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ICU nurses' adherence to the CDC's central line bundle: A qualitative study

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ICU NURSES' ADHERENCE TO THE CDC'S CENTRAL LINE BUNDLE: A QUALITATIVE STUDY

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ABSTRACT

ICU NURSES' ADHERENCE TO THE CDC'S CENTRAL LINE BUNDLE: A QUALITATIVE STUDY

By

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May 2023

Dissertation supervised by Dr. Karen Jakub

Background: Central line associated bloodstream infections (CLABSIs) are one of the most common healthcare associated infections and result in prolonged hospital stays, significant morbidity, and increased costs to the healthcare system. Adherence to the CDC central line maintenance bundle has been shown to be effective in decreasing CLABSI yet these infections continue to be a problem. ICU nurses play a vital role in managing central lines and adhering to the maintenance guidelines, however different situations may arise during the care that may impact CLABSIs.

Objectives: 1) To determine nurses' adherence to the CDC's maintenance central line bundle; 2) To determine if nurses are utilizing additional strategies when managing central lines vis-à-vis positive deviant behaviors; and 3) To explore nurses' beliefs, motivations, and perceptions related to non-adherence and the utilization of additional strategies.

Methods: Data for this study were obtained from semi-structured interviews and transcripts were analyzed with an interpretive description approach to generate conceptual themes. Interpretation included a focus on the concept of positive deviance to identify additional strategies.

Results: Twenty-seven participants were interviewed from across the United States. The following themes emerged: (a) surmountable barriers, (b) multidisciplinary collaborative impact, and (c) positive deviant behaviors.

Conclusion: This study provides a qualitative assessment of the challenges experienced and the innovative strategies employed by ICU nurses while adhering to the CDC central line maintenance bundle, optimizing patient care quality and preventing CLABSI. Examining the positively deviant behaviors nurses are using may provide the opportunity to improve practices and decrease CLABSI rates.

DEDICATION

This work is dedicated to my husband Todd Cox and my children Collin and Kelsey. Your love and support made this possible.

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I am grateful to the participants for their willingness to share their knowledge and experiences. I would like to personally thank my dissertation committee members, Drs. Karen Jakub, Jessica Devido, and Leo Yurek for their wisdom and guidance.

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1.0 INTEGRATIVE REVIEW OF THE LITERATURE

Manuscript #1

Integrative Review of the Literature

Burke C, Jakub K, Kellar I. Adherence to the central line bundle in intensive care: An Integrative Review. *Am J Infect Control*. 2021;49(7):937-956. doi:10.1016/j.ajic.2020.11.014

Abstract

Background: Central line-associated bloodstream infections (CLABSI) occurring in intensive care units are associated with increased morbidity and mortality, increased length of hospitalization, and cost of care associated with treating CLABSIs. The Centers for Disease Control and Prevention guidelines and checklist bundle are intended to provide evidence-based recommendations for the prevention of CLABSIs. Despite the promotion of central line bundle policies, wide variability exists in compliance and infection rates in intensive care units.

Objective: To evaluate and synthesize the existing literature on adherence to the central line bundle recommendations for the prevention of CLABSI.

Design: Integrative literature review.

Data sources: CINHAL, PubMed, and SCOPUS databases were searched.

Review Methods: Whittmore and Knafl's integrative review method.

Results: A total of 608 articles were identified, 407 articles were screened for topic of interest and adherence to the inclusion criteria, and 19 articles were included in this review. None of the 19 studies addressed adherence to all 14 recommendations of the central line bundle checklist.

Conclusion: This integrative review identified gaps in adherence to the central line bundle. Research is needed to determine the actual adherence to each item in the bundle, and to investigate factors that contribute to nonadherence. To achieve complete compliance with all the bundle items creative and innovative technology is needed.

Central line-associated bloodstream infections (CLABSI) occurring in intensive care units (ICUs) are associated with increased morbidity and mortality.[1-3] These infections increase the length of hospital stay for an affected patient, as well as the cost of care associated with treating CLABSI.[4] The Centers for Disease Control and Prevention (CDC) published guidelines for intravascular device infections in 1983,[5] with subsequent updates in 1996, [6] 2002[7], and 2011.[8] These guidelines are intended to provide evidence-based recommendations for the prevention of CLABSI (Figure 1). Based on these guidelines, the CDC provides a bundle checklist which includes proper insertion practices, appropriate maintenance and handling recommendations, and prompt removal of unnecessary central lines to prevent CLABSI.[8] The guidelines and checklist bundle have been extensively promoted and implemented nationally and internationally.

The use of proven guidelines to prevent infection of the blood from central lines is required of all hospitals accredited by The Joint Commission as part of the National Patient Safety Goals.[10] Although most hospitals in the United States (US) report adopting the central line bundle recommendations, the CDC estimates 30,000 CLABSI still occur in intensive care units (ICUs) and acute care units each year.[9] Furuya et al[11] noted that despite the promotion of central line bundle policies, wide variability exists in compliance and infection rates in ICUs across the United States. An international study by Valencia et al[12] reported that although there is interest and awareness for CLABSI prevention, the need for improved practices and collaboration to decrease the occurrence of CLABSI still exists.

Follow proper insertion practices
1. Perform hand hygiene before insertion
2. Adhere to aseptic technique
3. Use maximal sterile barrier precautions a) Mask b) Cap c) Gown d) Sterile gloves e) Sterile full body drape
4. Choose the best insertion site to minimize infections and noninfectious complications

a) Based on individual patient characteristics b) Avoid femoral site in obsess adult patients
5. Prepare the insertion site with >0.5% chlorhexidine with alcohol
6. Place a sterile gauze dressing or a sterile, transparent, semipermeable dressing over the insertion site
Handle and maintain central lines appropriately
1. Comply with hand hygiene requirements
2. Bathe intensive care unit patients over 2 months of age with a chlorhexidine preparation daily
3. Scrub the access port or hub with friction immediately prior to each use with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol)
4. Use only sterile devices to access catheters
5. Immediately replace dressings that are wet, soiled, or dislodged
6. Perform routine dressing changes using aseptic technique with clean or sterile gloves a) Change gauze dressings at least every 2 days b) Change semipermeable dressings at least every 7 days c) For patients ≥ 18 years of age, use chlorhexidine impregnated dressing with a Food and Drug Administration cleared label that specified a clinical indication for reducing CLABSI for short-term non-tunneled catheters, unless the facility is demonstrating success at preventing CLABSI with baseline prevention practices
7. Change administration sets a) For continuous infusions: no more frequently than every 4 days, but at least every 7 days b) For blood or blood products or gat emulsions: every 24 hours c) For propofol: every 6 to 24 hours or when vial is changed
Promptly remove unnecessary central lines
1. Perform daily audits to assess whether each central line is still needed

Figure 1. Adapted checklist for the prevention of CLABSI[9]

The CDC's National Healthcare Safety Network (NHSN) provides a tracking system for hospital acquired infections (HAIs) and national and state progress reports on CLABSI rates and prevention.[13] In the United States, most states have hospital acquired infection reporting laws but reporting requirements vary from state to state.[14] These variations include submission to a state agency or the NHSN, public reporting, public facility identification, as well as data collected in addition to CLABSI rates.[15] In some states, hospitals self-report compliance with the central line bundle along with CLABSI rates.[16] The purpose of this integrative review is to evaluate and synthesize the existing literature on adherence to the central line bundle recommendations for the prevention of CLABSI. The following questions guided this review: 1) What is the level of adherence to the central line bundle? 2) Are there recommendations that are more frequently adhered to than others? The knowledge extracted from this review will guide future research on this topic.

Methods

Design

This integrative review was conducted according to the methodological strategies of Whittmore and Knafal.[17] An integrative review allows for the inclusion of diverse literature and study designs, including qualitative, quantitative, mixed methods, non-experimental, clinical expert opinion, and gray literature to provide a comprehensive understanding of the current knowledge.[17] This methodologic framework includes: (1) problem identification, (2) literature search, (3) data evaluation, (4) data analysis, and (5) presentation. It incorporates a method of analyzing research from diverse empirical and theoretical sources and delineates a systematic framework that enhances the rigor of the integrative review process.

Literature Search

A systematic review of the literature was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) protocol.[18] Database searches were done with the assistance of a health science librarian.

Eligibility

The selection of inclusion and exclusion criteria were determined prior to the start of the literature search. The inclusion criteria were English or English-translated full text articles that focused on adherence to CDC guidelines for the prevention of CLABSI in nontunneled central lines in adult intensive care units worldwide. The CDC guidelines for prevention of CLABSI have been adopted and implemented internationally, therefore articles from other countries were included if they met the inclusion criteria. Due to updates to the central line bundle in 2002 and 2011, articles published from 2002 to October 2020 were included. Exclusion criteria included

peripherally inserted central venous catheters, hemodialysis catheters, or tunneled catheters; antimicrobial-coated catheters or other products, not included in the checklist, to prevent CLABSI; infections other than CLABSI; assessment of knowledge of guidelines; or implementation or summary of guidelines rather than actual adherence.

Information sources

CINHAL, PubMed, and SCOPUS databases were used. Search terms included *central venous catheters, central catheter related bloodstream infections, intensive care units,* and *guideline adherence.* The Boolean connectors AND and OR were used to combine keywords and additional terms. Appropriate subject headings based on the database searched (ie, CINHAL, subject headings, Medical Subject Headings and Indexterms) were also included. See specific search strategies in Electronic Database table.

Table

Electronic Database	**Search Strategy**
CINHAL	(Guideline* OR “central line bundle” OR “CLABSI bundle” OR “CVC bundle” OR (MH "Guideline Adherence") OR (MH "Professional Compliance") OR (MH "Practice Guidelines")) AND (“Critical care” OR “Intensive Care” OR “Acute Care” OR “ICU” OR “Coronary Care Unit” OR “CCU” OR “CTICU” OR “MICU” OR “SICU” OR “Neuro ICU” OR (MH "Intensive Care Units") OR (MH "Coronary Care Units") OR (MH "Respiratory Care Units") OR (MH "Post Anesthesia Care Units") OR (MH "Stroke Units") OR (MH "Critical Care Nursing")) AND (“CLABSI” OR “Catheter-related blood stream infections “ OR “CRBSI “ OR “CR-BSI” OR “Blood stream infection” OR “Central Venous Catheter blood stream infection “ OR “CVC-BSI” OR “Central line related infection “ OR “CR-I” OR (MH "Catheter-Related Infections") OR (MH "Catheter-Related Bloodstream Infections") OR (MH "Cross Infection") OR (MH "Infection Control+")) AND (“CVP lines” OR “Non-tunneled central lines “OR “CVPs” OR “CVCs “ OR “Central Venous Catheters” OR “Venous access device” OR (MH "Catheterization, Central Venous"))
PubMed	("Guideline Adherence"[Mesh] OR "Practice Guideline" [Publication Type] OR "Practice Guidelines as Topic"[Mesh]

	OR “Central Line Associated Bloodstream Infection bundle” [tw] OR “central line bundle” [tw] OR “Central Venous Catheter bundle” [tw] OR “CLABSI bundle” [tw] OR “CVC bundle” [tw] OR “Guideline*” [tw]) AND ("Intensive Care Units"[Mesh] OR "Burn Units"[Mesh] OR "Coronary Care Units"[Mesh] OR "Respiratory Care Units"[Mesh] OR "Critical Care"[Mesh] OR “Acute care” [tw] OR “Cardiothoracic intensive care unit” [tw] OR “CCU” [tw] OR “Coronary Care Unit” [tw] OR “Critical care” [tw] OR “CTICU” [tw] OR “ICU” [tw] OR “Intensive care unit” [tw] OR “Medical intensive care unit” [tw] OR “MICU” [tw] OR “Neuro ICU” [tw] OR “SICU” [tw] OR “Surgical intensive care unit” [tw] OR “Intensive Care” [tw]) AND ("Catheter-Related Infections"[Mesh] OR "Cross Infection"[Mesh] OR "Infection Control"[Mesh] OR “Blood stream infection” [tw] OR “Catheter-related blood stream infections” [tw] OR “CRBSI” [tw] OR “CR-BSI” [tw] OR “Central line related infection” [tw] OR “CR-I” [tw] OR “Central Venous Catheter blood stream infection” [tw] OR “CVC-BSI” [tw] OR “CLABSI” [tw]) AND ("Catheterization, Central Venous"[Mesh] OR "Central Venous Catheters"[Mesh] OR “Central Venous Catheters”[tw] OR CVC*[tw] OR CVP* [tw] OR “Non-tunneled central lines” [tw] OR “Venous access device”[tw])
SCOPUS	(INDEXTERMS("Guideline Adherence") OR INDEXTERMS("Practice Guideline") OR INDEXTERMS("Practice Guidelines as Topic") OR TITLE-ABS-KEY(“Central Line Associated Bloodstream Infection bundle”) OR TITLE-ABS-KEY(“central line bundle”) OR TITLE-ABS-KEY(“Central Venous Catheter bundle”) OR TITLE-ABS-KEY(“CLABSI bundle”) OR TITLE-ABS-KEY(“CVC bundle”) OR TITLE-ABS-KEY(“Guideline*”)) AND (INDEXTERMS("Intensive Care Units") OR INDEXTERMS("Burn Units") OR INDEXTERMS("Coronary Care Units") OR INDEXTERMS("Respiratory Care Units") OR INDEXTERMS("Critical Care") OR TITLE-ABS-KEY(“Acute care”) OR TITLE-ABS-KEY(“Cardiothoracic intensive care unit”) OR TITLE-ABS-KEY(“CCU”) OR TITLE-ABS-KEY(“Coronary Care Unit”) OR TITLE-ABS-KEY(“Critical care”) OR TITLE-ABS-KEY(“CTICU”) OR TITLE-ABS-KEY(“ICU”) OR TITLE-ABS-KEY(“Intensive care unit”) OR

TITLE-ABS-KEY(“Medical intensive care unit”) OR TITLE-ABS-KEY(“MICU”) OR TITLE-ABS-KEY(“Neuro ICU”) OR TITLE-ABS-KEY(“SICU”) OR TITLE-ABS-KEY(“Surgical intensive care unit”) OR TITLE-ABS-KEY(“Intensive Care”))
AND
(INDEXTERMS("Catheter-Related Infections") OR INDEXTERMS("Cross Infection") OR INDEXTERMS("Infection Control") OR TITLE-ABS-KEY(“Blood stream infection”) OR TITLE-ABS-KEY(“Catheter-related blood stream infections”) OR TITLE-ABS-KEY(“CRBSI”) OR TITLE-ABS-KEY(“CR-BSI”) OR TITLE-ABS-KEY(“Central line related infection”) OR TITLE-ABS-KEY(“CR-I”) OR TITLE-ABS-KEY(“Central Venous Catheter blood stream infection”) OR TITLE-ABS-KEY(“CVC-BSI”) OR TITLE-ABS-KEY(“CLABSI”))
AND
(INDEXTERMS("Catheterization, Central Venous") OR INDEXTERMS("Central Venous Catheters") OR TITLE-ABS-KEY(“Central Venous Catheters”) OR TITLE-ABS-KEY(CVC*) OR TITLE-ABS-KEY(CVP*) OR TITLE-ABS-KEY(“Non-tunneled central lines”) OR TITLE-ABS-KEY(“Venous access device”))

A total of 608 articles were identified via the electronic searches (Figure 2). After removing duplicates, the titles and abstracts of 407 articles were screened to determine if they met the topic of interest and the inclusion criteria. Articles not meeting the inclusion criteria or topic of interest (n=217) were excluded resulting in 190 articles for full text review. An additional 172 articles were excluded after the full text review because they focused on summary of guidelines, settings other than adult ICU, hospital acquired infections (not CLABSI specific), included tunneled central venous catheters, hemodialysis catheters or peripherally inserted central venous catheters, or failed to address adherence to central line guidelines. Ancestry

searches of the 18 articles extracted produced one additional article; in total 19 articles were included in this review.

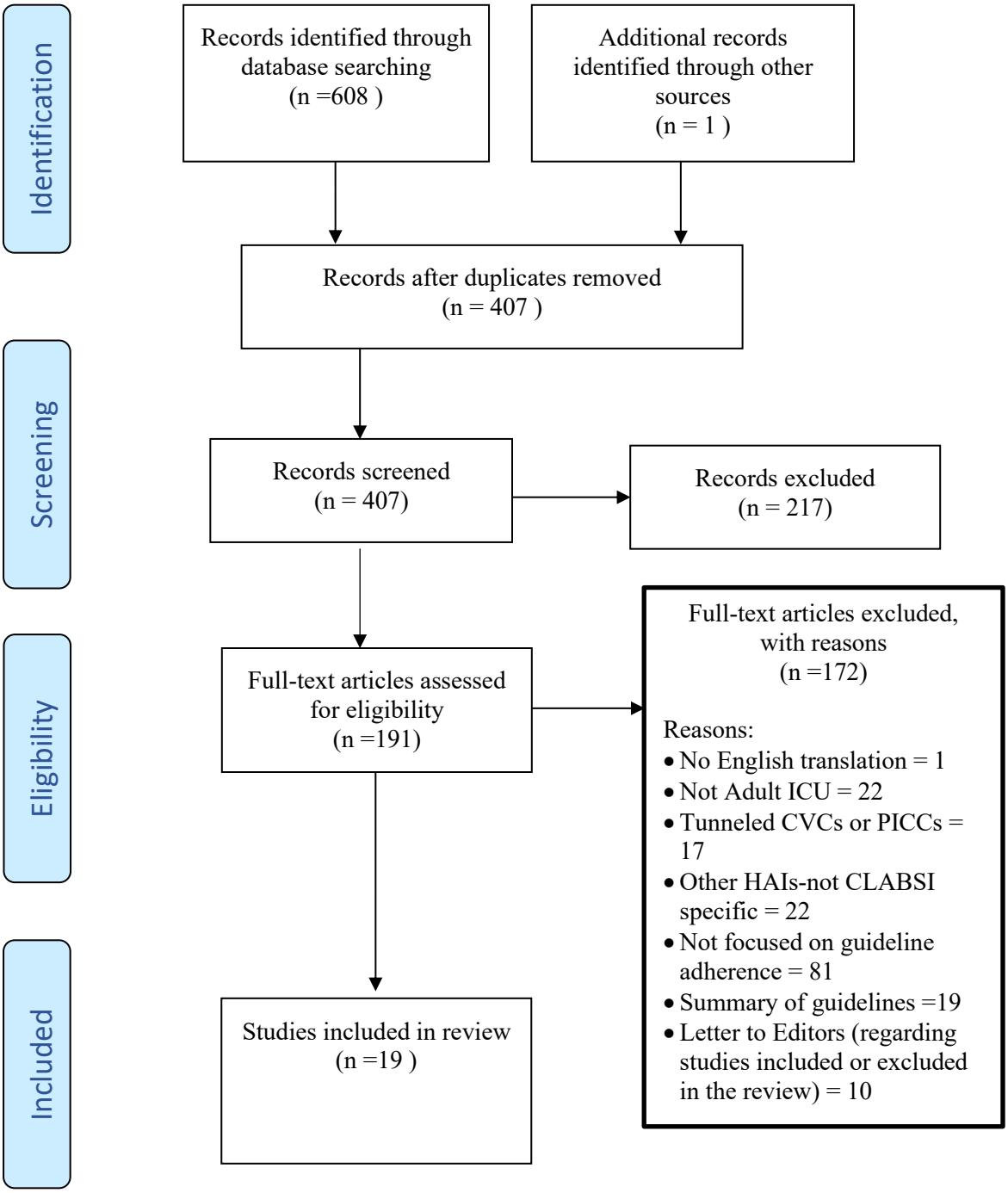

Figure 2. PRISMA flow diagram for article selection process.[18]

Data Evaluation

The final sample for this integrative review included 15 quantitative studies and 4 quality improvement projects (Table Summary of Search Results). All of the articles were written in English but the studies originated in many different countries. Due to the differences is the designs of the primary sources in this review, the studies were coded on a 2-point scale by the primary author based on methodological or theoretical rigor and data relevance.[17] Studies were rated 0 for low quality weaker study design or weak amount of evidence, 1 for medium quality, and 2 for high quality more rigorous study design and stronger evidence regarding the research question. For example, studies with a very small sample size and self-reported data were coded 0, whereas studies with a large sample size with statistical and correlational data were coded as 2. Each of the 19 studies included reported on adherence to central line guidelines. The included studies ratings ranged from 0 to 2 and all studies were retained for data analysis. Lower scored studies contributed less to the final analysis.

Data Analysis

After full text review, the 19 studies were analyzed using the Whittmore and Knafl approach.[17] This approach consists of: (1) data extraction from primary sources regarding the sample characteristics, methodology, and reference to the concept of adherence to central line guidelines; (2) extracting specific categories from the data (ie, hand hygiene, maximal barrier precautions, central line insertion site, dressings, etc.); (3) identifying related terms and proposed relationships of adherence to guidelines and other variables; (4) coding, analyzing and comparing the data; (5) and reviewing each primary source as data was conceptualized at higher levels of abstraction for congruency.[17] Using a matrix, data were extracted to include information regarding the study design, year of publication, sample characteristics (ie, size, location,

profession of respondents) as well as data related to adherence to the central line guidelines. The studies were then grouped by study design and systematically analyzed to compare the data across the primary sources in an attempt to discern common practices and identify patterns. Throughout the analysis, each primary source was repeatedly and thoroughly reviewed.

Results

Description of Studies

The 19 included studies were published between 2004 and 2018.[11,12, 19-35] Four were quality improvement projects and 15 were quantitative studies consisting of descriptive survey (n=3), combined multiple choice questionnaire with observation (n=1), cross-sectional prospective survey (n=4), cross-sectional prospective survey with observation (n=2), and prospective cohort (n= 5) designs. Sample population among the studies included nurses, physicians, healthcare workers, infection control directors, ICUs, and patients with central lines. The sample sizes were equally diverse ranging from one ICU at one hospital with 21 patients[25] to 1,071 ICUs in 792 hospitals.[26] More details are provided in Summery of Research Result Table.

Table

Summary of Research Results

Author(s)	Purpose and Design	Sample	Findings	Limitations	Data Evaluation
Al-Sayaghi[19] (2011) Yemen	To describe the current infection control practices of non-tunneled CVCs in ICUs in Sana'a Yemen and to compare current practices to CDC guidelines to determine extent of adoption of practices.	Nurse managers (n=22) or Senior Nurse on duty (n=3) in 13 ICUs at 4 tertiary teaching hospitals and 12 ICUs at 10 non-teaching hospitals.	Variation and lack of consistent adherence to guidelines among the ICUs. Insertion Practices: 1.Hand hygiene prior to and after insertion a)61% teaching hospital b)83% non-teaching hospital	Very small sample size. Convenience sample. One city in Yemen. Self-reported questionnaire survey (possibility of	Q: 0 Low quality

Descriptive: survey	2. Preferred CVC insertion site a) subclavian vein = 56% (n=14) b) jugular vein = 16% (n=4) c) either subclavian or jugular = 28% (n=7) 3. Skin antiseptic prep used a) 10% povidone-iodine = 52% (n=13) b) 70% alcohol + 10% povidone iodine = 36% (n=9) c) 70% alcohol + 1% iodine =4% (n=1) d) 1% tincture of iodine = 4% (n=1) e) 0.5% alcoholic chlorhexidine = 4% (n=1) f) 2% chlorhexidine = 0% (n=0) 4. Barrier precautions a) cap = 56% (n=14) b) mask 84% (n=21) c) sterile gloves 100% (n=25) d) sterile gown 52% (n=13) e) large sterile drapes 36% (n=9) f) smaller sterile drapes 20% (n=5) g) non-sterile gown 16% (n=4) h) Maximal sterile barrier precautions 28% (n=7) Care of insertion site: 1. Dressing material a) transparent, semi-permeable = 12% (n=3) b) occlusive, sterile gauze = 52% (n=13) c) either gauze or transparent = 28% (n=7) d) other = 8% (n=2) 2. Frequency of dressing change	self-reporting bias).

a) transparent, semi-permeable
- ≤ weekly = 40% (n= 10)
- >weekly = 0% (n=0)
b) occlusive sterile gauze
- <48 hours = 48% (n=12)
- 48 hours = 4% (n=1)
- >48 hours = 28% (n=7)

3. Dressing change techniques
a) sterile procedure = 56% (n=14)
b) clean procedure = 28% (n=7)
c) either sterile or clean = 16% (n=4)

4. Barrier precautions used for dressing change
a) hat = 16% (n=4)
b) mask = 64% (n=16)
c) sterile gloves = 76% (n=19)
d) non-sterile gloves = 24% (n=6)
e) sterile/non-sterile gown = 32% (n=8)

5. Skin antiseptic used for dressing changes
a) 10% povidone-iodine = 52% (n=13)
b) 70% alcohol = 24% (n=6)
c)70% alcohol + 10% povidone iodine = 12% (n=12)
d) 70% alcohol + 1% iodine =4% (n=1)
e) 1% tincture of iodine = 4% (n=1)
f) 0.5% alcoholic chlorhexidine = 4% (n=1)
g) 2% chlorhexidine = 0% (n=0)

Accessing and administration set practices:
1. Disinfection of IV access ports/needleless connectors before

			accessing or manipulation -Yes: swabbed with a) 70% alcohol = 36% (n=9) b) povidone-iodine = 16% (n=4) c) normal saline = 12% (n=3) -No = 32% (n=8) -Either Yes or No = 4% (n=1) Replacement of IV administration sets: 1. Non-lipid TPN infusions a) Yes (within) - <72 hours (24-48 hours) = 40% (n=10) - ≥72 hours (3 to 7 days) = 12% (n=3) b) With each new infusion bottle = 16% (n=4) c) No, only when indicated = 24% (n=6) d) Other = 8% (n=2) 2. Lipid emulsions infusions a) Yes - ≤ 24 hours of initiation = 28% (n=7) - > 24 hours (from 48-96 hours = 16% (n=4) - With each new infusion bottle = 16% (n=4) - No, only when indicated 32% (n=8) - Other = 8% (n=3) 3. Propofol infusions a) Yes (within) - ≤ 12 hours = 36% (n=9) - > 12 hours (48-96 hours) = 32% (n=8) - No, only when indicated = 20% (n=5) -Others (not used in the unit) = 12% (n=3)		
Alkubati et al[20] (2015) Egypt	To assess the knowledge of health care workers in ICUs about guidelines for the	N=100 Physicians (n=40) Nurses (n=60) Working in the ICUs at a	Most health care workers had low-level knowledge of the guidelines for preventing CLABSI and did not follow-up on the	Convenience sample. One hospital in Egypt	Q: 1 Medium quality

	prevention of CVC-RI and their adherence to these guidelines in practices. Descriptive: interviewer administered multiple choice questionnaire on knowledge of guidelines and follow up observation of insertions and maintenance of CVCs	university hospital in Egypt	EBP during the insertion and care of CVCs. Total Correct Answers to questionnaire on knowledge a) Physicians 36.94% b) Nurses 32.72% Adherence to guidelines 1)Hand hygiene: a) Physicians 87.5% b) Nurses 22.5% 2) Maximal barrier precautions -Cap a) Physicians 80% b) Nurses 5% -Mask a) Physicians 85% b) Nurses 30% -Gloves a) Physicians 90% b) Nurses 45% -Sterile gown a) Physicians 80% b) Nurses 15% -Applied Large Sterile Body Drape a) Physicians; Not applicable (N/A) b) Nurses 55% -Opened catheter kit using sterile technique a) Physicians; N/A b) Nurses 45% -Flush the lumens with normal saline after catheter insertion a) Physicians: N/A b) Nurses 90% -Label the dressing with time and date a) Physicians: N/A b) Nurses 62.5%	Self-reported questionnaire survey (possibility of self-reporting bias).	
Aloush and Alsaraireh[21] (2018) Jordan	To assess nurses' compliance with central line associated bloodstream infection (CLABSI) prevention guidelines	N= 171 ICU nurses from 15 hospitals located in 5 cities in Jordan. Recruitment was made after observational sheet was	Majority of nurses were sufficiently compliant. Nurses working with a lower nurse-patient ratio had higher compliance scores. 1. Daily assessment of CVC insertion site	Observations were during day shift only. Observations were of in-situ CVCs. No observations of insertions of	Q: 1 Medium quality

related to maintenance of the central line and the predictors of compliance. Descriptive: cross-sectional with observational non-active approach.	completed. If nurses did not want to participate, data was destroyed and not included.	a) Done completely accurate = 58% b) Done but not complete or not accurate = 19% c) Not done = 39% 2. Assessment of the date is made for dressing a) Done completely accurate = 47% b) Done but not complete or not accurate = 27% c) Not done = 26% 3. Dressing is maintained clean and dry a) Done completely accurate = 62% b) Done but not complete or not accurate = 28% c) Not done = 10% 4. Hand washing a) Done completely accurate = 34% b) Done but not complete or not accurate = 44% c) Not done = 22% 5. Sterile gloves a) Done completely accurate = 45% b) Done but not complete or not accurate = 33% c) Not done = 22% 6. Swab port with antiseptic a) Done completely accurate = 59% b) Done but not complete or not accurate = 18% c) Not done = 23% 7. Flush with 0.9 % normal saline a) Done completely accurate = 61% b) Done but not complete or not accurate = 17% c) Not done = 22% 8. Change IV sets a) Done completely accurate = 73% b) Done but not complete	CVC were conducted. Possibility of Hawthorne effect and inter-observer reliability and bias.

			or not accurate = 15% c) Not done = 12% 9. Cover all lumens when not in use a) Done completely accurate = 79% b) Done but not complete or not accurate = 16% c) Not done = 5% 10. Use minimum number of lumen, unless in need a) Done completely accurate = 77% b) Done but not complete or not accurate = 18% c) Not done = 5%		
Boltz et al[22] (2008) Australia	To describe current practices for CVC insertion and ongoing care among a representative sample of Australian ICUs, and, to describe variation in practices among ICUs and compare current practice to international guidelines. Descriptive telephone administered survey	Random selection of 160 nurses yielded 133 (83%) willing to participate.	Insertion Results: 1.Skin Asepsis a) Chlorhexidine 0.5%/alcohol 70% n= 89 (66.9%) b) Sometimes 70% ethanol/povidone iodine 10%; sometimes chlorhexidine 0.5%/alcohol 70% n=44 (33.1%) 2. CVC site insertion a) Subclavian mostly, jugular sometimes n=40 (30.1%) b) Jugular mostly, subclavian sometimes n=48 (36.1%) c) Subclavian/Jugular mostly, sometimes femoral n=45 (33.8%) 3. CVC Access Practices a) Hand wash before access/CVC prepped with alcohol/needle free access system n=90 (67.6%) b) Hand wash before access/CVC prepped with chlorhexidine/3-way stopcock access system n=8 (6%) c) Hand wash before access/ CVC sometimes prepped with alcohol,	Self-reported survey (possibility of self-reporting bias). No direct observations.	Q: 2 High quality

sometimes no prep/3-way stopcock n=5 (3.8%)
d) Hand wash before access/ CVC prepped with alcohol/Injectable bung n=30 (22.6%)

4. Dressing Management
a) Transparent polyurethane immediately after insertion and ongoing/Hand washing with 2% chlorhexidine before dressing change n=81 (60.9%)
b) Transparent polyurethane immediately after insertion and ongoing/Hand washing with 4% chlorhexidine before dressing change n=46 (34.6%)
c) Other type of dressing and ongoing/ Hand washing with 2% chlorhexidine before dressing change n=6 (4.5%)

5. Replacement of Administration Sets
a) Hand wash before replacing sets/Frequency of TPN replacement sets $\leq$ 24 hours/Frequency of propofol replacement sets 7-12 hours n=54 (40.6%)
b)) Hand wash before replacing sets/Frequency of TPN replacement sets $\leq$ 24 hours/Frequency of propofol replacement sets 13-24 hours n=37 (27.8%)
c) Hand wash before replacing sets/Frequency of TPN replacement sets $\leq$ 24 hours/Frequency of propofol replacement sets 7-48 hours n=31 (23.3%)
d) Hand wash before replacing sets/Frequency

of TPN replacement sets 49-72 hours/Frequency of propofol replacement sets 13-24 hours n=11 (8.3%)

6. CVC Replacement
How often is CVC removed
a) n=38 (28.6%)
-If in place not in use and peripheral IV sufficient = most of time
-CVC routinely replaced = only when clinically indicated
-CVC replaced over guidewire = sometimes
-Is catheter inserted at a new site = most of the time
b) n=42 (31.6%)
-If in place not in use and peripheral IV sufficient = always
-CVC routinely replaced = only when clinically indicated
-CVC replaced over guidewire = rarely
-Is catheter inserted at a new site = always
c) n=46 (34.6%)
-If in place not in use and peripheral IV sufficient = always/most of time
-CVC routinely replaced = every 7 days
-CVC replaced over guidewire = rarely
-Is catheter inserted at a new site = always
d) n=7 (5.2%)
-If in place not in use and peripheral IV sufficient = never
-CVC routinely replaced = only when clinically indicated or every 7 days
-CVC replaced over guidewire = never
-Is catheter inserted at a new site = always

			7. Monitoring of CVC for signs of infections or other complications a) 1 time per shift (66.9%) b) every 2-3 hours (30%) 8. Removal of CVC if signs of local infection (85%) 9. Removal of CVC if CLABSI present (72.2%)		
Filgueira Gouveia Barreto et al[23] (2013) Brazil	To verify the association of nosocomial infection and the central venous catheter with noncompliance of the protocols in the intensive care unit. Observational prospective cohort study	Patients admitted to an ICU in Brazil who had a CVC inserted (n=31)	Deviations from guidelines on insertion ranged from 0 to 5 errors (1.2 ± 1.4); and for maintenance/management deviations ranged from 0 to 4 (2.3 ± 0.9) Main errors committed: 1) Did not sanitize their hands before and after handling CVC a) Insertion = 48.4% b) Maintenance = 87.1% c) Procedure = 67.7% 2) Did not use expanded and sterile field a) Insertion = 35.5% b) Maintenance = 96.8% c) Procedure = 66.1% 3) Did not use sterile gloves a) Insertion = 6.5% b) Maintenance = 100% c) Procedure = 53.2% 4) Did not use sterile gown a) Insertion =16.1% b) Maintenance = 61.3% c) Procedure = 38.7% 5) Did not use mask a) Insertion = 12.9% b) Maintenance = 3.2% c) Procedure = 8.0% Lack of standardization in skin asepsis at time of insertion and dressing	Small sample size. Single hospital setting in Brazil. Possible Hawthorne effect.	Q: 1 Medium quality

			changes was noted. Povidone-iodine and chlorhexidine were used but in the absence of these products, physiological saline was used Dressing were sterile gauze with micorpore tape changed very 24 hours during the majority of the study. During the last days of the study, transparent film dressings were started and changed every 7 days.		
Furuya et al[11] (2011) United States	To examine the extent of adoption of the central line bundle in ICUs across the US; to determine the effectiveness of individual bundle elements on reducing infections; to determine the effectiveness of combinations of the bundle elements on reducing infections; and to determine if the effect of the bundle elements was specific, or if compliance reduced infection rates in non-targeted HAIs such as ventilator-associated pneumonia (VAP) Cross-sectional survey	Central line bundle data from 415 ICUs, from 250 Hospitals that had conducted National Healthcare Safety Network (NHSN) CLABSI surveillance according to CDC protocol. (57% response rate) The ICU must have had a minimum of 500 central line device days.	49% of ICUs had a written policy regarding the central line bundle, and 38% of ICUs that monitored the policy (n = 35) reported having implemented the CL Bundle 95% of the time or greater. ICUs reporting correct implementation: 1) Central Line Bundle a) Presence of written policy= 49% (n=204) b) Presence of monitoring for implementation = 45% (n=91) Correctly Implemented c) At least sometimes = 77% d) At least usually = 68% e) All of the time = 38% (n=35) 2) Barrier precautions a) Presence of written policy= 94% (n=392) b) Presence of monitoring for implementation = 74% (n=292) Correctly Implemented c) At least sometimes = 86% (n=229)	Self-reported survey with 57% response rate (possibility of self-reporting bias). Data were collected from larger NHSN hospitals, based on criteria of a minimum number of device days for study eligibility.	Q: 2 High quality

			d) At least usually = 83% (n=242) e) All of the time = 64% (n=186) 3) Chlorhexidine use a) Presence of written policy= 95% (n=394) b) Presence of monitoring for implementation = 68% (n=266) Correctly Implemented c) At least sometimes = 86% (n=229) d) At least usually = 84% (n=223) e) All of the time = 73% (n=194) 4) Optimal site selection a) Presence of written policy= 57% (n=235) b) Presence of monitoring for implementation = 57% (n=133) Correctly Implemented c) At least sometimes = 87% (n=116) d) At least usually = 78% (n=104) e) All of the time = 44% (n=58) 5) Daily infection check a) Presence of written policy= 82% (n=341) b) Presence of monitoring for implementation = 57% (n=194) Correctly Implemented c) At least sometimes = 78% (n=152) d) At least usually = 76% (n=148) e) All of the time = 54% (n=104)		
Furuya et al[24] (2016) United States	To describe compliance with the central line insertion bundle overall, as well as with	Central line bundle data from 984 adult ICUs in 632 non-VA hospitals	Most ICUs had central line bundle policies. 69% reported excellent compliance (≥95%) with at least 1 element.	Self-report compliance data (possibility of self-reporting bias).	Q: 2 High quality

individual bundle elements in US adult intensive care units (ICUs) and to determine the relationship between an individual bundle element or overall bundle compliance and CLABSI rates. Cross-sectional survey	(located in 51 states and territories) reporting into the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) CLABSI surveillance	These results are similar to Furuya et al[11] study, but this study provided updated data, and a significantly larger sample size in this study. Presence and Compliance with: 1) Hand hygiene a) Presence of written policy = 93.8%(n=923) b) Portion of time correctly implemented: - All of the time($\geq$ 95%) = 53.7% (n=528) -Usually (75-94%) = 17.2% (n=169) -Sometimes (25-74%) = 1.6% (n=16) -Rarely/Never/No monitoring = 21.3% (n =210) 2) Maximal barrier precautions a) Presence of written policy = 97.8%(n=962) b) Portion of time correctly implemented: - All of the time($\geq$ 95%) = 56.3% (n=554) -Usually (75-94%) = 16.7% (n=164) -Sometimes (25-74%) = 1.6% (n=16) -Rarely/Never/No monitoring = 23.2% (n =228) 3) Chlorhexidine use a) Presence of written policy = 98.2%(n=966) b) Portion of time correctly implemented: - All of the time($\geq$ 95%) = 65% (n=640) -Usually (75-94%) = 10% (n=98) -Sometimes (25-74%) = 1.0% (n=10) -Rarely/Never/No monitoring = 22.2% (n =218) 4) Optimal catheter site	Potential sample selection bias data collected from NHSN participating hospitals (may be high performers).

			selection a) Presence of written policy = 93.1%(n=916) b) Portion of time correctly implemented: - All of the time(≥ 95%) = 39.3% (n=387) -Usually (75-94%) = 26.5% (n=261) -Sometimes (25-74%) = 3.6% (n=35) -Rarely/Never/No monitoring = 23.7% (n =233) 5) Daily assessment of central line need a) Presence of written policy = 87.9%(n=865) b) Portion of time correctly implemented: - All of the time(≥ 95%) = 30.4% (n=299) -Usually (75-94%) = 25.3% (n=249) -Sometimes (25-74%) = 6.7% (n=66) -Rarely/Never/No monitoring = 25.5% (n =251)		
Hickox[25] (2015) United States	To determine if nurses in the medical cardiac ICU were deviating from the department's procedural guideline when performing central line site care. If so, what exactly were the deviations? If a non-occlusive dressing was present, what is the reason? Quality improvement	Nursing staff of a 16 bed adult medical cardiac intensive care unit at a large academic medical center N= 63 Nurses participated in the intervention (95% of the nursing staff).	A large disparity in technique for central line site care was determined anecdotally during the define and measure phase, and central line dressings in the IJ position frequently were found to be non-occlusive. Pre-intervention audits found: -some nurses were not using a central line site care kit at all; -few nurses were using the optimal dressing, which was found not to be in the central line site care kit; -no nurses were using the large alcohol wipe in the kit to scrub the hub of the catheter (this is	Small convenience sample. One ICU in one hospital. Possible Hawthorne effect. Quality improvement projects are not generalizable outside of their context and causal relationships cannot be established.	Q: 0 Low quality

distinct from the chlorhexidine gluconate [ChloraPrep, CareFusion Corporation] applicator used to clean the skin);
-nurses inconsistently documented the date, their initials, and skin-to-tip distance of the catheter, if applicable, on the dressing.

Site care was performed at the CDC recommended interval of 7 days in only 3 pre-intervention audits.

Pre-intervention audits occurred on patients whose lines had been indwelling a mean (SD) of 7.5 (9.3) days. Some patients in this sample had dwell times as long as 34 days.

In all post-intervention audits:
-nurses used a central line site care kit,
-the optimal dressing, and the large alcohol wipe.
-Use of the appropriate dressing increased 600% (from 3/21 to 21/21);
-hand washing before site care increased 27% (from 15/21 to 19/21);
-cleansing of the exposed catheter with an alcohol swab increased 320% (from 5/21 to 21/21);
-documentation of the date and initials, and skin-to-tip distance, improved 50% and 142%, respectively.

Post-intervention, the mean (SD) number of days catheter indwelling 6.2 (4.5); notably, no

			patients had a line indwelling longer than 21 days at the time of post-intervention audit. Post-intervention audits showed that many more patients were free of dressing disruption until at or near the CDC recommended dressing change interval of 7 days.		
Hsu et al[26] (2014) United States	To report the compliance with 5 evidence-based CLABSI prevention practices in adult ICUs, and to examine the links between the self-reported use of those prevention practices and reductions in CLABSI rates in the program. Cross sectional survey	Adult ICUs from 792 hospitals (from 44 states, DC and Puerto Rico) participating in On the CUSP: Stop BSI a national program N = 1071	Compliance with all of the CLABSI prevention practices increased over time during the study period. Pre-Intervention: Chlorhexidine skin preparation had the highest self-assessed compliance (90-96%). Hand hygiene had the second highest self-assessed compliance (81-94%). Removal of unnecessary lines and daily review of line necessity had the lowest self-assessed compliance (74%). Less than one-half of the units reported always or almost always reviewing line necessity daily Avoidance of the femoral site had the second lowest compliance. Use of central line carts and central line checklists increased over time. Post-Intervention: Consistent performance of all line insertion related prevention practices was significantly associated with lower CLABSI	Self-report compliance data (possibility of self-reporting bias). Response rates over the time of the study decreased. Potential sample selection bias data collected from On the CUSP: Stop BSI participating hospitals (may be high performers). In addition, ICUs were added as the study progressed. The survey questions and the response options used to measure compliance with CLABSI prevention practices were modified in the middle of the program.	Q: 1 Medium quality

rates.

Higher CLABSI rates were associated with performing only 3 of the 4 bundle practices well (incidence rate ratio [IRR], 1.41; 95% CI, 1.12-1.76) or performing 3 or fewer practices (3 practices: IRR, 1.26, 95% CI, 1.04-1.54; 0-2 practices: IRR, 1.28; 95% CI, 1.00-1.64).

There was no association between good performance of 0, 1, or 2 practices and higher CLABSI rates compared with performance of all 4 practices (IRR, 0.86; 95% CI, 0.54-1.38).

Consistently removing unnecessary lines was independently associated with lower CLABSI rates in model 1 (IRR, 0.80; 95% CI, 0.65-0.99) and showed a trend toward lower CLABSI rates in model 2 (IRR, 0.83; 95% CI, 0.67-1.02).

Avoidance of the femoral site was significantly associated with lower CLABSI rates (TCT version 1: IRR, 0.70; 95% CI, 0.54-0.90; TCT version 2: IRR, 0.78; 95% CI, 0.65-0.95).

Use of a central line cart and central line checklist. practices were not significantly associated with CLABSI rates when added into the models, indicating no independent effect on CLABSI rates when controlling for specific

			practices.		
Jardim et al[27] (2013) Brazil	To evaluate the adherence to best practices for prevention of CLABSI. Cross-sectional observational	A total of 5877 observations in Cardiothoracic Surgical ICU of a public teaching hospital in Brazil during the morning, afternoon and evening shifts.	The number of specific observations, percentage of total observations, and percentage of adherence are noted below: 166 (2.8%) on the CVC indication and permanence records showed adherence of 95% for indication and 96% for permanence. 415 (7.1%) on the insertions of the CVC showed 0.0% because all cases involved non-adherence to application of occlusive dressing after the insertion of the CVC. All other components reached full conformity (100%). 1986 (33.8%) on the care and maintenance of dressing of the CVC and its devices showed 51.5%. Principally due to the sanitization of hubs and connectors scores (below 40.0%) in all shifts. 3310 (56.3%) hand sanitizations for selected procedures showed 10.7% overall conformity.	One ICU in Brazil. Possibility of Hawthorne effect. Possible observer reliability and bias.	Q: 2 High quality
Joeng et al[28] (2013) South Korea	To evaluate central line bundle compliance before and after an intervention; to determine the incidence of CLABSI; and the length of time between insertion and CLABSI	Four ICUs (39 beds) in a 900 bed university affiliated teaching hospital in Korea. Although pediatric patients were in the adult ICUs, adult and pediatric data	During the baseline phase, full compliance of the central line bundle in the adult patient group was 0.0%, and it increased significantly to 37.1% during the intervention phase ($p < .001$). Increases in handwashing were not significantly different between phases	Single hospital in Korea. Central line compliance data was collected by 2 different methods (paper checklist and electronic checklist) due to	Q: 1 Medium quality

	occurrence. Prospective Cohort-chart monitoring	was separate. Only adult data is included in this table.	from 99% to 99.7% (p =.317) Compliance with maximum barrier precautions increased significantly from 31.0% to 83.7% (p < .001). Chlorhexidine skin antisepsis increased significantly from 0.0% to 40.0% (p < .001); The use of alcohol and povidone-iodine decreased significantly from 100% to 43.2% (p < .001). The selection of the femoral vein as the insertion site decreased slightly after intervention, (from 6.0% to 2.7%,) but the difference was not significant Adherence to entire central line bundle pre-intervention was 0% and post intervention was 37.1% (p<.001) Review of central line necessity and prompt removal of unnecessary lines was not reviewed.	implementation of electronic health record during data collection. No direct observations; data based solely on documentation in patient records. Documentation of practices may differ from actual practices. Lack of ICU physician involvement may have effected buy-in and resistance to implementation . Due to resistance from ICU physicians, daily review of central line necessity and prompt removal of unnecessary lines was not studied. Recent hospital wide hand hygiene and infection control education for Joint Commission International certification may have biased results.	
Leblebiciogl u et al[29] (2013) Turkey	To analyze the impact of the International Nosocomial Infection	Adult patients hospitalized in 13 ICUs, from 13 hospitals,	Post intervention compliance surveillance rates noted the following changes: 1. Hand hygiene: 32%	Data on only 5 central line bundle elements were studied.	Q: 1 Medium quality

	Control Consortium (INICC) multidimensional infection control approach to reduce the rates of CLABSI Prospective surveillance before-after cohort study	from 8 cities in Turkey. (n=4017)	baseline to 49% 2. Date on administration set: 33% to 39% 3. Placed sterile dressing: 78% to 90% 4. Correct condition of dressing: 76% to 73%	Data was only collected 5 days/week. Possible inter-observer reliability and bias. Possible Hawthorne effect.	
Musu et al[30] (2017) Italy	To determine whether an educational program addressed at ICU healthcare workers, together with constant monitoring of adherence to evidence-based practices, led to a significant change in the level and trend of CRBSIs Prospective surveillance before-after cohort study	A total of 173 healthcare workers (physicians n=49, nurses n=104, and nurse aides n=20) were observed across five mixed medical/surgical ICUs in five hospitals.	Overall hand hygiene compliance increased significantly from 431/918 (47.0%) observations pre-study to 2159/2414 (89.4%) during the study phase (RR: 5.02; 95% CI: 4.41-5.73; P < 0.001). Compliance results for each of the four key aspects of hand hygiene observed were: 1.Hand hygiene before patient contact increased from 41.2% to 89.0% (RR: 5.33; 95% CI: 4.35-6.53; P < 0.001); 2. Compliance after contact with inanimate objects, including medical equipment, improved from 39.3% to 91.9% (RR: 7.48; 95% CI: 5.81-9.62; P <0.001); 3. Compliance with hand hygiene technique improved from 64.6% to 87.3% (RR: 2.78; 95% CI: 2.15-3.59; P < 0.001); 4. Compliance with glove removal increased from 68% to 93.0% (RR: 4.57; 95% CI: 3.29-6.34; P < 0.001). Compliance with standard precautions rose from 174/256 (68.0%) to	Small sample size. Only 5 hospitals in Italy with ICUs (total ICU beds =35). Observations were only done in the morning. Possible inter-observer reliability and bias. Possible Hawthorne effect.	Q: 1 Medium quality

			623/670 (93.0%; RR: 4.57; 95% CI: 3.29-6.34; P < 0.001).		
Rickard et al[31] (2004) Australia	To describe current infection control practices regarding CVC care in Australian ICUs and to compare practice with evidence-based practice guidelines. Prospective, cross-sectional descriptive survey	Australian ICUs (n=14) in public (government-operated) teaching hospitals in metropolitan or major regional areas	Duration of IV administration set use: 1. Standard IV infusions: 72–168 hours (mean =114.9 hours, SD 43.3) 2. TPN: 24-168 hours (mean = 87.4, SD 54.8) 3. Propofol: 12-168 hours (mean = 96, SD 50.5) Dressing change frequency: 72-240 hours 1. Semi-permeable transparent: Mode = 168 hours, Mean = 142.2, SD 59.2 2. Gauze dressing (used in only 1 ICU): >48 hours max= 96 hours Skin Prep during dressing change: 1. Tincture of iodine =21.5% 2. 70% Alcohol = 21.5% 3. 70% Alcohol/ 0.5%chlorhexidine = 21.5% 4. Saline = 21.4% 5. Chlorhexidine sponges = 14% Barrier Precautions: A. Protective garments to perform dressing or IV set changes = 57% of ICUs Most frequently used: 1. Sterile plastic gown 2. Non-sterile plastic gown 3. Sterile cloth gown B. Gloves: 1. Sterile = 57% 2. Non-sterile = 43% C. Most did not wear masks. 14 % reported wearing masks for processes involving TPN	Small sample size. Self-reported survey (possibility of bias). Information requested was on the unit's policy or predominant unit practice. Participants were only the senior nurse on duty, which may not be accurate or reflect all unit nurses' practices.	Q: 0 Low quality

Salama et al[32] (2016) Kuwait	To study the impact of central line insertion bundle on incidence of CLABSI and study the causative microbial agents. Prospective cohort	Twenty three bed adult medical-surgical ICU in Kuwait	Compliance with the different elements of the central line insertion bundle showed fluctuation through-out the period of observation (February 2011 – February 2012) 1: Hand hygiene by inserter (94.4% -95.8%) Lowest: 80.5% March 2011. Highest: 100% January 2012 2. Maximal barrier precautions (92.6-92.7) Lowest: 75.7% March 2011. Highest: 98.1% October 2011. 3. Chlorhexidine skin prep (73.1%-88.54%) Lowest: 73.1 % February 2011. Highest: 100% November 2011. 4. Optimal catheter site selection (91.6% - 97.9%). Lowest: 79.3% March 2011. Highest: 100% January 2012. 5. Daily line necessity review and prompt removal if unnecessary (83.3% -99.0%). Lowest: 67.5% March 2011. Highest: 99% February 2012. Total central line days (108-96) Lowest: 92 November 2011. Highest: 158 October 2011. Total compliance with all elements (61.1% -77.0%) Lowest: 57.4% May 2011. Highest: 92.4% September 2011. Low compliance with central line bundle during March, April and May 2011 coincided with periods of reported high CLABSI/1000 catheter	Small sample size. Single ICU in Kuwait. Post insertion maintenance data was not collected. Possibility of Hawthorne effect.	Q: 0 Low quality

			days of 18.04, 14.07, 16.85, respectively. A decrease in the total CLABSI/1000 central line days from 14.9 to 11.08 infections was observed; but was not statistically significant (p = 0.0859).		
Shedlarski and White-Williams[33] (2013) United States	To determine whether an educational campaign improved CVC bundle usage practices. Quality improvement	Total of 26 CVCs placed in 21 patients in a 25 bed adult ICU in an academic medical center with ~ 108 RNs	Most CVCs were placed in the internal jugular vein. CVC dressings were changed every 2.86 days. Efforts to reduce CVC accesses demonstrated some success.	Single ICU in one hospital. Possible Hawthorne effect. Documentation may not reflect actual practice (possibility of reporting bias). Quality improvement projects are not generalizable outside of their context and causal relationships cannot be established.	Q: 0 Low quality
Sichieri et al[34] (2018) Brazil	To identify the current practice in regards to CVC maintenance; to improve knowledge amongst nursing staff; and to assess increased compliance with evidence-based best practice. Quality Improvement	Twenty four patients with a CVC in a12 bed adult ICU in a university teaching hospital in Brazil	Baseline / Audit Results: 1. Removal of the central line, or possible date of removal discussed daily during patient round. Baseline 7% /Audit 33% 2. Healthcare staff has received education and training in regards to management of central lines. Baseline 0% /Audit 100% 3. A gauze and tape dressing has been changed daily. Baseline 87% /Audit 90% 4. A transparent dressing was changed every 7	Small sample size. Single ICU in Brazil. Only a 2-week observation/data collection period. Possible Hawthorne effect. Quality improvement projects are not generalizable outside of their context and	Q: 0 Low quality

			days, or sooner if it is no longer intact or moisture collects under the dressing. Baseline 32% /Audit 83% 5. Hand hygiene was performed by the clinician prior to use of the central line. Baseline 9% /Audit 47% 6. Sterile gloves were used by the clinician prior to using the central line (or a sterile no-touch technique). Baseline 96% /Audit 79% 7. The clinician cleaned the dressing area with 0.5% or higher chlorhexidine in alcohol solution. Baseline 65% /Audit 93% 8. The chlorhexidine solution was allowed to dry prior to accessing the central line. Baseline 38% /Audit 89% 9. A pulsated flushing technique (push-pause technique) was used when the catheter was flushed. Baseline 6% /Audit 53% 10. When parenteral nutrition is administered, a dedicated lumen is utilized. Baseline 100% /Audit 100%	causal relationships cannot be established.	
Tang et al[35] (2014) Taiwan	To evaluate the different impacts of each bundle on ICU CLABSI rates. Quality Improvement	A total of 687 CVC insertions on 481 patients in five adult ICUs (63 total ICU beds) at a regional teaching hospital in	The internal jugular vein was the most common site of CVC insertion (n = 375, 54.6%), followed by the femoral vein (n = 261, 40.0%) and the subclavian vein (n = 51, 7.4%).	Single hospital in Taiwan. Post insertion maintenance data was not collected.	Q: 0 Low quality

		Taiwan	Overall compliance of all four components of central line insertion bundles was 55.2%. 1. Hand hygiene: 100% 2. Chlorhexidine skin asepsis 99.6% 3. Maximal sterile barrier precaution 87.3% 4. Optimal site selection 62.2%	Possibility of Hawthorne effect. Quality improvement projects are not generalizable outside of their context and causal relationships cannot be established.	
Valencia et al[12] (2016) Worldwide	To document, attitudes and practices (clinical and measurement) regarding CLABSI prevention in ICUs in low, middle and high income countries in order to assess compliance with CLABSI prevention guidelines, its measurement and identify priorities for interventions. Descriptive: Worldwide survey	Three thousand four hundred seven completed individual responses from 95 countries. Nurses = 40% of respondents Doctors = 60% of respondents High income countries (n=2414) Middle income countries (n=836)	In middle income countries, the use of chlorhexidine >0.5% for skin preparation and full body drape during CL insertion were less commonly implemented. Overall, 23% and 62% of respondents from middle and high income countries reported full compliance to the recommended practices and avoided antimicrobial prophylaxis. The majority of respondents in middle and high income countries have a positive attitude towards measurement to stimulate quality improvement. Wide variations exist between countries. 80% of respondents report the existence of CLABSI prevention guidelines in their ICU. During maintenance, dressings are changed more often than recommended and assessment of need of the	Non-random sampling (through international and national societies) Respondents may be better informed and have better prevention practices than non-respondents. Self-reported questionnaire survey (possibility of self-reporting bias). Selection and reporting bias may overestimate CLABSI prevention practices in ICUs.	Q: 1 Medium quality

	central line is not always done on a daily basis.
	Less than 50% of hospitals reported monitoring compliance to recommended measures. 38% of those that monitored bundle implementation reported full compliance.

Adherence in clinical practice is defined as the extent to which one's behavior corresponds with the recommendations of the provider or protocol.[36] Protocol adherence is often defined as the proportion of all recommended steps that are performed.[37] Although all studies reported some data on adherence to the central line bundle, there was great variability with the number of bundle items reported and the actual adherences reported. More details regarding individual studies reporting of the specific bundle items is provided in Specific bundle items reported and CLABSI rates table. None of the studies addressed adherence to all 14 recommendations of the central line bundle checklist. Five studies described current practices and compared those practices to recommended guidelines.[12,19,22,25,31] Several studies combined adherence to the bundle with other interventions, including knowledge assessment, education, feedback, and surveillance.[20,28,29,30,33-35] Two studies used direct observations to record compliance to guidelines, as well as sample demographics and additional noted observations in an attempt to determine predictors of adherence or lack thereof.[21,27] A national cross-sectional survey, from intensive care units located in hospitals participating in NHSN surveillance, described the adoption of the central line bundle items and their effectiveness in preventing CLABSI.[11] Furuya et al[24] repeated their 2011 study with the slight modification of comparing

overall bundle compliance as well as compliance to individual bundle items to determine the relationship between an individual bundle item vs. overall compliance.

Table

Specific bundle items reported and CLABSI rates.

CDC recommendation	**Articles reporting data on recommendation**
Follow proper insertion practices	
1. Perform hand hygiene before insertion	Al-Sayaghi,[19] Alkubati et al,[20] Filgueira Gouveia Barreto et al,[23] Furuya et al,[24] Hsu et al,[26] Jardim et al,[27] Joeng et al,[28] Leblebicioglu et al,[29] Musu et al,[30] Salama et al,[32] Tang etal[35]
2. Adhere to aseptic technique	Musu et al[30]
3. Use of maximal sterile barrier precautions f) Mask g) Cap i) Sterile gloves j) Sterile full body drape	Al-Sauaghi,[19] Alkubati et al,[20] Filgueria Gouveia Barreto et al,[23] Furuya et al,[11] Furuya et al,[24] Joeng et al,[22] Salama et al,[32] Tang et al[35]
4. Choose the best insertion site to minimize infections and noninfectious complications c) Based on individual patient characteristics d) Avoid femoral site in obese adult patients	Al-Sayaghi,[19] Boltz et al[22] Furuya et al,[11] Furuya et al,[24] Hsu et al,[26] Joeng et al,[28] Shedlarski and White-Williams,[33] Tang et al,[35] Valencia et al[12]
5. Prepare the insertion site with >0.5% chlorhexidine with alcohol	Al-Sayaghi,[19] Boltz et al,[22] Filgueria Gouveia Barreto et al,[23] Furuya et al,[11] Furuya et al,[24] Joeng et al,[22] Salma et al,[32] Tang et al,[35] Valencia et al[12]
6. Place a sterile gauze dressing or a sterile transparent, semipermeable dressing over the insertion site.	Al-Sayaghi,[19] Boltz et al,[22] Jardim et al,[27] Leblebicioglu et al,[29]
Handle and maintain central lines appropriately	
1. Comply with hand hygiene requirements	Aloush and Alsaraireh,[21] Boltz et al,[22] Filgueria Gouveia Barreto et al,[23] Furuya et al,[24] Jardim et al,[27] Joeng et al,[22] Leblebicioglu et al,[29] Musu et al,[30] Sichieri et al[34]
2. Bathe intensive care unit patients over 2 months of age with a chlorhexidine preparation daily	
3. Scrub the access port or hub with friction immediately prior to each use with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol)	Al-Sayaghi,[19] Aloush and Alsaraireh,[21] Hickox,[25] Jardim et al,[27] Sichieri et al[34]
4. Use only sterile devises to access catheters	
5. Immediately replace dressings that are wet, soiled, or dislodged	Aloush and Alsaraireh,[21] Boltz et al[22]
6. Perform routine dressing changes using aseptic technique with clean or sterile gloves d) Change gauze dressings at least every 2 days e) Change semipermeable dressings at least every 7 days f) For patients $\geq$ 18 years of age, use chlorhexidine impregnated dressing with a Food and Drug Administration cleared label that specifies a clinical indication for reducing CLABSI for short-term non-tunneled CLABSI with baseline prevention practices	Al-Sayaghi,[19] Aloush and Alsaraireh,[21] Boltz et al,[22] Filgueria Gouveia Barreto et al,[23] Hickox,[25] Jardim et al,[27] Leblebicioglu et al,[29] Rickard et al,[31] Shedlarski and White-Williams,[33] Sichieri et al,[34] Valencia et al[12]

7. Change administration sets d) For continuous infusions: no more frequently than every 4 days, but at least every 7 days e) For blood or blood products or fat emulsions: Every 24 hours. f) For propofol: every 6 to 24 hours or when the vial is changed	Al-Sayaghi,[19] Aloush and Alsaraireh,[21] Boltz et al,[22] Rickard et al[31]
Promptly remove unnecessary central lines	
1. Perform daily audits to assess whether each central line is still needed.	Aloush and Alsaraireh,[21] Boltz et al,[22] Furuya et al,[11] Furuya et al,[24] Hickox,[25] Hsu et al,[26] Joeng et al,[28] Salama et al,[32] Sichieri et al[34]

Synthesis of Results

The purpose of this integrative review was to evaluate and synthesize the existing literature on adherence to the central line bundle recommendations for the prevention of CLABSI. Careful analysis and synthesis of these studies resulted in the emergence of one major theme.

Poor adherence to recommendations.

None of the studies reported complete compliance with all of the bundle elements. The elements of hand hygiene, choice of best site for insertion, skin prep with >0.5% chlorhexidine plus alcohol prior to insertion, and dressings were reported most frequently.

Hand hygiene

Performance of hand hygiene prior to central line insertion was the item most recorded adherence item (13 of 19 studies). Adherence ranged from 53% to 100% in non-interventional studies.[12,19,22-24,26,28,35] Three studies measured hand hygiene pre and post intervention.

Insertion site

Selection of subclavian or internal jugular vein for insertion of a central line was reported with varying degrees of consistency in 11 studies.[11,12,19,21,22,24,26-28,32,35] In self-reported surveys, the adherence to best site selection ranged from 39% to 100%.[11,12,19,22,24,26] Pre and post

intervention studies reported 62% compliance post intervention for one and 97% for the other.[28,25] Observational studies reported the highest adherence (94-100%).[21,27]

Insertion site preparation

Preparation of the insertion site prior to placement of the central line with >0.5% chlorhexidine plus alcohol was reported as 4% to 100% adherence.[11,12,19,22-24,32] Adherence varied greatly from country to country. Data from 2 studies conducted in the United States reported adherence rates as 53-64% always, 16-83% usually, 1.6-85% sometimes, and 23.2% for rare, never, or not answered.[11,24] Reports from 2 pre and post intervention studies showed 40% and 99.6% post intervention adherence.[28,35]

Maximal barrier precautions

The use of maximal barrier precautions for insertion of central lines was reported as one overall item for some studies,[11,12,24,26-28,28,30,32,] but others measured each item (mask, cap, gown, sterile gloves, and sterile full body drape) individually.[12,19,20,22,23] Adherence to overall maximal barrier precautions was reported as 93-96% in a large online survey comparing high and middle income countries.[12] Others reported results of adherence as 54-56% always, 16-18% usually, 1.6-85% sometimes and 23.3% rare, never, or not measured.[11,24] Studies that reported each item individually were from Australia, Brazil, Egypt, and Yemen.[19,20,22,23] Use of sterile full body drape had the lowest compliance across all countries (28-92%), followed by cap (32-96%), gown (52-97%), mask (60-84%), and sterile gloves (93-100%) and no country was the lowest or highest in all the items.[12,19,22,23]

Dressings

Five of the 19 studies reported post insertion dressing applications of gauze or transparent semipermeable dressing with adherence rates from 0-100%.[19,22,25,27,31] One study observed 0

compliance with dressing guidelines post insertion, all of which were performed in the operating room.[27] Immediate replacement of a wet, soiled or dislodged dressing was reported to be 73-99.7%.[27,29] Report of adherence to aseptic technique while changing central line dressings data was collected by only one study which showed 59-84% compliance.[12] Adherence to appropriate time intervals for dressing changes was found to be 4-90% for gauze dressing, and 22-85% with semipermeable dressing.[12,19,22,23,25,27,31,35]

Administration sets

Adherence to changing administration sets was delineated in two studies which reported compliance of 12-100% for continuous infusion sets; 28-71% for blood, blood products, or fat emulsions; and 14-36% for propofol administration sets.[19,31] Of the three studies that did not delineate the types of sets, 2 were cross-sectional observational studies reporting 73-100% compliance.[21,27] and 1was a prospective surveillance before and after cohort study with 33% compliance before and 39% compliance after.[29]

Daily audits

Performance of daily audits to assess the continued necessity of the central line was reported in a large cross-sectional survey from 984 adult intensive care units in the United States as: 30.4%, always, 25.3% usually, 6.7% sometimes, and 25.5% rare, never, or not monitored[24] and 58% in a cross-sectional observational study.[21] In one pre and post interventional study, data on daily audits improved from 67.5% to 98.9%[32] but in a pre and post intervention quality improvement study the audits decreased from 13% to 11%.[34]

Access ports

Scrubbing the access port or hub with friction prior to each use with appropriate antiseptic ranged from 12.7 to 100%.[12,19,21,22,27,31] The use of only sterile devises to access

catheters was reported in one study which showed 73% compliance in middle income countries and 59% in high income countries.[12]

Daily bathing

The 2011 CDC guidelines for handling and maintaining central lines appropriately include the recommendation of daily bathing with chlorhexidine for adult patients.[13] None of the included studies reported compliance with this recommendation. Additional data from one study reported 62-84% documentation of utilizing a central line checklist[26] and two additional studies reported monitoring compliance to central line bundle but did not provide specific data.[11,12]

Discussion

A significant association exists between utilization of the central line bundle and a reduction of the incidence of CLABSI.[38,39] The CDC central line bundle is a useful tool to measure adherence to the recommended guidelines. Although studies identified for this review utilized the bundle as the basis for data collection, there was significant variation regarding which items in the bundle were included.

This integrative review shows that the level of adherence to the central line bundle varies significantly. The majority of studies included in this review used a self-reported survey for data collection, with only 5 studies including any direct observations and none of the observational studies included both insertion and maintenance observations. None of the 19 studies included data on all 14 elements of the bundle. Review of the 19 included studies showed low compliance to the central line bundle even in pre/post intervention studies. Due to the heterogeneity of data collected by the studies, it was not possible to determine if some recommendations are more frequently adhered to than others.

Implications for Practice and Research

This integrative review provides various implications for clinical practice as well as a basis for future research. Central line bundles have been shown to be effective in decreasing CLABSI and when compliance with each recommendation is checked for every patient, the greater the reduction in central line infections.[38-41] Future research on the exact compliance to all recommendations of the central line bundle is needed in order to determine if there are recommendations that are being adhered to more than others and to determine factors impeding adherence to the recommendations.

Quantitative and qualitative studies on adherence and compliance to the central line bundle are needed, especially in the United States. Only 5 of the 19 studies include in this review were conducted in the United States, of which 2 were quality improvement projects and the other 3 were self-reported surveys.[11,24-26] Although quality improvement interventions to decrease the incidence of CLABSI are numerous, without complete compliance to and accurate documentation of compliance to all of the items on the central line bundle sustainability of the results will be challenging. Innovative and creative strategies to improve adherence to the bundle are needed.

Limitations

There are several limitations to this integrative review. This integrative review included only studies published in English and non-tunneled central lines in patients in adult intensive care units. A large number of the studies included were from countries, where there may be a lack of the necessary resources to be adherent to the recommendations, which may have caused variability in the results. Although there was heterogeneity of study designs, there were no randomized control trials or non-randomized or quasi-experimental study designs. In addition, there were no qualitative studies to provide understanding of adherence to the guidelines or lack

thereof. The majority of the data in the included studies came from self-reported surveys and quality improvement projects. When providing self-reported data subjects may select the more socially acceptable answer rather than being truthful and may lack the ability to assess themselves accurately. Quality improvement projects have less generalizability outside the environment in which they are implemented. Lastly, regardless of the methodologic quality, all studies were included in this review. Although inclusion of lower quality studies could have affected the results, a conscious effort was made to assure lower studies contributed less to the final analysis.

Conclusion

The central line bundle is a proven intervention to decrease CLABSI when implemented and adhered to completely. This integrative review identified gaps in adherence to the bundle. Research is needed to determine the actual adherence to each item in the bundle, and to investigate factors that contribute to non-adherence. To achieve complete compliance with all the bundle items creative and innovative technology is needed.

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2.0 Dissertation Proposal

Examination of nurses' compliance and deviations regarding the CDC's central line bundle

Specific Aims

Central line associated bloodstream infections (CLABSI) are one of the most common healthcare associated infections and result in prolonged hospital stays, significant morbidity, and increased costs to the healthcare system.[1-3] Utilization of the Centers for Disease Control and Prevention's (CDC) central line bundle is associated with a reduction in the incidence of CLABSI.[4-5] Central line bundles have been shown to be effective in decreasing CLABSI, and when compliance with each recommendation is checked for every patient, the reduction in CLABSI is greater.[4-8] Despite the promotion of the CDC's central line bundle, wide variability exists in compliance to the bundle and infections rates in ICUs across the United States (US).[2,9-10]

Review of the literature on adherence to the CDC's central line bundle recommendations for the prevention of CLABSI found poor adherence to all the recommendations. Although all of the studies reported some data on adherence, there was great variability regarding which bundle items were reported, and the actual adherences reported.[10-28] Moreover, much of the research on this topic has been conducted outside of the US and is predominately self-reported questionnaires, and quality improvement projects.[10,12,14,17-19,22,24,26-28] Thus, there is a tremendous need to determine the actual adherence rates to all items on the CDC's bundle in the US, and increase research on the maintenance bundle items. Additionally, it may be useful to explore strategies in addition to those in the CDC bundle that nurses may be utilizing when managing central lines while caring for patients in the ICU.

Positive deviance is an approach to behavioral change based on the observation that in every community there are certain individual or groups (the positive deviants), whose uncommon but successful behaviors or strategies enable them to find better solutions to a problem than their peers.[29] In order to understand positive deviance one must first understand deviance. Wilkins[30] illustrated deviance by comparing it to a bell curve with conforming behavior in the middle, sinful at the left, and saintly to the right. Therefore, deviance from the norm (the middle) can be negative or positive. Sociological and psychological research has typically focused on negative deviance and the integration of positive deviance had been overshadowed until early 1990s.[31] Since then there has been greater use of the term across disciplines (business, economics, agricultural and biological sciences, arts and humanities, psychology, sociology, health professions and medicine).[31] Herington & van de Fliert[31] conducted a systematic review of the literature on positive deviance and found the discipline of medicine captured the majority of the positive deviance literature.

The positive deviance approach has been applied to improving patient outcomes and organizational change.[32] This approach identifies the behavioral practices of positively deviant individuals within the community and builds solutions from the bottom up.[33] Bradley et al[34] outlined the following steps in the positive deviance approach: 1) identifying the positive deviants (those individuals or organizations that consistently demonstrate high performance in the area of interest), 2) study the positive deviants in-depth using qualitative methods to generate hypotheses about the practices that enable the positive deviants to achieve top performance, 3) test the hypotheses in larger, representative samples, and 4) work with key stakeholders to disseminate the evidence about newly characterized best practices. In this study the aim is to identify nurses who consistently comply with the CDC central line guidelines and may be using

additional strategies. This would include steps 1 and 2 in the positive deviance approach. If steps 1 and 2 are successful, future research would be needed to complete steps 3 and 4. By identifying and learning from nurses who demonstrate positive deviance in managing central lines, and exploring additional strategies that may be being utilized, the incidence of CLABSI may be reduced.

I propose a focused ethnography study on the events relative to ICU nurses' management of central lines. This focused ethnography will include directly observing the ICU nurses' actions and behaviors while managing central lines for a limited amount of time in the cultural environment (the ICU). This study will be conducted in adult ICUs at an academic medical center located in Chicago, Illinois. Using participant observation of the nurses, the focus will be specific interactions with central lines. Data will be collected using the CDC maintenance guidelines as the basis for a standardized observational guide. All interventions specific to the management of central lines in addition to those listed in the CDC guidelines will also be recorded. Nurses noted to be using strategies in addition to the CDC recommendations as well as those identified as non-adherent to the CDC recommendations, will be asked to participate in interviews to explore their beliefs, motivations, and perceptions for utilization of additional strategies or non-adherence.

The specific aims of this study are:

1) To determine the actual adherence rates to the CDC's maintenance central line recommendations in the study sample.

2) To determine if there are any additional strategies being utilized by nurses when managing central lines.

3) To explore nurses' beliefs, motivations, and perceptions for non-adherence and the utilization of additional strategies.

My long term goal is to use the knowledge gained from this research to design and test interventions to increase compliance to the CDC recommendations and to possibly test additional strategies (if identified) to see if they further decrease the incidence of CLABSI. A decrease in the incidence of CLABSI would result in shorter hospital stays, less morbidity, and reduced costs of healthcare.[1,3-4,35]

Significance

Central line associated bloodstream infections (CLABSI) are one of the most common and deadly healthcare associated infections.[38] CLABSI result in prolonged hospital stays, significant morbidity, and increased costs to the healthcare system.[1-3] Although the CDC reported a 19% decrease in the incidence of CLABSI, of the 3,576 US acute care hospitals reporting to the CDC's National Healthcare Safety Network (the nation's most widely used HAI surveillance system) 21,173 cases of CLABSI were reported.[36] The Agency for Healthcare Research and Quality (AHRQ) estimated that each incidence of CLABSI carried on average an additional $48,108 in excess healthcare cost.[39]

Centers for Disease Control Recommendations for Prevention of CLABSI

The CDC provides recommendations in a checklist bundle to prevent CLABSI. The bundle consists of six steps for insertion of a central line, seven maintenance recommendations for handling and maintaining a central line, and one recommendation for prompt removal of unnecessary central lines through daily audits.[39] The seven maintenance recommendations are: 1) comply with hand hygiene requirements, 2) bathe ICU patients over two months of age with a chlorhexidine preparation on a daily basis, 3) scrub the access port or hub with friction

immediately prior to each used with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol), 4) use only sterile devices to access catheters, 5) immediately replace dressings that are wet, soiled, or dislodged, 6) perform dressing changes using aseptic technique with clean or sterile gloves at least every 2 days for gauze dressings and at least every 7 days for semipermeable dressings, 7) change administration sets no more frequently than every 4 days, but at least every 7 days for continuous infusions; every 24 hours for blood, blood products or fat emulsions; and every 6 to 12 hours or when the vial is changed for propofol.[39-40] Utilization of the CDC's central line bundle is associated with a reduction in the incidence of CLABSI.[4-5,41] Central line bundles have been shown to be effective in decreasing CLABSI, and when compliance with each recommendation is adhered to for every patient the reduction is greater.[4-8,41]

The use of proven guidelines to prevent infection of the blood from central lines is required of all hospitals accredited by The Joint Commission as part of the National Patient Safety Goals.[42] The CDC's National Healthcare Safety Network (NHSN) provides a tracking system for hospital acquired infections (HAI), as well as national and state progress reports on CLABSI rates and prevention.[39] Although most states have HAI reporting laws, the reporting requirements vary from state to state.[43] Most hospitals in the US report adopting the central line bundle recommendations but wide variability exists in compliance and infections rates in ICUs across the US.[2,9-10]

Lack of Adherence to the CDC Recommendations

Literature on adherence to the CDC's bundle recommendations for the prevention of CLABSI found poor adherence to the recommendations.[10-18, 20-22, 24, 27-28] The central line bundle is a proven intervention to decrease CLABSI when implemented and adhered to completely.[6-

[8,41,44] Exploration of the reasons for non-adherence to the recommendations is lacking. ICUs are unique, complex places and clinical experience suggests that even within the same hospital, ICUs have their own personality, governance, and culture.

Gaps in Current Literature

Previous research regarding CLABSI has focused on compliance or failure to comply with the central line bundle recommendations.[11,13,19,23,27-28] Many of the studies have focused only on compliance during insertion of central lines.[27,45-56] Although insertion is important, it is only a small fraction of the time a patient is exposed to the central line. The majority of studies on maintenance of central lines are quality improvement designs, prospective surveys, or before and after cohort designs.[17,21-23,25-26,47] Studies that involve direct observation to accurately document adherence to the seven bundle items for maintenance of central lines are lacking. Direct observation of nurses interacting with central lines will allow for the collection of objective documentation of the actual adherence to the maintenance items of the central line bundle. Self-reported survey data do not necessarily provide an accurate assessment of adherence, as participants often respond to how it should be done rather than how it is done.

According to Berenholtz et al[41] although the rates of CLABSI vary, “they are preventable.” Well-done clinical trials and systematic reviews support the CDC's guideline recommendations and if followed completely have been shown to decrease and eliminate CLABSI.[6,8,41,48] Despite this evidence, there is a disconnect between self-reported compliance to the central line bundle and the incidence of CLABSI. Reports of compliance to all the items on the central line bundle have not eliminated CLABSI. This leads to the following questions: what is the adherence to the central line bundle by ICU nurses during maintenance of a central line; are there additional strategies (positive deviant behaviors) that some ICU nurses are using in

addition to the central line bundle and do those additional strategies improve the prevention of CLABSI?

Importance of the Research to Health and Nursing

CLABSI are deadly and costly HAI that are preventable.[38,41,49] ICU nurses play a vital role in the management of central lines, the adherence to the bundle items, and therefore the prevention of CLABSI. Once a central line is in place, ICU nurses are responsible for central line dressing changes, antimicrobial cleansing of central line injection ports, and IV tubing changes. The contributions of this proposed study would allow for collection of data to evaluate of ICU nurses' adherence rates to the central line bundle, and if additional strategies are identified, testing and dissemination of these strategies provides an opportunity to potentially further decrease the incidence of CLABSI.

Innovation

This proposal is innovative in its methodology and goal. First, direct observation using an incomplete disclosure approach during consent will allow for a deeper understanding of the actual adherence rates, and interviewing nurses may allow for greater insight into reasons for deviations from or additions to the central line bundle items. There is a lack of observational data in the US on ICU nurses' adherence to the maintenance bundle items**.** Data obtained through observation will assist in determining if there is a disconnect between reported and actual adherence in the clinical setting of the ICU. To date, no qualitative studies looking at nurses' beliefs, motivations and perceptions for non-adherence or the utilization of additional strategies have been performed. Determining if there are some items that are adhered to more frequently than others and vice versa, will help to identify areas for improvement and education.

Second, opportunities to improve the maintenance bundle and further decrease the incidence of CLABSI may be identified if nurses are observed to be utilizing additional strategies or omitting recommendations of the CDC bundle. Customized guidelines, such as the central line bundle, do not always cover all the different situations that arise during the care of a patient with a central line. This can result in areas where nurses encounter situations that are not addressed in the accepted guidelines, and they are unsure how to proceed. In these situations, the nurse may independently develop and implement a solution to address the situation. These creative and practical behaviors used should be identified and tested to determine if they produce better outcomes and decrease CLABSI.

Third, by interviewing ICU nurses, data regarding the nurses' beliefs, perceptions, and motivations for non-adherence to the maintenance bundle items, as well as those positively deviant interventions, will be explored to provide insight on why nurses are non-adherent or positively deviant in order to improve adherence, provide education, and generate further opportunities for research to decrease and potentially eliminate CLABSI. Research is needed to determine the actual adherence to each item in the maintenance bundle and to investigate factors that contribute to non-adherence.

Approach

Preliminary Studies

Dr. Burke conducted a qualitative mini-study using Glaserian grounded theory to identify processes ICU nurses use when managing central lines. Grounded theory looks at an area of interest and seeks explanations through collection and analysis of data and allowing relevant ideas/theories to develop.[50] The processes were studied from the perspective of four ICU nurses from hospitals in Chicago. Data collection occurred through semi-structured interviews. Data

analysis using Nvivo 12® was conducted through coding, categorizing, and constant comparison. Findings of this study revealed the two main themes: 1) lack of adherence to the central line protocol in the operating room, and 2) nursing interventions to rectify operating room lapses in protocol adherence. Participants reported patients are arriving in the ICU without occlusive dressings and open infusion ports and nurses are changing central line dressings upon admission to the ICU during the critical time of assessing and caring for a newly admitted patient. Although the study size did not allow for the construction of a theory grounded from the data, the findings of this study provide useful information about lack of adherence to central line bundle in the operating room (OR), and the additional processes that ICU nurses use to rectify these lapses. The data from this study provide insight into the lack of adherence to the central line bundle in the perioperative setting and suggests the need for interventions and improvement strategies in the OR to improve adherence to the central line bundle to potentially decrease the rate of CLABSI. This preliminary work supports the need for accurate assessment of compliance to the items in the central line bundle. The proposed study will provide data on compliance to the maintenance items of the central line bundle by direct observation of ICU nurses, as well as strategies in addition to the central line bundle recommendations nurses may be using, and may provide insight into the nurses' beliefs, motivations, and perceptions for utilization of additional strategies or non-adherence.

Research Design

Using a focused ethnographic approach, the researcher will approach data collection using participant observation, mainly that of observer, during the collection of observational data.[51] The success of the participant observation approach is dependent on the relationship between those observed and the researcher.[52] The focused ethnographic approach will allow the

researcher to observe the nurses, the ICU activity, and the physical aspects of the environment.[51.53-53]

Purposeful sampling will be used to recruit nurses from the ICU who are caring for patients with a central line.[51] Field notes will be used to collect data on the environment and events occurring during the observations. A fieldwork journal will be kept by the researcher to record the researcher's experiences, ideas, reactions, feelings and challenges that arise during data collection. Using a pre-structured observational sheet, based on the maintenance items of the CDC's central line bundle, data on ICU nurses' adherence and non-adherence to the CDC's central line maintenance bundle, and additional strategies that nurses may be using will be collected. For example, did the nurse perform hand hygiene prior to touching the central line, was the central line dressing dated, dry and intact, did the nurse swab the access port prior to injecting a medication, or did the nurse utilize some procedure not listed in the recommendations? A new observation sheet will be completed each time the nurse interacts with the central line during the course of the observation.

To limit study bias, incomplete disclosure will be used during the consent and observation phase, and participants will be debriefed after all observational data collection has been completed. During the consent process, nurses will be informed that the researcher is researching nurse's interactions with ICU patients. The use of incomplete disclosure has been discussed with the medical center and is an approved approach to data collection at this facility.

After completion of all observations, data will be reviewed, and nurses who were found to be using strategies in addition to the CDC recommendations will be placed in one group and those identified as not having followed the CDC recommendations will be placed in another group. Nurses will be randomly selected from each group for individual semi-structured

interviews to explore their beliefs, perceptions, and motivations for adherence, and non-adherence to the maintenance bundle items, as well as observations of any additional interventions that may have been identified.

Setting

The study will be conducted in four adult ICUs located in an academic medical center in Chicago, Illinois. The ICUs consist of a 32-bed medical ICU, a 28-bed cardiac ICU, a 28-bed neuroscience ICU, and a 24-bed surgical ICU. Contacts will be made with departmental and unit directors. In meetings and email communications, I will outline the details of this proposal. After approval from the institutional directors, IRB approval will be obtained.

Sample

The study population will consist of registered nurses caring for ICU patients with non-tunneled central lines. Inclusion criteria will include: 1) registered nurse, 2) working in an adult ICU, and 3) caring for a patient with a non-tunneled central line. Exclusion criteria will include nurses caring for: 1) peripherally inserted central venous catheters (PICCs), 2) hemodialysis catheters, 3) port catheters, 4) tunneled catheters. It is anticipated that approximately 30 nurses or more will be selected to be observed in order to reach saturation. After completion of all observations, data will be reviewed and nurses who were found to be using strategies in addition to the CDC recommendation will be placed in one group and those identified as non-adherent to the CDC checklist will be place in another group. Nurses will be randomly selected from each group to participate in individual semi-structured interviews to explore their beliefs, perceptions, and motivations for using additional strategies or non-adherence to the maintenance bundle items, as well as observations of any additional interventions that may be classified as positively deviant behavior. Interviews will continue until saturation is achieved.

Recruitment and Consent

Participants will be recruited from four adult ICUs located in a magnet-status academic medical center in Chicago, Illinois. Prior to observation, written consent will be obtained from the nurses in the ICU explaining that the purpose of the study is to collect data on nurses' workflow and interactions with ICU patients. After all observational data has been collected, the nurse managers and all participants observed will be debriefed with a full explanation of the objectives of the study (i.e., central line care), the use of incomplete disclosure of participants, and the reasons why it was necessary.[51] After debriefing, the participants will be re-consented and provided the opportunity to withdraw the provided data. This sampling and consent process has been discussed with the medical center's IRB and is an acceptable method for this medical center.

Nurses who provide consent following the observation portion of the study, will be randomly selected equally from two groups: 1) those who utilized strategies in addition to those on the CDC's central line maintenance bundle, and 2) those identified as non-adherent to the CDC's central line bundle. The nurses will receive an invitation to participate in a private semi-structured interview in a mutually agreeable location, chosen by the participant and the PI. Before the interview, the participant will be informed of the purpose and procedures of the interview by the PI and written consent will be obtained. An audio recorded semi-structured interview will be conducted.

Data Collection

Participant observations. During the observation phase, the PI will wear the scrubs and a lab coat during the observations. By wearing a lab coat the PI will not be confused with the staff ICU nurses. Observations will occur in the patient room from a location that facilitates

collection of data but not too close to the patient to interfere with patient care. The PI will only enter the patient's room when the nurse enters and will leave when the nurse leaves. Observations will be conducted for the entire shift the nurse is working (i.e., 0700-1900 or 1900-0700). The PI anticipates being able to conduct approximately 3 observations per week on different days and shifts including weekends. It is anticipated that approximately 25 observations will be performed.

Participants will be asked to complete a demographic data sheet after consent and prior to commencement of observations (Appendix A). Observations will be documented on an observational sheet based on the CDC's central line maintenance bundle (Appendix B) developed by the PI. It will be sent to a panel of four experts comprising of nursing leadership, and infection control specialists for feedback and validation of the initial draft of the instrument. Based on feedback from the panel the observational sheet will be altered. The PI will also maintain field notes to include but not limited to observations of the space and objects in the scene, the sequence of activities, the interactions, and the feelings and emotions expressed by those being observed and those of the observer. For example, observations such as new admissions, unstable or coding patients, nurse to patient ratios, the location of supplies, will be noted in field notes. The observations and field notes will build the etic component of the focused ethnography.

A new observation sheet will be completed for each time the nurse interacts with the central line during the observation period. Each guideline item collected will have three choices: 1) done completely and accurately; 2) done but not completely or accurately; and 3) not done. During observations, for each item, if the nurse applies the action as detailed on the observation sheet during the interaction with the central line, the observer will document done completely

and accurately; if the nurse does not consistently or completely apply the recommendation (i.e. scrubs the hub initially when delivering a medication but then leaves the IV to obtain another medication from the dispenser and does not scrub the hub upon returning to administer the second medication) the observer will document done but not completely or accurately; and if the nurse fails to apply a guideline during the interaction with the central line, the observer will document not done. Not all items on the checklist will necessarily be applicable each time the nurse interacts with the central line (i.e., bathing with chlorhexidine, changing administration sets, auditing necessity of central line). Items on the observation checklist are not required to occur in a specific sequence.

Interviews. An equal number of participants from the two groups (those identified as using additional strategies and those identified as non-adherent to the guidelines) will be randomly selected by placing the unique ID numbers in a hat and drawing numbers. After random selection, the participants will be invited to participate in a semi-structured audio recorded interview, conducted at a mutually agreed upon location. Questions regarding additional behaviors observed (positive deviant behaviors) will be included in the interview to further determine positive deviant behaviors/individuals (Appendix C). In addition, the PI will attempt to capture relevant communication patterns and nuances of the interviewees without allowing her own familiarity to cloud the interview. An open, non-judgmental attitude and attentive listening will be utilized. Fieldnotes will be used to collect data on the setting, the body language, mannerisms, and hesitancies of the interviewee. Using a reflective field journal, the PI will document her feelings before, during and after the interviews to provide reflection and introspection.

Data Analysis

Data analysis will occur in collaboration with Dr. Karen Jakub, dissertation chair. Data analysis will occur concurrently as data collection progresses based on the Hammersley and Atkinson method for analysis.[55] Data will be analyzed and reviewed for commonalties, patterns, deviations and additions to the CDC recommendations.

Data preparation. All recordings will be transcribed and the field notes will be reviews and corrected. The transcripts will be read and proofed against audio-files for accuracy. Transcripts will be de-identified prior to being transcribed and only the unique ID case number will be retained. All data (demographic sheet, observational and interview data) will be linked by the ID case number and entered into computer assistance software NVivo12®. Demographic information will be used to provide a description of the work environment and the nurses' characteristics.

Analysis procedure. Each case will be read in its entirety, which helps a researcher make sense of the data and begin the process of generating concepts.[55] This will stimulate ideas, thoughts, and impressions before moving forward in the analysis process. Codes will be assigned to words or segments of data that are descriptive or inferential in nature.[55] Codes are labels that can be descriptive in nature, but may also be interpretive as the analysis progresses. Coding will be an ongoing process through data collection, which helps researchers reflect on their existing data and possibly "generate strategies for collecting new, often better data" in the field.[56] During the early stages of analysis, patterns may be identified by comparing and contrasting across cases.[55] Categories will be developed to indicate what is happening and why, with the aim of clarifying the meaning of the categories and to explore the relations among the categories until they are better understood.[55] Typologies will then be developed, which are ways of describing groups of respondents, displaying different clusters of behaviors, attitudes or views. Subtypes

may emerge under a given typology that further explains a situation or category.[55] Typology development will be done through reflexivity, description, and explanation of cases, which are then represented in a narrative report.[55] Analytic memos will be maintained throughout the project. These memos document impressions and provide an account of the analytic moves made by the researcher. As analysis progresses, weekly meetings with my dissertation chair will be ongoing to update the status of data collection and to discuss evolving interpretations of the data.

Potential Barriers

Recruitment may present a challenge in that nurses may not be willing to be observed or interviewed. A lack of patients with central lines during the study could extend the study's observation time and may pose a threat to data collection. In addition, the organizational culture of the individual ICUs regarding research could be a potential barrier to gathering data. Once participants have been debriefed, they may decide to withdraw their data leading to insufficient data to analyze. Nurses may decide not to participate in interviews after learning what was actually observed for fear of not having been compliant with the central line maintenance guidelines which could lead to lack of data.

Study Limitations

Using only one hospital will limit the transferability of the study results. Although the purpose of the study during the observations will be hidden from the participants, there is the possibility of Hawthorne effect.[57] The interviewees may respond in the way they believe the researcher wants them to respond. Individuals selected for interviews may discuss the types of questions with other participants prior to their interview. Although only one researcher will be analyzing the data, which may affect objectivity, this will be done in collaboration with the

dissertation chair, Dr. Karen Jakub. In addition, this study is limited because of time constraints of a dissertation study and lack of a long-term relationship with key informants.

In an attempt to overcome the limitations listed above, the full purpose of the study will be hidden from the participants, and the PI will use a non-active approach for data collection during the observational phase. Purposeful sampling will be used during the observation phase in an attempt to increase transferability.[54,58] Utilization of random selection of the participants for interviews using the unique ID number will assist in decreasing the bias of the PI. During the interview phase, participants will be instructed to be honest when answering questions and encouraged not to discuss the interview with other potential participants. Participants will be assured that their confidentiality will be maintained throughout the process and after the study has concluded.

Validity can be major strength of the ethnographic process but it is dependent on the reality and meaning of the group studied.[58-59] Bias and misinterpretation and assumptions by the PI are threats to validity.[60] In order to minimize these threats to validity the PI will maintain fieldnotes and a field journal to recognize possible factors influencing the PI's stance toward the participants and the setting in an attempt to avoid overriding or unconscious framing of the events. In addition, the PI will use reflection and recognition of her own experiences to decrease subjective influence on the interpretations.

Reliability in qualitative research is often referred to as dependability, consistency and audibility.[54,60] Reliability is concerned with the extent to which the study could be repeated and variations understood.[54] In order to minimize the threats to reliability, the PI will maintain meticulous documentation of the procedures and processes carried out during the research. In

addition, the PI will be the only data collector and will ensure that data collection is consistent and free from undue error.[60]

Protection of Research Participants

Full IRB board approval from the academic medical center will be sought. IRB approval from Duquesne University will also be obtained. After IRB approval, incomplete disclosure will be used when obtaining consent prior to observations. Once all observations are completed, participants will be debriefed to provide a full explanation of the purpose of the study and the reasons why it was necessary to not fully inform them (Appendix D). The opportunity for participants to ask questions will be provided. This research presents no more than minimal risk to participants. The participants will be re-consented after full disclosure, and the option to withdraw from the study will be explained. If the participant chooses to withdraw from the study, all data previously collected will be destroyed and not included in the study. All data from the audio recordings and transcriptions will be stored on a password protected computer by the PI. Data will be maintained in a secure environment for five years after the study has concluded. Study materials will be shredded (for written data) and erased (for audio recorded data) by the PI at the five-year mark.

PROPOSED DISSERTATION TIMELINE

					2020							
	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Refine proposal with chair												
Defend proposal w/committee												
Meet w/ ICU managers												
Send observational sheet to experts for												

feedback & await return												
Prepare IRB application												
Submit IRB												
Await IRB												
Begin observation data collection (After IRB approval)												
					2020 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Continue observation data collection & analysis												
Begin Interviews & Analysis of interviews												
Write results												
Revisions												
Defense												

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APPENDIX A

Demographic Information

1. What is your age? _____

2. What is your highest nursing educational degree?

   Diploma: _____ Associate's: _____ Bachelor's: _____

   Master's: _____ Doctorate: _____

4. How many years have you been a RN? _____

5. How many years have you worked as an ICU RN? _____

6. How many beds are in your ICU? _____

7. How many of your ICU beds are currently occupied? _____

8. How many patients are you caring for today? _____

APPENDIX B
Observational Sheet

Guideline	Done Completely & Accurately	Done but Not Completely or Accurately	Not Done	Comments
A) Performs hand hygiene prior to interaction with central line				
B) Scrubs the access port or hub with friction immediately prior to each use with chlorhexidine, 70% alcohol, povidone iodine, or idophor				
C) Uses only sterile devices to access the central line				
D) Immediately replaces dressings that are wet, soiled, or dislodged				
E) Performs routine dressing changes using aseptic technique with clean or sterile gloves • Changes gauze dressings at least every 2 days • Changes semipermeable				

dressings at least every 7 days				
F) Changes administration sets for continuous infusions no more frequently than every 4 days, but at least every 7 days • If blood or blood products or fat emulsions are administered tubing is changed every 24 hours • If propofol is administered tubing is changed every 6-12 hours or when the vial is changed				
G) Patients are bathed daily with chlorhexidine preparation				
H) Performs daily audits to assess whether the central line is still needed.				
I) List Additional Interventions Noted:				

APPENDIX C

Semi-Structured Interview Sheet

1. Can you tell me about what you do when managing a central line?

2. Have you experienced any difficulties when managing central lines? Can you tell me more about that?

3. Do you have any challenges using the central line bundle recommendations? Can you tell me more about those challenges?

4. What challenges do you see for the staff to adhere to the central line bundle recommendations?

5. Do you have any ideas on how to increase adherence to the central line bundle?

6. Do you have any ideas on how to improve the central line bundle?

7. Are there situations during your management of a central line for which you found solutions to practices where no clear recommendations exist?

8. Could you recommend colleagues who have practices/tips/unique behaviors that help improve management of central lines?

9. Have you had previous education on central line care? If so when? If so what did the training entail?

APPENDIX D

Debriefing Form

Thank you for your participation in my study. Your participation is greatly appreciated.

Purpose of the Study:

Earlier in the consent form, I informed you that the purpose of the study was to observe ICU nurse's interactions with critically ill patients. In actuality, my study was to observe ICU nurses to determine their actual adherence rates to the CDC's maintenance central line recommendations and to identify any additional strategies being utilized by nurses when managing central lines.

In order to accurately determine actual adherence rates, I could not provide you with all of the details prior to your participation. This ensures that your interactions in this study were reflective of your actual procedures and interventions and not influenced by prior knowledge about the purpose of the study. If I had told you the actual purposes of my study, your ability to care for your patient as usual might have been affected. I hope you understand the reason for my not disclosing the real purpose of my study.

Confidentiality:

Please note that although the purpose of this has changed from the originally stated purpose, everything else on the consent form is correct. This includes the how I will keep your data confidential. Your consent forms and observational data have been assigned a unique ID number and are kept in separate folders in separate secured, locked locations to assure your anonymity.

Now that you know the true purpose of my study and are fully informed, you may decide that you do not want your data used in this research. If you are still interested in participating in

my study, I would like to provide you a new consent form for your signature. If you would like your data removed and permanently deleted; I will provide you with a withdrawal from participation form.

If you have any questions or concerns regarding this study, its purpose or procedures or if you have a research-related problem, please feel free to contact the researcher:
Cherie Burke at XXX-XXX-XXXX or by email _____

If you have any questions concerning your rights as a research participant, you may contact the _____ Institutional Review Board office by calling XXX-XXX-XXXX or emailing _____.

***Please keep a copy of this form for your future reference. Once again, thank you for your participation in this study. ***

3.0 Revised Dissertation Proposal

Identification of central line management challenges and strategies of care to prevent central line-associated bloodstream infections in ICU

Statement of the Research Questions

What are the challenges intensive care unit (ICU) nurses experience regarding adherence to the Centers for Disease Control and Preventions' (CDC) central line bundle when caring for critically ill patients to prevent central line-associated bloodstream infections (CLABSI)? What strategies do ICU nurses utilize to overcome or address these challenges when caring for a critically ill patient to prevent CLABSI?

Purpose and Significance of the Study

The purpose of this study is to explore the nature of the challenges ICU nurses experience adhering to the CDC's central line bundle to prevent CLABSI as well as possible strategies used to address these challenges when caring for critically ill patients.

CLABSI occurring in intensive care units are associated with increased morbidity and mortality. These infections increase the length of hospital stay for an affected patient, as well as the cost of care associated with treating CLABSI. The CDC provides recommendations in a central line care bundle to decrease CLABSI occurrence. Despite most hospitals in the United States adopting the CDC bundle recommendations for central lines, CLABSI remains an issue.[1-3] According to the CDC[4], from 2008-2013, CLABSI decreased by 46% in U.S. hospitals, but an estimated 30,100 CLABSI still occur annually.

An international study by Valencia et al[3] reported that although there is interest and awareness for CLABSI prevention, the need for improved practices and collaboration to decrease the occurrence of CLABSI still exists. Furuya et al[5] noted that despite the promotion of central

line bundle policies, there is wide variability in compliance and infection rates in ICUs across the United States. In addition, Furuya et al[5] found no relationship between having a bundle policy in place and lower infection rates. Even when ICUs monitored the compliance of adherence to the central line bundle and with moderate adherence to the elements of the bundle, CLABSI rates were not lowered.[5] This leads to questions regarding the effectiveness and reliability of the CDC central line bundle.

Previous research regarding CLABSI has focused on compliance or failure to comply with all the steps in the CDC central line bundle recommendations. Reports of compliance to all the items on the central line bundle have not eliminated CLABSI. Customized guidelines, such as the central line bundle, do not always cover all the different situations that arise during the care of a patient with a central line. This can result in areas where nurses encounter situations that are not addressed in the accepted guidelines and are unsure how to proceed. In these situations, the nurse may independently develop and implement a solution to address the situation. Thus, there is a need to identify possible strategies ICU nurses utilize when managing central lines. Identifying these strategies used by ICU nurses when they encounter a challenge will allow for further research to potentially improve the CDC bundle and determine if they produce better outcomes and decrease the incidence of CLABSI.

Research Design and Procedures

This study will be conducted using the qualitative method of interpretive description (ID). ID is a qualitative research approach with epistemological roots from nursing science.[6] ID is "grounded in an interpretative orientation that acknowledges the constructed and contextual nature of human experience" to develop nursing knowledge.[7] The use of ID in this study will allow the researcher to collect and analyze the data through the researcher's lens, focusing on the

information pertinent to providers. In ID, the researcher is a valuable instrument of the research, and the technical knowledge and personal experiences of the researcher are significant sources of insight.[8] ID facilitates the development of evidence-based knowledge informed by the participants' perceptions and experiences and provides a credible process to develop understanding and generate knowledge that can advance clinical practice.[6]

Using purposeful sampling through a gatekeeper, who knows ICU nurses and snowball sampling, the researcher will seek to access ICU nurses. The ICU nurses will be individually interviewed via a secure ZOOM link to obtain new data regarding the challenges ICU nurses experience regarding adherence to the CDC central line bundle when caring for critically ill patients. Interviews will be semi-structured and recorded. Demographic data will also be collected from each participant.

Instruments

A semi-structured interview guide will be used to conduct interviews with the participants to explore challenges adhering to the CDC central line bundle when managing central lines in the ICU (Appendix A). Interviews will be audio recorded. Participants will also complete a demographic questionnaire created by the researcher (Appendix B).

Sample Selection and Size

Approximately 15 to 20 nurses will be accessed using a gatekeeper who knows ICU nurses and snowball sampling. The sample will consist of registered nurses who currently work in an ICU and have cared for at least one patient with a central line in the past six months. In ID, data saturation is not the desired outcome because the applied and practice disciplines tend to appreciate that experience can theoretically possess infinite variations; therefore, the focus is on

obtaining a deeper understanding of participant perspective while recognizing that variation in perceptions and outliers may exist.[6]

Recruitment of Subjects

A gatekeeper who has access to ICU nurses will assist with the recruitment of participants. The gatekeeper is not in a supervisory or power position over the participants. Participation is voluntary. Interested participants will contact the researcher via the contact information provided by the gatekeeper.

Informed Consent Procedures

The purpose of this study and the procedures will be explained to the participants by the primary researcher during the consent process. The confidentiality and privacy of all participants will be maintained. Once the participant's questions have been answered, and the individual agrees verbally to participate, the participant will be given time to read the consent form and ask questions before signing. Informed consent will be obtained using the informed consent form (Appendix C). The participant will be asked to sign the informed consent form via Qualtrics®. The participant will be provided an unsigned copy of the consent form via email, and the researcher will keep the signed consent form. Signed consent forms will be kept secure in a locked drawer in the primary investigator's locked office, separately from other data from the study.

Collection of Data and Method of Data Analysis

After the participant has signed the informed consent, the semi-structured interview will be conducted via ZOOM® and recorded. Transcripts from the recordings will be deidentified, and Nvivo12® will be used to assist in managing and analyzing the data. De-identified transcripts will be kept for data analysis. The researcher will also maintain field notes throughout

the study. All data from audio/video recordings and transcriptions will be stored on a password-protected computer by the primary researcher until destroyed. Signed informed consent forms will be stored in a locked drawer in the primary investigator's locked office. The researcher will work closely with the text, coding for insights into the participants' experiences and perspectives. In ID, coding is conducted from the bottom up, generating codes from the data rather than using pre-existing theory to identify codes that might be applied to the data. Detailed line-by-line coding is avoided in favor of asking broad questions.[6] The researcher catalogs the preliminary coding notes and looks for patterns or themes. The construction of themes remains tentative as the analytic process continues allowing the researcher to modify them as they develop. As coding allows for making connections within the data, analysis progresses to interpretation. As the analysis and interpretation deepen, a more complex picture is constructed, and a more cohesive concept of the participant experience begins to emerge. During engagement with the data, themes surface and become the tools to address the research question and assist in producing an account of the data set.[7]

Emphasize Issues Relating to Interactions with Subjects and Subject's Rights

Participants will be treated with respect throughout the recruitment, consent, and data collection process, and confidentiality will be assured. Participants will be informed of the ability to, and procedures of withdrawal from the study at any point during the research process and that participation is voluntary. If the participant withdraws from the study, all data collected from the participant will be destroyed and not included in the study. Collected data will be maintained in a secured environment for three years after the study has concluded. Study materials will be shredded (for written data) and erased (for audio/video recorded data) by the primary

investigator at the three-year mark. Participants will be informed that a summary of the research result will be supplied at no cost to the participant upon request.

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Appendix A

Semi-structured Interview Guide

1. Can you tell me about the work you do in the ICU?

2. Think about when you have cared for patients with central lines and tell me about what you do to manage the central line.

3. As you were caring for a patient with a central line, have you ever experienced any difficulties? Can you say more about that?

4. In the past six months, have you forgotten to complete an element(s) in the CLABSI bundle? Can you tell me more about that?

5. Have you ever been unsure how to complete an element or elements of the CLABSI bundle? How do you proceed when you encounter this?

6. Are there any components of the CLABSI bundle that you find more challenging to complete? Can you tell me more about that?

7. Are you aware of the CALBSI rates for your unit?

8. Have you ever been involved in a focused chart review to determine the cause of CLABSI?

9. Has your unit ever compared your practice guidelines to the CDC standards when/if you had an unexpected CLABSI?

    a. What did you find out

    b. Did your practice standards change?

    c. Did your practice change? If so, how?

10. Can you think of anything else you might want to tell me about the times you cared for patients with a central line?

11. Do you have any questions for me?

Appendix B

Demographic Information

1. What is your age? _____

2. What is the gender you identify with? _____

3. What is your race? _____

4. What is your highest nursing educational degree?

   Diploma: _____ Associate's: _____ Bachelor's: _____

   Master's: _____ Doctorate: _____

5. How many years have you been a RN? _____

6. How many years have you worked as an ICU RN? _____

7. How regularly do you care for patients with central lines?

   Daily _____ Weekly _____ Monthly _____ Infrequently _____

Appendix C

DUQUESNE UNIVERSITY
PITTSBURGH, PENNSYLVANIA

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE:
Identification of central line management challenges and care strategies to prevent central line-associated bloodstream infections in ICU

INVESTIGATOR:
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SOURCE OF SUPPORT:
This study is being performed as partial fulfillment of the requirements for the Doctor of Philosophy degree in Nursing at Duquesne University.

STUDY OVERVIEW:

Previous research regarding CLABSI has focused on compliance or failure to comply with all steps in the CDC central line bundle recommendations. Reports of compliance to all the items on the central line bundle have not eliminated CLABSI. Customized guidelines, such as the central line bundle, do not always cover differing situations that arise during care of a patient with a central line. This can result in areas where nurses encounter situations that are not addressed in the accepted guidelines and are unsure how to proceed. In these situations, the nurse may independently develop and implement a solution to address the situation. Thus, there is a need to identify possible strategies ICU nurses utilize when managing central lines. Identifying these strategies used by ICU nurses when they encounter a challenge will allow for further research to potentially improve the CDC bundle and determine if better outcomes are produced and incidence of CLABSI decrease.

PURPOSE:
You are being asked to participate in a research project that explore the nature of the challenges ICU nurses experience adhering to the CDC's central line bundle to prevent CLABSI as well as possible strategies used to address these challenges when caring for critically ill patients.

In order to qualify for participation, you must be currently working as a RN in an ICU and have cared for at least one patient with a central line in the past 6 months.

PARTICIPANT PROCEDURES:
If you provide your consent to participate, you will be asked to complete a brief demographic survey and allow me to interview you about your experiences caring for central lines in the ICU. The interviews will be conducted via a secure ZOOM® audio and video stream, which will be recorded and transcribed. You may be asked to be interviewed 1-2 time for approximately 1 hour. These are the only requests that will be made of you.

RISKS AND BENEFITS:
There are minimal risks associated with participating in this study, but no greater than those encountered in everyday life. A benefit for participation will be the sharing of the information that may improve the care of patients with central lines.

COMPENSATION:
You will be compensated for your participation with a $10 Target gift card at the completion of the initial interview. No partial payment will be given if you choose not to complete the study.

There is no cost for you to participate in this research study.

CONFIDENTIALITY:
Your participation in this study, and any identifiable personal information you provide, will be kept confidential to every extent possible, and will be destroyed three years after the data collection is completed. Your name will never appear on any survey or research instruments. All written and electronic forms and study materials will be kept secure. Your response(s) will only appear in de-identified summaries and/or quotes. Data from the audio recordings will be transcribed via ZOOM. Transcripts will be de-identified by the researcher. Zoom recordings and de-identified transcripts will be kept on a password protected computer by the primary investigator. Zoom recordings, de-identified transcripts and signed forms will be maintained for three years after the completion of the research and then destroyed. Any publications or presentations about this research will only use data that is combined together with all subjects; therefore, no one will be able to determine how you responded.

RIGHT TO WITHDRAW:

You are under no obligation to start or continue this study. You can withdraw at any time without penalty or consequence by notifying the principal investigator. If you withdraw from the study all data provided by you will be destroyed and not included in the study.

SUMMARY OF RESULTS:

A summary of the results of this study will be provided to at no cost. You may request this summary by contacting the researchers and requesting it. The information provided to you will not be your individual responses, but rather a summary of what was discovered during the research project as a whole.

FUTURE USE OF DATA:

Any information collected that can identify you will not be used for future research studies, nor will it be provided to other researchers.

COVID-19 CONSIDERATIONS

I understand that the researcher(s) running this study have put in place the following guidelines to address concerns related to COVID-19:

- All interviews will be conducted virtually via secure ZOOM

VOLUNTARY CONSENT:

I have read this informed consent form and understand what is being requested of me. I also understand that my participation is voluntary and that I am free to withdraw at any time, for any reason without any consequences. Based on this, I certify I am willing to participate in this research project.

I understand that if I have any questions about my participation in this study, I may contact Cherie Burke at 484-358-6317 burkec5@duq.edu and/or Karen Jakub at (412) 396-6535 jakubk@duq.edu If I have any questions regarding my rights and protections as a subject in this study, I can contact Dr. David Delmonico, Chair of the Duquesne University Institutional Review Board for the Protection of Human Subjects at 412.396.1886 or at irb@duq.edu.

This project has been approved/verified by
Duquesne University's Institutional Review Board

Proceeding to the next page indicates your voluntary consent to participate in this project.

4.0 RESULTS MANUSCRIPT

Manuscript #2

ICU NURSES'ADHERENCE TO THE CDC'S CENTRA LINE BUNDLE: A QUALITATIVE STUDY

Abstract

Background: Central line associated bloodstream infections (CLABSIs) are one of the most common healthcare associated infections and result in prolonged hospital stays, significant morbidity, and increased costs to the healthcare system. Adherence to the CDC central line maintenance bundle has been shown to be effective in decreasing CLABSI yet these infections continue to be a problem. ICU nurses play a vital role in managing central lines and adhering to the maintenance guidelines, however different situations may arise during the care that may impact CLABSIs.

Objectives: 1) To determine nurses' adherence to the CDC's maintenance central line bundle; 2) To determine if nurses are utilizing additional strategies when managing central lines vis-à-vis positive deviant behaviors; and 3) To explore nurses' beliefs, motivations, and perceptions related to non-adherence and the utilization of additional strategies.

Methods: Data for this study were obtained from semi-structured interviews and transcripts were analyzed with an interpretive description approach to generate conceptual themes. Interpretation included a focus on the concept of positive deviance to identify additional strategies.

Results: Twenty-seven participants were interviewed from across the United States. The following themes emerged: (a) surmountable barriers, (b) multidisciplinary collaborative impact, and (c) positive deviant behaviors.

Conclusion: This study provides a qualitative assessment of the challenges experienced and the innovative strategies employed by ICU nurses while adhering to the CDC central line maintenance bundle, optimizing patient care quality and preventing CLABSI. Examining the positively deviant behaviors nurses are using may provide the opportunity to improve practices and decrease CLABSI rates.

Central line associated bloodstream infections (CLABSI) are one of the most common healthcare associated infections (HAI), which result in prolonged hospital stays, significant morbidity, and increased costs to the healthcare system.[1-3] The CDC provides practice guidelines within a central line care bundle to decrease CLABSI occurrence. Adherence to the central line bundle has been shown to be effective in decreasing CLABSI.[4-6] When compliance with each element of the bundle is adhered to for every patient, the reduction in CLABSI is greater.[4-8] Despite the promotion of the CDC's central line bundle, wide variability exists with strict bundle adherence and infection rates within intensive care units (ICUs) across the United States.[2, 9-15] Even when ICUs monitored adherence to the central line maintenance bundle and moderate adherence to the elements of the bundle was achieved, CLABSI rates were not lowered.[10] The National Healthcare Safety Network (NHSN), the most widely used tracking system for HAI, reported an overall 7% increase in CLABSI with the largest increase in ICUs during 2020-2021.[16]

Previous research regarding CLABSI has focused on strict adherence or partial adherence with each element in the CDC central line maintenance bundle.[1-5,9-16] Although strict adherence

with each element on the central line bundle has not eliminated CLABSI. ICU nurses play a vital role in the management of central lines, adherence to the maintenance bundle elements, and, therefore, the prevention of CLABSI.

Customized practice guidelines, such as the central line maintenance bundle, do not always cover all the different situations that arise during the care of a patient with a central line. This results in nurses encountering situations that are not addressed in the accepted guidelines leading to uncertainty and subsequent practice variation, such as deviant behaviors, whether positive or negative. In these situations, the nurse may independently develop and implement a solution to address the situation. Identification of additional strategies or positive deviant behaviors ICU nurses use when they encounter a challenge while managing central lines may result in CDC bundle revisions and potentially decrease the incidence of CLABSI.

Given the disconnect between CLABSI bundle adherence rates and the fact that CLABSI rates still increased in ICUs, this study was conducted to explore the nature of the challenges ICU nurses experience adhering to the CDC's central line bundle, as well as the innovative strategies used to overcome or minimize these challenges while caring for critically ill patients to prevent CLABSI.

The specific aims of this study were:

1) To determine nurses' adherence to the CDC's maintenance central line bundle;

2) To determine if nurses are utilizing additional strategies when managing central lines vis-à-vis positive deviant behaviors; and

3) To explore nurses' beliefs, motivations, and perceptions related to non-adherence and the utilization of additional strategies.

Methods

This qualitative study used the method of interpretive description (ID). ID is a qualitative research approach with epistemological roots from nursing science. ID facilitates the development of evidence-based knowledge informed by the participants' perceptions and experiences and provides a credible process to develop understanding and generate knowledge that can advance clinical practice.[17] Semi-structured interviews were analyzed with an interpretive description approach to explore challenges ICU nurses have adhering to the CDC central line bundle and to identify additional strategies nurses may use when they encounter a challenge.

Sample and Setting

Following IRB approval, participants were recruited using purposeful and snowball sampling. Participants had to be ICU nurses from any adult ICU of any hospital type (community, rural, large tertiary) who had cared for at least one patient with a central line in the past 12 months. Twenty-seven participants (17 women and 10 men) were recruited from seven states. The participants' ages ranged from 25-42 years, and they had 1-11 years of ICU experience. Most of the participants had a BSN (n=23). The participants represented seven types of ICUs with an average nurse to patient ratio of 1:2, but as high as 1:4. Participant details are outlined in Table 1.

Participants were informed of the purpose of the study and the procedures during the consent process. Qualtrics® software was used to administer the consent and collect the demographic data. All interviews were conducted within a private location chosen by the participant via Zoom®. Participants who completed the interview received a $10 electronic gift card to Target®.

Consistent with recommended interpretative description research, the sample size was not set a priori, but enrollment continued until information redundancy occurred.[17] Information redundancy occurs when the collected information has been heard so often that it can be anticipated, and no new themes emerge.[17]

Data Collection

Data were collected through individual interviews using a semi-structured guide. ICU nurses were asked about the nature of the challenges they have experienced adhering to the CDC's central line bundle and the strategies they used to overcome or minimize these challenges when caring for critically ill patients to prevent CLABSI (Appendix A). Interview questions were generated by examination of relevant literature and in consultation with ICU experts and refined throughout the process based on emerging issues. Participants were encouraged to clarify and expand on specific aspects of their responses to capture what was not explicitly addressed in the interview guide. After each interview, a reflexive supplemental journal was used to record reflections about the interview and initial impressions resulting from the interaction with the participant. Reflexivity helped to enhance the quality of the interview questions[17] and guide development of additional questions for upcoming interviews.

Data Analysis

Zoom recorded interviews were reviewed in conjunction with the audio recordings and transcribed verbatim for coding and analysis in ATLAS.ti®. After each interview, the recordings were viewed and listened to, and transcriptions were reviewed numerous times to ensure accuracy. Data collection and analysis occurred concurrently to allow each to inform the other in an iterative process.

Codes were generated from the data and applied to all transcripts. Preliminary coding was catalogued and reviewed for patterns and connections within the data. Conceptual themes were derived inductively from the analysis among and between the individual interviews. The thematic analysis was guided by the analytical question(s): (a)What challenges do ICU nurses have adhering to the CDC central line bundle, and (b) What strategies do they use to overcome or minimize these challenges when caring for critically ill patients to prevent CLABSI? A journal was maintained during data analysis to record the analytic moves made throughout the process.

Aiding data analysis was the concept of positive deviance. Positive deviance is an approach to behavioral change based on the observation that in every community there are certain individuals or groups (the positive deviants), whose uncommon but successful behaviors or strategies enable them to find better solutions to a problem than their peers.[18] In order to understand positive deviance one must first understand deviance. Wilkins illustrated deviance by comparing it to a bell curve with conforming behavior in the middle, sinful at the left, and saintly to the right.[19] Therefore, deviance from the norm (the middle) can be negative or positive. In healthcare, the positive deviance approach has been applied to improving patient outcomes and organizational change.[20] This approach identifies the behavioral practices of positively deviant individuals within the community and builds solutions from the bottom up.[21]

Results

Participants in this study described the critical importance of adhering to the CDC's central line maintenance bundle and emphasized their commitment to protecting patients from CLABSI. Once provisional conceptual themes emerged, journal notes were reviewed to scrutinize the findings and to enhance trustworthiness. The following themes emerged: (a)

surmountable barriers, (b) multidisciplinary collaborative impact, and (c) positive deviant behaviors

Surmountable Barriers

Surmountable barriers were challenges participants experienced when attempting to be adherent to the CDC central line bundle, which they believed could be overcome. Eighteen participants discussed barriers that prevented their ability to adhere to each element of the CDC central line bundle every time for every patient when managing central lines. Such barriers included lack of supplies, dressing quality, staffing constraints and CDC bundle education for nurses.

Twenty-six participants expressed frustration due to lack of supplies available to ensure they are following the bundle elements. The items most often mentioned were the lack of curos® antimicrobial caps and bio patches. The participants voiced that the lack of supplies was not due to the supplies not being in the hospital, but more an issue of the supplies not being on the unit. Ensuring supplies are stocked and available by having central supply round at the beginning of each shift, tasking the charge nurse with notifying central supply of missing items, and placing items used together in the same area on the unit were suggestions to improve access to essential supplies. Dressing challenges, such as the inability to maintain occlusiveness, the number of times per shift nurses were changing the dressing due to lack of occlusiveness, and the need for a better dressing option were mentioned by 22 participants. One participant explained:

> "It's very difficult to keep the dressing adhered to the skin and covering it completely. Our central line dressings, by policy they have to be changed at least once every seven days. That never happens. They barely last a day with the heavier central lines they're

often pulling on the neck it's very difficult to keep it, you know, intact. Often, we are changing those dressing several times a day."

Eight participants voiced their concern about staffing constraints in the ICU when implementing the CDC central line maintenance bundle. The nurse to patient ratio also presented challenges in following the bundle. One participant said,

> "I can say that it's a lot easier to follow policy and procedure, even though the acuity of the patients is higher, by having a lower nurse to patient ratio means that I can, you know, really focus on that patient and provide them with the care that they really deserve when they have a central line."

The same eight participants were concerned that the lack of education for newer ICU nurses and traveling nurses on the unit's specific standards and requirements presented a challenge to maintaining the unit's standard of care.

All participants understood the nursing shortage and the need for traveling nurses but expressed the need for sound judgment when making daily clinical assignments. Participants not consistently but at times recommended that assignments should be based on the acuity and location of the patient in the unit and the number of central lines a nurse would be responsible for managing. One participant expressed that if the charge nurse was not required to take patients, they could be available to complete dressing changes.

Participants' suggestions for improving adherence to the CDC bundle included having a mandatory education module on the CDC central line bundle that all nurses would complete upon hire or when starting the travel assignment and annually. In addition, one participant recommended a poster, similar to those used for isolation precautions, with pictures and bullet points based on the CDC bundle, be placed at the head of the bed for patients with a central line.

Multidisciplinary Collaborative Impact

The participants provided examples of success with multidisciplinary collaboration. According to the participants, multidisciplinary collaborative impact was defined as individuals from different healthcare specialties (i.e., nursing, pharmacy, infection prevention, medicine) working collaboratively to decrease the number of CLABSIs with the ultimate goal of preventing all CLABSIs. The importance of multidisciplinary collaboration to prevent CLABSI was presented by 22 participants. They believed it takes many providers working together to ensure adherence to the CDC central line maintenance and to ensure the removal of unneeded central lines in a timely manner. Examples of multidisciplinary collaboration included huddles prior to each shift to present the number of patients in the ICU with central lines and the current number of CLABSIs, daily interprofessional rounds, and champions and super users advocating for adherence to the bundle. Champions and super users are staff nurses who work full time on a unit and are trained on best practice and standards for CLABSI prevention.[22-23] These nurses are assigned to oversee central line insertions and dressing changes to ensure the unit's standards are consistently maintained.[22-23] One participant stated,

> *"*We have huddles prior to each shift and go over infection control, like the patients with central lines and numbers of CLABSIs. Where we're at now and where we need to be so everyone is acutely aware of the numbers. When you get out of that huddle, and hear the infection rates, you are more vigilant about your, like you know, assessment and care. I think to myself, don't forget to check the dressing or for myself when you know clean your patient to prevent a CLABSI, it definitely helps."

Positive Deviant Behaviors

Ten participants presented innovative and creative strategies they utilize in addition to the CDC central line bundle when caring for patients with central lines in hopes of preventing CLABSI. Participants expressed challenges experienced and the desire to improve patient outcomes led them to implementing additional steps in an attempt to protect their patients from CLABSI. Additional strategies included being more aggressive with removal of peripheral IVs, improving hair hygiene and keeping hair away from the central line, more frequent bathing with CHG wipes, especially for diaphoretic patients, as well as innovative ideas to keep the central line dressing intact by preventing drag on the lines. One participant detailed how they tape the IV lines together and secure them to the back of the neck to prevent them from pulling on the dressing to maintain occlusiveness. Two participants shared the following strategies:

> "I think keeping their hair back and asking them to just if it's okay, if I put them in a ponytail just so I can avoid it getting underneath the line. Just the process of being in an ICU for 7 to 14 days and things go awry when you (the nurse) are not in the room. Things can go awry and now you have someone's hair hanging out. I don't know if there's a study that shows you like patients who have short hair versus patients who have long hair and how that works or patients who use this type of hygiene and that type of hygiene. I know that there is baseline to Hibiclens© promotions for central lines but I haven't seen anything, particularly on shampooing hair."

> "I think we need to be more aggressive with peripheral line removal. I think we get paranoid that oh, what are we going to do if they're hard stick? Let's hold on to these nasty peripherals because we know that one day, we're going to take out that central line and we don't want to get stuck trying to insert an IV, but what good are they if they

increase the rate of infection. I think that should be part of report. I think sometimes we're like oh, he has a central line and a couple peripherals, no big deal. But I try to remove peripherals."

Nurses presenting positively deviant behaviors discussed wanting to do more to provide and improve care that may prevent CLABSI. These nurses described wanting to share their ideas and educate others on strategies that do not require a significant amount of time but may decrease the incidence of CLABSI.

Institutional policies outside the CDC guidelines were present in eight ICUs requiring two nurses be present when performing a dressing change. When asked about the purpose of having two nurses present for the dressing change, participants described another set of eyes to ensure sterility was maintained; one nurse would be considered the sterile gloved nurse, and the other would be able to provide additional supplies as needed and to assist with maintaining the patients' cooperation. Although the participants felt that, in theory, this was a good process, the lack of staffing prevented the timely replacement of dressing that became soiled or non-occlusive.

Discussion

The findings of this study illustrate the critical role ICU nurses play in preventing CLABSIs and overcoming challenges they face adhering to the CDC central line maintenance bundle. The participants wanted to follow the bundle to ensure the highest standard of care for their patients. They were committed to doing everything required and then some to ensure patients do not develop CLABSI. These findings are consistent with those of Aloush and

Alsaraireh[12] who found that the majority of nurses were sufficiently compliant with the CDC maintenance bundle but the rate of CLABSI still varied throughout ICUs.

Health care facilities can assist with many of the challenges nurses identified to reduce CLABSI rates by improving resource allocation, supply management, and multidisciplinary collaboration. Lowering the nurse-patient ratio was consistent with the findings of Jansson et al.,[24] Lee et al.,[25] and Matlab et al.,[14] who reported improvements in nurses' compliance with guidelines and patient outcomes with lower nurse-patient ratios. During COVID-19, hospitals lacked supplies due to increased demand and global disruptions in the supply chain, which threatened patient care delivery.[26] This study found that although supplies were available in study hospitals, they were not available at the point of care within the ICUs.

Multidisciplinary rounds, intraprofessional and interprofessional huddles, and audits have all demonstrated success in decreasing the incidence of CLABSI.[27-32] In addition, the ICU nurses in this study felt supported and empowered when these strategies are implemented. They believed their voices and expertise were heard and appreciated. The literature supports the impact of multidisciplinary rounds, intraprofessional and interprofessional huddles, and audits as proven strategies to decrease the incidence of CLABSI.[27-32] This study found that nurses valued and supported these strategies to decrease the incidence of CLABSI.

The positive deviance approach has been utilized to prevent hospital acquired infections.[33-37] The positive deviance approach to organizational change tends to be more readily accepted and feasible within existing operating constraints because the solutions are generated within the ICU amongst professional colleagues.[38] The positive deviance approach to infection prevention attempts to bridge the gap between guidelines, their implementation to practice, and

improved outcomes. Commensurate with previous research, this study identified positively deviant nurses who independently implemented innovative strategies in addition to the CDC central line bundle guidelines in an attempt to improve patient outcomes and decrease CLABSI.

Strengths and Limitations

Limitations of this study were that it was carried out during the COVID-19 pandemic and direct observations were not possible. In addition, it was limited to one method of data collection and one interview per participant by a single investigator with no long-term relationship with the participants. Nevertheless, the findings of an ID inquiry are not a list of isolated themes but a synthesis of the main themes and patterns of the phenomena.[17] A strength of this study was that because of technology, data collection was not limited to one geographic location.

Nursing Implications

There is a paucity of literature on adherence to the CDC central line maintenance bundle. Most studies are self-reported survey data and focus on adherence to the CDC bundle during insertion of central lines.[9] Moreover, the research was not conducted in the United States, and most were in countries with fewer resources.[11-12,14-15,39] There is a significant association between adherence to all the elements of the central line bundle and a decrease in CLABSI.[4,6-8,25,40-41] However, even when all the bundle elements are adhered to, CLABSI still occurs. [4,6-8,25,40-41] This study showed nurses' knowledge and commitment to the CDC's central line bundle and the desire to adhere to every element of the maintenance bundle despite challenges. This study provided the nurses' voice on challenges and strategies to improve adherence to the CDC central line maintenance bundle as well as positively deviant behaviors nurses are using to reduce CLABSI.

The suggestions made by the participants in this study provide a starting point to improve patient care, increase adherence to the CDC central line maintenance bundle, and decrease the occurrence of CLABSI. These suggestions combined with positive deviant behaviors should be implemented and studied to see if they result in a decreased incidence of CLABSI. Additional research regarding the implementation of positively deviant behaviors presented by the participants is needed to determine if they are feasible and if they result in a decrease in the incidence of CLABSI.

Conclusion

This study provided a qualitative assessment of the challenges ICU nurses experience adhering to the CDC central line bundle and the innovative strategies they employ to prevent CLABSI. The participants expressed strong desires to adhere to the bundle and wanting to provide the highest quality of care to their patients. Examining the positive deviant behaviors nurses are using may provide an opportunity to improve bundle compliance, practice guidelines and decrease CLABSI rates. The results of this study confirm that ICU nurses believe that a multidisciplinary approach is necessary to adhere to all of the elements of the CDC central line bundle to achieve zero CLABSIs.

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Table 1

Sample Characteristics

Characteristic	n	%
Gender		
Males	10	37.0
Females	17	73.0
Age		
20-25	2	7.4
26-30	13	48.1
31-35	6	22.2
36-40	4	14.8
41-45	2	7.4
Highest educational degree		
BSN	23	85.1
MSN	4	14.8
Years as an RN		
1-5	14	51.8
6-10	12	44.4
11-15	1	3.7
Years an ICU RN		
1-5	19	70.3
6-10	7	25.9
11	1	3.7
States Employed		
California	3	11.1
Colorado	2	7.4
Illinois	1	3.7

New Jersey	5	18.5
New York	12	44.4
Pennsylvania	2	7.4
Texas	2	7.4
Frequency of Nurses Caring for Patients with Central Lines		
Daily	20	74.0
Weekly	4	14.8
Monthly	3	11.1
Type of ICU		
Mixed/Combo	9	33.3
Cardiothoracic	8	29.6
Coronary Care	3	11.1
Medical	3	11.1
Neuro	2	7.4
Transplant	1	3.7
Trauma	1	3.7

Appendix A

Semi-structured Interview Guide

1. Can you tell me about the work you do in the ICU?

2. Think about when you have cared for patients with central line and tell me about what you do to manage the central line.

3. As you were caring for a patient with central line have you ever experienced any difficulties? Can you say more about that?

4. In the past 6 months have you forgotten to complete an element(s) in the CDC CLABSI maintenance bundle? Can you tell me more about that?

5. Have you ever been unsure how to complete any element or elements of the CDC CLABSI maintenance bundle? How do you proceed when you encounter this?

6. Are there any components of the CDC CLABSI maintenance bundle that you find more challenging to complete? Can you tell me more about that?

7. Can you think of anything else you might want to tell me about the times you cared for patients with central line?

8. Do you have any questions for me?