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Bathing With 2% Chlorhexidine Gluconate

Evidence and Costs Associated With Central Line–Associated Bloodstream Infections

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In a coordinated national effort reported by the Agency for Healthcare Research and Quality, the use of 2% chlorhexidine gluconate (CHG) has reduced the central line–associated bloodstream infection (CLABSI) rate by 40%. Conversely, a recent randomized clinical trial determined that chlorhexidine bathing did not reduce the CLABSI rate. The objectives of this study were to conduct meta-analysis and clarify the effectiveness of 2% CHG bathing by nurses on CLABSIs in adult intensive care unit patients and to determine the contributing costs attributable to CLABSIs and 2% CHG bathing. Eligible studies that included the outcome of bloodstream infection rate for central lines were considered. A rigorous systematic review protocol and software tools available from the Joanna Briggs Institute via OvidSP were used. Agency for Healthcare Research and Quality tools assisted with identifiable CHG bathing costs. Four studies were included in the meta-analysis for the outcome of primary bloodstream infections, and 2 studies narratively supported the meta-analysis. A relative risk of 0.46 with 95% confidence interval (0.34-0.63) was determined. This significant effect is seen in an overall z-score of 4.84 ($P < .0001$). This meta-analysis supports that 2% CHG reduces CLABSIs. The estimated cost increase of 2% CHG-impregnated cloths is $4.10 versus nonmedicated bathing cloths. The cost associated with a single CLABSI is 10 times more than the cost of using 2% CHG-impregnated cloths. Nursing provides significant influence for the prevention of CLABSIs in critical care via evidence-based best practices. **Key words:** *adult, bloodstream infection, central venous catheter, chlorhexidine bath, CLABSI, ICU, ICU nursing, nursing intervention*

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CENTRAL VENOUS CATHETERS (CVCs) are necessary to deliver lifesaving medications and offer a source for hemodynamic monitoring of the intensive care unit (ICU) patient. However, the longer these catheters are in use, the potential for exposure to central line–associated bloodstream infections (CLABSIs) and development of sepsis increases greatly. CLABSIs and other hospital-acquired infections (HAIs) haunt the health care system by increasing hospital and

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patient costs, resulting in expensive antibiotic therapy[1] and death due to sepsis. Umscheid et al[2] reported that CLABSIs may be the second most preventable cause of hospital death. In addition, Stevens et al[3] found that patients with CLABSIs are more than twice as likely to die as patients without CLABSIs. In an effort to incentivize quality improvement nationwide, the Centers for Medicare & Medicaid Services no longer reimburses hospitals for CLABSIs or other HAIs[4] and hospitals are held financially responsible and must absorb the costs of CLABSIs. As a result, hospitals are pursuing solutions to prevent CLABSIs.

On the basis of the initiatives similar to that of the Agency for Healthcare Quality and Research (AHRQ) to prevent CLABSIs, strategies to be considered are the use of 2% chlorhexidine gluconate (CHG) for daily bathing, using antimicrobial-impregnated catheters, and CHG-impregnated dressings.[5] The Joint Commission requires implementing evidence-based practice to prevent CLABSIs, and the Hospital National Patient Safety Goals require that patients and families be educated on CLABSIs and infection prevention to make an informed decision for themselves or for their loved one.[6]

CLABSIs are likely to have extraordinary costs ranging anywhere between $960 million to $18.2 billion annually.[2] The expenses that occur from these preventable infections are called contributable costs; these include inpatient-days, antibiotic costs, and laboratory testing.[7] The AHRQ have developed a toolkit that helps estimate preventable CLASBI costs, patient-days, and contributive costs. For example, if the cost of each CLABSI is $45 254, a total of 13 CLABSIs calculate into an extra $588 302 per year (13 preventable CLABSIs × $45 254 = $588 302).[8] In addition, if the average mortality rate caused by CLABSIs is 18% and the average CLABSI rate is 5.3 per 1000 catheter-days, as many as 28 000 patients die of CLABSIs annually in ICUs.[9]

It has been established that using CHG inhibits microbial activity on skin for up to 24 hours after bathing.[9] CHG works by binding to the cell wall of bacteria and has broad coverage against gram-positive and gram-negative and anaerobic and aerobic bacteria, as well as yeasts and viruses.[10] Nursing provides significant influence for prevention of CLABSIs during a patient's stay. One part of that care includes applying CHG as part of evidence-based practice skin disinfection. AHRQ CLABSI tools state that a minimum of 0.5% CHG is necessary for skin disinfection during dressing changes and before catheter insertion, but greater CHG concentrations are recommended.[7] The Centers for Disease Control and Prevention also supports the need of daily CHG bathing for patients with central lines or other CVCs as a means to prevent CLABSIs.[4] No one source has defined the preparation concentration for nursing skin asepsis.

Recently, Noto et al[10] published a randomized controlled study with findings that *do not support* daily bathing with 2% CHG. Because their finding contradicts that of other studies and no clear CHG concentration guideline exists, we sought to clarify the use of evidence for 2% CHG bathing with 2 specific objectives. First, we aimed to examine research for 2% CHG bathing on CLABSIs in adult ICU patients via meta-analysis of data. Second, we aimed to establish that 2% CHG bathing is significant to limiting the contributing costs attributable to CLABSIs.

Systematic reviews exist that examine various CHG concentrations, multiple settings and patient types, and bathing techniques. Importantly, some of these reviews are not specific to current skin antisepsis protocols.[11,12] Other reviews include mixed patient samples or various catheter systems such as arterial monitoring.[13] We gathered the studies that specifically align with the maintenance of central line bathing practices by ICU nurses.[14]

METHODS

This systematic review considered studies that evaluated the effectiveness of 2% CHG bathing on adult patients with central lines in adult ICUs. Important to understanding the research evidence is the rigorous application of

inclusion criteria and methods used. A systematic review with meta-analysis can uncover and report the data central to the question of effectiveness for 2% CHG.

Eligible studies addressing the outcome of the bloodstream infection (BSI) rate for central lines were incorporated. Study designs of randomized controlled trials, nonrandomized controlled trials, pre- and post-quasi-experimental, prospective and retrospective cohort studies, and case-control studies were considered for inclusion. A comprehensive search strategy focused only on published studies.

A 3-step search strategy was used in this review. An initial limited search of MEDLINE and CINAHL (Cumulative Index to Nursing and Allied Health Literature) was undertaken, followed by analysis of the text contained in the title, abstract, and the index terms describing the article. Second, a search using all identified key words and index terms was applied to several databases. Finally, the reference list of all identified reports and articles was searched for additional studies in a backward search. Only research studies published in the English language were considered for inclusion in this review. The databases searched included Web of Science, PubMed, CINAHL through EBSCO Host, Cochrane Library, and EMBASE. The key words used were "central line," "central venous catheter," "catheter," "bloodstream infection," "CLABSIs," "HAIs," "intervention," "adult," "ICU," and "chlorhexidine bath or bathing."

Articles selected for retrieval were assessed by 2 independent reviewers for methodological validity prior to inclusion in the review using standardized critical appraisal instruments from the Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI), available through OvidSP.[15] Disagreements that had arisen between the reviewers were resolved through either discussion or with a third reviewer. Data were extracted using the standardized data extraction tool from JBI-MAStARI. Data included specific details about the interventions, populations, study methods, and outcomes of significance to the review question and specific objectives.

Quantitative data were pooled in statistical meta-analyses using the JBI-MAStARI and the Comprehensive Review Management System.[15] All results were subject to double data entry. Weighted risk ratio differences (for dichotomous data) and their 95% confidence intervals were calculated. Heterogeneity or variations of the characteristics among the studies were assessed using the standard χ^2 test. Heterogeneity occurred if there were significant differences among studies. Studies that did not include participant number data to calculate risk ratios but were deemed statistically significant are discussed narratively.

RESULTS

Search results

After searching 6 databases, 15 full-text articles were assessed for eligibility. The results for exclusion are reported according to PRISMA standards as shown in Figure 1.[16] Only 6 studies qualified for inclusion in critical appraisal. Definitions of primary BSIs used in the studies included the National Healthcare Safety Network of the Centers for Disease Control[17] and the Centers for Disease Control and Prevention.[1]

Description of studies

Of the 6 studies included, only 4 studies described in the Table were included in the meta-analysis that compared the intervention group for daily 2% CHG bathing with the control group consisting of daily bathing with nonantimicrobial wipes or soap and water. The 2 excluded studies met our criteria for the adult ICU population and use of 2% impregnated chlorhexidine wipes, but these 2 studies were not included in the meta-analysis because of the unreported sample population where the relative risk (RR) could not be calculated. However, the 2 excluded studies were important in the discussion of this article as their data were statistically significant.[22,23]

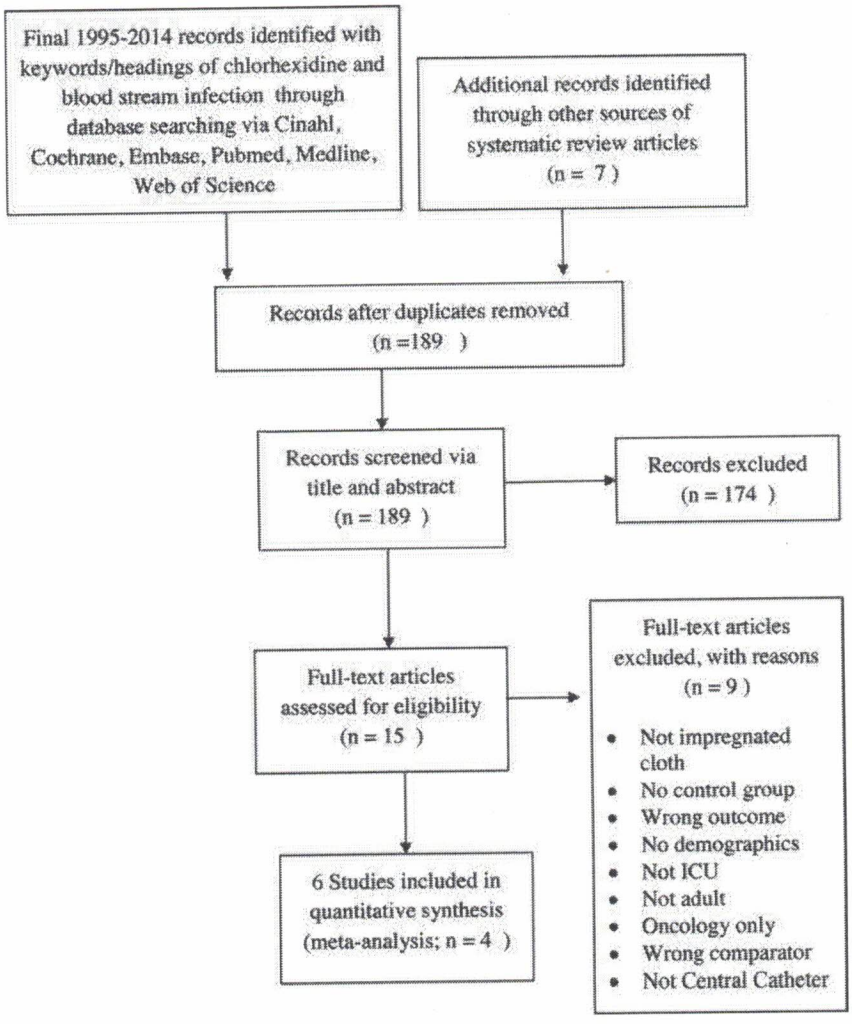

Figure 1. Search results. ICU indicates intensive care unit.

Popovich et al[22] determined from their pre/post-quasi-experimental study that 2% CHG bathing exhibited a statistically significant decrease in CLABSI rates in the medical ICU. Preintervention rates were 5.31 per 1000 CVC-days, and postintervention rates with 2% CHG were 0.69 cases per 1000 CVC-days. Munoz-Price et al[23] found from their quasi-experimental study that using a stepwise approach of implementing daily 2% CHG bathing and scrubbing the hub of the catheter port with 2% CHG resulted in a reduction of CLABSIs. Of the 3 ICU units evaluated during the intervention periods, there was a decrease in primary BSIs per 1000 CVC-days in each ICU.

META-ANALYSIS RESULTS

Because CLABSIs are a dichotomous variable, JBI-MAStARI can be used to generate the overall effect size calculation using the Mantel-Haenszel RR ratio as shown in Figure 2. A total of 33 794 central catheter-days was pooled from 4 studies (Table). In the 2% CHG intervention, 124 CLABSIs developed over 17 229 days compared with 223 over 16 565 CVC-days in the control group. For

Table. Study Characteristics for Meta-analysis

Study	Participants	Intervention vs Usual Care	Comments
Bleasdale et al[18]	Adult patients admitted to the medical ICU	Daily bath with no rinse 2% chlorhexidine-impregnated washcloths vs daily bath with soap and water	Adult patients in a medical ICU bathed daily with 2% CHG were at a lower risk of CLABSI than patients bathed with non-AM wipes or soap and water (6.4 vs 16.8 BSI per 1000 CVC-days) ($P = .01$)
Climo et al[19]	Patients from 9 different adult ICUs including medical, coronary, surgical, cardiac surgical, and bone marrow transplantation	Daily bath with 2% chlorhexidine-impregnated washcloths vs daily bath with non-AM washcloths	Incidence of CLABSIs was significantly lower during the intervention period with 2% CHG than during the control period with non-AM baths (1.55 vs 3.30 per 1000 catheter-days) ($P = .004$). Reduced rates of infections in diverse adult ICUs.
Evans et al[20]	Adult patients admitted to trauma ICU	Daily bath with 2% chlorhexidine-impregnated washcloths vs daily bath with non-AM washcloths	Study with a homogeneous trauma ICU population. The rates of CLABSIs were 2.1 vs 8.4 for non-AM bathing per 1000 catheter-days ($P = .01$).
Montecalvo et al[21]	Rates of CVC-associated blood stream infections were collected in the medical ICU and respiratory unit of a tertiary care hospital and medical ICUs of 4 community hospitals over same period of time.	Bathing with 2% chlorhexidine-impregnated cloths vs soap and water bath	Multihospital study noted 2% CHG bathing significantly decreased CLABSIs compared with non-AM soap and water baths. During the preintervention phase of the study with soap and water baths, 6.4 CLABSIs occurred in 1000 CVC-days compared with 2.6 per 1000 CVC-days in the intervention or 2% CHG group. This reduction was also found in phase 3 of the study when 2% CHG bathing was unmonitored.

Abbreviations: AM, antimicrobial; BSI, bloodstream infection; CHG, chlorhexidine gluconate; CLABSI, central line–associated bloodstream infection; CVC, central venous catheter; ICU, intensive care unit.

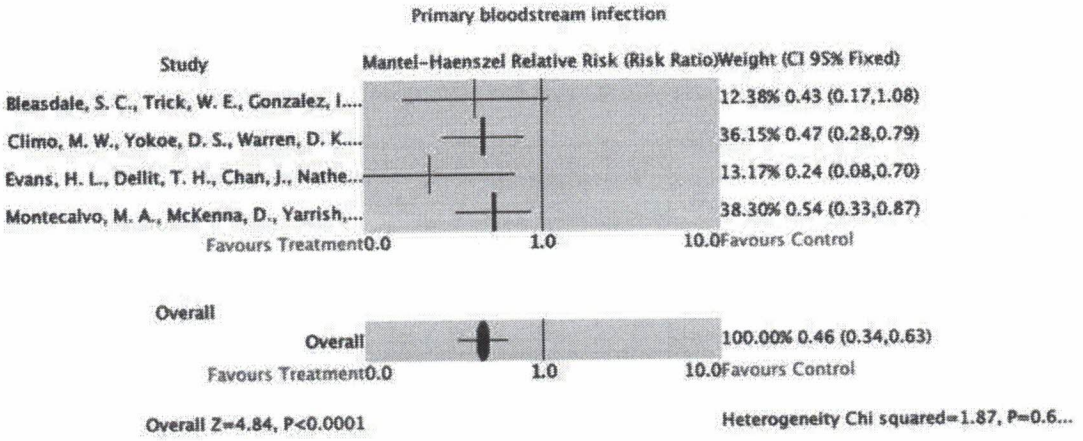

Figure 2. Meta-analysis results.

primary BSIs, a RR ratio of 0.46 with 95% confidence interval (0.34-0.63) was determined. The *P* value did not occur by chance alone, thus providing evidence against the null hypothesis. This significant effect was seen in an overall *z*-score of 4.84 ($P < .0001$). Heterogeneity was not observed in these studies ($\chi^2 = 1.87$; $P = .6$). This finding indicates that daily 2% CHG bathing lowers CLABSI rates in adult ICU patients. As previously mentioned, the studies conducted by Popovich et al[22] and Munoz-Price et al[23] support these results.

DISCUSSION

The evaluation resulted in 6 articles pertaining to the use of daily 2% CHG bathing with results of CLABSIs calculated per 1000 central catheter-days. Participants in this study included adult patients in medical, surgical, trauma, and bone marrow transplant ICUs. Studies in this review were examined as to whether daily bathing with 2% CHG versus nonantimicrobial wipes or a traditional soap and water bath decreases the rates of CLABSIs. Studies analyzed and presented here have shown that daily bathing with 2% CHG decreases the rates of CLABSIs in adult ICU patients (RR = 0.46). While some of these studies also examined the rates of secondary BSIs including ventilator-associated pneumonia and urinary tract infections, this review focused on the rates of CLABSIs.

Eliminating CLABSIs is imperative in preventing sepsis while ensuring patient safety.[24] The AHRQ is funding a national effort to prevent BSIs by implementing a Comprehensive Unit Based Safety Program (CUSP).[25] Proper policies and practices to reduce CLABSIs that are aligned with recommendations should become standards of nursing practice. Recommended "standards of practice," however, do not always mean that these practices are followed because of inconsistencies in the bathing of patients by nursing staff.[26] Nursing ICU leadership should consider the recent CUSP reports to evaluate that 2% CHG bathing protocols are followed according to AHRQ guidelines. Adherence to guidelines can standardize best practice across hospital environments. In addition to hand hygiene, dressing and tubing changes, and monitoring insertion technique, nursing can make a robust transformation in patient safety and sepsis prevention.[27]

Approaches to using CHG-impregnated cloths

AHRQ guidelines are adapted and described in Figure 3.[28] Key points include 2% CHG cloths be firmly massaged on skin and external portion of catheters, Foley catheters, G/J tubes, rectal tubes, and chest tubes within 6 in

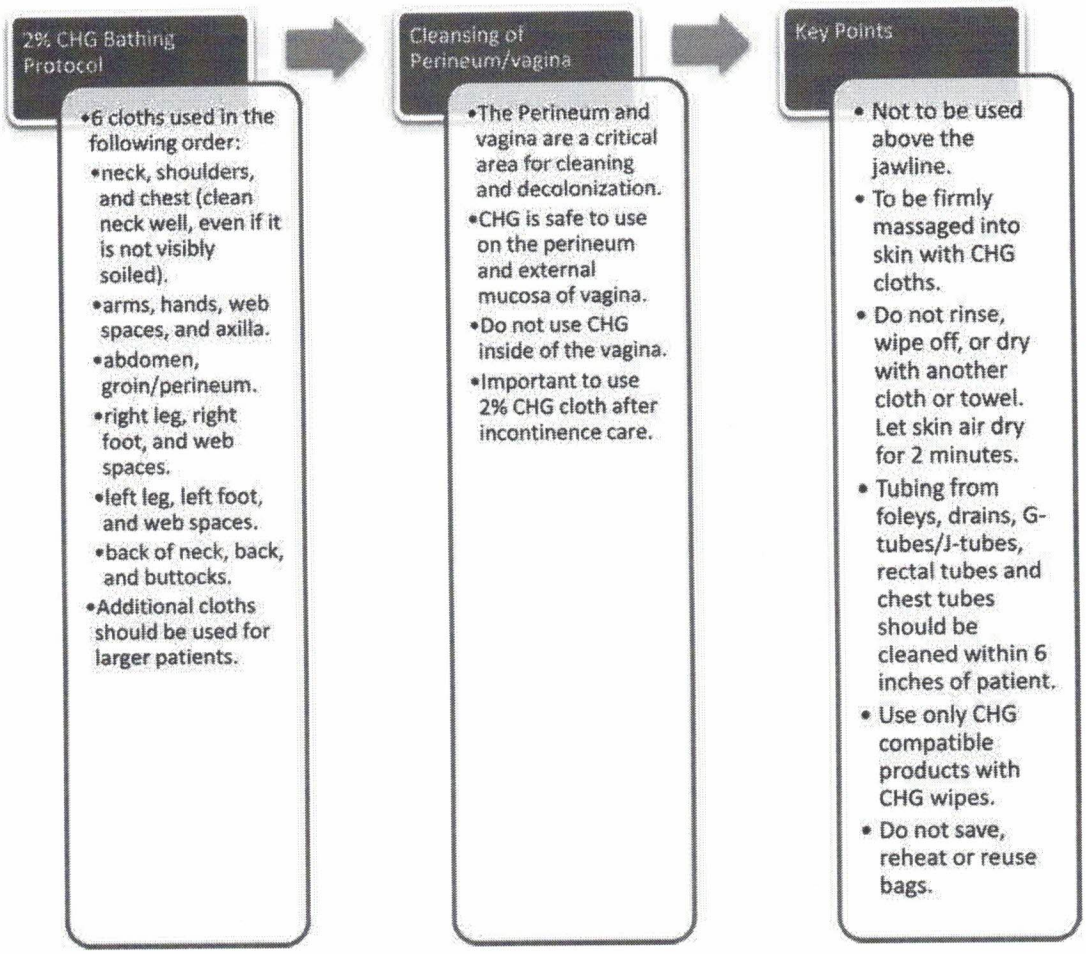

Figure 3. Agency for Healthcare Research Quality recommended 2% CHG bathing protocol. CHG indicates chlorhexidine gluconate. Adapted from printed guidelines.

from the patient and should be allowed to air-dry for a minimum of 2 minutes.[28] In patients with CVCs, one pack of six 2% CHG cloths should be used per bath per day and should be documented in the patient's electronic medical chart as a medicated bath. Dixon and Carver[29] suggest using 1 cloth for each of the following areas: neck, chest, and arms; back; right leg; left leg; perineum; and buttocks every 24 hours and point out that 2% CHG wipes should not be used on the head, face, or inside the vagina. It is important to note that it is safe to use CHG wipes on external vaginal mucosa and perineum and soap and water or nonantimicrobial wipes should be used for incontinence care before using 2% CHG cloths.[28]

LIMITATIONS

The meta-analysis included analysis from only 4 articles. In the study conducted by Noto et al,[10] 4 CVC infections occurred during the CHG bathing period as well as 4 infections occurred during the control bathing period. A cautionary editorial note pointed out that the Noto et al study had several limitations including that HAI rates were low to begin with and may not parallel other intensive care facilities. Accordingly, the Noto et al study was

not included in the meta-analysis, as it was severely limited and did not meet criteria for inclusion.

The study results from this meta-analysis may not be generalizable to all ICUs. Even with the use of CHG products, CLABSIs can also occur because of inconsistencies in hand washing, catheter technique, and asepsis measures during insertion. In the studies reviewed, the blinding of staff may not have occurred in all studies.

CONCLUSIONS

This review examined research for 2% CHG bathing on CLABSIs in adult ICU patients via meta-analysis of data. In addition, 2% CHG bathing is significant to limiting the contribution costs attributable to CLABSIs. This meta-analysis supports that 2% CHG does reduce CLABSIs. Although this review did not directly measure cost using 2% CHG wipes, Montecalvo et al[21] found that there was an estimated cost increase of $4.10 when using 2% CHG-impregnated cloths versus non-medicated bathing cloths. Costs increased by $4.94 to $5.10 when using 2% CHG-impregnated cloths versus soap and water. Interestingly, the nursing use of 2% CHG-impregnated cloths results in a 10-fold increase of cost.[21]

The use of CHG in the health care setting has become more widespread as evidence-based information is presented to the medical community. Not only has CHG become a preventive antimicrobial agent but it has also become widely used as a surgical scrub/skin prep, oral decontaminant, and skin prep for central line placement.[14,20]

Sepsis is life threatening and can be caused by BSIs associated with CVCs. The probability of infection with an increase in ICU stay at greater cost can occur with long-term CVC use. Because of the costs of primary BSIs, it is important to continue research on the effectiveness of any viable alternative. CLABSI tools for nursing in CUSP have been a reported and successful system formula.[5,8] But despite progress, CLABSIs are still a significant and unresolved issue in the hospital environment. Poor staff adherence to infection prevention practices and policies during insertion, poor care for the devices after insertion, and extended durations of catheter use are all important factors for the development of serious and costly infections.[26,30]

Patients deserve to have a healthy hospital environment with the least possible risks during the course of their hospital stay. Halm[30] points to an environment where the "search for and use of evidence" is contributory to an evidence-based culture, effecting improved outcomes in nursing. These results assist nurses with best practice and chlorhexidine tools to prevent BSIs.

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Beyond Best Practice

Implementing a Unit-Based CLABSI Project

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This article describes a hospital unit's successful central line–associated bloodstream infection reduction project. The focus is on decreasing and sustaining a low rate of infection by targeting improvement in central line maintenance. The Consolidated Framework for Implementation Research's 5 interacting domains (the intervention, inner and outer settings, individuals involved, and process) were used to guide the selection of 4 Plan-Do-Study-Act interventions. The rate decreased the rate from 3.2 to 0.6 infections per 1000 catheter-days. **Key words:** *bacterial infections/prevention and control, central line–associated bloodstream infections (CLABSIs), central venous/adverse effects, Consolidated Framework for Implementation Research, evidence-based nursing, Plan-Do-Study-Act*

THE quest to eliminate central line–associated bloodstream infections (CLABSIs) continues to challenge health care clinicians. Approximately 70% of CLABSIs appear preventable.[1] It has long been accepted that increased duration of a central line leads to higher infection rates[2]; consequently, there may be more infections outside the intensive care units where central venous access is needed for extended periods of time.[3] During this time, patients can be colonized with hospital-acquired organisms and a catheter may be manipulated multiple times per day for the administration of fluids, drugs, and blood products.[4] Accessing the central line for blood drawing creates an additional opportunity for contamination.

The Institute for Health Care Improvement's best practice recommendations are to use the Central Line Bundle that incorporates a multimodal approach including hand washing, full barrier precautions, chlorhexidine for skin antisepsis, avoidance of femoral catheters, and removal of unnecessary catheters.[5] However, in this group of hospitalized patients with long-term catheters, novel methods of surveillance, prevention, and treatment need to be developed to further reduce the incidence of CLABSIs.[6] The purpose of this article was to describe one acute care unit's successful nursing CLABSI reduction project and the elements used to implement and sustain the results over 5 years.

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BACKGROUND

The project took place on the orthopedic and trauma surgical unit in an academic health care system in the southeast United States. In

2008, the central line infection rate was 2.1 infections per 1000 catheter-days, above the National Health Care Safety Network (NHSN) benchmark of 1.5. Furthermore, the 2009 central line infection rate was increasing, reaching a total of 6 infections in 1892 catheter-days for a rate of 3.2 infections per 1000 catheter-days. The unit leadership recognized the need for action and formed a unit-based infection control team that comprised 3 nurses and 1 nursing assistant. The team searched the literature for nursing interventions to reduce CLABSIs on the unit.

There are 2 primary opportunities for transmitting a central line infection: insertion and maintenance. Within acute care settings, the physician or certified licensed provider is responsible for inserting the central line whereas the unit's clinical nurses are responsible for maintenance. Because catheters are inserted either outside the unit (eg, in the intensive care units or in vascular interventional radiology) or by specialized teams such as the intravenous team or the peripherally inserted central catheter team, maintenance has become the primary way clinical nurses can use their skills to decrease CLABSIs.

Maintenance includes central line dressing care, intravenous tubing changes, and drawing blood from the central lines. However, maintenance is more than technique. The Leapfrog Group found that significant effort is needed to monitor staff performance and adhere to the measures. Successful units have to implement continuous education to the clinical staff beyond a standard orientation.[7] The process the unit used to gain and maintain compliance demonstrates how process improvement (PI) with its Plan-Do-Study-Act (PDSA) cycles[8] can be used for both rapid and extended or continuous changes.

IMPLEMENTATION

O'Grady et al in "Guidelines for the Prevention of Intravascular Catheter-Related Infections" recommend that PI be used for hospital-specific or collaborative-based initiatives in which multifaceted strategies are "bundled" together to improve compliance with evidence-based recommended practices.[9(p1092)] In addition, Krein et al[10] noted that a number of the hospitals that focused on preventing CLABSIs used similar implementation strategies, but outcomes varied considerably given the organizational context. Specifically, positive emotional and cultural context, strong emotional commitment to patients, a unified culture focused on patient care, and active, engaged clinical leadership had better success with their PI initiatives. There has been marginal overall success with other PI strategies, such as audit and feedback.[11]

When a project proves successful, it is important to study not only the end product but also the building blocks that contributed to its effectiveness. Actions taken by the nurses reflect the success that can occur when the Consolidated Framework for Implementation Research (CFIR) is used to guide a PI project. The unit-based project's implementation process can be described by the CFIR, which has 5 major, interacting domains that describe how implementation is accomplished. These include the intervention, inner and outer settings, individuals involved, and process.[12]

In this project, the intervention (the first CFIR domain) was the nursing staff's effort to reduce the CLABSIs. Specifically, the unit manager charged the unit's infection control liaison with decreasing infections. This liaison was a clinical nurse III on the unit's leadership team who worked directly with the hospital's infection control committee. The intervention, the Institute for Health Care Improvement's Central Line Bundle, needed to be adapted to focus on the nursing-specific aspects of the bundle's checklist, maintenance of the lines. Adaptation is important in the CFIR framework; failure to adapt the intervention to the situation can produce resistance and incorrect methods. Initially, the maintenance intervention included 2 components: central line dressing change and blood draws.

The next 2 CFIR domains (the inner and outer settings) were closely coupled in the

project. At the time of the central line project implementation, the organization was undertaking a Lean/Six Sigma transformation. In addition, in 2008, the Centers for Medicare & Medicaid Services implemented the use of a new financial mechanism. Under this mechanism, the Centers for Medicare & Medicaid Services no longer reimbursed hospitals for care related to CLABSIs if they are not present on admission.[13] The Nursing department had formed a Nursing Practice Council and was working on an American Nurses Credentialing Center Magnet initiative that promoted bedside nursing research. In addition, the nursing unit had recently undertaken a study that found that central lines decreased nursing time starting peripheral intravenous catheters (especially vancomycin-related peripheral intravenous catheters).[14] The study's recommendation was to advocate for central line placement. Yet, high CLABSI rates on the unit made the nurses' study recommendation for central lines difficult to defend to physicians who ordered the lines.

The individuals involved with the intervention are the fourth CFIR domain. Unit management initiated and facilitated the efforts and appointed an infection control liaison who became the unit champion. The champion selected a unit-based infection control team that comprised 3 nurses and 1 nursing assistant. The nurse champion was a clinical nurse leader who staffed the unit, often acted as charge nurse, and served on the organization's infection control liaison committee. She was given authority to make decisions and implement interventions to improve the process.

The CFIR framework's fifth domain includes the implementation process. Investigators have found that standardization in processes decreases central line infections, such as chlorhexidine baths[15] or reporting processes as in the Agency for Healthcare Research and Quality's Comprehensive Unit-Based Safety Program.[16] Langley's[8] PDSA model guided PI as it evolved over a 4-year span and used 4 PDSA cycles. These cycles are detailed in the next section. As described by Damschroder et al,[12] some of the processes were linear, some formally planned, and others neither, but all were aimed in the same general direction.

METHODS

PDSA cycle 1

PDSA cycle 1 began with an assessment of individual knowledge and skills in performing central line care and blood drawing. Within the policy, the procedures are written in the order that the nurse performs the process. The unit champion used the procedure section of the organization's policy on central line dressing changes and blood drawing process to make a 7-question test.

Next, for the skills assessment, the unit champion met with each individual nurse on the unit, both permanent and per diem nurses, to perform dressing changes and blood draws on a mannequin as they would on a patient. The PDSA used the Lean/Six Sigma concept of standard work, a technique that ensures everyone does the right procedure, in the right way, at the right time for the patient; it provides a process baseline and exposes variation when using PI. The unit champion gave the same instructions to all the nurses, recorded the steps and any discrepancies from the procedures, and then provided immediate feedback to address steps missed or out of order. She also discussed incorrect answers to the test questions. Furthermore, to help nurses remember the steps, a paper with a list of these steps was inserted in the central line dressing kits assembled for the health care organization.

PDSA cycle 2

PDSA cycle 2 started after the organization began to focus on CLABSIs as a quality outcome, setting reduction of CLABSIs as an organizational goal. Nurses began to notice that patients transferred from unit to unit often had different dated labels on their tubing. Nurses who floated between units reported that they had to ask when that unit's line or dressing had to be changed. The nurses

then took this information to the department's Shared Governance Council, which developed a policy that all intravenous tubings and dressings would be changed on specific days. Consequently, the unit took on standardization of the intravenous tubing and central line dressing change as their next PDSA.

Unit nurses were consulted as part of the change; they determined how this process could best be implemented. Their main suggestion was to put the intravenous tubing and central line dressing changes on the medication administration record as a reminder to perform and document the procedures. Also, the charge nurses wanted a box on the charge nurse report sheet to indicate which nurses had patients with central lines, so the charge nurse could remind the nurses to change tubing and dressings. In addition, the unit's infection control team decided that any patient who arrived on the unit with a central line would have the dressing changed immediately to assess the site and again on the day established as the standard routine.

PDSA cycle 3

The nurses on the unit thought that having all central line supplies at the bedside would increase compliance and efficiency, so the unit infection control team created a packet of supplies placed in a clear bag to suspend from the patient's intravenous pole. The bag included a central line dressing kit, normal saline flushes, alcohol wipes, Clave line caps, catheter tip covers, and brightly colored laminated instruction sheets describing dressing change and blood drawing procedures. Each week the team made up 10 of these ready-to-grab packets, an amount based on the unit's number of central lines. The unit infection control team created a standardized process in which each member would check the central line packets when he or she arrived on his or her shift to determine how many packets were needed. The team members would then order supplies. Throughout the shift, they put together the packets. Because the unit's nurses determined what they needed at the bedside, staff education about the packets was minimal.

PDSA cycle 4

In the fourth PDSA cycle, the unit champion challenged the nurses to identify ways to include the patient in their central line care, since about half of the patients with a central line went home with it. As the CLABSI rate improved, physicians were more willing to order central lines. It became increasingly important to teach patients to be involved in their central line care both in and outside of the hospital. Likewise, the nurses on the unit observed that the patients needed to feel empowered to ask about inconsistencies and understand the care of their central line.

Patients and family members were asking more questions. Consequently, the charge nurses began to educate patients by rounding on newly admitted patients with a central line or those patients with a newly placed central line. Key points were as follows: (1) encouraging the patient to ask nurses "Did you wash your hands?" if they did not observe the nurse wash before performing central line care; (2) teaching procedures for care of tubing and dressings; (3) empowering patients to ask questions if they did not understand the procedure or think the care was performed incorrectly; and (4) explaining line safety and risks associated with a central line infection. The charge nurse discussed the central line packets and signage and included the reasons and process for disconnecting tubing.

On average, the charge nurse educated 1 patient per day, which typically required 10 minutes. One of the unintended outcomes was the creation of an environment of accountability for the nurses providing central line care. The nurses explained central line care with more detail and provided more home preparation. The patients asked more questions of the nurses about their central line and its maintenance, indicating their involvement in their care.

As discussions with patients increased, the nurses determined that additional signage would remind the patient and also the intraprofessional team members of the presence of the line. The first sign created was a list of the topics covered in patient education. Specifically, it included bulleted key points of central line care, Saturday central line dressing change day, and Wednesday and Saturday intravenous tubing day change. Another sign was placed on the door of the patient's room that indicated Central Line Bundle. This sign reminded physicians to discuss central line days; it also prompted physical therapy and transportation staff to consider tubing disconnection needs.

The charge nurses also determined that it would be useful to audit each shift's central line care compliance with the policy. The audit form can be found in the Supplemental Digital Content Table (available at: http://links.lww.com/JNCQ/A106).

Comprehensive hospital-wide surveillance for CLABSIs was conducted by the Infection Prevention department using the NHSN's case definitions.[15] Rates for CLABSIs were calculated as infections per 1000 central line-days and provided to inpatient nursing units monthly. The 2009 year ended with 6 infections for a rate of 3.2 infections per 1000 catheter-days, with an NHSN benchmark of 1.5 central line infections per 1000 catheter-days. In 2010, there were 5 infections or 3.0 infections per 1000 catheter-days (the NHSN benchmark was 1.4 central line infections); in 2011, the rate was 1.2 per 1000 catheter-days, with a benchmark of 1.1 infections per 1000 catheter-days. The 2012 CLABSI rate was 0.8 central line infections per 1000 catheter-days, and the 2013 CLABSI rate was 0.6 central line infections per 1000 catheter-days compared with the NHSN benchmark of 1.0 per 1000 catheter-days.

RESULTS

With each PDSA cycle, the CLABSI rate improved (Figure). *PDSA cycle 1* included a 7-item test about policy and an assessment of individual knowledge and skills in performing central line care and blood drawing. It encompassed an 8-week period from September 2009 to November 2009. The unit's rate was more than double the benchmark of 1.5 central line infections per 1000 catheter-days and far from the goal of zero infections. Because the PDSA was in its infancy, the end of the year 2009 data did not reflect the work in progress.

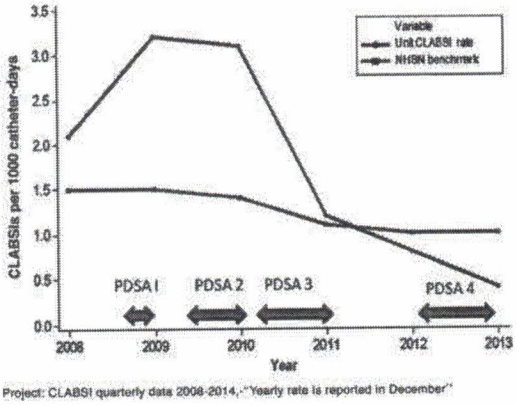

Figure. Unit CLABSI rates 2008-2013. CLABSI indicates central line-associated bloodstream infection; PDSA, Plan-Do-Study-Act; NHSN, National Health Care Safety Network.

PDSA cycle 2 included standardization of the intravenous tubing and dressing change times. This cycle began in March 2010 and ended in December 2010. While the unit's CLABSI rate moved downward, the benchmark also decreased and the unit's rate was still higher than the NHSN benchmark. This prompted a more aggressive approach with a third PDSA cycle.

PDSA cycle 3 centered on maximizing nurses' ability to perform the procedures. The cycle involved working out the logistics of having supplies at the bedside. This cycle evolved throughout the entire year of 2011. Each step required feedback and input from all nursing staff members to get not only a packet with the right supplies but also nurse buy-in. Members of the unit infection control team ensured packets were always available. *PDSA cycle 3* resulted in the largest impact on the unit's rates.

PDSA cycle 4 had several elements including auditing tubings and dressings on each patient each shift, empowering and involving patients in their central line care, and posting signs as reminders to patients and the interdisciplinary team. This final cycle began in March 2012 and was completed in November 2013. Efforts resulted in having only 1 central line infection in 2012 and 1 central line infection in 2013, with more than a year between infections. An unexpected outcome was that the number of catheter-days decreased significantly. In 2009-2011, there was a mean of 1730 catheter-days. In 2012, however, the mean was 1279 catheter-days, 460 days less than the mean in the other 4 years.

DISCUSSION

The CFIR framework helped describe the elements in successful project implementation. First, the intervention concentrated on the work of unit nurses. Implementing the Central Line Bundle was modified to focus on extended care of the lines. Second, the inner and outer settings aligned for success. The organizational structure was dynamic with goals that focused on improving quality and research. Within the organization, there was a supportive hospital Infection Control department with an infection control liaison program. A unit culture that embraced change to ensure quality and patient satisfaction provided a setting conducive to success.

Individual nurse's personalities provided energy for implementation. Individuals included creative and adaptive unit managers as well as a unit champion who was respected by staff, worked with the care processes, and served as the infection control liaison.

The processes included the PDSA, a concept that the nurses could understand. Individual instruction and feedback, standardization of work, and peer auditing were processes that contributed to the success of the project. The request for input and feedback increased nurses' involvement. Major improvements took place when the supplies were at the point of care and when signage gave visual cues to all involved. A team that carried out the many time-consuming duties associated with a project proved essential.

Although the CFIR framework does not address time, it affected the project in 2 ways: (1) the relatively slow rate of feedback (monthly) about the unit's CLABSI status, and (2) the 5-year length of the project. When hospital tracking changed to "days since last infection," the results were available daily; the unit's scores were displayed and staff awareness heightened. Sustaining energy-intensive efforts, such as audits, signage, and patient and staff education, was hard to maintain throughout the process. Celebrating 365 days of infection-free catheters helped the staff overcome the weariness that occurred with the project.

Like many other PI efforts, this project occurred on only 1 inpatient unit; thus, the results may not be generalizable to other units. Also, the project was not a controlled project and therefore was subject to the multitude of dynamic processes that occur on an inpatient unit. Although nursing turnover was low on the unit during these 5 years, there were new nurses, both experienced and new graduate nurses, and nurses who temporarily staffed the unit during these times. Although standardization of processes was stressed, some nurses or patients may have received more or less training.

Possibilities for future projects could isolate each PDSA. Since the most dramatic results occurred in the *PDSA cycle 3*, one question would be whether nurses' input, along with supplies at the point of care, would produce similar outcomes. Another future project would be to focus on decreasing central line–days. The decrease in catheter-days in 2012 may be related to the signs on the patient's door. The signs reminded physicians that patients had a central line. In 2013, as the use of the signs decreased, the number of catheter-days returned to the previous rate. While 5 data points do not provide enough information to draw a conclusion, a future study on visual cues or signage may be warranted.

CONCLUSION

This article describes 1 acute care unit's successful nursing CLABSI reduction project. It identifies the elements used to implement and sustain the results over 5 years with a focus on nursing care and maintenance of the central line. Applying the CFIR framework clarifies the implementation processes and allows for examination of the intervention, setting, people, and processes to determine which elements have an impact on outcomes. As with most PI projects, small, continuous changes interacted to achieve and sustain a low CLABSI rate.

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