Nursing Care for Pediatric Patients with Central Venous Access Devices

By

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Abstract

Central venous access devices (CVADs) have become essential interventions for pediatric patients. However, their use is associated with serious complications. The most common and potentially preventable complication is catheter related blood steam infections (CRBSIs). Despite the implementation of interventions that have been shown to decrease their risk, CRBSIs still occur. Pediatric nurses were surveyed regarding their knowledge and application of recommended CVAD care practices, and their perspectives on possible factors that could contribute to the incidence of CRBSIs. Donabedian's (1966) Structure-Process-Outcome Model guided the study. A cross-sectional, descriptive and exploratory mixed-methods survey design was used. The convenience sample consisted of 93 pediatric nurses. Findings indicate areas of concern related to adherence to CVAD care guidelines and situations that could interfere with the provision of recommended CVAD care. The primary factor identified was the use of improper technique by members of the healthcare team and the patients' families.

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ABBREVIATIONS

AE	Adverse Events
CDC	Centers for Disease Prevention and Control
CNISP	Canadian Nosocomial Infection Surveillance Program
CPSI	Canadian Patient Safety Institute
CRBSI	Catheter-Related Blood Stream Infections
CVAD	Central Venous Access Device
ENREB	Education/Nursing Research Board
HAIs	Healthcare-Associated Infections
HCW	Healthcare Workers
ICP	Infection Control Practitioner
ICU	Intensive Care Unit
IHI	Institute for Healthcare Improvement
IV	Intravenous
MCNHR	Manitoba Centre for Nursing and Health Research
NHSN	National Healthcare Safety Network
NICU	Neonatal Intensive Care Unit
NNIS	National Nosocomial Infection Surveillance
PICC	Peripherally Inserted Central Catheter
PICU	Pediatric Intensive Care Unit
SPSS	Statistical Package for the Social Sciences
TPN	Total Parenteral Nutrition

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Chapter 1: Statement of the Problem

Central venous access devices (CVAD) have become essential interventions for the management of critically and chronically ill pediatric patients. However, their usage is associated with serious infectious complications resulting in significant morbidity, increased duration of hospitalization, and additional medical costs (Eggimann, 2007; Jeffries, Mason, Brewer, Oakes, Munoz, Gornick, et al., 2009; O'Grady, Alexander, Dellinger, Gerberding, Heard, Maki, et al., 2002).

Most CVAD infections are preventable. A number of different interventions have been implemented to address infectious risks during the insertion of the device and during the provision of device care and maintenance. Despite these interventions, catheter-related blood stream infections (CRBSI) continue to occur. Responsibility for the prevention of CVAD infections belongs primarily to the healthcare personnel who insert and care for the devices. Therefore, lack of adherence to infection control practices during the provision of care may be responsible for an overwhelming proportion of infection in these patients (Eggimann, 2007; Jeffries et al., 2009; O'Grady et al., 2002).

Bedside nurses are the primary caregivers of pediatric inpatients. Therefore, their experience when caring for pediatric inpatients that have CVADs in-situ could be helpful to understand the challenges faced when caring for children with CVADs. In addition, this information could contribute to a better understanding of what interventions may be required to minimize the risk of CRBSIs in this patient population.

In this chapter, the use of CVADs, the risks associated with their use, and the rationale behind the infection prevention strategies that have been developed in efforts to prevent and mitigate CRBSIs will be introduced. Chapter Two consists of a review the literature related to the

impact of CRBSIs. Chapter Three includes an overview of Donabedian's Quality Improvement Structure-Process-Outcome Model which is the framework used to guide this study and the development of the research questions. Methodology utilized is described and discussed in Chapter Four. Chapter Five includes the results of the study and Chapter Six is the discussion of the findings and implications for practice and research.

Background and Significance of the Problem

The use of CVADs has changed the way medical care is provided to patients. CVADs are an indispensable intervention that provides easy vascular access for patients of all ages. With the increase in more aggressive and immunosuppressive oncologic and non-oncological therapies, along with an increase in treatments given in the home setting, long-term CVADs now frequently replace conventional peripheral venous access devices (Wallace, Twomey, & O'Reilly, 2012). Therapeutic benefits of CVADs are plentiful; CVADs provide easily accessible and reliable vascular access for the administration of fluids, medications, parenteral nutrition, and blood products for hemodynamic monitoring, blood sampling, and to provide hemodialysis (Lundgren, Zhou, Malone, Mcafee, Gantt, & Zerr, 2012; Mermel, Allon, Bouza, Craven, Flynn, O'Grady, et al., 2009; Miller-Hoover, & Small, 2009). CVADs reduce the need for peripheral cannulation and venipuncture and provide a safer route for the administration of vesicant therapies thereby decreasing the risk for extravasation in the pediatric oncology population (Wallace et al., 2012). Thus CVADs also diminish treatment-related trauma and anxiety for the patient as less pain and distress are associated with accessing CVADs than with frequent peripheral cannulation required for many medication therapies (Wallace et al., 2012). CVADs are at the core of medical therapy for many critically ill or chronically ill pediatric patients.

While the benefits of CVADs are substantial, there are significant risks associated with their use. On insertion, primary complications include air embolism, hemorrhage, brachial plexus injury, thoracic duct injury, arterial puncture, cardiac tamponade, pneumothorax, hemothorax, hydrothorax and infectious complications (Hamilton, 2004; McGee & Gould, 2003). Following insertion, potential complications include catheter breakage, leakage, occlusion, malfunction, phlebitis, dislodgement, thrombus formation, endocarditis, and infection such as CRBSI (CDC, 2002; Darbyshire, Weightman, & Speller, 1985; Lundgren et al., 2012; O'Grady et al., 2002; Wallace et al., 2012; Wisplinghoff, Bischoff, Tallent, Seifert, Wenzel, & Edmond, 2004). Among these risks, CRBSIs are the most common, costly, and potentially lethal complication (Institute of Healthcare Improvement (IHI), 2012; Parienti, du Cheyron, Timsit, Traore, Kalfon, Mimoz, et al., 2012; Salzman, Isenberg, Shapiro, Lipsitz, & Rubin, 1992). While CRBIs such as bacteremia or fungemia are the most common infectious complications of CVAD use, they are also the most preventable (Eggimann, 2007; Jeffries et al., 2009; Nakazawa, 2010; Royer, 2010; Schulman, Stricof, Stevens, Horgan, Gase, Holzman, et al., 2011).

In the U.S., there are between 200,000 and 400,000 nosocomial (hospital-acquired) bloodstream infections each year; over 90% of these infections are associated with intravascular catheter devices (Edwards, Peterson, Andrus, Dudeck, Pollock, Horan, et al., 2008; IHI, 2008; Yokoe, Mermel, Anderson, Arias, Burstin, Calfee, et al., 2008). According to data from the National Nosocomial Infection Surveillance (NNIS) system (as cited in Eggimann, 2007), it is estimated that at least 48,600 intensive care unit (ICU) patients develop a CRBSI every year in U.S. ICUs. This represents approximately 5 CRBSIs per 1000 catheter days (Eggimann, 2007). It has been estimated that between 500 to 4000 patients in U.S. hospitals die annually from blood stream infections related to CVAD use (IHI, 2008; Marschall, Mermel, Classen, Arias, Podgorny,

Anderson, et al., 2008; Miller-Hoover, & Small, 2009). Although there are no equivalent Canadian statistics (Rutledge-Taylor, Matlow, Gravel, Embree, Le Saux, Johnston, et al., 2012) it is reasonable to assume a similar rate to the U.S.

For children admitted to pediatric intensive care units (PICUs), CRBSIs are the most common type of hospital acquired infection (Edwards et al., 2008). In 2004, the Centers for Disease Prevention and Control (CDC) National Healthcare Safety Network System Report stated that pediatric ICU patients had a greater risk of developing CRBSIs than their adult counterparts; pediatric patients had an average of 6.6 CRBSI/1000 catheter days versus 4 CRBSI/1000 catheter days for their adult counterparts (p. 471). These CRBSI data were collected through the NNIS from January of 1992 to June 2004 from nearly 300 hospitals in the U.S. who participate in the NNIS System. In 2013, the National Healthcare Safety Network (NHSN) (formerly the NNIS) published the results of the data collected from 2012 on healthcare-associated infections (HAIs). Although the number of CRBSIs had decreased in ICU environments overall, the pediatric ICU population continues to have a greater number of CRBSIs than their adult counterparts (Dudeck, Weiner, Allen-Bridson, Malpiedi, Peterson, Pollock, et al., 2013).

For patients and their families, these infections are associated with increased stress, anxiety, fear, and personal hardship. From a broader and more global perspective, CRBSIs are associated with increased mortality and morbidity, prolonged hospitalization, extended hospital stays, and greater hospital costs (Burke, 2003). In 2003, Douglas Scott, an economist for the division of Healthcare Quality Promotion in the U.S., estimated the cost of a CRBSI to be between $5,734 to $22,939 U.S. per episode with an associated mortality rate ranging from 4% to 20%. Pronovost (2006) reported the associated costs to ICUs ranging from $11,971 to $54,000 per infection

(Pronovost, Needham, Berenholtz, Sinopoli, Chu, Cosgrove, et al., 2006). There are no equivalent Canadian statistics regarding costs.

Purpose of the Study

The purpose of this study was to evaluate pediatric nurses' experience when caring for patients in a pediatric setting with a CVAD in-situ. The nurses were invited to share their perspectives, observations, and experiences related to factors that may contribute to, or minimize, the risk of CRBSIs in this patient population. This study will contribute to a better understanding of the complex needs of this population and may allow for the advancement of knowledge regarding the challenges that pediatric nurses face when caring for their patients. The findings may also identify risk factors and guide potential practice changes necessary to reduce or prevent CRBSIs in the pediatric setting.

CHAPTER 2: Review of the Literature

A literature search was conducted using the Cochrane Library, CINAHL, Medline and PubMed data bases for the most recent seven year time period (2007-2014). Initial search words were “central venous catheter” OR “central venous access device” AND “pediatrics” AND “catheter-related blood stream infection” OR “central line-associated blood stream infection” AND “prevention” AND “guidelines.” This query provided 238,951 articles. Additional search words were added: “not intensive care” and “not neonates” not “hemodialysis” not “guidelines” and not “prevention” were removed to the advanced search. This led to 2794 publications. Studies were included if they were peer-reviewed and if the data were collected on pediatric patients who had a CVAD in-situ. References from relevant articles using the above search terms were also accessed. Additional publications were included if any reference to Safer Healthcare Now! or IHI central venous line care bundle, or some components of that bundle was included in the abstract. Articles including issues essential for the prevention of CRBSIs and care and maintenance guidelines for CVADs were also included in the literature review.

The review of the literature is intended to provide a backdrop for the study of the use of CVADs in the provision of pediatric patient care and the identification of risk factors associated with the use of these potentially lifesaving devices. The review includes literature relevant to the prevalence, prevention, and common characteristics of CRBSIs.

Patient Safety

Patient safety has been defined as prevention of harm to the patient (Health Canada, 2004). Although efforts to improve healthcare quality have grown over the last two decades, patient safety as a health policy issue is relatively new. The evolution of patient safety as a health policy issue is rooted in the release of the Quality in Australian Health Care Study (Wilson, Runciman, Gibberd,

Harrison, Newby, & Hamilton, 1995) and the "To Err is Human" report from the Institute of Medicine in the U.S. (Kohn, Corrigan, & Donaldson, 2000). These reports were the driving force for the patient safety movement. They focused the attention of governments and healthcare providers on adverse events and attached a moral as well as monetary value to adverse events. The CDC calculates that health-care-associated infections (HAIs) affect 5% of all patients hospitalized in the U.S. each year (U.S. Department of Health and Human Services, 2011) and includes CRBSI as one of the most important and deadly HAIs, with a reported mortality rate of between 12 to 25% (U.S. Department of Health and Human Services, 2011).

In 2002, the Canadian Nosocomial Infection Surveillance Program (CNISP) conducted a point prevalence study of HAIs for Canadian inpatients and found the prevalence to be 8% in pediatric patients (Gravel, Matlow, Ofner-Agostini, Loeb, Johnston, Bryce, et al., 2007). In that study, CRBSIs were found to be the most common HAI (Gavel et al, 2007) followed by pneumonia and viral gastroenteritis. In 2009, in order to assess HAI trends longitudinally, the CNISP repeated the study using the same methodology in the same patient population (Rutledge-Taylor et al., 2012). Results from that study showed that the prevalence of HAIs has remained fairly steady at 8.7% for children admitted to Canadian acute care hospitals (Rutledge-Taylor et al., 2012). These findings are consistent with the U.S. CDC results; CRBSI continues to be the most common HAI among pediatric patients in Canada hospitals with a prevalence of 2.8% (Rutledge-Taylor et al., 2012).

A number of studies have been undertaken to gain a better understanding of hospital safety. The incidence rates of adverse events (AE) in acute care hospitals have been reported in the U.S. (Brennan, Leape, Laird, Hebert, Localio, Lawthers, et al., 1991; Thomas, Studdert, Burstin, Orav, Zeena, Williams, et al., 2000), Australia (Wilson et al., 1995), the United Kingdom (Vincent,

Neale, & Woloshynowych, 2001), and more recently in Canada (Baker, Norton, Flintoft, Blais, Brown, Cox, et al., 2004). These studies indicate that between 5 and 20% of patients admitted to hospital will experience one or more AEs. Importantly, 36.9% to 51% of these AEs are preventable. AEs cost health care systems billions of dollars related to increased lengths of stay, as well as other personal costs that patients and their families must assume in relation to extended hospital stays, such as lost wages, and potentially lodging or accommodations if they are relocated away from their homes (McIntosh, 2002; Posfay-Barbe, Zerr, & Pittet, 2008).

Leape et al. (1991) indicate that more than two-thirds of AEs are preventable (Leape, Brennan, Laaird, Lawthers, Logalio, Barnes, et al., 1991). Together with reports in the media of deaths caused by health system error consumer demand and political pressure (Barach & Berwick, 2003), national policy documents have been developed in the United Kingdom (Department of Health, 2000), the U.S. (Institute of Medicine, 2001), Australia (Australian Council for Safety and Quality in Health Care, 2001) and in Canada (National Steering Committee on Patient Safety, 2002). These policy documents provide plans and direction for policymakers, health care leaders, and clinicians regarding system changes necessary to improve patient safety practices, the creation of patient safety cultures, and support for research and knowledge generation and translation around patient safety practices.

Baker et al. (2004) carried out the first study of adverse events for patients in Canadian hospitals, *The Canadian Adverse Events Study*, which focused only on adult acute care. The authors studied 20 hospitals of varying sizes in five provinces and conducted retrospective chart reviews of over 4100 hospital admissions. They assigned an incidence rate of adverse events of 7.5%. Their findings suggest that of the almost 2.5 million Canadian hospital admissions

annually, 185,000 were associated with an AE of which nearly 38% were potentially preventable (Baker et al., 2004).

In 2002, the Canadian government allocated $50 million over 5 years for the creation of the Canadian Patient Safety Council (Baker et al., 2004), now known as the Canadian Patient Safety Institute (CPSI),which provides a leadership role with respect to patient safety issues within the context of building upon quality health care (CPSI, 2002). Their initiatives include supporting research funding for patient safety, the development of patient safety tools, and root-cause analysis training. The CPSI initiated a grassroots approach to helping Canadian healthcare organizations institute safer care by initially focusing on six interventions aimed at reducing mortality and morbidity commonly known as the "Safer Healthcare Now Campaign" (CPSI, 2005). In 2012, the initial six interventions expanded to ten patient safety interventions. These interventions focus on myocardial infarction, infection prevention and control, central line-associated blood stream infection, reducing falls and injury from falls, medication reconciliation, rapid response teams, surgical site infection, ventilator associated pneumonia, venous thromboembolism, and safe surgery (Safer Healthcare Now!, 2012). The Safer Healthcare Now! interventions combine clinical and patient safety improvement expertise and are designed to provide health care institutions with tools that can be used to implement, measure, and evaluate safety initiatives undertaken to improve patient safety.

Prevention of Catheter Related Blood Stream Infections

In 2007, the Institute for Healthcare Improvement (IHI) presented the Central Line Care Bundle at the 100,000 Lives Campaign. Like the Canadian initiative, it was an attempt to engage teams of clinicians internationally to improve the quality of central line care. The central line care bundle is a group of evidence-based interventions for patients with intravascular CVADs that, when

implemented together, result in better outcomes than when implemented individually (IHI, 2008). It was hypothesized that if clinicians followed all the interventions outlined in the bundle, the results would demonstrate a significant improvement in patient care outcomes. These interventions were developed and implemented primarily in intensive care units; however, many authors believe that the bundle can be used in inpatient, ambulatory care, and hemodialysis units effectively (Eggimann, 2007; IHI, 2102).

The vast majority of the evidence-based interventions included in the Central-Line Care Bundle were developed from studies performed in adult populations. Many of the conclusions for pediatric patients are extrapolated from evidence provided by adult patient studies (Huang, Chen, Abdullah, Aspelund, Barnhart, Calkins, et al., 2011), indicating the need for evidence-based pediatric guidelines.

Central-Line Care Bundle. In 2000, Leonard Mermel completed a systematic review of 133 articles published between 1966 and 1999 addressing the prevention of infection in CVADs and subsequently developed guidelines for the care of CVADs. Mermel (2000) recommended the following four components be included in a central line insertion bundle: skin antisepsis with 2% chlorhexidine, the use of a maximum barrier precaution to reduce the incidence of CRBSI, removal of the CVAD as soon as possible, and insertion of the catheter into the subclavian vein is the preferred location to reduce the risk of infection.

In 2002, Naomi O'Grady led a multidisciplinary working group which reviewed 293 articles published between 1975 and 2000. This review led to the publication, "The Guidelines for the Prevention of Intravascular Catheter-Related Infections." Areas of emphasis include:

1) Education and training for health-care providers who insert and maintain catheters;

2) Use of maximum sterile barrier precautions during central venous catheter insertion;
3) Use of 2% chlorhexidine preparation for skin antisepsis;
4) Avoidance of routine replacement of central venous catheters as a strategy to prevent infection; and
5) Use of antiseptic/antibiotic impregnated short-term central venous catheters if the rate of infection is high despite adherence to other strategies (i.e., education and training, maximal sterile barrier precautions, and 2% chlorhexidine for skin antisepsis) (O'Grady et al., 2007)

These guidelines also identified performance indicators that could be used locally by health-care institutions or organizations to monitor their success in implementing the evidence-based recommendations. These guidelines provided health-care practitioners with background information and specific recommendations to reduce the incidence of intravascular CRBSIs.

Other systematic reviews added further evidence-based recommendations for the development of the IHI Central Line Bundle. In 2007, the Agency for Healthcare Research and Quality (AHRQ) (Ranji, Shetty, Posley, Lewis, Sundaram, Galvin, et al., 2007) published a review of 4847 articles published between 1991 and 2006. The review group concluded that in addition to the Mermel (2000) and O'Grady et al. (2002) recommendations, the careful selection of the CVAD insertion site and the inclusion of a checklist to improve fidelity to the care bundle and associated educational offerings should be included (Ranji et al., 2007).

In 2008, Yokoe led a group of 25 experts who reviewed 106 articles on the prevention of healthcare-associated infections (Yokoe, Mermel, Anderson, Arias, Burstin, Calfee, et al., 2008). The resulting guidelines include practical recommendations to assist hospitals in implementing and

prioritizing CRBSI prevention efforts (Miller-Hoover & Smith, 2009). Their findings strongly support the preventative components of care to be included in the CVAD care bundle to reduce CRBSIs. The bundle component recommendations from Mermel (2000), O'Grady et al., (2002), Ranji et al., (2007) and Yokoe et al., (2008) include:

1) The use of 2% chlorhexidine for skin antisepsis;
2) Adherence to maximal sterile bundle precautions;
3) Avoidance of femoral catheterization;
4) Hand hygiene;
5) Removal of the CVAD at the earliest opportunity;
6) Education regarding the components of the central-line care bundle; and
7) Assessing protocol adherence through the use of a central-line checklist.

(Marschall et al., 2008; Mermel, 2000; O'Grady et al., 2002; Yokoe et al., 2008)

In their systematic review, Ranji et al., (2007) found that an organized approach to protocol implementation, staff education, central line insertion, and ongoing surveillance for protocol adherence appeared to be necessary to ensure the reduction in the rate of CRBSIs.

Catheter Related Blood Stream Infections

Definition

One of the main issues in interpreting literature concerning infectious complications of CVADs is the inconsistent use of terms and definitions (de Jonge, Polderman, & Gemke, 2005). Catheter-related bloodstream infections are defined by the CDC (2002) as:

> …bacteremia/fungemia in a patient with an intravascular catheter with at least one positive blood culture obtained from a peripheral vein, clinical manifestations of

> infection (i.e., fever, chills, and/or hypotension), and no other apparent source for the bloodstream infection except for the catheter. Bloodstream infections are considered to be associated with a CVAD if the line was in use during the 48-hour period before the development of the bloodstream infection. If the time interval between the onset of infection and device use is greater than 48 hours then this should lead the clinician to the conclusion that the infection is related to the CVAD (CDC, 2002, p. 4).

In order to calculate the number of CRBSIs over time, one must calculate the proportion of the total number of days that CVADs are present and compare it to the total number of CRBSIs occurring during that time. For example, if in February there were 12 cases of CRBSI, the number of cases would be 12 for that month. If 25 patients had CVADs during the month and, for purposes of this example, each kept their line for 3 days, the number of catheter days would be 25 x 3 = 75 for February. The CRBSI rate per 1,000 catheter days then would be 12/75 x 1000 = 160. Prior to standardizing to this method, centres did not calculate infection rates in the same manner; therefore accurate comparisons were not possible. Centres across the world are now collecting data in the same way allowing for a more accurate understanding and comparison of CRBSI rates.

Calculating infection rates in this manner is a time consuming and often difficult endeavor, especially in an inpatient setting where patients are admitted, transferred from one unit to another, and potentially discharged in a short period of time. Documentation of the presence of a CVAD is often difficult to track without adequate human resources in infection control and prevention. Infection control practitioners have historically prioritized data collection for CRBSIs in ICU environments. Pronovost et al. (2006) suggest that an infrastructure of hospital-based infection control practitioners is necessary to measure and evaluate the effect of

interventions to increase patient safety. Funding this type of work is not always seen as a priority in our current healthcare systems.

It is only recently that inpatient units have formally been included in CRBSI prevention strategies (Dudeck, Weiner, Allen-Bridson, Malpiedi, Peterson, Pollock, et al., 2013). This quality improvement is primarily related to the work of the National Healthcare Safety Network (NHSN) which is tasked with collecting and analyzing data from health care facilities in the U.S. to allow for a valid estimation of the magnitude of adverse events among patients and health care personnel (Dudeck et al., 2013). The NHSN is designed to allow for surveillance of selected healthcare associated infections in hospital inpatient, outpatient and other types of healthcare facilities (Hidron, Edwards, Patel, Horan, Sievert, Pollock, et al., 2008).

Risk Factors for Catheter Related Blood Stream Infection

The risk of blood stream infection varies according to the type of device (Maki, Kluger, & Crinch, 2006); the intended use; the insertion site location; the experience and education of the individual inserting the device; the number of catheter lumens; the nurse to patient ratio; the duration of catheter placement, the characteristics of the patient, and the use of infection prevention strategies (Merrer, De Jonghe, Golliot, Lefrant, Raffy, Barre, et al., 2001; Maki, Kluger, & Crinch, 2006; O'Grady et al., 2002; Safdar & Maki, 2004). The frequency or number of times the device is accessed can also increase the risk for CRBSI. Any manipulation of the delivery system, especially the administration set, provides an effective means for the admission of microorganisms into the infusate (Macklin, 2010). Contamination of the hub of the CVAD also increases the risk of CRBSI and is a more common route for infections in long-term catheters (i.e., in place greater than 30 days), while skin contamination is the most likely cause for short-term catheters (i.e., in place less than10 days) (Raad, 1998).

In pediatrics, the younger the patient, the greater the risk for developing a CRBSI (Schulman et al., 2011). Patients who are immunocompromised, malnourished, and/or receiving parenteral nutrition for growth and survival are all at an increased risk for the development of a CRBSI (Oliveira, Nasr, Brindle, & Paul, 2011; Posfay-Barbe, Zerr, & Pittet, 2008). Some risk factors specific to children can be related to their inherent immunological naivety (Posfay-Barbe, Zerr & Pittet, 2008). Younger children have an increased susceptibility to many infections, particularly to common pathogens are that are prevented in older patients through vaccination or previous exposures (Posfay-Barbe, Zerr & Pittet, 2008). The mitigation of risk factors can directly impact the incidence of CRBSIs.

Routes of Infection

Bloodstream infections associated with CVADs can be attributed to four main routes. The most common cause of CRBSIs is related to the migration of skin organisms at the insertion site into the cutaneous catheter tract and along the outside surface of the catheter tip during or after CVAD insertion (Kallen, Patel, & O'Grady, 2010; O'Grady et al., 2002; O'Grady et al., 2011; Safdar, & Maki, 2004); this is often referred to as extraluminal migration. During CVAD insertion if the skin is not decontaminated adequately the outside of the catheter may become contaminated as it is pushed through the skin and organisms are delivered directly into the circulation. Extraluminal contamination may also occur when microorganisms from the patient's skin migrate down the catheter tract from the surface of the skin to the vein entry site (Scales, 2011). Extraluminal contamination source accounts for 60% of all CRBSIs (Kallen, Patel, & O'Grady, 2010).

The second most common route is through direct contamination of the catheter or catheter hub by contact with hands, contaminated fluids or devices (Dobbins, Kite, Kindon, McMahon, Wilcox, 2002; O'Grady et al., 2011); this route is referred to as intraluminal migration. Intraluminal migration refers to the contamination of the internal lumen of the CVAD. The catheter hub becomes contaminated with microorganisms from the patient's skin or from the hands of healthcare workers (HCW). If the device is used without cleansing the outside of it prior to accessing, organisms can gain entry to the internal lumen and gain direct access to the bloodstream (Scales, 2011).

The third cause of infections in CVADs occurs via hematogenous seeding from another focus of pre-existing infection, such as pneumonia, urinary tract infections, or mucositis (O'Grady et al., 2002; Raad, Hanna, Awad, Alrahwan, Bivins, Khan, et al., 2001). The organism causing the infection can enter the circulation and be transported around the body leading to colonization of the CVAD.

The least common route of infection is contamination of the infusate (Pratt et al., 2007). This refers to the administration of infusion fluids or medications that are contaminated with microorganisms. Infections related to the administration of contaminated intravenous fluids are rare but could be possible when bacteremia occurs in otherwise low-risk patients, or when there are clusters of bloodstream infections with unusual organisms (Raad et al., 2001).

The general consensus in infection control and prevention related to the most common causes of CRBSIs are: the improper and unsafe insertion of the CVAD, followed closely by improper care and maintenance (Dobbins et al., 2002; O'Grady et al., 2002, O'Grady et al., 2011; Raad et al., 2001; Royer, 2010; Safdar & Maki, 2004). These two points in care have been the main focus of CRBSI prevention strategies. Although the current study is not focusing on insertion

techniques or practices, having a greater understanding of the processes involved over a trajectory of time may allow for a more holistic sense of the complexity of the infection control strategies associated with CVADs.

Insertion

Skin is the largest organ in the body; healthy intact skin is the body's first line of defense against microbial invasion (Nakazawa, 2010). Human skin harbors resident and transient skin microflora, 80% of which can be found in the top five layers of the epidermis. The remaining 20% can be found deeper in the hair follicles and oil glands (Todar, 2010). Hydration, overall general health, and intactness of the skin are vital to supporting our inherent defenses against microbial invasion (Nakazawa, 2010). CVADs disrupt the integrity of the skin, making infection with bacteria or fungi possible. CRBSI may spread to the bloodstream and produce hemodynamic changes; subsequent organ dysfunction may result, possibly leading to death (Nakazawa, 2010).

As soon as a CVAD has been inserted through the skin, a surgical wound is created which immediately lowers the host's ability to defend against infection. The insertion site of a CVAD is the most common source of colonization and infection in CVADs that have been in-situ for less than 10 days (Raad, 1998). Patients' resident or transient microflora from the insertion site and the skin of medical personnel are the two most common sources of contamination (Boersma, & Schouten, 2009; Nakazawa, 2010; Newman, Issa, Greenberg, Kapelushnik, Cohen, Leibovitz, et al., 2012; Ramritu, Halton, Cook, Whitby, & Graves, 2008). Skin-dwelling microorganisms such as *Staphylococcus epidermidis* and *Staphylococcus aureus* are the most common CRBSI pathogens (Raad, Hohn, Gilbreath, Suleiman, Hill, Bruso, et al., 1994).

There are four key infection prevention strategies that are specific to the insertion of a CVAD. These strategies apply to the surgeon, intensivist or other healthcare personal who insert

the devices. The strategies include skin antisepsis, maximal barrier precautions, catheter site selection and protocol adherence.

Skin Antisepsis

Prevention of CRBSIs focuses primarily on a pristine aseptic insertion technique (Boersma, & Schouten, 2009). The goals of aseptic technique are to remove transient organisms from the skin, reduce the number of microbial flora and inhibit their growth, and create a sterile surface that acts as a barrier between the insertion site and any possible contamination (Macklin, 2010).

In animal studies undertaken by Cooper (1988, as cited in Raad et al., 1994, p. 232) it was found that contamination of the skin entry site during insertion resulted in catheter tip colonization within one hour of insertion. Antiseptic agents decrease the microbial burden at the insertion site and interrupt the migration of organisms along the cutaneous tract of the catheter, thus preventing catheter colonization and infection (Macklin, 2010; Raad et al., 2004). Preparation of the central venous and arterial sites with a 2% aqueous solution of chlorhexidine gluconate was found to lower blood stream infection rates compared to site preparation with 10% povidone-iodine or 70% alcohol (Maki, Ringer, & Alvarado, 1991). Evidence suggests that chlorhexidine-containing skin preparations are the superior option for skin asepsis (O'Grady et al., 2011; Pratt et al., 2007; Raad et al., 2004). A meta-analysis from 2002 demonstrated use of a chlorhexidine-containing preparation decreased central catheter-related infections by 49% compared to povidone-iodine preparations (Chaiyakunapruk, Veenstra, Lipsky, & Saint, 2002).

A separate clinical trial looking at surgical site antisepsis in 2010 consisted of the study of 809 subjects who were randomized to either a 2% chlorhexidine gluconate and 70% isopropyl alcohol preparation or a 10% povidone-iodine preparation for surgical site antisepsis (Darouiche, Wall, Itani, Otterson, Webb, Carrick, et al., 2010). A total of 409 subjects were randomized to the

chlorhexidine-alcohol group and 440 to the povidone-iodine group. The authors found that there was a significantly lower rate of surgical-site infections in the chlorhexidine-alcohol group (9.5%) than the povidone-iodine group (16.1%). Currently, the superiority of chlorhexidine and alcohol solutions for skin antisepsis remains undisputed.

Maximal Barrier Precautions

Once skin antisepsis has been completed the use of maximal sterile barrier is required to ensure that the least amount of organism contamination occurs prior to the CVAD insertion. In a randomized control trial Raad et al. (1994) looked at the use of maximal sterile barrier precautions during CVAD insertion. The intervention group consisted of the use of a maximal sterile barrier that included sterile gloves, gowns, and a large sterile drape, as well as non-sterile masks and caps; versus the control group which consisted only of sterile gloves and a small sterile drape. The authors found that the catheter-related septicemia rate was 6.3 times higher in the control group than the intervention group (Raad et al., 1994). Another study looking at the insertion of pulmonary artery catheters found that the odds of developing an infection were more than two times greater when maximal sterile barriers were not in place (Mermel, McCormick, Springman, & Maki, 1991).

Optimal Catheter Site Selection

The site at which a catheter is placed may influence the subsequent risk for catheter-related infection and non-infectious complications (Ranji et al., 2007). There are three different skin ecosystems that may contribute to catheter site selection: dry (arm), wet (chest, groin), and sebum-rich (jugular) (Hadaway, 2003). Not only does moisture allow bacteria to flourish, it provides a medium for organism transit over the skin and down the catheter tract via capillary action and diffusion (Macklin, 2010). In adults, normal colonization rates of unwashed skin on the neck or chest average between 1,000 and 10,000 colony-forming units per cubic centimeter ($CFUs/cm^2$)

(Todar, 2010). The skin on the arm is drier, less oily, and cooler, and therefore harbours lower endogenous resident microbial counts to approximately 10 CFUs/cm² (Todar, 2010). The skin of the axilla and groin is wet with the highest number and type of microbes, and should be avoided if other insertion sites are available (Ranji et al., 2007). CVADs placed in the jugular vein have higher rates of infection than subclavian insertions, likely related to the density of the skin flora (Pearsom, 1996) and the close proximity to respiratory and oral microorganisms (Macklin, 2010). For adults, lower extremity insertion sites are associated with a higher risk for infection than are upper extremity sites. As a result, in adults, some studies recommend that in order to reduce the risk for infection that the femoral vein be avoided, and the subclavian site may be preferred over the jugular (IHI, 2012).

In pediatric patients, the three most common sites for CVAD placement are the femoral, subclavian, and internal jugular veins (Karapinar & Cura, 2007). Although pediatric patients may be regarded as "little adults," there are many differences regarding CVAD use between adults and children, especially if the child is less than 8 years old (de Jonge, Polderman, & Gemke, 2005). For pediatric patients continuous changes in growth and development and diverse age categories may require different approaches when it comes to CVAD insertion. For children, the insertion site is often dependent on their age; the overall clinical situation; and the need for additional sedation, airway management and anesthesia during insertion (de Jonge, Polderman, & Gemke, 2005).

In pediatric studies examining catheter site selection for patients located in intensive care unit settings, there is no evidence to suggest that femoral sites should be avoided (Casado-Flores, Barja, Martino, Serrano, & Valdivielso, 2001; de Jonge, Polderman, & Gemke, 2005; Karapinar, & Cura, 2007). However, a study by McIntosh (2002) showed that patients under four years of age with catheters inserted in a femoral site close to the diaper area were at greater risk for line

infections. On inpatient units, when appropriate, patients are generally encouraged to be mobile; one could argue that a femoral CVAD may decrease activity level of the patient potentially leading to undesirable consequences such as pain, thrombosis and mechanical irritation. In younger patients who are still in diapers the CVAD may be at risk for exposure to feces and urine and thereby increase the risk of contamination and subsequent infection (McIntosh, 2002).

Types of Catheters

Catheter type also influences the incidence of infection in CVADs. The NHSN has defined a CVAD as a catheter whose tip terminates in a great vessel (Dudeck et al., 2013). The great vessels include the aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, external iliac veins, and common femoral veins. Neither the type of line or insertion site determines if a line is a central line; it is a CVAD only if it terminates in a great vessel (Dudeck et al., 2013). Dialysis catheters and umbilical catheters were not included in this review.

Non-tunnelled CVADs. Percutaneously inserted, non-tunnelled CVADs are commonly used for short term (less than 14 days) dwell times. These CVADs are frequently used in pediatric critical care settings. The devices are routinely inserted into central veins (subclavian, internal jugular, or femoral) and are anchored to the skin with sutures (O'Grady et al., 2011). As non-tunnelled CVADs have a significant risk of being dislodged or inadvertently removed (de Jonge, Polderman, & Gemke, 2005), these CVADs are often removed prior to the patient being transferred to inpatient settings where the level of observation tends to be less. This type of catheter accounts for the greatest majority of CRBSIs (O'Grady et al., 2011); they are also inserted into some of the most critically ill patients.

Tunnelled CVADs. Tunnelled CVADs are used commonly for long term dwell times ranging from months to years. These CVADs are implanted into subclavian, internal jugular, or femoral veins (O'Grady et al., 2011). Tunnelled CVADs are associated with lower rates of infection than non-tunnelled CVADs (O'Grady et al., 2011) and are available in a range of diameters, lengths, and number of lumens.

On insertion, these catheters are tunnelled subcutaneously from the entry site at the skin surface to the access point into the vascular system (Green, 2008). During insertion, the Dacron® cuff present on the catheter is positioned approximately 3-5cm from the exit site. The cuff induces an inflammatory response in the subcutaneous tunnel leading to fibrosis; this serves two purposes, one to keep the catheter in place, and secondly to act as a barrier between the skin and vascular system (Green, 2008). The Dacron® cuff may be impregnated with antimicrobial properties which can also decrease the risk for infection (O`Grady et al., 2011; Pratt et al, 2007). Tunnelled external catheters are inserted while the patient is under general anesthetic in an operating theatre. Once inserted, the external components of the catheter protrude from the skin; older children may experience distress and conflict with their body image (McInally, 2005). McIntosh (2002) found that children under the age of four years had a higher incidence of accidental removal of this type of CVAD. For this patient population surgically implanted ports may be beneficial.

Surgically implanted ports. These devices are commonly used if a long indwelling time is expected (months to years) and a single lumen is sufficient for the treatment regimen. These ports are surgically implanted under the skin; the surgeon creates a pocket, usually in the upper chest wall below the clavicle, and the catheter is then tunnelled and inserted into the subclavian or internal jugular veins (O'Grady et al., 2011). Once healed the pocket provides a barrier to block bacteria from migrating down the catheter tract into the bloodstream (Nakazawa, 2010).

One of the primary benefits of a totally implanted port is the low risk of displacement of the central part of the catheter (Munro, Gillett, Wratten, Shaw, Thomas, MacKinlay, et al., 1999) making it less intrusive. When not in use, there are no external components hanging from the body (McInally, 2005) thus allowing the patient to participate in activities of daily living that would be contraindicated if a CVAD with external components was present. When the port is not accessed, swimming, bathing, and exercise can be maintained (McInally, 2005). Implanted ports do not require regular catheter site care like externally placed CVADs and have a lower incidence of CRBSIs when compared to both tunnelled and non-tunnelled CVADs (Newman et al., 2012; O`Grady et al., 2011; Pratt et al., 2007).

Despite the lower risk of infections, implanted ports are not always the best treatment modality. One downfall is that they require access by inserting a non-coring needle through the skin into the septum of the port, thus requiring aseptic insertion technique by the healthcare personnel accessing the device. The insertion of the non-coring needle can also be painful; interventions such as topical anesthesia are often necessary to effectively and proactively mitigate any related pain and discomfort. A second downfall may occur if needle dislodgement or incomplete needle placement occurs (McInally, 2005) thus increasing the risk for infection, extravasation, discomfort and anxiety. The third downfall is that during insertion and removal a surgical intervention is required (O'Grady et al., 2011) exposing the patient to general anesthetic and its associated risks.

Peripherally inserted central catheters. (PICCs). PICCs are used for intermediate to long term use. This is the ideal device for patients with infectious complications for the delivery of intravenous antibiotics over a course of many weeks, and for patients who have medical conditions that contraindicate central access into the thoracic vessels (Nakazawa, 2010). PICCs are generally inserted by vascular access team nurses percutaneously into the basilica, cephalic or brachial veins

which then enter the superior vena cava (O'Grady et al., 2011). PICC insertion does not require a general anesthetic and in some cases PICCs are inserted without any sedation requirements. This may allow for a timelier insertion as operating theatres, anesthetists and surgeons are not required to be booked. PICCs are also associated with lower rates of infection than non-tunnelled and tunnelled CVADs (O'Grady et al., 2011).

In addition to the type of CVAD employed, the lumen number is also an important factor to consider in infection prevention strategies. Recommendations from the CDC (2002) include that single-lumen devices be used unless there is a clinical need for a multi-lumen catheter. Studies have also suggested that the number of lumens that the CVAD has can have an impact on CRBSI rates (Pratt et al., 2007). When able, CVADs with the minimum necessary number of lumens should be used; the aim is to minimize the number of manipulations of the external portion of the catheter and the number of openings into the vascular system (O'Grady et al., 2011), thereby decreasing the risk for CRBSI.

Central-Line Bundle Protocol Adherence

Healthcare-associated infections (HAIs) are a major threat to patient safety and are associated with mortality rates varying from 5% to 35% (Flodgren, Conterno, Mayhew, Omar, Pereira, Shepperd, et al., 2013). In addition to use of invasive medical devices (e.g., CVADs) that breach the body's normal defense mechanisms, important risk factors associated with HAIs are poor staff adherence to infection prevention practices during insertion and care for the devices when in place (Flodgren et al., 2013). In a review of the literature Flodgren found that adherence with infection control recommendations ranged from 14% to 89% of the time and that efforts to improve performance was not sustainable over longer follow-up times (Flodgren et al., 2013).

Adherence to infection control recommendations appears to be a challenge in many healthcare settings. In a study of ambulatory pediatric oncology patients, the authors found that despite 2 years of rigorous quality improvement interventions almost 1 in 5 CVAD encounters by healthcare personnel were not in compliance with the CVAD maintenance and care bundle (Rinke, Bundy, Chen, Milstone, Colantuoni, Pehar, et al., 2013). The IHI How-to Guide (2012) emphasizes that all components of the bundle are essential for success and 100% compliance with every bundle element is the goal.

In 2004 Didier Pittet concluded that looking at behaviour modification is necessary to create an environment where infection control practices were consistently followed. Pittet indicated that "most healthcare-associated infections were endemic and result from cross-contamination related to inappropriate patient care practices (p. 2)." Pittet suggested that despite policies and guidelines being present to help direct infection control practices for HCWs, that the guidelines either had not been applied strictly, or they were applied poorly (2004). Pittet indicated that all members of the healthcare team were culpable (2004) of non-adherence.

Despite outcomes from Flodgren et al., (2013) and Rinke et al., (2013), literature suggests that adherence to infection prevention strategies can occur. In 2006, Pronovost implemented a central-line insertion bundle in a multicentre study of 108 adult ICUs (Pronovost, Needham, Berenholtz, Sinopoli, Chu, Cosgrove, et al., 2006). The study targeted clinicians' use of five evidence-based procedures that would have the greatest effect on the incidence of CRBSIs and the lowest barriers to implementation (Pronovost et al., 2006). The five recommended procedures included hand washing, using full barrier precautions during insertion, cleaning the skin with chlorhexidine, avoiding the femoral site, and removing unnecessary catheters. The implementation strategy included education regarding practices to control infection, communication regarding the

harm that results from CRBSIs, the creation of a central-line cart to ensure all needed equipment was readily available when CVAD care was undertaken, development and implementation of a checklist to ensure adherence to infection control practices during insertion, and ongoing communication of CRBSI rates to the healthcare providers (Pronovost et al., 2006). During CVAD insertion, nursing was tasked to monitor compliance with the insertion bundle by documenting adherence to procedures on the checklist; nursing staff were empowered to halt the procedures if breaches in infection control practices were seen. Team discussion about the need for the CVAD was completed daily during patient care rounds, and lines that were no longer needed were removed in a timely fashion.

During the 18 month study, the authors found that the baseline rate of 7.7 CRBSIs per 1000 catheter days decreased to 2.7 CRBSIs per 1000 catheter days at 3 months, and 1.4 CRBSIs per 1000 catheter days at months 16 to 18, a 66% reduction in CRBSIs (Pronovost et al., 2006). The implementation of this central-line insertion bundle demonstrated that implementation of effective interventions that can easily be followed by HCWs are able to decrease the number of CRBSIs.

Education of Healthcare Personal Regarding Central Venous Access Device Care

When considering insertion bundles or care and maintenance bundles, HCWs need to be confident and proficient in infection prevention practices and be aware of the signs and symptoms of infection (Pratt et al., 2007). Facilities providing care to patients with CVADs must ensure that HCWs responsible for the insertion and maintenance of CVADs have received appropriate training and that they have demonstrated competence to perform the function (CDC, 2002; Kallen, Patel, & O'Grady, 2010; Pratt et al., 2007). Once initial training has been completed Pratt et al. (2007) recommend ongoing assessment of competency through audits to ensure the consistent adherence

to infection control practices. Royer (2010) believes that an aggressive educational program that reinforces good nursing practice is an essential component in any successful CRBSI rate reduction effort. In 2007, a study by Eggimann found that education-based preventive programs aimed at all HCWs could reduce the incidence of CRBSI by more than two thirds. To improve outcomes and reduce healthcare costs, it is essential that all participants involved in inserting and caring for patients with CVADs be educated about infection prevention initiatives.

In efforts to decrease CRBSI in their 18 bed adult ICU, Eggimann, Harbarth, Constantin, Touveneau, Chevrolet, and Pittet (2000) used a multiple-approach intervention including a 30 minute slide show and practical demonstration of CVAD care. This was completed by individual in-service training and through the provision of detailed written information regarding clinical pathways for hand hygiene procedures, vascular access insertion, and device maintenance and use (Eggimann et al., 2000). The authors postulated that "a well-implemented training and education program, coupled with strategies to reinforce the desired behaviour, are probably the most powerful tools to change physicians' and health-care workers' behaviour and to improve quality of care (p. 1867)." The authors credited their success to the standardization of aseptic care and the implementation of interventions across all disciplines (Pratt et al., 2007). When care and maintenance of CVAD is completed by inexperienced providers the risk for infection increases (Pittet, 2004; Pratt et al., 2007; Pronovost et al., 2006).

Care and Maintenance of Central Venous Access Devices

There are two primary mechanisms of CRBSI associated with ongoing care and maintenance: intraluminal and extraluminal contamination. In order for micro-organisms to cause CRBSIs they must first gain access to the CVAD where they can adhere and become incorporated into a biofilm that allows for sustained infection and hematogenous dissemination (Ryder, 2006;

Safdar & Maki, 2004). Safdar and Maki (2004) propose that micro-organisms can gain access by one of three mechanisms: 1) skin organisms invading the percutaneous tract of the CVAD, 2) micro-organism contamination on the catheter hub (and lumen when the catheter is inserted, or when the CVAD is revised over a guidewire), and 3) organisms carried hematogenously to the implanted device from remote sources of local infection as in the case of a pneumonia. Recommendations for care and maintenance address the need to minimize intraluminal and extraluminal contamination through the use of evidence based care and maintenance bundles. In all patient populations, nursing plays a major role in the implementation of care and maintenance CVAD bundles.

Guerin, Wagner, Rains, and Bessesen (2010) implemented a post-insertion CVAD care bundle in their adult 10-bed medical ICU and 13-bed surgical ICU. Pre-intervention, their CRBSI rate was 5.7 per 1000 catheter days; post intervention rates demonstrated a significant decrease of CRBSI to 1.1 per 1000 catheter days. Their insertion bundle included six evidence-based post-insertion interventions: daily inspection of the insertion site; site care if the dressing was wet or soiled, or had not been changed for 7 days; documentation of ongoing need for the catheter; proper application of a chlorhexidine-impregnated sponge at the insertion site; performance of hand hygiene before handling the IV system; and application of an alcohol scrub to the infusion hub for 15 seconds before each use.

In 2011, Schulman et al. published CRBSI rates following a statewide neonatal intensive care bundle implementation (Schulman, Stricof, Stevens, Horgan, Gase, Holzman, et al., 2011). The implementation of the CVAD maintenance checklist led to a decrease in CRBSIs in their vulnerable patient population. The focus of their maintenance bundle included: hand hygiene before and after accessing a catheter, or before and after changing the dressing; evaluation of the

catheter site daily for signs of infection and to assess dressing integrity; at minimum, if the dressing is damp, soiled, or loose change dressing aseptically and disinfect the skin around the insertion site with an appropriate antiseptic; develop and standardize IV tubing setup and changes; maintain aseptic technique when changing IV tubing and when entering the catheter including "scrub the hub"; and daily review of catheter necessity with prompt removal when no longer essential.

These interventions Schulman et al. (2011) proposed were virtually identical to the components in the Guerin et al. (2010) care bundle, except for the addition of the application of a chlorhexidine-impregnated sponge at the insertion site. This intervention has had much attention in the literature. In the 2007 eEPIC national guidelines published by Pratt et al. (2007), the use of topical antimicrobials at the insertion site as part of routine catheter site care is not recommended. The 2009 clinical practice guidelines presented by the Infectious Diseases Society of America, (Mermel et al., 2009) does not include a recommendation of CRBSI prophylaxis with the use of topical chlorhexidine-impregnated sponges. However, this panel does recommend the use of topical antimicrobial therapy in cases of uncomplicated exit site infections. The CDC (2011) guidelines do not recommend the use of topical antibiotic ointments or creams on insertion sites, except for dialysis catheters. The CDC only recommends the use of chlorhexidine-impregnated sponges in short-term catheters in patients greater than 2 months of age who have ongoing CRBSIs despite adherence to preventative measures. The rationale for limiting the use of chlorhexidine-impregnated sponges is related to the potential to promote fungal infections and antimicrobial resistance (O'Grady et al., 2011).

In a meta-analysis that included eight randomized control trials (Ho & Litton, 2006) the authors found that the chlorhexidine-impregnated sponge dressings were associated with a decrease in vascular and epidural catheter exit site colonization, but that there was no significant reduction in

CRBSIs. Because of the overwhelming evidence from key experts on CVADs to the contrary, the use of chlorhexidine-impregnated sponges for all patients with CVADs will not be considered in this study.

All of the components of the care and maintenance bundle attempt to minimize the risk for intraluminal and extraluminal contamination. These components are outlined below.

Daily inspection of the exit site. The insertion site provides a portal of entry from which organisms travel from the subcutaneous tract to the blood. In tunnelled catheters, both the exit and insertion site act as entryways for microorganisms into the circulation. In this study both entrance and exit sites will be encompassed by the term exit site. Daily inspection of the exit site needs to be undertaken by healthcare staff caring for patients with CVADs. Assessment of the exit site includes several components of the care and maintenance bundle.

Visualization and palpation of the exit site, tunnel pathway, or implanted port pocket needs to be completed during the daily CVAD assessment. If redness, tenderness or discharge is present at the exit site, along the tunnel pathway, or around the implanted port, the dressing must be changed (O'Grady et al., 2011) and communication of the assessment findings must be completed. If the patient is febrile with no other obvious source of infection, blood cultures must be drawn from the CVAD (O'Grady et al., 2011) and swabs from the exit site should be sent for culture and sensitivity (Mermel et al., 2009; O'Grady et al., 2011; Pratt et al., 2007). IV antibiotics are often initiated if the patient is febrile; however, if the patient is afebrile a topical antibacterial ointment may be considered (Mermel et al., 2009).

Exit site infections are described by the CDC (2002) as erythema, tenderness, induration, or purulence within 2 centimeters (cm) of the skin at the site of the catheter. Tunnel infections or pocket infections (with surgically implanted CVADs) are described by the CDC (2002) as

erythema, tenderness, and induration in the tissue overlying the catheter and 2 cm or greater from the exit site. Inspection of the exit site is an important component of the maintenance bundle as these infections need to be addressed in a timely fashion to prevent, or attempt to minimize their progression to CRBSI.

Dressing changes. CVADs are foreign objects that require their external components to be protected from microbial contamination and be secured to the skin. Dressings and securement devices ensure that CVADs do not become dislodged, fall out, or move within the vessels (Macklin, 2010). CVAD placement can be affected by movement or pressure on the external components of the device through forced or inadvertent removal; from the weight of infusion tubing; or catching on environmental structures (Ullman, Cooke, Mitchell, Lin, New, Long, et al., 2013). Dressings and securement devices are used to protect and support the external components by providing catheter stabilization, and minimize catheter movement. This support can minimize trauma to the exit site and external catheter components and decrease the physiologic response to trauma, including inflammation, edema, and fluid secretion which increase the ability of microorganisms to travel down the subcutaneous tract to the blood (Royer, 2010).

Transparent, semi-permeable polyurethane dressings permit continuous visual inspection of the catheter site and require less frequent changes than gauze and tape dressings (O'Grady et al., 2011). These dressings provide a protective barrier to decrease the risk of microbial colonization, are comfortable and non-irritating to the patient, and are easy to use (Ullman et al., 2013).

Consensus by leading experts in CVAD care unanimously recommend that transparent dressings be changed every 7 days or sooner if the dressing becomes damp, loosened, or visibly soiled (Mermel et al., 1991; Mermel et al., 2009; O'Grady et al., 2011; Pratt et al., 2007). If the exit site is oozing, or the patient has excessive moisture then the application of sterile gauze dressing

should occur. Gauze dressings require increased vigilance and need to be changed every two days (O'Grady et al., 2002), or sooner if the dressing is soiled. Once any drainage has resolved, the gauze dressing should be replaced with a transparent dressing.

Skin antisepsis. Skin antisepsis during post-insertion dressing changes decreases the microflora present on the skin. Recommended solutions for skin antisepsis are chlorhexidine, or chlorhexidine and alcohol solutions. Chlorhexidine in combination with alcohol increases the potential activity of the antisepsis (Ryder, 2006). The alcohol provides a rapid decrease in bacterial counts, but has no lasting antiseptic effect. The chlorhexidine remains active for at least 6 hours. With repeated use, the effectiveness of chlorhexidine increases over time due to the binding and retention of the active antiseptic on the skin surface (Aly, Bayles, & Maibach, 1988 cited in Ryder, 2006). If allergies or sensitivities to chlorhexidine are present, a povidone-iodine solution may be indicated. One important consideration when contemplating the use of alcohol on a CVAD is the material of the catheter; care must be taken to follow manufacturer's recommendations as some catheters will become brittle and crack with continued exposure to alcohol containing solutions (O'Grady et al., 2011; Pratt et al., 2007; Ryder, 2006). Therefore, depending on the catheter type, chlorhexidine alone, chlorhexidine plus alcohol, or a povidone solution may be indicated for skin antisepsis.

It is recommended that the application of the antiseptic solution should occur in a multidirectional, back and forth motion (Ryder, 2006) over a period of 30 seconds. Following this step the antiseptic solution must be allowed to air dry before the transparent dressing is applied. This is of dual purpose, first, if the chlorhexidine is not allowed to dry a chemical reaction with the adhesive on the back of the transparent dressing may occur, leading to a chemical burn on the

patient's skin and second, once it is dry the antiseptic solution has a greater ability to kill microorganisms (O'Grady et al., 2002; Pratt et al., 2007).

Application of an alcohol scrub to the infusion hub. Microorganisms can gain entrance to the internal lumen of the catheter at any point along the fluid pathway where the intravenous (IV) system is manipulated (Ryder, 2006). Frequent manipulation of catheter hubs, connection sites, administration tubings, access portals, and needleless connectors affect the integrity the system which can lead to an increase in the risk for developing CRBSI (Macklin, 2010; Maki, Ringer, & Alvarado, 1991; Ryder, 2006). If connection site and hub antisepsis are omitted during CVAD care and maintenance, contamination from the access site(s) can lead to colonization of microorganisms on the inside of the catheter lumen (intraluminal) and a subsequent CRBSI. Hub contamination is most common in CVADs that have been in place for more than 10 days, as these devices have been accessed and manipulated (Linares, Sitges-Serra, Garau, Perez, & Martin, 1985).

Hub and connection site disinfection is the primary intervention for minimizing intraluminal contamination (Macklin, 2010). Recommendations for hub and connection cleansing vary in both the recommended antiseptic solution and the length of time that the catheter should be cleansed. A meta-analysis undertaken by Chaiyakunapruk, Veenstra, Lipsky, and Saint (2002) looked at data from eight randomized trials that compared antiseptic solutions. The authors found that the use of chlorhexidine gluconate solutions were more effective than povidone-iodine for intravascular catheter-site care. This analysis has greatly contributed to the present management of CVADs.

When searching the literature, a number of studies looking specifically at the antiseptic solution used prior to accessing hub and connection sites of CVADs were found. In 2009, Soothill et al. undertook an observational before/after study that looked specifically at the use of a 2%

chlorhexidine and 70% isopropanol solution for connection and hub antisepsis. Their data suggest that the change from 70% isopropanol alone to 2% chlorhexidine and 70% isopropanol led to a substantial decrease in CRBSIs (Soothill, Bravery, Ho, Dip, Macqueen, Collins, et al., 2009) in their pediatric patient population.

In 2002 the CDC recommended a 70% alcohol, or a povidone iodine solution for CVAD access site disinfection. In a randomized clinical trial, Casey et al. (2003) concluded that disinfection of needleless connectors could be undertaken with chlorhexidine, alcohol, or povidone iodine solutions with an equivalent reduction in external microbial contamination (Casey, Worthington, Lambert, Quinn, Foroqui, & Elliott, 2003).

Despite the fact that there was not a clear consensus on a single antiseptic solution for CVAD connection and hub anti-sepsis, there was 100% agreement that hub and connection site antisepsis is mandatory prior to each access to minimize the microorganisms present on the access points and that the longer the scrub time with the antiseptic solution the greater the disinfection of the hub and connection sites (Ryder, 2006).

Documentation of ongoing need for the catheter. One of the most effective strategies for preventing CRBSIs is to eliminate or at least reduce the patient's exposure to the CVAD. Many studies have demonstrated that the incidence of CRBSIs increases with the duration of catheter placement (Cox, Flaspohler, Jennings, Bringman, Crumpacker, Cordes, et al., 2011; O'Grady et al., 2011). The decision regarding the need for a CVAD is complex and difficult to standardize into a practice guideline. Nonetheless, to reduce exposure to CVADs, the multidisciplinary team must adopt strategies to systematically evaluate daily whether any catheters can be removed (Waitt, Waitt, & Pirmohamed, 2004). Many facilities find that CVADs are not being removed in a timely

fashion (Cox et al., 2011; Kallen, Patel, O'Grady, 2010), thereby increasing the risk for CRBSI in that patient population.

Administration sets. Guidelines outlining how often that IV sets should be changed have been clearly established by a number of CVAD experts (Mermel et al., 2000; O'Grady et al., 2002; Pratt et al., 2007). The fewer manipulations that the IV tubing undertakes, the lower the risk for CRBSI. There are several exceptions to this rule: Exposure to lipid containing products has been identified as an independent risk factor for development of coagulase-negative staphylococcal bacteremia in very low birth weight infants, thus requiring daily IV tubing changes. The National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in National Health System Hospitals in England (Pratt et al., 2007) recommends that a dedicated single lumen catheter or a dedicated port in a multi-lumen catheter be used for hyperalimentation or total parenteral nutrition (TPN). Infusion of blood products also necessitates more frequent IV tubing changes. Knowledge of these practices is essential to limit CRBSI in patients.

Performance of hand hygiene before handling the intravenous system. Hand hygiene is the single most important factor in preventing hospital acquired infections (World Health Organization, 2009). Cross-transmission or the transfer of microorganisms between individuals can occur directly via the hands, or indirectly through an environmental surface such as a commode or wash basin (Pratt et al., 2007). Epidemiological evidence concludes that hand-mediated cross-contamination is a major contributing factor to infection threats to hospital inpatients (Pratt, Pellowe, Loveday, Robinson, Smith, Barrett, et al., 2001; Pittet, 2004). A number of studies have shown that improvement in hand hygiene significantly decreases a variety of infectious complications. Proper hand hygiene procedures can be achieved through the use of either a waterless, alcohol-based product or antibacterial soap and water with adequate rinsing.

Without hand hygiene, microorganisms present on the hands of HCWs can be deposited directly onto patients presenting a direct clinical threat to patients leading to potentially life-threatening infections. HCWs' hands are the most common vehicle for the transmission of healthcare-associated pathogens from patient to patient and within the healthcare environment (Allegranzi & Pittet, 2009). Hand hygiene is the leading strategy for preventing the spread of antimicrobial resistance and reducing healthcare-associated infections but healthcare worker compliance with optimal practices remains low in most settings (Allegranzi & Pittet, 2009). A number of studies have suggested that the hand washing compliance rate averages from approximately 40% to 51% (Creedon, 2005; Pittet et al., 2000).

In 1999, investigators identified hospital-wide predictors of poor adherence to recommended hand hygiene measures during routine care (Pittet, Mourouga, & Perneger, 1999). The authors found that compliance was predicted by professional category, hospital ward, the time of day/week, type and intensity of care, which the authors defined as the number of opportunities for hand hygiene per hour of patient care. In 2834 observed opportunities for hand hygiene, the average adherence was 48%. In their analysis, adherence to recommended hand hygiene opportunities was highest amongst nursing staff compared to other HCWs. Non-adherence was higher in ICU compared to internal medicine during procedures that carried an increased risk of bacterial contamination and when intensity of patient care was high. In their discussion the authors found that the higher demand for hand hygiene, the lower the adherence. In this study, adherence to hand hygiene in the ICU area was 36%. In the same study, the authors found the highest rates of hand hygiene occurring at 59% in pediatric units. When comparing the 1999 results to today, little improvement has been seen.

Pittet and Posfay-Barbe (2001) reported that less than 50% of healthcare professionals comply with hand hygiene protocols. In 2012-2013, hand hygiene audits were implemented in a pediatric hospital located in central Canada. The audits were completed by infection control practitioners (ICP) approximately every 3 to 6 months. The areas included in the audits were the NICU and intermediate care nurseries, PICU, 3 medical and 1surgical inpatient units and the emergency department. During these audits, healthcare professionals from a variety of disciplines were knowingly observed by ICP during the provision of patient care. The ICPs documented successful hand hygiene opportunities, the observed opportunities where hand hygiene should have occurred, and the discipline involved in the hand hygiene opportunity. The first audit was completed in July 2012; the results showed that the successful completion of hand hygiene ranged from 39% to 93% with an average of 55.5%. These baseline audit results were slightly better than those reported by Pittet (2001).These results were communicated to staff and a global educational "blitz" was undertaken by the senior management and infection prevention and control teams. A second audit was completed in January 2013 which resulted in an adherence range of 46% to 94% with an average of 73.6% successful hand hygiene opportunities. The third audit was completed in April 2013; the range of successful hand hygiene opportunities was 37% to 89%, with an average of 63.2% (Hand Hygiene Compliance Audit, 2013). Despite global hand hygiene education initiatives, the percentage of HCWs who do not perform hand hygiene appropriately in their practice remains unacceptably high.

Hand hygiene is the one of the most important components of both the IHI Central-Line Insertion Bundle and all care and maintenance bundles. Many authors believe the most common cause of CRBSIs is through the unwashed hands of healthcare providers (Eggimann, 2007; O'Grady et al., 2002; Pittet, & Posfay-Barbe, 2001). Priority needs to be placed on ensuring hand

hygiene becomes an automatic activity before handling the CVAD or and component of the intravenous system by all HCWs and families caring for the CVAD.

Infant and Pediatric Infection Control: The Challenges

In pediatric patients, there are other challenges in adhering to infection control strategies. Children are eager to explore their worlds, exert their independence, and their curiosity sometimes leads to practices that are a direct contradiction to safe infection control practices. Infants explore the environment through tactile exploration and commonly they put objects in their mouths. Intravenous tubing and CVAD hubs are not exempt from oral exploration, leading to the potential for self-inoculation of bacteria and other micro-organisms.

Teething is also a normal phenomenon present in young children. Teething usually begins around 6 months of age, but may start at any time between 3 and 12 months of age (CDC, 2008). Babies may bite on their fingers or toys to help relieve the pressure in their gums leading to drool, which in turn can produce a rash on the chin, face, or chest potentially interfering with CVAD dressings and securement devices.

If infants' environments are contaminated by HCWs hands, the risk for infection in this patient population is significant. Due to expected child development-related activities, infants and young children require close contact with care-givers, HCWs, family members, and siblings (de Jonge et al., 2005). Cuddling, feeding, diapering, consoling, and general interaction with children requires direct contact. This level of contact can result in an increased risk for transmission of both HAIs and community pathogens (Posfay-Barbe, Zerr & Pittet, 2008). Unclean hands, toys and medical equipment all pose potential threats to the pediatric patient.

In children of all ages, adherence to hand hygiene and infection control practices can be challenging. In a study looking at hand hygiene practices in elementary school children, the authors

found that teaching children appropriate hand hygiene practices could significantly reduce the spread of infection (Hammond, Ali, Fendler, Dolan, & Donovan, 2000). Day (1993) as cited in Hammond et al. (2000) concluded that other behaviours in children affected hand washing compliance, and that over time; children were less interested in complying with hand hygiene initiatives. When placing children in healthcare environments where healthcare worker compliance with hand hygiene is less than optimal another layer of cross contamination is possible.

CRBSIs: Outside the ICU

In a study conducted through the CDC comparing ICU CRBSI rates from 2001 to 2009 the authors were able to estimate a reduction of approximately 25,000 fewer CRBSIs in 2009 than in 2001 (U.S. Department of Health and Human Services, 2011), a 58% reduction, leading to a savings of approximately 3,000-6,000 lives and an estimated cost savings of $414 million in ICUs alone (U.S. Department of Health and Human Services, 2011). The authors attributed the reduction to the coordinated efforts of state and federal agencies, professional societies, and health-care professionals implementing best practice strategies for the insertion of CVADs and care and maintenance bundles (U.S. Department of Health and Human Services, 2011) in ICUs. The CDC now believes that the majority of CRBSIs are occurring outside of the ICUs on inpatient units and outpatient dialysis units.

In 2009, the CDC embarked on a study attempting to identify rates of CRBSI in inpatient units. The estimated calculation of total inpatient days was based on data collected through the Healthcare Cost and Utilization Project's National Inpatient Sample and from the Hospital Cost Report Information System. Central line utilization data and CRBSI rates were obtained through the NHSN. The results of this data collection showed that in 2009 approximately 23,000 CRBSIs occurred on inpatient units in American hospitals who participate in Hospital Cost Report

Information System (U.S. Department of Health and Human Services, 2011). Although there are no equivalent Canadian data, based on similar findings in other components of CVAD care, one could infer that the rate of incidence of CRBSI in Canadian acute care facilities may be similar to that of our American counterparts.

There is a paucity of literature related to CRBSI in Canadian Health Care institutions especially in relation to pediatric patients located outside of critical care settings (Rutledge-Taylor et al., 2012). In pediatric inpatient units, a better understanding of the patient population is needed to comprehend and address issues related to infection prevention in patients with CVAD in-situ. General duty nurses in these areas have a unique perspective on the daily activities of pediatric patients and the subtle and not so subtle differences in the care and maintenance issues that surround CVADs in this patient population. A study that would add to the knowledge of health care providers' knowledge of, and adherence to infection prevention strategies would potentially have a great impact on the quality of care that is provided to this patient population.

CHAPTER 3: Theoretical Framework

Theory is a set of interrelated concepts, which provides a systematic view of a phenomenon. Theory guides practice and research; practice enables testing of theory and generates questions for research; and research contributes to theory. In this section, Donabedian's Structure-Process-Outcome Model will be described in detail. The concepts for the theory will then be explained in relation to quality improvement in healthcare, specifically in nursing experiences while caring for patients with central venous access devices.

Donabedian's Structure-Process-Outcome Model

Health care quality is a concern for health care professionals, employers, organizations and consumers alike. Although agreement about the need for quality improvement in health care is almost universal, the means of achieving effective improvements in overall care are not well understood (Glickman, Baggett, Krubert, Peterson, & Schulman, 2007). Clinicians, nurses and managers need tools for building organizations that are able to handle emerging medical technologies and methods, while maintaining quality of care (Blumenthal, 1996; Kunkel, Rosenqvist, & Westerling, 2007).

Current methods of organizing and delivering care are, at times, unable to meet the expectations of patients and their families because the science and technologies involved in health care, the knowledge, skills, care interventions, devices, and drugs have advanced more rapidly than our ability to deliver them safely, effectively, and efficiently (The Robert Wood Johnson Foundation, 1996). Quality of care is a complex, multi-perspective concept where different stakeholders may hold differing views on what comprises quality and how it should be measured (Hays, Veitch, & Evans, 2005). Health care professionals might tend to focus on technical skills; patients may focus on access, availability, cost, interpersonal communication and functional

outcomes; and organizational hierarchy may focus on cost control (Hays, et al., 2005). In an attempt to describe and evaluate methods used for assessing the quality of health care Donabedian developed the "Structure-Process-Outcome Model" (Donabedian, 1966). Donabedian's model for quality improvement in health care will be analyzed using theory analysis framework by Walker and Avant (2011). According to Walker and Avant there are six steps in theory analysis. They include identification of the origins of the model, examination of the meaning of the model, analysis of the logical adequacy of the model, model usefulness, defining the degree of generalizability of the model and finally determination of testability of the model.

Origins of the Model

The Donabedian Model is one of the best known conceptual models for quality assessment and is widely used throughout the field of health care quality (Rodkey & Itani, 2009). In his 1966 article, Donabedian describes and evaluates methods used for assessing quality of medical care related to physician-patient interactions. Donabedian succeeded in describing this through his review of empirical studies from literature relating to the need for evaluation, and control of the quality of care in organized programs of medical care (1966). From this review, he found the main contributors to quality were derived from the structure present within the organization, the processes in place, and the outcomes that were achieved.

In Donabedian's initial published work (1966), he focussed much effort on ensuring that he followed a positivist empirical approach of the assessment of quality. For example, the data collection methodology, the sampling and selection process, and the measurement processes he used were described at length so he could ensure the reliability of the data to minimize or remove bias and improve the validity of the outcomes.

Donabedian proposed that the assessment of quality can be precisely defined and is amenable to accurate measurement (2003). In order to understand how quality of medical care is achieved and its ability to be measured, he asserted that conceptual and operational definitions were required. He offered the following definition from Lee and Jones (1933), that criteria of quality "are nothing more than value judgments that are applied to several aspects, properties, ingredients or dimensions of a process called medical care" (Donabedian 1966, p. 167). This definition allows quality to be almost anything that one would want it to be, but Donabedian suggested that ordinarily quality was "a reflection of values and goals current in the medical care system and in the larger society of which it is a part" (1966, p. 167). Based on his literature review, Donabedian (1966) also postulated that quality of patient care would never be measured by a single criterion, but that multiple factors would impact the measurement of quality including factors outside of the actual medical care provided. These other factors could be related to the environment in which health care is provided, and whether there were standardized methods to follow in the provision of care. Specifying the components or outcomes of care, formulating the appropriate criteria and standards, and obtaining the necessary information about the phenomena of interest, are steps that Donabedian believed needed to be followed to allow for the provision of quality care. Donabedian (1988, p. 1743) defined different scenarios of how quality of care is determined:

1. Whether one is assessing the performance of practitioners and the contribution of patients and of the health care system;
2. How broadly health and responsibility for health are defined; whether the most effective, or optimally effective care is sought; and
3. Whether individual or social preferences define the optimum care.

Donabedian believed that an agreement on which elements that constituted quality care was needed: “To proceed with measurement without a firm foundation of prior agreement on what quality consists of would lead to confusion and disorder” (Donabedian, 2003, p. 52). In 2003, Donabedian described quality as the product of two factors: the science and technology of health care; and the application of that science and technology in actual practice.

Quality of care has often been determined by outcomes, recovery, restoration of function, safety and survival. This is Donabedian’s first assumption; that outcomes tend to be the end-point of quality improvement initiatives. Outcomes are likely to be concrete, and in most cases are measurable. Donabedian believed that comparative studies of outcomes, under controlled situations were necessary to determine valid conclusions about quality. Donabedian alleged that outcomes remained the ultimate validators to the effectiveness and quality of medical care (1966). However he believed that outcomes do not “give an insight into the nature and location of the deficiencies or strengths to which the outcome might be attributed” (1966, p. 169), and therefore must be used with discrimination.

The second assumption that Donabedian describes relates to the examination of the process of care itself, rather than the outcomes. This assumption implies that “one is interested not in the power of medical technology to achieve results, but in whether what is now known to be “good” medical care has been applied” (Donabedian, 1966, p. 169). These judgements are based on considerations such as whether medicine is properly practiced; the appropriateness and completeness of information obtained from clinical history, physical examination and diagnostic tests; justification for diagnosis and therapy; technical competence; prevention management strategies; coordination and continuity of care; and satisfaction of care by the patient/family.

The last assumption refers to the approach used to assess the setting in which care takes place. This is the assessment of structure. The assumption is that given proper settings and equipment, good medical care will follow. However, the relationship between process and structure, or outcome and structure is often difficult to establish (Donabedian, 1966).

Donabedian developed his model deductively, based on empirical data collected from literature related to the evaluation and control of quality of care, and based on the values and goals present in the society in which he practiced. The structure-process-outcome model has the ability to test previous phenomena in a different situation or to compare phenomenon at a different period of time.

Meaning of the Model

Concept Identification

Donabedian (1966) identified three major concepts required to assess quality of care: structure, process, and outcome; a triad that has gained widespread acceptance by many researchers because of its simplicity and intuitive persuasiveness (Donabedian, 2003). The primary antecedent that must be present to improve quality of care is the desire of an organization or individual to look at what it is that they do, and determine ways in which the quality of care can be improved. According to Donabedian all obstacles to providing good care could be removed or circumvented if the practitioner really wished to do and an implicit contract existed between health care professionals and society. This contract placed an ethical imperative which would govern the conduct of all caregivers (Donabedian, 2003), placing the commitment to quality in moral and ethical terms.

Structure. This first key concept is meant to designate the conditions under which care is provided. Structure could include material resources such as facilities and equipment; human

resources, such as the number, variety, and qualifications of professional and support personnel; and organizational characteristics, such as the organization of the medical and nursing staffs, the presence of teaching and research functions, kind of supervision and performance reviews. Donabedian described that depending on the phenomena of interest, structure could potentially be a major determinant of the quality of care (Donabedian, 2003). This is related to the fact that some attributes of structure are more readily observable, easily documented, and more stable with less variation than process and outcomes.

Process. The second concept is process, the activities that constitute health care. Process includes diagnosis, treatment, rehabilitation, prevention and patient education. These activities are generally carried out by professional personnel, but also include care provided by both patients and their families. The process of care refers to what is actually done in giving and receiving care (Donabedian, 1988). The performance of practitioners is divided into two separate elements: technical and interpersonal. Technical performance depends on the knowledge and judgement used by the practitioner in arriving at an appropriate strategy of care. The technical performance that Donabedian refers to is based on what is believed to be the best in the knowledge and technology at that point in time (Donabedian, 1988). Interpersonal relationships are the second component of a practitioner's performance. Through an interpersonal exchange, the patient communicates information that allows the practitioner to come to an appropriate plan of care. Interpersonal relationships are viewed as the vehicle that allows technical care to be implemented (Donabedian, 1988).

Processes of care are more directly related to outcomes than the characteristics of structure (Donabedian, 2003). The process of applying care is directed towards identifying smaller variations in quality. Process also takes place during the present time and can provide immediate indications

of whether quality care was provided. Information about quality care can be accessed through patient records, asking patients about the care they received, and through direct observation. Of the three assessments, only direct observation can tell us how skillfully the care has been executed; medical records and patients are not often able to define this (Donabedian, 2003).

Outcome. The third key concept is outcome, which includes the changes (desirable or undesirable) in individuals and populations that can be attributed to health care. Outcomes can include changes in health status, changes in knowledge acquired by patients and family members that may influence care, changes in the behaviour of patients or family that may influence future health, and satisfaction of patients and family members with the care received and its outcomes. Outcomes reflect both on what was done for the patient, and on how skilfully it was performed; these outcomes can be easily observed and assessed. Outcomes also guide the conduct of care, and may indicate if changes in care are required (Donabedian, 2003).

Outcome assessment is important, as what matters most is the effect that the care has on the patient's health and well-being and that the care received is responsible for the outcome observed (Donabedian, 2003). One cannot be certain that a given set of processes has led to specified outcomes. Because of this, Donabedian proposed that larger numbers of cases are needed to establish firm relationships between process and outcomes, in keeping with his positivist nature.

Definition and use. The three major concepts identified in this model are clearly defined in the structure-process-outcome model. Concept analyses continue to be published on structure, process, and outcomes based on the definitions Donabedian proposed in 1966 (Coyle, Kaplan, Palmer, & Biff, 2000; Hearld, Alexander, Fraser, Jiang, 2007; Ramsay, Sainfort, & Zimmerman, 1995).

This model can be described as using operational definitions. Operational definitions are used by Donabedian to define quality of care and the three concepts structure, process, and outcome. Descriptive definitions are used in the sense that the operational definitions can be applied to a multitude of quality improvement initiatives and therefore the description of what the structure, process, and outcome is measuring may change based on the context in which the concepts are being applied; however, the operational definitions would remain the same. Donabedian is consistent with the definitions used for the concepts throughout not only the initial model developed in 1966, but throughout his life-time of writing. The model has been applied to a wide variety of published health care quality improvement initiatives, and has passed the test of time.

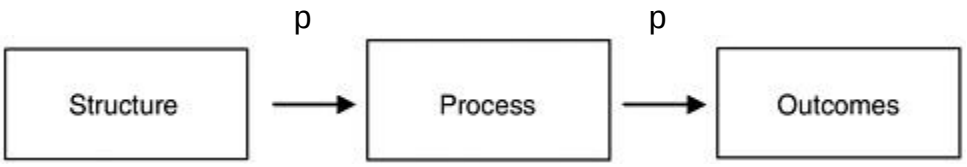
Identify statements and examine relationships. Donabedian links the major concepts of structure, process, and outcome throughout the model's operational definitions. The definitions remain consistent throughout the published works reviewed during the completion of this analysis. In Donabedian's last published work in 2003, he sought to clarify that the concepts of "structure, process and outcome are not attributes of quality; they are the kind of information that one can obtain based on which one can infer whether quality is good or not" (p. 47) and that "inferences of quality are not possible unless there is a predetermined relationship among the three approaches, so that structure influences process and process influences outcomes" (p. 47).

In 1966, Donabedian initially described the structure, process, outcome model in a linear fashion, but the "reality of the model was a much more complex reality" (Donabedian, 2003, p. 47). See Figure 3.1 for the description proposed in 1966. Donabedian discussed that certain causes lead to specific effects, and then those effects became the causes of subsequent effects. He believed that it was arbitrary where structure ended and process began, or where process ended and outcomes

began (Donabedian, 2003). Figure 3.1 does not depict the dynamic relationships between the concepts and seemingly oversimplifies the interactions. Donabedian defined the relationships between the concepts as probabilities that may be well established by scientific evidence or largely believed to be true (p. 49). The greater the probability, the higher the likelihood of good quality care being provided. Conversely, the weaker the probability, the weaker the evidence that will lead to more uncertain judgements about the quality of care. The more credible the evidence, the more confident you can be about judgements that are made regarding quality of care (Donabedian, 2003, p. 50). Donabedian assigned the probabilities of quality care as a lower-case "p" in his linear relation described in Figure 3.1.

Figure 3.1

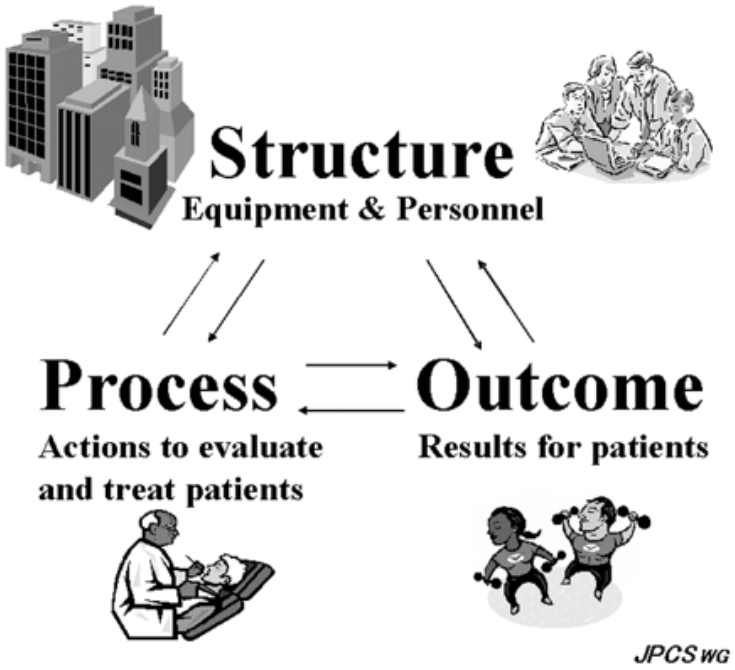
Donabedian 1966 Structure-Process-Outcome Model (as depicted by Donabedian, 2003, p. 47).



Process and outcome are linked together, a precursor followed by a reaction that leads to another reaction; Donabedian (1966, p. 169) described this as "an unbroken chain of antecedent means followed by intermediate ends which are themselves the means to still further ends." Teshima (2005) has provided readers with a very clear interpretation of the structure-process-outcome model in his study concerning clinical quality assurance in radiation oncology. See Figure 3.2 which illustrates how to enable health care providers of all levels of experience to understand the Donabedian model "at a glance"; structure, process and outcome working together to create quality improvement in health care.

Figure 3.2

Donabedian's model of quality assessment (Teshima, 2005, p. 498). The relationship between structure, process and outcome.



Quality of care is created through a number of different processes. For example, structure, or the way that health care is set up has an important influence over how people in that system behave and consequently on the quality of care that is offered. Variations in organizational systems such as equipment, qualified practitioners and providers can lead to improved quality of care; or in cases where the structure is not in place the outcome may be poor quality of care. Detailed health-care processes can provide judgements about the ability to provide quality of care. Donabedian (2003, p. 52) stated that this claim was "self-evident because quality of care can be taken to mean quality of the process of care." Outcomes, whether good or bad, must be attributable first to health care then to the contribution of the practitioner whose performance is being assessed. Each concept on its own is not responsible for quality improvement. Donabedian stated that "the best course of

action is to use a combination of approaches, the precise mix of which is to be determined by the nature of the problem to be studied and the availability of the information needed" (2003, p. 56).

According to Walker and Avant (2011) different relationships exist between concepts. The definition of associational relationships as described by Walker and Avant (2011) can be applied to the concepts of process and outcome. The interaction between process and structure, and structure and outcome, is a positive relationship. For example, if structure increases, process will also do so; therefore quality improvement in health care outcomes will occur.

The boundaries present in this model can be considered a middle range theory which is "a testable theory/model that contains a limited number of variables, and is limited in scope as well, yet is of sufficient generality to be useful with a variety of clinical research questions" (Nursing Theory Network, 2010). The model is not highly abstract and is applicable in improving the quality of health care and in a variety of quality improvement projects. In 1995, Starfield, Riley, Green, Ensminger, Ryan, Kelleher, and colleagues applied the model to a large organization during their assessment of adolescent child health and illness profile: a population-based measure of health. In 2010, Zorowitz applied the model to a specific inpatient population of stroke patients when he developed quality indicators for a stroke rehabilitation facility. In 2008, McKay and Crippen followed the model in efforts to improve care in specific topics/areas such as multidisciplinary collaboration in an acute care setting. Kunkel et al. (2007) in their study of the structure of quality systems and its importance to process and outcomes concluded that the model could successfully be used to describe and evaluate single quality systems or to compare different quality systems. They found that Donabedian's model could also be an aid to implement systematic, evidence-based systems with the goal of quality improvement in their hospital departments. The ability to apply the

model to a wide range of quality improvement situations broadens the focus of the model, but it remains relatively circumscribed to still be considered a middle range theory.

Logical adequacy. The structure-process-outcome model provides a logical method to assess quality. The model has been used in numerous studies, and provides a framework for understanding how structure, developing processes and evaluating outcomes are important in efforts to improve quality of care. Through its simplicity, practitioners who do not usually participate in research can apply the model to specific unit based quality improvement projects. Because of the current requirement for the provision of evidence based care, the model can be predictive in some circumstances, but not all. Donabedian presents a deductive model as described by Toulmin in Walker and Avant (2011, p. 203): if all of the premises are true, and the conclusions drawn are valid, then the reasoning taken from the conclusions are also true.

Usefulness of the model. The structure-process-outcome model provides us with insight into the concepts that need to be addressed when quality improvement initiatives are undertaken in health care settings. Because of the wide focus of the concepts within the model, it can be applied to many topics related to quality improvement. Despite Donabedian's lack of description of the literature reviewed in developing his model, which can be viewed as a weakness, the model has been used to guide research in a number of different health care topics (Glickman, et al., 2007; Hays, et al., 2005; Kunkel, et al., 2007; Ljunggren, & Sjoden, 2003; McKay, & Crippen, 2008; Starfield, et al., 1995; Teshima, 2005; Zorowitz, 2010) and valid outcomes have been obtained.

Generalizability and testability. The model is simplistic in the operational definitions of the concepts; however, it is broad in content. Walker and Avant (2011) describe this as parsimonious in that the model "explains a complex phenomenon simply and briefly without sacrificing the model's content, structure, or completeness." Donabedian's model allows for the

generation of hypotheses, and has clearly added to the body of knowledge surrounding quality improvement in health care.

The model can be reproduced in different environments looking at the same phenomenon of interest. Outcomes of the interaction between the concepts within the model can be measured and for the most part be tested. Various measurement tools are present in the literature to accomplish this. Depending on the phenomena being studied, the measurement tool assessing quality of care will vary.

Use of the Structure-Process-Outcome Model in the Current Study

Donabedian's Structure-Process-Outcome Model provides a useful framework for the purpose of this study in looking at compliance with the central-line care bundle and nursing care related to CVADs. When considering a quality improvement strategy to improve CVAD care, structure, processes, and outcomes need to be identified.

Structure will include easily accessible policy and procedures outlining CVAD care and maintenance; training and education of HCWs to appropriate hand hygiene opportunities; easily accessible CVAD and hand hygiene products; written communication, such as posters outlining appropriate hand hygiene opportunities; and reminders about required care when accessing CVADs, such as when intravenous sets require changing, information regarding blood draws and flushing practices. For example, when evaluating hand hygiene compliance, faulty structure occurs when sinks, soap and water, single use towels, and alcohol rub are not readily accessible. If hand hygiene is not performed then inadequate process is present leading to an increased risk for infection and its related morbidity, mortality and costs – the outcomes of poor care. On insertion of the CVAD the use of an insertion checklist to ensure compliance with Central-Line Bundle is

important in developing and maintaining infection control processes. Ongoing audits can communicate compliance with infection control practices and to inform HCWs of CRBSI rates.

In addition to the above interventions, this study can potentially identify other factors that may need to be addressed to achieve a greater success in quality improvement of care of pediatric patients with CVADs. With the identification of challenges that nurses face during the care of patients with CVADs institutional structures can be implemented to address areas of concern leading to a more robust, population specific, CRBSI prevention strategy.

Process can include health care workers' ability to demonstrate correct CVAD care and maintenance practices maintain infection control practices. An example of a change in process that could occur as a result of this study may include the annual assessment of CVAD care and maintenance practices through written examinations and hands-on demonstration in a laboratory setting. HCWs will provide care following the institutions policies surrounding CVAD care and infection control practices.

When appropriate structure and process interventions are in place, quality improvement outcomes can be achieved. In this study, the potential for improved quality of CVAD care and maintenance practices could lead to a decrease in the number of CRBSIs in the institution. In the long run this will decrease hospital costs, morbidity and mortality, patient and family hardships, and improve patient, family and staff satisfaction.

Donabedian's model can be seen to be practical, and has relevance for practitioners wanting to improve the quality of care in their health care environments. The model is concrete and provides practitioners with a clear understanding of the processes involved in quality improvement. In order for clinicians to use scholarly materials, such materials must first be simple, easy to use and understand, easy to score, and easy to interpret (Doran & Pringle, 2011).

Research Questions

Based on the literature reviewed, the implementation and sustained use of the central-line care bundle can decrease the incidence of CRBSIs in all patient populations and care environments. Despite implementation of central-line care bundles, CRBSIs continue to occur. In inpatient units pediatric patients are encouraged to be "kids" which means that they are active and participating in developmentally appropriate activities that can be challenging at times when providing medical and nursing care. An exploratory research question related to nursing experience and practice was included to determine if there were associated differences in care provided.

The following research questions guided this study:

1. Are nurses providing expected central-line care and maintenance bundle components when caring for pediatric patients with CVADs?
2. Are there developmental or environmental considerations when caring for pediatric patients with CVADs that could contribute to the development of CRBSIs?
3. Are years of experience or age of the nurse associated with the practice of expected care of pediatric patients with CVADs?

CHAPTER 4: Methodology

This chapter includes a description of the methods and procedures used to explore pediatric nurses' experiences and knowledge of care and maintenance practices when caring for children with CVADs. The design, setting and sample will be discussed. Data collection procedures are outlined. Finally, data analysis techniques and ethical considerations will be presented.

Research Design

Research that seeks to identify or describe phenomena can be conducted using either quantitative or qualitative research methods (Polit & Beck, 2008). "Quantitative description focuses on the prevalence, incidence, size, and measurable attributes of phenomena" while qualitative studies "describe the dimensions, variations, and importance of the phenomena" (Polit & Beck, 2008, p. 19). A cross-sectional, descriptive and exploratory mixed-methods survey design was used. This study incorporated a mixed method design with quantitative and qualitative components.

The Setting

The settings for the study are pediatric medical and surgical units in the Child Health Program, Health Sciences Centre site. The hospital is located in central Canada, and is the only tertiary pediatric hospital in the province of Manitoba. In addition to Manitoba, Children's Hospital provides services for pediatric patients from North-Western Ontario and Nunavut.

The units involved in the study include CH3- Pediatric Day Unit, CK3 Pediatric Surgery and Burns, CH4-Pediatric Medicine, CK4-Pediatric Special Care Unit, CH5-Pedatric Transitional Care Unit, and CK5-Pediatric Medicine. In these units care is provided for patients from newborn to seventeen years of age. CH3 is a day unit that provides a variety of services for children who are not admitted to hospital but require medical day treatments. CK3 is a 21- bed unit which primarily admits pediatric surgery and burn patients however CK3 also admits over-flow medicine patients.

CH4 is a 22- bed acute medical unit that specializes in respiratory medicine including asthma, bronchiolitis, tuberculosis, other infectious diagnoses, and metabolic disorders. CK4 is a 6-bed medical unit that provides care to technology dependent children who require tracheostomies and long-term ventilator support. CH5 is a 20-bed medicine unit that specializes in eating disorders in the newborn to adolescent patients, and the cystic fibrosis population. In addition to these populations, CH5 admits patients with complex discharge requirements, and patients who need intensive rehabilitation prior to a safe discharge home, as well as a wide range of both infectious and non-infectious medical admissions. CK5 is a 16-bed medicine unit that specializes in hematology, oncology, bone marrow transplant, peritoneal and hemodialysis and renal transplantation. All of the inpatient units have assigned Child Life Therapists. A priority in all inpatient areas is to allow the child to be a child even in a foreign environment, and to provide stimulation through age appropriate growth and development activities.

The Sample

A convenience sample was obtained from the study population of 151 nurses (both licensed practical nurses and registered nurses) who work on the pediatric medical and surgical units and the Relief Team at the Children's Hospital. Inclusion criteria were nurses who are employed in casual, part-time or full-time positions from the seven areas. This included job classifications of General Duty Nurses, Licensed Practical Nurses, Nurse Clinicians, and Clinical Resource Nurses. In order to participate all of the nurses needed to have experience in caring for pediatric patients with CVADs in-situ; if they did not have experiences caring for CVADs they were automatically excluded from participating.

Nurses employed the PICU, NICU and Intermediate Care Nurseries, the Emergency Department, Children's Operating and Recovery Room, Hemodialysis and ambulatory care clinics

were excluded from the study as the care that they provide is fundamentally different than the care that is provided on the medical and surgical units. Patients admitted to critical care areas are critically ill, and exposed to different modalities of care than those seen on an inpatient unit. These children have additional risks for the development of a CRBSI that will not been discussed as part of the scope of this study. Nurses in management and educator positions were also excluded from the study as they do not provide direct care to patients with CVADs on a regular basis.

Measurement

Survey research as described by Polit and Beck (2008) is designed to obtain data about specific variables within a population. The data in this study were obtained from a population of pediatric nurses by means of self-report (Polit & Beck, 2008); the study participants answered questions posed by the investigator in order to answer the research questions. The survey allowed for the collection of data from the sample population that included a wide range of clinical experience and expertise.

Instrument

The survey instrument was developed by the researcher. The survey instrument was reviewed with, and validated for content by, Child Health Educators; Managers of Patient Care; and the Adult Vascular Access Team Nurse Educator and Manager. These individuals were not included in the study population but have knowledge and experience in caring for CVADs, or educating patients and staff on CVAD care and maintenance practices. The survey validation group was asked to comment on the appropriateness of the content, the appearance of the questionnaire, the length of time it took to complete the questionnaire, and to offer any comments about the survey process. Based on their feedback questions were revised and the tool was finalized.

The survey instrument consists of twenty-one questions and was developed using a four-point Likert scale to assess environmental factors that may affect care and contribute to the development of CRBSIs in pediatric patients; and the nurses current practice related to nursing care of pediatric patients with CVADs (See Appendix A). The survey questions were developed to reflect best practices for CVAD care and maintenance practice as described in the literature review and current Child Health CVAD policies, procedures and guidelines.

A four-point Likert scale was used with the measurement ordinals of: "all of the time," "most of the time," "occasionally," and "never." The option to choose "not applicable" was made available for participants who had not had an opportunity to complete a task related to CVAD care. For example, if in the last twelve months the participant had not had an opportunity to care for a patient receiving total parenteral nutrition (TPN), they did not have had an occasion to infuse the TPN through a dedicated lumen, nor to change the TPN IV tubing every twenty-four hours. In these instances, "not applicable" could have been chosen as a response as opposed to "never" which might suggest a knowledge deficit in relation to CVAD care and maintenance practices.

An additional three questions were included related to participant demographics. The demographic data collected in the study are: participants' age, number of years of nursing practice, and the length of time that they have been employed in their current area. Other demographic data that would be important to consider would include level of education, gender, and the years of practice as a pediatric nurse. However, since the population of eligible nurses was limited, the anonymity of the participants may have been placed at risk if these questions were asked.

Analysis

Descriptive statistical analyses utilized to obtain frequencies and percentages. Polit and

Beck (2008) refer to descriptive statistics as those used to describe and synthesize data that can guide in the understanding of quantitative research evidence (Polit & Beck, 2008).
In this study the ordinal measurements include: “all of the time,” “most of the time,” “occasionally,” and “never.” These ordinal measurements are used to capture information about equivalence and relative rank among the objects (Polit & Beck, 2008). The information obtained will not explain if one response is better than another, it only tells the relative ranking of the attributes level. When looking at CVAD care and maintenance knowledge and practice, the frequency of response, and percentage, are used provide a summary of the data.

Participants were asked three demographic questions namely numbers of years of nursing practice, number of years of practice on the current unit, and age. Frequencies and percentages were completed to provide a general description of the participants. To answer the third research question regarding any association between experience, age and expected CVAD care, Chi Square and Pearson’s Correlation Coefficient analyses were used to determine correlations. The Statistical Package for the Social Sciences (SPSS) was used for quantitative data analysis.

One open-ended question was asked at the end of the survey: “Please comment on any possible factors or situations that you think might contribute to the development of catheter related blood stream infections in pediatric patients.” Open-ended questions are used to gain an understanding of the context or setting in which the participants practice in order to address a problem or issue (Creswell, 2007). One of the goals of this research study was to learn about caring for a pediatric patient with a CVAD from the perspective of a bedside nurse. This can be achieved only if the nurse is willing to share their experience. Qualitative research is characterized by a focus on the participants’ perspectives (Speziale & Carpenter, 2007). The

open-ended question allowed respondents the opportunity to offer their perception, based on their experiences of caring for children with CVADs.

The qualitative research methodology of interpretive description was used for this study. In 1997, Thorne, Reimer Kirkham, and MacDonald-Emes published an article in which they identified the need to "build methods that are grounded in our own epistemological foundations, adhere to the systematic reasoning of our own discipline, and yield legitimate knowledge for our practice" (p. 172). The aim of interpretive description is to generate knowledge relevant for the clinical context of nursing (Thorne, Reimer Kirkham, & MacDonald-Emes, 1997; Thorne, Reimer Kirkham & O'Flynn-Magee, 2004). As Thorne (2008) explains, this approach "recognizes that the clinical mind tends not to be satisfied with 'pure' description, but rather seeks to discover associations, relationships and patterns within the phenomenon that has been described" (p. 50). The starting point for interpretive description is the critical exploration of existing knowledge and theory.

A content analysis was used to describe and interpret the participants' responses to the open-ended question. Data analysis in interpretive description involves inductive reasoning to make sense of the data from a clinical perspective through an immersion in the data to search for broad themes or ideas (Thorne, 2008). A thematic analysis approach as outlined by Braun and Clarke (2006) was used to analyze patterns in the data and to identify themes. These authors provide a step-by-step approach to thematic analysis. The six steps in the process are "1) familiarizing yourself with your data; 2) generating initial codes; 3) searching for themes; 4) reviewing the themes; 5) defining and naming themes; and 6) producing the report" (Braun & Clarke, 2006, p. 87).

The hardcopy and online comments from the open-ended question were compiled into a single document. Initially, the researcher reviewed and reflected on the comments submitted by the participants. Thorne (2008) cautions against coding too narrowly in the early review of data, and she advocates for an "active process" (p. 147) of on-going critical evaluation of categories and possible patterns. The steps that were taken are: coding the data, which reduces the data into meaningful segments and assigning names for the segments; combining the codes into broader categories or themes to identify patterns; and finally making comparisons from the data groups (Creswell, 2007). A thematic analysis approach as outlined by Braun and Clarke (2006) was used to analyze patterns in the data and ultimately identify themes. The coding from the content analysis was then independently reviewed and assessed for reliability and validity by the Thesis Advisor. Based on the themes identified from the participants' experiences, the knowledge of CVAD care and maintenance practice in the pediatric patient will be expanded upon; and high risk CRBSI activities that are not currently located in the literature may be identified.

Procedure

After validating the survey content with Child Health Educators, Managers of Patient Care, Adult Vascular Access Team Nurse Educator, and the Adult Vascular Access Team Manager, the researcher met with the research technician from the Manitoba Centre for Nursing and Health Research (MCNHR) to finalize the survey template and input instrument questions into the appropriate FluidSurvey format. This allowed for accurate instruction in preparation for downloading the participant response into SPSS software. The expertise of the MCNHR staff was essential in assisting in setting up the survey in a manner that safeguarded the anonymity of the participants, and ensured that the researcher did not have access to any identifying information provided by the participants.

Once Education/Nursing Research Ethics Board (ENREB) and Health Sciences Centre Research Impact Committee approval was obtained (See Appendix B and C), the researcher met with the Managers of Patient Care from CH5, CH4, CK4, CH3, CK3 and CH3. The "Script for Contact with the Child Health Management Team" (See Appendix D) was presented to the group, and copies were provided to the managers. Any questions the Managers had were addressed, and unanimous approval was obtained. A "Manager Script for Discussion with Nurses on the Units" (See Appendix E) was provided to the managers. This script was available for managers to enable knowledgeable communication regarding the study to their nursing team. The script could potentially be used during staff meetings, shift hand overs, or at any time that was deemed appropriate by the manager. Posters (See Appendix F) advertising the research study were then posted in strategic locations on the study units and in the Nursing Administration Office.

The Managers of Patient Care from the study areas were responsible for communicating with their nursing staff following the "Manager Script for Discussion with Nurses on the Units" (See Appendix E). The Manager from CH5 and CK4 agreed to communicate with the researcher's staff on CK5 and the Children's Relief Team to mitigate any ethical implications as elaborated under ethical considerations.

The survey could be accessed online in two ways: through an online link to the FluidSurvey advertised on the study poster (See Appendix F), and via an email link that was included in the invitation to participate sent through the Health Sciences Centre Global email service to the potential study participants (See Appendix G). The online Research Subject Information and Consent Form (See Appendix H) was accessed when the participants entered the FluidSurvey link. If nurses wished to participate, they were able to read the consent form and if they agreed to participate they could proceed directly to the survey questions.

Hard copies of the survey were placed on each of the study units, and in the Nursing Administration Office. Packages containing the Research Subject Information and Consent Form, the survey, and a sealable envelope with the study name written on the outside were provided. Two large brown office envelopes were present; the first envelope included the participant packages and the second envelope was available for nurses to place their completed surveys (both envelopes were clearly labeled). By completing the survey, and placing it in the sealable envelope, consent was presumed. Participants had three weeks to complete the survey. During this time, one reminder email was sent to the study participants to both thank those who had already completed the survey and to encourage participation. The sealed envelopes containing the hardcopy surveys were collected at various times throughout the three week period by the researcher. The researcher was responsible for getting the sealed envelopes to the research assistant. The research assistant was responsible for inputting data from the hardcopy surveys verbatim into the FluidSurvey link. Once the data transfer was complete, the research assistant placed the hardcopies into a sealed box; the researcher then gave the hardcopy data to the Thesis Advisor, for storage. The researcher did not see any of the original survey documents.

Ethical Considerations

The study adheres to the Tri-Council Policy Statement regarding *Ethical Conduct for Research Involving Humans* (Canadian Institute for Health Research, 2010) (See Appendix I). Consent was inferred with the return of the completed FluidSurvey. The nature of the study and respondents' participation was clearly outlined in the Research Subject Information and Consent Form (See Appendix H). The outline for ensuring informed consent was included in the written information provided to the participants. Voluntary participation of subjects in the study was established and reinforced on the consent form. Participants were encouraged to read the consent

form carefully prior to completing the FluidSurvey. If the study participants had any concerns or questions related to their participation, the name and contact information of the researcher, thesis advisor and ENREB Coordinator were provided. Anonymity was safeguarded by having no identifying information on the survey, or on the sealed envelopes provided in the survey package for the completed hard copies to be placed.

The study did not involve any deception of the participants. The results of the study will be communicated to them if they indicated they wished to receive a copy of the summary of the research findings. No harm to the participants was foreseen. Although there was no actual benefit to the participant, the results may lead to improved outcomes for children with CVADs within the Child Health program. Participants were assured that they may choose not to complete the survey, and would be free to withdraw from the study with no negative consequences. At the end of the survey, participants were asked if they would like to participate in a draw for one of four $50.00 gift cards; and if they would like a summary of the results of the study. If they chose to place their name in for the draw or to receive the summary report they were required to provide an email address. This address will only be used to communicate if they won one of the draws or to send the summary report. A separate FluidSurvey link was created and monitored by the research technician at the MCNHR to randomly draw four email addresses for the gift card winners, and to track those who wished for a summary report.

Anonymity of the participants was addressed through a number of strategies. The FluidSurvey link was sent to the nurses via the Health Sciences internal email group listing to the nurses located on CH3, CK3, CH4, CK4, CH5, CK5, and the Children's Hospital relief team. Hard copies were also available on the units and in the Nursing Administration Office. Hard copies from

the inpatients units were placed in a self-addressed envelope and were collected at multiple points over the duration of the data collection period.

The researcher is a Manager of Patient Care for one of the pediatric units, the Children's Relief Team, and is the Nursing Supervisor for a five-day period every ten weeks. Therefore, as there is a power differential between researcher and participants, steps were taken to ensure the maintenance of confidentiality and anonymity amongst the participants. No coercion was used to encourage participation. Posters advertising the study were on the inpatient units and in the Nursing Administration Office during the duration of the survey period. Ethics approval was obtained through the Education Nursing Research Ethics Board at the University of Manitoba and approval from the Child Health IMPACT occurred prior to any data collection. All data including hard copies and computer files will be kept for seven years and then destroyed via confidential waste disposal.

CHAPTER 5: Results

In this chapter the findings from a survey on nurses' knowledge of CVAD care and maintenance practices are presented. Data for this study were collected over a three week period from August 21 to September 11, 2014. Completed surveys were received from ninety-seven (97) of the 151 eligible participants; which is a response rate of 62.4%. Thirty-eight (38) participants completed the survey online and 59 participants completed the hardcopy version. The hardcopy survey responses were entered verbatim into the FluidSurvey program by the Research Assistant. Once the data were entered into FluidSurvey, they were cleaned and double-checked to ensure accuracy, transferred into SPSS Version 21(IBM Corp. 2012) Software program. The open-ended responses were placed into a Word document. Descriptive statistics (frequencies and percentages) were completed to summarize the sample characteristics and the responses to each survey question. Bivariate correlations between respondents' age, years of nursing experience and years of working on their current unit were calculated to determine whether any of these variables were significantly related to the survey questions.

Of the 97 responses, two respondents reported that they were not employed in the study areas, and therefore were excluded from participating in the study. In response to question two, "In your practice, do you care for patients with CVADs?" ninety-five nurses responded. Of those 93/95 (97.9%) of the nurses indicated that they cared for CVADs in their practice; therefore ninety-three participants were included in the study. Over 40% of the participants (44.6%) indicated that they cared for CVADs on most shifts; almost a third (29.3%) reported that they cared for CVADs occasionally; and one quarter (25%) indicated that they cared for CVADs every shift; while only one participant indicated that they rarely cared for CVADs (See Table 5.1).

Table 5.1

Participant Characteristics (N=93)

Years practiced as a Nurse	%	n
Less than 5	25.8%	24
5 to 10	25.8%	24
11 to 15	10.7%	10
16 to 20	16.1%	15
Greater than 20	18.3%	17
Missing	3.2%	3

Years employed on current unit	%	n
Less than 1	5.4%	5
1 to 3	22.6%	21
4 to 6	19.4%	18
7 to 10	16.7%	11
Greater than 10	37.6%	35
Missing	3.2%	3

Age in years	%	n
25 or less	8.6%	8
26 to 35	35.5%	33
36 to 45	24.7%	23
46 to 55	21.5%	20
56 to 65	7.9%	5
Missing	4.3%	4

Frequency of caring for patients with CVADs	%	n
Every Shift	24.7%	23
Most Shifts	44.1%	41
Occasionally	29%	27
Rarely	1.1%	1
Missing	1.1%	1

Demographic Data

Three demographic questions were asked of the participants; their age, years of experience, and number of years they were employed on their current unit. Over a quarter (26.7%) of the study participants indicated that they had less than five years of nursing experience; the same number reported between five and ten years of experience. Eleven percent (11.1%) indicated that they had

eleven to fifteen years of experience; 16.7% of the participants reported between sixteen and twenty years of experience; and almost 20% reported having greater than twenty years of experience.

Just over half of participants (51.1%) had been on their units more than seven years and close to half (48.9%) had been on their units less than seven years. The age of the participants were fairly evenly divided between those who were thirty-five years or less (46.1%); and those who were greater than thirty-five years of age (53.9%) (See Table 5.1).

Expected Central Venous Access Device Care and Maintenance

The first research question was addressed by asking participants to answer survey questions regarding their CVAD care and maintenance practices. These survey items were answered utilizing a four-point Likert scale. Of the 21 quantitative questions asked in the survey, 16 were based on care and maintenance practices (questions: 1 - 8, 10, 12, 13, 16 – 20). These data are summarized in Table 5.2. Respondents were instructed to choose "not applicable" as a response if they had not had an opportunity to perform a specific intervention. No consistency or pattern was recognized in the missing data, and a supposition was made that these data were missing at random. The response percentage was then based on the total number of responses.

Developmental and Environmental Considerations

The aim of the second research question was to gain information about the pediatric nurses' experience and observations when caring for pediatric patients with CVADs. This question sought answers in two ways. First, five of the survey questions (questions: 9, 11, 14, 15, and 21) were related specifically to environmental or developmental factors that may lead to an increase in the risk for the development of CRBSIs (See Table 5.3). Second, the respondents were asked to

comment in an open-ended question on factors that they believed could contribute to the development of CRBSIs.

Table 5.2

Expected CVAD Care Responses (N=93)

Question:	All the Time % (n)	Most of the Time % (n)	Occasionally % (n)	Never % (n)	Not Applicable % (n)	Missing % (n)
1. Family Teaching	20.4 (16)	16.1 (15)	40.8 (38)	8.6 (8)	16.1 (15)	1.1 (1)
2. Hand hygiene	89.2(83)	8.6 (8)	1.1(1)	0	0	1.1(1)
3. Assess exit site	75.3(70)	12.9(12)	9.7(9)	0	0	2.2(2)
4. Aseptic technique	93.5(87)	2.2(2)	0	1.1(1)	1.1(1)	2.2(2)
5. Scrub hub/connections	87.1(81)	10.8(10)	0	1.1(1)	0	1.1(1)
6. Allow alcohol to dry	62.4(58)	25.8(24)	6.5(6)	4.3(4)	0	1.1(1)
7. Dedicated TPN lumen	46.2(43)	22.6(21)	19.4(18)	6.5(6)	0	6.5(6)
8. Tubing change	80.6(75)	7.5(7)	1.1(1)	3.2(3)	6.5(6)	1.1(1)
10. Flush with turbulence	70.9(66)	23.7(22)	3.2(3)	0	1.1(1)	1.1(1)
12. Flush visible blood/cap	39.8(37)	40.9(38)	15.1(14)	2.2(2)	0	2.2(2)
13. Change cap/visible	9.7(9)	33.3(31)	44.1(41)	9.7(9)	0	3.2(3)
16. Change dressing if wet	77.4(72)	18.3(17)	1.1(1)	0	0	3.2(3)
17. Change dressing/peeling	37.6(35)	52.7(46)	8.6(8)	0	1.1(1)	3.2(3)
18. Scrub skin with friction	84.9(79)	7.5(7)	2.2(2)	1.1(1)	1.1(1)	3.2(3)
19. Allow CHG to dry	91.4(85)	4.3(4)	0	1.1(1)	0	3.2(3)
20. Review need for CVAD	4.3(4)	27.9(26)	44.1(41)	8.6(8)	11.8(11)	3.2(3)

Table 5.3

Developmental or Environmental Considerations in CVAD Care Responses (N=93)

Question:	All the Time % (n)	Most of the Time % (n)	Occasionally % (n)	Never % (n)	Not Applicable % (n)	Missing % (n)
9. IV tubing on floor	3.2(3)	6.5(6)	78.5(73)	9.7(9)	0	2.2(2)
11. IV tubing in mouth	2.2(2)	1.1(1)	78.5(73)	15.1(14)	0	3.2(3)
14. IV tubing in diaper area	1.1(1)	1.1(1)	69.9(65)	24.7(23)	0	3.2(3)
15. IV tubing in bath water	2.2(2)	0	43(40)	47.3(44)	3.2(3)	4.3(4)
21. Assistance with active pt.	47.3(44)	31.2(29)	17.2(16)	0	1.1(1)	3.2(3)

To answer the third research question and determine if there were any associations between the demographic variables of age, years of experience as a nurse and years employed on their current unit and their responses to the CVAD care questions, Chi square and Pearson's Correlation Coefficient analyses were conducted. The numbers of data in some categories were not sufficient enough to determine statistical significance. Pearson's Correlation Coefficient was used to measure the correlation between two variables. The demographic variables of age, numbers of years or experience, and numbers of years on the unit were compared against each of the participant responses from questions one to twenty-one. There were no significant correlations noted, even when the demographic data were collapsed into larger categories: for example nursing experience zero to ten years' experience and greater than ten years' experience.

The open-ended question: "Please comment on any possible factors or situations that you think might contribute to the development of catheter related blood stream infections in pediatric patients" was answered by 54 participants. Twenty-eight (28) of the participants answered the survey in hardcopy form, and 26 of the participants responded on-line and altogether they provided over 110 comments on factors or situations that they believe may increase the risk for the development of CRBSI. Participant responses to the open-ended question indicated a variety of

opinions about contributing factors for CRBSIs. The goal of the qualitative analysis was to categorize and gain a better understanding of the factors and situations that the participants described based on their experiences while caring for pediatric patients with CVADs.

After the qualitative data were compiled, the comments were coded. The codes were then grouped into categories to help determine if relationships or patterns existed in the participant comments, and to help answer the research question. A thematic analysis approach as outlined by Braun and Clarke (2006) was used to analyze patterns in the data and to identify themes. When exploring themes, consideration was given to how the various codes could fit together. This work was carried out by the researcher and thesis advisor individually, who then met to discuss ways to organize and group the categories until themes were agreed upon. After discussion, the themes were then broken down further to gain a better understanding of the meaning of the data. The themes were then coded based on their grouping and category.

The main categories were derived from inductive analysis and followed the steps outlined by Braun and Clarke (2006). The participants' responses were reviewed several times to achieve a deeper understanding of the meaning of the data; notes were manually written and compiled to assist in the identification of initial patterns and ideas for codes. The initial codes were categorized and analyzed leading to the identification of themes. The data were reviewed again to determine the appropriate category and labeling of the themes occurred. The identification of the theme is based on the content of the theme; Braun and Clarke describe this as "define what your themes are and what they are not" (p. 92, 2006). The authors suggest that the scope and content of each theme be describable in several sentences (Braun, & Clarke, 2006). Five themes and five sub-themes emerged.

Perception of Factors or Situations that May Contribute to the Development of CRBSIs

The second research question is related to factors or situations that the participants thought may contribute to the development of CRBSIs. The participants shared their experiences and thoughts on the factors or situations that they believed contributed to CRBSI rates. Overall, all of the themes were related to the introduction of micro-organisms into the CVAD. The five themes identified included: 1) improper technique with sub-themes of dressing changes, hand washing, and hub and connection care; 2) patient factors with sub-themes of growth and developmental status, and factors associated with treatments or conditions; 3) site location; 4) supervision of patient; and 5) frequency of accessing CVAD.

Improper Technique

The most common factor, as indicated by 47 participants, was related to improper technique when handling CVADs. These comments were applied to varying members of the healthcare team, including nurses, physicians, healthcare aides, the patient and their family. Examples of the use of improper technique were provided by the participants in relation to dressing changes, hand hygiene practices, and the care and maintenance of IV tubing, hub and connections. The lack of use of aseptic technique when accessing the CVAD, IV tubing, and CVAD dressings were described in multiple ways.

Dressing changes. Numerous comments on factors or situations that may increase the risk for developing CRBSIs related to CVAD dressing changes were provided by the participants. During the CVAD dressing change high risk activities or practices were communicated through the following comments:

"Soiled dressings not being changed appropriately."

"Staff/families fixing dressings that have been open/peeling off."

"Staff not using aseptic technique with dressing changes, not cleansing ports properly with med. [ication] infusions."

"…no dressing change orders post-op by surgeon."

"I have seen PICC lines [dressing] that should be changed 24 hours after insertion but have original dressing with +++ dried blood 5-6 days later."

"Lines should be scrubbed 30 sec, and left to dry…more diligence in dressing changes would make a big difference."

"Children being very mobile dressings pealing [sic] on arms, needing constant dressing changes, introducing bacteria to the site."

"When changing dressing and patient is breathing/coughing/sneezing on their line."

"Aseptic technique not maintained with CVAD dressing change."

"Site soiled with old blood after insertion and not cleaned properly."

"Improper cleaning, using anything other than aseptic technique when cleansing site, changing dressing, tubing or caps."

Hand hygiene. The lack of hand hygiene related to patients and their families was a theme identified by a number of participants. Examples of these comments are as follows:

"Hands of patients and families are not always clean. "Parents/visitors not hand washing prior to touching the lines."

"…patients and parents not washing hands enough and touching/picking at the line or dressing."

"Hand hygiene pediatrics challenges i.e. diapers etc."

"Poor patient/family hygiene."

Intravenous, hub and connection care. Improper technique when accessing hubs and connections of the CVAD were commented on most frequently. This theme was applied to numerous members of the healthcare team including nurses, physicians, and healthcare aides. These comments were related to numerous care and maintenance activities which included accessing the hub and connections, initiating IV solutions, timing of blood draws, lines becoming disconnected at hub and connections, IV tubing(s) touching the floor or becoming submerged in bath water, and equipment concerns. Examples of comments include:

"People taking "shortcuts" when providing line care or using the CVL (i.e. not cleaning the hub for 15 seconds or at all; not "protecting" the end of the IV tubing when disconnecting and potentially contaminating prior to reconnecting)."

"I see people prime tubings and let the tubing dangle to touch a sink. Diligence with cleansing with access I think has room for improvement, especially when lines are being accessed for bloodwork needs. I feel the time gets shortened."

"During a burn dressing change, I watched anesthesia administer medications into IV lines (PICC) without cleaning any ports."

"Poor handling, cleaning techniques. IV tubings dragging on the floor."

"…improper cleaning of the IV tubing hubs prior to accessing. IV tubings in the tub or diaper area. CVAD connection exposure to fluids such as tub water. Improper technique in changing IV bags."

"Lack of education of lines by HCA's (changing diapers/bathing, etc)."

"Adhesive present of the line itself or ie. Hubs above PICC lumens that is not removed from taping of lines."

"Doing bloodwork in dark patient rooms at 6AM-? Contaminating without knowing it."

"Drawing bloodwork on night shifts or while patient napping – some nurses may not ensure adequate space/lighting for fear of waking patients up."

"Staff not cleansing caps properly prior to accessing the cvad."

"…tears or breaks occurring in the CVAD; sutures being pulled out unintentionally."

"New tubing and caps with the screw on system. I question if cleaning the hubs before each access is sufficient as there seems to be nooks in the hubs."

"The new injection caps when the silicone gets pushed in and doesn't pop back out."

"New caps- unable to get inside the cap properly."

Regardless of how the participants described their opinions of contributing factors, there were common words and phrases throughout the comments including "improper cleaning technique," "not using aseptic technique," "poor hand washing/no hand washing," "[lack of] consistency," "people not adhering to protocols," and "carelessness when setting up tubing for TPN/fluids – not maintaining aseptic technique." The use of improper technique when handling CVADs was the most common theme and was identified by almost half of the participants. The second most common theme was related to patient factors.

Patient Factors

The second theme identified was patient factors. Patient factors were broken down into two sub-themes: growth and development, and factors associated with treatments or conditions.

Growth and development. Growth and developmental factors were identified by 28 participants as a situation or factor that may contribute to CRBSIs. Many of the participants made comments regarding growth and developmental factors specific to younger patients who have limited understanding of the concepts of aseptic technique and prevention of infection. Some of the participants' comments in this sub-theme are:

"Children handling/playing with central line tubing or caps-children's lack of ability to self-regulate cleanliness of cvad - young children may vomit or poop on central line tubing/connections-difficulty ensuring that a child holds still and does not cause contamination (ex. kicking, moving child may cause a nurse's hand to slip) during dressing change…"

"Younger patients "playing" with their dressing/tubing."

"Activity level of small children with limited supervision."

"Children handling/playing with central line tubing or caps."

"Children are a difficult population - they cry/move while trying to keep everything sterile, poop/throw-up/spill things on their lines that we don't always know about."

"Very active, smaller patients who play and twist the line."

Factors associated with treatments or conditions. Treatment or condition related factors were a sub-theme of patient factors. Participants identified situations and factors such as the patients' underlying disease process, e.g., immunocompromised patients, patients requiring treatments such as total parenteral nutrition, patients who require frequent blood draws from CVAD as high risk factors, and situations for the development of a CRBSI.

"Lots of TPN- high breeding ground for bacteria."

"Immunocompromised children- natural skin flora can infiltrate the line."

Site Selection

The location of the CVAD was the third theme regarding factors that participants felt may contribute to CRBSIs. Nurses indicated their concern regarding catheter site selection as a risk factor that may contribute to CRBSIs through the following examples:

"Cvads in the groin area are notoriously exposed to voids and feces."

"Cvads in the intrajugular are exposed to grabbing fingers and at risk for being pulled out more often than not."

"Cvads being placed in the jugular vein in small infants, dripping milk when eating, causing the dressing to consistently soil and peal, needing frequent dressing changes."

"Cvads being placed in the femoral vein, being soiled by voiding and bowel movements."

Length of time CVAD remains in-situ. A sub-theme of catheter site was related to the length of time that the CVAD remained in-situ. Respondents expressed a number of concerns related to the length of time that CVADs were kept in-situ when they were no longer needed for the provision of care. Examples that participants provided include:

"Services are very reluctant to take PICC lines out when not needed. The Services tend to keep the lines for some days "for just in case". This practice tends to manifest itself for a week or so putting the child at risk of an unused line becoming infected."

"Line left in too long."

Supervision of Patient

The fourth theme is related to the supervision of the patient by staff and or their family. Participants contributed the following examples related to risk factors that they believe contribute to CRBSIs through activities, or in some cases, inactivity by family members:

"Some parents don't monitor their child's behaviour and don't stop them from doing high risk activities like playing or sucking on their central line. Despite securing lines with safety pins, parents often let the line hang without support."

"…when parents are present they are not always mindful of what their children are doing – not caring for them."

"Sibling spreading germs to patient."

"Social Factors (presence of a parent)."

When families are not present to care for their children, care is assumed by the staff on individual units, including both nursing and support staff. One nurse voiced concern regarding the education that is provided to the support staff being a contributing factor to the development of CRBSIs:

"Lack of education of lines by HCA's (changing diapers/bathing, etc.)."

Frequency of Accessing CVAD

The fifth theme identified was related to the frequency of accessing the CVAD. Concern regarding the number of times that a nurse is required to access the CVAD during the provision of daily care was identified by seven participants as a factor that could contribute to CRBSIs. The participants included blood work, starting and stopping infusions, locking off lines between medications, accessing and disconnecting CVAD, IV tubing and cap changes. Participants provided the following examples:

"Multiple accesses per day for bloodwork, meds, transfusions."

"…accessing lines frequently in a single day for frequent bloodwork or locking between meds."

"Frequent stopping and starting of various infusions."

"Too frequent accessing and disconnection."

All of the comments that the participants provided were felt to contribute to the development of CRBSIs; however based on these comments, the majority of respondents felt that the inconsistent use of aseptic technique was the most common factor contributing to the development of CRBSI in their pediatric patients. Patients, families and healthcare staff were all implicated in introducing micro-organisms into the CVAD through differing modalities.

CHAPTER 6: Discussion

In this chapter the research study findings will be discussed based on the results presented previously. The primary objective of this chapter is to address the research questions. The study results will be discussed in relation to relevant literature on care and maintenance practice of CVADs and Donabedian's Quality Improvement Model. Study limitations will be highlighted and implications and recommendations for nursing practice, education, and research will be presented.

Study Sample

The demographic information in this study was included to provide a basic description of the study participants and a brief insight into the representativeness of the study sample. The limitations present in the study related to participant demographics will be discussed in the limitations section of the document.

Of the 151 possible participants, 97 nurses completed the survey resulting in a 62.4 % response rate. The two methods of obtaining survey data were hardcopy and online. Hardcopy mail surveys on average generally provide a 50% to 60% response rate and according to Sheehan (2001), estimated response rates for e-mail surveys are approximately 30%. This survey reflects a higher than average response rate. A number of factors may have contributed to this. The survey was targeted at a specific population of nurses that have a vested interest in the care that is provided. These nurses may believe if they participated in the survey, improvements in the quality of care that is provided to patients with CVADs in the institution could occur. The potential improvements in quality of care could also have been perceived as a benefit, and as such, the respondents may have wanted to participate in a quality improvement process.

Manager support on the patient units may also have contributed to the overall response rates. Discussion regarding CRBSIs was generated in some of the units and managers encouraged staff to participate to gain a better understanding of practices regarding CVAD care in their specific areas. The gift card incentives, e-mail reminders, and colorful posters may also have contributed to the over-all response rates. Because of the above average response rate, the reliability of the data to reflect the truth, and represent the experiences of the target group may be improved (Polit & Beck, 2008).

All of the nurses who met inclusion criteria in the study cared for children with CVADs as part of their practice. The majority of the participants (70%) reported that they cared for patients with CVADs either daily, or on most shifts whereas the remaining 30% indicated occasional or rare contact with CVADs. Although the nurses were not required to provide which area they were employed, because of the above average response rate, a greater confidence that the study population may be representative of all the possible participants may be reasonable.

Findings

The findings from the study provide data on CVAD care and maintenance practices present in the Winnipeg Children's Hospital patient care areas. No published studies were found that explored the research questions posed in the current study. As such, limited opportunities were available to compare these findings to others. In response to the question "Are nurses providing expected central-line care and maintenance bundle components when caring for pediatric patients with CVADs?" the study included questions that could identify gaps in both knowledge and practice.

CVAD Care and Maintenance Compliance

Improper technique. The first item on the survey was "I follow aseptic technique when providing CVAD care." The vast majority (93.5%) of respondents indicated that they followed aseptic technique "All of the Time;" only two participants indicated that they followed aseptic technique "most of the time;" and one nurse responded as "never" using aseptic technique. It seems highly unlikely that a nurse would never use aseptic technique and as this was only one response it seems reasonable to assume that there may have been a misunderstanding of what the question asked or in indicating their response. Having even a small percentage of individuals caring for CVADs not following aseptic technique all of the time would indicate a need to redevelop the structure and processes in place when educating nurses in the facility.

Data on the second research question related to developmental or environmental considerations when caring for pediatric patients with CVADs indicate that situations or factors that participants thought contributed to the development of CRBSIs most often were related to improper technique. Numerous examples of improper technique were provided by the participants. Despite the vast majority of the participants indicating that they follow aseptic technique in the expected CVAD care responses, a contradiction seems to be present based on the responses to the open-ended question.

These contradictory findings are also present in the literature. Jeffery and Pickler (2014) undertook a study to explore nurses' perceived barriers to adherence of CVAD care practices. The authors found that the barriers the nurses revealed had to do with the nurses' own limitations. The authors concluded that despite nurses knowing the literature on the prevention of CRBSIs, nurses come up with creative ways to rationalize or justify their behaviour when non-adherence practice is occurring (Jeffery & Pickler, 2014). In a study conducted by Debono,

Greenfield, Travaglia, Long, Black, and Johnson (2013) nurses described "work-arounds" being necessary when there was an unavailability of equipment, lack of awareness of policies, perceptions that policies were unnecessary, and when staffing deficiencies were present. Although the respondents were not asked to identify barriers to adherence of CVAD care guidelines, they acknowledged many instances where they observed others breaching technique. Interestingly, there were no respondents who indicated that staffing deficiencies, lack of awareness of policies, or equipment availability was a source of concern.

Dressing changes. According to the literature reviewed and as reflected in generally accepted practice, the initial dressing change should occur 24 hours after the insertion of the CVAD. Subsequent dressings need to occur if the dressing becomes wet, soiled, dislodged, or if the last dressing change was seven days or greater (Guerin et al., 2010; O'Grady et al., 2011; Pratt et al., 2007; Raad et al., 2001).

When the dressing is removed, a chlorhexidine solution is recommended to be used as skin antisepsis. The chlorhexidine is applied in a manner that creates friction; creating friction allows for greater penetration of chlorhexidine into the skin (Guerin et al., 2010; Macklin, 2010; Ryder, 2006) generating a longer kill time. Findings from the current study indicate that almost 85% of the participants apply chlorhexidine for 30 seconds in a manner/motion that creates friction. Fifteen percent (15%) of the participants did not follow this practice consistently, leading to possible concerns regarding skin antisepsis techniques when dressing changes occur.

When using chlorhexidine, one of the most important factors related to its use is to allow the chlorhexidine to dry before the new dressing is applied. Allowing the chlorhexidine to dry has a two-fold purpose, it allows the chlorhexidine to bind to the proteins on the skin thus creating a longer kill time; and it prevents the adhesive on the polyurethane dressing from

coming into contact with the moist chlorhexidine which can lead to a chemical burn on the patient's skin. In response to the item "I allow the chlorhexidine to dry before I replace the dressing" the majority of the participants indicated that they did this "all of the time" (91.4%). Although the majority of the participants follow the appropriate care guidelines, for the 8.5 % of the participants who do not undertake this practice consistently harm to patients through the development of a CRBSI and/or chemical burn may occur.

When asked about changing the CVAD dressing when it is wet, just over three quarters of the participants indicated that they would change the dressing "All of the Time." Participants who would change the dressing "most of the time" totaled 18.3 %. When the participants were asked "When the CVAD dressing is starting to peel off, I change it," close to 40% percent of the participants indicated that they would change the dressing "All of the Time," while over half would change the dressing "most of the time," and just 8.6 % indicated they would change the dressing "occasionally." Participants' overall level of compliance with the recommended care and maintenance practices of CVADs in this regard are concerning.

Comments made during the open-ended question indicated that there were a number of issues related to dressing changes that participants thought may contribute to CRBSIs. One comment that appeared several times involved surgeons writing orders post-operatively to not change the initial dressing for seven days, contradicting best practice literature that indicates the dressing should be changed 24 hours post insertion (O'Grady et al., 2011; Pratt et al., 2007; Raad et al., 2001). The generally understood rationale for this practice is the surgeons' fear that the CVAD will become dislodged, requiring re-insertion. This unfortunate circumstance has occurred on a number of the units and these surgeons have determined the best way to 'save their lines' is to prevent nurses for removing the dressing. This potentially leaves the dressing soiled

with dry blood and fluids for a seven day period, creating a rich environment for the growth of micro-organisms. It may be a belief of these surgeons that the risk associated with CVAD dislodgement is greater than the risk for infection.

A second common comment regarding dressing changes was related to "staff and family fixing dressings that have been open/peeling." Depending on the age of the child, dressing changes can be a very traumatic event for the child and subsequently the family and staff might be reinforcing dressings to defer a dressing change from occurring. Having to hold a child to prevent them from "squirming" and potentially contaminating exit sites is at times difficult to accomplish. In order to circumvent early dressing changes, some nurses and family members simply apply another dressing over the initial dressing. Unfortunately, in such instances, the integrity of the initial dressing can be compromised and the child may be placed at a greater risk for the development of a CRBSI. Balancing the psychological needs of the child to feel safe in the hospital environment and the need to decrease or prevent the opportunity for the development of a CRBSI can place nurses in a precarious position.

When reviewing the responses to the five questions related to dressing changes, the open-ended comments seem to imply that the dressing change itself is fraught with potential risk factors. The majority of participants seem to be following recommended care and maintenance practices. However, quality improvement activities were identified for almost all aspects of dressing changes.

Exit site assessment. Three-quarters of the participants indicated that they assessed the exit site on every shift, 13% indicated that they assessed the exit site "most of the time" and about 10 percent of the participants indicated that they assessed the site "occasionally." The early identification of exit site complications assessed through daily inspection of the exit site is an

important component of the CVAD care and maintenance bundle (Guerin et al., 2010). It would be interesting to be able to determine the barriers which prevented the assessment of the exit site on every shift, or follow care and maintenance practices. In situations where site assessments did not occur on a regular basis, the family may interpret site assessments as unimportant following discharge and not undertake them on behalf of their children. Families who are aware of possible complications and how to intervene if any occur are better able to handle the problem (Marcoux, Fisher, & Wong, 1990). Education of the patient and family plays a significant role in decreasing the risk for a CRBSI. A number of issues that have been discussed could be alleviated with a more robust education plan in place.

Site selection. The surgical site where the device is placed may be a risk factor for the development of a CRBSI. Site selection in children is often dictated by the size of the child and their vascular access needs. Although there is no intent on the part of surgeons to place the CVAD in a location that would contribute to infections, certain locations of CVAD insertion may pose more risks than others. Nurses may need to identify and implement interventions for those children who are found with formula, saliva, or any other substances on their dressings to help mitigate the need for frequent dressing changes.

Hub and connection care. One item regarding hub and connections was "Prior to accessing the hub and connections, I scrub the hub and connections for 15 second with alcohol." The response to this question demonstrated that participants adhered to this practice 87 % of the time while 10% of the participants indicated that they did this "most of the time."

Hub and connection disinfection is the primary intervention used to minimize intraluminal contamination (Macklin, 2010). A minimum scrub time of 15 seconds is recommended in the literature, however, Ryder (2006) suggests that the longer the scrub time,

the greater the disinfection of hub and connection sites. Current policy provides nurses with an option of 15 to 30 second scrub times. As some nurses may in fact scrub for 30 seconds, they may have chosen "most of the time, occasionally or never" as their response to an item specifically indicating a scrub time of 15 seconds. The question would have been better worded to ask about scrubbing for *at least* 15 seconds. The option for a 30 second scrub was embraced by the vascular access experts at the Health Sciences Centre Winnipeg, despite full knowledge that a 15 second scrub was recommended through evidence based practice. It was thought that nurses would shorten the scrub times from, for example, 15 seconds to 10 seconds; so that 15 second scrubs would always occur if the recommended scrub time remained 30 seconds (personal communication, C. Pinkerton, November 17, 2014).

A second item related to hub care was "I allow the alcohol to dry before I access the hub or connections." The majority (62.4%) of participants specified that they allowed the alcohol to dry "All of the Time;" one-quarter of the participants indicated that they allowed the alcohol to dry "most of the time," and 10.8 % chose "occasionally" or "never." Despite this practice being a recommended component of the care and maintenance practice (Guerin et al., 2010; Hadaway, 2006; Segreti et al., 2011) rationale for this practice was not found in the literature reviewed. Although Baxter Corporation® (the supplier of the IV tubings and injection caps) was contacted for their rationale as a recommended procedure, no response has been received to date. Lack of clear evidence for practice may play a role in the varying responses from the participants.

A number of participants indicated their perception of an increased risk of CRBSIs as being related to the new style of injection caps that had been implemented in the facility three weeks prior to the study. Two specific concerns were raised, the first was regarding the nurses' inability to apply antiseptic solution and scrub all areas on the surface of the cap. Concern was

also raised about the inner septum of the cap not consistently returning to a closed system post removal of the syringe or IV tubing. In discussion with Baxter® representatives, their response was that this should not occur and product complaints should be generated if the cap behaves this way (J. Prichodko, personal communication, October 22, 2014). Despite these concerns, no significant increases in CRBSIs have been seen to date; however, anecdotal monitoring continues to occur by the infection control nurse clinician (K. Olekson, personal communication, November 18, 2014).

Injection cap care. Two items were provided that are specific to injection cap care; first, "When I see visible blood in the injection cap, I flush with normal saline." Three-quarters of the participants indicated that they would flush the injection cap with saline "all the time" or "most of the time" while one-quarter of respondents indicated "occasionally" or "never." Blood in the injection cap may contribute to micro-organism growth and may also increase the risk for the development of clot formation or fibrin occlusions (Moureau, 2010).

"When I see visible blood in the injection cap, I change the cap" is the second item specific to injection cap care. Forty-three percent (43%) of the participants indicated that they would change the injection cap "All the Time" or "most of the time" while the rest of the participants indicated that they would "occasionally" or "never" change the injection cap in this instance. In retrospect, it is possible that these two questions were asked in an unclear manner and as such the responses were difficult to interpret. If the clarifiers of "fresh blood" or "old blood" were visible in the cap, the responses may have been different. If old blood was present, the number of participants who indicated that they would change the cap may have been greater. Similarly, if fresh blood was present in the cap, a greater number of participants may have

indicated that they would flush the cap with saline. For each question, the answer is different if fresh or old blood is present in the cap.

When assessing knowledge of flushing techniques the following question was asked "when flushing the CVAD with normal saline, I instill the saline in a manner that creates turbulence." The majority of participants (70.9%) indicated that when they flush the CVAD turbulence is created.

Intravenous care. Two questions were asked about intravenous tubing. The first question was related to the use of total parenteral nutrition: "I infuse TPN through a dedicated lumen." Less than half of the participants indicated that this was their practice. One-quarter of the participants indicated that this occurred "most of the time," less than one-quarter indicated that it occurred "occasionally" while 6.5% indicated that this never happened. Of all the survey questions, this question had the highest number of missing responses. This is a very interesting result. Current practice on the oncology/bone marrow transplant unit is for surgeons to insert double lumen CVADs into this patient population. When these patients' complete blood counts are at nadir (hemoglobin, white blood cells and platelets are at their lowest), mucositis is common and often requires continuous infusions of narcotics for pain control, antibiotics for fevers, IV fluids for hydration, other IV medications for supportive care, and TPN for nutrition. When the patient only has a double lumen catheter, difficulties arise with the compatibilities of the parenteral treatment modalities; narcotics, IV fluids and antibiotics are often "piggy-backed" with the TPN and infused via a single lumen.

Although the IHI (2012) recommends the use of the smallest number of lumens possible; the practice of having a dedicated lumen for TPN is not easily accommodated in this scenario. Participants may have felt conflicted when answering this question as little can be done when

equipment limitations are present as described in this scenario. The only solution to this issue would be to insert a peripheral IV, and unless under dire circumstances, this solution would likely not be desirable to the patient, family or staff.

The second item regarding changing IV tubing is in situations where crystalloid solutions are used and tubing should be changed every 96 hours demonstrated that that the majority (80.6%) of the participants complied with the recommended care and maintenance practices. Fourteen percent of the participants indicated that they did not follow this practice. Several explanations may account for this. In scenarios where there is a purposeful interruption of IV fluids, for example during the administration of intermittent IV antibiotics, the IV tubing is to be changed after 24 hours of use. Some uncertainties may have been present in the participants' responses related to this practice.

The second factor that may have affected care is related to the Pediatric Day Unit (PDU) hours of operation. The PDU operates from 8am to 4:15pm Monday to Friday; these nurses only establish IV sets for patients who attend the hospital during these hours. Once the patient leaves the IV set up is discarded, therefore, these participants would not have opportunity to change the IV tubing at 96 hours.

Time of blood draws. Several participants indicated their concern regarding increasing the risk for CRBSI when they access CVADs for bloodwork in the early morning hours, commonly at 6am. At this time the patient room is dark, and the child is sleeping. Fear of unknowingly contaminating the CVAD was participants' primary concern and of secondary concern was waking the child or their parent. In order to have bloodwork results available for physician rounds, blood collection needs to occur early in the morning. Historically, numerous complaints from family members have been received regarding this early morning practice and

nurses are typically at the receiving end of these complaints. Nurses are frequently placed between two competing factions: the patient and their family, and the physicians. No comments were made regarding the unavailability of equipment such as flashlights to mitigate the need for turning on the overhead lights and thus waking the child.

Assistance with active children. Numerous comments were generated by the participants regarding active children contaminating the injection caps, hubs and exit sites of their CVADs in response to the open-ended question. Active children are a common occurrence in pediatric hospitals where, in fact, activity is encouraged. In the open-ended question participants identified the need for assistance when providing care to active children to prevent breaches in aseptic technique. In the question "I seek assistance from co-workers when accessing the CVAD on active or mobile children" less than half of the participants indicated that they sought out assistance when providing care to these children. Even fewer participants (31.2%) indicated that they solicited assistance "most of the time," and even fewer (17.2%) indicated they "occasionally" pursued assistance. Determining why this is so may be complex.

Hand hygiene. Hand hygiene is one of the best ways to prevent the spread of micro-organisms (Pittet, 2004; Pratt et al., 2007; World Health Organization, 2009; Allegranzi & Pittet, 2009) and therefore it is important to determine adherence to hand washing when caring for patients with CVADs.

Nursing staff. Participants in this study reported that they practiced hand hygiene prior to touching the CVAD or IV tubing(s) "All the Time" 89.2 %; while 9.7 % of the participants' performed hand hygiene "most of the time" and "occasionally." Hand hygiene compliance audits (2013) at the Winnipeg Children's Hospital identified 37% to 89 % successful hand hygiene opportunities with an average compliance rate of 63.2 %. Nurses' adherence to recommended

hand hygiene opportunities is highest when compared to other health care workers (HCW) (Pittet et al., 1999). Therefore, the rates of hand hygiene compliance reported by participants in this study may accurately reflect current practice.

Although the majority of respondents indicated that they perform hand hygiene all the time, almost 10% of the nurses reported they do not perform hand hygiene appropriately. Despite structures and processes present in the facility, such as teaching handbooks and CVAD education sessions for new employees, adequate staffing ratios, and easily accessible supplies, a deficiency continues to be present and may need further focus.

Patient and family. Several comments by participants related to hand hygiene by the patients and their families were identified as factors which contributed to CRBSIs. Interestingly, no comments regarding other nurses or HCWs who neglect hand hygiene opportunities were identified. When one considers the first survey item "I teach patients and families about CVAD care and maintenance prior to their discharge," it is interesting to note that less than 40% of participants indicated that they taught the family "all of the time" or "most of the time," and therefore it should not be surprising that families are not enacting consistent hand hygiene practices. This potentially leaves a large percentage of patients and families without appropriate teaching regarding care and maintenance practices prior to their discharge.

Opportunity to improve processes to increase the quality of care when teaching patients and families has been identified. Marcoux, Fisher and Wong (1990) emphasize the need for families to be educated on not only the complications that can arise from having a line in-situ, but also on the preventative strategies that they can take to help mitigate, or intervene if a complication is identified. Marschall et al. (2008) advocate for the education of physicians, nurses, and other healthcare personnel about guidelines to prevent CRBSIs through the use of

easily accessible online and hardcopy tools or guidelines. Based on the comments of participants, concerted efforts to educate patients and families in the same manner should occur. Segreti, Garcia-Houchins, Gorski, Moureau, Shomo, Zach et al. (2011) indicate that patients and families need to be educated on risks of infection, catheter type, insertion site, hand hygiene, aseptic technique, catheter care, and limits to activities of daily living related to the presence of the CVAD. Currently, structures and processes are present to facilitate patient and family education. This includes CVAD teaching packages, which includes a patient education booklet, a teaching record, and age appropriate pamphlets describing CVADs; visual aids including puppets and plastic mannequin chests are available for demonstration and play. Despite the availability of these teaching supports, inconsistency of use is present in a number of areas.

Many of the factors and situations that participants felt contributed to CRBSIs were applied to patients and families. If the structures and processes associated with patient and family education were strengthened, improvement in the quality of CVAD care could be seen.

Need for central venous access device. The last questionnaire item was "I discuss/review the need for the CVAD with the medical service during daily rounds." In the literature reviewed, adherence to this component of the Central-Line Bundle is challenging. In some instances authors recommended the development of internal processes such as integrated check-lists and audits to ensure documentation of daily evaluations confirming the CVAD necessity was completed (Hadaway, 2003; Loveday, Wilson, Pratt, Golsorkhi, Tingle, Bak, et al., 2014; Nakazawa, 2010). In the current study, the most common response to this question was "occasionally." Ongoing education of all members of the healthcare team regarding central-line bundle components will be required to improve quality outcomes. This may be partially achieved through the introduction of mandatory yearly CVAD reviews (which include all components of

the Central-Line Bundle) for nurses who care for CVADs; as well as mandatory usage of daily CVAD care and maintenance flow sheets. However, this component of the Central-Line Bundle affects more disciplines than nursing. How to address this bundle requirement with the physician group may prove to be problematic. An interdisciplinary approach will be needed to improve clinician compliance with the evidence-based guidelines (Ayse, Marstellar, Ant Ozok, Xiao, Owens, Pronovost, 2010)

Developmental and Environmental Considerations

The open-ended question which asked whether there were "developmental or environmental considerations present when caring for pediatric patients with CVADS" did not reveal any overwhelming concern from nurses surrounding this issue. The majority of participants acknowledged only occasional observations of high risk activities such as IV tubings on the floor, in the patients' mouths, in the bath water, or in the diaper area. Based on the responses from the participants, one would conclude that the main contributor to CRBSIs is not related to developmental or environmental factors, but to improper technique. Many of the participant comments reflect normal growth and developmental factors which provide inherent challenges for nurses while caring for children with CVADs.

Other Possible Reasons for Non-Adherence

In addition to what has been discussed, the literature has identified several other possible reasons why staff does not practice according to available practice standards. Debono et al. (2013, p. 6) postulated that "work-arounds" such as circumventing policies and procedures are created by staff in response to a number of factors including organizational work processes, patient related factors, individual, social and professional factors, group norms and

organizational culture, being perceived as competent, and collegiality influence. All of these factors may influence the adherence to care and maintenance practices in the study areas.

Jeffery and Pickler (2014) attributed non-adherence to CVAD policy and guidelines based on the extent of experience that the staff members had in caring for the devices. In this study, nurses reported a variety of responses in the frequency that they had cared for CVADs; the greater the experience that the nurses had in caring for CVADs the greater the adherence to standards of care. If Debono et al.'s (2014) postulate is to be believed, nurses who care for CVADs on every shift should provide superior care to those nurses who only care for CVADs "occasionally." Findings from this study do not support this notion. In fact, one might counter-propose that nurses become complacent, and their familiarity with CVADs creates an environment where the risk factors associated with CVADs become overlooked in the work load, and CVADs simply become a tool to provide care, not a treatment modality that is associated with significant risk.

Theoretical Framework Revisited

The framework chosen for this study was Donabedian's Structure-Process-Outcome Model (1966). The purpose of a theoretical framework is to guide the research process through explanation of the relationships between study variables (Wood & Ross-Kerr, 2006). Therefore, the following discussion will highlight how the frameworks achieved this goal.

Donabedian's Structure-Process-Outcome Model was developed to assist with describing and evaluating methods used for assessing the quality of medical care related to physician-patient interactions (Donabedian, 1966). Donabedian described quality as the product of two factors: the science and technology of health care; and the application of that science and technology in actual practice - or a triad between structure, process and outcome. Applying Donabedian's framework to

this study, it would be expected that by impacting structure and process, outcomes for patients with CVADs will be improved, along with overall quality of care.

Donabedian's model provided the framework to assess the process and structures present related to CVAD care and maintenance practices. The study illuminated a number of process and structural deficiencies within the facility, particularly in relation to education of staff, patients, and families; questionable technical competencies in terms of the use of improper technique; and the use of asepsis by nurses, physicians and support staff were also identified as possible risk factors for CRBSI by some of the participants. Nurses identified a number of valid concerns related to care and maintenance practices that will need to be addressed if the quality of care for CVADs to be improved. Overall, the model was a valuable tool to explore the research questions posed in this study.

Study Limitations

The limitations of a study involve critical analysis of the study design, method, and results in order to determine internal and external validity. This analysis determines the applicability and generalizability of the results (LoBiondo-Wood & Haber, 2013). The main limitations of this study are related to the sampling strategy, instrumentation, and demographics.

Sampling strategy. The current study used a convenience sample which, although commonly used, has a major disadvantage. That is, there is an increased risk of bias since participants volunteer to participate and information is not obtained from non-respondents (LoBiondo-Wood & Haber, 2013). Nurses who chose not to participate may have done so because of a number of factors such as a lack of knowledge of, or value placed on, the topic of CVAD care or even being fearful that anonymity of the participants would not be maintained.

Therefore, findings cannot be generalized to all pediatric nurses who care for patients with CVADs at Winnipeg General Hospital.

Instrumentation. The second study limitation relates to instrumentation. In this study the tool used was developed by the researcher to specifically look at questions related to CVAD care and maintenance practices and growth and developmental considerations. Despite the tool being validated by educators and managers, two questions were missing key descriptors, and one question could have been interpreted in different ways which led to difficulty when assessing the results. This tool has not been tested previously and therefore has no reportable psychometrics. Because of this, the reliability and validity of some of the questions may be problematic.

Demographic results. The demographic data in this study were included to provide a superficial description of the study respondents. Because of the risk to the anonymity of the subjects, limited information was obtained from the participants.

When comparing the number of years that the nurse had practiced and the responses to the survey questions, there was no correlation demonstrated. Being able to correlate the years of nursing experience, area of employment, and the question responses may have provided very interesting insight into the research questions. Having this information may have identified areas of concern related to specific components of the central-line care and maintenance bundle. Does one particular identified group of nurses have knowledge deficits in caring for CVADs? If yes, specific structures and processes could be implemented in the area of concern to improve the quality of care provided in that area.

In summary, although there were a number of limitations related to sampling strategy, instrumentation, and demographics, the response rate was higher than usually reported which contributes to confidence that the sample may be representative of the nurses currently practicing

in the Children's Hospital Winnipeg who work in pediatric areas providing care to patients with CVADs.

Implications and Recommendations

Prior to this study, there was a gap in the literature in relation to understanding if a relationship existed between CRBSIs and the growth and developmental stage of pediatric patients. Historically, the risk for the development of CRBSIs was attributed primarily to breaches in technique. A greater understanding of how development factors contribute to the risk of CRBSI was assessed. Findings from this study contribute to a greater understanding that the care that is provided is much more complex than originally thought, and multiple levels of care providers may contribute to the development of CRBSIs in differing ways. Participants identified many contributing factors in the development of CRBSIs that will need to be addressed in efforts to improve the quality of CVAD care at the site. Thus, this study has implications and recommendations for practice, education, and research.

Practice. The literature describes many initiatives that have been undertaken to decrease the risk of CRBSIs. Understanding how CVADs are cared for and maintained sheds light on possible reasons why CRBSIs continue to occur despite the implementation of care and maintenance of best practice bundles. Through education, and following the latest care and maintenance recommendations, great strives can be achieved in preventing these potentially avoidable nosocomial infections. Clear unambiguous, realistic goals based on the IHI (2008) recommendations need to be established. Interventions to achieve the goals need to be developed, monitored, and be re-assessed on a yearly basis.

Hospital administrators need to be aware of the role of each discipline when addressing issues surrounding CRBSIs. Administrators need to support and enforce interventions that will

potentially decrease the risk for developing CRBSIs. Interdisciplinary teams consisting of members who are invested and engaged in developing best practice guidelines related to CVAD care and maintenance are required for the successful implementation of the initiative. The team could potentially include (but is not limited to) physicians from a variety of specialty and sub-specialties including pediatricians, surgeons, intensivists, oncologists, medical physicians; nurses from a variety of specialties including pre and perioperative care, surgical, medical, emergency departments, infection control, nurse educators, and managers; and support staff including healthcare aides, child life specialists, housekeeping staff, occupational and physiotherapists. The last and most important member of the interdisciplinary team are the patient and their family.

The role of the Infection Control Nurse Clinician should be expanded. Once the members of the healthcare team recognize the relationship between their actions (structure and process) and the development of CRBSIs (outcome), communication related to the prevention of CRBSIs needs to occur. In order to do this important work, additional support is needed to allow for consistent tracking of CRBSI rates by the Infection Control Nurse Clinician in all areas of the facility, not just the ICUs. Ensuring that all team members are aware of an occurrence is an important piece of the learning process as it closes the loop by identifying and communicating potential issues to members of the team who may now be external to the patient, such as the surgeon. Posting CRBSI rates for staff and families to see may also assist in keeping nosocomial infections at the forefront for every team member. This work is time consuming, but highly valuable. It is difficult to assess if a problem is present if no one is tracking the data.

Education. Education of the medical, nursing and other healthcare staff plays a significant role in reducing CRBSI rates. The educational component currently available for staff

is not standardized and should be re-evaluated. Redevelopment of the structures and processes supporting CVAD care and maintenance practices will be essential as we move forward.

As identified by the study participants, educational endeavors that reach all members of the healthcare team including the patient and family are critical. Studies have shown that a mandatory self-study process with a pretest and posttest, fact sheets, and posters placed in patient care areas has resulted in an approximate reduction of CRBSIs by 50%; this is one possible initiative that could be adopted. The development and implementation of tools used for ongoing educational assessment will need to address various learning styles of the participants; written and on-line options may need to be available. A number of examples of such tools are available in the literature.

Future research. The results of this study have identified three further research topics that might provide further insight and knowledge on the role that nurses may have in the prevention of CRBSIs in a pediatric setting.

Participants identified a number of opportunities where a lack of patient and family education may contribute to CRBSIs. However, only one-third of the participants indicated that they provided education to families regarding CVAD care prior to their discharge. Gaining further insight on why this is so would be an interesting addition to our present state of knowledge. Do nurses feel empowered to do this important work; or do they believe it is the work of others?

A second research topic that may be very informative is to explore further study on the perceived barriers that nurses identify in relation to non-adherence to CVAD care and maintenance practices. Gaining a better understanding of the barriers could lead to process and

structural changes that could alleviate undesirable circumstances or conditions which contribute negatively to the provision of high quality care.

The last research topic that could impact the quality of care that is provided to patients is related to gaining a better understanding on what actions (if any) the nurses took when improper techniques were observed. Do nurses feel empowered to confront perpetrators of substandard care, or do they choose to ignore it due to discomfort or in order to maintain good working relationships with others? All three questions could contribute to the body of knowledge related to pediatric CVAD care.

Conclusion

The study explored nurses' knowledge of CVAD care and maintenance practices and their perceptions of whether developmental or environmental considerations were present when caring for pediatric patients that may contribute to CRBSIs.

Donabedian's Model for quality improvement provided the guiding theoretical framework for this thesis. The Model provided a practical guide for the study. This study used a mixed method design with quantitative and qualitative components. Specifically, the study was a cross-sectional survey, conducted on a convenience sample of pediatric nurses working in pediatric medical and surgical units in Winnipeg, Manitoba.

The study identified factors and situations that potentially interfere with the provision of high quality CVAD care. The primary factor identified was the use of improper aseptic technique by varying members of the healthcare team and the patients' families. Further work, separate from this study, will be undertaken to address the concerns that were identified by the participants that may contribute to the development of CRBSIs in pediatric patients with a CVAD. Having a greater understanding of the nurses' experiences may facilitate the recruitment of bedside nurses and other

care providers on the interdisciplinary teams. The development of practice guidelines to meet the needs of all stakeholders including the healthcare team, the patient, and their families will then be undertaken.

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APPENDIX A Questionnaire

Nursing Care for Pediatric Patients with CVADs

Have you read the consent form for this study and agreed to participate?

- ○ YES
- ○ NO

Are you a nurse employed in one of the following areas: CH3, CK3, CH4, CK4, CH5, CK5, or the Children's Relief Team?

- ○ YES
- ○ NO

In your practice, do you care for patients with CVADs?

- ○ YES
- ○ NO

How often?

- ○ EVERY SHIFT
- ○ MOST SHIFTS
- ○ OCCASIONALLY
- ○ RARELY

Central Venous Access Devices (CVAD): include all tunnelled and non-tunnelled catheters, implanted ports, and peripherally inserted central catheters (PICC).If you have not had an opportunity to perform a specific intervention, for example change a CVAD dressing, please indicate not applicable as your answer.

	ALL THE TIME	MOST OF THE TIME	OCCASIONALLY	NEVER	NOT APPLICABLE
I teach patients and families about CVAD care and maintenance prior to their discharge.	○	○	○	○	○
I perform hand hygiene before I touch the CVAD or IV tubing(s).	○	○	○	○	○
I assess the exit site every shift.	○	○	○	○	○
I follow aseptic technique when providing CVAD care.	○	○	○	○	○
Prior to accessing the hub and connections, I scrub the hub and connections for 15 seconds with alcohol.	○	○	○	○	○
I allow the alcohol to dry before I access the hub or connections.	○	○	○	○	○
I infuse TPN through a dedicated lumen.	○	○	○	○	○
I change the IV tubing of crystalloid solutions every 96 hours (i.e. Normal Saline, Dextrose solutions).	○	○	○	○	○
I have observed IV tubing(s) dragging on the floor.	○	○	○	○	○
When flushing the CVAD with normal saline, I instill the saline in a manner that creates turbulence.	○	○	○	○	○
I have observed the CVAD or IV tubing(s) in a child's mouth.	○	○	○	○	○
When I see visible blood in the injection cap, I flush the cap with normal saline.	○	○	○	○	○

When I see visible blood in the injection cap, I change the cap.	○	○	○	○	○
I have observed the CVAD or IV tubing(s) in the diaper area.	○	○	○	○	○
I have observed the CVAD or IV tubing(s) submerged in the bath water.	○	○	○	○	○
When the CVAD dressing is wet, I change it.	○	○	○	○	○
When the CVAD dressing is starting to peel off, I change it.	○	○	○	○	○
When changing the CVAD dressing, I scrub the skin with chlorhexidine using a friction motion.	○	○	○	○	○
When changing the CVAD dressing, I allow the chlorhexidine to dry before I replace the dressing.	○	○	○	○	○
I discuss/review the need for the CVAD with the medical service during daily rounds.	○	○	○	○	○
I seek assistance from co-workers when accessing the CVAD on active or mobile children.	○	○	○	○	○

How many years have you practiced as a nurse?

- ○ Less than 5
- ○ 5 to 10 years
- ○ 11 to 15
- ○ 16 to 20
- ○ Greater than 20

How many years have you been employed on the current unit?

- ○ Less than 1
- ○ 1 to 3 years
- ○ 4 to 6
- ○ 7 to 10
- ○ Greater than 10

How old are you?

- ○ 25 years or less
- ○ 26 to 35 years
- ○ 36 to 45 years
- ○ 46 to 55 years
- ○ 56 to 65 years
- ○ Greater than 65 years

Please comment on any possible factors or situations in hospitalized patients that you think might contribute to the development of central venous access device blood stream infections in pediatric patients.

Thank you for participating in this study. You can make a difference in the care we provide to children! If you would like to place your name in a draw to win one of four $50.00 gift cards, please provide your email address below.

Send summary report: O YES O NO

Email: _____

APPENDIX B University of Manitoba Education/Nursing Research Ethics Board Approval

APPROVAL CERTIFICATE

August 13, 2014

TO: **Jacqueline G. Reid** **(Advisor C. Ateah)**
Principal Investigator

FROM: [redacted] **Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2014:088**
"Nursing Care for Pediatric Patients with Central Venous Access Devices"

Please be advised that your above-referenced protocol has received human ethics approval by the **Education/Nursing Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2)**. This approval is valid for one year only**.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:
- If you have funds pending human ethics approval, please mail/e-mail/fax (261-0325) a copy of this Approval (identifying the related UM Project Number) to the Research Grants Officer in ORS in order to initiate fund setup. (How to find your UM Project Number: http://umanitoba.ca/research/ors/mrt-faq.html#pr0)
- if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html**) in order to be in compliance with Tri-Council Guidelines.**

APPENDIX C HSC Research Impact Committee Approval Form

Health Sciences Centre
Winnipeg

Office of the Director of Research

Dial Direct 204-787-4831
Fax 204-787-4547

August 14, 2014

Jacqueline Reid
Principal **Investigator**
CK531

Dear Jacqueline Reid

RE: NURSING CARE FOR PEDIATRIC PATIENTS WITH CENTRAL VENOUS ACCESS DEVICES.

ETHICS #: E2014:088 RIC #: R12014:097

The above-named protocol, **has been evaluated and approved** by the HSC Research Impact Committee.

The Department of Research wishes you much success with your study.

Research Protocol Officer
Health Sciences Centre

cc: Director of Research
Ancillary Services, Finance Department

APPENDIX D Script for Contact with the Child Health Management Team

Script for Contact with the Child Health Management Team

The following are the key points that will be discussed at the Nursing Management meeting with the Child Health Manager of Patient Care Team weekly meeting.

- I am seeking your help in regards to a study that will be initiated in the near future

The title of the study is: Nursing Care for Pediatric Patients with Central Venous Access Devices

- I would like to tell you about the study, and ask for your assistance to help inform your staff about the study
- This study has been approved by the University of Manitoba Education/Nursing Research Board. Any concerns or complaints can be directed to the Human Ethics Coordinator at [redacted]
- Here is a brief overview of the study:
    - The primary purpose of the study is to explore factors that contribute to catheter related blood stream infections in pediatric patients that have central venous access devices in-situ.
    - The research is being conducted as a component of my Master degree through the University of Manitoba.
    - The target population is nurses who care for pediatric patients on medical and surgical units and the relief team at Children's Hospital.
    - An email will be sent via the Health Sciences Centre Global Address book, to all nurses employed on CH5, CK5, CH4, CK4, CH3, CK3 and the Children's Relief Team; this email will provide a link to the FluidSurvey program, which will include information about the study and survey.
    - Hard copies of the participation request and survey will be made available on all of the inpatient units, along with an envelope to place the completed surveys.
    - The survey has 27 questions and should take approximately 10 minutes to complete.
    - The completed surveys will be picked up periodically over the 3 week survey period.
    - Reminder emails will be sent to the nurses throughout the 3 week study period.

    - If you would like further information about the study, I would be happy to send a copy of the ethics proposal to you.

- Would you be willing to help me by informing your staff about the study and/or putting up several posters about the study on your in-patient units?

- I will send you the posters and a script to read to your staff at appropriate times, such as staff meetings and/or change of shift report.

    - Please note that it is important that you do not encourage or discourage participation in this study as this may be perceived as coercion as you are in a position of power/authority over your staff. I would ask that you simply inform your staff about the study.

Any questions?

APPENDIX E Manager Script for Discussion with Nurses on the Units

Nursing Care for Pediatric Patients with Central Venous Access Devices

Dear Managers of Patient Care from CH5, CH4, CK4, CH3 and CK3,

I have developed a frequently asked questions document that you can use to discuss the research study with your staff. Please note that it is important that you do not encourage or discourage participation in this study as this may be perceived as coercion as you are in a position of power/authority over your staff. I would ask that you simply inform your staff about the study during staff meetings, hand over rounds, or when you feel it is appropriate.

- Nurses are invited to participate in a research project designed to explore factors that may influence the risk of developing a catheter related blood stream infection in pediatric patients who have a central venous access device.
- The goal of the study is to gain knowledge from the experiences that nurse's share in order to develop strategies that may decrease the risk for infection in pediatric patients with central venous access devices in-situ.
- General Duty Nurses including Licensed Practical Nurses, Clinical Resource Nurses, and Nurse Clinicians from your areas are all welcome and encouraged to participate in the study.
- Involves completing a survey of 27 questions; it should take approximately 10 minutes.
- The survey can be accessed either via an electronic link attached to a FluidSurvey, or by completing a hard copy of the survey.
- Surveys will be located on the 6 units involved in the study and in the Child Health Nursing Administration Office.
- Participation in the study is voluntary.
- All responses will be kept confidential.
- At the end of the survey, participants will be asked if they would like to submit their email address into a random draw for one of four $50.00 gift cards or if they would like to receive a summary of the research findings. If they choose to be included in the draw, or to receive the summary findings, their email address will be used only to notify them if they have won, or to send them the results summary; it will not be used for any other purpose.
- The study is being conducted as a component of Jackie Reid's Masters of Nursing degree through the University of Manitoba, and has been approved by the University of Manitoba Education/Nursing Research Board and the Child Health IMPACT committee. Any concerns or complaints can be directed to the Human Ethics Coordinator at [redacted]

If you have any questions please contact Jackie Reid at [redacted]

APPENDIX F Research Poster Advertising

Nursing Care for Pediatric Patients with Central Venous Access Devices

ATTENTION: ALL PEDIATRIC NURSES FROM CH5, CK5, CH4, CK4, CH3, CK3 and the CHILDREN'S HOSPITAL RELIEF TEAM

WHAT? As pediatric nurses working on units in the Children's Hospital, you will be receiving an e-mail requesting your participation in a research study that is designed to explore your experiences while caring for children with central venous access devices.

WHY? Children with central venous access devices are at significant risk for catheter related blood stream infections. Pediatric nurses are in a perfect position to identify factors that may increase the risk for infection in this patient population.

WHO? All nurses working on CH5, CK5, CH4, CK4, CH3, CK3 and the Children's Relief Team will receive an e-mail invitation to participate in the study.

WHERE? The survey can either be completed on-line via FluidSurvey, or in a hard copy form which will be located on the patient units and the Nursing Administration Office. Or you may access the survey through the link located at the bottom of this page, or at:

http://fluidsurveys.com/s/pediatric-cvad-survey/

Thank-you for taking the time to read this information.

It is through research projects such as this that we can gain a better understanding of experiences that nurses have while caring for children

with a central venous access device. Based on your responses, changes to improve the quality of care that pediatric patients with central venous access devices receive may be identified.

This study has been approved by the University of Manitoba Education/Nursing Research Board and the Child Health IMPACT Committee. Any concerns or complaints can be directed to the Human Ethics Coordinator at [redacted]

YOU CAN MAKE A DIFFERENCE IN THE CARE WE PROVIDE TO CHILDREN!

APPENDIX G: Attention Pediatric Nurses: Invitation to participate in a research study e-mail

Nursing Care for Pediatric Patients with Central Venous Access Devices

ATTENTION: ALL PEDIATRIC NURSES FROM CH5, CK5, CH4, CK4, CH3, CK3 and the CHILDREN'S HOSPITAL RELIEF TEAM

WHAT? As pediatric nurses working on units in the Children's Hospital, you are receiving an e-mail requesting your participation in a research study that is designed to explore your experiences while caring for children with central venous access devices.

WHY? Children with central venous access devices are at significant risk for catheter related blood stream infections. Pediatric nurses are in a perfect position to identify factors that may increase the risk for infection in this patient population.

WHO? All nurses working on CH5, CK5, CH4, CK4, CH3, CK3 and the Children's Relief Team are receiving an e-mail inviting their participation in the study.

WHERE? The survey can either be completed on-line via FluidSurvey, or in a hard copy form (which are located on the patient units and the Nursing Administration Office). You may access the survey by "clicking" on the following link, or by pasting the link into your browser.

http://fluidsurveys.com/s/pediatric-cvad-survey/

WHEN? The survey will be available from August 21 to September 11, 2014.

Thank-you for taking the time to read this information.

It is through research projects such as this that we can gain a better understanding of experiences that nurses have while caring for children with a central venous access device. Based on your responses, changes to improve the quality of care that pediatric patients with central venous access devices receive may be identified.

This study has been approved by the University of Manitoba Education/Nursing Research Ethics Board and the Child Health IMPACT Committee. Any concerns or complaints can be directed to the Human Ethics Coordinator at [redacted]

YOU CAN MAKE A DIFFERENCE IN THE CARE WE PROVIDE TO CHILDREN!

APPENDIX H Research Subject Information and Consent Form

Information and Consent Form

Study Name: Nursing Care for Pediatric Patients with Central Venous Access Devices

Principal Investigator: Jacqueline Reid

Faculty of Graduate Studies, University of Manitoba

[redacted]

Thesis Advisor: Dr. Christine Ateah, Professor,

Faculty of Nursing, University of Manitoba

[redacted]

Sponsor: None

This consent form, a copy of which you may save or print for your records and reference at this time (it will not be available later), is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to contact the Principal Investigator or Thesis Advisor. Please take the time to read this carefully and to understand any accompanying information. The Child Health Program has allowed the opportunity for you to participate in a study which is in partial fulfillment of the requirements for a Master of Nursing degree. The proposal has been approved by the thesis committee, which is led by Dr. Christine Ateah. The study has received approval from the Child Health IMPACT Committee.

Pediatric nurses like yourself, are being asked to participate in the study to share your experiences when caring for children with a central venous access device (CVAD). Your participation would be greatly appreciated and may be used to develop recommendations for changes in the care and maintenance practices for CVAD in the Child Health Program, Health Science Centre site.

Your participation in the study is completely voluntary. Your involvement would consist of completing a survey either on-line or in hardcopy. The survey will take approximately 10 minutes to complete. Your answers are anonymous and your name is not required on any documents. The FluidSurvey will not track any IP addresses. You may refuse to answer any of the questions and you may choose not to participate. You may withdraw from the study at any time without penalty. Your decision whether to participate will not affect you in any way. However, since submitted surveys are anonymous, once the online or hardcopy survey is submitted, there is no way to withdraw from the study. All of the answers you provide will be kept confidential. Any information you provide will be stored on the encrypted and password protected site, FluidSurvey, and on password-protected computers of the Principal Investigator and Thesis Advisor. Only the Principal Investigator, Thesis Advisor, and Research Assistant will have access to your survey data. The Principal Investigator will not have access to the original survey hardcopies; the data from the hardcopies will be inputted into the FluidSurvey link verbatim by the Research Assistant. Once the data has been inputted by the Research Assistant, the survey hardcopies will be stored in a locked filing cabinet in the office of the Thesis Advisor and be shredded and destroyed after 5 years.

It is the intent of the Principal Investigator to share and publish the findings of the study to add to the knowledge of CVAD care and maintenance practices in a pediatric patient

population. There are no known risks associated with participating in the study. There are also no direct benefits; however, it is hoped that results of the research study will add to the knowledge of pediatric CVAD care and maintenance practices.

By participating in the study you are eligible to enter a draw for one of four $50 gift cards. If you respond on-line, a separate link where you can enter the draw, and not be connected to your survey response will be available. If you respond via hardcopy, you will be requested to provide an email address. The Research Assistant, who is not associated with the research study, will enter your email address to the on-line link. In both methods, the email address you provide will only be used to notify the draw winners. Winners will be notified by personnel from the Manitoba Centre for Nursing and Health Research. If you would like to receive a summary of the findings of this research study, a separate link that is not connected to your survey response will be available for you to provide your email contact information. You only need to provide this information if you wish to receive a summary of the results. The survey results will be sent out through the Manitoba Centre for Nursing and Health Research. The projected timeline for sharing of the findings is the Fall of 2014.

If you complete and submit the survey through the link provided, or place the completed hardcopy into the survey envelope, this indicates that you have understood to your satisfaction the information regarding participation in the research study and agree to participate as a subject. Clicking the FluidSurvey link at the bottom of the consent form, or proceeding with hardcopy survey indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. Should you choose to withdraw at any point prior to

submitting the survey or feel that you would rather leave some question(s) unanswered, you may still enter the draw for the opportunity to win 1 of 4 $50.00 gift cards. If you wish to withdraw, simply close the browser window at any time, or leave hardcopy survey questions blank. If you do choose to withdraw from this study, we will destroy any data that you have provided and not include it in the analysis.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way. The Education/Nursing Research Ethics Board at the University of Manitoba has approved this research. If you have any concerns or complaints about this project you may contact the Human Ethics Coordinator at [redacted]. If you are completing the survey on-line, you are strongly encouraged to save or print a copy of this consent form now for your records, as it will not be available later.

If you have read the information presented in this form and do not have any questions about this study, please click on FluidSurvey link, or proceed with hardcopy survey when you are ready to begin. You should only click on the link or proceed if you agree to participate with full knowledge of the study presented to you in this information and consent form, and of your own free will. If you do not wish to participate in this study now, please close your web browser. You may choose to participate at a later date and time (remember, you have 3 weeks if you wish to participate in this study).Thank you for considering participating. If you agree to participate, please click on the “Next” button below to be taken to the first question.

APPENDIX I TCPS 2: CORE Completion Certificate

Certificate of Completion

This document certifies that

Jacqueline Reid

has completed the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **8 June, 2014**

Copyright Releases

Figure 3.1 Donabedian (1966) Structure-Process-Outcome Model

Dear Ms Reid,

Thank you for your request. You have our permission to use the OUP Material you list in your email below in your thesis for submission to University of Manitoba.

If at some future date your thesis is published it will be necessary to re-clear this permission. Please also note that if the material to be used is acknowledged to any other source, you will need to clear permission with the rights holder.

Kind regards,

[redacted]

[redacted]
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Figure 3.2 Donabedian's model of quality assessment (Teshima, 2005, p. 498). The relationship between structure, process and outcome.

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