CENTRAL VENOUS CATHETER RELATED INFECTIONS: THE IMPACT OF AN EDUCATIONAL PROGRAM ON NURSES' KNOWLEDGE AND INFECTION RATES IN AN ICU.

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Abstract

For improved client outcomes, nurses must be able to synthesize information from research and implement this information in the care of complex clients' needs. The purpose of this study was to assess registered nurses' knowledge of the evidence based guidelines for preventing central line infections in the context of Intensive Care Units, before and after implementation of a checklist and an educational program, using quasi-experimental pre-test and post-test interrupted time series design. The questionnaire "Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection" developed by Labeau, Vereecke, Vandijck, Claes, and Blot (2008) was used to assess the nurses' knowledge with respect to central venous catheter maintenance factors as outlined in the Centers for Disease Control (CDC, 2002) guidelines. Following ethics approval, a convenience sample of registered nurses was given a self report questionnaire. Guideline knowledge was examined by age, education level, number of years in practice, and gender to explore potential differences within and between groups; no statistically significant differences were found between the groups. After the intervention, there was a statistically significant increase in mean knowledge score for the intervention group, but not for the comparison group. In addition, the mean post-test score was significantly higher for the intervention group compared to the comparison group. In the 12 months following the intervention, no primary bloodstream infections were reported at the intervention site. The results indicate that implementation of a checklist with educational reinforcement can increase nurses' knowledge and may contribute to decreasing central venous catheter blood stream infection rates. An understanding of the nurses' current knowledge level allows adaptation of beneficial strategies to increase research utilization and synthesize information toward better client outcomes in the context of the intensive care specialty.

Decreasing infection rates saves lives, improves quality of care, and leads to better patient outcomes.

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I am greatly appreciative of all the nurses who work in the Intensive Care Units. For the dedication and compassion you demonstrate in the work you do every day. It has been a pleasure to work with you!

I have met many generous and inspiring people, and I cherish each contribution you have made to my life. To my invaluable network of family and friends for their love, support, and understanding, I love you!

Not all that can be counted, counts.

And not all that counts can be counted.

Albert Einstein

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CHAPTER 1: INTRODUCTION

Healthcare is complex and there are risks for adverse events. Errors are unfortunate, but they do occur. In the Canadian Adverse Events Study (2002), the overall adverse event rate was estimated to be 7.5% in Canada, in 2000, when "between 9,000 to 24,000 patients experienced an adverse event that was preventable and later died" (Baker et al., 2004, p. 1678). Examination of the factors surrounding adverse events has resulted in protocol and guideline development. Many safeguards, developed in response to errors, are in place but often not utilized to their full potential because of decreased human and financial resources.

Guidelines for the prevention of intravascular catheter-related infections, prepared by O'Grady et al. (2002), reflect consensus of the Healthcare Infection Control Practices Advisory Committee (HICPAC) of the Centers for Disease Control and Prevention (CDC). A multidisciplinary team from "critical care medicine, infectious diseases, health-care infection control, surgery, anesthesiology, interventional radiology, pulmonary medicine, pediatric medicine, and nursing" (O'Grady et al., 2002, p. 1) contributed in the development of the guidelines. The guidelines highlight education and training for the insertion and maintenance of central venous catheters as a key component for the prevention of infection.

Central venous catheters are routinely used in Intensive Care Units (ICU) to provide vascular access. Vascular access is essential to maintain support for most patients with a critical illness. Central venous catheters are used to access a large vessel (internal jugular, subclavian or femoral) to monitor central venous pressure (CVP), administer fluids, blood products, total parental nutrition (TPN), and medications. Patients in Intensive Care Units are at a higher risk for infection due to multiple factors such as age, severity of illness, and underlying disease conditions combined with a critical illness. Use of central venous catheters can increase the risk

for infection, which may develop and spread into the blood stream, contributing to an increase in morbidity in this client population.

The National Nosocomial Infections Surveillance (NNIS) System revealed an average rate of 5.3 central venous catheter infections per 1,000 catheter days in the ICU (CDC, 1998). In Canada, the overall national mean was reported as a baseline of 5.0 central venous catheter related blood stream infections (CLA-BSI) per 1000 catheter days (Safer Healthcare Now, 2007). The Canadian targeted goal is now < 1.9 central venous catheter infections per 1,000 catheter days (Safer Healthcare Now, 2009a). In previous intervention studies, rates for central venous catheter related blood stream infections (CLA-BSI) varied from 2.1- 24.6 per 1000 catheter days (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004; Eggimann et al., 2000; Eggimann et al., 2005; Galpern et al., 2008; Harnage et al., 2007; Lobo et al., 2005; Maki, Kluger, & Crnich, 2006; Missett et al., 2004; Muto et al., 2005; Pronovost et al., 2006; Warren et al., 2004; Warren et al., 2006; Zuschneid et al., 2003). Human and financial costs of central venous catheter infections place a significant burden on all levels of the health care system. The estimated cost per central venous catheter infection has been estimated at $6000 -$56,000 (Blot, Depuydt, Annemans, et al., 2005; Maki & Crnich, 2003; O'Grady et al., 2002; Shorr, Humphreys, & Helman, 2003). Findings of previous intervention studies, which controlled for risk factors associated with central venous catheter insertion and maintenance care based on the CDC guidelines, indicated that a multifaceted education program was effective in reducing infection rates, improving client outcomes, and reducing costs.

Critical care nurses are responsible for ensuring that clients with a critical illness or potentially life threatening condition receive optimal care. Critical care nursing occurs in a dynamic environment that continually adapts to advances in new research and technology. To

provide appropriate care, nurses rely on specialized knowledge, skills, and experience. How nurses use research is vital to client outcomes.

The gap between knowledge generation and its use is well recognized by researchers, policy-makers, educators, administrators, and clinicians. The Canadian Intensive Care Foundation (CICF) stated, "Intensive care nursing is an area in which clinical research is most valuable. Research utilization can have the biggest impact on who survives and who does not" (CICF, 2006, ¶ 6). The challenge is how to facilitate the uptake of research findings. In order to accomplish this we must understand and be aware of the current knowledge level registered nurses have regarding the evidence based guidelines for preventing central line infections in an Intensive Care Unit. An understanding of the current knowledge level will allow adaptation of beneficial strategies to increase research utilization and use of this information toward better client outcomes in the context of the intensive care specialty. For improved client outcomes, nurses must be able to apply information from research and implement those evidence-based decisions in the care of complex clients' needs. The cost of a single life is irreplaceable and priceless. Even one loss is one too many.

Purpose

The main purpose of this study was to identify changes in registered nurses' knowledge level of the evidence-based guidelines for preventing central line infections in an Intensive Care Unit (ICU) before and after implementation of a checklist and educational session. A quasi-experimental pre-test and post-test interrupted time series design was utilized. In addition, the researcher assessed the impact of the interventions on central venous catheter infection rates.

The questionnaire, "Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection," developed by Labeau, Vereecke, Vandijck, Claes, and Blot

(2008) was used to assess the nurses' guideline knowledge with respect to central venous catheter maintenance (permission received, see Appendix A).

The checklist was modified from the Safer Healthcare Now example provided by the B.C. Children's Hospital (Safer Healthcare Now, 2007). The checklist was used to incorporate and reinforce the use of the central venous catheter insertion guidelines. The intent of the checklist is to reinforce behaviours associated with central venous catheter insertion. Registered nurses assist the physician performing the insertion.

Relevance and Significance

Constant advances in technology and research continue to increase the complexity of the practice environment. Patients in ICU are at a higher risk for infection due to the multiple etiologies associated with a critical illness. Strategies to decrease central venous catheter infection rates based on the CDC guidelines have been found to improve client outcomes.

The findings of this study are important to all the stakeholders within the Health Region. Patients and families expect safe, competent care. Patients are often unable to speak for themselves while they are temporarily supported through their critical illness, and an increased burden is often placed on the family. The information needs of the patient and families require timely, clear, and concise information. Treatment measures associated with support do not come without risks. Unfortunate complications do occur and infections are common among critically ill patients because of the invasive measures used to support them. Patients and families expect care based on best practices and processes to reduce risks and complications.

From the moment patients enter the health care system it is the health care provider's job to protect them. Patients put their trust in their health care providers who have a responsibility to protect and guard that trust. Increases in complexity of the Intensive Care environment have

occurred in the last few decades because of multiple advances in technology. The goal of evidence-based practice is to ensure the highest quality of care for patients and their families. Through the use of evidence based guidelines, skilled providers are better able to provide safe, efficient, effective, and comprehensive care to those with a critical illness.

Human and financial costs affect service provision on a global level. Central venous catheter infections place a significant burden and increase risk to patient outcomes. Prolonged hospitalization associated with nosocomial infections increases costs to the health region. Financial burden can affect resource allocation within the Health Region, which operates on a finite budget. Cost containment and reform within the health care system does affect care provided to clients. It was hypothesized that focusing on fully implementing the central venous catheter guidelines will help reduce or eliminate these infections and potentially free up resources.

In 2003, in Canada $121.4 billion was spent on healthcare, which equalled 10% of the Gross Domestic Product (Canadian Institute for Health Information, 2007). The Provincial Health ministries and Health Canada are concerned with the health of the population and the fiscal responsibilities inherent in the provision of health care. As managers of the health system, they implement policy to meet the needs of providers and consumers of health care. Detailed or streamlined evidence-based practice and benchmarking associated with results indicate how we are doing, which can facilitate decision making in the local context.

Expected Benefit of the Research

Research results from the Institute for Healthcare Improvement (IHI) the 5 Million Lives Campaign (2006) and Canada's Safer Healthcare Now campaign (2009b), as well as various previous studies (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004;

Eggimann et al., 2000; Eggimann et al., 2005; Galpern et al., 2008; Harnage et al., 2007; Lobo et al., 2005; Missett et al., 2004; Muto et al., 2005; Pronovost et al., 2006; Racco et al, 2007; Warren et al., 2004; Warren et al., 2006; Zuschneid et al., 2003) indicate that decreasing central line infections:

1. saves lives, improves quality of care, and leads to better patient outcomes,
2. reduces central venous catheter related infection rates,
4. improves satisfaction for the nurses, physicians, clients, and their families, and
5. is cost effective to implement.

CHAPTER 2: LITERATURE REVIEW

Search Strategy

A review was conducted of published research, 2000 – 2010, indexed in Cumulative Index of Nursing and Allied Health Literature (CINAHL), MEDLINE® [PubMed] , Embase, the Cochrane Library, University of York Center for Reviews and Dissemination (CRD) databases, Centers for Disease Control and Prevention (CDC), National Guideline Clearinghouse (NGC) and the Public Health Agency of Canada (PHAC). The MeSH search terms of central venous catheter, infection, education, and intensive care unit were used to initially refine the search. Relevant reference lists, bibliographies, and book chapters were reviewed for additional studies.

Criteria for inclusion were: adults and intensive care units, medical, surgical, and mixed. Articles were included if a definition of central venous catheter related infections was provided and the article reported on central line associated blood stream infection (CLA-BSI) rates as an outcome, included some type of educational intervention, and presented complete and published results. Poster abstracts and abstracts of incomplete published studies were excluded. The search included articles published in English between 2000 and 2010. No filters were applied to limit the retrieval by study type.

Studies were excluded if they focused primarily on pediatric populations, peripherally inserted catheters (PICC), or tunnelled central venous catheters, or if the studies were not conducted in intensive care units. In addition, studies of arterial catheters and non infusion devices (i.e., for pacemaker devices) were excluded. Reports of studies specifically using antimicrobial central venous catheters and use of antibiotic patches were also excluded because the Health Region in the study area does not currently use these devices.

Search Outcome

Review of the 105 resulting article abstracts led to exclusion of 76 articles because the abstracts did not meet the inclusion/exclusion criteria, had incomplete information, or were abstracts from conference presentations or poster abstracts; others lacked specific information on the educational intervention or procedures and techniques used. A further 12 were excluded as the primary focus was not prevention of central venous catheter infections, but assessment of current practice, review of practices and their rationales. The remaining articles were reviewed to further assess whether the inclusion criteria were met. Of the 17 studies, six were excluded because of incomplete pre-intervention or post-intervention comparison data for CLA-BSI rates (Harnage, 2008; Misset et al., 2004; Racco & Horn, 2007; Zuschneid, Schwab, Geffers, Ru¨den, & Gastmeier, 2003). Gnass (2004) did not specify when or what type of training took place and Warren (2003) specifically used antibiotic coated catheters. Eleven studies met all the inclusion criteria: Berenholtz et al. (2004), Coopersmith et al. (2002), Coopersmith et al. (2004), Eggimann et al. (2000), Galpern et al. (2008), Higuera et al. (2005), Lobo et al. (2005), Pronovost et al. (2006), Rosenthal et al. (2003), Warren et al. (2004), and Warren et al. (2006). The target population of interest was adults. Pronovost et al.(2006) studied 103 ICUs, only one was reported as a pediatric ICU, and because it was a large multi-site study it was retained.

Following is a review of the 11 reports of published studies of central venous catheter associated blood stream infections which included infection rates and an educational intervention.

Definitions

Central venous catheter associated blood stream infections (CLA-BSI) are also abbreviated CVC-BSI or CRBSI. To eliminate bias in defining CLA-BSI, studies were reviewed

for a standard definition. The Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN), formerly the National Nosocomial Infections Surveillance (NNIS) system, definition was used in all the studies reviewed (Appendix B). The CDC (2006) defined a central venous line as a vascular access device that terminates at or close to the heart or one of the great vessels and a blood stream infection is attributed to a central venous catheter if, "the line was in use during the 48-hour period before development of the blood stream infection (BSI)" (O'Grady et al., 2002, p. 28). The CDC, Institute for Healthcare Improvement (2004) and Safer Healthcare Now! (2007) campaigns recommended that the rate of catheter-associated blood stream infections (BSI) be expressed as the number of catheter associated blood stream infections per 1,000 central venous catheter days.

Findings of the Previous Studies

Approvals

Eight of the reviewed studies acknowledged receiving ethics approval (Coopersmith et al., 2002; Warren et al., 2004) or institutional approval (Berenholtz et al., 2004; Eggimann et al., 2000 ; Higuera et al., 2005; Lobo et al., 2005 ; Rosenthal et al., 2003; Warren et al., 2006). No mention of approval was found in the reports of three studies (Coopersmith et al., 2004; Galpern et al., 2008; Pronovost et al., 2006).

Characteristics of the ICU's

Most studies were conducted in single institutions (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004; Eggimann et al., 2000; Galpern et al., 2008 ; Higuera et al., 2005; Lobo et al., 2005 ; Warren et al., 2004), or within a single city.(Rosenthal et al., 2003). The study by Pronovost et al. (2006) took place in multiple institutions within the state of

Michigan, and as part of an international study, the CDC Prevention Epicenter Program. Warren et al. (2006) used 12 ICU's and one bone marrow transplant unit for their research.

Intensive care units are classified by the services provided to patients and are designated as medical, surgical, or mixed for adults. Mixed ICU's are a combination of medical and surgical; they often include burns, cardiothoracic, neurosurgical, and trauma specialties.

Hospital size in the reviewed studies ranged from 150 beds to 1400 beds. The hospital designations were teaching [Coopersmith et al. (2002), Galpern et al. (2008), Lobo et al. (2005), Pronovost et al. (2006) 52% teaching], university affiliated (Higuera et al., 2005; Warren et al., 2006) or academic medical centers (Eggimann et al., 2000; Warren et al., 2004), referral hospital (Berenholtz et al., 2004; Coopersmith et al., 2004), and medical center (Rosenthal et al., 2003).

Of the studies conducted in a single ICU, three were in medical ICU's (MICU) (Lobo et al., 2005; Eggimann et al., 2000; Warren et al., 2004) and three were in a surgical ICU (SICU) (Coopersmith et al., 2002; Coopersmith et al., 2004; Galpern et al., 2008). Berenholtz's (2004) study included two ICU's, one SICU, and one cardiovascular (CV) ICU, which was selected as the control group. Rosenthal et al. (2003) used two mixed and two coronary ICU's. Higuera (2005) studied one mixed ICU and one neurosurgical ICU. Warren 2006 studied 12 ICU's and one bone marrow transplant unit. Pronovost (2006) studied 103 (85%) of all ICU beds in the state of Michigan and of the 103 participating ICU's, 48 did not contribute baseline data.

The number of ICU beds per hospital ranged from 7-30 with a median size of 18. In the studies, the model of care was reported as a closed model of care in which the ICU Intensivist is responsible for directing care (Warren et al., 2004) or a consult model, where coverage is shared between the intensivist and the admitting doctor (Berenholtz et al., 2004). The model of care was not reported for the other studies.

Infection Rates

In all of the previous similar studies, the researchers found a decrease in the incidence of CLA-BSI in the post-intervention period. Statistically significant decreases in infection rates were noted in all but two studies (Coopersmith et al., 2004; Lobo et al., 2005). Lobo et al. (2005) observed a pre-intervention infection rate of 20 CLA-BSI per 1000 catheter days and a post-intervention infection rate of 11-12 CLA-BSI per 1000 catheter days (P = 0.07). Coopersmith et al. (2004) reported a pre-intervention rate of 3.4 CLA-BSI per 1000 catheter days and a post-intervention rate of 2.8 CLA-BSI per 1000 catheter days (P = 0.40). Coopersmith commented, "It was easy to show improvement when our infection rates were double the national average, but much more difficult to show further improvement when our rates were one half to one third the national average" (2004, p. 135).

Interventions

In all 11 reviewed studies, the goal of the educational intervention was to increase awareness of evidence-based information to reduce infection rates, specifically nosocomial infections related to central venous catheters. In most studies, a multidimensional intervention strategy was used, which did not include any expensive technologies, resources, or additional staffing. The interventions were relatively simple to implement. Didactic presentations and self instruction also facilitated the educational components in the studies reviewed.

In the United States, the Institute of Health Improvement (IHI), founded in 1991, developed the 100k Lives Campaign (IHI, 2004). In 2005, the Canadian Safer Healthcare Now! initiative was started. The primary focus of both endeavours was to improve patient safety and quality of care. Utilizing a systems approach, challenges and barriers were addressed. The risk to patients in an intensive care unit of developing a blood stream infection is a potential

complication of having a central line. The contributing factors are related to patient acuity, insertion of the central venous catheter, and maintenance techniques.

Bundles are a set of evidenced based interventions that improve patient care and safety. According to the Canadian ICU Collaborative (2009) the insertion bundle components, which potentially decrease infections, include hand hygiene, maximal barrier precautions, chlorhexidine skin asepsis, and optimal site selection. The maintenance bundle components include accessing the line aseptically, prompt removal of unnecessary lines, assessing the insertion site, and having a dedicated line for delivery of total parenteral nutrition (TPN). Facilitators of the bundle include using a cart to keep all the supplies in one easily accessible place and use of a checklist for insertion.

According to Pronovost (2006), based on the CDC guidelines of the level IA recommendations, five infection prevention components were chosen: hand hygiene, maximal barrier precautions, chlorhexidine skin asepsis, prompt removal of unnecessary lines and optimal site selection. These five components were used in other studies (Berenholtz et al., 2004; Eggiman et al., 2000; Galpern et al., 2008) because of the ease of implementation related to low technology and cost.

Models for improvement based on multidisciplinary teams working together have shown common barriers and potential solutions to improve patient outcomes (IHI, 2004; SHN, 2005). The limit of using a bundle or multidimensional intervention is the inability to know which component made a difference.

The purpose of the reviewed studies was to decrease blood stream infection rates associated with central venous catheters and evaluate the impact of procedural and educational

interventions. Measuring the infection rates is a good indicator of whether improvement strategies have had an impact on the infection rates, and hence an improvement in patient safety.

Bundle Facilitators

Creating a Central Line Insertion Cart

Both the human factors engineering (Wickens, Gordon-Becker, & Liu, 2004) and the LEAN methodology model (Shinkle, Gooding, & Smith, 2004) indicate that the more steps in a process the more likely the process is to fail at some point. Each step has the potential for error. The more points or steps, the greater the potential for an omission or error to occur. Decreasing the complexity of the system, especially in a busy unit or situation, by having all the required supplies in one place potentially eliminates risks associated with omission. Keeping all necessary supplies in one place makes it easy to do the right thing. Berenholtz (2004), Galpern (2008), and Pronovost (2006) implemented the use of a central line cart to decrease the potential for errors or misuse of products associated with central line insertion. To assemble the appropriate supplies, Berenholtz (2004), found that eight different areas within the unit that had to be accessed to assemble the supplies. None of the reviewed articles elaborated on the number of steps in the process required to gather the appropriate supplies. Findings of previous research suggests that reducing the number of steps required to gather the necessary supplies needed to insert a central venous catheter would facilitate compliance with proper insertion technique (Berenholtz et al., 2004; Galpern et al., 2008; Pronovost et al., 2006).

Checklist

"Clinical reminders at the point of care are one of the most effective strategies for affecting daily practice" (Bero, Grilli, Grimshaw, Harvey, & Oxman, 1998, p. 466). A checklist is a measurement tool that can reinforce and remind physicians and nurses about the key steps in

a procedure, adherence to infection-control practices (Pronovost et al., 2006), and compliance with the evidence-based guidelines (Galpern et al., 2008) associated with insertion of a central venous catheter. The central venous catheter insertion checklist has been used as safeguard or redundancy check (Berenholtz et al, 2004) to reinforce correct procedure and care during the insertion of a central venous catheter.

Berenholtz (2004) reported that nurses in their study "felt more comfortable intervening if they observed a violation, because they felt an expectation had been set" (p. 2017) by using a checklist. Documentation on the checklist included a section to indicate if a procedure was stopped (Berenholtz et al., 2004; Pronovost et al., 2006); however, the checklist did not include a section for the specifics of the violation. The violation rate was estimated at 15 – 25 % in the study by Berenholtz et al.(2004).

When breaches in technique were observed and not willingly corrected, nurses were empowered to stop the procedure in the previous studies (Berenholtz et al., 2004; Higuera et al., 2005; Pronovost et al., 2006). Providing a key contact person whom the nurses could call if a violation was not corrected gave them power (Berenholtz et al., 2004). This did not apply to emergency situations (Berenholtz et al., 2004; Pronovost et al., 2006). Emergency situations require immediate action in the situation to prevent risk to a patient's life due to acute illness or injury. The checklist was pilot tested and modified according to feedback from the ICU nursing staff (Berenholtz et al., 2004). Pilot testing of the checklist was not mentioned in the reports of the other 10 reviewed studies. Literature from the Institute for Healthcare Improvement (2004), the Canadian Patient Safety Institute (2008), and the Canadian ICU Collaborative (2009) indicate success in decreasing central venous catheter infection rates with multiple measures.

Berenholtz et al. (2004) observed increased communication and teamwork with the use of a checklist. Berenholtz et al. (2004) estimated that it took less than 2 minutes to complete the checklist. None of the other studies examined compliance rates with using the checklist.

Pre-test/Post-test

In the previous studies, the pre-test and post-test included questions related to risk factors and infection prevention techniques in the insertion and maintenance of a central venous catheter. Berenholtz et al. (2004), Coopersmith et al. (2002), Coopersmith et al. (2004), Warren et al. (2004), and Warren et al. (2006) used identical tests for the pre-test and post-test interventions. The pre-tests were completed prior to the start of a study module. The number of questions on each test was 10 (Berenholtz et al., 2004; Lobo et al., 2005), 20 (Coopersmith et al., 2002; Coopersmith et al., 2004; Warren et al., 2004), and 26 questions (Warren et al., 2006).

In one study, a pass mark of 85% was required to pass the post-test and the test was required to be retaken until a pass mark was achieved (Warren et al., 2004). In another study, a test score below 80% on the post-test required participants to repeat the study module (Coopersmith et al., 2002); however, there was no mention of having to repeat the post-test. No other studies commented on pass marks required or criteria.

Educational Intervention

In all the studies reviewed, multidisciplinary teams collaborated to develop and implement an educational program that focused on central venous catheter (CVC) insertion and maintenance techniques. Teams consisted of physicians (Berenholtz et al., 2004; Coopersmith et al.,2002; Coopersmith et al., 2004; Lobo et al., 2005; Rosenthal et al., 2003), nurses (Berenholtz et al., 2004; Coopersmith et al., 2004; Lobo et al., 2005; Rosenthal et al., 2003), infection control practitioners (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004;

Galpern et al., 2008; Lobo et al., 2005; Pronovost et al., 2006; Warren et al., 2004), medical directors of the hospital infection control group (Warren et al., 2004); medical directors of the ICU (Berenholtz et al., 2004; Galpern et al., 2008 ; Pronovost et al., 2006), nurse managers from the ICU Galpern et al., 2008; Pronovost et al., 2006), pharmacist (Coopersmith et al., 2004), and quality improvement specialists (Coopersmith et al., 2004).

The infection control components of hand hygiene, maximal barrier precautions, and skin disinfection were common throughout the studies. “Hand hygiene is the primary measure to reduce infections. Though the action is simple the lack of compliance among health-care providers is problematic throughout the world” (WHO, 2005, p. 5). Compliance with hand hygiene increases with the hand washing campaigns, but then decreases (Boyce & Pittet, 2002; Pittet, Mourouga, & Perneger, 1999).

Maximal sterile barriers include the simultaneous use of gloves, gown, mask, and full patient drape during insertion of a central venous catheter. Maximal barrier precautions were used in most studies. Higuera et al. (2005) indicated using maximal barrier precautions when resources permitted. Coopersmith et al. (2002) did not comment on the insertion component or barriers technique; their focus was primarily maintenance as it related to nursing.

The skin or skin flora can be a source of infection. The use of skin disinfection prior to insertion and with maintenance is believed to reduce this risk. The CDC (2002; 2011) guidelines recommend using a 2% chlorhexidine solution as the preferred antiseptic for skin preparation. In previous studies, skin asepsis was primarily with chlorhexidine (Berenholtz et al., 2004; Coopersmith et al., 2004; Eggimann et al., 2000; Galpern et al., 2008; Pronovost et al., 2006; Warren et al., 2004). Pronovost (2006) had all hospitals switch from povidone-iodine to chlorhexidine prior to the start of the study. Lobo (2005) used povidone-iodine because

chlorhexidine was not available in Brazil. Rosenthal et al. (2003) and Higuera et al. (2005) both commented on the lack of availability of chlorhexidine in Argentina and Mexico, respectively.

In previous studies researchers have examined the impact on central venous catheter related blood stream infections with avoiding the femoral site for the insertion of a central venous catheter (Coopersmith et al., 2004; Galpern et al., 2008 ; Pronovost et al., 2006; Warren et al., 2004; Warren et al., 2006) or tracking the insertion site (Berenholtz et al., 2004; Warren et al., 2004; Pronovost et al., 2006) and daily reassessment of the need for a central venous catheter (Berenholtz et al., 2004; Eggimann et al., 2000; Pronovost et al., 2006). In the previous studies, no information was available regarding whether femoral line sites had greater infection rates than the subclavian or internal jugular sites either before or after the educational intervention.

In the previous studies, the primary messages of the educational material used in the intervention were based on the CDC guidelines for prevention of central venous catheter infections (O'Grady, 2002). In all 11 studies, the focus on central venous catheter maintenance technique was referenced and all incorporated methods to decrease risk. Detailed descriptions of specific maintenance factors were lacking in most of the reports. Components described included catheter insertion site dressing site care, including documention or dating dressings to ensure regular dressing changes (Coopersmith et al., 2002; Eggimann et al., 2000; Warren et al., 2004; Warren et al., 2006), proper technique for obtaining blood cultures (Coopersmith et al., 2002; Warren et al., 2004), technique for sending catheter-tip culture (Coopersmith et al., 2002), guidelines for changing intravenous tubing and the administration sets (Coopersmith et al., 2002; Eggimann et al., 2000; Warren et al., 2004), aseptic access to lines (Coopersmith et al., 2002),

and methods for detecting potential clinical signs and symptoms of local infection (Coopersmith et al., 2002).

In some studies a central line insertion cart was used (Berenholtz et al., 2004; Galpern et al., 2008; Pronovost et al., 2006) to make it simple to use the right supplies to facilitate the interventions. In other studies a checklist for central venous catheter insertion was used to reinforce correct procedure and care during insertion (Berenholtz et al., 2004; Galpern et al., 2008; Pronovost et al., 2006). These relatively simple and inexpensive interventions which focus on good technique for insertion and maintenance of central venous catheters used in combination, have been found to be beneficial in the intensive care setting and could be beneficial outside the intensive care unit setting.

Nurses were represented in all the reviewed studies. In addition, a variety of other health care professionals received the educational intervention including: physicians (Berenholtz et al., 2004; Lobo et al., 2005; Warren et al., 2004; Warren et al., 2006), residents, fellows or medical students (Berenholtz et al., 2004; Coopersmith et al., 2002; Higuera et al., 2005; Lobo et al., 2005; Warren et al., 2004; Warren et al., 2006), nursing assistants (Coopersmith et al., 2002; Lobo et al., 2005), and physician extenders (Berenholtz et al., 2004).

All of the studies included some form of didactic presentation. Staff education on multifaceted infection prevention and control strategies were presented using a number of modalities. Presentations included PowerPoint or slide presentations (Eggimann et al., 2000 ; Pronovost et al., 2006), in-services or group presentations (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004; Warren et al., 2006), and separate individual instruction (Coopersmith et al., 2004; Eggimann et al., 2000). Additional education was provided to new staff over and above the standard educational intervention (Higuera et al., 2005). Direct feedback

regarding CLA-BSI rates was provided monthly or at least quarterly to unit practitioners. (Coopersmith et al., 2002; Galpern et al., 2008; Higuera et al., 2005; Lobo et al., 2005; Rosenthal et al., 2003; Warren et al., 2004).

Self study components included posters (Berenholtz et al., 2004; Coopersmith et al., 2002; Coopersmith et al., 2004; Lobo et al., 2005 ; Pronovost et al., 2006; Warren et al., 2004), a self study module (Coopersmith et al., 2002; Coopersmith et al., 2004; Warren et al., 2004; Warren et al., 2006), web based training (Berenholtz et al., 2004; Pronovost et al., 2006), articles (Pronovost et al., 2006), fact sheets (Coopersmith et al., 2002; Pronovost et al., 2006; Warren et al., 2004), and updated policies (Galpern et al., 2008 ; Pronovost et al., 2006; Warren et al., 2006).

Finding a strategy to decrease infection rates, which is easy to use and implement and does not put increased stress or workload on already tight resources, has been found to have a benefit (Pronovost et al., 2006). There are many steps in the insertion and maintenance of a central venous catheter especially for patients in intensive care. Each step or access into a central venous catheter creates an opportunity for a breach in the system and an increase in the risk for infection. It makes sense to have an intervention strategy that is multidimensional targeting each step.

Practice guidelines are evidenced-based and guide clinical decision making. Providing information or educating staff on the effectiveness of care practices used in the insertion and maintenance of central venous catheters is important in clinical practice. Education programs delivered based on infection prevention and control strategies in combination with performance feedback or CLA-BSI rates has been found to be beneficial (Coopersmith et al., 2002; Galpern et

al., 2008 ; Higuera et al., 2005; Lobo et al., 2005; Pronovost et al., 2006; Rosenthal et al., 2003; Warren et al., 2004).

Nurses play a key role in the management of patient care in the intensive care setting. It is important to raise awareness of infection prevention and risk reduction strategies for preventing nosocomial infections like central line associated blood stream infections. Focus on insertion and maintenance requires buy-in from a multidisciplinary team from the grass roots to senior leadership. Evidence-based practice provides a focus for each intervention and a trend to provide more comprehensive targeted interventions addressing each step of the process. Health care resources are limited both in financial and human costs and it is appropriate to implement low cost, low technological and relatively easy interventions first.

Inconsistencies in the Previous Studies

Potential effects of central venous catheter related infections emphasize the importance of specific measures for infection control with critically ill patients. Details on the techniques or solutions used for aseptic access of lines and dressing site care, at minimum, would be beneficial. Incomplete descriptions of the qualities and characteristics of the individual ICU's was found in the literature review. Information on demographic characteristics, patient acuity, mortality rates, and average length of stay, would allow for site comparisons.

The insertion bundle components include hand hygiene, maximal barrier precautions, chlorhexidine skin asepsis, and optimal site selection according to the Canadian ICU Collaborative (2009). Determining the relationship between compliance of the interventions for maintenance care with central venous catheters was not reported because of the resources, time and effort needed to collect this information would not be realistic. "It is necessary to balance

what data are needed to be scientifically sound compared with what is feasible to collect" (Pronovost, 2008, p.3).

Health care facilities in Latin America "lack the resources to implement many of these preventative technologies." (Higuera et al., 2005; Rosenthal et al., 2003). Higuera et al. (2005) recommended using maximal barrier precautions when resources permitted, but specific information on frequency and type were lacking.

Skin asepsis prior to line insertion was addressed but skin asepsis with dressing changes was not specifically addressed. It would be helpful to know the type of solution used to cleanse the skin.

No information was provided that indicated the proportion of central venous catheters inserted in the ICU's versus prior to admission to the ICU's. Most of the reviewed articles did not report comparative rates for use of the femoral site either before or after the educational intervention with the exception of Coopersmith et al. (2004), Warren et al. (2004), and Warren et al. (2006). Coopersmith et al. (2004) reported 6% of central venous catheters were inserted in the femoral vein in the pre-intervention period and actually increased to 7% in the post-intervention period. No reasons for the increase were described. Warren (2004) observed a statistically significant decreased in the proportion of central venous catheters inserted in the femoral vein between the pre-intervention period and the post-intervention period [26.3 ± 5.8% vs 20.4 ± 6.6%, p = 0.002] (p. 1615). Warren (2006) found 12.9% of central venous catheters were inserted in the femoral vein during the pre-intervention period and this proportion decreased to 9.4% during the post-intervention period "[relative ratio, 0.73; 95% CI, 0.61-0.88]" (p. 666). The previous investigators did not report on CLA-BSI rates specifically in relation to femoral line sites. Since optimal site selection is a component of the bundle for prevention of central venous

catheter related infections, comment on rates of use would have been appropriate for comparison purposes across studies.

The maintenance bundle components include accessing the line aseptically, prompt removal of unnecessary lines, assessing the insertion site, and having a dedicated line for delivery of total parenteral nutrition (TPN). Educational interventions included maintenance in all of the reviewed studies, but details on the techniques for aseptic access of lines or solutions used (alcohol, alcohol chlorhexidine, or provodone iodine) was lacking in the reports.

Total parenteral nutrition (TPN) can be a component of patient care in the ICU. There was no indication of the percentage of TPN use before, during, or after study intervention in any of the reviewed studies. This information would have been helpful as a guide to other centers. The article by Coopersmith et al. (2002) was the only article to report on demographic characteristics of the ICU study population. Patient acuity and average length of stay, at minimum, would be helpful for site comparison purposes.

Infection Rates

Patients in intensive care can have more than one central venous catheter per admission. Acutely ill patients may have two CVLs at the same time. When a CVL is changed, although the patient had two separate lines, it would only be counted as one catheter day. Berenholtz et al. (2004) found the statistical inference unchanged when duplicate CLA-BSIs were removed from the numerator and a repeat analysis was done. None of the other authors commented on this.

Comparisons with rates from non-participating ICUs within the jurisdiction, state, or country in which the study was conducted would be helpful but are not easily available. In the previous studies, centers with high baseline rates compared to the national averages experienced dramatic decreases in infection rates with the intervention. These dramatic results were not seen

in hospitals with lower baseline rates. Coopersmith et al. (2004) stated, “It was easy to show improvement when our infection rates were double the national average, but much more difficult to show further improvement when our rates were one half to one third the national average” (p. 135).

Insertion care and maintenance are multifaceted and should be targeted accordingly. Multiple interventions are complex and there is no way to tell if one intervention is better or more effective than another. Because the human and financial cost is relatively low and the interventions are easy to implement, multiple strategies should be applied.

CHAPTER 3: FRAMEWORK

Research findings can contribute to the health of all people, communities, and countries. Findings contribute to prevention and intervention strategies and to the formation or strengthening of policies, procedures, and clinical practice guidelines. The best research is irrelevant if it is not used. To ensure maximum utilization of the best available research communication and dissemination to key stakeholders must occur. In Canada, this process is more commonly referred to as knowledge translation.

The Canadian Institutes of Health Research (2009) defined knowledge translation (KT) "as a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically-sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system." The gap between knowledge generation and its use is well recognized by researchers, policy-makers, educators, administrators, and clinicians. Challenges in knowledge transfer exist within and between all levels of the healthcare system.

The knowledge-to-action framework developed by Graham et al. (2006) provides a model to guide the application of research and the process of knowledge translation. Simply put it is the "exchange of knowledge between relevant stakeholders that results in action" (Graham et al., 2006, p. 22). At every stage in the knowledge-to-action cycle process there are barriers and challenges that must be addressed according to the targeted stakeholders (policy makers, researchers, clinicians, and patients) and the type of information and complexity required. Graham, Harrison, Logan, and the KT Theories Research Group (2005, as cited in Graham et al., 2006 p. 20) identified commonalities from over 60 theories or frameworks regarding KT. Eight commonalities in KT were identified by Graham et al. (2006, p. 20):

1. Identify a problem that needs addressing
2. Identify, review, and select the knowledge or research relevant to the problem (e.g., practice guidelines or research findings)
3. Adapt the identified knowledge or research to the local context
4. Assess barriers to using the knowledge
5. Select, tailor, and implement interventions to promote the use of knowledge (i.e., implement the change)
6. Monitor knowledge use
7. Evaluate the outcomes of using the knowledge
8. Sustain ongoing knowledge use

Knowledge creation and the action process are not separate processes, but are inter-related. Like the nursing process, this framework is fluid and dynamic. Feedback at every stage is important.

Personality and communication behaviour of individuals and groups can influence the climate of the workplace and affect knowledge translation. “Social rather than scientific forces play a central role, and at each step, characteristic errors in both reasoning and research may occur” (Dixon, 1990, p. 201). Decision and implementation processes must be compatible with nurses, organizations, and research. Using the knowledge gained from research improves client, nursing, and organizational outcomes. The process of communication and evaluation of existing knowledge is inherent within the nursing process and is central to the knowledge-to-action model.

Objectives, Hypotheses and Research Questions

Objectives

1. To assess intensive care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections (CLA-BSI).
2. To ascertain if implementation of a checklist and educational program affects intensive care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections in the Intensive Care Units.
3. To ascertain if implementation of a checklist and educational program affects central venous catheter bloodstream infections rates in the Intensive Care Units.
4. To explore potential relationships between nurses' demographic characteristics (education, experience, age, and gender) and their knowledge of the central venous catheter guidelines

Research Questions

1. What is the knowledge level of intensive care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections (pre-test level)?
2. What is the impact of implementation of a checklist with educational reinforcement on Registered Nurses' knowledge of the evidence-based guidelines for preventing central venous catheter infections?
3. What is the impact of implementation of a checklist with educational reinforcement on central venous catheter related blood stream infections?
4. What are the relationships between nurses' demographic characteristics and their knowledge of central venous catheter related blood stream infections?

Hypotheses

1. Implementation of a checklist and educational program will increase nurses' knowledge of the guidelines for preventing CLA-BSI, within three months.
2. An increase in nurses' knowledge of the central venous catheter care will be associated with a decrease in CLA-BSI rates in the Intensive Care Units.
3. A decrease in CLA-BSI to the national goal of < 1.9 CLA-BSI per 1000 CLI days will be seen within the first three months after implementation of the study intervention (checklist and education) when compared with baseline.

Variables

The dependant variables of interest in this study were the intensive care nurses' knowledge of the guidelines for prevention of central venous catheter related infection and the central venous catheter related blood stream infection rates. Measurement of the covariate variable severity of illness was captured using the Acute Physiology and Chronic Health Evaluation II (APACHE II Score) severity of disease classification system developed by Knaus, Draper, Wagner, and Zimmermann (1985). Other research variables were demographic in nature and included age, education, number of years practicing, hospital size, and gender. The independent variables were the educational program and a central venous catheter insertion checklist.

Knowledge

Knowledge is defined as, "a fluid mix of framed experience, values, contextual information, evidence interpretation and expert insight that provides a framework for decision making, evaluating and incorporating new experiences and information. It may be explicit or tacit, and individual or collective" (Davenport & Prusak, 1998, p. 5).

Central Venous Catheter Related Blood Stream Infection (CLA-BSI)

For the purpose of this research, central venous catheter related blood stream infections will be defined using the CDC (2002) definition. In the presence of a central venous catheter a primary bloodstream infection has been described as a "positive blood culture and clinical manifestations of sepsis with no other apparent source [e.g., pneumonia, wound, or urinary tract infection]" (Public Health Agency of Canada, 2002, p.1). Please see Appendix C.

CLA-BSI Rate

The CLA-BSI rate will be measured as central line-associated blood stream infection (BSI) rate per 1000 central line days (CDC, 2002; Institute for Healthcare Improvement, 2006; Safer Healthcare Now, 2007). This standard measure, which aggregates infection rates and has been used locally, nationally, and internationally, will allow comparisons with other reported data.

Severity of Illness

Illness can be defined as an impairment of health. Any condition that causes abnormal functioning of health or physiological function and affects part or all of an individual is considered as illness. The Acute Physiology and Chronic Health Evaluation II (APACHE II) score estimates ICU mortality rates. It is based on a combination of the patient's laboratory values and vital signs within the first 24 hours of admission. Acute and chronic disease conditions are also a consideration of this scoring system (Knaus, Draper, Wagner, & Zimmerman, 1985).

Table 3.1

Operational definitions

Variable	*Operationalization*
Independent Variable:	
Checklist and education	The BC Children's hospital ICU/TCU vascular access device insertion checklist. (Appendix D). Permission to use & modify has been obtained from Bruce Harries (Appendix E). Modified Checklist (Appendix F)
Dependent Variable:	
CLA-BSI rate	Central line-associated blood stream infection (CLA-BSI) rate per 1000 central line days
Knowledge of Guidelines	"Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection" questionnaire developed by Labeau, Vereecke, Vandijck, Claes, and Blot, 2008. (Appendix G). Permission to use was obtained from Dr. S. Labeau (Appendix A).
Covariate Variable:	
Severity of Illness	Acute Physiology and Chronic Health Evaluation II Score (APACHE II)
Demographic variables:	
Age	Age at time of study – calculated based on reported year of birth
Education – basic	Reported as the highest level achieved at the time of the study - Diploma, BSN, MN, PhD
Education – additional	Critical Care course or Certification
Experience	Number of years worked in ICU; Number of years since graduation from basic nursing education program
Gender	Male or Female
Setting	Hospital A or Hospital B
	(Please see Appendix H for demographic variables)
ICU Patient population:	
ICU patient admissions	Number of admissions per year
ICU mortality rates	Number of deaths per year
ICU lengths of stay.	mean number of days

Concept Map

The following concept map identifies the predicted relationships between the nurses' knowledge of the evidence based guidelines and demographic variables (age, gender, years of experience, education) and the effect on central venous catheter related infection rates.

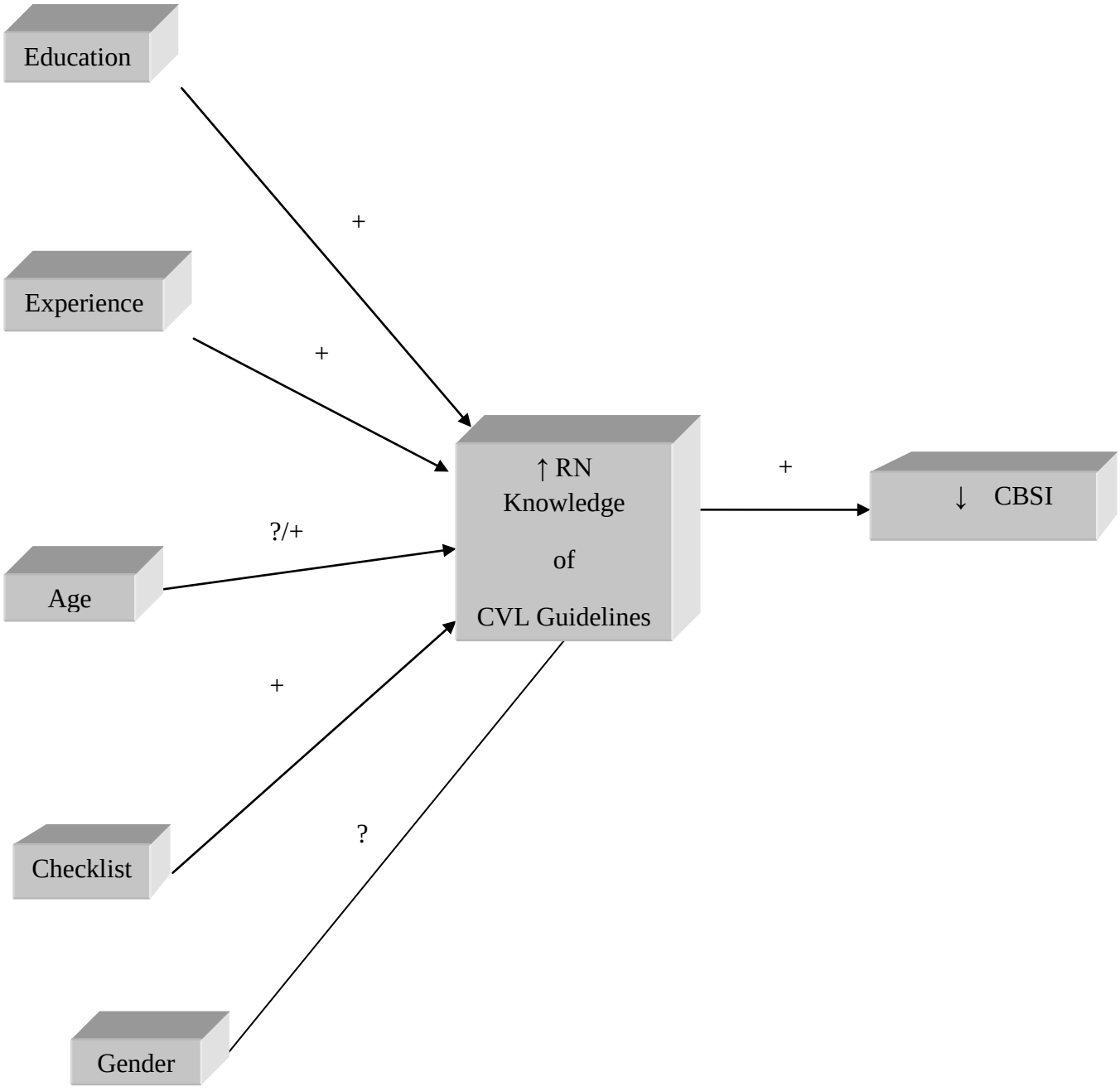


Figure 3.1 Concept Map

Definition of Relevant Terms

Critical care nursing occurs in a dynamic environment which continually adapts to advances in new research and technology. Nurses can have the most significant impact on client outcomes and efforts to reduce complications can be attributed to research-based knowledge in practice. “Intensive Care nursing is an area in which clinical research is most valuable. Research utilization can have the biggest impact on who survives, and who does not” (Canadian Intensive Care Foundations, 2006, ¶ 6). The best research is irrelevant if it is not used. Constant advances in technology and research continue to increase the complexity of the practice environment and patient management strategies. For improved outcomes, nurses must be able to integrate information from research and implement this information in the care of complex client needs. To ensure maximum utilization of the best available research, communication and dissemination to key stakeholders must occur.

Advanced Practice

“Umbrella term for an advanced level of clinical nursing practice that maximizes the use of graduate education preparation, in-depth nursing knowledge and expertise in meeting the health needs of individuals, families, groups, communities and populations. It involves analyzing and synthesizing knowledge; understanding, interpreting and applying nursing theory and research; and developing and advancing nursing knowledge and the profession as a whole” (Canadian Nurses Association, 2008 , p. 40).

Clinical Practice Guidelines

“A set of systematically developed statements, usually based on scientific evidence, to assist practitioners and patient decision making about appropriate healthcare for specific clinical

circumstances” (Marquez, 2001, p. 5). Synonyms include practice guidelines, guidelines, and practice parameters.

Dissemination

“An active and strategically planned process whereby new or existing knowledge, interventions or practices are communicated to targeted groups in a way that encourages them to factor the implications into their work. Dissemination goes well beyond simply making research available through the traditional vehicles of journal publication and academic conference presentations” (Kiefer et al., 2005, p. I-14, as cited in Public Health Agency of Canada, 2009)

Evidenced-based Practice

"A problem solving approach to practice that involves the conscientious use of current best evidence in making decisions about patient care; EBP incorporates a systematic search for and critical appraisal of the most relevant evidence to answer a clinical question along with one's own clinical expertise and patient values and preference." (Melnyk, & Fineout-Overholt, 2005, p. 186).

CHAPTER 4: METHODOLOGY

The purpose of this study was to identify changes in registered nurses' knowledge level of the evidence based guidelines for preventing central line infections in the context of two Intensive Care Units before and after implementation of a checklist and an educational program. Complex interventions are defined as "those that include several components" (Campbell et al., 2000, p. 694). Many of the interventions that improve health require an "iterative step wise approach to determine the state of knowledge about a complex intervention" (CIHR, 2010, ¶ 3). For these reasons, a quasi-experimental pre-test and post-test interrupted time series design was utilized (Table 2).

Table 3.2

Quasi-experimental Pre-test and Post-test Interrupted Time Series Design, Intervention Site and Comparison Site Comparison Chart.

Intervention Site

Archival Data	Checklist In Use	Knowledge Pre- Test →	Guidelines Introduced →	Checklist Reinforced →	Knowledge Post -test →	
CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score		CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score
Time 0	Time 1	Time 2	Time 3	Time 4	Time 5	Time 6

Comparison Site

Archival Data		Knowledge Pre- Test →	→	→	Knowledge Post -test →	
CLA-BSI Rates APACHE Score	CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score			CLA-BSI Rate APACHE Score	CLA-BSI Rate APACHE Score
Time 0	Time 1	Time 2	Time 3	Time 4	Time 5	Time 6

*CLA-BSI – Central Line Associated Blood Stream Infection

Setting

The federal government partners with the ten provinces and three territories to provide health care to the people of Canada. Canada has a publicly funded health care system where provision of medically necessary care is provided on a "prepaid basis without direct charges at the point of service" (Health Canada, 2008, p. 3). Most of the province's health services are provided at a local level by regional health authorities. The target Health Region in the study area is the largest health region in the province of Saskatchewan. It is responsible for approximately one third of the province's population (SHR, 2006). The Health Region serves over 300,000 residents in 100 cities, towns, villages, and First Nations communities (Saskatoon Health Region, 2009). The intervention site and the comparison site are provincial hospitals within the Health Region. There are two Intensive Care Units (ICU) in the Health Region located in the city of Saskatoon. The intervention site has 14 ICU beds and the comparison site, which has the capacity for 15 ICU beds, operates 10 beds.

The Intensive Care Units at both hospitals operate under a closed model of care. Patients are transferred to an intensivist who assumes care for all patients admitted to the ICU. The intensivist leads a multidisciplinary team consisting of nurses, residents, and respiratory therapists, with support from pharmacy, nutrition, social work, and pastoral care.

Population and Sample

The population of interest is Registered Nurses working in Intensive Care Units (ICU's). The hospitals were purposively sampled on the basis of their geographical location. A convenience sample was used and the entire population was considered for study. Questionnaires were distributed to all potential study participants by the researcher and not the senior leadership to decrease selection bias.

Selection Criteria

The target population included all registered nurses currently working in the Intensive Care Units in the target Health Region. This population was chosen because research utilization can have a large impact on client outcomes within the intensive care units.

Inclusion Criteria

To qualify for inclusion, all full-time, part-time, and casual registered nurses who had worked in the unit for at least one month prior to administration of the questionnaire were eligible. This included nurses not based in the unit (allowing for participation by part time, job share, and casual employees familiar with the unit). All participants were currently registered with the Saskatchewan Registered Nurses Association (SRNA), which is a criterion of employment within the province.

Exclusion Criteria

No limits to gender, ethnicity, or number of years of practice, or educational level were applied to the participant population being recruited. Employees who were not currently registered or were awaiting registration (such as grad nurses or international nurses) were not eligible for the study.

Initial Communication with Potential Participants

In order to recruit participants, following ethics approval and institutional approval, presentations regarding the study were made by the researcher at the regularly scheduled Intensive Care Unit “Lunch and Learn” sessions. “Lunch and Learn” sessions are informal learning sessions that build up knowledge and foster communication in a relaxed way among the intensive care workforce. These sessions are designed to facilitate interaction between colleagues

with the introduction of evidenced- based practices and a discussion of current practices and how to bridge that gap between them. The small group setting offers participants an intimate discussion style format while enjoying lunch.

The presentation and information letter (Appendix I) encompassed information regarding the study purpose, objectives, required time commitment (15 minutes), potential risk/benefits, contact information for the researcher, and knowledge that participation was voluntary. The group format presentation alleviated any potential concerns regarding coercive issues surrounding recruitment.

Ethical Considerations

Prior to the start of the study, the research proposal including the questionnaire, information letter, checklist, and demographic form was reviewed and approved by the University of Saskatchewan Advisory Committee on Ethics in Behavioural Sciences Research (Appendix J). Once ethical approval was obtained, permission to conduct the study was obtained from the target Health Region Research Operational Approval Committee (Appendix K).

Research related risks were minimized by using procedures that are consistent with careful data security measures. The data entry and storage was done on a password-protected computer. The computing resources or internet when utilized was assessed for adequate firewalls and security services. Information was password protected and the password was only known to the investigator. Any print copies of the information were kept in a locked file. As per the University of Saskatchewan protocol, the research data will be held by the thesis supervisor, Dr. Karen Semchuk, in a locked cabinet in the College of Nursing for a minimum of five years.

Concerns about patient privacy and risk management were addressed by using a de-identified process related to the checklist information. If a checklist had identifying information,

it was de-identified by the resource nurse prior to the researcher receiving it. De-identified checklist information will not allow analysis of individual patient outcomes; hence, only aggregate data were used in the analysis. Data collection for the severity of illness scoring consisted of aggregate data on all patients in the ICU during the year prior to the start of the study and until study completion. There was no observation of the nurses' behaviors on the unit.

There were no foreseen risks to participation in this study and no risks were noted during the study. Data were collected by self-report. Respondents were instructed not to put their names on the questionnaire or demographic form. Demographic data and the nurses' knowledge of the guidelines were provided by the respondents. Central venous catheter associated infection rates and severity of illness scores are reported as aggregate data and were obtained from the Adult Critical Care Operations committee of the target Health Region (see letter of support in Appendix L). To ensure confidentiality, responses were compiled and the data are presented in group format using aggregated data. No groupings of fewer than five responses were used.

Instruments

Questionnaire

The questionnaire "Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection" developed by Labeau, Vereecke, Vandijck, Claes, and Blot (2008) was used to assess the nurses' guideline knowledge with respect to central venous catheters. This questionnaire was developed to assess whether non-adherence with the CDC guideline recommendations was "due to nurses' lack of knowledge of the guidelines" (Labeau et al., 2008, p. 65). The test results were evaluated for item difficulty (0.1 to 0.9), item discrimination (0.1 to 0.9), and the quality of the response. "The quality of the response alternatives (0.0-0.8) indicated widespread misconceptions among the critical care nurses in the

sample" (Labeau et al., 2008, p. 65). Permission was obtained to use this questionnaire (S. Labeau, personal communication, October 27, 2008).

Each correct answer was given one point, for a total potential score range of 0 to 10 points per questionnaire. A total of 136 multiple choice tests were completed (68 pre-test and 68 post-test). Of the 1,340 potential correct responses, 10 questions (0.7%) had multiple responses and were coded as incorrect even if one of the choices were correct in the analysis.

Threats to internal validity were minimized by using participants as their own controls in the pre-test and post-test design of the study, the addition of a non-equivalent control group, and the use of a previously validated and reliable questionnaire.

Participants acted as their own controls in the pre-test and post-test phase of the study. The same questionnaire was used to assess knowledge in the pre-test and post-test phases. The process of testing participants against themselves allowed for an additional estimate of test/retest reliability.

To further strengthen this design a non-equivalent control group was utilized. Using a non-equivalent comparison group allowed comparison of pre-test and post-test results between RN's in the intervention group and the non-intervention group to determine if an educational program increases the nurses' knowledge. The control and intervention groups in this study were registered nurses who worked in the intensive care units. Demographic data (age, gender, education, and ICU practice experience) were collected to describe the groups.

Checklist

The checklist was modified from the Safer Healthcare Now (2006) version to incorporate and reinforce the central venous catheter insertion guidelines. The intent of the checklist was to reinforce the guidelines associated with central venous catheter insertion. Registered Nurses

assist the physician performing the insertion. To encourage conversation and a sense of empowerment a “Yes after correction” section was added.

Sampling Methods and Assignment

In this study it was not possible to randomly assign nurses or patients within the same Intensive Care Unit. If participants were divided into control and intervention groups within the same unit the control group would be exposed to the intervention as a matter of proximity and the team approach to nursing. Nurses may work with a number of different patients in the same day. It would not be possible to have some given the intervention because that knowledge would follow them to a client who may not have been randomly assigned to the intervention group. In addition, intentional communication between nurses would occur because of the dynamics of the team and unintentional communication could occur because of the physical layout of the units. For this reason, study group assignment was one of convenience made based on pre-existing units determined by hospital site.

Procedure

The questionnaire developed by Labeau et al. (2008) was initially piloted by Labeau et al. to develop a reliable and valid questionnaire for evaluating critical care nurses’ knowledge of evidence-based guidelines for preventing infections associated with central venous catheters. The pilot was conducted at the annual congress of the Flemish Society of Critical Care Nurses in 2006 (n = 762; response rate 89.1%). A repeat test conducted in 22 European countries included 3,405 ICU nurses (70.9 % response rate) (Labeau et al., 2009). Finding of these studies can be used to improve or expand the education programs for the prevention of central venous catheter related infections. Therefore, a pilot test of ICU nurses was not conducted in the present study.

The knowledge questionnaire developed by Labeau et al. (2008) was used to assess the nurses' guideline knowledge with respect to central venous catheters.

In the present study, the researcher made a presentation on the study purpose, objectives, and relevance at an Intensive Care Unit "Lunch and Learn" sessions held in April 2010 at the intervention and comparison sites. This information was also included in the information letter provided to all potential study participants. Participants were informed that completion and return of the questionnaire constituted consent for the researcher to use the data and that the information obtained from them will be kept confidential and not shared with others outside of the research team. To ensure confidentiality responses were compiled and all of data are presented in group format using aggregated data. No groupings of fewer than five responses have been used.

The questionnaire data were collected by self-report. Respondents were instructed not to put their names on the questionnaire or demographic form. Demographic data and the nurses' knowledge of the guidelines were provided by respondents.

Administration Techniques

The first "Lunch and Learn" session was approximately 15-30 minutes in duration. The presentation and information letter encompassed information regarding the study purpose, objectives, required time commitment, potential risk/benefits, contact information for the researcher, and knowledge that participation was voluntary.

Following the presentation, each participant was given an envelope with the information letter, a demographic form, and the questionnaire. The information letter informed the participants that the proposed research project had been approved by the University of Saskatchewan Advisory Committee on Ethics in Behaviour Sciences Research (Beh-REB) and

the target Health Region Research and Innovation department. The information letter included the study purpose, relevance, information regarding the implied consent, and the researcher's contact information. Participation was voluntary with consent implied upon return of the completed questionnaire and demographic form. There was no time limit for completing the questionnaire; however, 5 minutes was a sufficient amount of time allotment for completion of the questionnaire.

Each participant was asked to return the questionnaire and demographic form sealed in the envelope provided, whether the questionnaire was completed or not; this allowed participants to respond or not without anyone else in the room knowing who did or did not participate. Envelopes containing the questionnaire and demographic form were returned to the researcher. The researcher numbered the envelopes in the order they were received and assigned the corresponding study number to the study participant, generating a master list of the participants' names and study numbers. The envelopes were placed in a collection box.

The master list with the participants' names and their study numbers was sealed in a separate envelope and used to assign the appropriate study numbers to the participants at the post-test. As per the study protocol, the master list was stored in a locked cabinet separately from the completed questionnaires and demographic forms.

Following the pre-test session, the intervention group was instructed on the key messages and best-practices associated with the central venous catheter insertion checklist, and instructions for the completion of the checklist. For the intervention group, a printed copy of the educational module (Appendix M) was placed in the intensive care unit in a designated resource manual with a copy of the CDC (2002) guidelines after completion of the pre-test phase of the research.

Staff education was presented using a number of modalities. Presentations included a slide presentation during the "Lunch and Learn" sessions and separate individual instruction upon request. Direct feedback to the ICU staff regarding CLA-BSI rates occurred at least quarterly during the study period. Self study components included posters (Appendices N & O), fact sheets (Appendices P, Q, R, & S), a self-study module, reference to web-based resources and articles referenced in the literature review (Appendix T). For the control group, this information was made available after the post test phase of the study.

The second "Lunch and Learn" session was approximately 45 minutes in duration. It was available only to the intervention group. The second session allowed time for an interactive session, with ample time for discussion and debate of the educational content among the participants. In the second session, the researcher introduced the Evidence-Based Guidelines for Preventing Central Venous Catheter-Related Infection (O'Grady et al., 2002) and led a discussion of current practices and how to bridge that gap between the guidelines (i.e., best practices) and current practices. This didactic presentation capitalized on the experience of participants.

Post-test

The post test occured approximately three months following the pre-test phase (June 2010). The third "Lunch and Learn" session was approximately 30 minutes in duration for the intervention group and 45 minutes for the control group. A post-test questionnaire was distributed, followed by a presentation of preliminary data from the pre-test and an opportunity for the participants in both groups to discuss the evidenced-based guidelines.

For the post-test, each participant was given an envelope containing the information letter, a demographic form, and the questionnaire. The information letter and questionnaire were

identical to the pre-test. Each participant was asked to return the questionnaire and demographic form to the researcher sealed in the provided envelope, whether they completed the questionnaire and demographic form or not. Using the master list, the researcher assigned to each participant's envelope the same number that was assigned at the pre-test. The master list was sealed in a separate envelope by the researcher after completion, and stored in a locked cabinet separately from the completed questionnaires and demographic forms. Upon completion of the study the master list will be destroyed.

Central venous catheter associated infection rates and severity of illness scores have been reported as aggregate data and were obtained from the Adult Critical Care Executive Committee of the target Health Region. To ensure confidentiality, responses were compiled and data was reported in group format using aggregated data. No groupings of less than five responses have be used.

Data Management

The time required for data entry was minimal. Time required for data entry was five minutes per questionnaire. Analysis did not require a third party to categorize or sort the data. Values were pre-coded for the demographic variables to allow for consistent coding of information provided. Data entry was done by the researcher. The data were double entered for verification purposes and every questionnaire was manually rechecked by the researcher, to ensure accurate information.

Data Analysis

The quantitative data were coded, entered, and analyzed using the Statistical Package for the Social Sciences Software (SPSS 18®). Outliers and missing data were manually rechecked. Missing data were excluded from the analysis.

Testing of the hypothesis about group differences and the association between the independent variables (education and checklist), dependent variables (knowledge scores and central venous catheter related blood stream infection rates), and the demographic variables (gender, additional course, professional role, hospital site, and age category) was done using chi square analysis and ANOVA's. For all statistical tests significance will be indicated by an alpha of 0.05.

For the knowledge questionnaire the proportion of correct responses was compared between the intervention and the control group, and for each group a comparison was made between the pre-intervention scores and the post-intervention scores. This information will be useful for comparisons with the information published by Labeau et al. (2008; 2009). Descriptive analyse of the variables were used to "summarize the data, explore deviations in the data, and to describe patterns across time" (Burns & Grove, 2005, p. 2620).

The categorical or nominal variables of gender, additional courses (critical care course or certification), and hospital site (intervention or control) were described using frequencies and percent. For these variables, differences in the distribution of proportions between the intervention and control groups were examined using Chi square (x^2) analysis. For variables with expected frequencies of less than 5 for one or more of the categories the Fisher's exact test has been used for 2 x 2 comparisons. The Yates' correction for continuity (Fleiss, 1981) has been used for all chi square tests with one degree of freedom.

The ordinal variable educational experience included the categories of diploma, degree, MN, and PhD. This variable was described using frequencies and percent. The chi-square test was used to test for differences in the distribution of educational experience between the intervention and control groups.

Interval data, experience (number of years work experience as a nurse and number of years of work experience in the ICU), central venous catheter related blood stream infections, and ratio data (age), were summarized using measures of central tendency (mean, median), and measures of variability (range and standard deviation). Differences in the mean responses for the independent samples were examined using t-tests and ANOVA. For single samples t-tests between groups (intervention group versus control group at Time 2 and Time 5, respectively) and paired t-test for test/retest within groups (Time 2 versus Time 5) were used. Pearson's product moment correlation coefficient (Pearson's r) was used to determine the extent to which variables were associated with each other (Burns & Grove, 2005).

The incidence of primary bloodstream infections between the groups and between the pre-intervention and post-intervention period have been presented for comparison purposes. The ICU patient population has been described with respect to severity of illness (APACHE II) score, mortality rate, and length of stay (average days) in ICU for each study unit.

Dissemination of Findings

Findings will be disseminated to the study participants, senior leadership and the Critical Care Operations Committee within the target Health Region. The researcher is committed to the dissemination and implementation of the research findings generated by this research and intends to publish the findings in the health services research and discipline related journals (nursing, critical care, and quality improvement). Academic papers, presentations, seminars, and conferences to support the exchange of information will be pursued. Publishing articles in professional newsletters and the production briefing notes targeted at different stakeholder groups detailing the findings will be given to the appropriate stakeholders.

CHAPTER 5: RESULTS

Response Rates

The target population of registered nurses in the study health region who were employed in the Department of Adult Critical Care Intensive Care Units between April – June 2010 was 167 (Intervention Site n = 95; Comparison Site n = 72). Table 5.1 shows the distribution of study participants and estimated target population by study site and gender. Of the 180 RN's who participated in some aspect of the study, 68 (37.8%) participated in both the pre-test and post-test phases of the study, 20 (11.1%) participated only in the pre-test, and 92 (51.1%) participated only in the post-test. Only one participant did not complete the demographic form at both the pre-test and at the post-test. All the questionnaires were returned completed . For the purpose of this study the study population included only those RNs who completed both the pre-test and the post-test.

Table 5.1

Distribution of Study Participants and Estimated Target Population by Study Site and Gender

	Intervention Site						Comparison Site					
	Male		Female		All		Male		Female		All	
	n	%	n	%	n	%	n	%	n	%	n	%
Pre-test only	1	5.3	12	15.6	13	13.5	2	13.3	5	7.2	7	8.3
Post-test only	7	36.8	29	37.7	36	37.5	8	53.3	48	69.6	56	66.7
Pre-test and Post-test	11	57.9	36	46.8	47	49.0	5	33.3	16	23.2	21	25.0
Total	19	100.0	77	100.0	96	100.0	15	100.0	69	100.0	84	100.0
Target Population*	19	20	76	80	95	100	12	16.7	60	83.3	72	100

* Total full-time and part-time ICU staff - An accurate estimate of the size of the target population was not possible because the staff included full-time, part-time and casual staff during the study period, and it was not possible to estimate the number of casual staff. Hence the estimated number of full-time and part-time staff is presented for information only.

Demographic Characteristics

The demographic characteristics of the study population are shown in Table 5.2. The sample of 68 registered nurses included 16 men (23.5%) and 52 women (76.5%). The distribution of participants was 47 in the intervention group (69.1%) and 21 in the comparison group (30.9%). The demographic characteristics of the Registered Nurses (RNs) included in the study, i.e., who participated in both the pre-test and the post-test, did not differ significantly between the study groups. Specifically, there were no significant differences between the intervention and comparison groups for the variables gender, age, level of education, year of graduation, years of work experience as a RN, years of ICU experience, work status, or completion of a research class, critical care course, or specialty certification. When the demographic characteristics of all the men and the women were compared, the only statistically significant differences observed between the men and the women were for the variables years of work experience as a RN and years of ICU experience. The mean number of years of work experience as a RN was significantly longer for women (mean ± SD = 17.6 ± 11.63 years) compared to men (mean ± SD = 10.4 ± 8.01 years) [$F = 5.212$ (1, 66), $p = .026$]. In addition, the mean number of years of ICU experience was significantly longer for women (mean ± SD = 11.21 ± 9.69 years) compared to men (mean ± SD = 5.63±5.24 years) [$F = 4.848$ (1, 66) $p = .031$].

Table 5.2

Demographic Characteristics of the Study Population by Study Group

Demographic Characteristics	Intervention Group		Comparison Group		All	
Gender (n, %)						
Male	11	23.4	5	23.8	16	23.5
Female	36	76.6	16	76.2	52	76.5
All	47	100.0	21	100.0	68	100.0
Year of Birth						
Median	1971		1966		1970	
Mode	1964*		1959		1964	
Range	1951 – 1985		1952 – 1985		1951 - 1985	
Estimated Age (years)						
Mean ± SD	40.6 ± 10.1		41.5 ± 9.9		40.9 ± 10.0	
Median	39		43		40	
Mode	32*		46*		46	
Range	25 – 59		22 – 58		22 – 59	
Level of Education (n, %)						
Diploma	19	40.4	12	57.1	31	45.6
Baccalaureate	28	59.6	9	42.9	37	54.4
All	47	100.0	21	100.0	68	100.0
Year of Graduation						
Median	1995		1993		1995	
Mode	2002		2009		2009	
Range	1971 – 2009		1972 – 2010		1971 -2010	
Years of Work Experience as a RN						
Mean ± SD	15.9 ± 11.3		15.8 ± 11.3		16.1 ± 11.7	
Median	14		16		14	
Mode	1*		1*		1	
Range	1 – 38		1 – 34		1 – 38	

Table 5.2 (continued)

Demographic Characteristics	Intervention Group		Comparison Group		All	
Years of ICU Experience						
Mean ± SD	10.5 ± 9.6		8.6 ± 8.1		10.0 ± 9.4	
Median	8		4		8	
Mode	1		1		1	
Range	1 – 33		1 – 25		0 – 35	
Work Status (n, %)						
Full-time	30	63.8	15	71.4	45	66.2
Part-time	17	36.2	6	28.6	23	33.8
All	47	100.	21	100.0	68	100.0
Research Class (n, %)						
Yes	21	44.7	7	33.3	28	41.2
No	26	55.3	14	66.7	40	58.8
All	47	100.0	21	100.0	68	100.0
Critical Care Course (n, %)						
Yes	31	66.0	18	85.7	49	72.1
No	16	34.0	3	14.3	19	27.9
All	47	100.0	21	100.0	68	100.0

* Multiple modes exist

Table 5.3 presents the demographic characteristics of the participants by study group and gender. The study participants were asked to provide their year of birth. The reported year of birth ranged from 1951-1985. Using the study year (2010) and the reported year of birth the mean (SD) age of participants was estimated at 40.3 (SD=11.14) years for the entire sample, 39.1 (SD=5.1) years for the men, and 40.7 (SD=12.37) years for the women. The estimated mean age did not differ significantly between men and women for the entire sample [F (1, 65) = .225, p = .637] or when the intervention group [F (1, 45) = .034, p = .854] or for the comparison group [F (1, 18) = .376, p = .548] were compared separately.

Information on the participants' level of education is shown in Table 5.3. For the entire sample, the distribution of education level was diploma (n=32, 47.1%), BSN (n =36, 52.9%), and MN (n=0). The Intervention Group had a larger proportion of baccalaureate prepared nurses (59.6%) than diploma prepared nurses (40.4%). For the Comparison Group the distribution of education level was in the opposite direction with a larger proportion of diploma prepared nurses (57.1%) than baccalaureate prepared nurses (42.9%). Chi-square tests for independence with Yates Continuity Correction indicated there were no statistically significant differences in the distribution of the level of education (diploma, degree) by study group (X_c^2= 1.031, p = .310) or gender (X_c^2= .029, p = .866).

The reported year of graduation ranged from 1971 – 2010 (Table 5.3). The reported year of graduation for the men ranged from 1985 -2010 and from 1971 – 2010 for the women. The most frequently occurring year of graduation, or mode, was 2009 (intervention group - 2002, comparison group - 2009).

The mean (SD) reported years of work experience as a RN was 15.9 (11.25) years. The mean (SD) reported years of work experience as a RN was 10.4 (8.01) years for the men and

17.6 (11.63) years for the women. A two-way ANOVA revealed that a statistically significant difference in the mean reported years of experience as a RN varied significantly by gender [F (1, 66) = 4.782, p = .032], but not by site [F (1, 66) = 0.028, p = .868].

The participants' ICU work experience is summarized in Table 5.3. The mean (SD) reported number of years of ICU experience for the entire sample was 9.9 (9.13) years. There was no statistically significant difference in the mean number of years of ICU work experience between the intervention and control groups. [F (1, 66) = 0.570, p = .453].

The mean (SD) years of work experience in the ICU was 5.63 (5.24) years for the men and 11.21 (9.69) for the women. A two-way ANOVA revealed that the Years of ICU work experience differed significantly across genders [F (1, 66) = 4.848, p = .031]. There was no significant correlation between the participants' years of experience as an RN and years of ICU experience (r = .263, n = 135, p = .002).

Participants reported working full time (n = 45, 66.2 %) or part-time (n = 23, 33.8%). The participants' work status did not vary significantly by study group (X_c^2 = .112, p = .738) or gender (X_c^2 = .304, p = .582).

Twenty-eight participants (41.2%) reported having taken a research class in the past (Table 4.2). Although the proportion of participants who had taken a research class was larger for the intervention group compared to the comparison group, the proportion of participants who had taken a research class did not differ significantly by site (X_c^2 = .374, p = .541). A significantly smaller proportion of participants with a diploma (n = 29, 93.5%) indicated they had taken a research class compared to the participants with a degree (n = 13, 36%) [X_c^2 = 25.789, p = < .001].

Forty-nine (72%) of the participants (men = 85.0%, women = 67.3%) reported having taken a critical care course in the past. The proportion of participants who had taken a critical care course was larger for the comparison group (85.7%) compared to the intervention group (66.0%) [$X_c^2 = 1.918$, $p = .166$]. In addition, the proportion of participants who had taken a critical care course did not differ significantly by gender for the entire sample ($X_c^2 = 1.576$, $p = .209$) or for the intervention group (Fischer's Exact Test, $p = 0.287$) or for the comparison group (Fischer's Exact Test, $p = 0.549$) when considered separately.

No statistically significant association was found between the participants' level of education (diploma/degree) and history of haven taken a critical care course. ($X_c^2 = .995$, $p = .319$).

Participants in the intervention (21.3%) and comparison (23.8%) groups reported having a specialty certification. Specialty certifications reported included Certified Critical Care Registered Nurse (CCRN), Emergency, Chemotherapy, Community Health, and Continuous Renal Replacement Therapy (CRRT) certifications.

Table 5.3

Demographic Characteristics of Study Participants by Study Group and Gender

	Intervention Group			Comparison Group		
	Male n = 11	**Female n = 36**	**All n = 47**	**Male n = 5**	**Female n = 16**	**All n = 21**
Characteristics						
Year of Birth						
Median	1971	1971	1971	1971	1964	1966.5
Mode	1962	1964	1964[a]	1965[a]	1959	1959
Range	1962-1978	1951-1985	1951-1982	1965-1978	1952-1985	1952-1985
Estimated Age (years)						
Mean ± SD	39.3 ± 5.1	41.0 ± 11.2	40.6 ± 10.1	38.8 ± 5.9	42.2 ± 10.7	41.5 ± 9.9
Median	39	39	39	39	46	44
Mode	40	46	32	32 [a]	46 [a]	46
Range	32-48	25-59	23 - 58	32-45	22-58	22 - 58
Level of Education (n, %)						
Diploma	5 45.5	14 38.9	19 40.4	2 40.0	10 62.5	12 57.1
Baccalaureate	6 54.5	22 61.1	28 59.6	3 60.0	6 37.5	9 42.9
All	11 100.0	36 100.0	47 100.0	5 100.0	16 100.0	21 100.0
Year of Graduation						
Median	1997	1991	1996	2003	1990	1994
Mode	1995[a]	2002	2002	1985[a]	1978[a]	2009
Range	1988-2009	1971-2009	1971 - 2009	1985-2010	1972-2009	1972 - 2010

Table 5.3 (continued)

	Intervention Group			Comparison Group		
	Male	Female	All	Male	Female	All
Years of Work experience as RN*						
Mean ± SD	10.9 ± 7.3	17.4 ± 12.0	16.2 ± 11.6	9.4 ± 10.2	17.8 ± 11.2	15.9 ± 12.2
Median	12.5	16.5	13	6	23	15
Mode	1	3[a]	1	1	25	1
Range	1-22	1-38	1 – 38	1-25	1-34	1 - 34
ICU experience (Years)**						
Mean ± SD	5.6 ± 4.3	11.9 ± 10.3	10.6 ± 9.9	5.6 ± 7.6	9.6 ± 8.2	8.9 ± 8.3
Median	7	9	8	3	10	4
Mode	1	2	1	1	10	1
Range	1-12	1-33	1 – 34	1-19	1-25	1 - 25
Work Status (n, %)						
Full-time	8 72.7	22 61.1	30 63.8	4 80.0	11 68.8	15 70.0
Part-time	3 27.3	14 38.9	17 36.2	1 20.0	5 31.3	6 30.0
All	11 100.0	36 100.0	47 100.0	5 100.0	16 100.0†	21 100.0
Research Class (n, %)						
Yes	4 36.4	17 47.2	21 44.7	3 60.0	4 25.0	7 33.3
No	7 63.6	19 52.8	26 55.3	2 40.0	12 75.0	14 66.7
All	11 100.0	36 100.0	47 100.0	5 100.0	16 100.0	21 100.0
Critical Care Course (n, %)						
Yes	9 81.8	22 61.1	31 66.0	5 100.0	13 81.3	18 85.7
No	2 18.2	14 38.9	16 34.0	- -	3 18.8	3 14.3
All	11 100.0	36 100.0	47 100.0	5 100.0	16 100.1†	21 100.0

* F = 5.212 (1, 66) p = .026

** F = 4.848 (1, 66) p = .031

†does not add up to 100.0 due to rounding

a – multiple modes exist

Results of the Knowledge Test

Research Question 1

What is the level of intensive care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections (pre-test level)?

The participants' knowledge was tested using the validated multiple-choice test developed by Labeau, et al. (2008) entitled "Critical care nurses' knowledge of evidence-based guidelines for preventing infections associated with central venous catheters." The test highlights and examines knowledge regarding10 recommendations from the CDC guidelines (2002).

The pre-test scores ranged from 3 – 8 (mean = 5.75, SD = 1.17) for the intervention group and from 5 - 8 (mean = 6.19, SD = 0.93) for the comparison group (Table 5.4). Two-way ANOVA revealed no statistically significant differences in the pre-test score between the intervention group and the comparison group [$F = 3.278$, $p = .075$] or between men and women [$F (1, 66) = 0.795$, $p = .376$]. Table 5.5 shows the proportion of responses for each of the highlighted CDC recommendations examined, by study group, at pre-test and post-test.

Table 5.4

Test Score (Mean ± SD) by Study Group and Demographic Variable of Interest at Pre-test and Post-test*

	Pre-test		Post-test	
	Intervention Group	Comparison Group	Intervention Group	Comparison Group
	n = 47	n = 21	n = 47	n = 21
Mean ± SD *	5.75 ± 1.17	6.19 ±0.93	7.17 ± 1.55	6.28 ± 1.19
Median	6	6	7	7
Mode	5	6	8	7
Range	3 – 8	5 – 8	3 – 10	3 – 8
Estimated Age Category (Mean ± SD)				
46 – 60	5.59±1.33	6.00±1.07	8.06±1.29	6.56±0.53
35 – 45	5.62±1.12	6.43±0.98	6.67±1.78	6.29±1.25
22 – 34	6.00±1.10	6.50±0.58	7.00±1.27	6.50±1.29
Years of ICU Experience (Mean ± SD)				
0-2	5.75±1.29	6.43±0.79	5.80±1.62	6.43±1.13
3-9	5.88±0.86	6.25±0.96	7.82±1.01	6.20±1.30
10-15	5.43±1.27	5.40±0.55	7.33±1.58	6.50±0.58
16-40	5.73±1.49	6.60±1.14	7.50±1.58	6.00±1.73
Years of Work Experience as a RN (Mean ± SD)				
0-6	5.77±1.30	6.43±0.53	6.17±1.19	6.33±1.21
7-14	6.00±0.77	5.67±0.58	7.29±1.59	6.00±1.73
15-25	5.18±1.33	6.20±1.30	7.50±1.71	6.13±1.36
26-40	6.00±1.13	6.20±1.30	7.91±1.30	6.67±0.58

*SD = Standard Deviation

Research Question 2

What is the impact of implementation of a checklist with educational reinforcement on Registered Nurses' knowledge of the evidence-based guidelines for preventing central venous catheter infections?

After administration of the pre-test, both groups were verbally presented with the correct responses to each question. The comparison group had no further educational reinforcement. The intervention group, following implementation of the modified checklist (targeted the insertion components), and a lunch and learn session (focused on the maintenance components of the CDC guidelines), received fact sheets on a variety of the CDC guideline components. The educational component was completed one month prior to the post-test.

At the pre-test there was no statistically significant difference in the mean test score between the intervention and the comparison group [independent samples t-test, $t(66) = -1.541$, $p = 0.128$]. At the post-test, the mean test score was significantly higher for the intervention group compared to the comparison group [independent samples t-test, $t(66) = 2.373$, $p = 0.021$].

For the intervention group (Table 5.4) there was a statistically significant increase in the mean test score from pre-test to post-test [paired t-test, $t(46) = 6.014$, $p = <.001$ (two-tailed)]. For the comparison group there was no statistically significant difference in the mean test score between the pre-test and the post-test [paired t-test $t(20) = 0.400$, $p = 0.693$]. The mean (SD) difference in test score from the pre-test to post-test was 14.47 (16.26) for the intervention group and for the comparison group the mean (SD) difference in test score from the pre-test to post-test was 0.95 (10.91).

Hypothesis 1 was supported by the data. *Exposure to a checklist and an educational program was associated with a statistically significant increase in the study participants' level of knowledge of the CDC guidelines for preventing CLA-BSI.*

Research Question 3

What is the impact of implementation of a checklist with educational reinforcement on central venous catheter related blood stream infections?

As Figure 5.1 shows, from April 2007 to March 2010, at the intervention site the reported mean (SD) central line associated blood stream infection (CLA-BSI) rate was 2.93(3.48) / 1000 catheter days (9,574 CVC days). At the comparison site, the reported mean (SD) CLA-BSI rate was 1.63 (3.50) / 1000 catheter days (6,803 CVC days) during the same time period. For three months (October – December 2009), no data were reported for the comparison site. In the 12 months prior to the study (April 2009 – April 2010), at the intervention site the reported CLA-BSI rate was 1.35/1000 catheter days and at the comparison site the CLA-BSI rate was 3.17/1000 catheter days.

During the study period (April 7, 2010 to June 30, 2010) the CLA-BSI rate was 1.47/1000 catheter days at the intervention site and 2.03/1000 catheter days at the comparison site. Interestingly, during the intervention period there were no documented CLA-BSI at either site in April or May 2010; however, each site reported one CLA-BSI infection in June 2010.

In June, following the post-test, the checklist was introduced and a review of the guidelines for the prevention of central venous catheter related infections occurred at the Comparison site. In the 12 month period following the study (July 1, 2010 – June 30, 2011) there were no reported CLA-BSI infections at the intervention site and two infections were reported at the comparison site during the same time period.

Hypotheses

Hypothesis #2 - An increase in nurses' knowledge of the central venous catheter care will be associated with a decrease in CLA-BSI rates in the Intensive Care Units.

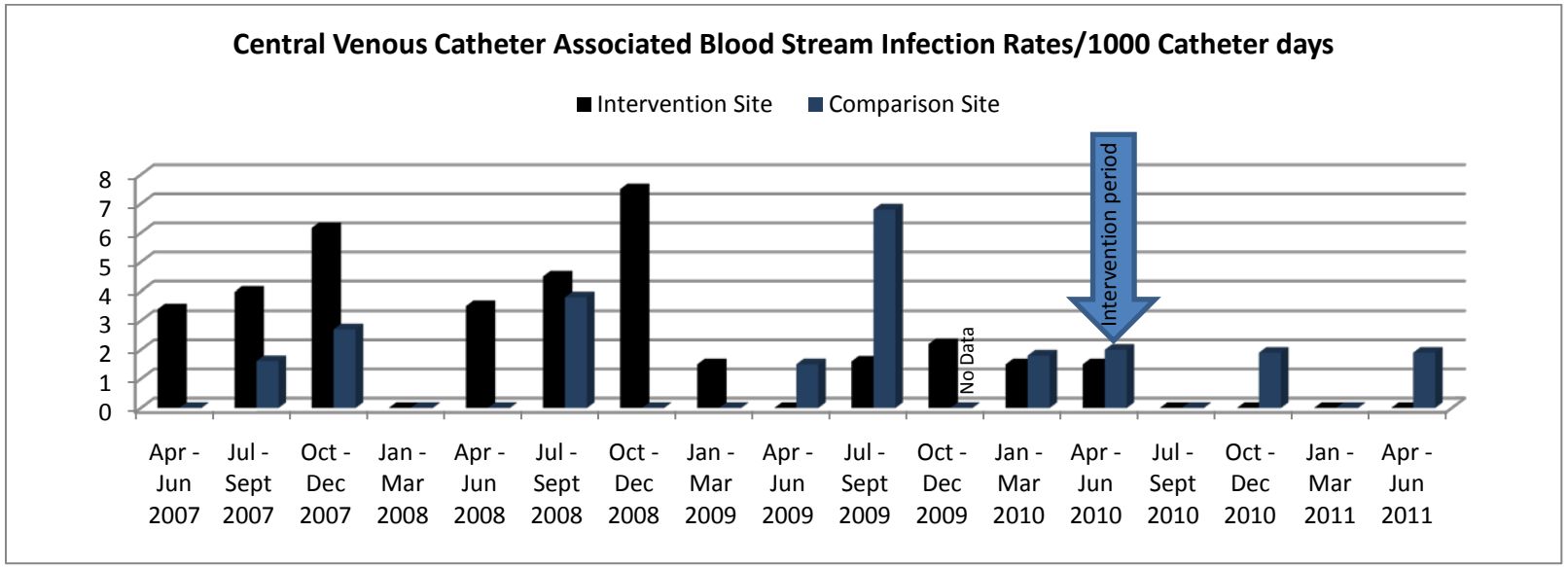
A significant increase in knowledge was observed for the intervention group, but at each site there were no reported CLA-BSI in April or May and one reported CLA-BSI infection at each site in June 2010. In June, the comparison site received the educational intervention and introduction of the checklist. The CLA-BSI rates dropped to zero at the intervention sites from July 2010 to June 2011. The comparison site reported two CLA-BSIs during the same time period (November 2010, April 2011). Hypothesis #2, therefore, was not supported by the data. At both sites the CLA-BSI rates were comparable during the study period.

Hypothesis #3 - A decrease in CLA-BSI to the national goal of < 1.9 CLA-BSI per 1000 catheter days will be seen within the first three months after implementation of the study intervention (checklist and education) when compared with baseline.

Hypothesis 3 is supported by the data - A decrease in CLA-BSI rate to zero was observed at both the intervention and comparison sites during the three months after implementation of the study intervention (checklist and education). This is less than the national goal rate of 1.9 CLA-BSI/1000 catheter days. In addition, there were no reported CLA-BSI from July 2010- January 2011 at either site.

Figure 5.1

Central Venous Catheter Associated Blood Stream Infection Rates/1000 Catheter Days



Research Question 4

What are the relationships between nurses' demographic characteristics and their knowledge of central venous catheter related blood stream infections?

Potential relationships were examined between the nurses' pre-test scores on knowledge of the guidelines and the variables gender, age, year of graduation, work experience as an RN, ICU work experience, and work status. No statistically significant associations were found between any of the demographic variables and the pre-test scores for the intervention group or for the comparison group. The post-test scores ranged from 3 - 10 (mean = 7.17, SD =1.55) for the intervention group and from 3 – 8 (mean = 6.28, SD = 1.19) for the comparison group (Table 5.4). A two-way ANOVA revealed a statistically significant difference in the post-test scores between the intervention group and the comparison group [$F = 5.63$, $p = 0.021$]. Table 5.5 shows the proportion of responses for each of the highlighted CDC recommendations examined, by study group, at pre-test and post-test.

Table 5.5

Proportion of Responses for each CDC Recommendation Examined by Study Group at Pre-test and Post-test.

Question	Intervention Group		Comparison Group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
1. It is recommended to replace CVCs routinely . . .				
a. Yes, every seven days	44.7	12.8	33.3	23.8
b. Yes, every three weeks	10.6	8.5	14.3	4.8
c. <u>No, only when indicated *</u>	**38.3**	**76.6**	**47.6**	**66.7**
d. I do not know	6.4	2.1	0	4.8
Multiple responses	0	0	4.8	0
Total	100.0	100.0	100.0	100.1
2. It is recommended to replace CVCs over a guidewire . . .				
a. Yes, every three days	0	0	0	0
b. Yes, every seven days	21.3	4.3	0	0
c. <u>No, only when indicated *</u>	**66.0**	**87.2**	**95.2**	**81.0**
d. I do not know	12.8	6.4	4.8	19.0
Multiple responses	0	2.1	0	0
Total	100.1	100.0	100.0	100.0
3. It is recommended to replace pressure transducers and tubing routinely . . .				
a. <u>Yes, every four days *</u>	**100.0**	**100.0**	**100.0**	**100.0**
b. Yes, every eight days				
c. No, only when indicated				
d. I do not know				

Table 5.5 (continued)

Question	Intervention Group		Comparison Group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
4. In settings with a high rate of catheter-related infections it is recommended to use a CVC coated or impregnated with an antiseptic agent				
a. <u>Yes, in patients whose CVC is expected to remain in place for more than five days *</u>	**17.0**	**36.2**	**4.8**	**19.0**
b. No, because the use of such catheters is not cost-effective	27.7	6.4	9.5	9.5
c. No, because the use of such catheters does not result in a significant decrease in the rate of catheter-related infections	53.2	38.3	38.1	61.9
d. I do not know	0	17.0	47.6	9.5
Multiple responses	2.1	2.1	0	0
Total	100.0	100.0	100.0	99.9
5. It is recommended to change the dressing on the catheter insertion site . . .				
a. On a daily basis	4.3	0	4.8	0
b. Every three days	34.0	17.0	14.3	14.3
c. <u>When indicated (soiled, loosened, . . .) and at least weekly *</u>	**55.3**	**83.0**	**81.0**	**85.7**
d. I do not know	0	0	0	0
Multiple responses	6.4	0	0	0
Total	100.0	100.0	100.1	100.0

Table 5.5 (continued)

Question	Intervention Group		Comparison Group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
6. It is recommended to cover up the catheter insertion site with				
a. Polyurethane dressing (transparent, semipermeable)	93.6	70.2	90.5	95.2
b. Gauze dressing	0	0	0	0
c. Both are recommended because the type of dressing does not affect the risk for catheter-related infections *	**4.3**	**29.8**	**9.5**	**4.8**
d. I do not know	2.1	0	0	0
Multiple responses	0	0	0	0
Total	100.0	100.0	100.0	100.0
7. It is recommended to disinfect the catheter insertion site with				
a. 2% aqueous chlorhexidine *	**87.2**	**72.3**	**85.7**	**76.2**
b. 0.5% alcoholic chlorhexidine	6.4	23.4	9.5	19.0
c. 10% povidone-iodine	4.3	2.1	4.8	0
d. I do not know	0	0	0	4.8
Multiple responses	2.1	2.1	0	0
Total	100.0	99.9	100.0	100.0

Table 5.5 (continued)

Question	Intervention Group		Comparison Group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
8. It is recommended to apply an antibiotic ointment at the insertion site of a CVC				
a. Yes, because it decreases the risk for catheter-related infections	2.1	2.1	9.5	9.5
b. No, because it causes antibiotic resistance *	**17.0**	**46.8**	**9.5**	**19.0**
c. No, because it does not decrease the risk for catheter-related infections	61.7	46.8	66.7	57.1
d. I do not know	17.0	4.3	14.3	14.3
Multiple responses	2.1	0	0	0
Total	99.9	100.0	100.0	99.9
9. When lipid emulsions are administered through a CVC it is recommended to replace the administration set				
a. Within 24 hrs *	**100.0**	**97.9**	**100.0**	**100.0**
b. Every 72 hrs		2.1		
c. Every 96 hrs		0		
d. I do not know		0		
Multiple responses		0		
Total	100.0	100.0	100.0	100.0
10. When neither lipid emulsions, nor blood products are administered through a CVC it is recommended to replace the administration set				
a. Every 24 hrs	8.5	6.4	4.8	19
b. Every 48 hrs	0	4.3	9.5	4.8
c. Every 96 hrs *	**89.4**	**89.4**	**85.7**	**76.2**
d. I do not know	2.1	0	0	0
Multiple responses	0	0	0	0
Total	100.0	100.1	100.0	100.0

** – denotes correct response*
CVC – Central venous catheter/line

CHAPTER 6: DISCUSSION

Characteristics of the Sample

In this study a quasi-experimental pre-test post-test interrupted time series design was used to determine if nurses' knowledge increased following an intervention consisting of a modified checklist and educational sessions, and (2) assess the impact of the intervention on central venous catheter blood stream infection rates. In this chapter, the results will be discussed in the context of the current relevant empirical literature. In addition the strengths and limitations of the study will be identified. Lastly, implications for nursing and future research will be discussed.

According to the Canadian Institute for Health Information (CIHI, 2007), in 2007 the majority of registered nurses (RNs) in Canada were women (94.2%) and 5.8% were men, while in Saskatchewan, men comprised 3.7% of the registered nursing workforce. In Canada, of the RN's employed in critical care areas 7.6% were men (CIHI, 2007; Canadian Nurses Association, 2007). The proportion of male respondents in this study was 21.0%, which is comparable to the 24.0% reported by Labeau et al. (2008) and 19.5% reported by Labeau et al. (2009).

In Canada, in 2007, the average age of registered nurses was 45.1 years (women – 45.2 years, men – 42.4 years) and in Saskatchewan the average age was 46.0 years (CIHI, 2007). The average age of participants in this study was somewhat lower at 40.9 (SD = 10.0) years for the entire sample, 40.7 (SD = 12.4) years for the women, and 39.1 (SD = 5.2) years for the men.

Prior to 2000, Saskatchewan had two options to obtain a Registered Nurse designation: a diploma in nursing (2 year program) and a bachelor of science degree in nursing (4 year program). In 2000 in Saskatchewan the baccalaureate degree in nursing became the requirement for entry to practice. In the present study, the sample was comprised of diploma prepared

(45.6%) and baccalaureate prepared (54.4%) RN's. Only 14.7 % of the study participants had obtained a baccalaureate degree prior to the year 2000.

In this study, the number of years of ICU work experience as a registered nurse ranged from 1- 33 years. Approximately 66% of the study participants had worked 10 years or less and about 44 % had less than 5 years of experience working in the ICU. Labeau et al. (2008, 2009) found that 54% and 62% of nurses in Europe had less than 10 years of ICU experience. The proportion of respondents who reported working full time (66.2%) was somewhat higher than previously reported national (53.3%) and provincial (56.0%) estimates, and for registered nurses working full time within the Critical Care field (61.2%) in Canada in 2007 (CNA, 2009).

Approximately 39% of the respondents reported haven taken a research class (Diploma – 9.5%, Baccalaureate 75.3%). Of these, most took the research class prior to graduation from a basic nursing program. Only two reported taking a research class after graduation. The current undergraduate nursing education curriculum in Saskatchewan includes a research course (University of Saskatchewan, College of Nursing, 2010). An assumption was that those nurses with a research class may be more aware of evidenced-based practice and have higher test scores. This was not supported by the data.

In Saskatchewan, the Basic Critical Care Nursing course began on January 12, 1999. It is an advanced certificate program, which combines theoretical learning with tutorials, labs, and a clinical practicum (Saskatchewan Institute of Applied Science and Technology, 2009). In the present study, most of the respondents (72.1%) had taken the critical care course, which is comparable to the 73% observed by Labeau et al. (2008). A special degree in intensive care and emergency nursing is "acknowledged as a bachelor-after bachelor degree" (Labeau, 2008, p. 68-69) and is obtained at "a higher education institution or similarly professionally accredited

organization" (Labeau et al., 2009, p. 321). Approximately 28 percent of the participants in this study reported having a specialty certification; this excludes the critical care course and Advanced Cardiac Life Support (ACLS) courses that are a required by nurses who work in the ICU. The majority of those who reported having a specialty certification (54.5%) held the national certification in Critical Care.

Research Question 1

What are the relationships between nurses' demographic characteristics and their knowledge of central venous catheter related blood stream infections?

No statistically significant differences were found between the intervention and comparison groups for any of the demographic variables examined or the pre-test scores on the knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections. Labeau et al. (2009) found "professional seniority and number of ICU beds showed to be independently associated with better test scores" (p. 320). Labeau's findings were not supported by the results of this study or by the findings of Csomós, Orbán, Konczné Réti, Vass, and Darvas (2008), a study conducted in 11 intensive care units (178 questionnaires) throughout Hungary as part of the study by Labeau's et al. (2009).

At the time of the present study, the average daily census for the intervention ICU was 11patients with a capacity for 14 patients while the average daily census for the comparison ICU was nine patients with a capacity for 15 patients. Not only were the ICU's similar in size and located within the same city, they shared the same medical department head and director, and meetings involved the medical directors and managers of nursing for both study ICU's, as well as physician and nursing representation from both sites. The only difference in the patient population between the two sites was that the Intervention ICU specializes in Trauma,

Neurosurgery and Cardiovascular surgeries while the comparison site ICU did not have a specialty. The intervention site typically admits approximately 80.9 patients per month and the comparison site 37.7 patients per month. The mortality rate for the intervention site ranged between 6% - 13% and for the comparison site the range was 8% - 17%. The average length of stay for the ICU's was 5.2 (Intervention site – 3.9; comparison site - 5.7).

The APACHE II (Acute Physiology and Chronic Health Evaluation II) score developed by Knaus, Draper, Wagner, and Zimmerman (1985) is a scoring system based on a patient's physiological signs and facilitates prediction of morbidity and mortality. The Charlson Comorbidity Index (CCI) is a weighted score that includes 19 co-morbid conditions in the scoring to predict mortality, length of stay, and the risk of dying (Charlson, Pompei, Ales, & MacKenzie, 1987). The CCI may have provided more insight into the ICU patient populations, but the study ICUs historically have reported APACHE II scores and, so, the already existing data on the APACHE score was used for the purposes of this study. During the study period, the mean (SD) APACHE II score was 19.9 (8.6) for the Intervention ICU (Cardiovascular surgeries were excluded) and 22.1 mean (9.7) for the comparison ICU. The similar mean APACHE scores, at the two sites indicate similar patient acuity levels at the intervention and comparison sites.

Research Question 2

What is the level of intensive care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections (pre-test level)?

At the pre-test, the mean (SD) test scores for the nurses' knowledge of the CDC evidence-based guidelines for preventing central venous catheter bloodstream infections was 5.75 (1.17) for the intervention group and 6.19 (0.93) for the comparison group. The pre-test scores ranged from 3 – 8 for the intervention group and from 5 – 8 for the Comparison Group.

These findings suggest a higher baseline level of knowledge regarding central line care for participants in the present study compared to participants in previous studies. In the study by Csomós, Orbán, Konczné Réti, Vass, and Darvas (2008) a mean test score of 3.66 (178 respondents) was reported, while Labeau et al. (2009) reported a mean test score of 4.44 (3,405 respondents). Labeau (2009) tested the knowledge of European nurses from October 2006 to March 2007. The study by Csomós et al. (2008) was conducted in 2006, four years after the release of the CDC guidelines. The present study occurred 8 years after the release of the CDC guidelines and could account for the higher scores because of the increased time frame to embed the CDC Guideline recommendations into practice.

Replacement of Central Venous Catheters (CVCs)

Knowledge of the recommendation to replace Central Venous Catheters (CVC`s) only when indicated was demonstrated by 41.2% of the respondents in the present study. The majority of respondents selected a scheduled change as the correct answer, which is reflective of older standards of care. It was expected that nurses who had practiced longer would have chosen either response, but this was not supported by the data. In previous studies, Labeau et al. (2008) found that approximately 60% of a sample of 762 nurses was aware of this guideline and approximately 56% of the sample of 3,405 European intensive care nurses (Labeau et al., 2009) knew CVC's should only be replaced when indicated and not at a predetermined or scheduled time. Csomós et al. (2008) found that only 18% of the Hungarian nurses studied were aware of this recommendation.

Replacing a CVC over a guide wire, which should be done only when indicated, was known by 80.6% of the participants (intervention group – 66.0%, comparison group – 95.2%) in the current study. Labeau et al. (2008, 2009) found that approximately 70% - 75% of nurses in

their study responded correctly, which is higher than the 61% reported by Csomós et al. (2008). Best practice suggests selecting a new site, this appeared to be the practice on the units in the present study, unless no other site was available, as can be the case with major burn patient.

Application of an Antibiotic Ointment at the Insertion Site of a CVC

Application of an antibiotic ointment at the insertion site of a CVC can cause antibiotic resistance and was known by 17.0% of the intervention group and 9.5 % of the comparison group. These results differ from the previous reports of 14% by Csomós et al. (2008) and 30% by Labeau et al. (2008, 2009). In the current study area, it is the policy not to use antibiotic ointment at the insertion site. The standard education module for the study area does not mention this and the educators do not teach this concept because it is not best practice, which may account for the observed variation in responses.

Use of a CVC Coated or Impregnated With an Antiseptic Agent

In settings with a high rate of catheter-related infections the CDC recommends the use a CVC coated or impregnated with an antiseptic agent. The use of a CVC coated or impregnated with an antiseptic agent in settings with a high rate of catheter-related infections was known by only 17.0% of the intervention group and 4.8% of the comparison group. At the time of the study, coated CVC's were not used in any of the intensive care units in the province. Unfamiliarity with this type of product may account for the observed variation in responses to this question. Comments made by the study participants regarding these devices were that they are something new. Interestingly, the antimicrobial-impregnated catheter has been available since 1990 (Arrow, 2010). Labeau et al. (2008, 2009) found that approximately 20% of the respondents in their study were aware of coated CVC usage; however, "the German guidelines still consider this issue unresolved" (Gastmeister & Geffers , 2006, as cited in Labeau et al.,

2009, p. 322). Labeau et al. thought this may account for the wide variation in responses among the European nurses. Conversely, Csomós (2008) found that approximately 66% of the Hungarian respondents were aware of the recommendation to use a coated CVC. Practice change is made based on the level of evidence presented. If an issue is unresolved, practice change is unlikely to occur. It is up to the professional nursing staff at each individual facility to determine what components of the CDC guidelines they will or will not implement. This is likely the reason for the differences observed across studies.

Dressing

Changing the transparent dressing when indicated and at least weekly was known by 55.3% of the intervention group and 81.0% of the comparison group. Either gauze and tape dressings or polyurethane dressings are acceptable for use in covering the insertion site, but 93.6% of the intervention group and 90.5% of the comparison group chose polyurethane dressing only and 4.3% and 9.5%, respectively, knew that both dressing types were acceptable.

Although the type of polyurethane dressing used in the study region can remain insitu for 7 days provided it is not loose, soiled, or damp, the practice on the unit where the intervention group was located was to change the dressing when the IV lines are changed, i.e., every 96 hours or 4 days. This schedule became standardized to facilitate quality patient care and decrease the occurrence of missed episodes of dressing changes. This practiced was developed, in part, because there was no clear way to document the next change date on the dressing and documentation in the care plan was inconsistent. At one time, nurses used a permanent marker to date the dressing and IV tubing, but this practice was stopped on the intervention unit and no other visual reminders are presently attached to those items. In the comparison unit, the nurses

used pre-printed stickers, on the IV tubing and sometimes on the dressings, to designate the appropriate scheduled date change for dressings and IV tubing changes.

Although the intervention group was reminded, during the "lunch and learns", that a gauze dressing and tape can be used and that a gauze and polyurethane dressing is essentially a gauze dressing the proportion of correct responses only increased from 4.3 to 9.8% in the intervention group and most respondents in that group chose polyurethane (70.2%) on the re-test. In the study by Csomós et al., approximately 35% of the respondents recognized that both polyurethane and gauze dressings are appropriate choices. Participants found this question confusing and as suggested by Labeau et al. (2009) this question should be rephrased because it can lead to "misunderstanding because the CDC guidelines recommend replacing gauze dressings every 2 days and transparent dressing at least every 7 days" (2009, p. 323). For comparison purposes, in this study, the question was left worded as originally stated by Labeau et al. (2008).

In intensive care units a variety of high risk medications [such as inotropes, which can cause extravasation and tissue necrosis, and Total Parenteral nutrition (TPN), which poses a higher risk of infection because of the lipid emulsion] it is important to visualize the site and monitor frequently for signs and symptoms of infection. A gauze and tape dressing does not allow direct visualization of the site and is, therefore, a rarely chosen option. It has become a standard practice to use a polyurethane dressing to be able to visualize the site and keep it dry. Nurses also favour the polyurethane dressing because of less frequent changes, which is more comfortable for the patient and decreases access to the site, which plays a role in decreasing infection rates.

In this study, none of the participants chose a gauze dressing as an option, compared to 10% (Labeau et al, 2008) and 26% (Labeau et al., 2009) in previous studies. In the present study, over 90% of the respondents selected the polyurethane dressing (intervention group - 93.6%, comparison group - 90.5%), compared to 70.0% (Labeau et al., 2008), 62.6% (Labeau et al., 2009), and 93% (Rickard et al., 2004) in previous studies. Because of its simplicity and functionality, the practice of using a polyurethane dressing is followed in accordance with the CDC guidelines as evidenced by multi-country data.

Disinfection Of The Catheter Insertion Site

In the study area, chlorhexidine solution has been used in the intervention ICU since 1998. The majority of respondents knew 2% chlorhexidine is the solution of choice to disinfect the skin (intervention group - 87.2%, comparison group - 85.7%) and 4.5% chose 10% povidone-iodine (which is an alternative for patients who are allergic to chlorhexidine). The CDC guidelines recommend using 2% chlorhexidine as the preferred solution, but indicate that tincture of iodine or 70% alcohol can be used as well (CDC, 2002). In some countries, chlorhexidine is not available or only sporadically available (Higuera, Rosenthal, Duarte, Ruiz, Franco, & Safdar, 2005; Rosenthal, Guzman, Pezzotto, & Crnich, 2003) and some patients can be sensitive or allergic to chlorhexidine.

Labeau et al. (2008) found that 90% of the respondents in their study chose chlorhexidine, but only 10% knew the appropriate concentration was a 2% solution. In this study, 94.5 % of all respondents chose chlorhexidine and 86.5% knew a 2% solution was required. Chlorhexidine comes in multiple preparations including a bottle of solution, an impregnated swab, and sponge solution applicators. The primary principles of aseptic technique apply regardless of the solutions used. If one was to use sponge solution applicators and read the

directions for its use with regard to central venous catheter insertion or pre-op cleansing and not pay attention to a site with a line insitu, a serious breach of infection prevention principles could occur. Cleaning around the insertion site is to be done in a circular motion starting at the site and moving further away. Although guidelines are in place, when new products are introduced end users must be educated about the products, the various applicability of their uses, and they should be included in the selection of appropriate products. End users have the knowledge to assist in making informed choices which ultimately benefit the patients.

Tubing Changes

Three questions inquired about the frequency of tubing changes, 100% of the respondents in both study groups knew that if lipid emulsions are administered the IV tubing should be changed every 24 hours. This percentage is higher than that the 85% observed by Csomos et al. (2008) and the 90% observed by Labeau et al. (2009). The 2002 CDC recommendation to replace pressure transducers tubing every 4 days was also known by 100% of the respondents in the intervention and comparison groups, which is much higher than the 53% reported by Labeau et al. (2009) or the 48% reported by Csomos et al. (2008). At the post-test, the proportion of correct responses to the question regarding replacement of administration sets when neither lipid emulsions nor blood products are administered through a CVC was 89.4% for the intervention group and 85.7% for the comparison group as compared to 26% noted by Labeau et al. (2009) and 5% noted by Csomos et al. (2008).

Changing IV lines and pressure tubing was stated in the 2002 guidelines as “no more frequently than 72 hours” but at least every 96 hours, the 2011 guidelines state that “In patients not receiving blood, blood products or fat emulsions, replace administration sets that are

continuously used, including secondary sets and add-on devices, no more frequently than at 96-hour intervals, but at least every 7 days" (O'Grady et al., p. 19).

Checklist

A group of interventions or bundles has become a popular way to promote best practice and contribute to enhanced patient care. Improvement strategies have been developed and research from the Institute for Healthcare Improvement (2004), Canadian Patient Safety Institute (2008), and the Canadian ICU Collaborative (2009) indicates success with multiple interventions.

Decreasing the complexity of the system, especially on a busy unit, by having all of the required supplies in one place potentially eliminates risks associated with omission. Berenholtz et al. (2004), Galpern et al. (2008), and Pronovost et al. (2006) implemented the use of central line carts to decrease the potential for errors or misuse of products associated with central line insertion. At the intervention site, a central line cart has been in use since 1998. The comparison site introduced the use of a central line cart in the spring of 2009, one full year prior to the study.

A checklist is a tool that can reinforce and remind physicians and nurses about the key steps in a procedure, adherence to infection-control practices (Pronovost et al., 2006), and compliance with the evidence-based guidelines (Galpern et al., 2008) associated with insertion of a central venous catheter. At the intervention site, the checklist had been in use for eight months prior to the start of the study, but no analysis was conducted or dialogue started regarding how it could be used to create discussion and enhance patient care and staff learning.

Use of a variety of tools, such as the checklist, should be done as a team to create a sense of team work, turning the focus from one of "I'm watching and marking you" to a collaborative mindset of "Can we do this better?" Extra effort must be put in to foster a cohesive sense of

team work. This is challenging within a teaching hospital were medical residents, with various years of education, rotate through every 3 to 6 weeks. With a continuous introduction of new members to the team it can be hard to maintain a consistent approach. A checklist facilitates one aspect of consistency. “Clinical reminders at the point of care are one of the most effective strategies for affecting daily practice” (Bero, Grilli, Grimshaw, Harvey, & Oxman, 1998, p. 466). It is necessary to continue to orientate new staff and residents within the unit to these principles.

When the modified checklist was introduced to the nursing staff at the intervention site, the residents were gathered and a dialogue was conducted regarding the purpose of its use. It was made clear the checklist was to be used as a redundancy check and a teaching tool for all staff (nurses and residents) because the intervention unit had been introducing a number of new nurses, several with less than 1 year of nursing experience or no previous nursing experience (16.2%), and there was a continuous influx of new medical residents.

Part of the medical resident orientation to CVC’s is a DVD with articles and a video. Some medical residents honestly admitted to not having or making time to read or view the videos prior to their first day in the ICU, but were “sure they could rely on unit staff” to guide them through the process. The checklist is beneficial to all members of the team to standardize and promote consistent care. It has been argued that by using a checklist we are taking away the individuals’ critical thinking skills. Critical thinking skills only develop after the basics are learned in combination with experience. The role of nurses is to protect patients entrusted in their care to the best of their abilities, using any tool necessary to accomplish best care.

The modified checklist included a “yes with correction” section and some nurses said this made them feel more able to offer a correction to the resident/physician inserting the line. Berenholtz et al. (2004) reported that in their study nurses “felt more comfortable intervening if

they observed a violation, because they felt an expectation had been set" (p. 2017) by using a checklist. On the intervention unit, after introduction of the modified checklist, it was observed by the writer that more comments and discussions occurred amongst the nurses, residents, and physicians around proper technique. Corrections were made and discussed at rounds, possibly preventing continuation of breaks in technique. The experience with the modified checklist at the intervention site is consistent with the observations by Berenholtz et al. (2004) of increased communication and teamwork with the use of a checklist.

An item on the checklist is either done or not done, i.e., a sterile field is maintained or it is not; if it is not done it is considered a violation. The documented violation rate was estimated at 15 – 25% in the study by Berenholtz et al. (2004). The violation rate from September 2009 through March 2010 for the intervention unit was reported to be 17.6% (66 checklists). In the present study, the violation rate was 10.5% (68 checklists) for the intervention unit using the modified checklist which included a "yes after correction" section. The decreased violation rate on the intervention unit may have been, in part, due to ongoing discussions during the study period between nurses, medical residents, and physicians regarding insertion techniques when the "yes with reminder" section was checked.

Having a checklist with only "yes" and "no" responses may become another piece of paper the nurses have to fill in as opposed to a tool that can stimulate and promote dialogue. Experienced nurses and physicians do not rely greatly on these types of tools because their knowledge and skill levels have them functioning at what Benner (1982) referred to as the "expert level." It is when the experienced staff uses the tool to guide the less experienced members through the steps in a standard order and by monitoring where correction is needed, educators and experts can refocus and enhance the teaching and apply it with the next round of

new staff. To be effective, education must be fluid and dynamic and adapt to the changing needs of the unit personnel. An understanding of breaks in technique or potential breaks in technique ("Yes after correction") is key to facilitate compliance with proper techniques and improve patient safety and decrease nosocomial infection rates.

At the comparison site ICU, the physician (Critical Care Associate) or Intensivist usually inserts the CVC lines; hence, the checklist is not so much a teaching tool as a redundancy check for the physicians. The checklist serves as a reminder of all the components that represent best practice and it can greatly facilitate learning for novice nurses. At the intervention site, new medical residents continuously rotate through the ICU and the checklist becomes more of a teaching tool than a redundancy check. Anything that empowers the staff, enhances knowledge, and encourages communication should be utilized. Decisions to change tools should be done collaboratively after evaluation of what is in place. This way an intervention or bundle can be customized specifically to meet the local needs. Evaluation of new interventions is key. Staff on units where interventions are continuously changed without evaluation lack understanding of what worked and what didn't and why. A lack of understanding of the need to evaluate effectiveness of current processes based on evidence unfortunately still exists amongst those who have the authority to make changes. We need leaders who are willing to advocate for what is effective based on evaluation of processes based on sound evidence.

The modified checklist has added value by creating discussion and guiding education regarding central line insertion techniques. Since the study health region has strong ties to the nursing and medical education programs at the local university information could be conveyed to the educators within these learning institutions and reinforced at various points during the nursing students' and medical residents' clinical rotations. Central venous catheters are inserted

within a variety of departments/locations throughout the hospital: the emergency room, operating room, diagnostic imaging, and various wards/units. Teaching about care of central venous catheter lines in the clinical setting has great potential to benefit all patients throughout the healthcare system. Improved compliance with the CDC guidelines for CVC care can be accomplished by increasing knowledge and understanding of the guidelines and the rationale behind the guidelines. The goal is to attain a consistent effective approach to practice, which ultimately will contribute to increased quality of care and patient safety.

Research Question 3

What is the impact of implementation of a checklist with educational reinforcement on Registered Nurses' knowledge of the evidence-based guidelines for preventing central venous catheter infections?

For the intervention group (Table 5.4) there was a statistically significant increase from the pre-test to the post-test in the knowledge test score [paired t-test, t (46) = 6.10, p = <.001 (two-tailed)], which indicates there was a significant increase in the respondents' knowledge of the CDC guidelines for the prevention of central venous catheter infections over the study period between the pre-test and the post-test. For the comparison group, the overall test scores did not differ significantly between the pre-test and the post test [paired t-test t (20) = .400, p = .693]. These results support the hypothesis that implementation of a checklist and an appropriate educational program will increase nurses' knowledge of the guidelines for preventing CLA-BSI.

Research Question 4

What is the impact of implementation of a checklist with educational reinforcement on central venous catheter related blood stream infections?

At the intervention site, following the introduction of a central line cart and the use of chlorhexidine, central line associated blood stream infection (CLA-BSI) rates dropped drastically from 18.9/1000 catheter days observed in 1998 (personal communication, Dr. J. Pinilla, past Medical Director of the intervention ICU, September 12, 2008). Prior to introduction of the checklist in September 2008 at the intervention site the CLA-BSI rate was 3.51/1000 catheter days for the previous 12 months (Figure 6.1). After the education sessions and introduction of the modified checklist, no CLA-BSI cases were reported for the intervention site during the 12 month post intervention period (July 2010 – June 2011). At the comparison site, there were two reported CLA-BSI during the 12 month follow-up period.

From April 2007 to March 2010, at the intervention site, the mean (SD) central line associated blood stream infection (CLA-BSI) rate was 2.93 (3.48) infections for 9,574 CVC days. In the 45 months during which this information has been collected, no infections were reported at the intervention site 50.0% of the time. In contrast, for the comparison site, during the same observation period no infections were reported 75.8 % of the time with a mean (SD) rate of 1.63 (3.50) infections for 6,803 CVC days [excluding October – December 2009 due to missing data].

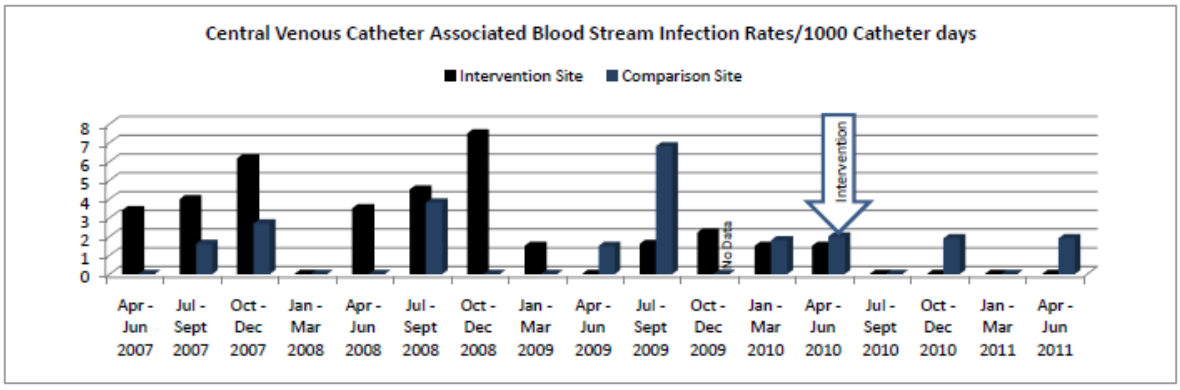


Figure 6.1 Central Venous Catheter Associated Blood Stream Infection Rates/1000 Catheter days

Prior to the start of the study from April 2009 to April 2010, at the intervention site the rate of CLA-BSI was 1.35/1000 catheter days and 3.17/1000 catheter days at the comparison site. During this 12 month period, no CLA-BSI infections were reported 66.7% of the time for the intervention site and 55.6% of the time for the comparison site.

During the study period from April to June 2010 the CLA-BSI rate was 1.47/1000 catheter days at the intervention site and 2.03/1000 catheter days at the comparison site. Interestingly, while there was no reported central line associated blood stream infection in April or May 2010, for either site, one infection (CLA-BSI) was reported for each site in June 2010.

At the comparison site, in June 2010, following the knowledge test and review of the CDC guidelines for the prevention of central venous catheter related infections, the modified checklist was introduced. Between July 2010 and April 2011 there were no reported infections (CLA-BSI) for the intervention site and two CLA-BSIs were reported for the comparison site (one in November 2010 and one in April 2011). More time is needed to see if these trends will hold.

The CLA-BSI infection rates can be used as a quality of care indicator within the study region and can be used to benchmark, locally and nationally. In the study region, in 2010, the Department of Adult Critical Care committed to reporting on bundle compliance (insertion and maintenance components of CVC's) and CLA-BSI associated infections nationally. Safer Healthcare Now! is the Canadian campaign, based on the American Institute for Healthcare Improvement (2004), which " promote improvements in patient safety" (SHN, 2009), provide assistance and collate the national results.

Strengths and Limitations

The study's main weakness comes from the inability to randomly allocated participants into the intervention and non-intervention groups. A quasi-experimental pre-test post-test interrupted time series design was chosen with the study groups designated based on the location of the Intensive Care Units. The target population was registered nurses who worked in Intensive Care Units in the study health region. The participation rate varied from 48.4% at pre-test to 89.0% participation rate at the post test. For this reason, only those who participated in both the pre-test and post-test were included as participants in the study. The small sample size, therefore, is a limitation of the study.

To facilitate control of potential extraneous variables this study was conducted utilizing an intervention group and a comparison group located in the within the same health region and city. Utilizing a comparison group helped to control for potential threats to internal validity related to selection, maturation, and history (Shadish, Cook & Campbell, 2002). "Maturation threats can be reduced by ensuring that all groups are roughly the same age and by ensuring that they are from the same location so that local secular trends are not differently affecting them" (Murray, 1998, as cited in Shadish, Cook & Campbell, 2002, p. 57). Changes that occur over time (history) and changes that can occur within the participants (maturation) were not a major consideration in the present study because of the short time duration of this study.

The intervention group did not differ significantly from the comparison group with respect to the demographic characteristics and the mean pre-test score; this allowed for strong control of extraneous variables or subject variables related to the demographic characteristics and knowledge level. The researcher delivered all components of the study for both study groups, thus controlling for extraneous variables associated with the experiment variable (Burns & Grove, 2005).

Selection

Each participant's contribution is multidimensional and includes not only factors encompassing basic demographic information, but personality, mental aptitude, and motivation based on past and present experiences. When an individual chooses to complete a questionnaire a form of selection bias can exist (Burns & Grove, 2005). The reasons for choosing to participate can vary widely based on loyalty to being truly interested in the study question and the answers that could be obtained. Regardless of the reasons, the results could be influenced. Conversely, the results could be influenced by the researcher's selection of participants. In the present study, selection of participants was based on specific criteria that participants were registered nurses who worked in the ICU's and the use of an intervention and comparison group based on specific criteria helped to control for this potential threat to internal validity. This specific selection will not allow generalizability to all nurses, but the results may be generalized to nurses who work in the ICU's in the study health region.

At the pre-test there were no statistically significant differences between the intervention and comparison groups on any of the demographic characteristics. The impact of the study intervention and observed outcome, therefore, can be more likely attributed to the study intervention. Information on demographic characteristics were gathered in order to make comparisons between the study groups and with the studies conducted by Labeau et al. (2008; 2009).

Information Bias

The National Institute for Health and Clinical Excellence (2009) described a form of information bias that can exist within questionnaires. The bias is associated with the wording of the questions, i.e., too difficult for the intended respondents or those worded to illicit a specific

response. The potential for information bias is very low and not believed to exist in this study; participants either answered a question correct or incorrect and, therefore, accuracy of the results is not a concern in this study.

All participants were provided with the correct answers following the pre-test and if any discussion or clarification was required it was discussed, even in the comparison group. This was done because it would be irresponsible to not provide individuals with the proper and correct knowledge to do their work, which in turn could put patients at risk. The results of this study showed the limited impact of providing only correct answers and not allowing for discussion in the comparison group results.

Repeated Testing

The use of a pre-test and post-test design using the same test may lead to an increase in the post-test scores. "Individuals usually score higher when they take a test a second time regardless of the treatment" (LoBiondo-Wood & Haber, 2005, p. 240). Participants may remember the correct answers, or may have studied or reviewed concepts presented within the test. In the present study, the intervention and comparison groups provided an excellent foundation against which to compare the educational intervention and the modified checklist. The potential threat to internal validity of testing was controlled by administering the test to both the intervention and comparison groups at Time 1 (pre-test) and Time 2 (post-test). "A reliable test gives approximately the same score each time a person takes it" (Coon & Mitterer, 2007, p. 365). This was supported by the evidence in the present study in which the comparison group mean (SD) test score at pre-test was 6.19 (.93) and at post-test was 6.29 (1.19).

Testing or recall of information immediately following an educational session or at the end of the day is different than recall of information one month later. An additional strength of

this study was the focus on long term retention of the information as evidenced by the time period between the "lunch and learn" sessions and the post-test. The time period between the educational session and the repeat test was 4-6 weeks for the present study. The correct answers for the knowledge test were not posted at any time during the study or discussed prior to the retest so study participants could not memorize the answers and artificially inflate the test scores. In reality, it would be good to post the test with the correct answers highlighted, so individuals could look at the results, perhaps facilitating a conversation regarding the different responses chosen. For this study the educational session was multimodal. Information was presented visually on a PowerPoint, handouts and fact sheets were given, and discussions occurred.

Response Bias

Participants were assured of the confidentiality of their provided responses. The collection of the questionnaire in a sealed envelope with only a number assigned to the outside of the envelope and a separate tracking sheet stored separately facilitated confidentiality. In addition, participants were reminded not to put their names on the questionnaire. The nursing profession is one that deals daily with confidentiality issues; therefore, confidentiality was not a concern expressed among the participants.

Reliability and Validity of the Instrument

Validity is the term for how well the instrument (knowledge test) measures what is claims to measure (Saunders & Trapp, 1994). Knowledge was tested using the questionairre "Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection" (Labeau et al., 2008). The content validity of this instrument was established by Labeau et al. (2008). The initial panel of seven experts included "6 [individuals who had] had at least 10 years of experience in an ICU; 1, who had worked as a nursing hospital hygienist for

several years, had 3 years of ICU experience. All 7 had at least a master's degree in nursing sciences (or medical-social sciences) and were involved, at least locally, in research on ICU-acquired infections" (Labeau et al., 2008, p. 68). The multiple choice test was first tested with 762 nurses who completed the questionnaire (89.1% response rate), "the level of difficulty and the discrimination of each item on the questionnaire were determined, and each of the 4 response alternatives or options for each question was evaluated for quality." (Labeau et al., 2008, p. 68). Follow-up testing occurred between October 2006 and March 2007 with 3,405 questionnaires from multiple European countries (Labeau et al, 2009).

External Validity

A sample that is not representative of the target population poses threats to external validity in that the results cannot be generalized beyond the chosen sample (Burns & Grove, 2005). The target population of interest was Registered nurses who worked in the Intensive Care Units in the study health region during the study period. The intervention group and the comparison group were similar with respect to demographic characteristics and will contribute to the empirical and literature in this area. Compared to the findings of Labeau et al. (2008; 2009) the study population in the present study were similar to study participants in other countries. The results of this study cannot be generalized to registered nurses beyond the study areas. Generalization, however, was not a primary objective of this study. The primary objective was to assess whether or not an intervention that included education and a modified checklist increased nurses' knowledge.

Study Power

A reduction in sample size usually results in an increased potential for a Type II error or missing a difference that exists between two groups being compared (Polit & Beck, 2008). The

minimum sample size was 21; therefore, with alpha = .05, the study had a power of 60% to detect a large effect size (0.70), i.e., mean post-test scores between the intervention group and the comparison group (See Table 22.6, Polit & Beck, 2008, p. 604).

Implications for Nursing and Future Research

Once something is ingrained in practice, whether based on evidence or not, it is difficult to change that "standard practice" without a clear plan based on evidence. Nursing educators must place more emphasis on evidenced-based practice and guidelines associated with care. Within basic nursing programs, a focus on evidenced-based care will allow students to understand what is done is purposeful and the consequences associated with improper care or techniques can have significant impact on client outcomes. The revised CDC guidelines for the prevention of intravascular catheter-related infections have been in use since 2002. In 8 years, an expectation would have been a more widespread development of knowledge of the guidelines and that the health regional policy would reflect of information as presented in the guidelines. It is unacceptable that practice is that far behind the evidence. Our educators, academic and professional, must take more responsibility for providing the information in a timely fashion and assisting to translate it into practice. Just as nurses must be responsible for their own practice, they need to be encouraged to search out best practice and guidelines. In addition, our in-house educators should be responsible for reinforcing this. It is evident from the results reported by Labeau et al. (2008, 2009), Pronovost et al. (2006), and Berenholtz et al. (2004) that knowledge translation is not just a local problem. Worldwide, nurses must do a better job of translating empirical evidence on best practice initiatives into practice in a more timely fashion.

Although best practice initiatives are occurring, results of this study show presentation of evidenced-based information presented to front line staff along with reflective discussion of this

information increases knowledge and may contribute to reducing central venous catheter related infections. When educators, medical or nursing, decide to follow guidelines and introduce practice changes, detailed discussion with the front line staff must occur and information must be presented frequently throughout the year. As Graham et al. (2006) indicated in the Knowledge to Action Framework a crucial component is to sustain knowledge use, which is accomplished through the cycle of identification, review, and evaluation, which must be ongoing.

Formally, there must be, at a minimum, protocols and policies in place that are based on current evidence as a starting point to initiate a dialogue about current practices and how or why change is needed. According to Graham et al. (2006) these knowledge tools/products are at the center of the knowledge translation process or action cycle. There needs to be a formal high level plan of targeted educational strategies for a specific time period. The educators, coordinators, and managers need to have the skills necessary to support the staff and patients in a variety of ways. It is the responsibility of management and educators to make sure evidenced-based practice initiatives are understood at the front line.

Formally and informally, nursing educators must encourage dialogue about practice issues, and support the informal learning process using current clinical cases. Learning needs to be facilitated using a wide variety of methods, but the best learning comes from an openness to discuss and support practice. As noted by Benner (1984), educators must take into account the experience of a nurse and tailor learning to the individual. New nurses are often overwhelmed in the intensive care setting and often start with little to no experience. Initially, education is focused on providing information to novice staff, not furthering their critical thinking skills. Novice learners benefit from formal education like the guidelines. In time, discussions can take

place and opportunities to seek out information will occur as experience increases and development of critical thinking evolves.

Continuous interventions and learning opportunities have been observed to reduce CLA-BSI (Lobo et al., 2005). Multimodal education efforts (lecture, audiovisual, fact sheets, knowledge tests, appropriate care discussions, lunch and learn sessions etc.) need to be ongoing. A consistent approach using multiple methods should occur to reinforce best practice for experienced nurses and facilitate learning for new or novice nurses.

Sessions at a planned education day, which staff members are paid to attend, provide access to the majority of staff. Participants at these sessions will more often be focused on learning because they are not worried about what is going on with their patients. It has historically been difficult and more labour intensive to educate shift workers. It requires commitment and time from educators and managers to target all employees. Lunch and learn sessions are a great method for providing brief and targeted in-services, but for shift workers these must be offered multiple times. On units where nurses work in teams and have a set rotation it is much easier to plan and implement interventions. On units where each nurse has an individual rotation it is much more difficult to plan and execute educational interventions in the work place. Strategically, looking at a schedule to plan education sessions that would capture most employees followed by individual sessions would be the best. On any given day the workload of the unit could be exceptionally busy and limit attendance. Flexibility and adaptability of the educators is a key.

Resources regarding basic teaching and learning principles consistently emphasize the different learning styles (Bastable, 2003). Multimodal interventions should be applied to encompass all learning types. The Institute for Healthcare Improvement (IHI) and Safer

Healthcare Now (SHN) have reported the benefits of bundling techniques together to be effective in reducing the rate of CLA-BSI infections. This study has demonstrated the value of educational interventions in reinforcing best practices. Research is needed to determine whether this strategy could be utilized with other nosocomial infections, such as ventilator associated pneumonia (VAP) or antibiotic resistant organisms.

The challenge is to engage front line workers and keep them engaged. An example of this was the impact of the modified check list, which empowered nurses to stop a procedure if criteria were not met. This tool can be used as a redundancy check between physicians and nurses. It must be understood the checklist is not a grading tool. Rather, it is designed to stimulate discussion, facilitate best practice, and improve teaching and patient care. If used in a punitive way this useful tool could destroy collaborative efforts and care of the patient.

There is always room for improvement. The responsibility for learning and education requires a whole team of people. Even health board members must be aware of infection rates and how responsibility and accountability for this patient safety issue is everyone's role. Every nurse has to take the responsibility and the accountability for his or her practice, but it is easy to follow what has always been done. Educators must take the lead in the introduction of best practice initiatives and make sure practice is up to the current standard of care with well defined standards and clear expectations. But educators cannot do it alone they need the support of the charge nurses, clinical coordinators, managers, physicians, dieticians, pharmacists, directors, etc., as well as each nurse on the unit. By identifying champions to assist with practice initiatives based on evidence quality patient care will result.

Continuous learning opportunities must be evaluated for understanding and effectiveness of translation of evidenced-based knowledge to practice. It is the responsibility of all staff to

make sure this information is understood at all levels of the organization to benefit patients. Effective leadership, which encourages this type of environment, is required to facilitate successful learning and development of staff. A curriculum more focused on evidenced-based practice and clinical practice guidelines should be incorporated into undergraduate nursing programs and specialty certification courses, with emphasis on the development process and utilization of practice guidelines.

Changing the accepted culture takes time (Lee, 2004). A cultural change that embraces practice based on the evidence instead of "this is what we always have done" takes time to build; allowing an openness to create a dialogue instead of a monologue is key to this process.

Future Research

The results of this study are consistent with the findings of previous studies in which a decrease in central line associated blood stream infections (CLA-BSI) was observed following educational interventions. Future studies should focus on educational interventions and guideline recommendations to further reduce nosocomial infection rates in the intensive care units.

Any approach should focus on the whole care team, i.e., everyone who has a responsibility for care of a patient/client, across the continuum of care. More emphasis on the involvement of a multidisciplinary team and interventions to enhance quality patient care should be a high priority of focus for future research. Just like one intervention in isolation may not make a difference, one care provider group in isolation of the others is unlikely to result in significant change. It is a suggestion that future studies should utilize the MRC Framework for evaluating complex interventions (CIHR, 2010) because the healthcare interventions cannot operate in isolation, but require a multidisciplinary team to maximize benefit to the patient.

Insertion

The health region in which the current study was conducted does not supply sterile normal saline syringes. The nurse, therefore, assists with flushing of the central venous catheter which is not best practice related to maintaining sterile aseptic technique (AORN, 2008). Best practice suggests that the physician who inserts the CVC line should flush the lines, place the adaptors, and place the dressing. The addition of sterile normal saline syringes, which are used to flush the central venous catheter after insertion and the impact on infection rates, should be considered by the target health region. This component could easily be added into an insertion checklist and follow-up evaluation could occur without an additional impact on human resources. The information provided would be relevant to the prevention of CLA-BSI and could enhance educational programs and provide more specific information, which could be beneficial to similar units.

Maintenance

Future research should focus on maintenance techniques associated with central venous catheter care. Opportunities exist to increase compliance with post-insertion care techniques especially site care and line access techniques within the study health region. The procedure of accessing the CVC should include monitoring hand hygiene compliance before and after accessing the CVC, whether gloves are worn or not, and the length of time the port is cleansed with alcohol ("scrub the hub") prior to accessing the CVC, to see if infection rates decrease.

An audit of CVC dressings and site care to see if documentation exists in the nursing care plan and daily documentation of the site's appearance may provide evidence for education for all nursing departments. Front line staff can be highly effective in identifying and correcting problems. Input from staff, patients, and families should be continually explored to further

identify area for improvements. The feedback will help educators design better educational programs which ultimately benefit the patients who are the focus of nursing care.

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Appendix A

Permission to Use Questionnaire

Date: Mon, 27 Oct 2008 18:30:05 +0100

From: "Sonia Labeau"

To: Jill Friedt

Cc: "'Stijn Blot'"

Subject: CVC-RI evaluation questionnaire

-->
Dear Ms. Friedt,

Thank you very much for your interest in our research. Attached is a pdf-copy of our questionnaire for your use. Please bear in mind to refer to the original article when using it.

You also might be interested to know that we have used this questionnaire in a major survey, including over 3400 intensive care nurses in 22 European countries. The results of this survey will be published in *Critical Care Medicine*, probably in the January 2009 issue.

We wish you lots of success with your thesis!

Best regards,
Sonia Labeau
PhD student
for Prof. dr. S. Blot

Appendix B

CDC Definitions

Catheter Associated BSI (Appendix A of CDC Guideline MMWR Aug. 9, 2002/51(RR 10); 27-28 and the JCAHO Core Measures Glossary): The major site of infection is a bloodstream infection and the specific site is either laboratory confirmed BSI or clinical sepsis. For example, a patient with leukemia with a vascular catheter has two positive blood cultures with coagulase-negative staphylococci. Even if there are clinical signs and symptoms of localized infection at the vascular access site, but no other infection can be found, the infection is considered a primary bloodstream infection. Also, when a vascular access device is present and no other infection site is evident, then the BSI is considered a primary BSI regardless of whether there are localized signs of infection at the vascular access site (JCAHO). BSI is considered to be associated with a central line if the line was in use during the 48-hour period before development of the BSI. If the time interval between onset of infection and device use is >48 hours, there should be compelling evidence that the infection is related to the central line (CDC).

Laboratory-Confirmed BSI*:* Must meet at least one of the following criteria:
Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures, and the pathogen cultured from the blood is not related to an infection at another site.
Criterion 2: Patient has at least one of the following signs or symptoms: fever (100.4 [38C]), chills, or hypotension, and signs and symptoms and positive laboratory results are not related to an infection at another site, and at least one of the following:
1. Common skin contaminant [e.g., Corynebacterium sp. (formerly diphtheroids), Bacillus sp., Propionibacterium sp., coagulase-negative staphylococci, or micrococci] cultured from two or more blood cultures drawn on separate occasions.
2. Common skin contaminant [e.g. Corynebacterium sp. (formerly diphtheroids), Bacillus sp., Propionibacterium sp., coagulase-negative staphylococci, or micrococci] is cultured from at least one blood culture from a patient with an intravascular line, and the physician institutes appropriate antimicrobial therapy.
3. Positive antigen test on blood (e.g., H. influenzae, S. pneumoniae, N. meningitidis, or Group B streptococcus).

Secondary BSI*:* A culture-confirmed bloodstream infection related to infection at another site. For example, a patient has pneumonia with Pseudomonas aeruginosa and grows the same pathogen in his blood cultures. The pneumonia is considered the primary infection site and the BSI is secondary to it. Another example is a leukemic patient who appears septic and the blood cultures grow E. coli. The patient has a vascular catheter and also has signs and symptoms of a urinary tract infection, but no urine culture is ordered. The patient's primary infection is a symptomatic UTI complicated by a secondary bloodstream infection. Secondary BSIs are not included in this measure (JCAHO).
Calculate as: Number of central line-associated bloodstream infections / Number of central line-days [x 1,000] = Central Line-Associated Primary Bloodstream Infection rate per 1000 central line days
Please see CDC guidelines and for more specific information (from Appendix A off CDC Guideline MMWR Aug. 9,2002/51(RR 10); 27-28 and the JCAHO Core Measures Glossary).

Appendix C

Criteria for Diagnosis of CVC-BSI (CLA-BSI)

Criteria for diagnosis of CVC-BSI the from Canadian Nosocomial Infection Surveillance Program (CNISP, 2007) Appendix A page 2:

1. Recognised pathogen cultured from one or more blood cultures, unrelated to infection at another site.

2. At least one of: fever >38°C, chills, hypotension (if aged < 1 yr: one of fever >38°C, hypothermia, apnea, or bradycardia) or signs of infection of catheter insertion site, tunnel or pocket

AND

Common skin contaminant (e.g. diphtheroids, Bacillus spp, Propionibacterium spp, coagulase negative staphylococci, micrococci) cultured from two or more blood cultures drawn on separate occasions.

3. At least one of: fever >38°C, chills, hypotension (if aged < 1 yr: one of fever >38°C, hypothermia, apnea, or bradycardia) or signs of infection of catheter insertion site, tunnel or pocket

AND

Common skin contaminant (as in 2 above) cultured from one blood culture from a patient with an intravenous line and the physician institutes appropriate antimicrobial therapy.

Appendix D

Checklist

Safer Healthcare Now! Campaign **Updated: May 2007**
How-to Guide: Prevent Central Line Infections

APPENDIX B: Sample Central Line Insertion Checklist

BC CHILDREN'S HOSPITAL ICU/TCU VASCULAR ACCESS DEVICE INSERTION CHECKLIST

Patient Addressograph

Purpose:	To work as a team to decrease patient harm from catheter-related bloodstream infections
When:	During all central venous line, central line re-wire or PIC insertions
By whom:	Bedside nurse

1.	Today's date:		_____/_____/_____ Month Day Year		
2.	Procedure:	❒ PIC line	❒ New central line		❒ Line rewire
3.	Is the procedure:		❒ Elective		❒ Urgent
4.	**Before the procedure, did the physician:**		Yes	No	Don't Know
	Remove jewelry?		❒	❒	❒
	Apply eye protection?		❒	❒	❒
	Wash hands using 2% chlorhexidine soap (pump soap at sinks in ICU/TCU)		❒	❒	❒
	Use hat, mask and sterile gown?		❒	❒	❒
	Use sterile gloves?		❒	❒	❒
	Disinfect procedure site using 2% chlorhexidine with 70% alcohol.		❒	❒	❒
	Drape entire patient in a sterile fashion.		❒	❒	❒
5.	Did the physician maintain a sterile field during the procedure?		❒	❒	❒
6.	Was a sterile dressing applied to the site?		❒	❒	❒
7.	Was the procedure documented in the chart?		❒	❒	❒
8.	Was the procedure aborted and restarted for break in technique?		❒	❒	❒
9.	Was ultrasound used to visualize the vessel?		❒	❒	❒
10.	How many line attempts were made?		_____		
11.	Line site (e.g., R fem vein)		_____		

PLEASE RETURN COMPLETED SHEET TO CVC BINDER ON LINE CART

W:/CR-BSI Collaborative/Insertion Bundle/Insertion Checklist Aug 2005

Appendix E

Permission to modify & use checklist

From: Bruce Harries
Sent: March-05-09 12:00 PM
To: Friedt, Jill
Cc: 'Tracie Northway'
Subject: RE: CLI Checklist

Hi,
This sounds like an interesting topic. Yes the checklist example on page 37 of the Getting Started Kit is meant as a starting point and could be modified.
Would you be willing to share your modified checklist as an additional example, and how you will know that it's an improvement?
I've copied Tracie Northway from our Faculty as she has a lot of experience with the example and the topic in general, and as a bonus is also a nurse.
Please call if any questions.
Regards,
Bruce

From: Friedt, Jill
Sent: March 5, 2009 8:50 AM
To: Bharries
Subject: CLI Checklist

Bruce Harries
Improvement Associates Ltd.
Collaborative Director

Hi Bruce
I am doing a Masters of Nursing thesis at the University of Saskatchewan in Saskatoon, SK.
My thesis will assess critical care nurses' knowledge of evidence-based guidelines for preventing central venous catheter bloodstream infections (CBSI) and ascertain if implementation of a checklist and educational program affects nurses' knowledge and CBSI rates in the Saskatoon Health Region.
Could I use and modify the checklist from the Safer Healthcare Now! campaign to facilitate my research?
If you need more information or clarification please don't hesitate to contact me.
Thanks in advance
Jill Friedt

Appendix F

Modified ICU Central Line Insertion Checklist

1. Today's date _____ (day) / _____ (month) / _____ (year)
2. Is the procedure: □ Elective □ Emergent
3. Procedure: □ New line □ Rewire
4. Site: □ right □ left □ Internal Jugular □Subclavian □ Femoral

	YES	YES - AFTER CORRECTION	NO	DON'T KNOW
BEFORE THE PROCEDURE, DID THE PHYSICIAN/RESIDENT:				
Wash hands (chlorhexidine or soap) immediately prior (ask if needed)	❑	❑	❑	❑
Was hand washing directly observed?	❑	❑	❑	❑
Remove jewelry?	❑	❑	❑	❑
Place pt in trendelenburg position - < 0 degrees, to prevent air embolism	❑	❑	❑	❑
Disinfect procedure site (2% chlorhexidine with 70% alcohol).	❑	❑	❑	❑
Drape entire patient in a sterile fashion using a large drape	❑	❑	❑	❑
DURING THE PROCEDURE, DID THE HOUSE STAFF:				
Use Eye protection, hat, mask, sterile gown and gloves	❑	❑	❑	❑
Maintain a sterile field	❑	❑	❑	❑
Did all personnel assisting follow the above precautions	❑	❑	❑	❑
Ensure line aspirates blood to prevent hemothorax	❑	❑	❑	❑
Was a sterile dressing applied to the site by the physician/resident	❑	❑	❑	
Transduce CVP	❑	❑	❑	❑
Was ultrasound used to visualize the vessel?	❑	❑	❑	❑
Was the procedure aborted and restarted for break in technique?	❑	❑	❑	❑
AFTER THE PROCEDURE:				
Was a CXR done to confirm placement?	❑		❑	
Was the procedure documented in the chart?	❑		❑	❑

5. How many line attempts were made? _____

6. Who inserted the line? □ Intensivist □ Resident

7. Was a correction required? □ Yes □ No Explain:

Addressograph on reverse

Please return to charge nurse/coordinator for Jill Friedt CNS

Appendix G

Questionnaire Part 2

Knowledge of Evidence-Based Guideline for Preventing Central Venous Catheter-Related Infection

1. It is recommended to replace central venous catheters (CVCs) routinely

- ❑a Yes, every 7 days
- ❑b Yes, every 3 weeks
- ❑c No, only when indicated
- ❑d I do not know

2. It is recommended to replace CVCs over a guidewire …

- ❑a Yes, every 3 days
- ❑b Yes, every 7 days
- ❑c No, only when indicated
- ❑d I do not know

3. It is recommended to replace pressure transducers and tubing routinely …

- ❑a Yes, every 4 days
- ❑b Yes, every 8 days
- ❑c No, only when indicated
- ❑d I do not know

4. In settings with a high rate of catheter-related infections it is recommended to use a CVC coated or impregnated with an antiseptic agent

- ❑a Yes, in patients whose CVC is expected to remain in place for more than 5 days
- ❑b No, because the use of such catheters is not cost-effective
- ❑c No, because the use of such catheters does not result in a significant decrease in the rate of catheter-related infections
- ❑d I do not know

5. It is recommended to change the dressing on the catheter insertion site

- ❑a On a daily basis
- ❑b Every 3 days 0.3
- ❑c When indicated (soiled, loosened, …) and at least weekly
- ❑d I do not know

6. It is recommended to cover up the catheter insertion site with …

- ❑a Polyurethane dressing (transparent, semipermeable)
- ❑b Gauze dressing
- ❑c Both are recommended because the type of dressing does not affect the risk for catheter-related infections
- ❑d I do not know

7. It is recommended to disinfect the catheter insertion site with …

- ❑a 2% aqueous chlorhexidine
- ❑b 0.5% alcoholic chlorhexidine
- ❑c 10% povidone-iodine
- ❑d I do not know

8. It is recommended to apply an antibiotic ointment at the insertion site of a CVC …

- ❑a Yes, because it decreases the risk for catheter-related infections
- ❑b No, because it causes antibiotic resistance
- ❑c No, because it does not decrease the risk for catheter-related infections
- ❑d I do not know

9. When lipid emulsions are administered through a CVC it is recommended to replace the administration set …

- ❑a Within 24 hours
- ❑b Every 72 hours
- ❑c Every 96 hours
- ❑d I do not know

10. When neither lipid emulsions nor blood products are administered through a CVC it is recommended to replace the administration set …

- ❑a Every 24 hours
- ❑b Every 48 hours
- ❑c Every 96 hours
- ❑d I do not know

Labeau, S., Vereecke, A., Vandijck, A, Claes, B., & Blot, S.I. (2008). Critical care nurses' knowledge of evidence-based guidelines for preventing infections associated with central venous catheters: An evaluation questionnaire. American journal of critical care 17(1), 65-71.

Appendix H

Questionnaire Part 1

Demographic Information

Gender ❑ Male (1) ❑ Female (2)

Age – What year were you born Year _____

Level of Education ❑ Diploma (1) ❑ BSN (2) ❑ MN (3) ❑PhD (4)

In what year did you complete your basic nursing education? _____

Years of work experience _____ years

Years of experience in ICU _____years

Work status ❑ full-time (1) ❑ part-time (2) ❑ casual (3)

Have you ever attended a research class? ❑ Yes (1) ❑ No (2) Year_____

Have you taken the Critical Care Course? ❑Yes (1) ❑ No (2) Year_____

Do you hold a speciality certification? ❑Yes (1) ❑ No (2)
If yes, which certification did you complete and when did you complete it?

(SPECIALITY) _____ (b) (YEAR) ____

THANK-YOU FOR YOUR TIME AND EFFORT
(Use the back of this page to write any additional comments)

Appendix I

Information Letter

A study entitled: Central Venous Catheter Related Infections: The Impact of an Educational Program on Nurses' Knowledge and Infection Rates in an ICU.

Researcher: Jill Friedt, College of Nursing, University of Saskatchewan
Phone numbers: (306) 249-1887 or 655-5022 or 281-5912

Study Purpose: The purpose of this study is to identify changes in registered nurses' knowledge level of the evidence based guidelines for preventing central line infections in an Intensive Care Unit (ICU) before and after implementation of a checklist and educational program.

Procedures: You will be asked to answer basic questions about yourself (year of birth, education, nursing practice, experience) and your awareness about the guidelines for preventing central line infections.

Risks: There are no forseen risks of this study to you.

Benefits: Decreasing infection rates saves lives, improves quality of care, and leads to better patient outcomes. An understanding of the current knowledge level will allow adaptation of beneficial strategies to increase research utilization and synthesize information toward better client outcomes in the context of the intensive care specialty.

Storage of Data: All data will be stored, by the thesis supervisor, Dr. Karen Semchuk, in a locked cabinet at the College of Nursing, University of Saskatchewan for a minimum of 5 years. Only the research team will be able to look at the information.

Confidentiality: Your name will not be on any of the information you provide; no one can identify you. Your name will not appear in any report. All information from this study will be reported in a group format for conferences and publications.

Right to Withdraw: You may withdraw from the study for any reason, at any time, without consequence.

Questions: If you have any questions concerning the study, please feel free to contact me, Jill Friedt at any of the numbers listed above. This study has been approved on ethical grounds by the University of Saskatchewan Advisory Committee on Ethics in Behaviour Sciences Research (Beh-REB) on DATE. Any questions regarding your rights as a participant may be addressed to that committee at the Office of Research Services (966-2084).

Consent to Participate:

I have read and understood the description provided above. I consent to participate in the study described above, understanding, that I may withdraw this consent at any time. A copy of this information letter has been given to me for my records.

Thank you in advance for your participation!

_____ _____

Jill M. Friedt, RN, BSN

Karen Semchuk, PhD
Professor

Appendix J

Ethics Approval

UNIVERSITY OF SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB)

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BEH#
Karen Semchuk	Nursing	10-37

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED
University of Saskatchewan

STUDENT RESEARCHERS
Jill Marie Friedt

SPONSOR
UNFUNDED

TITLE
Central Venous Catheter Related Infections: The Impact of an Educational Program on Nurses' Knowledge and Infections Rates in the ICU

ORIGINAL REVIEW DATE	APPROVAL ON	APPROVAL OF:	EXPIRY DATE
09-Feb-2010	15-Mar-2010	Ethics Application Consent Protocol	14-Mar-2011

Full Board Meeting ☐ Date of Full Board Meeting:

Delegated Review ☒

CERTIFICATION
The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: *http://www.usask.ca/research/ethics_review/*

John Rigby

John Rigby, Chair
University of Saskatchewan
Behavioural Research Ethics Board

Please send all correspondence to:

Research Ethics Office
University of Saskatchewan
Box 5000 RPO University, 1602-110 Gymnasium Place
Saskatoon SK S7N 4J8

Appendix K

Institutional Approval

Associate Vice-President Research – Health
(University of Saskatchewan)
Vice-President Research and Innovation
(Saskatoon Health Region)
Room B527 Health Sciences Building
University of Saskatchewan
107 Wiggins Road
Saskatoon, SK S7N 5E5
Phone: (306) 966-8745

DATE: April 7, 2010

TO: **Dr. Karen Semchuk**
College of Nursing
University of Saskatchewan

FROM: Martha E. (Beth) Horsburgh
Associate Vice-President Research – Health (University of Saskatchewan)/
Vice-President Research & Innovation (Saskatoon Health Region)

RE: **RESEARCH PROJECT ETHICS COMMITTEE (EC)#: B2010-37**
PROJECT NAME: Central Venous Catheter Related Infections: The Impact of an Educational Program on Nurses' Knowledge and Infection Rates in the ICU
PROTOCOL #:

Saskatoon Health Region is pleased to provide you with operational approval of the above-mentioned research project.

Kindly inform us when the data collection phase of the research project is completed. We would also appreciate receiving a copy of any publications related to this research. As well, any publications or presentations that result from this research should include a statement acknowledging the assistance of Saskatoon Health Region.

We wish you every success with your project. If you have any questions, please feel welcome to contact Shawna Weeks at 655-1442 or email shawna.weeks@saskatoonhealthregion.ca

Yours truly,

Martha E. (Beth) Horsburgh, RN, Ph.D
Associate Vice-President Research – Health (University of Saskatchewan)/
Vice-President Research & Innovation (Saskatoon Health Region)

cc: David Mandzuk, Manager, ICU, RUH
Dr. Susan Shaw, Medical Director, Adult Critical Care
Patti Simonar, Director, Emergency & Critical Care Services, SHR
Betty Wolfe, Manager, ICU, SPH

Catalyzing Health Research and Innovation Together

Appendix L

Letter of Support

Department of Adult Critical Care
Administration Offices
1702 20th Street West
Saskatoon, Saskatchewan
S7M 0Z9

Tel: 306 655-5518
Fax: 306 655-5555

November 23, 2009

Dear *U of S Behavioural Research Ethics Board*

RE: letter of Support for research on "Central Venous Catheter Related Infections: The Impact of an Educational Program on Nurses' Knowledge and Infections rates in the ICU." by Jill M. Friedt

I am writing to express my strong support for the research that Jill Friedt, College of Nursing, University of Saskatchewan is submitting to ethics to fulfill her thesis requirements.

The Saskatoon Health Region and the Department of Adult Critical Care Executive has a continuing interest in the research which Jill Friedt plans to perform. We will be available to support this research by providing APACHE scores, length of stay, admission rates, mortality rates, and central venous line associated blood stream (CLA-BSI) infection rates for the intensive Care Units, within the Saskatoon Health Region.

The possibility of furthering our commitment to improved quality care is important to the Saskatoon Health Region. I believe this research will advance the knowledge and improve the ability of the Intensive Care units to continue to provide quality care within the department.

I am writing to endorse these research activities of Jill Friedt.

Should you have any questions or concerns please feel free to contact me

Sincerely

Patti Simonar
Director Acute Care
Emergency & Critical Care Services
Phone: 655-5518

Dr. Susan Shaw
Head, Department Adult Critical Care
Phone: 655-1183

Healthiest people ~ Healthiest communities ~ Exceptional service

Appendix M

Educational Module based on the CDC Guidelines

Summary of the Guidelines for the Prevention of Intravascular Catheter-Related Infections
By O'Grady, N. P., Alexander, M., Dellinger, E. P., et al. (2002)

O'Grady, N.P., Alexander, M., Dellinger, E.P., et al. (2002). Guidelines for the prevention of intravascular catheter-related infections. *MMWR Morb Mortal Wkly Rep, 51*(RR-10), 1-29.

Key Messages'

 # 1. Handwashing

 # 2. Cleaning ports prior to use

- ☑ Dressing changes.
  - Replace gauze dressings every 2 days on short-term catheters.
  - Replace transparent dressings every 7 days on short-term catheters.

  Replace the dressing when the catheter is replaced or when the dressing becomes damp, loosened, or soiled, or when inspection of the site is necessary. Transparent dressings reliably secure the device, permit continuous visual inspection of the catheter site, permit patients to bathe and shower without saturating the dressing, and require less frequent changes than do standard gauze and tape dressings; the use of these dressings saves personnel time.
- ☑ Disinfect catheter site with 2% chlorhexidine; preferably use 2% chlorhexidine gluconate in 70% isopropyl alcohol and allow to dry.
- ☑ Clean injection ports with 70% alcohol before accessing the system.
- ☒ Antibiotic ointment usage is associated with antibiotic resistance and should not routinely be used.
- ☑ Change administration sets every 72 – 96 hours Replace tubing used to administer blood products or lipid emulsions within 24 hours of initiating the infusion. Propofol tubing should be changed every 12 hours.
- ☒ Do not replace catheters routinely to prevent catheter-related infection.
- ☒ Do not use guidewire exchanges routinely for nontunneled catheters to prevent infection.
- ☑ Use a guidewire exchange to replace a malfunctioning nontunneled catheter if no evidence of infection is present .
- ☑ Use an antimicrobial or antiseptic-impregnated central venous catheter (CVC) in adults whose catheter is expected to remain in place >5 days if, after implementing a comprehensive strategy to reduce rates of catheter related blood stream infection (CRBSI), the CRBSI rate remains above the goal set by the individual institution based on benchmark rates and local factors.

Insertion Components

Catheter type

- Use a CVC with the minimum number of ports or lumens essential for the management of the patient
- Consider antimicrobial impregnated catheter if the risk of catheter related blood stream infection CLA-BSI is high.

  Use an antimicrobial or antiseptic-impregnated CVC in adults whose catheter is expected to remain in place for greater than 5 days if, after implementing a comprehensive strategy to reduce rates of CRBSI, the CRBSI rate remains above the goal set by the individual institution based on benchmark rates and local factors.

Personnel

Designate personnel who have been trained and exhibit competency in the insertion of catheters to supervise trainees who perform catheter insertion.

Insertion site considerations

- Weigh the risk and benefits of placing a device at a recommended site to reduce infectious complications against the risk for mechanical complications (i.e.,pneumothorax, subclavian artery puncture, subclavian vein laceration, subclavian vein stenosis, hemothorax, thrombosis, air embolism, and catheter misplacement).
- The use of bedside ultrasound for the placement of a central venous catheter substantially reduced mechanical complications compared with the standard landmark placement technique.
- Consideration of comfort, security, and maintenance of asepsis as well as patient-specific factors (e.g., pre-existing catheters, anatomic deformity, and bleeding diathesis), relative risk of mechanical complications (e.g., bleeding and pneumothorax), the availability of bedside ultrasound, and the risk for infection should guide site selection.

- Do not routinely use arterial or venous cut down procedures as a method to insert catheters.
- For patients requiring frequent or continuous access, a periphallly inserted central catheter (PICC) or tunneled central venous catheter (CVC) is preferable.

Site of Catheter Insertion

- Use a subclavian site (rather than a jugular or a femoral site).
- Place catheters used for hemodialysis and pheresis in a jugular or femoral vein rather than a subclavian vein to avoid venous stenosis if catheter access is needed. For adults, lower extremity insertion sites are associated with a higher risk for infection than are upper extremity sites.

Selection and replacement of intravascular catheters

- Select the catheter, insertion technique, and insertion site with the lowest risk for complications (infectious and non-infectious) for the anticipated type and duration of IV therapy.
- Promptly remove any intravascular catheter that is no longer essential.
- When adherence to aseptic technique cannot be ensured (i.e., when catheters are inserted during a medical emergency), replace all catheters as soon as possible and after no longer than 48 hours.
- Use clinical judgment to determine when to replace a catheter that could be a source of infection.
- Replace any short-term CVC if purulence is observed at the insertion site, which indicates infection .
- Replace all CVCs if the patient is hemodynamically unstable and CRBSI is suspected.

- Do not use guidewire techniques to replace catheters in patients suspected of having catheter-related infection.

Replacement of catheter

- Do not routinely replace CVCs, PICCs, hemodialysis catheters, or pulmonary artery catheters to prevent catheter-related infections.
- Do not routinely replace central venous or arterial catheters solely for the purposes of reducing the incidence of infection.
- Do not remove CVCs or PICCs on the basis of fever alone.
- Do not routinely replace venous catheters in patients who are bacteremic or fungemic if the source of infection is unlikely to be the catheter.
- Use clinical judgment regarding the appropriateness of removing the catheter if infection is evidenced elsewhere or if a non-infectious cause of fever is suspected.

Guidewire exchange

- Do not use guidewire exchanges routinely for nontunneled catheters to prevent infection.
- Use a guidewire exchange to replace a malfunctioning nontunneled catheter if no evidence of infection is present.
- Use a new set of sterile gloves before handling the new catheter when guidewire exchanges are performed.

Maximal sterile barrier precautions during catheter insertion

- Use aseptic technique including the use of a cap, mask, sterile gown, sterile gloves, and a large sterile sheet, for the insertion of CVCs.

- Maximal sterile barrier precautions (e.g., cap, mask, sterile gown, sterile gloves, and large sterile drape) during the insertion of CVCs substantially reduces the incidence of CLA-BSI compared with standard precautions (e.g., sterile gloves and small drapes).

Skin preparation

- Preferably use 2% chlorhexidine gluconate in 70% isopropyl alcohol and allow to dry.
- If patient has a sensitivity use a single patient use povidone-iodine application.

Personal protective equipment

- Gloves - Use of gloves does not obviate the need for hand hygiene.
- Eye/face protection is indicated if there is a risk of splashing with blood or body fluids.

Hand hygiene

- Decontaminate hands before and after each patient contact.
- Use correct hand hygiene procedure.

Aseptic technique

- Gown, gloves, and drapes as indicated should be used for the insertion of invasive devices.

Dressing

- Use a sterile, transparent, semi-permeable dressing to allow observation of insertion site.

Safe disposal of sharps

- A sharps container should be available at the point of use and should not be overfilled. Do not disassemble needle and syringe. Do not pass sharps from hand to hand.

Documentation

- Record the operator, date, and time of catheter insertion and removal, and dressing changes on a standardized form.

Maintenance

Hand hygiene

- Decontaminate hands before and after each patient contact.
- Use correct hand hygiene procedure.
- Use good hand hygiene before catheter insertion or maintenance, combined with proper aseptic technique during catheter manipulation, provides protection against infection.
- Use of either a waterless, alcohol-based product or an antibacterial soap and water with adequate rinsing, is acceptable.
- Observe hand hygiene before and after palpating catheter insertion sites, as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter.
- Palpation of the insertion site should not be performed after the application of antiseptic, unless aseptic technique is maintained.
- Use of gloves does not obviate the need for hand hygiene.

Aseptic technique during catheter insertion and care

- Maintain aseptic technique for the insertion and care of intravascular catheters.
- Sterile gloves should be worn for the insertion of arterial and central catheters.
- Wear clean or sterile gloves when changing the dressing on intravascular catheters.

Surveillance of Catheter site: Inspection

- Observe the site regularily for signs of infection, at least daily.
- Monitor the catheter sites visually or by palpation through the intact dressing on a regular basis, depending on the clinical situation of individual patients.

- If patients have tenderness at the insertion site, fever without obvious source, or other manifestations suggesting local or BSI, the dressing should be removed to allow thorough examination of the site.
- Encourage patients to report to their health-care provider any changes in their catheter site or any new discomfort.

Central Venous Site Care and Dressings

- An intact, dry, adherent transparent dressing should be present.
- Replace gauze dressings every 2 days.
- Replace transparent dressings every 7 days on short-term catheters.
- Replace the dressing when the catheter is replaced; when the dressing becomes damp, loosened, or soiled; or when inspection of the site is necessary.

Catheter-site dressing regimens

- Use either sterile gauze or sterile, transparent, semipermeable dressing to cover the catheter site.
- If the patient is diaphoretic, or if the site is bleeding or oozing, a gauze dressing is preferable to a transparent, semi-permeable dressing.
- Replace catheter-site dressing if the dressing becomes damp, loosened, or visibly soiled
- Change dressings at least weekly for adult and adolescent patients depending on the circumstances of the individual patient.
- Do not use topical antibiotic ointment or creams on insertion sites (except when using dialysis catheters) because of their potential to promote fungal infections and antimicrobial resistance.

Catheter Site Dressing Regimens

- Transparent dressings reliably secure the device, permit continuous visual inspection of the catheter site, permit patients to bathe and shower without saturating the dressing, and require less frequent changes than do standard gauze and tape dressings; the use of these dressings saves personnel time.

Central Venous Site Care

Cutaneous antisepsis

- Disinfect clean skin with an appropriate antiseptic before catheter insertion and during dressing changes. A 2% chlorhexidine based preparation is preferred.
- Allow the antiseptic to remain on the insertion site and to air dry before catheter insertion.
- Allow povidone iodine to remain on the skin for at least 2 minutes, or longer if it is not yet dry before insertion.
- Do not apply organic solvents (e.g., acetone or ether) to the skin before insertion of catheters or during dressing changes.

Catheter access

Use aseptic technique and swab ports or hub with 70% isopropyl alcohol or an iodophor prior to accessing the line for administering fluids or injections.

Replacement of administration sets*, needleless systems, and parenteral fluids

*Administration sets include the area from the spike of tubing entering the fluid container to the hub of the vascular access device. However, a short extension tube might be connected to the catheter and might be considered a portion of the catheter to facilitate aseptic technique when changing administration sets.

Changing Fluids and Infusion (Administration) Sets

- Following administration of blood, blood products - change immediately.
- Following total parenteral nutrition – change after 24 hours (72 hours if no lipid).
- With other fluid sets – change no more frequently than at 72-hour intervals – 96 hours.
- Replace IV tubing and add-on devices no more frequently than at 72- hour intervals – 96 hour. Replace tubing used to administer blood products or lipid emulsions within 24 h of initiating the infusion.
- No recommendation for the hang time of IV fluids, including non–lipid-containing parenteral nutrition fluids. Complete infusions of lipid-containing fluids within 24 h of hanging the fluid.
- Replace administration sets, including secondary sets and add-on devices, no more frequently than at 72-hour intervals, unless catheter-related infection is suspected or documented.
- Replace tubing used to administer blood, blood products, or lipid emulsions (those combined with amino acids and glucose in a 3-in-1 admixture or infused separately) within 24 hours of initiating the infusion.
- If the solution contains only dextrose and amino acids, the administration set does not need to be replaced more frequently than every 72 hours.
- Replace tubing used to administer propofol infusions every 6 or 12 hours, depending on its use, per the manufacturer's recommendation.

Parenteral fluids

- Designate one port exclusively for hyperalimentation if a multilumen catheter is used to administer parenteral nutrition.
- Complete the infusion of lipid-containing solutions (e.g., 3-in-1 solutions) within 24 hours of hanging the solution.

- Complete infusions of blood or other blood products within 4 hours of hanging the blood.
- When a fluid that enhances microbial growth is infused (e.g., lipid emulsions and blood products), more frequent changes of administration sets are indicated because these products have been identified as independent risk factors for CLA-BSI.
- IV-injection ports - Clean injection ports with 70% alcohol or an iodophor before accessing the system.
- Cap all stopcocks when not in use.
- Preparation and quality control of IV admixtures Admix all routine parenteral fluids in the pharmacy in a laminar-flow hood using aseptic technique.
- Do not use any container of parenteral fluid that has visible turbidity, leaks, cracks, or particulate matter or if the manufacturer's expiration date has passed.
- Use single-dose vials for parenteral additives or medications when possible.
- Do not combine the leftover content of single-use vials for later use.
- If multidose vials are used :

  1. Refrigerate multidose vials after they are opened, if recommended by the manufacturer.

  2. Cleanse the access diaphragm of multidose vials with 70% alcohol before inserting a device into the vial.

  3. Use a sterile device to access a multidose vial and avoid touch contamination of the device before penetrating the access diaphragm.

  4. Discard multidose vial if sterility is compromised.
- In-line filters - Do not use filters routinely for infection-control purposes.

Needleless intravascular devices

- Change the needleless components at least as frequently as the administration set.
- Change caps no more frequently than every 72 hours or according to manufacturer's recommendations.
- Ensure that all components of the system are compatible to minimize leaks and breaks in the system.
- Minimize contamination risk by wiping the access port with an appropriate antiseptic and accessing the port only with sterile devices.
- When the devices are used according to manufacturers' recommendations, they do not substantially affect the incidence of CRBSI.

Stopcocks

- Stopcocks (used for injection of medications, administration of IV infusions, and collection of blood samples) represent a potential portal of entry for microorganisms into vascular access catheters and IV fluids. Stopcock contamination is common, occurring in 45% and 50% in the majority of series. Whether such contamination is a substantial entry point of CRBSI has been difficult to prove.

Prophylactic antimicrobials

Do not administer intranasal or systemic antimicrobial prophylaxis routinely before insertion or during use of an intravascular catheter.

Systemic Antibiotic Prophylaxis

- No studies have demonstrated that oral or parenteral antibacterial or antifungal drugs might reduce the incidence of CRBSI among adults.

- Because the prophylactic use of vancomycin is an independent risk factor for the acquisition of vancomycin-resistant enterococcus (VRE) the risk for acquiring VRE likely outweighs the benefit of using prophylactic vancomycin.

Antibiotic/Antiseptic Ointments

- Studies have yielded conflicting results regarding the reduction in the risk for CRBSI, and an association with resistance organisms has been indicated.
- To avoid compromising the integrity of the catheter, any ointment that is applied to the catheter insertion site should be checked against the catheter and ointment manufacturers' recommendations regarding compatibility.

Antibiotic lock solutions

- Do not routinely use antibiotic lock solutions to prevent CRBSI.
- Use prophylactic antibiotic lock solution only in special circumstances (e.g., in treating a patient with a long-term cuffed or tunneled catheter or port who has a history of multiple CRBSI's despite optimal maximal adherence to aseptic technique)

Replacement of CVL

- Do not routinely replace catheters.

Documentation

- Record the operator, date, and time of catheter removal, and dressing changes on a standardized form.

Health-care worker education and training

- The comprehensive strategy should include the following three components:
    1. Educating persons who insert and maintain catheters,
    2. Use of maximal sterile barrier precautions, and

3. A 2% chlorhexidine preparation for skin antisepsis during CVC insertion.

- Educate health-care workers regarding the indications for intravascular catheter use, proper procedures for the insertion and maintenance of intravascular catheters, and appropriate infection control measures to prevent intravascular catheter related infections.
- Assess knowledge of and adherence to guidelines, periodically, for all persons who insert and manage intravascular catheters
- Ensure appropriate nursing staff levels in icus to minimize the incidence of CRBSIs

Clinical Definitions

Exit Site Infection

- Erythema or induration within 2 cm of the catheter exit site, in the absence of concomitant bloodstream infection (BSI) and without concomitant purulence.

Clinical Exit Site Infection (Or Tunnel Infection).

- Tenderness, erythema, or site induration >2 cm from the catheter site along the subcutaneous tract of a tunneled (e.g., Hickman or Broviac) catheter, in the absence of concomitant BSI.

Pocket Infection

- Purulent fluid in the subcutaneous pocket of a totally implanted intravascular catheter that might or might not be associated with spontaneous rupture and drainage or necrosis of the overlaying skin, in the absence of concomitant BSI.

Infusate-Related Blood Stream Infection

- Concordant growth of the same organism from the infusate and blood cultures (preferably percutaneously drawn) with no other identifiable source of infection.

Catheter-Related Blood Stream Infection

- Bacteremia/fungemia in a patient with an intravascular catheter with at least one positive blood culture obtained from a peripheral vein, clinical manifestations of infections (i.e., fever, chills, and/or hypotension), and no apparent source for the BSI except the catheter. One of the following should be present: a positive semiquantitative (>15 CFU/catheter segment) or quantitative (>103 CFU/catheter segment catheter) culture, whereby the same organism (species and antibiogram) is isolated from the catheter segment and peripheral blood; simultaneous quantitative blood cultures with a >5:1 ratio CVC versus peripheral; differential period of CVC culture versus peripheral blood culture positivity of >2 hours.

Clinical Definitions for Catheter-Related Infections

- Significant growth of a microorganism (>15 CFU) from the catheter tip, subcutaneous segment of the catheter, or catheter hub.
- Cultures - Do not routinely culture catheter tips.
- Laboratory-Confirmed BSI should meet at least one of the following criteria:

Criterion 1: The patient has a recognized pathogen cultured from one or more blood cultures, and the pathogen cultured from the blood is not related to an infection at another site.

Criterion 2: The patient has at least one of the following signs or symptoms: fever [>100.4º F (>38º C)], chills, or hypotension, and at least one of the following:

1. Common skin contaminant (e.g., diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negativestaphylococci, or micrococci) cultured from two or more blood cultures drawn on separate occasions.

2. Common skin contaminant (e.g., diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci, or micrococci) cultured from at least one blood culture

from a patient with an intravenous line, and the physician institutes appropriate antimicrobial therapy.

3. Positive antigen test on blood (e.g., *Hemophilus influenzae, Streptococcus pneumoniae, Neisseria meningitides,* or group B streptococcus) and signs and symptoms with positive laboratory results are not related to an infection at another site.

Criterion 3: Patient aged <1 year has at least one of the following signs or symptoms: fever [>100.4º F (>38º C)], hypothermia (<98.6º F [<37º C]), apnea, or bradycardia, and at least One of the following:

1. Common skin contaminant (e.g., diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci, or micrococci) cultured from two or more blood cultures drawn on separate occasions.

2. Common skin contaminant (e.g., diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci, or micrococci) cultured from at least one blood culture from a patient with an intravenous line, and the physician institutes appropriate antimicrobial therapy.

3. Positive antigen test on blood (e.g., *Hemophilus influenzae, Streptococcus pneumoniae, Neisseria meningitides,* or group B streptococcus) and signs and symptoms with positive laboratory results are not related to an infection at another site.

Clinical Sepsis

A diagnosis of clinical sepsis is made when one of the following criteria is met:

- The patient has at least one of the following clinical signs with no other recognized cause: fever [>100.4º F (>38º C)], hypotension (systolic pressure <90 mm Hg), or oliguria (<20

ml/hr), and blood culture not done or no organisms or antigen detected in blood and no apparent infection at another site, and physician institutes treatment for sepsis.

Catheter Venous Catheter

- A central venous catheter is a vascular access device that terminates at or close to the heart or one of the great vessels. An umbilical artery or vein catheter is considered a central line.

Catheter-Associated Blood Stream Infection

- A blood stream infection (BSI) is considered to be associated with a central line if the line was in use during the 48-hour period before development of the BSI. If the time interval between onset of infection and device use is >48 hours, there should be compelling evidence that the infection is related to the central line.

Epidemiology

- Migration of skin organisms at the insertion site (patient's skin or the health worker's hands during insertion or dressing changes) into the cutaneous catheter tract with colonization of the catheter tip is the most common route of infection short-term catheters.

Surveillance

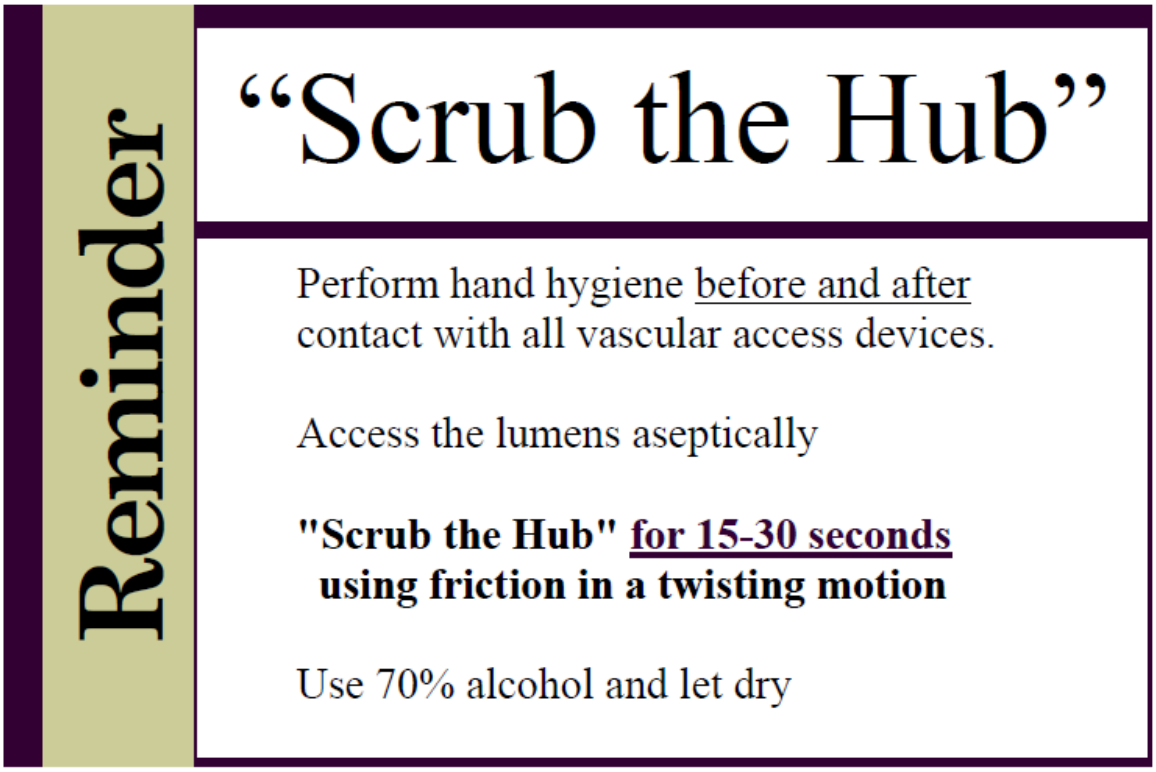
- Conduct surveillance to determine CRBSI rates, monitor trends in those rates, and assist in identifying lapses in infection control practices.
- Express Intensive Care Unit (ICU) data as the number of catheter-associated BSIs per 1,000 catheter-days to facilitate comparisons with national data in comparable patient populations and health-care settings.

Appendix N

Lunch and Learn Poster

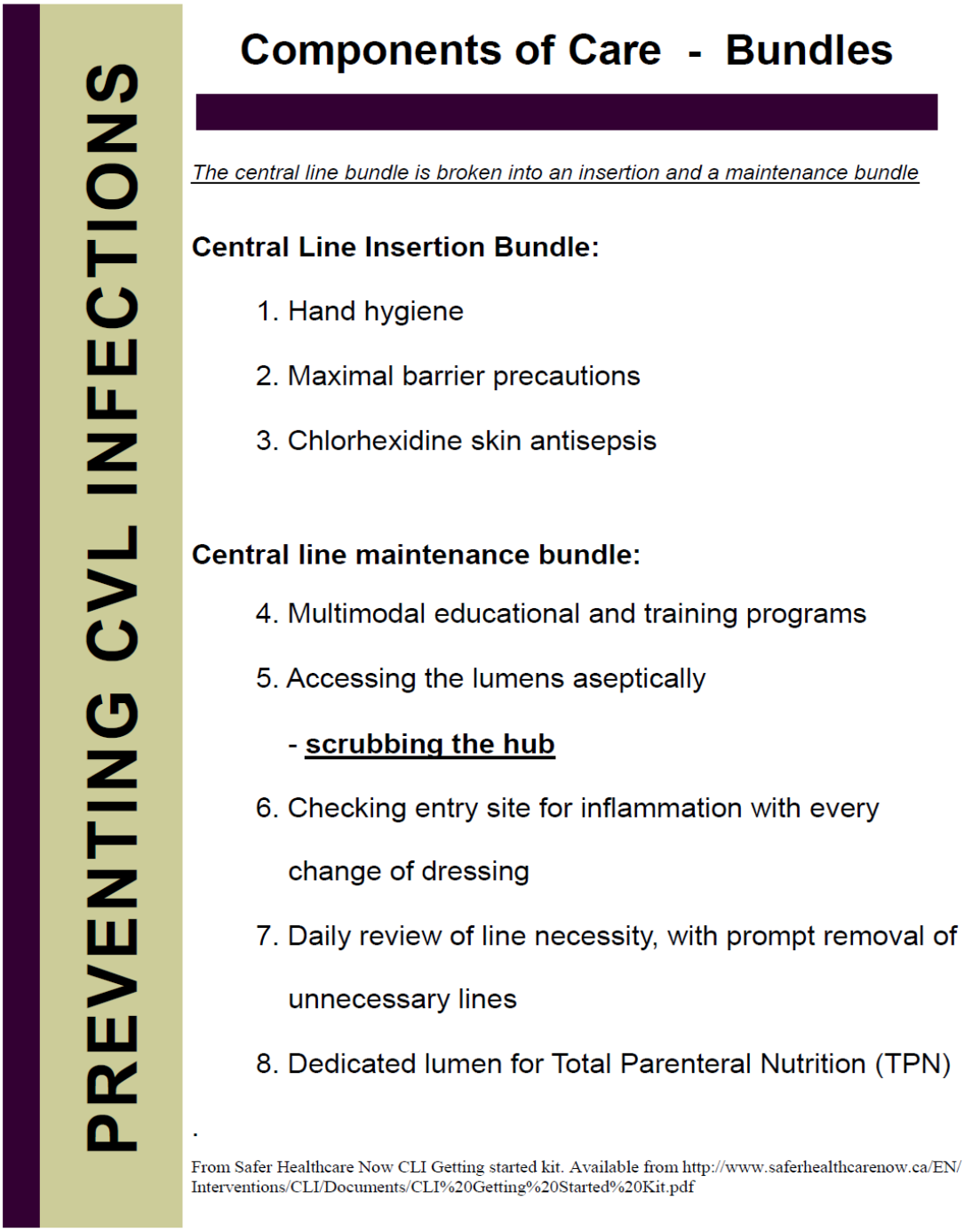
Appendix O

"Scrub the Hub" Poster



Appendix P

Fact Sheet Preventing Central Line Infections: Components of Care



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From Safer Healthcare Now CLI Getting started kit. Available from http://www.saferhealthcarenow.ca/EN/Interventions/CLI/Documents/CLI%20Getting%20Started%20Kit.pdf

Appendix Q

Fact Sheet for Checklist

Hand Hygiene:

Recommendations about hand hygiene are found in the CDC guidelines www.cdc.gov/mmwr/PDF/rr/rr5110.pdf

- When caring for central venous catheters, wash hands or use an alcohol-based waterless hand cleaner:
- Before and after palpating catheter insertion sites
- Before and after inserting, replacing, accessing, repairing, or dressing and intravascular catheter
- Palpation of the insertion site should not be performed after the application of antiseptic, unless aseptic technique is maintained.
- Wash hands if hands are obviously soiled or if contamination is suspected.
- Wash hands or use an alcohol-based waterless hand cleaner between patients, after removing gloves and after using the bathroom.

Maximal barrier precautions during insertion:

Include all of the following:

- For the Provider: Hand hygiene, non-sterile cap and mask, all hair under cap, mask covering nose and mouth tightly, and sterile gown and gloves
- For the Patient: Cover patient's head and body with a large sterile drape
- Chlorhexidine skin antisepsis: Includes all of the following:
- Prepare skin with antiseptic/detergent chlorhexidine 2% in 70% isopropyl alcohol by saturating the pad, pressing it against the skin, and applying chlorhexidine solution using a back-and-forth friction scrub for at least 30 seconds. Do not wipe or blot.
- Allow antiseptic solution time to dry completely before puncturing the site (~ 2 minutes).

Optimal catheter site selection: there are many factors to consider in any given patient when choosing the optimal site. (e.g., the potential for mechanical complications such as pneumothorax or hemorrhage, risk for subclavian vein stenosis, and catheter-operator skill) should be considered when deciding where to place the catheter.

From Safer Healthcare Now CLI Getting started kit. Available from http://www.saferhealthcarenow.ca/EN/Interventions/CLI/Documents/CLI%20Getting%20Started%20Kit.pdf

Appendix R

Ongoing Care Actions

Ongoing Care Actions

Mechanism of Contamination
Intrinsic contamination, i.e. faults already present,
e.g. manufacturing fault.

Extrinsic contamination, i.e. due to the way the system is used
i.e. inadequate swabbing of surfaces or inadequate hand washing

Hand hygiene
- Decontaminate hands before and after each patient contact.
- Use correct hand hygiene procedure.

Catheter site inspection
- Regular observation for signs of infection, at least daily.

Dressing
- An intact, dry, adherent transparent dressing should be present.

Catheter access
- "Scrub the Hub" - Use aseptic technique and swab ports or hub with alcohol, using friction in a twisting motion, prior to accessing the line for administering fluids or injections.

Administration set replacement
- Following administration of blood, blood products - immediately.
- Following total parenteral nutrition (TPN) – after 24 hours (72 hours if no lipid).
- Replace administration sets, including secondary sets and add-on devices, no more frequently than at 72-hour intervals and up to 96 hours

No routine catheter replacement

Appendix S

Central Venous Line - Site Care and Dressings

Central Venous Catheters

Site Care and Dressings

Surveillance of Catheter site: Inspection

Observe the site regularly for signs of infection, at least daily. (erythema, swelling, purulence, pain, and heat).

Monitor the catheter sites visually or by palpation through the intact dressing on a regular basis.

If patients have tenderness at the insertion site, fever without obvious source, or other manifestations suggesting local or BSI, the dressing should be removed to allow thorough examination of the site.

Central Venous Site Care and Dressings

An intact, dry, adherent transparent dressing should be present.

Replace gauze dressings every 2 days.

* Sterile gauze dressing under a transparent dressing is considered a gauze dressing

Replace transparent dressings every 7 days.

Replace the dressing when the catheter is replaced; when the dressing becomes damp, loosened, or soiled; or when inspection of the site is necessary.

Dressing regimens

Use either sterile gauze or sterile, transparent, semipermeable dressing to cover the catheter site.

If the patient is diaphoretic, or if the site is bleeding or oozing, a gauze dressing is preferable to a transparent, semi-permeable dressing.

Replace catheter-site dressing if the dressing becomes damp, loosened, or visibly soiled

Change dressings as noted above

Do not use topical antibiotic ointment or creams on insertion sites because of their potential to promote fungal infections and antimicrobial resistance.

Transparent dressings reliably secure the device, permit continuous visual inspection of the catheter site, permit patients to bathe and shower without saturating the dressing, and require less frequent changes than do standard gauze and tape dressings; the use of these dressings saves personnel time.

Central Venous Site Care - Cutaneous antisepsis

Disinfect clean skin with an appropriate antiseptic during dressing changes.

A 2% chlorhexidine based preparation is preferred.

Allow the antiseptic to remain on the insertion site and to air dry prior to applying transparent dressing

Document - date, time, condition of site

Appendix T

Additional Resources

Additional References you may find useful.

Web based

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Appendix U Pinch Tables

Year	2005
Author(s)	Lobo et al.
Title	Impact of an educational program and policy changes on decreasing catheter-associated bloodstream infections in a medical ICU in Brazil.
Journal	Am J Infect Control 2005; 33(2), 83–87
Purpose	determine the impact of an educational program targeted to specific points observed during CVC care practices on decreasing CVC-BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☑ n/a
Sample	Teaching Hospital Hospital Size: 1000 beds # ICU beds: 7
Location	Hospital das Cl´nicas of University of Sa˜o Paulo, Sa˜o Paulo, Brazil.
Setting	# ICU's 1 ☐ SICU ☑ MICU ☐ combined med/surg ☐ other
# ICU beds	7
Model of care	☐ open ☐ closed ☑ not stated ☐ patient acuity recorded
Inclusion criteria	Adult; >24hrs
exclusion criteria	Pediatric
Generalizability	The generalizability of findings from single-center studies is limited.
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no /☐ not stated
Data Collection	Dates: Jan 2001 to Dec. 2002 baseline date - # months prior: 16
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI – definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI – rates	pre–intervention period 20 post intervention 11 p = 0.07 40% change
# central line days	pre–intervention period 2450 post intervention 1381
# infections	pre–intervention period 48 post intervention 16 microorganism isolated
Instrument	
Intervention	Developed by: multidisciplinary task force ☑ poster ☑ didactic presentations - monthly ☐ self study module ☐ fact sheets ☑ pretest ☐ post test # questions – 10 ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☑ RN ☑ DR ☑ resident ☑ other nurse assistants ☐ not stated
Components	☑ hand hygiene ☑ maximal barriers (insertion) ☐ insertion cart ☑checklist
	Skin disinfection: ☐ chlorhexidine ☑provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☑ unknown Reassess CVC daily ☐ yes ☐ no ☑ unknown Other:
Design	Observational - 3 month observation period
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported; Hawthorne effect
Statistical Test	A database was performed using the program EPIINFO, CDC, version 6, 04. Relative risk ratios, 95% CI & P values ; x2 linear - compare phases
Costs Identified	No
Implications	A multiple approach included an educational strategy, targeted to specific problems observed during a careful evaluation of CVC care practices, and policy changes can decrease rates of CVC-BSI. However, despite the good results, our rates are still high, and reinforcement of CVC care practices will be continued

Year	2002
Author(s)	Coopersmith et al.
Title	Effect of an education program on decreasing catheter-related bloodstream infections in the surgical intensive care unit.
Journal	Crit Care Med 2002; 30 (1), 59–64
Purpose	education initiative aimed at improving cvc insertion and care could decrease the rate of primary bloodstream infections
PICO	Population – Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☑ n/a
Sample	university-affiliated teaching hospital Hospital Size: 1000 beds # ICU beds: 7
Location	Barnes-Jewish Hospital,(primary and tertiary care facility) located in Saint Louis, MO.
Setting	# ICU's 1 ☑SICU –burn/trauma ☐ MICU ☐ combined med/surg ☐ other
Model of care	☐ open ☐ closed ☐ not stated ☑ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric
Generalizability	The generalizability of findings from single-center studies is limited
Approval	Ethics ☑ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: Jan 1998 to Dec 2000 baseline date - # months prior - 18
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 10.8 post intervention 3.7 p = <0.0001
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention
Instrument	
Intervention	Developed by: questionnaire re RN & DR practices ☑ poster ☑ didactic presentations ☑ self study module 10 pages ☑ factsheets ☑ pretest ☑ post test # questions – 20 ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☑ Pirmary RN ☐ DR ☑ resident/fellows ☐ other ☐ not stated
Components	☑ hand hygiene ☐ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other:
Design	Pre- and post intervention observational study
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize;
Statistical Test	Data were analyzed using the statistical software program Graph-Pad Prism 3.0 The incidence Mann-Whitney test; paired t-tests _ SD.
Costs Identified	$US3,700 and $US56,167 for each catheter infection
Implications	A focused intervention primarily directed at the ICU nursing staff can lead to a dramatic decrease in the incidence of primary BSI. Educational programs may lead to a substantial decrease in cost, morbidity, and mortality attributable to central venous catheterization

Year	2008
Author(s)	Galpern et al.
Title	Effectiveness of a central line bundle campaign on line-associated infections in the intensive care unit.
Journal	Surgery, 144(4), 492-5.
Purpose	to find a way to decrease central line--associated BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☑ no ☐ n/a
Sample	Community teaching hospital Hospital Size: 628 # ICU beds: 30
Setting	# ICU's 1 ☐ SICU ☐ MICU ☐ combined med/surg ☑ unknown
Location	New York Methodist Hospital in Brooklyn
Model of care	☐ open ☐ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric
Generalizability	The generalizability of findings from single-center studies is limited
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☐ yes ☐ no ☑ not stated
Data Collection	Dates: feb 1, 2005 to April 31, 2007 baseline date - # months prior 1-5
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 5.0 post intervention 0.90 p = < 0.001
# central line days	pre–intervention period 9938 post intervention 1395
# infections	pre–intervention period ? post intervention ?
Instrument	
Intervention	Developed by: ☐ poster ☐ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☐ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☑ feedback to staff ☐ updated policies
Target	☐ RN ☐ DR ☐ resident ☐ other ☑ not stated
Components	☑ hand hygiene ☑ maximal barriers (insertion) ☑ insertion cart ☑ checklist
	Skin disinfection: ☑ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☑ unknown Reassess CVC daily ☑ yes ☐ no ☐ unknown Other: avoid femoral; 3.0silk; no antibiotic patch; intermittent U/S No change in materials during the study period
Design	Intervention study
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported; Mechanism of CLA-BSI not collected
Statistical Test	Microsoft excel spreadsheet for Windows 98 and descriptive analysis
Costs Identified	No
Implications	The implementation of a central line bundle campaign resulted in a significant decrease in line-associated bloodstream infections. Based on our study, we recommend that this protocol be adopted nationwide.

Year	2006
Author(s)	Warren et al.
Title	A multicenter intervention to prevent catheter- associated bloodstream infections.
Journal	Infect Control Hosp Epidemiol 27(7), 662–669
Purpose	To assess the effect of a multicenter intervention to prevent CLA-BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	Acedemic medical center Hospital Size: 427-1385 mean 775 # ICU beds: ?mean
Setting	# ICU's 12 ☐ SICU ☐ MICU ☐ combined med/surg ☑ bone marrow transplant unit
Location	Missouri, Maryland, Iowa, New York, Virginia; Illinois
Model of care	☐ open ☐ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric
Generalizability	
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: Jan 2002 to Dec 2003 baseline date - # months prior 5-7
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☐ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 11.2 post intervention 8.9 p= not reported (relative rate, 0.79; 95% CI, 0.67-0.93).
# central line days	pre–intervention period post intervention
# infections	
Instrument	
Intervention	Developed by: ☐ poster ☑ didactic presentations ☑ self study module 9 pages ☐ factsheets ☑ pretest ☑ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☑ updated policies
Target	☑ RN ☑ DR ☑ resident ☐ other
Components	☐ hand hygiene ☐ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other: CVCs inserted into the femoral vein decreased from 12.9% to 9.4%
Design	An observational study with a planned intervention
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	individually and in aggregate. x2 test was used to compare the proportions.
Costs Identified	approx 131 infections prevented /260-286 days of hospitalization $3,111,381 to $4,358,108
Implications	An education-based intervention that uses evidence-based practices can be successfully implemented in a diverse group of medical and surgical units and reduce CLA-BSI

Year	2004
Author(s)	Warren et al.
Title	The effect of an education program on the incidence of central venous catheter-associated bloodstream infection in a medical ICU
Journal	Chest 126(5), 1612–1618
Purpose	To determine whether an education initiative could decrease the rate of CLA-BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	Size: Hospital Size: 1400 # ICU beds: 19
Setting	# ICU's 1 ☐ SICU ☑ MICU ☐ combined med/surg ☐ _____
Location	Barnes-Jewish Hospital at Washington University School of Medicine
Model of care	☐ open ☑ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult; no antimicrobial cvc; all pt with cvl
exclusion criteria	Pediatric; arterial catheters
Generalizability	The generalizability of findings from single-center studies is limited
Approval	Ethics ☑ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: Jan 2000 to Dec 2003 baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 9.4 post intervention 5.5 p = 0.019
# central line days	pre–intervention period 7,879 post intervention 7,455
# infections	pre–intervention period 74 post intervention 41 micro-organisms Isolated
Instrument	
Intervention	Developed by: task force – ICP 9 hospitals (1998) ☑poster ☑ didactic presentations – 45 minute lecture ☑ self study module 10 page ☑ factsheets ☑ promotional campaign ☑ pretest ☑ post test # questions – 20 ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☑ RN ☑ DR ☑ resident ☐ other
Components	☐ hand hygiene ☐ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other:
Design	Pre-intervention and post intervention observational study
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	SPSS for Windows (Version 10.0; SPSS; Chicago, IL). A Fisher Exact Test; X2; Wilcoxon rank-sum test
Costs Identified	estimated cost savings (24 months post) $103,600 and $1,573,000.
Implications	An intervention focused on the education of health-care providers on the prevention of CLA-BSI may lead to a dramatic decrease in the incidence of primary bloodstream infections. Education programs may lead to a substantial decrease in medical-care costs and patient morbidity attributed to central venous catheterization when implemented as part of mandatory training

Year	2004
Author(s)	Coopersmith et al.
Title	The impact of bedside behavior on catheter-related bacteremia in the ICU
Journal	Arch Surg, 139(2),131-136
Purpose	The success of an educational program in July 1999 (Coopersmith, 2002) is correlated with compliance with "bestpractice" behaviors.
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	Referral hospital Hospital Size: 1000 # ICU beds: 18 - 24
Setting	# ICU's 1 ☑ SICU ☐ MICU ☐ combined med/surg ☐ _____
Location	Barnes-Jewish Hospital at Washington University School of Medicine
Model of care	☐ open ☐ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric; arterial catheters
Generalizability	The generalizability of findings from single-center studies is limited
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no ☑ not stated
Data Collection	Dates: July 2001 audit & 2nd audit December 2001 –(after Coopersmith 2002)
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 3.4 post intervention 2.8 p = 0.40
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention micro-organisms Isolated
Instrument	
Intervention	Developed by: ☐ poster ☐ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☐ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☑ RN ☐ DR ☐ resident ☐ other
Components	☐ hand hygiene ☐ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other:
Design	Before & after trial – Audit
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	GraphPad Prism 3.0 software (Graph-Pad Software, Inc, San Diego, Calif). Fisher exact test; Mann- Whitney test
Costs Identified	No
Implications	Although a previous educational program decreased the CRBSI rate, this was associated with only modest compliance with best practice principles when bedside audits were performed 18 months later. A behavioral intervention improved all identified deficiencies, leading to a nonsignificant decrease in CRBSIs.

Year	2004
Author(s)	Berenholtz et al.
Title	Eliminating catheter-related bloodstream infections in the ICU
Journal	Crit Care Med. 32(10), 2014–2020
Purpose	To determine whether a multifaceted systems intervention would eliminate CLA-BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☑ yes ☐ no ☐ n/a
Sample	Hospital Size: 926 # ICU beds: 16/16
Setting	# ICU's 2 ☑ SICU – 16 bed ☐ MICU ☐ combined med/surg ☑ CV ICU – 16 bed
Location	The Johns Hopkins University School of Medicine, Baltimore, MD
Model of care	☑ open ☐ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult; in ICU at least 48 hours
exclusion criteria	Pediatric; arterial catheters
Generalizability	Yes
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: Jan 1 1998 to Dec 31 2002 baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 11.3 post intervention 0 p = ? Control group pre–intervention period 5.7 post intervention 1.6 p= 0 .56
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention
Instrument	
Intervention	Developed by: ☑ poster ☑ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☑ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☑ RN ☑ DR ☑ resident ☐ other – physician extenders
Components	☐ hand hygiene ☐ maximal barriers (insertion) ☑ insertion cart ☑ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☑ yes ☐ no ☐ unknown Other: empower RN to stop insertion procedure
Design	Prospective cohort study with concurrent control group
Methodology	Control group not same type of ICU
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	A Poisson regression model with a spline (A knot); regression model included six covariates, allowing the intervention and control groups to each have its own intercepts, slopes before the knot, and slopes after the knot; Student's t-tests
Costs Identified	estimate interventions may have prevented 43 CLA-BSIs, 8 deaths, and $1,945,922 in additional costs per year in the study ICU
Implications	Multifaceted interventions that helped to ensure adherence with evidence-based infection control guidelines nearly eliminated CR-BSIs in our surgical ICU

Year	2006
Author(s)	Pronovost et al.
Title	An intervention to decrease catheter-related bloodstream infections in the ICU
Journal	N Engl J Med, 355(26), 2725-32.
Purpose	reductions in the rates of catheter-related bloodstream infection
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	52% Teaching Hospital Size: # ICU beds: 85% Michigan
Setting	# ICU's 108 ☑ SICU ☑ MICU ☑ combined med/surg ☑ one PICU
Location	All Michigan hospitals with ICUs for adults were invited to participate in the Keystone ICU project, launched in October 2003
Model of care	☐ open ☐ closed ☑ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric; arterial catheters
Generalizability	Yes
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☐ yes ☐ no ☑ not stated
Data Collection	Dates: 2004 to baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☐ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period mean 7.7 median 2.7 post intervention mean 4 median 0 p = < 0.002
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention
Instrument	
Intervention	Developed by: ☑ poster ☑ didactic presentations ☑ self study module – web based ☐ factsheets ☐ pretest ☑ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies
Target	☐ RN ☐ DR ☐ resident ☐ other ☑ not stated
Components	☑ hand hygiene ☑ maximal barriers (insertion) ☑insertion cart ☑ checklist
	Skin disinfection: ☑ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☑ yes ☐ no ☐ unknown Reassess CVC daily ☑ yes ☐ no ☐ unknown Other: empower RN to stop insertion procedure
Design	prospective cohort study design
Methodology	
Methodological Strengths	Repeated measures; multiple sites
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported; Mechanism of CLA-BSI not collected
Statistical Test	Stata software (version 9.1) Medians and interquartile ranges; two-sample Wilcoxon rank-sum test; linear latent and mixed model with a Poisson distribution; sensitivity analysis
Costs Identified	Generalized literature estimate x reduction
Implications	An evidence-based intervention resulted in a large and sustained reduction (up to 66%) in rates of catheter-related bloodstream infection that was maintained throughout the 18-month study period

Year	2000
Author(s)	Eggimann et al.
Title	Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care.
Journal	Lancet ,355, 1864-8.
Purpose	A multiple-approach intervention strategy targeted at the reduction of vascular-access infections
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	University affiliated Hospital Size: 1500 # ICU beds: 18
Setting	# ICU's 1 ☐ SICU ☑ MICU ☐ combined med/surg ☐ _____
Location	University of Geneva Hospital - Geneva, Switzerland
Model of care	☐ open ☐ closed ☐ not stated ☐ patient acuity recorded
Inclusion criteria	Adult; >48hrs
exclusion criteria	Pediatric; arterial catheters
Generalizability	The generalizability of findings from single-center studies is limited
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: to baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☐ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 11.3 post intervention 3.8 p = not stated relative risk 0·33 [95% CI 0·20–0·56]
# central line days	pre–intervention period post intervention
# infections	incidence of nosocomial infections decreased from 52·4 to 34·0 episodes per 1000 patient-days (0·65 [0·54–0·78])
Instrument	
Intervention	Developed by: ☐ poster ☑ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☐ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☐ feedback to staff ☐ updated policies ☑ individual training
Target	☐ RN ☐ DR ☐ resident ☐ other ☑ not stated
Components	☑ hand hygiene ☑ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☑ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☑ yes ☐ no ☐ unknown Other:
Design	cohort study with longitudinal assessment measured by on-site surveillance
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	EpiInfo 6.0 (CDC, Atlanta, USA) and SPSS 8.0 (SPSS Inc, Chicago, USA) means of a X2 test for binomial proportions; t tests or Wilcoxon's test
Costs Identified	prevention of those infections would amount, at least, to the annual salary of three full-time infection-control nurses
Implications	A multiple-approach prevention strategy, targeted at the insertion & maintenance of vascular access, can decrease rates of vascular-access infections and can have a substantial impact on the overall incidence of ICU-acquired infections.

Year	2005
Author(s)	Higuera et al.
Title	The effect of process control on the incidence of central venous catheter–associated bloodstream infections and mortality in intensive care units in Mexico*.
Journal	Crit Care Med, 33(9), 2022-2027
Purpose	To ascertain the effect of an infection control program including process control on ICU rates of intravascular device (IVD)–BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	University Hospital Size: 1000 (6 ICU's) # ICU beds: 12/12
Setting	# ICU's 2 ☐ SICU ☐ MICU ☑ combined med/surg – 12 bed ☑ neuro – 12 bed
Location	Mexico City, Mexico - part of an international multicenter project of nosocomial infection surveillance and infection control - International Infection Control Consortium
Model of care	☐ open ☐ closed ☑ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric; arterial catheters
Generalizability	The generalizability of findings from single-center studies is limited.
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: June 2002 to May 2003 baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☑ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 46.3 post intervention 19.5 p = 0.0001
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention
Instrument	
Intervention	Developed by: ☑ poster ☑ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☐ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☑ feedback to staff ☐ updated policies site care; gauze dressing no transparent drsg (?permeable)
Target	☑ RN ☐ DR ☑ resident ☐ other
Components	☑hand hygiene ☑ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☑ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other: * as resources permit
Design	Prospective before/aftert trial 2 phases
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	EpiInfo version 6. chi-square; Student's t-test; Fisher's exact
Costs Identified	No
Implications	Implementation of an infection control program utilizing education, process control, and performance feedback was associated with significant reductions in rates of IVD-associated BSI and mortality

Year	2003
Author(s)	Rosenthal et al.
Title	Effect of an infection of an infection control program using education and performance feedback on rates of intravascular device–associated bloodstream infections in intensive care units in Argentina.
Journal	Am J Infect Control, 31(7), 405-409.
Purpose	to ascertain the effect of an infection control program, using education and performance feedback on intensive care units, for intravascular device (IVD)-BSI
PICO	Population - Adults ICU patients; Intervention – CVC; Outcome measured – CBSI Control group ☐ yes ☐ no ☐ n/a
Sample	Type Size: 840 pts Hospital Size: 180 bed type:medical center # ICU beds: 10/10 Hospital Size: 150bed # ICU beds: 17/15
Setting	# ICU's 4 ☐ SICU ☑MICU ☐ combined med/surg ☑ coronary
Location	Buenos Aires, Argentina (Bernal Medical Center & Colegiales Medical Center)
Model of care	☐ open ☐ closed ☑ not stated ☐ patient acuity recorded
Inclusion criteria	Adult
exclusion criteria	Pediatric; arterial catheters
Generalizability	The generalizability of findings is better with two center studies but a coronary unit comparison is limited.
Approval	Ethics ☐ yes ☐ no Institutional Review Board ☑ yes ☐ no
Data Collection	Dates: April 1999 to July 2001 baseline date - # months prior
primary outcome variable	rate of CLA-BSIs # per 1,000 catheter days.
CBSI - definition	☐ National Nosocomial Infection Surveillance System (CDC) ☐ other
CBSI - rates	pre–intervention period 46.63 post intervention 11.10 p = < 0.0001
# central line days	pre–intervention period post intervention
# infections	pre–intervention period post intervention
Instrument	
Intervention	Developed by: ☐ poster ☑ didactic presentations ☐ self study module ☐ factsheets ☐ pretest ☐ post test # questions – ☑ CVC Insertion ☑ CVC Maintainance ☑ feedback to staff ☐ updated policies
Target	☐ RN ☐ DR ☐ resident ☐ other
Components	☑ hand hygiene ☐ maximal barriers (insertion) ☐ insertion cart ☐ checklist
	Skin disinfection: ☐ chlorhexidine ☐ provodone iodine ☐ other _____ CVC insertion site tracked - ☐ yes ☐ no ☐ unknown Reassess CVC daily ☐ yes ☐ no ☐ unknown Other: gauze dressing
Design	Prospective before/after trial 3 phases – 1 no intervention 2 education 3 feedback
Methodology	
Methodological Strengths	Repeated measures
Limitations	No evaluation of components individually; inability to randomize; patient acuity not reported
Statistical Test	EpiInfo version 6. Chi-square; Student's t-test; Fisher's exact
Costs Identified	prolongation of hospital stay of 12 days, an excess cost of $4888
Implications	Implementation of an infection control program, using education and performance feedback, resulted in significant reductions in rates of IVD-associated BSI