the MICU and WICU patient days, device days, and infections for CLABSI, CAUTI, and VAP from January 2009-December 2014 based on unit similarity and for simplicity of data visualization. Rates were calculated by dividing the total number of device-associated infections by the total number of device days and then multiplying the result by 1,000. We calculated device utilization ratios for devices by dividing the number of days of device use by the number of patient days. We calculated quarterly rates for each infection type both by device days (as per NHSN definitions[19]) and by patient days. The reason for the latter calculation is that one of the main strategies to reduce any device-related infection is avoidance or prompt removal of the device, which decreases the denominator (device days) and therefore the rate may not fully represent the improvement in reducing infections.[20] We also calculated quarterly device utilization ratios (device days/patient days) for the combined units. Data were assigned to 1 of 3 categories on the basis of implementation of the CUSP interventions: a 1.5-year baseline (pre-CUSP) period (January 2009-June 2010), two 1-year CUSP periods (year 1: July 2010-June 2011; year 2: July 2011-June 2012), and 2 post-CUSP periods (year 3: July 2012-June 2013; year 4: July 2013-December 2014).

We calculated rate ratios for years 1-4, all compared with the baseline period, using OpenEpi version 3.03,[21] and standardized infection ratios using NHSN data for each period. The standardized infection ratio is a ratio of observed and expected infections based on historical data (2006-2008 for CLABSI; 2009 for CAUTI) from all hospitals reporting to the NHSN, adjusted for unit type and size and affiliation with a medical school. Other quality and patient safety measures included restraints and hand hygiene compliance.

RESULTS

Over a 6-year period, CLABSI rates in the MICU and WICU decreased 84%, from a combined average of 3.9 infections per 1,000 central line days at baseline to 0.1 per 1,000 central line days post-CUSP (Table 1 and Fig 2). CAUTI increased slightly at the

Table 1
Combined CLABSI rates, standardized infection ratios, and rate ratios for the MICU and WICU (combined), January 2009-December 2014

Timeframe		Infections	Device days	CLABSI rate per 1,000 device days	Rate ratio per device days (vs baseline) (95% CI)	Standardized infection ratio (95% CI)	Patient days	CLABSI rate per 1,000 patient days	Rate ratio per patient days (vs baseline) (95% CI)	Device utilization ratio
Baseline (January 2009-June 2010)		33	8,555	3.9	—	0.84 (0.48-1.38)	12,520	2.6	—	0.68
CUSP period	Year 1	7	6,001	1.2	0.30 (0.12-0.66)*	0.35 (0.13-0.78)	8,877	0.8	0.30 (0.12-0.65)†	0.68
(July 2010-June 2012)	Year 2	7	5,481	1.3	0.33 (0.14-0.72)*	0.51 (0.22-1.00)	8,995	0.8	0.30 (0.12-0.64)†	0.61
Post-CUSP	Year 3	6	4,458	1.3	0.35 (0.13-0.79)*	0.53 (0.22-1.11)	8,793	0.7	0.26 (0.10-0.59)†	0.51
(July 2012-December 2014)	Year 4	1	6,937	0.1	0.04 (0.002-0.20)‡	0.05 (0.002-0.24)	13,462	0.1	0.03 (0.001-0.15)‡	0.52

CI, confidence interval; *CLABSI*, central line–associated bloodstream infection; *CUSP*, Comprehensive Unit-based Safety Program; *MICU*, Christiana Hospital medical intensive care unit; *WICU*, Wilmington intensive care unit.
*$P \leq .01$.
†$P \leq .001$.
‡$P < .0001$.

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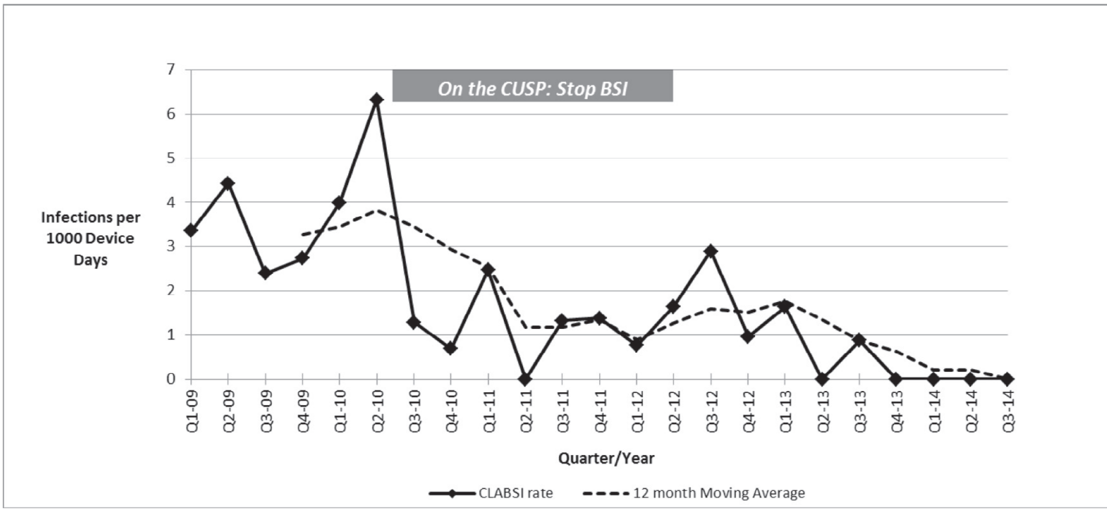

Fig 2. Combined quarterly CLABSI rate and 12-month moving average for MICU and WICU (combined), 2009-2014. The shaded box represents the period of the On the CUSP: Stop BSI initiative. *CLABSI*, central line–associated bloodstream infection; *MICU*, Christiana Hospital medical intensive care unit; *Q*, quartile; *WICU*, Wilmington intensive care unit.

beginning of the CUSP period, but then began to decrease particularly during year 2 of the CUSP project. When calculated per device day, CAUTIs decreased from 3.5 per 1,000 catheter days at baseline to 2.1 per 1,000 catheter days in year 4, which was not statistically significant (Table 2 and Fig 3). However, when calculated per patient day, the decrease from 3.0 per 1,000 patient days at baseline to 1.0 per 1,000 patient days, indicating a 67% reduction in infections, was highly significant (Table 2). Accordingly, the device utilization ratio for Foley catheters decreased by nearly half from 0.87 (indicating 87% of ICU patients had a Foley catheter) to 0.45 (Fig 4). The device utilization for central lines also decreased from 0.68 to 0.52. Combining years 3 and 4 to a single 2.5-year post-CUSP period demonstrated 0.6 CLABSI per 1,000 device days (84% reduction) and 1.2 CAUTI per 1,000 patient days (32% reduction).

During the baseline period, the combined VAP rate in the 2 ICUs was 2.7 per 1,000 ventilator days. This rate decreased to 1.6 per 1,000 ventilator days during CUSP (rate ratio, 0.58; 95% confidence interval [CI], 0.30-1.10). The post-CUSP period was abbreviated because of substantial changes in the NHSN VAP definition in January 2013; the combined unit rate during this period (July 2012-December 2012) was also 1.6 per 1,000 ventilator days. The VAP rate ratio of the combined CUSP and post-CUSP periods, compared with baseline, was 0.58 (95% CI, 0.30-1.10). Of note, the device utilization decreased from 61% at baseline to 57% during CUSP to 49% post-CUSP, indicating decreased ventilator days in both ICUs. The number of VAP cases per 1,000 patient days decreased from 1.6 at baseline to 0.7 during CUSP, and stabilized at 0.9 during the post-CUSP period (rate ratio compared with baseline, 0.5; 95% CI, 0.30-0.98).

Quality and safety measures significantly affected by nursing care are collected through a combination of medical record review and administrative data. MICU and WICU have been below the National Database Nursing Quality Indicator benchmark mean for restraint use for their units since early 2013. Reported hand hygiene observations and compliance by electronic survey has also been consistently above the hospital mean goal of 90%, with at least 100 observations completed per month in both units, with rare exceptions. Compliance with the central line insertion checklist increased in MICU from 80.9% (November-December 2010) to 100% (June 2011). Additionally, subjective feedback from unit staff regarding the standardized central line cart was uniformly positive, citing availability of needed supplies, increased staff efficiency, decreased traffic in and out of patient rooms during central line insertion, and ease of use.

DISCUSSION

MICU and WICU team members used CUSP principles to create a process improvement culture in which staff amplified existing resources to improve patient care, learn innovative strategies through peer monitoring, and enhance organizational developments. The program allowed for a grassroots, frontline team-based approach and peer monitoring, allowing individual staff to have a significant role in the process and contribute to effective problem-solving. These efforts not only improved accountability but also increased teamwork within the units. Subjective and objective measures during and post-CUSP periods demonstrate significant system improvements, including discernible process change and reduced infection rates.

In a comparison of CLABSI rates from baseline to 2.5 years post the official CUSP period, CLABSI rates in the MICU and WICU decreased 84%. CLABSI leads to significant morbidity, mortality, increased length of stay, and significant costs. With >15 million catheter days in ICUs annually, the potential impact of CLABSI is substantial in this population alone.[22] Using institutional data, CCHS determined that each CLABSI increases costs by $18,079 per patient. The successes experienced during this initiative demonstrate improved patient outcomes in addition to reduced economic burden.

Although the ultimate measure of success for CUSP was the reduction of CLABSI rates, the teams achieved significant improvement in additional quality and patient safety measures, including CAUTI, VAP, device utilization, falls, pressure ulcers, and restraints. The CUSP framework became a way of thinking about safety defects because the principles extended beyond CLABSI and CAUTI prevention measures to general safety measures. Preventing patient falls and related injuries, preventing pressure ulcers, and use of restraints in acute care settings have been elusive goals for many hospitals, and these incidents affect the quality of care and patient outcomes. The MICU and WICU have demonstrated improved sustained progressive metrics for these measures.

Culture change, in large part, is attributed to formal and informal leadership that believed and communicated continued support during the program. In a leadership role, the unit-based medical

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Table 2
Combined CAUTI rates, standardized infection ratios, and rate ratios for the MICU and WICU (combined), January 2009-December 2014

Timeframe		Infections	Device days	CAUTI rate per 1,000 device days	Rate ratio per device days (vs baseline) (95% CI)	Standardized infection ratio (95% CI)	Patient days	CAUTI rate per 1,000 patient days	Rate ratio per patient days (vs baseline) (95% CI)	Device utilization ratio
Baseline (January 2009-June 2010)		38	10,867	3.5	—	1.1 (0.48-2.14)	12,520	3.0	—	0.87
CUSP period	Year 1	39	7,610	5.1	1.45 (0.93-2.28)	1.96 (1.37-2.74)	8,877	4.4	1.45 (0.92-2.27)	0.86
(July 2010-June 2012)	Year 2	19	6,818	2.8	0.78 (0.44-1.35)	1.21 (0.75-1.86)	8,995	2.1	0.70 (0.39-1.20)	0.76
Post-CUSP	Year 3	14	4,644	3.0	0.85 (0.45-1.55)	1.3 (0.75-2.15)	8,793	1.6	0.52 (0.28-0.95)*	0.53
(July 2012-December 2014)	Year 4	13	6,061	2.1	0.60 (0.31-1.11)	0.93 (0.52-1.56)	13,462	1.0	0.32 (0.16-0.59)†	0.45

CAUTI, catheter-associated urinary tract infection; *CI*, confidence interval; *CUSP*, Comprehensive Unit-based Safety Program; *MICU*, Christiana Hospital medical intensive care unit; *WICU*, Wilmington intensive care unit.
*$P \leq .05$.
†$P \leq .001$.

director attended monthly meetings, encouraged the team, and informed his peers about improvements in the unit. The engagement of physicians, including partnership with physicians and physician assistants, for line insertion was crucial to the units' success. Interdisciplinary daily rounding provides active discussion of central line usage and prompt removal when no longer indicated, minimizing device days and improving compliance with evidence-based practice. However, best central line management for appropriate line removal or exchanging a femoral line transcends all nursing and physician shifts.

Accountability for ensuring the safety of patients contributed to significant and sustained improvement. Specific to central line insertions, nursing staff were in charge of the room and the procedure. Conducting a timeout using the checklist provided staff the ability to not only monitor but also stop the procedure if appropriate to follow the policy. In essence, they mandated a standardized, flawless approach to ensure patient safety. Nursing became the advocate for discontinuation of the line when not needed. Ultimately, the units took full ownership of their infection rates, and the infection prevention staff became partners with them in prevention rather than being seen as the police or just bearers of bad news when infections were reported.

The ability to individualize CUSP to each unit's culture and the teamwork that ensued contributed to the decreased infection rates. CCHS has a proven track record of teaching and supports providers to conduct process improvement. Small tests of change approach allows providers to test an idea temporarily, trialing a change and assessing its impact. With the variety of interventions introduced, team members were able to implement change and use data to reflect on what was learned before planning the next change cycle or full implementation. The model, based in scientific method, provides an iterative process to determine appropriate interventions at a unit level. An important driver of success is the understanding that educational efforts are never stagnant; there will always be room for improvements or new initiatives based on trending data. Benefits secondary to program goals include improved data availability and timely presentation of data and trends to staff. Additionally, the opportunities for units to share via a common CUSP Web site, CCHS meetings, and statewide meetings and teleconferences contributed to the vigor of the program. The sustained success of the program is demonstrated with CUSP-involved staff sharing and encouraging the next generation of providers and nurses.

In addition to the objective success demonstrated in these units, subjective feedback from unit staff verified significant culture change as the foundation of process improvement. Staff conveyed that not only did infection rates drop below the national average, but also that the whole thought process of the units changed. During the CUSP period, the mindset shifted from zero infections is impossible to the belief that zero is attainable, motivating the team to sustain the implemented changes. Anecdotally, staff also identified that the participation of multiple teams in CUSP was a driving factor for change based on camaraderie and competition, further driving success. The momentum that changed the units' mindset came in part from the minor and major successes occurring throughout the program. As the infection rates began to drop in each unit, staff were motivated to achieve the same success, truly believing that zero was attainable.

There are obvious limitations to the study because the results represent 2 ICUs from a single health care system. The collaboration of the units has grown over the years because the units share providers. At times, the process is spelled out specifically for both units to follow, and other times, units have flexibility that allows for differences in logistics. Although multiple units participated in CUSP, these 2 ICUs had the most impactful results, suggesting that there may be unique characteristics of these units or their unit

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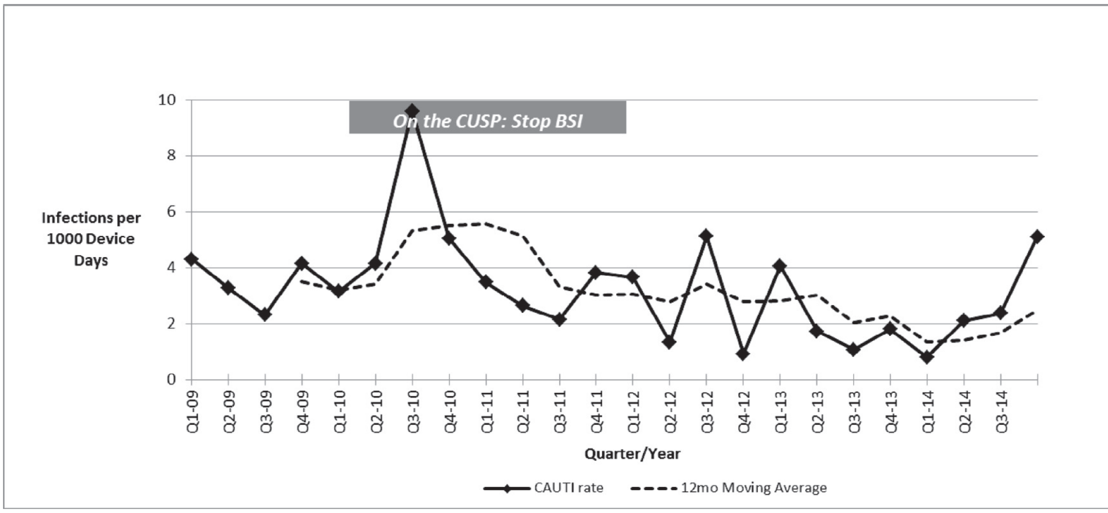

Fig 3. Combined quarterly CAUTI rate and 12-month moving average for MICU and WICU (combined), 2009-2014. The shaded box represents the period of the On the CUSP: Stop BSI, cohort 4, national initiative. *CAUTI*, catheter-associated urinary tract infection; *MICU*, Christiana Hospital medical intensive care unit; *Q*, quartile; *WICU*, Wilmington intensive care unit.

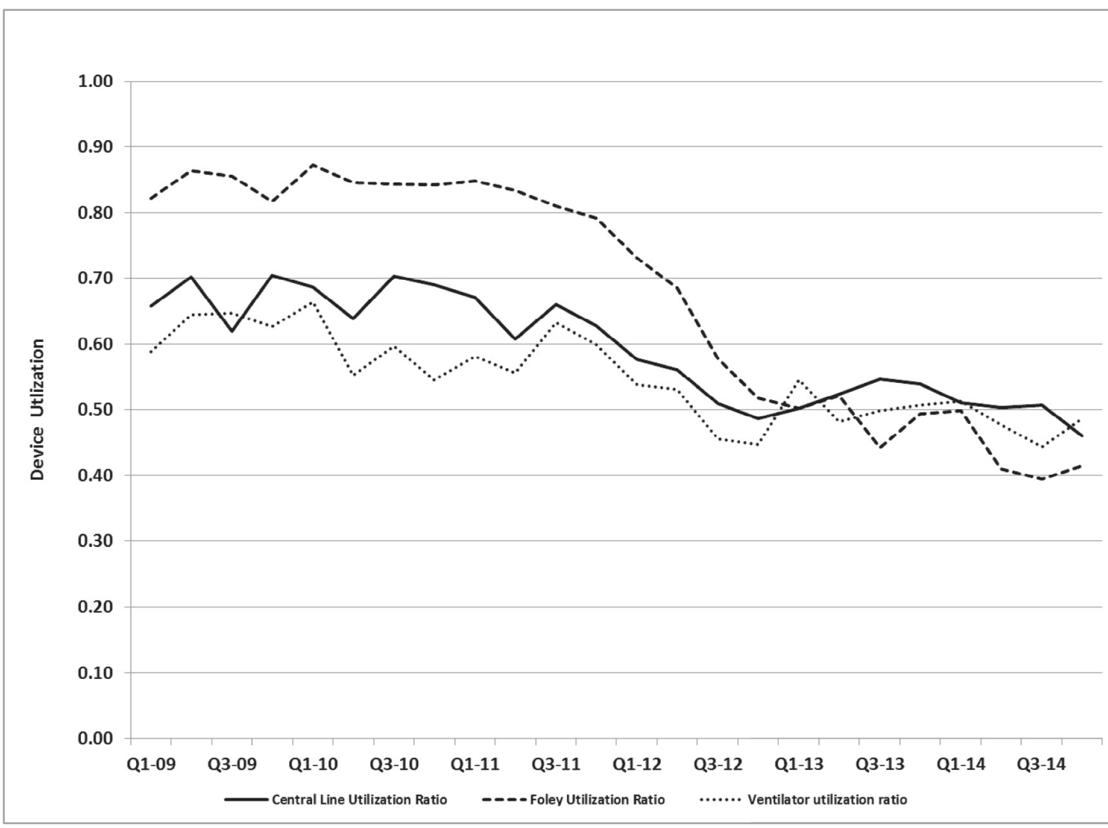

Fig 4. Quarterly central line, Foley catheter, and ventilator utilization ratios for MICU and WICU (combined), 2009-2014. *MICU*, Christiana Hospital medical intensive care unit; *Q*, quartile; *WICU*, Wilmington intensive care unit.

leaders that led to continual sustained efforts. Understanding what these characteristics may assist in obtaining buy-in for future initiatives. Challenges remain with communication across multiple individuals and teams, sharing of best practices and lessons learned, maintaining low infection rates, and sustainability of program efforts. The primary lesson learned was to establish relationships in order to guide efforts and be an inspiring stimulus for change.

The national implementation collaborative designed to improve safety culture provides a structured strategic framework for safety improvement and draws from frontline providers, those that have the most knowledge of safety hazards and the means to lessen the severity of those hazards. The principles of CUSP did not end with the completion of the official CUSP period. Because of CUSP's success, the institution adopted CUSP-like value improvement teams for all

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inpatient care units and additional departmental levels to address specific quality and safety issues. Larger units, such as the MICU, have even developed value improvement subteams or task forces; for example, the MICU CLABSI value improvement team was formed in November 2011 and has evolved to become forefront leaders in infection prevention by improving culture and teamwork with medical and ancillary staff hospitalwide. Therefore, CUSP and the lessons learned from it remain a flexible and effective way to engage front-line staff to successfully promote continued process improvement.

References

1. Agency for Healthcare Research and Quality. CUSP toolkit. Available from: http://www.ahrq.gov/professionals/education/curriculum-tools/cusptoolkit/index.html. Accessed July 6, 2015.
2. Pronovost P, Needham D, Bereholtz S, Sinopoli D, Chu H, Cosgrove S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006;355:2725-32.
3. Pronovost PJ, Goeschel CA, Colantuoni E, Watson S, Lubomski LH, Berenholtz SM, et al. Sustaining reductions in catheter-related bloodstream infections in Michigan intensive care units: an observational study. BMJ 2010;340:c309.
4. Centers for Disease Control and Prevention (CDC). Vital signs: central-line associated blood stream infections—United States, 2001, 2008 and 2009. MMWR Morb Mortal Wkly Rep 2011;60:1-6.
5. Deliberato R, Marra A, Correa T, Martino M, Correa L, Dos Santos O, et al. Catheter related bloodstream infection (CR-BSI) in ICU patients: making the decision to remove or not to remove the central venous catheter. PLoS One 2012;7:e32687.
6. Goudie A, Dynan L, Brady PW, Rettiganti M. Attributable cost and length of stay for central line-associated bloodstream infections. Pediatrics 2014;133:e1525-32.
7. Stone P, Braccia D, Larson E. Systematic review of economic analyses of healthcare-associated infections. Am J Infect Control 2005;33:501-9.
8. Marschall J, Mermel L, Classen D, Arias K, Podgorny K, Anderson D, et al. Strategies to prevent central-line associated bloodstream infections in acute care hospitals. Infect Control Hosp Epidemiol 2008;29(Suppl):S22-30.
9. Sexton JB, Berenholtz SM, Goeschel CA, Watson SR, Holzmueller C, Thompson DA, et al. Assessing and improving safety climate in a large cohort of ICUs. Crit Care Med 2011;39:1-6.
10. Berenholtz SM, Pham JC, Thompson DA, Needham D, Lubomski L, Hyzy R, et al. An intervention to reduce ventilator- associated pneumonia in the ICU. Infect Control Hosp Epidemiol 2011;32:305-14.
11. Wick EC, Hobson D, Bennett J, Demski R, Maragakis L, Gearhart SL, et al. Implementation of a surgical comprehensive unit based safety program (CUSP) to reduce surgical site infections. J Am Coll Surg 2012;215:193-200.
12. Timmel J, Kent P, Holzmueller C, Paine L, Schulick R, Pronovost P. Impact of the comprehensive unit-based safety program (CUSP) on safety culture in a surgical inpatient unit. Jt Comm J Qual Patient Saf 2010;36:252-60.
13. Agency for Healthcare Research and Quality. Toolkit for Reducing CAUTI in Hospitals. October 2015. Available from: http://www.ahrq.gov/professionals/quality-patient-safety/hais/tools/cauti-hospitals/index.html. Accessed May 10, 2016.
14. John Hopkins Medicine, Armstrong Institute for Patient Safety and Quality Portal. CUSP for mechanically ventilated patients - ventilator associated pneumonia (CUSP 4 MVP-VAP). Available from: https://armstrongresearch.hopkinsmedicine.org/cusp4mvp.aspx. Accessed April 24, 2015.
15. Berenholtz SM, Lubomski LH, Weeks K, Goeschel CA, Marsteller JA, Pham JC, et al. On behalf of the on the CUSP: stop BSI program. Eliminating central line-associated bloodstream infections: a national patient safety imperative. Infect Control Hosp Epidemiol 2014;35:56-62.
16. Timsit JF, Schwebel C, Bouadma L, Geffroy A, Garrouste-Orgeas M, Pease S, Herault MC, et al. Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically Ill adults a randomized controlled trial. JAMA 2009;301:1231-41.
17. Roberts B, Cheung D. Biopatch™–a new concept in antimicrobial dressings for invasive devices. Aust Crit Care 1998;11:16-9.
18. Simmons S, Bryson C, Porter S. Scrub the hub": cleaning duration and reduction in bacterial load on central venous catheters. Crit Care Nurs Q 2011;34:31-5.
19. Dudeck M, Horan T, Peterson K, Allen-Bridson K, Morrell G, Pollock D, et al. National healthcare safety network (NHSN) report, data summary for 2010, device-associated module. Am J Infect Control 2011;39:798-816.
20. Hidron A, Edwards J, Patel J, Horan TC, Sievert DM, Pollock D, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the national healthcare safety network at the centers for disease control and prevention, 2006-2007. Infect Control Hosp Epidemiol 2008;29:996-1011.
21. Sullivan KM, Dean A, Soe MM. OpenEpi—a web-based epidemiologic and statistical calculator for public health. Public Health Rep 2009;124:471-4.
22. Mermel LA. Prevention of central venous catheter-related infections: what works other than impregnated or coated catheters? J Hosp Infect 2007;65(Suppl):30-3.

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