Implementation Science: Implementation Methods Used by Pediatric Intensive Care Units in a National Collaborative

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A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2012

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Abstract

Implementation Science: Implementation Methods Used by Pediatric Intensive Care Units in a National Collaborative

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Problem Statement: In 2001, the Committee on Quality in Health Care in America found it took 17 years for evidence from randomized controlled trials to be applied to practice. There has been little improvement over the last decade, despite the national approach to package evidence-based practices into abbreviated formats. Even summarized evidence fails to be consistently implemented at the bedside. More emphasis needs to be placed on understanding, which Implementation Methods are most effective in successfully implementing evidence-based practice at the bedside. **Aims:** The purpose of the study was to examine Implementation Strategies, Methods, and Dimensions used by 57 Pediatric Intensive Care Units (PICUs) participating in the National Association of Children's Hospitals and Related Institutions (NACHRI, 2011) collaborative to eliminate central line associated blood stream infections (CLABSI) in critically ill children. **Methods:** This descriptive research study was conducted using survey methods and retrospective outcome data. The relationships between Implementation Dimensions and three outcomes of central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate were explored with the computation of correlations and multiple regression analysis. **Findings:** Most Implementation Methods had high or very high use across the 57 PICUs. There were no significant correlations or predictive relationships between any of the Implementation Dimensions and any of the three outcomes of central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate.

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Glossary

Bundle-A bundle is a scientifically grounded group of elements essential to improving clinical outcomes. They are relatively small and straightforward, including a set of 3 to 5 evidence-based practices or steps in a cohesive unit. They are intended to be easy to apply, because of their simple and brief nature (IHI, 2009).

Central Line-A central line is a catheter placed in a large vein near the heart such as the subclavian, superior vena cava, or inferior vena cava. It is utilized to administer medications, obtain blood samples, and/or monitor central venous pressure.

CLABSI-Central line associated blood stream infection. A blood stream infection that is associated with a central line, based on CDC definitions and criteria.

DOI Theory-Diffusion of Innovations theory is based on Everett M. Rogers' definitions and concepts. This theory provided the theoretical framework for this research study.

Implementation Definitions

Implementation Dimensions-Implementation Dimensions are seven broad categories that are comprised of the 20 Implementation Methods. The seven Implementation Dimensions were developed based on conceptualization of how the 20 Implementation Methods grouped together within the context of PICUs.

Implementation Methods-Implementation Methods are 20 literature based methods, which may or may not be used by individual units to implement practice changes. The 20 Implementation Methods are described in the literature and supported by some empirical evidence (9 methods) or included in the KTF (11 methods).

Implementation Science-Implementation science is "the use of strategies to adopt and integrate evidence-based health interventions and change practice patterns within specific settings." The NIH also states, "Research on implementation will address the level to which health interventions can fit within real-world public health and clinical service systems (NIH, 2011)."

Implementation Strategies-Implementation Strategies include71 individual items on the survey tool intended to represent the 20 Implementation Methods under exploration.

KTF-Knowledge Transfer Framework. The KTF is a health care operational model of implementation, which was used for this research study.

NACHRI-National Association of Children's Hospitals and Related Organizations. NACHRI was a nonprofit association whose primary goal was to promote the health and well-being of children by supporting hospitals in their effort to achieve excellence in care. After the study was completed, NACHRI merged with Children's Health Care Corporation of America (CHCA) to form the Children's Hospital Association (2012).

NACHRI PICU CLABSI collaborative-National Association Children's Hospitals and Related Institutions, Pediatric Intensive Care Unit, central line associated blood stream infection collaborative. The collaborative included a group of 57 PICUS working together under the leadership of NACHRI and other national experts to eliminate central line associated blood stream infections in critically ill children age newborn to 21 years.

PICU-Pediatric Intensive Care Unit. Pediatric Intensive Care Units care for children age newborn to 21 years old with a variety of medical and surgical conditions.

Acknowledgements

I sincerely thank my committee, UW faculty, and Seattle Children's Hospital nursing leadership for their support and guidance.

Dedication

This project is dedicated to my family. First, my dear husband Lonnie Long for his enduring support. Next, to both of my children, Ava Long who had barely joined our family and Emma Long who joined our family during this process.

Chapter One: Background and Significance

In the last decade, more emphasis has been placed on evidence-based practice throughout healthcare with specific efforts focused on how best to minimize the time between scientific discovery and its application to clinical practice. In 2001 the Committee on Quality in Health Care in America, reported it took 17 years for evidence generated from randomized controlled trials to be applied to practice (Committee on Quality Health Care in America, 2001). There has been little improvement over the last decade, despite the delay from discovery to practice being widely recognized as a significant problem throughout health care (Arrington, et al., 2008; Battacharyya, Reeves, & Zwarenstein, 2009; Estabrooks, 2008; Hysong, Best & Pugh, 2006; Rycroft-Malone, 2007; Titler, 2010; Titler, 2008; van Achterberg, Schoonhoven & Grol, 2008).

Increasingly, governmental and other national organizations, such as the National Institutes of Health, (NIH, 2011), Institutes of Medicine (IOM, 2011), Agency for Healthcare Research and Quality (AHRQ, 2011), and the Institute for Healthcare Improvement (IHI, 2011) recognize an unacceptable delay exists between the discovery of sound clinical evidence and application to the bedside. This delay can result in costly and substandard care. The care is not only substandard, but can be dangerous. For example, when failing to take measures to prevent a central line associated blood stream infections (CLABSI), a patient can become infected, leading to septic shock and critical illness, which can result in significant morbidities and even mortality.

Recognition of this problem has prompted national attention. This has led governmental and other national organizations to make evidence more accessible to clinicians by packaging it into abbreviated, easy to use formats. Abbreviated evidence is made available to health care providers and institutions through government or regulatory agencies, professional organizations,

national meetings, or on-line through searchable databases. Three examples of evidence provided in abbreviated formats include clinical practice guidelines, bundles, and checklists.

The first example of evidence packaged in an abbreviated format is a clinical practice guideline. A clinical practice guideline may be defined as, "synthesis of best available evidence that support decision making by clinicians, managers, and policy makers about the organization and delivery of health care (Gagliardi, Brouwers, Palda, Lemieux-Charles, & Grimshaw, 2011)." Clinical Practice Guidelines tend to be comprehensive detailed documents, including multiple aspects of care related to a single medical condition. Though they are abbreviated, compared to the compilation of evidence that was synthesized to create them, they are lengthier than some other abbreviated formats. Examples of clinical practice guidelines are those published by the American Heart Association (2011). Three examples include clinical practice guidelines for the prevention of heart disease in women, the treatment of myocardial infarction, and the treatment of hypertension. There are many other examples of clinical practice guidelines provided by professional, governmental, and other organizations, as well.

The second example of evidence packaged into an abbreviated format is called a bundle. The IHI defines a bundle as scientifically grounded elements essential to improving clinical outcomes. They are briefer than clinical practice guidelines. They are relatively short and straightforward, typically including a set of three to five evidence-based practices or steps in a cohesive unit (IHI, 2009). They are intended to be easy for clinicians to apply to the bedside, because of their simple and brief nature. Three examples published by the IHI include bundles to prevent hospital-acquired infections; such as those associated with central line insertion, use of ventilators, and indwelling urinary catheters.

The third example of evidence packaged into an abbreviated format is a checklist. A checklist may be defined as a document, which prescribes the critical steps healthcare workers need to take to execute procedures correctly (Science Daily, 2010). They are intended to be easy for clinicians to apply to the bedside. For example, a surgical checklist published by the IHI (2009) as part of the 5 Million Life Campaign has proven to decrease morbidity and mortality by ensuring the appropriate staff and equipment are available to perform the correct operation on the correct side of the correct patient.

Although summarizing evidence into abbreviated formats is an important step, the implementation of such evidence at the bedside has often failed. Applying evidence to the bedside is a complex process even when using abbreviated formats. Individual clinical practice guidelines, bundles, and checklists are rarely accompanied with comprehensive evidence-based strategies for implementation. Simply packaging evidence into abbreviated formats does not ensure they are applied at the bedside. There are numerous examples of how evidence in these formats is not reliably implemented.

For example, two clinical practice guidelines for the care of patients with pneumonia and myocardial infarction were converted into national quality measures, which hospitals were required to adopt. Hospitals were required to use the guidelines, audit compliance, and submit data to a national database. Performance data indicated that hospitals were consistently less than 100% compliant with use of these mandated guidelines. For example, the national average for compliance with pneumonia care was 90%; the state of Washington reported their lowest hospital was only 44% compliant (Washington State Hospital Association, 2010). Even though the elements included in the clinical practice guidelines were clearly stated, they were not reliably implemented in all hospitals.

Another example of failed implementation at the bedside is related to use of a surgical checklist, endorsed by the IHI. The latest data published in November 2008 indicated that only 26 of the 50 states were endorsing the surgical checklist, with a minority of hospitals implementing it (IHI, 2009). Even with great strides in the development of abbreviated tools, some believe that the gap between evidence-based practice and application in the clinical setting is worsening.

In response to this reality, the NIH collaborated with the Institute of Medicine (IOM, 2011), academic medical centers, and others to identify solutions and needed resources. This resulted in the development of the Clinical and Translational Science Awards (CTSA, 2010) Consortium in October 2006. The consortium developed institutes to promote clinical and translational research. The institute started with 12 academic health centers, with a plan for 60, by 2010**.** One such example was the development of translation centers, such as the Institute of Translational Health Science (ITHS) (2010), located in Seattle, Washington. The institute represents a collaborative partnership between the University of Washington, Seattle Children's Hospital, and the Fred Hutchinson Cancer Research Center, as well as other local institutions.

Though this national resource is valuable, much of the emphasis continues to be focused on translating bench research to bedside research. The institute specifically focuses on training investigators to conduct studies in "real" clinical settings, with a more diverse subject pool. This provides for a more representative sample of the population, rather than homogenous groups typically enrolled in randomized controlled trials. Though this is essential work, there still needs to be a focus on implementing the outcomes of such clinical research into real patient care settings at the bedside. Implementing evidence-based practices is complex and requires its own evidence-based methods, which are not yet fully understood.

More attention has recently been placed on developing evidence-based approaches for implementation, partially through the growth of implementation science. Implementation science focuses on identifying and understanding the most salient implementation strategies that are cost effective in translating the latest scientific evidence into the real world of every day practice.

There is a growing body of literature describing the emerging science of implementation. The nomenclature and definitions are not standardized within the literature, including terms such as translation, dissemination, knowledge transfer, knowledge uptake, diffusion, research uptake, and others. These terms are often used interchangeably to define implementation. The National Institutes of Health (NIH, 2010) has acknowledged the inconsistency in language, creating standard definitions for funding opportunities. The NIH definition for implementation science was utilized for this study, which is "the use of strategies to adopt and integrate evidence-based health interventions and change practice patterns within specific settings." The NIH also states, "Research on implementation will address the level to which health interventions can fit within real-world public health and clinical service systems."

Purpose of Research Study

In the real world of clinical practice, resources are limited. It is critical that quality improvement efforts are directed wisely to achieve practice improvements in cost effective ways. Though there are a growing number of studies, which examine implementation approaches, they usually include only 1-2 elements, often in a single site of care. Little is known about how innovation is adopted in the naturalistic world of every day clinical practice. Descriptive naturalistic studies that encompass samples from multiple sites of care captures the rich clinical heterogeneity required to ask a range of critical questions about innovation adoption. For

example, what types of Implementation Methods are used by hospitals to facilitate the adoption of evidence-based bundles of care in view of limited resources? Are certain Implementation Methods more effective than other methods in the successful adoption of evidenced-based bundles?

The National Association of Children's Hospitals and Related Institutions (NACHRI, 2011) facilitated a collaborative to eliminate central line associated blood stream infections (CLABSIs) in critically ill children cared for in 57 pediatric intensive care units (PICUs) across the country. The collaborative offered the opportunity to study the process of adoption of evidence-based bundles in naturalistic settings.

The purpose of the study was to examine Implementation Strategies, Methods, and Dimensions used by 57 Pediatric Intensive Care Units (PICUs) participating in the National Association of Children's Hospitals and Related Institutions (NACHRI, 2011) collaborative to eliminate central line associated blood stream infections (CLABSI) in critically ill children.

Research Questions

Definitions for Implementation Strategies, Implementation Methods, and Implementation Dimensions are provided in the Glossary. This study was designed to address seven questions, which include:

Research Question One**:** Which Implementation Strategies are most commonly used across a national sample of PICUs?

Research Question Two: Which Implementation Methods are most commonly used across a national sample of PICUs?

Research Question Three: What are the frequency distributions for the three outcomes of central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate across a national sample of PICUs?

Research Question Four: Is there empirical support for clustering specific Implementation Methods according to the conceptually proposed Implementation Dimension taxonomy?

Research Question Five: Which Implementation Dimensions are most commonly used across a national sample of PICUs?

Research Question Six: Are any of the Implementation Dimensions significantly correlated with central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate?

Research Question Seven: Do any of the Implementation Dimensions predict central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate?

Chapter Two: Theory and Operational Model

The theoretical framework and health care operational model of implementation, which provided a foundation for this study, are described below. The Diffusion of Innovations Theory (Rogers, 2003) provided the theoretical framework and the Knowledge to Transfer Framework (Nieva, et al., 2005) provided the operational model of implementation for this study.

Diffusion of Innovations Theory

The advancement of implementation science needs to be based on theoretical concepts that guide the formulation of research questions. Diffusion of Innovations (DOI) Theory has been internationally recognized for providing a way of thinking about the timely and effective spread and implementation of innovation. The DOI Theory provides an explanation of the process whereby innovations are diffused and adopted within a social system. In brief, an individual or other decision-making unit passes through different stages while considering the innovation. They start with knowledge of the innovation and end with adoption or rejection. The adoption or rejection of the innovation is dependant on characteristics of the innovation, as well as characteristics of the individual or other decision making unit within a social system. This concept is illustrated on Figure 1, Rogers Diffusion of Innovation Stages of Innovation-Decision Process.

History of Diffusion of Innovations Theory

A brief history of the development of the DOI Theory is described. The foundation for the development of the DOI Theory began greater than a century ago in Europe, when anthropology and sociology were developing as true sciences. Academics and researchers attempted to understand how new ideas were accepted, considering the importance of human behaviors, within social systems. Additionally, they began to recognize that some individuals

and groups adopted new ideas earlier than others (Rogers, 2003, pg 41). However, researchers within anthropology and sociology provided the foundation for the DOI Theory, researchers within education, public heath, communication, marketing, geography, and others (Rogers, 2003, pg 44-45) followed them.

Everett M. Rogers began to study DOI Theory 50 years ago and became the foremost leader in developing and describing the Theory. He began his early work within rural agricultural settings, attempting to understand how innovations in the farming industry were either diffused and adopted or not accepted. He published the first version of his theory in 1962, and then continued to develop his theory over time, publishing updates, approximately every decade. Though core elements of his theory have remained the same, they have been updated over the years with important contemporary ideas, which are published in his most current book, in its fifth edition (Rogers, 2003).

Rogers reported on recent exponential growth within marketing, public health, and communication, all which require strong approaches to the diffusion of new ideas. He also emphasized the importance of communication advances with technologies, like the internet. Additionally, Rogers writes of his expanded understanding of diffusion networks and the use of pilots and surveys to move innovations into adoption. Diffusion of innovations research has greatly expanded over the years. Rogers indicated that in 1962, 405 publications were identified about this topic and by 2003, there were greater than 5,200 (Rogers, 2003, pg xviii). The DOI Theory has become one of the most commonly applied mid-range theories by researchers interested in making changes at local, national, and international levels. The DOI Theory, as interpreted and described by Rogers provided the theoretical framework for this study.

Key aspects of the DOI Theory are described below including, the definitions of theoretical concepts, description of the four main elements, and explanation of its application to implementation science.

Main Elements of Diffusion of Innovations Theory

DOI theoretical concepts are based on Rogers's understanding and interpretation, which are defined below.

- Diffusion of Innovations Theory is defined as the process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 2003, pg 5).
- Innovation is defined as an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003, pg 12).
- Communication Channels is defined as a process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas (Rogers, 2003, pg 5).
- Social System is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems (Rogers, 2003, pg 23).

The DOI Theory includes four main elements, which are Innovation, Communication Channels, Time, and Social System. The elements of The Innovation and Time include sub parts, as well. The main elements and subparts are outlined on Table 1. The descriptions and definitions of the four main elements of The Innovation, Communication Channels, Time, and Social System are provided below.

Innovation. The first main element of the DOI Theory is the Innovation, which is defined as an idea, practice, or object that is perceived as new by an individual or other unit of adoption. The rate of adoption of innovations varies widely from several weeks, to many years, to never. Five characteristics determine the rate of adoption of an innovation, which include relative advantage, compatibility, complexity, trialability, and observability. The five characteristics are defined below.

1. Relative advantage is the perception that the innovation is better than the idea it supersedes. This may be measured in economic terms, social prestige, convenience, or satisfaction. It is important for the individual or group to perceive an advantage of the innovation. The greater the perceived advantage of an innovation, the more rapid it's rate of adoption will be.

2. Compatibility is the degree to which the innovation is perceived as being consistent with existing values, previous experience, and the needs of the potential adopter. The innovation must also be compatible within the existing social system. If the innovation is not compatible, its adoption will be much slower.

3. Complexity is the degree to which the innovation is complex or easy to understand. New ideas that are simple to understand are easy to adopt.

4. Trialability is the degree to which the innovation may be experimented with, trialed, or practiced. Innovations that can be practiced in small segments should adapt earlier than those innovations that are not divisible. The ability to learn by practice and doing aids the adoption practice.

5. Observability is the ability to see visible results of the innovation, especially to others. The visibility of results facilitates discussion among peer groups within social systems, which also promotes adoption.

Communication channels. The second main element of the DOI Theory is Communication Channels, which is defined as a process in which an innovation is communicated through certain channels over time among the members of a social system; the steps, tasks, and processes by which information is shared for a common understanding. A Communication Channel is how a message gets from one individual to another. Mass media channels are important in creating knowledge about the innovation. Interpersonal methods of communication are important in changing attitudes towards the innovation. Most individuals evaluate innovation not on the merit of the evidence supporting the innovation alone, but also on feedback from peers that have or have not adopted the innovation.

Time. The third main element of the DOI Theory is Time, which is not succinctly defined. It is described within the context of three aspects including, the innovation–decision process, the innovativeness of adopter categories, and the innovations' rate of adoption in a system. These three aspects are defined below.

1. The first aspect of Time is the innovation-decision process through which an individual or other decision-making unit passes from first knowledge to innovation. There are five steps within the innovation-decision process, which are knowledge, persuasion, decision, implementation, and confirmation. These five steps are defined below.

a. Knowledge develops when individuals or decision-making units learn of the innovations' existence and gain some understanding of how it functions. Individuals learn about an innovation and begin to understand it.

b. Persuasion occurs when an individual or decision-making unit forms a favorable or unfavorable attitude toward the innovation.

c. Decision occurs when an individual or decision-making unit engages in activities that lead to a choice to adopt or reject the innovation.

d. Implementation occurs when an individual or decision-making unit puts an innovation into use.

e. Confirmation occurs when an individual or decision-making unit seeks reinforcement of an innovation-decision that has already been made, but he/she may reverse the previous decision if exposed to conflicting messages about the innovation.

2**.** The second aspect of Time is the Innovativeness of the Adopter Categories, which is not succinctly defined. It is described as the understanding that individuals adopt innovations at different rates. There are five adoption categories, which are innovators, early adopters, early majority, late majority, and laggards. The five adoption categories are described below.

a. Innovators generally represent 2.5% of the population within a group. Innovators are described as those individuals who are typically active seekers of new ideas. They have a high degree of mass media exposure, and their interpersonal networks extend over a wide area, reaching outside their locals system. Innovators must be able to cope with a high degree of uncertainty about

an innovation. Since an innovator takes on more risk by adopting early, they also must be able to accept an occasional setback when a new idea proves unsuccessful. An innovator may or may not be respected by members of a local system. Since they are usually the minority in their group, others may be reluctant to follow along. However, they play a very important role in the diffusion process, because they often launch new ideas from outside the system's boundaries.

b. Early adopters generally represent 13.5% of the population within a group. Early adopters are described as those individuals who are more integrated into the local social system than are innovators. This adopter category typically has the highest degree of opinion leadership in most systems. The early adopter is often considered "the individual to check with" before adopting a new idea. Individuals within this category are generally sought by those driving change to speed up the diffusion process. They can help trigger the critical mass when they adopt an innovation. Early adopters are typically respected by their peers and have the ability to decrease uncertainly about a new idea by adopting it, themselves.

c. Early majority generally represent 34% of the population within a group. Early majority are described as those individuals who adopt ideas just before the average member of the system. They usually do not hold positions of opinion leadership. They may deliberate for a longer period before adopting a new idea. They often follow along, but rarely lead.

d. Late majority generally represent 34% of the population within a group. Late majority are described as those individuals who adopt new ideas just after the early majority. Their acceptance of an innovation may be related to economic necessity or peer pressures. They are typically skeptical and cautious. The system norms must definitely favor an innovation before the late majority is convinced to adopt. Most of the uncertainty of the idea must be removed before they feel safe to adopt. Peer pressure is usually a necessary element to motivate their adoption.

e. Laggards generally represent 16% of the population within a group. Laggards are described as those individuals that are last to adopt an innovation. They possess almost no opinion leadership and are often isolated from the social network of their system. They tend to be suspicious of innovation and change agents and base their decisions on what was done in the past. Their innovation decision process is relatively lengthy and is usually lagging far behind initial awareness of a new idea. They are extremely cautious before adopting innovations.

3. The third aspect of Time is the Rate of Adoption, which is defined as the relative speed with which an innovation is adopted by members of a social system. The rate of adoption can be plotted on an S-shaped curve. At first, only a few adopt the innovation, which are typically the minority of the social system, also termed innovators. Soon the diffusion curve begins to climb as more adopt the innovation. Eventually, as the curve flattens out, the innovation is considered adopted. Though most innovations have an

S-shaped curve, the slope varies between innovations, based on the rate, which could be over months, years, or decades.

Social system. The fourth main element of the DOI Theory is the Social System, which is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members of a Social System may be individuals, groups, units, or organizations. The social norms within the Social System determine how an innovation will/will not be diffused and or accepted. Opinion leaders and change agents are very important within a Social System. Opinion leaders informally influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency. Change agents are able to influence other's innovation-decisions in a direction that is deemed desirable by the individual attempting to make the changes.

The DOI Theory has developed over the course of many decades. The DOI Theory has been widely used to provide a theoretical framework for many scientific studies, including those within the science of implementation. The movement of diffusion of innovation elements from theoretical concepts to discipline specific implementation work demonstrates the applicability of The DOI Theory to applied implementation science research.

Application of Diffusion of Innovations Theory to Implementation Science

Two examples of the application of the DOI Theory to clinical practice are described within counseling and social work. Murray (2009) published a manuscript titled, *Diffusion of Innovations Theory*: *A bridge for the research-practice gap in counseling*. In his publication, he described the challenges that counseling researchers faced in translating their findings into meaningful strategies for practice and care of their patients. Similar to the challenges within nursing, counselors also struggle with the gap between evidence and practice. Murray (2009)

outlined characteristics of the DOI Theory as it applied to the implementation of practice changes within the counseling profession. He outlined nine postulates, which were based on the DOI Theory. In his description of the postulates, he detailed strategies within the profession of counseling that should be utilized for implementing practice changes.

In a second example, Dearing (2009) completed similar work within the discipline of social work. Similar to Murray (2009), he acknowledged the delay in applying evidence to practice, though within social work, rather than counseling. He described seven concepts, based on the DOI Theory that was important in moving evidence into practice. Some of his concepts were extracted directly from the DOI Theory, such as the concept of relative advantage. Other concepts were developed based on the DOI Theory, such as the concepts of demonstration projects and pilot tests, which evolved from the concept of trialability. Dearing (2009) also called out the importance of both opinion leaders and change agents, which are core principles of the DOI Theory.

Both Dearing (2009) and Murray (2009) described how they applied the DOI Theory to practice settings. Though each author emphasized different concepts from the DOI Theory, one can see the direct link from the DOI theoretical concepts to the implementation strategies within both counseling and social work. The DOI Theory has widespread application within the science of implementation. For example, of the nine operational models of implementation (described in the Health Care Operational Models of Implementation section to follow), three utilized DOI Theory as the foundation for their model (Rycroft-Malone & Bucknall, 2011). As noted above, the DOI Theory is widely accepted as a relevant framework for implementing change and was used as the theoretical framework for this study.

Health Care Operational Models of Implementation

The DOI Theory provides a broad theoretical framework for understanding the successful spread of innovation. Though a theoretical foundation is essential, a more practical model is useful for a more practical understanding of concepts as they apply to the bedside. The interface between a broad conceptual theory and specific health care implementation approaches and methods is critical to study and understand. This understanding will assure that a theoretical foundation supports relevant questions about the spread and implementation of scientific discoveries to every day clinical practice. In this section, nine health care operational models of implementation are reviewed and evaluated for theoretical and operational clarity in advancing the science of implementation within the health care context.

Nine models reported in the literature had relevance to implementation science. The nine models identified included, ARCC-Advancing Research and Clinical Practice through Collaboration (Melnyk & Fineout-Overholt, 2010), Dissemination and Use of Research Evidence for Policy and Practice (Dobbins, 2010), Iowa Model of EBP (Titler, 2010), Joanna Briggs Institute Model of EBP (Pearson, 2010), Knowledge to Action Framework (Graham & Tetroe, 2010), Ottawa Model of Research Use (Logan & Graham, 2010), PARIHS-Promoting Action on Research Implementation in Health Services (Rycroft-Malone, 2010), Stetler Model (Stetler, 2010), and The Knowledge Transfer Framework for the Agency of Health Care Research and Quality (Nieva, et al., 2005).

An abbreviated description of each of the nine models, including limitations within each as it applied to this study are provided in Table 2. Many of the models described robust approaches for evidence-based practice nursing regarding the collection and appraisal of

evidence, but less so for the implementation of evidence into practice. Specific Implementation Methods that could be used in the clinical setting are less prominent in most of the models.

Though some models addressed specific Implementation Methods, they were limited in terms of clear alignment to this study. Three models addressed Implementation Methods more thoroughly than others. The first was the Dissemination and Use of Research Evidence for Policy and Practice framework (Dobbins, 2010). This model included nine Implementation Methods. They were intended for dissemination of research findings at the national level, not the individual unit level, as was the focus of this study. The second model that addressed Implementation Methods was the PARIHS-Promoting Action on Research Implementation in Health Services model (Rycroft-Malone, 2010). This model addressed Implementation Methods in sufficient detail, but the model was complex to understand and not easily adaptable to this study.

The final model that included Implementation Methods was The Knowledge Transfer Framework (KTF) for the Agency of Health Care Research and Quality (AHRQ) (Nieva, et al., 2005). In comparison to the previously discussed health care operational models of implementation, the KTF had the most detailed focus on Implementation Methods. The KTF identified 11 Implementation Methods intended for application to the clinical unit level; thus well suited for this study, which examined Implementation Methods use at the Pediatric Intensive Care Unit level. The KTF was utilized as the operational model of implementation for this study.

In summary, there has been great effort and attention directed towards creating evidence-based resources and making them available to staff at the bedside. We need to move beyond just identifying evidence-based practices and invest an equal amount of effort in developing robust

Implementation Methods. Simply making evidence available for bedside staff is not sufficient to change practice. The lack of focus on Implementation Methods within most health care implementation models further demonstrates the need to understand the science of implementation and to identify the Implementation Methods that are most effective in making practice changes in complex clinical settings.

Knowledge Transfer Framework Operational Model of Implementation

The Knowledge Transfer Framework (KTF) (Nieva, et al., 2005) was utilized as the operational model for this study because it offered in-depth thinking about specific Implementation Methods that should facilitate the efficient and timely movement of evidence into practice, especially at the unit-level of nursing care at the bedside.

There are three phases within the KTF, which include, 1) Knowledge Creation and Distillation, 2) Diffusion and Dissemination, and 3) Adoption, Implementation, with Institutionalization. The three phases are illustrated in Figure 2, The Knowledge Transfer Framework for the Agency of Health Care Research and Quality (KTF). The descriptions of each of the three phases are provided in *Appendix* A, Knowledge Transfer Framework: Phases of Translation. The focus of this study was within phase three.

The KTF is particularly applicable for quality improvement projects that focus on translating evidence to enhance patient safety programs. The emphasis on patient safety aligned well for this study that was conducted within a national multi-site collaborative, sponsored by NACHRI. The collaborative goal was to eliminate CLABSI in critically ill children who were cared for in PICUs. The collaborative provided two bundles of evidence-based elements. These included one for central line insertion and one for central line maintenance. The two bundles

were based on evidence that should include the essential elements necessary to reduce the risk of infection, associated with central lines.

Additional benefits of the KTF included the ability to easily understand, describe, and apply it to practice changes within complex clinical settings. A recent example of the application of the KTF to a complex clinical setting was reported in the 2010, in a publication, entitled "*Facilitation of evidence-based nursing practice during military operations"* (Bridges, 2010). Bridges utilized the KTF as a conceptual bases and described methods used to implement practice changes in the mobile critical care environment within the combat military setting.

Eleven Implementation Methods were identified in the KTF, which included Training, Monitoring and Measurement Tools, Cultural Assessments, Cost Benefit Analyses, Implementation Tools, Technical Assistance, Help Line User Groups, Standards and Guidelines, Policy Change, Internal Stakeholder Analysis, and Organizational Communications.

In addition to those 11 Implementation Methods included in the KTF, there were nine additional Implementation Methods identified based on further empirical evidence reported in the literature. The additional nine Implementation Methods were deemed important for this study to assure that a comprehensive listing of Implementation Methods was evaluated across nationally diverse PICUs. The nine literature based Implementation Methods included, Performance Feedback (Hysong, et al., 2006), Incentives (Arrington, Kimmey et al. 2008), Change Champions (Redfern & Christian, 2003), Opinion Leaders (Irwin & Ozer, 2004), Boundary Spanners (Alexander, Wells, Jiang & Pollack, 2008), Local Consensus (Arrington, Kimmey et al. 2008), Marketing (Grilli, Ramsay, & Minozzi, 2009), Social Networks (Luck, Hagigi et al. 2009); Norman & Huerta, 2006), and Reminders (Grimshaw, Eccles et al. 2006).

The 11 KTF Implementation Methods combined with the nine literature based Implementation Methods provided 20 Implementation Methods, which were explored in this study. The Implementation Methods are defined in Table 3. The 20 Implementation Methods were grouped into one of seven Implementation Dimensions, as described below.

Seven Implementation Dimensions

As outlined in Table 4, the 20 Implementation Methods were grouped into seven broader categorical Implementation Dimensions, based on conceptualizing how Implementation Methods grouped together under general concepts. These Implementation Dimensions were explored to determine if the groupings were statistically justified.

A comparative analysis between each of the seven Implementation Dimensions and main DOI Theory elements was completed to determine relationships and alignment. An explanation of the relationships between the DOI theoretical concepts and each of the seven Implementation Dimensions are illustrated on Table 5 and described below.

Dimension One: Education and Training and Theoretical Bases

The first Implementation Dimension of Education and Training was aligned with two main elements of the DOI Theory, Innovation, and Time.

Within the element of Innovation, both relative advantage and trialability are important characteristics. Relative advantage is the first characteristic of Innovation that aligned with the Implementation Dimension of Education and Training. In order for individuals to determine the relative advantage of an innovation, they must be able to understand it, which is facilitated through education and training. Trialability is the second characteristic of innovation that was aligned. The ability to learn by practice and doing through training facilitates the adoption

process. Training provides access to trialability, where the individual is able to experiment, trial, and practice the innovation before being expected to perform it in a clinical setting.

The second main element aligned with the Implementation Dimension of Education and Training was Time. Within the element of Time, both knowledge and persuasion are important steps. In the first step, knowledge, individuals learn about an innovation and begin to understand it. Knowledge is developed from information obtained through both education and training. The second step of the innovation-decision process, persuasion is influenced by many things, including education and training. Education and training can be provided in a way to persuade the individual to accept or reject the innovation.

Dimension Two: Audit and Performance Feedback and Theoretical Basis

The second Implementation Dimension of Audit and Performance Feedback was aligned with two main elements of the DOI Theory, Innovation, and Time.

Within the element Innovation, observability is an important characteristic. The visibility of results of the innovation facilitates discussion among peer groups, which also promotes adoption. In order to make results visible, data must be collected. Audits are used to collect data, so they may be shared and viewed by those recipients of the innovation, which makes the innovation observable.

The second main element aligned with the Implementation Dimension of Audit and Performance Feedback was Time. Within the element of Time, confirmation is an important step. Utilizing audits to collect data and then make the findings visible to individuals is a necessary step for individuals to confirm results and adopt the innovation. When results are visible, especially when positive, it assists the individual with integrating the innovation into their own practice.

Dimension Three: Culture and Theoretical Basis

The third Implementation Dimension of Culture was aligned with the main element of the DOI Theory, Social System.

Culture is a way to conceptualize the Social System. Culture is defined as "values, attitudes, norms, practices, and general attitudes of personnel. It may also be defined as, the way we do things around here" (Pronovost & Sexton, 2005). Culture is abstract and difficult to describe and measure, but important to consider within implementation activities. Within the context of this study, safety culture was utilized as the method to evaluate culture, because it is measurable, and widely accepted as a sound, concept within PICUs. Safety Culture is defined "as a group of individuals guided in their behavior by their joint belief in the importance of safety…with a shared understanding that every member willingly upholds the group's safety norms and will support other members to that common end" (Helmreich and Merritt as cited in Ashcroft, 2005).

Dimension Four: Cost Benefit Analysis and Theoretical Basis

The fourth Implementation Dimension of Cost Benefit Analysis was aligned with two main elements of the DOI Theory, Innovation, and Time.

First, within the element of Innovation, relative advantage is an important step. It is important for the individual or group to perceive the advantage of the innovation. The greater the perceived relative advantage of an innovation, the more rapid the rate of adoption will be. If the innovation is viewed as better than the current state of practice, it is more likely to be adopted. One way for individuals and groups to evaluate an innovation is by considering the costs and benefits. If the benefit outweighs the cost, the innovation will be perceived as having a relative advantage over current state.

The second element aligned with the Implementation Dimension of Cost Benefit Analysis was Time. Within that element of Time, persuasion is an important step. Individuals must be convinced that the innovation is worth doing. Though some of the persuasion components are related to a belief that the innovation is the right thing to do, others are driven by economics. In general terms of health care economics, the cost of innovations can be compared to the cost of poor outcomes, if the innovation were not to be implemented. The financial consequences of poor outcomes can be persuasive in making innovation changes. Economics can also be persuasive to individual clinicians. Individuals can receive financial or other incentives based on compliance with standards or clinical outcomes.

Dimension Five: Resources and Tools and Theoretical Basis

The fifth Implementation Dimension of Resources and Tools was aligned with one main element of the DOI Theory, Innovation.

Within the element of Innovation, both complexity and trialability are important characteristics. First, related to complexity, if innovations are too difficult or complex to practice, they will not be adopted. Resources and tools can be put into place to facilitate use of the innovation. Making the innovation easier to use than the current practice can be a strong driver of adoption. The second characteristic of Innovation that is important within the Implementation Dimension of Resources and Tools is trialability. The ability to learn by practice aids the adoption practice. Providing resources and tools in the clinical setting, allows for individuals to trial the innovation with adequate support, which facilitates adoption. The importance of trialability drives the resource and tool implementation strategies.

Dimension Six: Local Participation and Theoretical Basis

The sixth Implementation Dimension of Local Participation was aligned with three main elements of the DOI Theory, Innovation, Social System, and Time.

First, within the element of Innovation, compatibility is an important characteristic. The innovation must be compatible within the existing Social System, or its rate of adoption will be much slower. The use of local participants can assure that the innovation is going to be a good fit within the system. Local participants can also modify innovations in such a way to ensure they are compatible with the local setting.

The second main element aligned with the Implementation Dimension of Local Participation is the Social System. The Social System may include individuals, groups, units, or organizations. Working within the Social System to drive changes is essential and should include local participants including opinion leaders and change agents.

The third main element aligned with the Implementation Dimension of Local Participation is Time. Within the element of Time, the step of the innovation-decision process that is important is persuasion. The stage at which an individual forms an opinion can be greatly influenced by their ability to participate locally. Utilizing local clinicians, opinion leaders, and change agents within the Social System, facilitates the adoption of the innovation.

Dimension Seven: Communication and Marketing and Theoretical Basis

The seventh Implementation Dimension of Communication and Marketing was aligned with three main elements of the DOI Theory, Communication Channels, Social System, and Time.

First, within Communication Channels, two approaches are equally important. They include mass media channels for creating knowledge about an innovation and interpersonal

channels important for changing attitudes about an innovation. An individual's decision to adopt an innovation or not are influenced by the communication they receive from peers and other sources.

The second main element that is aligned with Implementation Dimension of Communication and Marketing is the Social System. Social Systems vary by unit and hospital and include customs and norms of communication as part of their culture. Customizing communication and marketing approaches to fit the Social System are essential, or they will not be well received.

The third main element that is aligned with the Implementation Dimension of Communication and Marketing is Time. Within the element of Time, two of the steps of the innovation decision process are important characteristics, knowledge, and persuasion. The first step, knowledge is developed as individuals begin to learn about an innovation. Knowledge is acquired in a number of different ways beyond formal education, including communication and marketing. The individual may begin to develop knowledge about an innovation before they have been formally educated, through communication and marketing channels. Both can be used to increase awareness of the innovation and assist the individual to begin to understand it and develop knowledge. The second step, persuasion can be influenced by Communication and Marketing. Developing targeted communication and marketing strategies in such a way to persuade individuals is an important element of implementation. For example, messaging can include the rationale, consequences, and other compelling arguments why an individual should accept an innovation.

Described above are the conceptual based relationships between the DOI Theory and each of the seven Implementation Dimensions. Described below are the seven Implementation

Dimensions as they relate within the KTF, which was the health care operational model used for this study.

Visual Mapping of the Interrelationship among the Implementation Dimensions/Methods and the Knowledge Transfer Framework Translational Phases

The interrelationships of the seven Implementation Dimensions and 20 Implementation Methods, within the context of the KTF are illustrated on Figure 3, Conceptual Research Map for this study. Additionally, although effectiveness is not a part of the KTF, it is discussed within the conceptual research map in the context of this study. The diagram and its interrelated elements are discussed in the following section. This study is described as it relates to all three phases of the KTF, though the focus of this study is within phase three.

KTF Phase One: Knowledge Creation and Distillation

Phase one, Knowledge Creation and Distillation are represented in the yellow boxes numbered 1-3 on the left side of the diagram. The activities that took place within phase one occurred before both the NACHRI PICU CLABSI collaborative began and during the collaborative, but were not the focus of this study. These activities are described within the conceptual research map to illustrate how the NACHRI PICU CLABSI collaborative activities were represented within the KTF.

Knowledge creation at the national level (yellow box 1 in Figure 3). Knowledge creation occurred at the national level, which supported the central line insertion and central line maintenance care standards. The knowledge was created by many sources through bench, clinical, and quality improvement (QI) research. The evidence base for central line practices is extensive and spans greater than a decade.

Knowledge distillation at the national level (yellow box 2 in Figure 3). Knowledge distillation occurred at the national level prior to the formation of the NACHRI PICU CLABSI collaborative. This included the development of the IHI (2009) central line insertion bundle for adults. Additionally The Centers for Disease Control (CDC, 2010) and Infusion Nursing Society (INS, 2011) created guidelines for central line insertion and maintenance. These national guidelines were developed by synthesizing the evidence from research and QI literature and distilling it into abbreviated formats.

Knowledge distillation at the NACHRI level (yellow box 3 in Figure 3). At the NACHRI PICU CLABSI collaborative level, the distilled evidence from the national level was further distilled into two bundles of care. One bundle was created for central line insertion and one was for central line maintenance.

There was a national IHI insertion bundle, which was brief and easy to use, but required modification and further distillation at the NACHRI collaborative level, because it did not include pertinent pediatric evidence.

There was no concise national central line maintenance bundle. The CDC published general recommendations for central line insertion and maintenance together, but it was greater than 100 pages in length, and difficult to use. It was also absent of many aspects of care related to the maintenance of central lines. The Infusion Nursing Society (2011) published guidelines, which included a greater focus on central line maintenance, but it was also greater than 100 pages in length, and difficult to use. The CDC and INS guidelines were greatly distilled at the NACHRI collaborative level into a bundle for central line maintenance.

KTF Phase Two: Diffusion and Dissemination

Phase two of Diffusion and Dissemination are represented in the green boxes numbered 4 and 5 in Figure 3. The activities that took place within this phase occurred within the NACHRI PICU CLABSI collaborative, but were not the focus of this study. These activities are described within the conceptual research map to illustrate how the NACHRI PICU CLABSI collaborative activities were represented within the KTF.

Diffusion (green box 4 in Figure 3). Diffusion occurred through the NACHRI PICU CLABSI collaborative level by one-way communication. This included posting information on a website and pushing out information by email on a list serve to collaborative participants.

Dissemination (green box 5 in Figure 3). Dissemination occurred through the NACHRI PICU CLABSI collaborative in an interactive, two way manner. Interactive communication was promoted within the collaborative through in person education sessions at least two times a year and interactive web-ex learning sessions multiple times per year. In-person meetings included facilitated small group discussions with collaborative leaders. Additionally, individual units presented their activities and outcomes followed by interactive discussions with collaborative participants.

KTF Phase Three: Adoption, Implementation, Institutionalization

Phase Three of Adoption, Implementation, Institutionalization is represented in blue boxes 6-8 in Figure 3. Phase three, was the focus of this study.

Adoption and implementation (blue box 6 in Figure 3). Adoption and implementation are represented by Implementation Methods that may or may not be utilized by individual units. The 20 Implementation Methods listed are those elements that were either included in the KTF or derived from the literature. The 11 KTF methods included, Training, Monitoring and

Measurement Tools, Cultural Assessments, Cost Benefit Analyses, Implementation Tools, Technical Assistance, Help line User Groups, Standards and Guideline, Policy Change, Internal Stakeholder Analyses, Organizational Communications. The remaining nine literature based Implementation Methods included, Performance Feedback, Incentives, Change Champions, Opinion Leaders, Boundary Spanners, Local Consensus, Marketing, Social Networks, and Reminders.

The participating units received the central line insertion bundle and central line maintenance bundle within the context of the NACHRI PICU CLABSI collaborative through both distillation and dissemination as described above. In phase three, each individual unit adopted the bundles and implemented them, using any number of Implementation Methods, which were not directed by the NACHRI PICU CLABSI collaborative. It was not known which Implementation Methods were used by individual units to implement the central line care bundles. It was also not known if any particular Implementation Method was more effective than others were. Understanding which Implementation Methods were utilized and most effective by individual units, was the focus of this study.

Institutionalization (blue box 7, 8 in Figure 3). Institutionalization is represented by compliance with the central line insertion bundle compliance and central line maintenance bundle compliance. Each participating unit was required to audit compliance with the bundles, utilizing standardized data collection strategies and tools. Those units with high central line insertion bundle compliance and central line maintenance bundle compliance demonstrated institutionalization of the new practices.

Effectiveness (purple box 9 in Figure 3)

Effectiveness was not represented within the KTF. The lack of an effectiveness phase within the KTF is a limitation of the health care operation model of implementation, since all innovations should be carefully monitored for effectiveness. In the context of this study, effectiveness may be defined as the CLABSI rate, which was one of the three outcomes under exploration. A reduction in CLABSI for an individual unit demonstrates effectiveness. Though the CLABSI rate was explored, it was within the context of Implementation Methods used, not effectiveness as intended by the KTF.

As noted above, the focus of this study was within phase three, Adoption and Implementation. Specifically the focus was on the broad concept of Implementation Methods, which were used by individual units as illustrated in box 6 on Figure 3 on the conceptual research map.

Summary of Theory and Operational Model of Implementation

As noted above, there continues to be an unacceptable delay between the time new knowledge is discovered and timing of implementation in the clinical setting. In order to understand the process of implementing evidence into practice, it is important to draw from a theoretical base. As described above, the DOI Theory has been utilized within a number of disciplines for over 50 years, and was utilized as the theoretical framework for this study. Though a theoretical base is necessary to provide a broad understanding of implementation concepts, such a theory lacks sufficient operational concepts important in fully understanding and evaluating specific methods of implementation.

As the DOI Theory provided a theoretical framework for this study, the KTF provided a health care operational model of implementation, which is more tangible with specific aspects of

implementation clearly described. Together, concepts from the DOI Theory, the KTF, and the literature provided justification for 20 Implementation Methods and seven Implementation Dimensions that were studied.

Chapter Three: Design and Methods

This study was conducted using survey methods and retrospective outcome data. Results from the survey were used to describe Implementation Methods used by PICUS and investigate the relationship between Implementation Methods used and outcomes. Research subjects were recruited from individuals participating in the NACHRI PICU CLABSI Quality Improvement Collaborative.

Background and Evidence to Support Quality Improvement Collaboratives

Collaboratives bring groups of professionals, organizations, and units together for mutual learning and sharing in order to improve patient care and outcomes. An important assumption is that, the depth and speed of improvement is accelerated when done in a group rather than by an individual person or unit.

Collaboratives have gained popularity over the last 5-10 years as a vehicle to diffuse and actively disseminate evidence and knowledge to target audiences for improving the quality of care. In most cases, collaboratives facilitate quality improvement activities, though some may include clinical research, as well. In order for a quality improvement group to be categorized as a collaborative, it should include five essential features, which include:

- There is a specific topic or area of clinical practice that has wide variation between units or gaps exist between best and actual practice.
- Both clinical and quality improvement experts collaborate and work together to provide ideas for improvement.
- There are multidisciplinary teams from multiple units that are willing to work together to share ideas and improve.

- The improvement efforts include data collection, testing changes, and setting measureable targets.
- The collaborative process involves a series of structured activities, such as meetings, active email, etc.

An example of one of the first collaboratives is The Vermont Oxford Network (VON), which was established in 1988 (VON, 2011). The VON is a nonprofit collaborative for clinicians interested in improving the quality and safety of medical care for critically ill newborn infants cared for in neonatal intensive care units (NICUs). There are 850 participating neonatal intensive care units (NICUs). Members collect and submit quality data to a national database, which allows them to benchmark their performance with others.

Other examples of collaboratives include those facilitated by the Children's Healthcare Corporation of America (CHCA, 2011) focusing on clinical topics, such as the elimination of hospital acquired pressure ulcers, reduction of adverse drug events, and reduction in peripheral intravenous catheter infiltrations. There are many other examples of collaboratives as well such as those sponsored by the IHI (2011), New England Cardiovascular Study Group (NECSG, 2011), and the Michigan State Hospital Group (Share, et al., 2011).

Collaboratives require resources, which are associated with a cost. Not only is there a cost to those leading and facilitating the collaborative activities, but a cost to those who are participating. For example, time must be allocated for staff to participate in collaborative activities, collect data, and travel to national meetings. Since there is a cost associated with collaboratives, it is important to consider their effectiveness. Schouten and colleagues completed a systematic review of the literature to determine the effectiveness of collaboratives, entitled, *Evidence for the impact of quality improvement collaborative: systematic review* (Schouten, et

al., 2008). They searched the literature through Medline, CINAHL, Embase, PsycINFO, and Cochrane databases for articles on quality improvement collaboratives. They included publications between 1995 and 2006. Articles could be included in the review if they reported on an "organized, multifaceted approach to quality improvement with five essential features," as described above.

Schouten and colleagues initially identified 1104 articles and found 72 that met criteria for their review. Two reviewers used a standardized extraction checklist and independently screened each article for the five essential features, as well as methods, measures, and outcomes. Articles were included in the systematic review if both reviewers agreed they met criteria. The reviewers categorized each article based on the project design. Of the 72 articles that were included, they found 60 (83%) used an uncontrolled study design. Of the 60 articles that used an uncontrolled study design, 37 (62%) were based on self-report measures rather than specific measurable outcomes. Eight articles reported the use of a comparison group study design and two used randomized controlled trials.

As noted above, collaboratives are a common approaches used to facilitate quality improvement activities across many units. Overall, the authors concluded that collaboratives demonstrate modest, but positive results. The NACHRI PICU CLABSI collaborative represents such an example.

NACHRI PICU CLABSI Collaborative Overview

NACHRI was an organization of children's hospitals with greater than 200 member hospitals in the United States and beyond. NACHRI was a nonprofit association whose primary goal was to promote the health and well-being of children by supporting hospitals to achieve excellence in care. Part of their methodology to facilitate this work, was through quality

improvement collaboratives. A quality improvement collaborative may be defined as, "multidisciplinary teams from various healthcare departments or organizations join forces for several months to work in a structured way to improve their provisions of care" (Schouten, Hulscher, Everdingen, Huijsman, & Grol, 2008).

The NACHRI PICU CLABSI collaborative started in 2006, when a group of PICU nurse leaders, PICU intensivists, infectious disease physicians, and quality improvement experts gathered to discuss how to work together across PICUs in different organizations to reduce and ultimately eliminate CLABSI in critically ill children. NACHRI agreed to provide the oversight and infrastructure to facilitate the collaborative activities. Part of the early development of the collaborative included identifying expert PICU nurses and physicians from across the country to provide leadership and clinical expertise. The principle investigator for this study served as one of the two nurse leaders on this collaborative. The role included facilitating a collegial and non-competitive environment between the participating units as well as providing clinical expertise related to the care of central lines in PICUs. Once the leadership was in place, goals were established, which included:

- Overall Goal: Eliminate CLABSI in critically ill children
- First Year Goals:
    - Decrease CLABSI by 50%
    - Accomplish 90% central line insertion bundle compliance
    - Accomplish 70% central line maintenance bundle compliance

NACHRI PICU CLABSI collaborative activities. As described in Table 6, all features that should be included in a collaborative existed in the NACHRI PICU CLABSI collaborative.

Additionally, though not noted as an essential element above, an important and unique aspect of the NACHRI PICU CLABSI collaborative was transparency. Specifically, all units agreed to de-identify their process and outcome data to share with all collaborative participants. This allowed units to view other's data related to central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rates. This further facilitated learning and collaboration, because individual units were able to learn from those with better results than their own. The activities and results of the collaborative were published in 2010 (Miller, et al., 2010), with a second manuscript currently in press.

NACHRI PICU CLABSI collaborative participants. As of November 2011, 57 PICUs were participating in the NACHRI PICU CLABSI collaborative, which represented approximately 20% percent of all PICUS in the US. PICUs care for critically ill children age newborn to 21 years with medical and surgical conditions. Each PICU provided a project lead who directed the unit based team to work on the collaborative activities. In most cases, the project lead was a PICU RN in a leadership position, such as a director, clinical nurse specialist, or manager. Teams typically included staff members who had interest in driving change within their unit. Members typically included PICU nurse leaders, PICU physicians, infectious disease physicians, infection control professionals, and quality improvement professionals. The teams participated in unit-based activities, WebEx learning sessions, and national meetings.

Research subject recruitment. The project lead from each PICU participating in the NACHRI PICU CLABSI collaborative was invited to participate in this study. This study was initially presented at a NACHRI PICU CLABSI collaborative leadership meeting on July 15, 2010, and again on August10, 2011. The leadership group was composed of RN and MD clinical experts from across the country as well as NACHRI quality improvement staff. The

group met at least three times per year and together set the direction and goals for the collaborative. This study was approved and endorsed by all leadership.

Study participants were recruited during a national NACHRI PICU CLABSI collaborative meeting on November 2, 2011. Time was allotted on the agenda for subject recruitment. The recruitment of minorities and underserved populations was not relevant to this study, since all 57 PICU project leads were invited to participate.

Recruitment of subjects occurred only within the NACHRI PICU CLABSI collaborative. Though this approach limits the ability to generalize research findings beyond the context of the NAHCRI PICU CLABSI collaborative, it is a reasonable approach to recruitment because the participating PICUs represent approximately 20% of the total PICUs in the country, which is significant. There are also important advantages to consider when studying a cohort of units, all working on the same improvement project, within the same collaborative content, and identical goals. Specifically, since all units are similar in regards to acuity and population served, Implementation Methods used can more easily be compared and evaluated across units. Finally, there has been no such study published in the literature, so the findings will be an important contribution to the developing implementation science literature base.

***Human subjects' protection*.** A request was made to the Investigational Review Board (IRB) for approval of this study, which included a request for a waiver of the requirement for written documentation of informed consent, which was granted. The IRB policy allows such a waiver when one of the following criteria is met:

- The research presents no more than minimal risk of harm to participants and involves no procedures for which written consent is normally required outside of the research context.

  OR

- The only record linking the participant and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality (i.e. this is a minimal risk study and no identifying information other than name/signature/etc. on consent form will be collected or retained).

Though only one criterion is required for waiver of written informed consent, both were met for this study.

During the same time as subject recruitment on November 2, 2011, an overview of this study was provided, including the required elements of informed consent. The elements of informed consent were presented both verbally and in writing on a PowerPoint presentation. The required elements of informed consent that were pertinent to this study include:

- Indication the activity is part of a study
- The purpose of the study
- Duration of participation
- Procedures involved
- Risks and benefits
- Who to contact for questions
- The fact it is voluntary
- The use of incentives (none will be used)
- Financial disclosures (none)
- Time for questions

After the elements of informed consent were reviewed, data collection was completed.

Data Elements

Survey data were collected from each PICU lead to determine which Implementation Methods were used to implement the central line insertion bundle and central line maintenance bundle on November 2, 2011. The Implementation Methods used represented the independent variables for this study. The outcome data including central line insertion bundle compliance, maintenance bundle compliance, and CLABSI rate were retrospectively collected for the period of May 1 through October 31, 2011. This represented six months of data just prior to the data collection period for the Implementation Methods. The outcome data were obtained nearly four months after October 31, 2011, to ensure all units had adequate time to enter data and the NACHRI statistician had adequate time to ensure data was intact. The final data were obtained on February 20, 2012.

Justification for utilizing survey methods for data collection. Though quantitative data was collected with a survey for this study, qualitative data collection methods were also considered. Using qualitative methods such as interviews or focus groups were considered as a means to determine which Implementation Methods were used by individual units. An advantage to such qualitative methods may have included learning about novel Implementation Methods that have not been reported in the literature, which may not have been captured in a structured data collection instrument, such as a survey. Additionally, qualitative methods may identify new implementation science contextual issues that were previously unknown, and worthy of further exploration.

Though there are some important advantages when considering qualitative approaches to data collection, the methods were found to be unacceptable for this study, due to the need to collect data from all 57 units for both the Implementation Methods used and the unit-specific

outcomes during a very narrow timeframe. Due to the limited resources, it was not feasible to use qualitative methods to collect data from 57 units during the same timeframe. Collecting data during the same timeframe was essential to reduce the risk of random error.

Efforts were taken to minimize the risk for random measurement error. A random error was defined as a wrong result by chance. (Hulley, Cummings, Browner, Grady, Newman, 2007). Random errors can occur by chance, when activities or events external to a study, affect the outcome. Though it was not possible to control for events that occurred at the unit level, it was possible to control for events that occurred at the NACHRI PICU CLABSI collaborative level, by timing data collection carefully. Due to quality improvement approaches used within collaboratives, changes typically occur regularly as a means to accelerate improvement. For example, over the course of the NACHRI PICU CLABSI collaborative there have been changes to the central line maintenance bundle elements, methods used for data collection, and methods used for data entry. These are examples of changes that could influence study results, because they could have affected the outcome measures that were correlated with the Implementation Dimensions. Data collection were timed to occur during a period where all bundle elements, data collection methods, and data entry methods were stable for at least 12 months. In addition to planning data collection after one year of stability, it was timed just before changes within the collaborative were going to be introduced.

Specifically, the NACHRI PICU CLABSI collaborative leadership had planned to introduce several changes to the central line maintenance bundle and data collection tool at the November 2011 collaborative meeting in response to some national changes in the CDC guidelines. Additionally, the collaborative leadership had developed two new bundles of care related to central line openings and central line patency that were due to be implemented early

spring, 2012. Due to the importance of completing data collection during a narrow timeframe of collaborative stability, a data collection tool was required that could facilitate this approach. A survey instrument was found to be the most appropriate data collection tool for this need.

Justification for development of survey tool. Described below is the background and rationale for developing a new survey tool to collect Implementation Methods used by individual units. A search of the literature was conducted to determine if a validated tool to determine Implementation Methods used by individual units for implementing a practice change was available for data collection. There was a single publication, which described a survey tool that was utilized to collect Implementation Methods used across VA (Veterans Administration) hospitals. Implementation Methods were explored related to guideline implementation in primary care (BootsMiller, et al., 2004). They utilized a survey with yes/no response anchors to determine if 13 Implementation Methods were used by individual units to implement guidelines. The survey tool was not published, so the primary author was contacted to learn more about the tool and research study (personal communication, August 6, 2010). The author indicated the survey tool had been developed based on a review of the literature. Face validity had been established through an informal review of the survey tool with the intended respondents. It had not been further validated. Additionally, the survey tool had not been further developed or utilized. Unfortunately, no other tools were located in the literature.

Of note, in a personal correspondence with M. Titler, an international expert in the field of implementation science, the availability of such a tool to collect Implementation Methods was discussed. She was unaware of such a tool and suggested if developed, it would be a valuable contribution to the implementation science literature (personal communication, June 30, 2010).

Though it would have been preferable to utilize an existing, validated tool for data collection, no acceptable tool was located in the literature, so a new tool was developed. It was determined that the most feasible method to collect which Implementation Methods were used by individual units, would be to ask the units to identify them through self report. In order to standardize the collection of the Implementation Methods used across units, it was determined a self-report survey would be the most effective method for data collection of the independent variables.

Survey Development Process

The survey tool was developed by this researcher, specifically for this study. The two major stages utilized to develop the survey tool were 1) item generation and 2) establishment of content validity. The first major stage in developing the survey tool was item generation, which included determining the measurement format. Items may be thought of as "questions" on a survey, but it is more appropriate to identify them as items, since not all pose actual questions. The term "item" will be used for this discussion.

Measurement format. The measurement format selected was that of a self-report survey, utilizing a Likert scale. Likert scales present items in declarative sentences, followed by ordinal response anchors. The response anchors should be developed with enough variability, to identify real differences within items. For example within Likert scales, there are usually two extreme responses, such as strongly disagree and strongly agree, with varying degrees of agreement or disagreement across the ordinal scale, with a neutral response anchor in the middle. Five to seven response anchors are optimal for capturing the most variability in responses (Devillis, 2012). Too few response anchors decreases the amount of variability that the item is

able to indicate and too many response anchors makes the survey too difficult for respondents to complete, which can contribute to measurement errors.

Each item was created with five response anchors with sufficient variability to include no agreement to complete agreement across the item with a neutral response anchor in the middle. Five response anchors were selected based on survey theory (Devillis, 2012). Though an attempt was initially made to standardize response anchors for all items, it was not possible due to the characteristics of the items that were required to capture the Implementation Methods under exploration. For example, many items include the response anchors of strongly disagree, disagree, neutral, agree, and strongly agree, but there are also items which include response anchors in percentages of 0, <50%, 50%, >50%, >90%, as well as others. Though response anchors varied, they were all based on low to high intensity ordinal responses.

For example, response anchor selections of strongly disagree in one item, and 0% in another item, were both considered the lowest level of response, and of equal value, even though the response anchors were not identical. This was important for analysis when all items response anchors were re-coded as 1 to 5, so that individual items could be compared to each other, summarized, and averaged.

Another consideration when developing the items was defining time periods that respondents should consider when scoring items. The decision to include time frames or not, is dependant on the concept that is being considered. For the purposes of this survey, the period was initially set broadly, without any clear definition, in the opening instructions of the survey. Specifically, the instructions stated, “This survey specifically focuses on activities associated with your work to reduce/eliminate CLABSI in your unit.” Though not explicit about the timeframe, an attempt was made to frame the survey as it applied to the timeframe of the units

CLABSI initiative. Though there was no overall timeframe, there were some included in individual items. For example, many items asked the respondent to score the item based on the activities in the "last year." Once the overall format was determined, the pool of items was generated.

Development of pool of items. The pool of items was developed to represent the 20 Implementation Methods under evaluation, which are defined on Table 3. During the initial generation of items, an attempt was made to create an exhaustive list of items that would adequately represent and measure the Implementation Method within the context of PICUs. The generation of most items was based on a blend of the literature, personal clinical experience, and consultation with experts.

An example of items that were mostly literature based were those for the Implementation Method of Monitoring and Measurement Tools. Results from a published research study were utilized to build the initial items, which were further customized to fit within the context of PICUs (Hysong, et al., 2006).

Some items were primarily based on personal clinical expertise. Twenty five years of clinical and leadership experience in PICUs, as well as five years experience providing faculty leadership for the NACHRI PICU CLABSI collaborative provided the researcher with the qualifications to develop some items. An example of items that were primarily based on personal expertise were those within the Implementation Method of Cultural Assessments. Though included in the KTF and noted as important in the literature, methods for measurement of Cultural Assessments within the context of implementation science were not located in the literature. The researcher felt confident in developing that pool of items, based on experience.

Additionally, safety culture was well understood and measured by PICUs participating in the NACHRI PICU CLABSI collaborative, since it was part of the collaborative activities.

An example of items that were primarily based on expert opinion were those for the Implementation Method of Marketing. Though included in the KTF, a clear definition of Marketing was not located in the implementation science literature. Without clear direction from the literature, the director of a hospital marketing department was consulted to assist with the development of those items. He was able to describe core elements of marketing, which were then incorporated into items, then reviewed and further refined.

As the items were drafted, they were carefully developed to ensure they were clear and representative of the specific Implementation Method under evaluation. It was important to develop well-written items, avoiding problematic elements. For example, elements that were avoided included lengthy items, use of jargon (unless contextually appropriate), or use of double-barreled items. A double barreled item is one that contains two concepts within the same item, which makes it difficult for both the respondent to answer and difficult for the investigator to analyze the true meaning of the response.

No reverse order items were included. Reverse order items are typically worded in the opposite direction of other items on the survey tool. Reverse order items are more applicable to surveys for evaluating human behavior, such as depression or suicide risk (Devillis, 2012). When used out of this context, they may be confusing to the respondent, which can contribute to measurement error.

The reading level of each item was also considered, though it was not the primary focus of developing items. Surveys intended for the general population are generally prepared for those who read at the 5th grade level (Terwee, et al., 2007). Readability for the survey

instrument was established by Microsoft Word 2010, and found to be between Flesh Kincaid grade levels 7-12. Due to the technical nature of many of the items and the use of NACHRI PICU CLABSI collaborative terminology, it was difficult to reduce the reading level. Though the reading level was considered high for a typical survey directed at the general population, it was believed to be acceptable for the intended respondents since they had between four and 12 years of college education and were knowledgeable about the subject matter. Additionally, during the initial development of the pool of items, intermittent assistance from colleagues was obtained to obtain feedback on item format, clarity, and response anchors.

Reducing and refining the pool of items. Once the initial pool of items was developed, there were three phases of further iterative development and refinement. The three phases included development and refinement at the individual item level, the concept (Implementation Method) level, and the overall instrument (survey tool) level.

During the first phase, each item was evaluated using three criteria within the context of PICUS. These included, 1) accurate reflection of the concept (Implementation Method), 2) clarity of the item, and 3) appropriate response anchors for the items. Individual items were revised, as necessary.

During the second phase, each Implementation Method was evaluated using two criteria. These included 1) adequate representation of the concept within the context of PICUs and 2) lack of duplication of items. If the concept was not fully represented, new items were generated. Conversely, if items appeared to be repetitive, they were removed. At this phase of the development, the overall length of the survey was considered, attempting to eliminate non-essential items, so the survey tool would include the necessary representation of concepts without being too lengthy. Additionally, each Implementation Method within each

Implementation Dimension, related to the same concept was placed adjacent to each other. Once similar items were grouped together, they were placed in a logical order, first starting with items thought to be the least complex or controversial.

During the third phase, the overall survey tool was evaluated using three criteria. These included, 1) consideration for the total number of items, 2) placement order of the seven Implementation Dimensions containing the Implementation Methods, and 3) general readability. Aspects of general readability included the evaluation of the overall format of the survey such as font, spacing, length in terms of page numbers, and general layout. Great attention was paid to ensure the survey was complete in terms of adequately measuring the Implementation Methods under evaluation, while balancing the length of the survey to ensure it was not too lengthy or onerous for participants to complete.

Validity. The second stage of developing the survey tool was the establishment of face and content validity. Face validity was defined as, the instrument appears to measure what it is intended to measure. Face validity is often established by having an expert review the instrument and make a determination regarding its appropriateness (Streiner & Norman, 2008). Face validity may be thought of as an informal process. Establishing content validity is a more rigorous process than determining face validity. Content validity was defined as, the degree to which an instrument has an appropriate sample of items for the construct being measured (Polit & Beck, 2006). This included completing a more formalized review of the instrument. This review ensured the tool appeared to measure what it was intended to measure, as in face validity. Additionally, it also included a review to ensure there were sufficient items to represent the concepts under investigation.

Face validity. Face validity was established through two levels of review. The first review included obtaining opinions from three experienced nursing leaders. The second level of review was completed by a single experienced nursing leader, who provided expert representation of the NACHRI PICU CLABSI collaborative.

The participants in the first level of review included two nurse leaders that practiced in a children's hospital and one in an adult hospital. Each nursing leader had greater than 30 years of clinical experience and represented the semi-target audience for the survey, in that they were individuals in roles that may have been asked to respond to such a survey. The three nurses represented a diverse group with extensive expertise in implementing practice changes within their settings.

The purpose of the survey tool was described in person and then the survey tool was emailed to the reviewers with additional instructions. They were provided two weeks to review the survey tool before meeting in person. Meetings occurred individually, so feedback could be provided reflective of the individual review, without the influence of others.

The first reviewer was a doctorly prepared nursing leader with a broad background in clinical practice, who practiced on a pediatric ambulatory setting. She provided some meaningful, critical feedback regarding sentence structure and overall readability, but indicated the survey seemed to be specific and complete as related to Implementation Methods. The second reviewer was a clinical nurse specialist who practiced on an inpatient pediatric unit. She found the survey tool to be completely acceptable, with no changes recommended. The third reviewer was a clinical nurse specialist who practiced on an adult ICU. She offered some important suggestions related to response anchors and confirmed that the items were understandable as written, without confusing or ambiguous jargon.

After these reviews were completed, revisions were made to the survey tool, mostly in clarifying language and response anchors. No significant changes were made to individual items or the overall survey tool. After the revisions were made, the second level of review to establish face validity was completed.

The second level of review was completed by an RN, with an MA and ND (more commonly known as DNP) who was the Associate Director, Clinical Quality Improvement for NACHRI. She also provided leadership for the NACHRI PICU CLABSI collaborative, and had a strong foundation in change theory within hospitals. She was asked to review the survey tool based on her own expertise and overall fit for the NACHRI PICU CLABSI collaborative. Since she was based in Washington DC, she also offered a perspective outside the Pacific Northwest. The initial request for the review was completed by phone, and then the survey tool was emailed to her one week prior to a scheduled phone call. After she completed the review, the survey tool was discussed by phone, reviewing every item, Implementation Method, Implementation Dimension, and the overall survey tool.

She indicated the survey was very relevant to the NACHRI CLABSI PICU collaborative activities and completely inclusive of all Implementation Methods that should be considered. She suggested repositioning the section of Marketing and Communication to the end of the survey, to avoid early confusion between what was done at the NACHRI PICU CLABSI collaborative level, versus individual unit level. In addition, based on her feedback, an instructional sentence was inserted in that section to indicate items should be scored based on what was done at the local unit level, not by NACHRI.

Content validity. Content validity was established through a more rigorous process than face validity. The establishment of content validity was completed by calculating the content

validity index (CVI) for each item. The CVI may be defined several ways, but for the purposes of this survey tool, it was defined as "the proportion of experts who scored items as relevant or representative with either three or four (Grant and Davis, 1997)." In this context, reviewers score each item on a one through four scale, with one indicating the lowest level of agreement and four the highest level of agreement with the item. Eighty percent agreement among reviewers is generally required to indicate an item is valid (Polit & Beck, 2006).

In order to calculate the CVI, content experts were identified as the leadership for the NACHRI PICU CLABSI collaborative. Each collaborative leader, including two nurses, five physicians, and two NACHRI quality improvement staff were invited to participate in the CVI review They were provided with the CVI instructions, CVI template, and survey tool by email one week prior to the August 2011 leadership meeting. The template for the CVI review is attached in *Appendix* B. The materials were then formally presented at the meeting and a request was made for each leader to complete the CVI review. Additionally, a nurse colleague enrolled in the University of Washington PhD program was asked to complete the CVI review, because of her in depth knowledge related to implementation science. In all, six individuals completed the CVI review. The participants represented a multidisciplinary group with perspectives from every major region of the US.

Two nurses, two physicians, and two NACHRI PICU CLABSI quality improvement experts completed the CVI review. Out of 73 items on the survey, the two nurses scored every item with a four, indicating they found 100% of the items on the survey to be valid. Additionally, there were no Implementation Methods that the nurse reviewers identified as absent from the survey. Utilizing two content experts is considered an acceptable way to conduct a CVI review (Polit & Beck, 2006), though more experts may be used, as was done in this case.

When reviewing the average CVI scores for all six reviewers, including two nurses, two physicians and two NACHRI PICU CLABSI Quality Improvement Experts, 58/73 (79%) of the items were scored higher than 80%. Of the 15 items that were scored less than 80%, nine items were within the Dimension of Cost Benefit Analysis. The low scores of these items by physicians and NACHRI PICU CLABSI Quality Improvement experts were explored by reviewing the individual comments provided on the CVI review form. It appeared that these reviewers did not agree that the Implementation Dimension of Cost Benefit Analysis was a valid concept to consider. Those items were retained, because they are included on the KTF, discussed heavily in the implementation science literature, and strongly endorsed by the nurses who established both face validity and content validity.

The remaining six items that were scored less than 80% were items within the Dimension of Communicating and Marketing. Of note, both nurses and one physician ranked all items with four, indicating 100% endorsement. The low score of these items by one physician and two NACHRI PICU CLABSI Quality Improvement experts was explored by reviewing the individual comments provided on the CVI review form. It appeared that these reviewers did not agree that the Implementation Dimension of Communication and Marketing was a valid concept to consider. Those items were retained, because communication is included in the KTF, and both communication and marketing are discussed heavily in the implementation science literature, and strongly endorsed by the nurses who established both face validity and content validity.

As indicated above, items that scored less than 80% were carefully considered, but not deleted. Though no items were deleted based on a CVI score of less than 80%, all feedback and comments were carefully considered, which lead to several revisions. There were five types of

revisions completed. The first type of revision included the deletion and addition of two items within the Implementation Dimension of Audit and Feedback. The second type of revision included the substantial re-wording of items within the Implementation Dimension of Cost Benefit Analysis. The third type of revision included changes to response anchors of three items within the Implementation Dimension of Audit and Feedback. The fourth type of revision included re-ordering of one item within the Implementation Dimension of Audit and Feedback. Finally, the fifth type of revisions included minor word changes to ten items within five of the seven Implementation Dimensions.

Reliability. Reliability had not been established for this survey tool, because it had not been previously deployed. Reliability was defined as an instrument that performs in a consistent and predictable way (DeVillis, 2012). That is, the score will not change between individuals, settings, or time intervals, unless the underlying concept that is being measured has changed. Reliability may be established a number of different ways, but within the context of this study, there were three possibilities identified. The first method included the comparison of scores on this survey tool to a validated instrument. Since no other instrument exists, this was not possible. The second method included asking the same participant to complete the survey at a different time interval, within close proximity to each other, and then comparing the results to see if they were consistent. This was not possible due to the limited time allotted for NACHRI PICU CLABSI collaborative participants to complete the survey. The third method included asking two collaborative leads from each unit to complete the same survey, and then comparing the results, to determine the inter-rater reliability. This was not possible, since each unit had only one collaborative lead. It was not possible to establish the reliability of this instrument, since it was only deployed once to one project lead from each unit.

Though not establishing reliability was a limitation of the survey tool, there was no plan to apply it outside the context of the NACHRI PICU CLABSI collaborative, because the tool was developed for the purposes of this study only. Additionally, the survey tool included a number of elements that were specific to the NACHRI PICU CLABI collaborative, including particular terminology that would not be applicable to other settings.

Internal Consistency. Internal consistency had not been established for this survey tool prior to its use for this study, because it had not been previously deployed. Internal consistency was defined as items that are highly inter-correlated with each other within the survey tool. Internal consistency typically relates to an entire survey tool, when it is intended to measure a single concept, like depression. However, internal consistency can also relate to survey tools intended to measure greater than one concept, as is the case with this one. In this case, the survey tool was designed to measure seven concepts, which were identified as the seven Implementation Dimensions, comprising 20 Implementation Methods. As described in the analysis plan and findings section to follow, exploratory analysis was conducted to determine if the survey tool exhibited internal consistency within the seven Implementation Dimensions. Internal consistency was identified for six of the seven Implementation Dimensions. When internal consistency was present, further correlation and predictive analysis was performed, as described in the analysis section to follow.

Characteristics of final survey tool. The final survey tool is included in *Appendix* C. The survey tool contained four main sections, 1) abstract of this study, 2) instructions for completion with informed consent language, 3) demographic questions, and 4) main body of the survey, with 73 items. There were seven sections, which represented the seven Implementation Dimensions. Contained within the seven sections were the items that represented the 20

Implementation Methods, which were comprised of 71 Likert items that represented the Implementation Strategies. Each item as it related to the specific Implementation Dimension, Implementation Method, and DOI theoretical concept is illustrated in Table 7. There was one additional item with a yes/no response anchor, which states, **"**was there any additional Implementation Methods used on your unit that was not mentioned above?" This item was followed by a final open-ended item that stated, was "If yes, please describe."

Data Collection of Implementation Methods (Independent Variables)

The survey was deployed by paper at a national NACHRI PICU CLABSI collaborative meeting in an organized group setting on November 2, 2011. A brief presentation was provided by the principal investigator, which included the purpose of the study, request for participants to complete the survey, and the required elements of informed consent identified by the Investigation Review Board (IRB). Twenty minutes was allotted during the meeting for participants to complete the survey. Fifty seven surveys were completed and collected at the end of the period. All eligible units completed the survey, which was an excellent response rate of 100%.

Data Collection of Outcomes (Dependent Variables)

The mean scores for central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate for each individual unit was provided by NACHRI on February 20, 2012. The data was collected as part of the collaborative activities. The data included the aggregate mean results for the time period May 1 through October 31, 2011, which represented the six month time period just prior to data collection for the Implementation Methods used (independent variables) on November 2, 2011.

Central line insertion bundle compliance. Central line insertion bundle compliance data were collected by each individual unit, using pre-established data collection methods with a standardized tool. Every central line inserted in each PICU was audited for compliance with the central line insertion bundle. The audits were completed by direct observation of the three core elements of hand hygiene, sterile barriers, and chlorhexidine gluconate scrub. The raw data from each unit were entered into a pre-existing secure database by each individual unit as part of the NACHRI PICU CLABSI collaborative.

The compliance for each individual observation was calculated based on the formula determined by the collaborative leadership. Specifically, in order for the observation to be scored as compliant, all three elements had to be scored as compliant. For example, if any element of an observation was scored as noncompliant, the overall compliance score for that observation was scored as noncompliant. Each observation score (compliant or noncompliant) was then averaged for an overall compliance percentage. All results for central lines inserted over the six month period (May1-October 31, 2011), just prior to collecting the Implementation Methods (November 2, 2011) was averaged to provide an aggregate compliance score for each unit. The audit methodology, including calculation for compliance had been pre-established within the NACHRI PICU CLABSI collaborative, and was not altered for this study.

Central line maintenance bundle compliance. Central line maintenance bundle compliance was collected by each individual unit, using pre-established data collection methods with a standardized tool. Once per week, every central line within any child in the PICU was audited for central line maintenance bundle compliance. The audit included observation of seven elements including assessment of central line necessity, assessment of central line insertion site, antiseptic use for line entry, dressing change procedure, cap change procedure, tubing change

procedure, and needle change procedure (for implanted ports only). The audit data from each unit were entered into a pre-existing secure database by each individual unit as part of the NACHRI PICU CLABSI collaborative.

The compliance for each individual observation was calculated based on the formula determined by the collaborative leadership. Specifically, in order for the observation to be scored as compliant, all seven elements had to be scored as compliant. For example, if any element of an observation was scored as noncompliant, the overall compliance score for that observation was scored as noncompliant. Each observation score (compliant or noncompliant) was then averaged for an overall compliance percentage. All results for central lines audited over the six month period (May1-October 31, 2011), just prior to collecting the Implementation Methods (November 2, 2011) was averaged to provide an aggregate compliance score for each unit. The audit methodology, including calculation for compliance, had been pre-established within the NACHRI PICU CLABSI collaborative, and was not be altered for this study.

CLABSI rate. CLABSIs were collected by each individual unit, using pre-established data collection methods with a standardized tool as part of the NACHRI PICU CLABSI collaborative. All positive blood cultures were screened by an infection preventionist to determine if the blood culture was associated with a central line, or not. The determination of the association between a central line and a positive blood culture was based on the Centers Disease Control definition (CDC, 2010). Core elements of the CDC criteria include the presence of a central line prior to the infection, a positive blood culture not related to an infection at another site, and at least one symptom that indicates the presence of an infection. Additionally, if the blood culture represented an organism that may have been a skin contaminate, it must have

been present in two different blood cultures. See *Appendix* D for further details as defined by the CDC.

In order to calculate the CLABSI rate, the number of central lines in place, per day was determined. Every patient with at least one central line was counted as one line day. If a patient had greater than one central line, it was still counted as one line day, based on CDC definitions. The method for determining the number of central lines varied by each unit based on human and technology resources, available at that site. The number of central line days was entered into a pre-existing secure database as part of the NACHRI PICU CLABSI collaborative. The database calculated the CLABSI rate as the number of infections per 1000 line days. For example:

If there were 10 patients in the PICU every day, all with at least one central line for 100 days, there would be 1000 line days in 100 days. If there were 2 CLABSI within these 100 days, the CLABSI rate would be 2 per 1000 line days. The measure of the number of CLABSI/1000 line days is the national standard, as defined by the CDC.

All CLABSIs and central line days over the six-month period (May1-October 31, 2011) were collected, just prior to collecting the Implementation Methods (November 2, 2011). The six-month rate was calculated based on the total number of infections and total number of central line days, as defined above.

Data Management

Survey results from each unit, which represented the independent variables for this study, were entered into a secure, password protected Excel spreadsheet. Outcome data, which represent the dependent variables for this study, including central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate were obtained from NACHRI in an Excel spreadsheet. Both data sets were matched by unit and merged. Once all

data was correctly matched by unit, the data was de-identified by removing unit names and replaced with a unique numerical identifier. Additionally, the unit names were removed from the paper survey forms and replaced them with the same unique identifier. This ensured the data was maintained in a confidential manner. Additionally, the investigator was blinded to which data represented which specific unit, to assure the analysis was unbiased. A code sheet including the unit names and unique identifiers was maintained in a separate document, within a separate file, apart from the actual data. There was no plan to access the code sheet once analysis began. However, it was retained during data analysis, in case there were questions related to data integrity, such as possible data entry errors.

Analysis Plan

There were three phases of analysis completed, which were based on this research questions being explored. Phase one of analysis included descriptive statistics for the Implementation Strategies, Implementation Methods, and outcomes. The outcomes were defined as central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate. Phase two of analysis focused on exploration of the survey tool for internal consistency within the Implementation Dimensions. The internal consistency within the Implementation Dimensions was explored to determine if it was acceptable for correlation or predictive analysis, as described in phase three. Since there was internal consistency within six of the seven Implementation Dimensions, Phase three of analysis was completed as planned. Phase three of analysis included descriptive statistics, correlations, and exploration of predictive relationships between the Implementation Dimensions and outcomes.

Phase One of Analysis: Description of Implementation Strategies, Implementation Methods, and Outcomes.

Research Question One**:** Which Implementation Strategies are most commonly used across a national sample of PICUs?

The frequency distributions of mean, median, mode, range, and standard deviation were determined for the 71 Implementation Strategies collected on the survey tool as reported on Table 8.

Research Question Two: Which Implementation Methods are most commonly used across a national sample of PICUs?

1. The frequency distributions of mean, median, mode, range, and standard deviation were determined for the 20 Implementation Methods as reported on Table 10. Each Implementation Method was represented by conceptual groupings of Implementation Strategies, as identified on Table 7. The composite Implementation Method score was calculated by averaging the scores from Implementation Strategies, which represented the Implementation Methods that were collected on the survey tool.

2. Implementation Methods identified by survey participants through "write-in" responses were categorized within the previously determined 20 Implementation Methods as reported on Table 9.

Research Question Three: What are the frequency distributions for the three outcomes of central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate across a national sample of PICUs?

The frequency distributions of mean, median, mode, range, and standard deviation were determined for each of the three outcomes as noted on Table 11.

Phase Two of Analysis: Internal Consistency of the Survey Tool

Research Question Four: Is there empirical support for clustering specific Implementation Methods according to the conceptually proposed Implementation Dimension taxonomy?

Phase two of the analysis focused on the survey tool to determine the degree to which Implementation Strategies, which represented Implementation Methods within each Implementation Dimension were internally consistent with each other. Implementation Strategies that are internally consistent with each other suggests they represent the same concept. Concepts within the study were identified as each of the seven Implementation Dimensions. Internal consistency is often determined for an entire survey tool, when the tool is intended to measure a single concept, like depression. However, internal consistency can also be determined for more than one concept within a single survey. In the case of the study, the survey tool was not intended to measure a single concept, but seven distinct Implementation Dimension concepts. Therefore, the internal consistency was determined within each Implementation Dimension.

In order to determine the internal consistency for each Implementation Dimension, Cronbach's alpha coefficient was computed for each grouping of Implementation Strategies within each of the seven Implementation Dimensions. In general, a Cronbach's alpha coefficient of $\geq .7$ is considered acceptable. The range of coefficients and interpretations include, $\geq .9$: excellent; $\geq .8$-.9: good; $> .7$-.8: acceptable; $> .6$-.7: Questionable; $\geq .5$-.6: poor; $< .5$: unacceptable. When the Cronbach's alpha coefficient was $\leq .7$, individual Implementation Strategies were deleted in an attempt to improve the alpha coefficient to $\geq .7$ to allow for further explanatory analysis, as described below in phase three.

Phase Three of Analysis: Descriptions and Relationships Between Implementation Dimensions and Outcomes

Phase three of analysis was completed, because there was sufficient internal consistency within six of the seven Implementation Dimensions. The analysis included the description of the Implementation Dimensions and examination of relationships between Implementation Dimensions and the three outcomes by computing correlations and multiple regressions. The three outcomes included central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate.

Each Implementation Dimension was represented by Implementation Strategies, which represented conceptual groupings of the Implementation Methods as identified on Table 7. The composite Implementation Dimension score was calculated by averaging the scores from those Implementation Strategies, representing each individual Implementation Dimension, collected on the survey tool.

Research Question Five: Which Implementation Dimensions are most commonly used across a national sample of PICUs?

The frequency distributions of mean, median, mode, range, and standard deviation were determined for the seven Implementation Dimensions as reported on Table 12.

Research Question Six: Are any of the Implementation Dimensions significantly correlated with central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate?

Correlations were computed to determine if there were any significant positive relationships between Implementation Dimensions and any of the three outcomes. Coefficients (r) were calculated for this portion of the analysis, utilizing *Pearson r*. The models evaluated the

linear relation between these variables. When utilizing *Pearson r*, the correlation represents a linear relationship between two variables. A perfect relationship may be a positive association with a score of 1.0 or a negative association with a score of -1.0. The further from either 1.0 or -1.0, the weaker the correlation. A correlation of 0.0 represents no correlation. Scatter plots were generated to ensure the simple linear approach was appropriate.

Research Question Seven: Do any of the Implementation Dimensions predict central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate?

Multiple regression analysis was completed to determine if there were any significant predictive relationships between any of the Implementation Dimensions and the three outcomes as reported on Tables 13-16. Multiple Regression analysis was used for this portion of analysis. Multiple regressions are useful for determining the relationship between one dependant variable and greater than one independent variable. The predictive nature of specific Implementation Dimensions will be explored. Standard multiple regressions with simultaneous independent variable entry will be computed separately for each of the three outcomes.

In general, when conducting multiple regression analysis, there should be an approximate sample size of 20 respondents for each variable, representing a 20:1 ratio (Tabachnick & Fidell, 2007). Since the total sample size for this study was 57, the respondent to variable ratio was approximately 8:1, which is less than desired. In order to address the suboptimal respondent to variable ratio, expert opinion was obtained from two statisticians, Dr. Liz Sanders (Personal Correspondence, April 2011) and Dr. Jerald Herting (Personal correspondence, March 2012). Both indicated that though a 20:1 ratio might be considered the gold standard, it is commonly violated within clinical and applied research settings. They indicated multiple regressions would be an acceptable approach for analysis for this study.

Chapter Four: Findings

There were three phases of analysis completed, which were based on this research questions being explored. Phase one of analysis included computing descriptive statistics for the Implementation Strategies, Implementation Methods, and outcomes. The outcomes were central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate. Phase two of analysis included exploration of the survey tool for internal consistency within the Implementation Dimensions. Phase three of analysis included computing descriptive statistics for the Implementation Dimensions. Additionally, in phase three of analysis, the positive correlations, and predictive relationships between the Implementation Dimensions and outcomes were explored.

Sample Characteristics

All 57 PICUS that were eligible to participate in this study completed the survey. The sample characteristics collected included the unit description and the respondent demographics.

Unit description. There were two unit characteristics collected, which included the unit size and unit type. There was one missing data from unit size, and no missing data from unit type.

The mean unit size was 22.02 (*SD*=10.03*)* beds, with a range of 9-72. The majority of units had between 9 and 33 beds. There were two outlier values, one unit with 55 beds and one with 72 beds. Survey respondents identified their unit type as PICU, CICU, or PICU/CICU combined. Though all three unit types fall under the broad category of PICU, and are considered equivalent within the NACHRI PICU CLABSI collaborative, they may be more specifically defined as PICU, CICU, or PICU/CICU combined. PICUs typically care for critically ill children excluding those who require cardiac surgery. CICUs typically care for critically ill

children who have a primary cardiac diagnosis, with the majority of patients recovering from corrective cardiac surgery for a congenital heart defect. PICU/CICU combined units typically care for critically ill children with both cardiac and non-cardiac conditions. 44 (77%) respondents identified their units as PICU, 11 (19%) respondents identified their units as CICU, and two (4%) respondents identified their units as PICU/CICU combined.

Demographic characteristics of respondents. There were two demographic characteristics collected from each survey respondent, which included profession and primary role on the unit. Both items on the survey representing the demographic characteristics of the respondents were completed by all 57 respondents.

Survey respondents identified their profession as follows: 41 (72%) RNs, 13 (23%) MDs, and three (5%) "Other." Survey respondents identified their role in the ICU either 17 (30%) Manager/Director, or 10 (18%) provider. In most cases, the provider was an MD, but in one case, the respondent identified them self as an advanced practice nurse. There was a fair amount of distribution across the remaining role types, which included eight (14%) Direct Care Staff, eight (14%) "Other," seven (12%) Clinical Nurse Specialists, five (9%) Educators, and two (3%) roles in Quality or Outcomes. As the data revealed, the majority of the respondents were nurses, but the primary role of the respondents varied considerably, encompassing both direct patient care and leadership nurses.

Phase One of Analysis: Description of Implementation Strategies, Implementation Methods, and Outcomes.

Research Question One**:** Which Implementation Strategies are most commonly used across a national sample of PICUs?

A survey was used to determine which Implementation Strategies were used by a national sample of PICUs. The implementation strategies represented 20 Implementation Methods, which were further categorized into seven Implementation Dimensions, as outlined on Table 7. Of the 77 items on the survey, 71 measured Implementation Strategies. The respondents were asked to score a Likert type scale "1 to 5" that reflected the intensity of using each of the 71 Implementation Strategies. A score of "1" indicated the lowest use and a score of "5" indicated the highest use of the Implementation Strategy. The survey tool is included in Appendix C.

For the purposes of analysis and discussion, the ranges of scores for use of the Implementation Strategy were defined as follows:

1.0-1.7.... very low use
1.8-2.5… low use
2.6-3.4… average use
3.5-4.2… high use
4.3-5.0… very high use

Sixty out of 71 (85%) of the Implementation Strategies were scored by all 57 units. There were 13 Implementation Strategies with missing data. Out of the 13 Implementation Strategies with missing data, eight were missing one score, three were missing two scores, and two were missing three scores. The 13 Implementation Strategies with missing scores were noted across different units. No single unit failed to score greater than one Implementation Strategy.

The frequency distributions for each Implementation Strategy was normal and without outlier values as defined by greater than two standard deviations above/below the mean. The ranges of scores were 1.21-4.75. The frequency distributions for the 71 Implementation Strategies are noted on table 8. Two (3%) of the Implementation Strategies were scored as very

low use, ten (14%) were scored as low use, 17 (24%) were scored as average use, 27 (38%) were scored as high use, and 15 (21%) were scored as very high use.

The two Implementation Strategies in the very low use category (score 1-1.7) both represented the use of incentives. The lowest score was for Implementation Strategy 31, "*Leaders were offered incentives (money, salary, gift) to participate in the CLABSI initiative"* (*M*=1.21, *SD=.78*). The second lowest score was for Implementation Strategy number 29, "*Direct care staff were offered incentives (money, salary, gift) to participate in the CLABSI initiative" (M*=1.39, *SD=1.05*). As noted, there were 15 Implementation Strategies in the very high use category (score 4.3-5). Within the very high use category, there were two Implementation Strategies with scores greater than 4.5. The highest score was for Implementation Strategy 1, "*Staff received didactic/lecture/on-line education about CLABSI since joining the collaborative"* (*M*=4.75, *SD*=.54). The second highest score was for Implementation Strategy 16, *"Every element of the NACHRI recommended insertion audits were completed"* (*M*=4.58, *SD*=.78).

Overall, Implementation Strategies were scored in the high to very high use category far more frequently (59%) than the low to very low use categories (17%).

There were two additional items collected on the survey that did not measure Implementation Strategies, and did not represent specific Implementation Methods or Implementation Dimensions. They included item 72, "*Were there any additional Implementation Methods used on your units that were not mentioned above?"* and item 73*, "If yes, please describe (optional)."* Seventeen (30%) units answered yes to item 72. Sixteen (94%) units who answered yes wrote in a response. Eight of those 16 units included greater than one response. The responses were categorized within the following Implementation Methods:

Training (K), Performance Feedback (L), Cost Benefit Analysis (K), Implementation Tools (K), Technical Assistance (L), Local Consensus (L), Internal Stakeholder Analysis (L), Organization Communication (K), Marketing (L), or Reminders (L).

In some cases, it was difficult to categorize the response within a single Implementation Method, because insufficient information was provided. For example, one unit noted the used of computer screen savers. The content used on the screen savers was not provided, so it was difficult to categorize this method as Marketing (L), Organizational Communication (K), Performance Feedback (L), Reminders (L), or a combination of Implementation Methods.

A second "write-in" response that was difficult to categorize, was the use of monthly meetings. The contents of the monthly meeting was not provided, so it was difficult to categorize this Implementation Method as Performance Feedback (L), Local Consensus (L), Internal Stakeholder Analysis (L), Organizational Communication (K), or a combination of Implementation Methods.

There was a single "write-in" response, which could not be categorized into any of the Implementation Methods, which was the use of root cause analysis for the review of CLABSIs. Two units indicated they used root cause analysis. The Joint Commission (2011) defined root cause analysis as a process to determine the fundamental reason(s) for the failure or inefficiency of one or more processes. There is a general assumption that the majority of failures have multiple root causes. If one is able to determine the root causes of the failure, they are able to apply interventions to change performance and prevent an undesirable outcome in the future. Within the context of this study, many consider a CLABSI a failure in processes. Though the use of root cause analysis is not a required element of the NACHRI PICU CLABSI collaborative, many units use this approach when a CLABSI occurs. Typically, they utilize a multidisciplinary

team to evaluate how the central line was inserted, maintained, and utilized over time. Additionally, they consider patient variables that may have contributed to the CLABSI. Based on the survey responses, two units identified this as an Implementation Method. The use of root cause analysis may represent a previously unidentified Implementation Method. However, the use of root cause analysis may be more appropriately categorized within effectiveness or sustainability of a practice change, which was not the focus of this study.

In summary, all but one response was categorized across all seven Implementation Dimensions. Ten of the 20 Implementation Methods were represented as noted on table 9. It appears that all Implementation Methods used by PICUS as part of the NACHRI PICU CLABSI collaborative have been correctly identified as part of this study, with the possible exception of root cause analysis.

Research Question Two: Which Implementation Methods are most commonly used across a national sample of PICUs?

As described in Chapter Two, the Implementation Methods were identified from the literature, and the KTF, and are defined on Table 3. Each Implementation Method was represented by a cluster of Implementation Strategies on the survey tool. As noted above, there were 71 Implementation Strategies included on the survey, which represented the 20 Implementation Methods as identified on Table 7. The Implementation Method score was calculated by averaging the scores from those Implementation Strategies representing each individual Implementation Method.

Implementation Strategies 30 and 32 were removed prior to calculating the Implementation Method scores, because of the high number of N/A responses. Both of these Implementation Strategies were follow-up items related to the use of incentives identified in

Implementation Strategies 29 and 31. Specifically, the follow-up Implementation Strategy 30, "*if incentives were used for direct care staff, indicate the monetary one-year value given to each individual,"* was scored as N/A 47 times, not scored two times(missing data), so there were only eight scores available for that Implementation Strategy. The follow-up Implementation Strategy 32, "*If incentives were used for leaders, indicate the monetary <u>one year value</u> given to <u>each individual</u>*," was scored as N/A 50 times, not scored three times(missing data), so there were only four scores available for that Implementation Strategy.

For the purposes of analysis and discussion, the ranges of scores for use of the Implementation Methods were defined as follows:

1.0-1.7.... very low use
1.8-2.5… low use
2.6-3.4… average use
3.5-4.2… high use
4.3-5.0… very high use

The frequency distributions for each Implementation Method was normal and without outlier values as defined by greater than two standard deviations above/below the mean. The ranges of scores for the 20 Implementation Methods were between 1.78-4.40. The frequency distributions are included on table 10. There were no Implementation Methods in the very low use category (score 1-1.7). There was one Implementation Method in the low use category (score 1.8-2.5), which was Incentives (L). There were four Implementation Methods in the medium use category (score 2.6-3.4) which included Social Networks (L), Training (K), Marketing (L), and Performance Feedback (L). There were twelve Implementation Methods in the high use category (score 3.5-4.2) which included, Reminders (L), Organization Communication (K), Cost Benefit Analysis (K), Cultural Assessments (K), Opinion Leaders (L), Internal Stakeholder Analysis (L), Change Champions(K), Implementation Tools (K),

Monitoring and Measurement Tools (K), Technical Assistance (L), Boundary Spanners (L), and Policy Change (K). There were three Implementation Methods in the very high use category (4.3-5), which included Help Lines Users Groups (L), Local Consensus (L), and Standards and Guidelines (K).

Overall, Implementation Methods were scored in the high to very high use category far more frequently (75%) than the low to very low use categories (2%).

Research Question Three: What are the frequency distributions for the three outcomes of central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rate across a national sample of PICUs?

Outcome variable data were obtained from pre-existing data available through the NACHRI CLABSI PICU collaborative. CLABSI rate was available for 49 of 57 (86%) units, central line insertion maintenance bundle compliance was available for 52 of 57 (91%) units, and central line maintenance bundle compliance was available for 54 of 57 (95%) units. Outcome variable missing data was due to failure of the individual unit to report their data to NACHRI. Missing data were excluded from analysis.

The frequency distribution for each outcome was normal and without outlier values as defined by greater than two standard deviations above/below the mean. The Frequency distributions for each of the three outcomes is included on Table 11. The mean central line insertion bundle compliance was .84 (*SD*=0.13), with a range between 0-1.0. The mean central line maintenance bundle compliance was .59 (*SD*=0.24), with a range between 0-1.0. The mean rate of CLABSI was 2.06 (*SD*=1.69), with a range between 0-6.76.

Phase Two of Analysis: Internal Consistency of the Survey Tool

Research Question Four: Is there empirical support for clustering specific

Implementation Methods according to the conceptually proposed Implementation Dimension taxonomy?

Phase two of analysis focused on the survey tool. The survey tool was developed for the purpose of this study, so its reliability had not been previously established. To begin to establish reliability for the survey tool, the degree of internal consistency among Implementation Dimensions, as represented by Implementation Strategies was determined. Determining the internal consistency is a method to identify the presence of a single scale or subscales. The presence of a scale or subscales suggests the tool is reliable, representing the concept as intended. The presence of a scale is often determined for an entire survey tool, when that tool is intended to measure a single concept, like depression. However, internal consistency and the presence of a scale can also be determined for greater than one concept within a single survey tool, identified as subscales. The survey tool was not intended to measure a single concept, but seven distinct concepts of Implementation Dimensions. Therefore, the internal consistency was determined for each individual Implementation Dimension.

In order to determine the presence of subscales for the Implementation Dimensions, Cronbach's alpha coefficient was computed for each grouping of Implementation Strategies, representing the seven Implementation Dimensions. An alpha coefficient $\geq .7$ is considered acceptable for preliminary research (Peterson, 1994), and was used as the target threshold for this study.

Five of the seven Implementation Dimensions subscales had Cronbach's alpha coefficient $\geq .7$. These included the Implementation Dimensions of Education and Training with 11 Implementation Strategies ($\alpha = .86$), Local Participation, with nine Implementation Strategies ($\alpha = .82$), Communication and Marketing with 14 Implementation Strategies ($\alpha = .81$), Cost

Benefit Analysis with nine Implementation Strategies (α= .75), and Resources and Tools with 11 Implementation Strategies (α=.70).

Two Implementation Dimensions had Cronbach's alpha coefficient <.7, which included Audit and Performance Feedback and Culture. The Audit and Performance Feedback Implementation Dimension included eight Implementation Strategies (α=.62). To improve the Cronbach's alpha coefficient for this Dimension, SPSS scale reliability analysis was used to evaluate the impact of the deletion of Implementation Strategies on the Cronbach's alpha coefficient. Initial analysis determined the deletion of Implementation Strategy 12) "*The NACHRI recommended maintenance audits were completed a minimum of weekly,"* would increase the Cronbach's alpha coefficient to α=.64. This Implementation Strategy was deleted, then iterative; by Implementation Strategy, analysis was completed to improve the Cronbach's alpha coefficient.

Based on the analysis, additional Implementation Strategies were deleted, one at a time. The following Implementation Strategies were sequentially deleted: 13) "*Every element of the NACHRI recommended maintenance audits were completed*," 14) "*NACHRI recommended maintenance audits were done by direct observation),"* 15) "*NACHRI recommended insertion audits were completed for every central line was placed," 16) "Every element of the NACHRI recommended insertion audits were completed."* The deletion of these five Implementation Strategies resulted in acceptable reliability for the Audit and Performance Feedback Dimension resulting in three Implementation Strategies (α=.73). This Implementation Dimension was re-named Audit Performance Feedback-revised.

The deletion of these five Implementation Strategies represented every Implementation Strategy within the Implementation Method of Monitoring and Measurement Tools. Since all

five Implementation Strategies from this Implementation Method were deleted, Cronbach's alpha coefficient was computed to determine if that Implementation Method could represent a previously unidentified Implementation Dimension. The Cronbach's alpha coefficient was below the threshold of .7 (α=.55). In an attempt to improve the Cronbach's alpha coefficient, SPSS scale reliability analysis was used to evaluate the impact of the deletion of Implementation Strategies on the Cronbach's alpha coefficient. There were no Implementation Strategies identified for deletion, which could improve the Cronbach's alpha coefficient. The deletion of any single Implementation Strategy decreased the Cronbach's alpha coefficient further, so the Implementation Method of Monitoring and Measurement Tools was not added as a new Implementation Dimension.

The second Implementation Dimension with a Cronbach's alpha coefficient of < .7 was Culture with five Implementation Strategies (α=.66). In an attempt to improve the Cronbach's alpha coefficient for this Dimension, SPSS scale reliability analysis was used to evaluation the impact of the deletion of Implementation Strategies on the Cronbach's alpha coefficient. There were no Implementation Strategies identified for deletion, which improved the Cronbach's alpha coefficient. The deletion of any single Implementation Strategy further decreased the Cronbach's alpha coefficient.

Phase Three of Analysis: Descriptions and Relationships Between Implementation Dimensions and Outcomes

Since there was adequate internal constancy for six of the seven Implementation Dimensions, phase three of analysis was conducted. Phase three of the analysis included completing descriptive statistics for the Implementation Dimensions. Additionally, the relationships between Implementation Dimensions and the three outcomes were explored by

computing correlations and multiple regressions. Each Implementation Dimension was represented by conceptual groupings of the Implementation Methods, as identified on Table 4. The Implementation Methods and Implementation Dimensions were represented by Implementation Strategies, collected on the survey. The alignment of Implementation Strategies to Implementation Methods and Implementation Dimensions are indicated on Table 7. The Implementation Dimension scores were calculated by averaging the scores from those Implementation Strategies, representing each individual Implementation Dimension. As described above under Research Question Two, Implementation Strategies 30 and 32 were removed prior to calculating the Implementation Dimension scores, because of the high number of N/A responses.

There were six Implementation Dimension scores used for analysis. Five of the original Implementation Dimension scores were retained for analysis, which included Education and Training, Cost Benefit Analysis, Resources and Tools, Local Participation, and Communication and Marketing. A sixth revised Implementation Dimension was included, which was Audit and Performance Feedback-revised. The seventh Implementation Dimension, Culture was excluded from analysis, since the internal consistency was insufficient.

For the purposes of analysis and discussion, the ranges of scores for use of the Implementation Dimensions were defined as follows:

1.0-1.7.... very low use
1.8-2.5… low use
2.6-3.4… average use
3.5-4.2… high use
4.3-5.0… very high use

Research Question Five: Which Implementation Dimensions are most commonly used? across a national sample of PICUs?

The range of scores was between 2.93-4.14. The frequency distributions for the Implementation Dimensions are included on table 12. There were no Implementation Dimensions within the very low (score 1-1.7) or low use (score 1.8-2.5) categories. There were three Implementation Dimensions in the medium use (score 2.6-3.4), category which included, Cost Benefit Analysis, Education and Training, and Communication and Marketing. The remaining three Implementation Dimensions were all in the high use (score 3.5-4.2) category and included Audit and Performance Feedback-revised, Local Participation, *and* Resources and Tools. There were no Implementation Dimensions in the very high use (4.3-5) category. Overall, all six Implementation Dimensions were in the medium or high use categories.

Research Question Six: Are any of the Implementation Dimensions significantly correlated with central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate?

Correlations were calculated for each relationship. The probability level for significance was set at p=<.05 level. There were no significant correlations between any of the Implementation Dimensions and central line insertion bundle compliance. One Implementation Dimension correlated with central line maintenance bundle compliance. This was the use of Local Participation, which had a statistically significant negative correlation r (55) = -.27, p <.05. Higher use of Local Participation correlated with lower central line maintenance bundle compliance. There were no significant positive correlations between any of the Implementation Dimensions and CLABSI rate.

Overall, there were no statistically significant positive correlations between any of the Implementation Dimensions and any of the three outcomes.

Research Question Seven: Do any of the Implementation Dimensions predict central line insertion bundle compliance, central line maintenance bundle compliance, or CLABSI rate? Standard multiple regression analysis was completed separately for each of the three outcomes. The probability level for significance was set at p=<.05 level. There were no significant positive predictive relationships identified between any of the six Implementation Dimensions and any of the three outcomes. See table 13 for report of regression coefficients.

To further explore for positive predictive relationships, multiple regressions were completed evaluating the relation of the six Implementation Dimensions with each of the three outcomes while controlling for unit size and unit type. Though unit size was a statistically significant co-variant for CLABSI, it did not affect the relationship between any of the six Implementation Dimensions and CLABSI; these remained non-significant. See tables 14, 15, 16 for report of regression coefficients for each of the three outcomes.

Overall, there were no statistically significant predictive relationships between any of the Implementation Dimensions and any of the three outcomes, even when controlling for unit size and unity type.

Chapter Five: Discussion and Conclusions

As noted in the findings section, there were three phases of analysis. Phase one focused on simple descriptive statistics, including the unit's use of Implementation Methods. Phase two focused on exploration of the survey tool for internal consistency. Phase three focused on correlations and predictive relationships between Implementation Dimensions and outcomes.

Implementation Methods

All 20 Implementation Methods that were identified as part of this study had some use by all 57 PICUS participating in the NACHRI PICU CLABSI collaborative. In general, units reported either high or very high use for the majority of the Implementation Methods. As noted in the findings, there was only one Implementation Method that had low or very low use, which was Incentives (L). Only eight units used Incentives (L) for direct care staff and only six units used them for leadership. Though Incentives (L) are well documented in the literature as an important Implementation Method for motivating staff to adhere to standards of care, most of the literature focuses on community physicians, rather than hospital based nursing and physician staff. Perhaps incentives should be explored by hospitals as an Implementation Method.

The 20 Implementation Methods explored in this study were based on either the Knowledge Transfer Framework (KTF) or the literature. Nearly all (eight of nine) of the KTF Implementation Methods had high or very high use. One Implementation Method identified on the KTF did not have high or very high use, which was training; it had medium use. It is unclear why training did not have higher use, but it may be related to how it was represented on the survey. Specifically, most Implementation Strategies representing training referred to use in the "last year." Units may have had strong use of some of the Implementation Strategies in the previous years. However, it is possible that the elements of training were performed through

other Implementation Methods, such as those identified within the Implementation Dimensions of Resources and Tools. Specifically, perhaps Implementation Methods such as Technical Assistance (L) or Help Line User Groups (L) were used as a vehicle for training.

Seven of the eleven literature based Implementation Methods had high or very high use. Three had medium use and only one had low or very low use. The Implementation Method with low use was Incentives (L), which was discussed above. PICUs used Implementation Methods identified on the KTF more frequently than that those identified in the literature.

Seventeen survey respondents identified additional Implementation Methods used by their units through "write-in" responses on the survey. Each "write-in" response was carefully considered to determine if it represented a newly identified Implementation Method that had not been represented in this study. All but possibly one "write-in" response was categorized into one of the 20 previously identified Implementation Methods, as noted on Table 9. As described in the findings section, the one response that was not categorized within an existing Implementation Method was the use of root cause analysis. It is unclear if the use of root cause analysis is an Implementation Method or a concept that is better categorized within sustaining practice changes, which was not the focus of this study. Either way, perhaps units that engage in root cause analysis, represent units with a unique culture that focuses on understanding reasons for failures as a means to continuous improvement.

It is unclear why survey respondents wrote in Implementation Methods, which were already represented by the survey. One explanation may include failure of the Implementation Strategy on the survey to capture the particular Implementation Method. It is also possible that the survey respondent intended to emphasize certain Implementation Methods that they felt were the most important or effective for their units.

It appears that the 20 Implementation Methods identified for this study correctly accounted for nearly all Implementation Methods used by PICUS participating in the NACHRI PICU CLABSI collaborative. Since the 57 PICUS represented approximately 20% of all PICUs in the United States, it is reasonable to conclude that most Implementation Methods used by PICUs are included in those 20 identified within this study. However, further survey analysis based on samples that are more heterogeneous would be valuable.

Survey Tool

The survey tool was developed for the purpose of this study and had no prior use. Though its face and content validity had been established for the intended participants, its reliability had not been established. Though there was no intent to use the survey tool outside of this study, its internal consistency was explored to determine if clustering the Implementation Methods, as represented by Implementation Strategies, into seven Implementation Dimensions, was inherently logical. As noted in the findings section, an acceptable level of internal consistency was observed for six of the seven Implementation Dimensions. Culture was the only Implementation Dimension with inadequate internal consistency level. Culture is a complex concept; it is possible that there were insufficient Implementation Strategies included within that Implementation Dimension to adequately measure Culture. Culture is more thoroughly explored below.

Considering this is the first survey of its kind, observing internal consistency among six of the seven Implementation Dimensions is significant and suggests the survey tool could be further developed for future use.

Relationship Between Implementation Dimensions and Outcomes

As noted in the analysis section, there were no statistically significant positive correlations or predictive relationships between any of the Implementation Dimensions and any of the three outcomes, even when controlling for unit type and unit size. The lack of significant findings may be related to the survey tool properties that need further development as previously discussed. There may be other reasons that explain the lack of significant findings. These may include variables related to sample characteristics, environmental factors, or patients that were not measured as part of this study.

Sample characteristics. The sample was represented by 57 PICUs all working within the same quality improvement collaborative. Most of the Implementation Methods (15 of 20) had high or very high use. It is possible that this group of PICUs represented a more engaged and motivated group who used Implementation Methods more broadly or intensely than the general population of PICUs. Perhaps if a more heterogeneous sample of PICUs were studied, there would be more variation in the use of Implementation Methods.

Environmental factors. Environmental factors may have an important influence on the successful implementation of practice changes in the clinical setting. Environmental factors were recognized as an element on the conceptual research map as illustrated on figure 3. However, environmental factors were not included as part of this study. Environmental factors may include those related to the unit and or staff.

Unit factors that may be important include characteristics of the unit, such as culture, level of innovation, physical environment, and/or staffing. First, the unit culture was only partially explored through the Implementation Dimension of Culture. As noted above, Culture was the only Implementation Dimension with inadequate internal consistency. The

Implementation Strategies on the survey simply identified if units measured their safety culture or attempted to improve it. There was no attempt to measure the unit's general culture or safety culture within the scope of this study. It is probable that staff that practice in a safer culture may be more willing and able to adhere to unit standards, because of their emphasis on safety. It seems reasonable that units with a safer culture may have higher compliance with central line bundles.

Second, the level of innovation the unit experiences may also be an important characteristic. Unit innovation may be associated with Magnet designation status (ANCC, 2012), academic status, or tertiary/quaternary status. It is probable that staff that practice on a more innovative unit are more willing to try new things, such as implementation and adherence to practice changes such as implementation of central line bundles.

Third, the physical environment and availability of resources are also likely to be important characteristics. For example, a physical environment with sufficient handwashing sinks and adequate storage for central line care supplies should facilitate staff's ability to adhere to central line care bundles.

Finally, staffing is probably an important characteristic. Aspects of staffing such as leadership to staff ratio, hours of care per patient day, skill mix, turnover, and use of temporary staff, may be important. It is probable that staff that practices in units with adequate staffing, have more time available to practice according to unit standards, such as compliance with central line bundles.

It is unclear how unit characteristics may affect outcomes. It is probable that staff that practice in a safe culture, with an innovative environment, adequate resources, and optimal

staffing are better able to practice according to unit standards, such as compliance with central line bundles.

Staff factors may also have an important impact on outcomes. Staff may be categorized as either leadership or direct care. Leadership factors that may be important include longevity, experience level, education level, certification status, management style, and reporting structure. Highly effective leaders are able to influence staff adherence to unit standards, such as compliance with central line bundles. Direct care staff factors that may be important include experience level, education level, and certification status. Highly skilled staff are probably more capable of practicing according to unit standards, such as compliance with central line bundles.

Additionally, there may be some important physician staff factors that affect the outcome of CLABSI rate. Physicians may affect CLABSI rate by their individual practice patterns. For example, there may be variation between physicians related to blood culture practices, prophylactic use of antibiotics, and central line utilization. Some physicians may be more effective at preventing CLABSI by minimizing the use of central lines, and removing them earlier.

Patients. Patient characteristics that vary between units may have an impact on the CLABSI rate, but not necessarily compliance with central line bundles. Patient variables such as age, diagnosis, acuity, immune status, and length of stay, may have an impact on CLABSI. Some units hold tertiary status, caring for the most ill and complex patients from a large geographical areas; whereas others may be more community based, caring for lower risk patients. It seems likely that those units who care for a more complex and high-risk population may experience a higher CLABSI rate, due to the vulnerability of the patients. However, tertiary

centers may have more resources and experience than less complex community units and may be more effective at reducing CLABSI.

Overall, numerous complex environmental, staff, and patient variables probably have a significant impact on both the ability to comply with central line bundles and the overall CLABSI rate. Those variables were not included in this study and require further exploration.

Study Limitations

The major study limitations are related to the previously unused survey tool, homogenous sample of PICUs studied, and lack of exploration of environmental and patient issues. The survey tool was developed explicitly for this study, so its reliability had not been established. The survey tool requires further development and application across a more diverse group of units and perhaps other collaboratives to establish its validity and reliability for a broader sample.

The sample of PICUs included a highly motivated group, working together in a collaborative to make improvements in care. It is possible that this group had higher use of Implementation Methods, than a random sample of PICUs not participating in the collaborative. Perhaps the sample of PICUs was too similar to each other, not offering enough variability to demonstrate real differences in the use of various Implementation Methods and their impact on outcomes. Additionally, since the sample size only included those PICUS participating in a national collaborative, it may be difficult to generalize findings beyond this population.

As indicated above, environmental and patient variables were not explored as part of this study. They are likely very important variables to consider when implementing evidence-based practice changes.

Conclusions and Implications for Nursing Practice

There are many examples within healthcare of failures to implement evidence-based practices into clinical settings. Examples include practices around hand hygiene, pressure ulcer prevention, required times for NPO status before surgery, and the use of medical restraints (van Achterberg, Schoonhoven et al. 2008). Examples of such failures were published in an article in Critical Care Nurse, titled, "*Seven Evidence-Based Practice Habits: Putting Some Sacred Cows Out to Pasture.*" Estabrooks and colleagues present clear evidence for seven critical care practices that are not followed in many ICUs (Estabrooks, Derksen et al. 2008). Implementing practice changes in clinical settings require further understanding through scientific inquiry (Hysong, Best et al. 2006; Bhattacharyya, Reeves et al. 2009). Clearly, there needs to be a better understanding of which Implementation Methods are most effective in clinical settings within hospitals.

The results of this study add to the literature by identifying Implementation Methods used in PICUs across the US. The results of this study are foundational to better understand which Implementation Methods are used to make evidence-based practice changes in the clinical setting. Understanding which Implementation Methods are used will facilitate future experimental studies designed to evaluate and compare the effectiveness of various Implementation Methods. Additionally this study identified six Implementation Dimensions, which have not been previously reported in the literature.

There also may be Implementation Methods or Implementation Dimensions identified that were unknown to some readers that could be used in clinical practice. Specifically, as units plan for practice changes, they can consider their use the 20 Implementation Methods across the seven Implementation Dimensions.

Additionally, though the survey was developed explicitly for the use of this study, it could be further developed for future use. Currently, the survey includes some terminology that is only pertinent to the NACHRI PICU CLABSI collaborative, but it could be modified for use in other collaboratives or made more generic for use in other implementation projects

Implementation Science is an evolving field of science. More research is needed to identify and understand the most effective and efficient way to implement evidence-based practice changes in the clinical setting to ensure our patients receive the most evidence-based care available.

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Table 1

Main Elements and Sub-parts of DOI Theory

Main Element from DOI Theory	Sub-parts of Main Element from the DOI Theory		
The Innovation			
	5 characteristics		
		1. Relative Advantage	
		2. Compatibility	
		3. Complexity	
		4. Trialability	
		5. Observability	
Communication Channels			
	no subparts		
Time			
	3 Aspects		
	1. Innovation-Decision Process		
		5 Steps	
			a. Knowledge
			b. Persuasion
			c. Decision
			d. Implementation
			e. Confirmation
	2. Innovativeness of the adopter categories. Early versus late adopters		
		5 Categories	
			a. Innovators
			b. Early adopters
			c. Early majority
			d. Late majority
			e. Laggards
	3. Rate of adoption		
Social System			
	no subparts		

Table 2

Health Care Operational Models of Implementation

Model	General Components or Steps	Limitations related to this research study
ARCC-Advancing Research and Clinical Practice Through Collaboration (Melnyk & Fineout-Overholt, 2010)	Determine current versus ideal state of EBP ARCC strategies target EBP mentors and champions EBP knowledge and skills EBP valuing	Not an implementation model. Focused on EBP mentors and advancing EBP within academic hospitals
Dissemination and Use of Research Evidence for Policy and Practice (Dobbins, 2010)	Knowledge-Identification of evidence Persuasion-Consider individual, organization, and environment Decision-Decide to adopt Implementation-Dissemination of information about innovation. Includes nine implementation strategies Confirmation-Measure process and outcomes	Focused on dissemination at the national level, not the unit level
Iowa Model of EBP (Titler, 2010)	Model for appraising evidence and focusing on evidence-based practice approaches Trigger (identified problem or new knowledge) Determine if practice question is a priority Form a team Collect literature and evidence Critique and synthesize evidence Pilot Determine if change appropriate Institute the change	No focus on Implementation Methods
Joanna Briggs Institute Model of EBP (Pearson, 2010)	Evidence generation Evidence synthesis Evidence knowledge transfer (consider systems, information, education) Evidence utilization	Focused on importance of knowledge transfer/ implementation. Limited focus on Implementation Methods

Knowledge to Action Framework (Graham & Tetroe, 2010)	Identify the problem Identify the knowledge to implement Adapt knowledge to local context Asses the determinants of knowledge use Select interventions Monitor knowledge use Evaluate outcomes Ensure sustained use of knowledge	Limited focus on Implementation Methods
Ottawa Model of Research Use (Logan & Graham, 2010)	Assess barriers and supports Monitor process and degree of use Interventions (barrier management) Adoption Evaluate Impact Outcomes of patient, practitioner, system	Focused on identification of barriers and context up front and planning strategies specifically for that environment. Limited focus on Implementation Methods
PARIHS-Promoting Action on Research Implementation in Health Services (Rycroft-Malone, 2010)	Successful implementation based on function, nature, and type of evidence. Discusses ways that evidence application is facilitated. A number of important concepts are included in the model such as, using a holistic approach, partnerships, enabling others, using critical reflection, giving meaning. Focused on involving participants in appraising and packaging evidence up front.	Comprehensive, but complex to understand and describe
Stetler Model (Stetler, 2010)	Preparation-find evidence Validate evidence Compare and consider feasibility Translate/Application & prepare for use in practice Evaluate effectiveness	Focused on evaluating and packaging evidence. Limited focus on Implementation Methods
The Knowledge Transfer Framework for the Agency of Health Care Research and Quality (Nieva, et al., 2005)	Knowledge creation and distillation Diffusion and dissemination Adoption, implementation, and institutionalization	**Selected for this research study, because of focus on Implementation Methods.**

Note. EBP=Evidence-Based Practice

Table 3

Definitions of Implementation Methods

Implementation Method	Definition
KTF Based Implementation Methods	
Training	Training is defined as "narrowly focused program that leads to high proficiency in a specific skill (Zare, 1998)." Education is defined as a more broad approach than training and, "encourages general approaches to problem solving and inculcates ways of thinking that are productive, effective, and rewarding (Zare, 1998)."
Monitoring and Measurement Tool	Monitoring is defined as an objective way to verify adherence to an expected standard of care. Measurement tool is defined as standardized instruments to facilitate monitoring of an expected standard of care. An audit tool is one such example. Audit and Feedback is defined as "any summary of clinical performance of health care over a specified period of time(Grimshaw, Eccles et al. 2006)."
Cultural Assessment	Culture is defined as "values, attitudes, norms, practices, and general attitudes of personnel. It may also be defined as, the way we do things around here (Pronovost & Sexton, 2005)." Safety Culture is defined as "a group of individuals guided in their behavior by their joint belief in the importance of safety…with a shared understanding that every member willingly upholds the group's safety norms and will support other member to that common end (Helmreich & Merritt as cited in Ashcroft, Morecroft, Parker, & Noyce, 2005)." Cultural Assessment is defined as a method to measure culture.
Cost Benefit Analyses	Cost Benefit Analysis is defined as the ratio of net health care costs to net health benefits, which provide an index for which priorities may be set (Weinsten, 1977).
Implementation Tool	Implementation tool is defined as an item to help achieve a task. The national guideline clearing house includes these items: • Documentation tool/Checklist/Forms • Clinical Algorithm-Diagrams include step-by-step decision-tree • Pocket Guide/Reference card • Tool Kit-Collections of tools and/or strategies for implementing clinical practice guidelines • Wall Poster-At-a-glance summary of guideline recommendations (National Guideline Clearing House, 2011)

Technical Assistance	Technical Assistance is defined as providing advice, assistance, or training to support the performance of a new skill or activity. It is often provided at the point of care, customized to the individual in need of assistance.
Help Line User Group	Help Line User Group is defined as telephone or on-line methods of support, which is individualized, real time, and available to those who need it.
Standard and Guideline	Guideline is defined as a "synthesis of best available evidence that support decision making by clinicians, managers, and policy makers about the organization and delivery of health care (Gagliardi, et al., 2011)." Standard is defined as treatment and/or procedures that a clinician should follow for a certain type of patient, illness, or clinical circumstance. A standard is often thought of as more "prescriptive" or regulatory than a guideline.
Policy Change	Policy is defined as a principle or rule indicating the way to behave or perform care; typically in a written, formal document.
Internal Stakeholder Analyses	Internal Stakeholder Analysis is defined as "an approach, a tool or set of tools for generating knowledge about actors-individuals and organizations-so as to understand their behavior, intentions, interrelations and interests; and for assessing the influence and resources they bring to bear on decision-making or implementation processes (Varvasovsky & Brugha, 2000)."
Organizational Communication	Organizational Communication is defined as "sending and receiving messages that create and maintain a system of consciously coordinated activities or forces of two or more persons (Allen, Tompkins, Busemer, 1996, p. 384)."
Literature Based Implementation Methods	
Performance Feedback	Audit and Feedback is defined as "any summary of clinical performance of health care over a specified period of time (Grimshaw, Eccles et al. 2006)."
Incentive	Incentive is defined as bonuses, cash, or other in-kind financial incentives for providers and consumers to engage in specific preventive care or health promotion practices (AHRQ, 2011).
Change Champion	Change Champion is also known as a change agent. It is defined as an individual who attempts to influence clients' innovation-decisions in a direction that is deemed desirable by a change agency core and essential elements to consider and leverage within social systems. A change agent is able to influence innovation decisions (Rogers, 2003).
Opinion Leader	Opinion Leader is defined as the degree to which an individual is able to influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency. An Opinion Leader is able to influence other individual's attitudes and behaviors (Rogers, 2003).
Boundary Spanner	Boundary Spanner is defined as "those who engage in significant transactions without group members. Rather than any individual within a group, they work independently to facilitate intergroup transactions and manage intergroup conflicts (Richter, 2006)"
Local Consensus	Local consensus is defined as, "Participants publicly express their views, the aggregate of which may be summarized by the group's leader and considered the final decision (National Guideline clearinghouse, 2011)."

Marketing	Marketing is defined as, “the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational objectives (Kotler, as cited in (Luck, Hagigi et al. 2009).”
Social Network	Social Network is defined as, a social structure with regular patterns of relationships with actors (individuals) as nodes in the network, and relationships between actors (individuals) as connectors between the nodes. The relationships may be based on friendship, common interest, or belief (Haythornthwaite, 2002).
Reminder	Reminder is defined as “patient or encounter-specific information, provided verbally, on paper, on a computer screen that is designed or intended to prompt a health professional to recall information (Grimshaw, Eccles et al. 2006) .”

Table 4

Implementation Dimensions with Corresponding Implementation Methods

Seven Implementation Dimensions	Twenty Implementation Methods
1. Education and Training	Training (K)
2.Audit and Performance Feedback	Monitoring and Measurement Tools (K) Performance Feedback (L)
3. Culture	Cultural Assessments (K)
4.Cost Benefit Analysis	Cost Benefit Analysis (K) Incentives (L)
5. Resources and Tools	Implementation Tools (K) Technical Assistance (L) Help Lines Users Groups (L) Standards and Guidelines (K) Policy Change (K)
6. Local Participation	Change Champions(K) Opinion Leaders (L) Boundary Spanners (L) Local Consensus (L) Internal Stakeholder Analysis (L)
7. Communication and Marketing	Organization Communication (K) Marketing (L) Social Networks (L) Reminders (L)

Note. (K) = Implementation Method is from the KTF. (L) = Implementation Method is based on the literature.

Table 5

Diffusion of Innovations Theory Elements and Relationship to Implementation Dimensions

Main Element from DOI Theory	Sub-parts of Main Element from The DOI Theory		Implementation Dimension (ID)
The Innovation			
	5 characteristics		
	1. Relative Advantage		Education and Training (ID 1) Cost Benefit Analysis (ID 4)
	2. Compatibility		Local Participation (ID 6)
	3. Complexity		Resources and Tools (ID 5)
	4. Trialability		Education and Training (ID 1) Resources and Tools (ID 5)
	5. Observability		Audit and Performance Feedback (ID 2)
Communication Channels			Communication and Marketing (ID 7)
	no subparts		
Time			
	3 Aspects		
	1. Innovation-Decision Process		
		5 Steps	
		a. Knowledge	Education and Training (ID 1) Communication and Marketing (ID 7)
		b. Persuasion	Education and Training (ID 1) Cost Benefit Analysis (ID 4) Local Participation (ID 6) Communication and Marketing (ID 7)
		c. Decision	Does not drive an Implementation Dimension. (is an outcome)
		d. Implementation	Does not drive an Implementation Dimension. (is an outcome)
		e. Confirmation	Audit and Performance Feedback (ID 2)

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	2. Innovativeness of adopter categories. Early versus late adopters		
		5 Categories	
		a. Innovators	Does not drive an Implementation Dimension. Members of this group may bring forth innovations.
		b. Early adopters	Does not drive an Implementation Dimension. Members of this group typically provide opinion leaders and change agents
		c. Early majority	Local participation (ID 6)
		d. Late majority	Cost benefit analysis (ID 4) Local Participation (ID 6)
		e. Laggards	Does not drive an Implementation Dimension.
	3. Rate of adoption		Does not drive an Implementation Dimension.
Social System			Culture (ID 3) Local Participation (ID 6) Communication and Marketing (ID 7)
	no subparts		

Note. ID refers to the number of the Implementation Dimension that is represented (1-7).

The four main elements of the DOI Theory including, The Innovation, Communication Channels, Time, and Social System are represented with their subparts. The table indicates which aspect of the DOI Theory (main elements with subparts) drives each of the seven Implementation Dimensions. As indicated on the table, some Implementation Dimensions are driven by greater than one DOI theoretical concepts.

Table 6

Key Features of Collaborative Activities Demonstrated Within the NACHRI PICU CLABSI Collaborative.

Key Features of Collaboratives as delineated above (Schouten, et al., 2008).	Key Features as demonstrated within NACHRI PICU CLABSI Collaborative
There is a specific topic or area of clinical practice that has wide variation between units or, gaps exist between best and actual practice.	CLABSI prevention strategies varied across PICUs. Additionally, evidence based practices that did exist, were not consistently followed across all PICUs.
Both clinical and quality improvement experts collaborate and work together to provide ideas for improvement.	PICU nurses, PICU physicians, infection prevention physicians, and quality improvement experts from across the country provide leadership and work together to set the goals and direction for the collaborative.
There are multidisciplinary teams from multiple units that are willing to work together to share ideas and improve.	Multidisciplinary teams of PICU nurses, PICU physicians, infection preventionists, and others work together at the unit level to improve their practices and share with other units.
The improvement efforts include data collection, testing changes, and setting measureable targets.	Data are collected for central line insertion bundle and central line maintenance bundle compliance on weekly bases. Changes are tested at the collaborative level such as the use of various disinfective products. Multiple changes are tested at the unit level, including the use of checklists, product kits, and carts. Targets for central line insertion bundle compliance, central line maintenance bundle compliance, and CLABSI rates have been established.
The collaborative process involves a series of structured activities, such as meetings, active email, etc.	Structured activities include at least two face-to-face national meetings per year, where all leadership and participants gathered for learning. There are formal WebEx presentations four to six times per year, where both leaders and participants present improvement work. There is an active list serve email, to facilitate interactions between participants. In addition, a website hosts materials from all learning sessions, as well as tools and template to facilitate improvement at the unit level.

Table 7

Alignment of Items (Implementation Strategies) With Implementation Dimension, Implementation Method, and DOI Theory Concepts

Implementation Dimension ONE

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Education and Training	Training	The Innovation • Relative advantage (education) • Trialability (training) Time • Knowledge (education) • Persuasion (education)
Item (Implementation Strategy) on Survey		DOI Theory Concept
1. **Staff** received didactic/lecture/on-line education about CLABSI since joining the collaborative		Knowledge Relative advantage Persuasion *Education**
2. **Staff** received didactic/lecture/on-line education about CLABSI within the last year		Knowledge Relative advantage Persuasion *Education**
3. If **staff** received didactic/lecture/on-line education about CLABSI within the last year, indicate the number of times		Knowledge Relative advantage Persuasion *Education**
4. **Nursing** Staff participated in interactive hands-on training related to central line maintenance in the last year.		Trialability
5. **Nursing** Staff performed return demonstration of alcohol scrub in the last year		Trialability
6. **Nursing** Staff performed return demonstration of the cap change procedure in the last year		Trialability
7. **Nursing** staff performed return demonstration of dressing change procedure in the last year		Trialability
8. **Physician** and other staff who place central lines participated in interactive hands-on training about central line insertion in the last year		Trialability
9. **Physician** and other staff who place central lines performed return demonstration of patient draping procedure in the last year		Trialability
10. **Physician** and other staff who place central lines performed return demonstration of full sterile barriers in the last year		Trialability
11. **Physician** and other staff who place central lines performed return demonstration of central line insertion procedure in the last year.		Trialability

Implementation Dimension TWO

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Audit and Performance Feedback	Monitoring and Measurement Tools	The Innovation • Observability Time • Confirmation
Item (Implementation Strategy)		DOI Theory Concept
12. The NACHRI recommended maintenance audits were completed a minimum of weekly		Observability Confirmation
13. Every element of the NACHRI recommended maintenance audits were completed		Observability Confirmation
14. NACHRI recommended maintenance audits were done by direct observation (for example, observation of the dressing change, line change, line entry, etc.)		Confirmation Confirmation
15. NACHRI recommended insertion audits were completed for every central line was placed		Observability Confirmation
16. Every element of the NACHRI recommended insertion audits were completed		Confirmation Confirmation

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Audit and Performance Feedback	Performance Feedback	The Innovation • Observability Time • Confirmation
Item (Implementation Strategy)		DOI Theory Concept
17. Audit results were discussed with direct care staff		Observability Confirmation
18. Audit results were tailored for specific individuals/groups		Observability Confirmation
19. The NACHRI CLABSI reports were tailored (e.g. annotated or edited) to fit our unit		Observability Confirmation

Implementation Dimension THREE

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Culture	Cultural Assessments	Social System
Item (Implementation Strategy)		DOI Theory Concept
20. A safety culture survey was conducted in the last 5 years		Social System
21. Direct care ICU staff received safety culture survey results in the last year		Social System
22. ICU leadership received safety culture survey results in the last year		Social System
23. An action plan was made to improve at least one aspect of the ICU safety culture within the last year		Social System
24. Improvements were made in ICU safety culture in the last year		Social System

Implementation Dimension FOUR

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Cost Benefit Analysis	Cost Benefit Analysis	The Innovation • Relative Advantage Time • Persuasion • Innovativeness of adopter categories (Innovativeness)
Item (Implementation Strategy)		DOI Theory Concept
25. It was easy to obtain approval for the cost of joining the NACHRI CLABSI collaborative		Relative Advantage Persuasion
26. When evaluating supplies to support adherence to the central line bundles, we considered the cost of supplies compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc)		Relative Advantage Persuasion
27. When planning our education and/or training, we considered the cost of education and/or training compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc)		Relative Advantage Persuasion
28. Staff was educated on the cost of a CLABSI (Indicate the percent of staff)		Relative Advantage Persuasion Innovativeness

Implementation Dimension FOUR (Continued)

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Cost Benefit Analysis	Incentives	Time • Persuasion
Item (Implementation Strategy)		DOI Theory Concept
29. Direct care staff were offered incentives(money, salary, gift) to participate in the CLABSI initiative		Persuasion
30. If incentives were used for direct care staff, indicate the monetary one year value given to each individual		Persuasion
31. Leaders were offered incentives (money, salary, gift) to participate in the CLABSI initiative.		Persuasion
32. If incentives were used for leaders, indicate the monetary one year value given to each individual		Persuasion
33. Units were offered incentives such as food, parties, or celebrations to participate in the CLABSI initiative		Persuasion

Implementation Dimension FIVE

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Resources and Tools	Implementation Tools	The Innovation • Complexity
Item (Implementation Strategy)		DOI Theory Concept
34. Checklists were created to facilitate the implementation of the elements of the CLABSI initiative		Complexity
35. Tools such as reference cards, posters, visual cues, and/or other job aids were created to facilitate the implementation of the CLABSI initiative		Complexity
36. Toolkits(electronic or hard copy) were created for staff to access information related to the CLABSI initiative		Complexity
37. Carts and/or kits were created to facilitate CLABSI insertion bundle adherence		Complexity
38. Carts and/or kits were created to facilitate CLABSI maintenance bundle adherence		Complexity
39. Changes were made to our clinical on-line computer order entry system to facilitate compliance with the CLABSI initiative		Complexity
40. Changes were made to our clinical on-line computer documentation system to facilitate compliance with the CLABSI initiative		Complexity

Implementation Dimension FIVE (Continued)

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Resources and Tools	Technical Assistance	The Innovation • Trialability
Item (Implementation Strategy)		DOI Theory Concept
41. Staff had in-person access (within 30 minutes) to a nurse skilled in central line maintenance to instruct and/or assist them whenever needed (Indicate percent of the time resource was available)		Trialability

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Resources and Tools	Help Line User Groups	The Innovation • Trialability
Item (Implementation Strategy)		DOI Theory Concept
42. Staff had phone or email access (within 30 minutes) to a nurse knowledgeable in performing central line maintenance to answer questions (Indicate percent of time the resource was available)		Trialability

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Resources and Tools	Standard and Guidelines	The Innovation • Complexity
Item (Implementation Strategy)		DOI Theory Concept
43. The standard of care in the ICU matches the NACHRI CLABSI bundles		Complexity

Implementation Dimension	Implementation Method	Comparative analysis of DOI Theory concepts and Implementation Methods
Resources and Tools	Policy Change	The Innovation • Complexity
Item (Implementation Strategy)		DOI Theory Concept
44. All written policies pertaining to central line care in the ICU reflect the NACHRI CLABSI bundles		Complexity

Implementation Dimension SIX

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Local Participation	Change Champions	Time • Persuasion Social System
Item (Implementation Strategy)		DOI Theory Concept
45. Select staff was recruited to act as change champions/coaches to work with their peer group to facilitate compliance with the CLABSI initiative		Persuasion Social System
46. If change champions/coaches were used, what percent of shifts were covered?		Persuasion

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Local Participation	Opinion Leaders	Time • Persuasion Social System
Item (Implementation Strategy)		DOI Theory Concept
47. Opinion leaders, who were direct care staff, were actively recruited to promote the CLABSI initiative		Persuasion Social System

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Local Participation	Boundary Spanners	Time • Persuasion Social System
Item (Implementation Strategy)		DOI Theory Concept
48. Individuals that could collaborate effectively across multiple disciplines, such as groups of physicians, nurses, administrators, supply, and/or finance, were included in the CLABSI initiative		Persuasion Social System

Implementation Dimension SIX (Continued)

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Local Participation	Local Consensus	Innovation • Compatibility Time • Persuasion • Innovativeness of adopter categories (Innovativeness) Social System
Item (Implementation Strategy)		DOI Theory Concept
49. When we first joined the collaborative, groups of staff met to discuss the CLABSI initiative		Compatibility Persuasion Innovativeness Social System
50. Groups of staff meet regularly to discuss the CLABSI initiative		Compatibility Persuasion Innovativeness Social System
51. Decisions about how to roll out the CLABSI initiative bundles were made by consensus		Compatibility Persuasion Social System

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Local Participation	Internal Stakeholder Analysis	Innovation • Compatibility Time • Persuasion Social System
Item (Implementation Strategy)		DOI Theory Concept
52. We met with key stakeholders before the CLABSI initiative bundles were rolled out		Compatibility Persuasion Social System
53. Elements of our CLABSI initiative bundle roll-out were changed based on key stakeholder feedback		Compatibility Persuasion Social System

Implementation Dimension SEVEN

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Communication and Marketing	Organization Communications	Communication Channels Time • Knowledge • Persuasion
Item (Implementation Strategy)		DOI Theory Concept
54. The communication about the CLABSI initiative was very visible		Communication
55. The communication about the CLABSI initiative was much more visible than the communication about other initiatives		Communication Knowledge Persuasion
56. The communication about the CLABSI initiative was different or unique compared to the communication about other quality or safety initiatives		Communication Knowledge Persuasion
57. The communication about the CLABSI initiative was customized and individualized to a variety of different audiences		Communication Knowledge Persuasion

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Communication and Marketing	Marketing	Communication Channels Time • Persuasion Social Systems
Item (Implementation Strategy)		DOI Theory Concept
58. Our marketing department promoted the CLABSI initiative		Communication Persuasion
59. A "brand" or logo was created to make the CLABSI initiative recognizable		Communication Persuasion Social Systems
60. Patient specific stories were included when communicating about the CLABSI initiative		Persuasion Social Systems
61. The rationale and importance of the CLABSI initiative were included in the communication		Persuasion
62. CLABSI reduction was a hospital goal within the last 5 years (indicate the number of times)		Persuasion
63. The CLABSI initiative was marketed to physicians or other providers outside the hospital		Communication Knowledge
64. The CLABSI initiative was marketed to insurers, competitors or regulators outside the hospital		Communication Knowledge Persuasion
65. The CLABSI initiative was marketed to patients and families		Communication Knowledge Persuasion

Implementation Dimension SEVEN (Continued)

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Communication and Marketing	Social Network	Communication Channels Time • Persuasion Social Systems
Item (Implementation Strategy)		DOI Theory Concept
66. Social media strategies, such as text messages, Twitter, Face book, or blogs were used as a means to promote the CLABSI initiative		Communication Persuasion Social Systems
67. Groups, such as shared governance councils, committees, or other professional groups were engaged to promote the CLABSI initiative		Communication Persuasion Social Systems

Implementation Dimension	**Implementation Method**	**Comparative analysis of DOI Theory concepts and Implementation Methods**
Communication and Marketing	Reminders	Communication Channels Time • Knowledge Social System
Item (Implementation Strategy)		DOI Theory Concept
68. Email reminders were sent to staff about the CLABSI initiative		Communication Knowledge
69. Staff was verbally reminded in person about the CLABSI initiative		Communication knowledge
70. Staff was verbally reminded in groups about the CLABSI initiative		Communication Knowledge
71. Hardcopy reminders were sent to staff about the CLABSI initiative		Communication Knowledge

Note: Education is not differentiated from training within the KTF, though there are distinct items to represent both education and training within the survey.

The table outlines the seven Implementation Dimensions with corresponding Implementation Methods. Each Implementation Method is represented by either an individual item or set of items on the survey. Each item or set of items is intended to measure an Implementation Method. The DOI theoretical concept that aligns with the particular Implementation Method and item on the survey question is identified. The alignments were determined by performing a post-hoc comparative analysis.

Table 8

Frequency Distributions for Items (Implementation Strategies) on Survey

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
1	**Staff** received didactic/lecture/on-line education about CLABSI since joining the collaborative	57	4.75	5.00	5.00	2.00	5.00	0.54
2	**Staff** received didactic/lecture/on-line education about CLABSI within the last year	57	4.25	5.00	5.00	1.00	5.00	1.14
3	If **staff** received didactic/lecture/on-line education about CLABSI within the last year, indicate the number of times	55	1.96	2.00	1.00	1.00	5.00	1.23
4	**Nursing** Staff participated in interactive hands-on training related to central line maintenance in the last year.	57	4.16	5.00	5.00	1.00	5.00	1.22
5	**Nursing** Staff performed return demonstration of alcohol scrub in the last year	57	3.26	4.00	5.00	1.00	5.00	1.71
6	**Nursing** Staff performed return demonstration of the cap change procedure in the last year	57	3.16	4.00	5.00	1.00	5.00	1.70
7	**Nursing** staff performed return demonstration of dressing change procedure in the last year	57	3.53	4.00	5.00	1.00	5.00	1.64
8	**Physician** and other staff who place central lines participated in interactive hands-on training about central line insertion in the last year	57	2.47	2.00	2.00	1.00	5.00	1.47
9	**Physician** and other staff who place central lines performed return demonstration of patient draping procedure in the last year	57	2.25	2.00	1.00	1.00	5.00	1.41

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
10	**Physician** and other staff who place central lines performed return demonstration of full sterile barriers in the last year	57	2.33	2.00	2.00	1.00	5.00	1.43
11	**Physician** and other staff who place central lines performed return demonstration of central line insertion procedure in the last year	57	2.47	2.00	1.00	1.00	5.00	1.49
12	The NACHRI recommended maintenance audits were completed a minimum of weekly	57	4.32	5.00	5.00	1.00	5.00	1.15
13	Every element of the NACHRI recommended maintenance audits were completed	57	4.25	5.00	5.00	1.00	5.00	1.04
14	NACHRI recommended maintenance audits were done by direct observation (for example, observation of the dressing change, line change, line entry, etc.)	57	3.05	3.00	2.00	1.00	5.00	1.39
15	NACHRI recommended insertion audits were completed for every central line was placed	57	4.40	5.00	5.00	2.00	5.00	0.75
16	Every element of the NACHRI recommended insertion audits were completed	57	4.58	5.00	5.00	2.00	5.00	0.78
17	Audit results were discussed with direct care staff	57	3.19	3.00	3.00	1.00	5.00	1.09
18	Audit results were tailored for specific individuals/groups	56	3.23	4.00	4.00	1.00	5.00	1.41
19	The NACHRI CLABSI reports were tailored (e.g. annotated or edited) to fit our unit	55	3.11	4.00	4.00	1.00	5.00	1.46
20	A safety culture survey was conducted in the last 5 years	57	3.40	3.00	3.00	1.00	5.00	1.35
21	Direct care ICU staff received safety culture survey results in the last year	57	4.00	5.00	5.00	1.00	5.00	1.34
22	ICU leadership received safety culture survey results in the last year	47	4.43	5.00	5.00	1.00	5.00	1.06

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
23	An action plan was made to improve at least one aspect of the ICU safety culture within the last year	56	3.82	4.00	5.00	1.00	5.00	1.29
24	Improvements were made in ICU safety culture in the last year	57	3.86	4.00	4.00	1.00	5.00	1.01
25	It was easy to obtain approval for the cost of joining the NACHRI CLABSI collaborative	56	3.68	4.00	4.00	1.00	5.00	1.11
26	When evaluating supplies to support adherence to the central line bundles, we considered the cost of supplies compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc	57	3.67	4.00	4.00	1.00	5.00	1.14
27	When planning our education and/or training, we considered the cost of education and/or training compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc	57	3.32	4.00	4.00	1.00	5.00	1.10
28	Staff was educated on the cost of a CLABSI (Indicate the percent of staff)	57	3.91	4.00	5.00	1.00	5.00	1.29
29	Direct care staff were offered incentives(money, salary, gift) to participate in the CLABSI initiative	57	1.39	1.00	1.00	1.00	5.00	1.05
30	If incentives were used for direct care staff, indicate the monetary one year value given to each individual	8	2.00	2.00	1.00	1.00	4.00	1.07
31	Leaders were offered incentives (money, salary, gift) to participate in the CLABSI initiative.	56	1.21	1.00	1.00	1.00	5.00	0.78
32	If incentives were used for leaders, indicate the monetary one year value given to each individual	4	3.00	3.00	1.00	1.00	5.00	1.83

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
33	Units were offered incentives such as food, parties, or celebrations to participate in the CLABSI initiative	57	2.84	3.00	4.00	1.00	5.00	1.46
34	Checklists were created to facilitate the implementation of the elements of the CLABSI initiative	57	4.35	5.00	5.00	2.00	5.00	0.94
35	Tools such as reference cards, posters, visual cues, and/or other job aids were created to facilitate the implementation of the CLABSI initiative	57	4.53	5.00	5.00	1.00	5.00	0.73
36	Toolkits(electronic or hard copy) were created for staff to access information related to the CLABSI initiative	57	3.86	4.00	5.00	1.00	5.00	1.23
37	Carts and/or kits were created to facilitate CLABSI insertion bundle adherence	57	4.54	5.00	5.00	2.00	5.00	0.66
38	Carts and/or kits were created to facilitate CLABSI maintenance bundle adherence	57	4.18	4.00	5.00	1.00	5.00	1.00
39	Changes were made to our clinical on-line computer order entry system to facilitate compliance with the CLABSI initiative	44	3.05	3.00	2.00	1.00	5.00	1.46
40	Changes were made to our clinical on-line computer documentation system to facilitate compliance with the CLABSI initiative	48	3.25	4.00	4.00	1.00	5.00	1.41
41	Staff had in-person access (within 30 minutes) to a nurse skilled in central line maintenance to instruct and/or assist them whenever needed (Indicate percent of the time resource was available)	57	4.14	5.00	5.00	1.00	5.00	1.14

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
42	Staff had phone or email access (within 30 minutes) to a nurse knowledgeable in performing central line maintenance to answer questions (Indicate percent of time the resource was available)	57	4.26	5.00	5.00	1.00	5.00	1.23
43	The standard of care in the ICU matches the NACHRI CLABSI bundles	57	4.40	4.00	5.00	2.00	5.00	0.68
44	All written policies pertaining to central line care in the ICU reflect the NACHRI CLABSI bundles	57	4.25	4.00	5.00	2.00	5.00	0.91
45	Select staff was recruited to act as change champions/coaches to work with their peer group to facilitate compliance with the CLABSI initiative	57	4.42	5.00	5.00	1.00	5.00	0.75
46	If change champions/coaches were used, what percent of shifts were covered?	57	3.63	4.00	5.00	1.00	5.00	1.33
47	Opinion leaders, who were direct care staff, were actively recruited to promote the CLABSI initiative	57	3.93	4.00	4.00	2.00	5.00	0.88
48	Individuals that could collaborate effectively across multiple disciplines, such as groups of physicians, nurses, administrators, supply, and/or finance, were included in the CLABSI initiative	57	4.19	4.00	4.00	1.00	5.00	0.91
49	When we first joined the collaborative, groups of staff met to discuss the CLABSI initiative	57	4.33	5.00	5.00	1.00	5.00	0.85
50	Groups of staff meet regularly to discuss the CLABSI initiative	57	4.16	5.00	5.00	1.00	5.00	0.91
51	Decisions about how to roll out the CLABSI initiative bundles were made by consensus	57	4.28	4.00	4.00	2.00	5.00	0.75

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
52	We met with key stakeholders before the CLABSI initiative bundles were rolled out	57	4.21	4.00	5.00	1.00	5.00	0.99
53	Elements of our CLABSI initiative bundle roll-out were changed based on key stakeholder feedback	57	3.79	4.00	4.00	1.00	5.00	1.16
54	The communication about the CLABSI initiative was very visible	57	4.21	4.00	4.00	2.00	5.00	0.75
55	The communication about the CLABSI initiative was much more visible than the communication about other initiatives	57	3.88	4.00	4.00	1.00	5.00	0.91
56	The communication about the CLABSI initiative was different or unique compared to the communication about other quality or safety initiatives	57	3.81	4.00	4.00	2.00	5.00	0.97
57	The communication about the CLABSI initiative was customized and individualized to a variety of different audiences	57	3.58	4.00	4.00	2.00	5.00	0.89
58	Our marketing department promoted the CLABSI initiative	57	2.44	2.00	2.00	1.00	5.00	1.18
59	A “brand” or logo was created to make the CLABSI initiative recognizable	57	2.16	2.00	2.00	1.00	5.00	1.18
60	Patient specific stories were included when communicating about the CLABSI initiative	57	2.84	2.00	2.00	1.00	5.00	1.40
61	The rationale and importance of the CLABSI initiative were included in the communication	57	4.00	4.00	4.00	1.00	5.00	0.94
62	CLABSI reduction was a hospital goal within the last 5 years (indicate the number of times)	57	4.39	1.00	5.00	1.00	5.00	0.98
63	The CLABSI initiative was marketed to physicians or other providers outside the hospital	56	2.82	2.00	3.00	1.00	5.00	1.36

	Implementation Item	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
64	The CLABSI initiative was marketed to insurers, competitors or regulators outside the hospital	56	2.50	2.00	1.00	1.00	5.00	1.24
65	The CLABSI initiative was marketed to patients and families	57	3.42	4.00	4.00	1.00	5.00	1.19
66	Social media strategies, such as text messages, Twitter, Face book, or blogs were used as a means to promote the CLABSI initiative	57	1.75	2.00	1.00	1.00	5.00	0.89
67	Groups, such as shared governance councils, committees, or other professional groups were engaged to promote the CLABSI initiative	57	4.05	4.00	4.00	1.00	5.00	0.99
68	Email reminders were sent to staff about the CLABSI initiative	57	3.23	3.00	3.00	1.00	5.00	1.15
69	Staff was verbally reminded in person about the CLABSI initiative	57	4.33	5.00	5.00	2.00	5.00	0.81
70	Staff was verbally reminded in groups about the CLABSI initiative	57	3.82	4.00	4.00	1.00	5.00	0.97
71	Hardcopy reminders were sent to staff about the CLABSI initiative	56	2.77	3.00	1.00	1.00	5.00	1.43

Table 9

Survey Respondents Open Ended Write-in Responses

Seven Implementation Dimensions	Twenty Implementation Methods	"Write-in" Responses
1. Education and Training	Training (K)	Video to teach central line insertion On-line education BSI workshop (2) Read and sign education packets Simulation labs (2) Just in time training (2) Product/vendor training
2.Audit and Performance Feedback	Monitoring and Measurement Tools (K)	None identified
	Performance Feedback (L)	CLABSI case review/ feedback to staff (2) Daily shift brief* Screen savers** Monthly meetings**
3. Culture	Cultural Assessments (K)	None identified
4.Cost Benefit Analysis	Cost Benefit Analysis (K)	Banner with money saved/infect. prevented*
	Incentives (L)	None identified
5. Resources and Tools	Implementation Tools (K)	Central line cart Dressing change kit, cap change kit
	Technical Assistance (L)	Consulting staff
	Help Lines Users Groups (L)	None identified
	Standards and Guidelines (K)	None identified
	Policy Change (K)	None identified
6. Local Participation	Change Champions (K)	None identified
	Opinion Leaders (L)	None identified
	Boundary Spanners (L)	None identified
	Local Consensus (L)	Monthly meetings**
	Internal Stakeholder Analysis (L)	Monthly meetings**
7. Communication and Marketing	Organization Communication (K)	Screen savers** Monthly meetings**
	Marketing (L)	Screen savers** Annual song contest Posters indicating days since last infect.(2)*
	Social Networks (L)	None identified
	Reminders (L)	Screen savers** Daily shift brief*

Note. (K) = Implementation Method is from the KTF. (L) = Implementation Method is based on the literature. (2) = two units provided same response. *Implementation Strategies likely represent greater than one Implementation Method. **Unable to accurately categorize, due to insufficient information.

Table 10

Frequency Distributions for 20 Implementation Methods

	Implementation Method	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
1	Training (K)	57	3.15	3.18	3.00	1.45	5.00	0.91
2	Monitoring and Measurement Tools (K)	57	4.12	4.20	4.20	2.00	5.00	0.63
3	Performance Feedback (L)	57	3.18	3.33	3.67	1.00	5.00	1.06
4	Cultural Assessments (K)	57	3.82	4.00	4.80	1.33	5.00	0.91
5	Cost Benefit Analysis (K)	57	3.64	3.75	3.75	2.00	5.00	0.76
6	Incentives (L)	57	1.78	1.67	1.00	1.00	4.50	0.76
7	Implementation Tools (K)	57	4.03	4.00	5.00	2.43	5.00	0.60
8	Technical Assistance (L)	57	4.14	5.00	5.00	2.00	5.00	1.14
9	Help Lines Users Groups (L)	57	4.26	5.00	5.00	1.00	5.00	1.23
10	Standards and Guidelines (K)	57	4.40	4.00	5.00	2.00	5.00	0.68
11	Policy Change (K)	57	4.25	4.00	5.00	2.00	5.00	0.91
12	Change Champions(K)	57	4.03	4.00	5.00	1.50	5.00	0.94
13	Opinion Leaders (L)	57	3.93	4.00	4.00	2.00	5.00	0.88
14	Boundary Spanners (L)	57	4.19	4.00	4.00	1.00	5.00	0.91
15	Local Consensus (L)	57	4.29	4.33	5.00	2.00	5.00	0.67
16	Internal Stakeholder Analysis (L)	57	3.93	4.00	4.00	1.00	5.00	1.09
17	Organization Communication (K)	57	3.58	3.60	3.60	1.80	5.00	0.68
18	Marketing (L)	57	3.16	3.14	2.86	1.57	5.00	0.73
19	Social Networks (L)	57	2.90	3.00	3.00	1.00	5.00	0.70
20	Reminders (L)	57	3.55	3.50	4.00	1.75	5.00	0.78

Note. N= sample size. M= Mean. Mdn= Median. Mi= Minimum lowest score. Max= Maximum highest score. s.d. = standard deviation.

Table 11

Frequency Distribution for Outcomes

	N	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
CLABSI Rate	49	2.06	1.63	0.00	0.00	6.76	1.69
Central Line Insertion Compliance	52	0.84	0.86	1.00	0.43	1.00	0.13
Central Line Maintenance Compliance	54	0.59	0.62	0.48	0.00	0.99	0.24

Note. *N*= sample size. *M*= Mean. *Mdn*= Median. *min*= Minimum lowest score. *max*= Maximum highest score. *s.d.* = standard deviation.

Table 12

Frequency Distributions for Six Implementation Dimensions

	Implementation Dimension	*N*	*M*	*Mdn*	*mode*	*min*	*max*	*s.d.*
1	Education and Training	57	3.15	3.18	3.00	1.45	5.00	0.91
2	Audit and Performance Feedback	57	3.81	3.91	4.02	2.22	5.00	0.59
4	Cost Benefit Analysis	57	2.93	2.88	3.41	1.63	4.50	0.63
5	Resources and Tools	57	4.14	4.18	5.00	2.95	5.00	0.54
6	Local Participation	57	4.11	4.08	4.85	2.50	5.00	0.61
7	Communication and Marketing	57	3.32	3.25	2.06	2.06	4.67	0.54

Note. N= sample size. *M*= Mean. *Mdn*= Median. *min*= Minimum lowest score.
max= Maximum highest score. *s.d*. = standard deviation.
Dimension 3: Culture was omitted from analysis due to inadequate internal consistency.

Table 13

Multiple Regression Coefficients for Six Implementation Dimensions and Three Outcomes

Outcomes	Insertion	Maintenance	CLABSI
Dimension 1	0.009	0.025	0.245
Dimension 2 revised	-0.016	0.031	0.15
Dimension 4	-0.032	0.069	-0.017
Dimension 5	0.066	0.024	-0.242
Dimension 6	-0.032	-0.133	0.168
Dimension 7	-0.024	-0.121	-0.953

Notes: Regression coefficients are unstandardized. * $p<.05$. Insertion: Central line insertion bundle compliance.

Maintenance: Central line maintenance bundle compliance.

CLABSI: Central line associated blood stream infection.

Dimension 1: Education and Training, Dimension 2-revised: Audit and Performance Feedback, Dimension 4: Cost Benefit Analysis, Dimension 5: Resources and Tools, Dimension 6: Local Participation, Dimension 7: Communication and Marketing.

Dimension 3: Culture was omitted from analysis due to inadequate internal consistency.

Table 14

Multiple Regression Coefficients for Six Implementation Dimensions and Outcome of Central Line Insertion Compliance, Controlling for Unit Size and Unit Type

Insertion Compliance Dimension Number	1	2- revised	4	5	6	7
Dimension	0.002	-0.012	-0.027	0.037	-0.012	-0.016
Unit Size	0.002	0.002	0.001	0.002	0.001	0.002
Unit Type	0.036	0.042	0.045	0.018	0.041	0.045

Notes: Regression coefficients are unstandardized. * $p<.05$. Insertion compliance: Central line insertion bundle compliance.
Dimension 1: Education and Training, Dimension 2-revised: Audit and Performance Feedback, Dimension 4: Cost Benefit Analysis, Dimension 5: Resources and Tools, Dimension 6: Local Participation, Dimension 7: Communication and Marketing.
Dimension 3: Culture was omitted from analysis due to inadequate internal consistency.

Table 15

Multiple Regression Coefficients for Six Implementation Dimensions and Outcome of Maintenance Compliance, Controlling for Unit Size and Unit Type

Maintenance Compliance Dimension Number	1	2- revised	4	5	6	7
Dimension	0.001	0.028	0.054	-0.01	-0.088	-0.09
Unit Size	0.004	0.004	0.005	0.004	0.003	0.005
Unit Type	0.017	0.004	0.005	0.022	0.03	0.058

Notes: Regression coefficients are unstandardized. * $p<.05$. Maintenance compliance: Central line maintenance bundle compliance.
Dimension 1: Education and Training, Dimension 2-revised: Audit and Performance Feedback,
Dimension 4: Cost Benefit Analysis, Dimension 5: Resources and Tools,
Dimension 6: Local Participation, Dimension 7: Communication and Marketing.
Dimension 3: Culture was omitted from analysis due to inadequate internal consistency.

Table 16

Multiple Regression Coefficients for Six Implementation Dimensions and Outcome of CLABSI Rate, Controlling for Unit Size and Unit Type

CLABSI rate						
Dimension Number	1	2- revised	4	5	6	7
Dimension	0.231	0.115	-0.204	-0.255	-0.071	-0.157
Unit Size	-0.085*	-0.079*	-0.082*	-0.081*	-0.079*	-0.076*
Unit Type	-0.684	0.591	-0.48	-0.461	-0.524	-0.458

Notes: Regression coefficients are unstandardized. * $p<.05$. CLABSI: Central line associated blood stream infection rate.
Dimension 1: Education and training, Dimension 2-revised: Audit and Performance Feedback,
Dimension 4: Cost Benefit Analysis, Dimension 5: Resources and Tools,
Dimension 6: Local Participation, Dimension 7: Communication and Marketing.
Dimension 3: Culture was omitted from analysis due to inadequate internal consistency.

Figure 1. Rogers Diffusion of Innovation Stages of Innovation-Decision Process

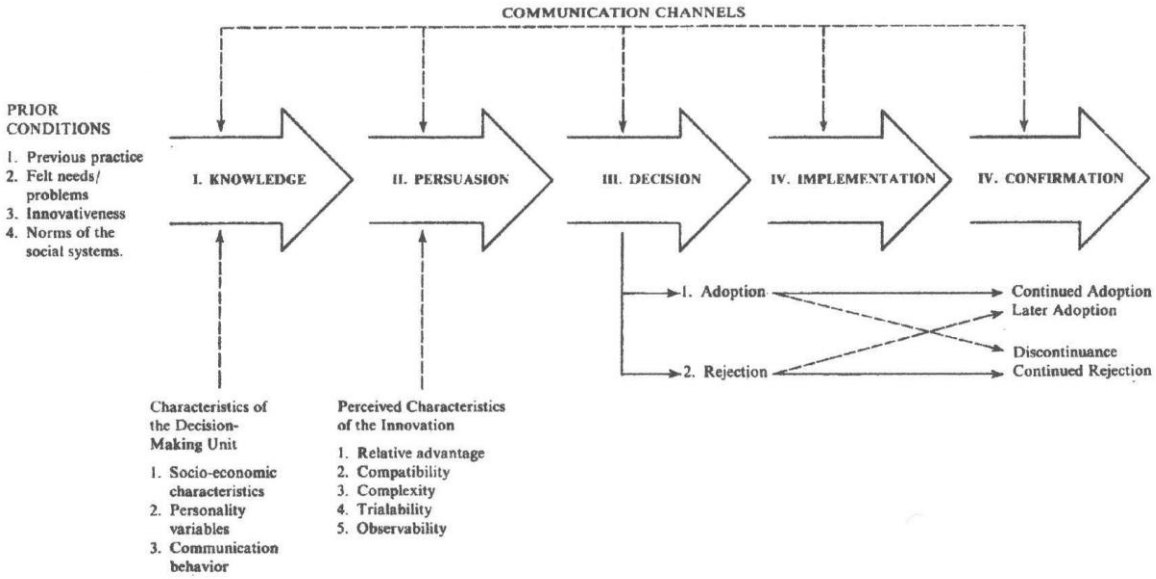

Figure 1. Rogers, E. M. (2003). *Diffusion of innovations* 5th ed.. p. 170. New York: Free Press.

Figure 2. The Knowledge Transfer Framework for the Agency of Health Care Research and Quality (KTF)

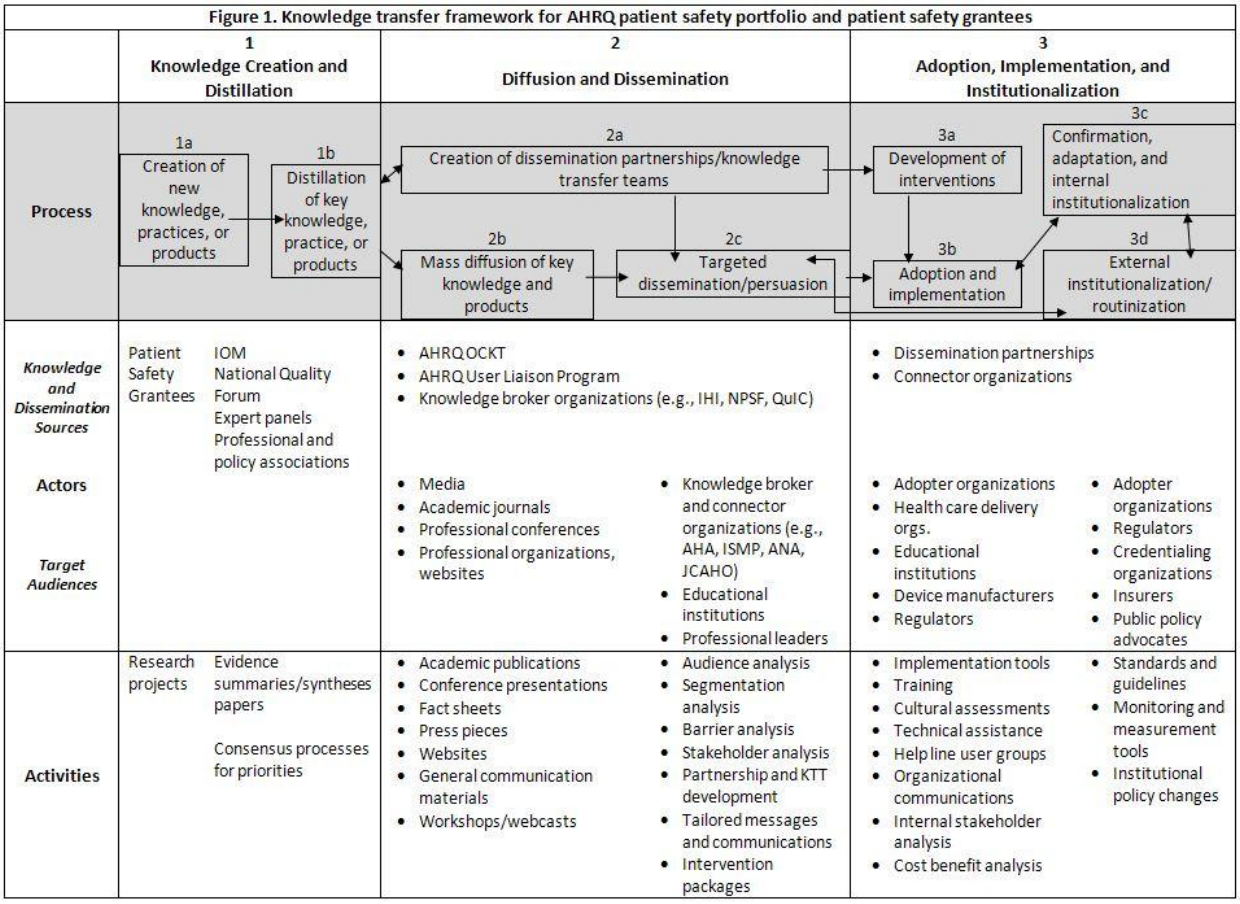

Figure 2. Recreated from Nieva, V., Murphy, R., Ridley, N., Donaldson, N., Combs, J., Mitchell, P…Carpenter, D. (2005). From science to service: A framework for the transfer of patient safety reserach into practice. *Advances in Patient Safety: From Research to Implementation*, 2, 441-453.

Figure 3. Conceptual Research Map for the Research Study.

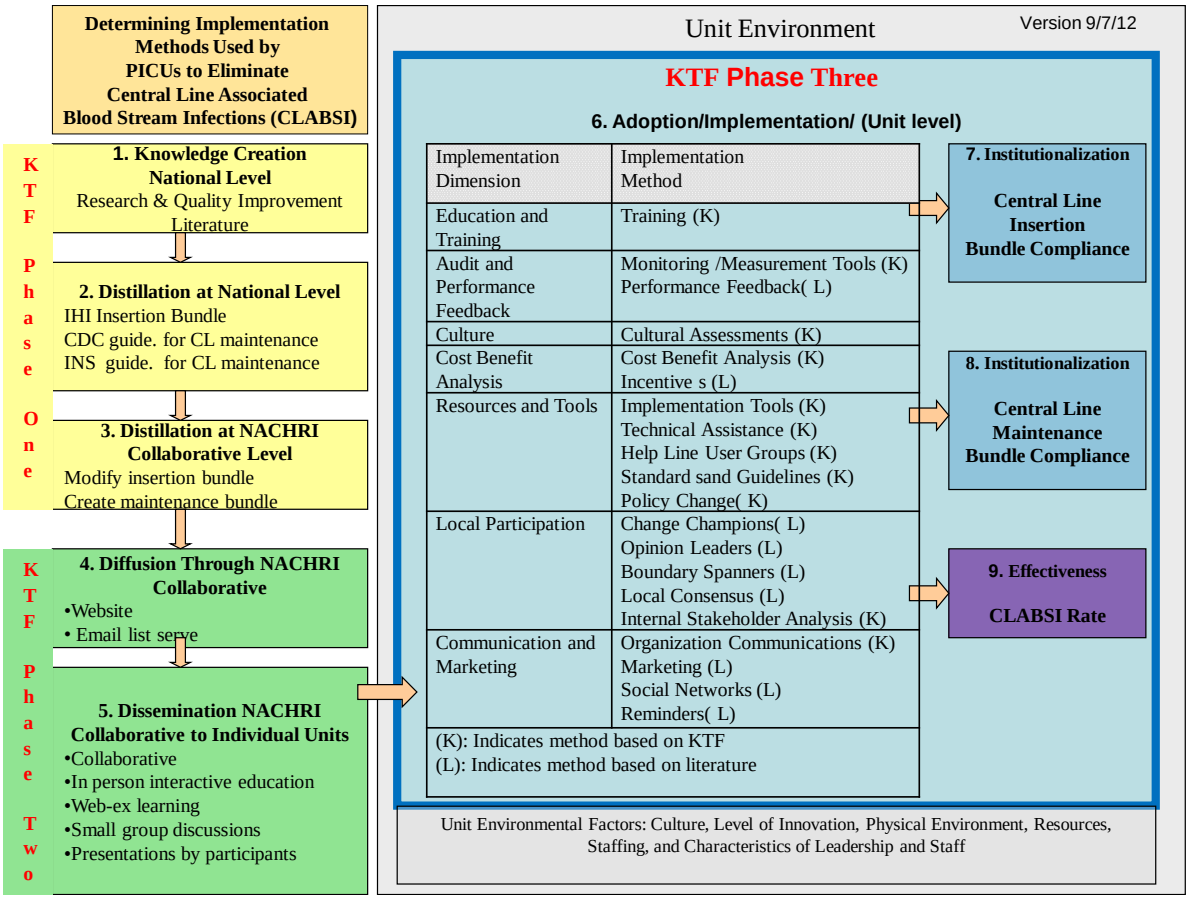

Figure 3. The research map indicates the alignment with the three major phases from the KTF with this research study. The focus of this study is within KTF Phase three.

Appendix A

Knowledge Transfer Framework (KTF): Phases of Translation

The KTF encompasses three sequential phases, which include 1) knowledge creation and distillation, 2) diffusion and dissemination, and 3) adoption, implementation, and institutionalization. Each phase is described below.

Phase One: Knowledge Creation and Distillation

The first part of phase one, knowledge creation is defined as the creation of new knowledge. New knowledge may evolve from a variety of sources of evidence including academic research, practice based research, government agencies, and other national organizations.

Evidence may be generated from a single randomized controlled trial, but more commonly, information is extracted from many research studies and other sources. New knowledge that is produced is rarely ready for direct application into the clinical setting. New knowledge often requires a distillation process to make it accessible to clinicians, which occurs within the second part of phase one.

The second part of phase one, distillation is defined as taking knowledge that has been generated and then inventoried, evaluated, and synthesized, for dissemination. The process includes summarizing the knowledge into concise easy to use evidence summaries, such as clinical practice guideline or bundles. Rather than individuals, units, or hospitals reviewing individual research studies and performing a local distillation processes, it is performed more centrally then shared broadly.

Knowledge is distilled in a manner to make it easy for end users to access and utilize. Knowledge distillation facilitates adoption, emphasizing findings that are both important and actionable.

Phase Two: Diffusion and Dissemination

Within phase two, both diffusion and dissemination steps are typically performed in parallel. Diffusion is defined as broadcasting information with the objective of sharing knowledge and creating awareness. Diffusion is typically done as passive one-way communication. The most typical approaches include sharing information at professional meetings, and through journal publications. Other one-way communication may include posting information on web sites, email, fact sheets, and newsletters. The diffusion process can be thought of as a passive process, of "getting the word out." Diffusion alone is typically unsuccessful in creating practice changes in clinical settings.

Dissemination includes interactive two-way communication and is generally more effective than diffusion alone. Dissemination is defined as linking knowledge sources (researchers and knowledge distillers) with potential intermediaries, such as knowledge brokers or connectors to the clinical practice level. Knowledge brokers are typically large national organizations that can amplify the awareness of important new knowledge for membership organizations, serving specific groups. They are able to customize and target messaging to specific groups such as regional hospital organizations, professional organizations, and quality improvement collaboratives.

Examples of knowledge brokers include the Institute for Healthcare Improvement (IHI, 2011), Agency Healthcare Research and Quality (AHRQ, 2011), educational institutions, and the media. Dissemination links are important in developing networks to facilitate the transfer of

knowledge into clinical practice, because they provide a respected "seal of approval," that is relevant to the clinician being targeted. They are also able to use individualized strategies within pre-established communication channels and partnerships to bring relevant knowledge to the clinical practice setting.

Phase Three: Adoption, Implementation, and Institutionalization

The first and early part of phase three, adoption, is typically integrated within the development and creation of Implementation Methods. Adoption is defined as the process where the end user must consider the new knowledge within the operational practice settings, considering the knowledge itself, the organization, structures and values, environment, and clinicians. This requires a deep understanding of how changes are made within that particular setting. Often, multidisciplinary practice teams are formed to consider the new knowledge and may modify elements of the new knowledge/innovation, to ensure they are compatible within their setting. The innovation is often "re-invented," making the unit or institution own it in a new way, which is often more accepted by clinicians. During this early phase, unit based teams also consider which Implementation Methods will be used to implement the particular knowledge/innovation.

The second part of phase three, implementation is defined by the NIH (2011) as "the use of strategies to adopt and integrate evidence-based health interventions and change practice patterns within specific settings." It is recognized that implementing change is complex and multiple strategies are typically required. There are 11 Implementation Methods identified on the KTF that should be considered for practice changes. The Implementation Methods include Training, Monitoring and Measurement Tools, Cultural Assessments, Cost Benefit Analyses, Implementation Tools, Technical Assistance, Help Line User Groups, Standards and Guidelines,

Policy Change, Internal Stakeholder Analysis and Organizational Communications. This portion of phase three, implementation was the focus of this research study.

The third part of phase three; institutionalization is defined as when the change is no longer new knowledge or an innovation, but is the standard of care. The change has been made and fully integrated within the practice setting. Even after the change seems to be fully integrated, it must be managed and confirmed, because it can be lost if not well supported. For example, changes in staff, care processes, and leadership can all lead to erosion of the change. Plans should be in place to confirm the change has been sustained, prospectively, moving forward.

Appendix B

Content Validity Index Template

CONTENT VALIDITY INDEX

(Implementation Methods Survey 8/3/11)

Reviewer Name:		
Construct	**Representativeness (or congruence, relevance)**	**General readability/clarity**
Implementation Research: Research into the delivery of effective, efficient, sustainable evidence based care, appropriate to the individual unit of care (i.e. ICU versus clinic, etc) **Implementation Method**: Interventions and practices conducted at the unit level as a means to rollout evidence based practice guideline or bundles of care.	1 = the item is not representative of an Implementation Method 2 = the item needs major revisions to be representative of an Implementation Method 3 = the item needs minor revisions to be representative of an Implementation Method 4 = the item is representative of an Implementation Method	1=the item is not understandable 2=the item is unclear, ambiguous includes inappropriate lingo, or is poorly worded 3=the item needs minor revision to make it understandable 4=the item is clear as written
Education and Training		
1. Staff received didactic/lecture/on-line education about CLABSI since joining the collaborative (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
2. Staff received didactic/lecture/on-line education about CLABSI within the <u>last year</u> (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
3. If staff received didactic/lecture/on-line education about CLABSI within the <u>last year</u>. (Indicate the number of times)	1 2 3 4 Comments	1 2 3 4 Comments
4. Nursing Staff participated in interactive hands-on training about central line	1 2 3 4 Comments	1 2 3 4 Comments

maintenance in the last year (Indicate the percent of staff)		
5. Nursing Staff performed return demonstration of alcohol scrub in the last year. (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
6. Nursing Staff performed return demonstration of the cap change procedure in the last year (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
7. Nursing staff performed return demonstration of dressing change procedure in the last year (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
8. Physician and other staff who place central lines participated in interactive hands-on training about central line insertion in the last year (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
9. Physician and other staff who place central lines performed return demonstration of patient draping procedure in the last year (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
10. Physician and other staff who place central lines performed return demonstration of full sterile barriers in the last year (Indicate the percent)	1 2 3 4 Comments	1 2 3 4 Comments
11. Physician and other staff who place central lines performed return demonstration of central line insertion procedure in the last year (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments

Audit and Feedback		
12.. Every element of the NACHRI recommended audit was completed most of the time	1 2 3 4 Comments	1 2 3 4 Comments
13. The NACHRI audits were completed a minimum of weekly most of the time	1 2 3 4 Comments	1 2 3 4 Comments
14. When performing weekly(or routine) audits, all the central lines in the ICU were evaluated that day	1 2 3 4 Comments	1 2 3 4 Comments
15. The number of audits conducted exceeded what NACHRI recommended	1 2 3 4 Comments	1 2 3 4 Comments
16. Direct observation audits were conducted	1 2 3 4 Comments	1 2 3 4 Comments
17. Audit results were shared with direct care staff	1 2 3 4 Comments	1 2 3 4 Comments
18. Audit results were individualized for specific individuals/groups	1 2 3 4 Comments	1 2 3 4 Comments
19. The NACHRI CLABSI reports were individualized to fit our unit	1 2 3 4 Comments	1 2 3 4 Comments
Culture		
20. A safety culture survey was conducted in the last 5 years (indicate number of times)	1 2 3 4 Comments	1 2 3 4 Comments
21. Direct care ICU staff received safety culture survey results in the last year (Indicate percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
22. ICU leadership received safety culture survey results in the last year (indicate percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
23. An action plan was made	1 2 3 4	1 2 3 4

to improve at least one aspect of the ICU safety culture within the last year.	Comments	Comments
24. Improvements were made in ICU safety culture in the last year	1 2 3 4 Comments	1 2 3 4 Comments
Cost Benefit Analysis		
25. It was easy to obtain approval for the cost of joining the NACHRI CLABSI collaborative	1 2 3 4 Comments	1 2 3 4 Comments
26. The cost of new or additional supplies was compared to the cost of a CLABSI when working on the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
27. The cost of education and/or training was compared to the cost of a CLABSI when working on the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
28. Staff was educated on the cost of a CLABSI (Indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
29. Direct care staff were offered incentives(money, salary, gift) to participate in the CLABSI initiative (indicate the percent of staff)	1 2 3 4 Comments	1 2 3 4 Comments
30. If incentives were used for direct care staff, indicate the monetary one year value paid to each individual	1 2 3 4 Comments	1 2 3 4 Comments
31. Leaders were offered incentives (money, salary, gift) to participate in the CLABSI initiative (Indicate the percent of leaders)	1 2 3 4 Comments	1 2 3 4 Comments
32. If incentives were used	1 2 3 4	1 2 3 4

for leaders, indicate the monetary one year value paid to each individual	Comments	Comments
33. Units were offered incentives such as food, parties, or celebrations to participate in the CLABSI initiative.	1 2 3 4 Comments	1 2 3 4 Comments
Resources and Tools		
34. Checklists were created to facilitate the implementation of the elements of the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
35. Tools such as reference cards, posters, visual cues, and/or other job aids were created to facilitate the implementation of the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
36. Toolkits(electronic or hard copy) were created for staff to access information related to the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
37. Carts and/or kits were created to facilitate CLABSI insertion bundle adherence	1 2 3 4 Comments	1 2 3 4 Comments
38. Carts and/or kits were created to facilitate CLABSI maintenance bundle adherence	1 2 3 4 Comments	1 2 3 4 Comments
39. Changes were made to our clinical on-line computer order entry system to facilitate compliance with the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
40. Changes were made to our clinical on-line computer documentation system to facilitate compliance with the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments

41. Staff had in-person access (within 30 minutes) to a nurse skilled in central line maintenance to instruct and/or assist them whenever needed (Indicate percent of the time resource was available)	1 2 3 4 Comments	1 2 3 4 Comments
42. Staff had phone or email access (within 30 minutes) to a nurse knowledgeable in performing central line maintenance to answer questions (Indicate percent of time the resource was available)	1 2 3 4 Comments	1 2 3 4 Comments
43. The standard of care in the ICU matches the NACHRI CLABSI bundles	1 2 3 4 Comments	1 2 3 4 Comments
44. All written policies pertaining to central line care in the ICU reflect the NACHRI CLABSI bundles	1 2 3 4 Comments	1 2 3 4 Comments
Local Participation		
45. Select staff was recruited to act as change champions/coaches to work with their peer group to facilitate compliance with the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
46. If change champions/coaches were used, what percent of shifts were covered?	1 2 3 4 Comments	1 2 3 4 Comments
47. Informal opinion leaders, who were direct care staff, were actively recruited to promote the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
48. Individuals that could collaborate effectively across multiple disciplines, such as groups of physicians, nurses, administrators, supply, and/or	1 2 3 4 Comments	1 2 3 4 Comments

finance, were included in the CLABSI initiative		
49. When we first joined the collaborative, groups of staff met to discuss the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
50. Groups of staff meet on an ongoing bases to discuss the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
51. Decisions about how to roll out the CLABSI initiative bundles were made by consensus	1 2 3 4 Comments	1 2 3 4 Comments
52. We met with key stakeholders before the CLABSI initiative bundles were rolled out	1 2 3 4 Comments	1 2 3 4 Comments
53. Elements of our CLABSI initiative bundle roll-out were changed based on key stakeholder feedback	1 2 3 4 Comments	1 2 3 4 Comments
Communication and Marketing		
PLEASE NOTE: When answering the following set of questions, consider the communication and marketing that originated from YOUR unit or hospital, not NACHRI		
54. The communication about the CLABSI initiative was very visible	1 2 3 4 Comments	1 2 3 4 Comments
55. The communication about the CLABSI initiative was much more visible than the communication about other initiatives	1 2 3 4 Comments	1 2 3 4 Comments
56. The communication about the CLABSI initiative was different or unique compared to the communication about other initiatives	1 2 3 4 Comments	1 2 3 4 Comments
57. The communication about the CLABSI initiative was customized and individualized to a variety of	1 2 3 4 Comments	1 2 3 4 Comments

different audiences		
58. Our marketing department promoted the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
59. A “brand” or logo was created to make the CLABSI initiative recognizable	1 2 3 4 Comments	1 2 3 4 Comments
60. Patient specific stories were included when communicating about the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
61. The rationale and importance of the CLABSI initiative were included in the communication	1 2 3 4 Comments	1 2 3 4 Comments
62. The CLABSI initiative was a hospital goal within the last 5 years (indicate the number of times)	1 2 3 4 Comments	1 2 3 4 Comments
63. The CLABSI initiative was marketed to physicians or other providers outside the hospital	1 2 3 4 Comments	1 2 3 4 Comments
64. The CLABSI initiative was marketed to insurers, competitors or regulators outside the hospital	1 2 3 4 Comments	1 2 3 4 Comments
65. The CLABSI initiative was marketed to patients and families	1 2 3 4 Comments	1 2 3 4 Comments
66. Social media strategies, such as text messages, Twitter, Face book, or blogs were used as a means to promote the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
67. Groups, such as shared governance councils, committees, or other professional groups were engaged to promote the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments

68. Email reminders were sent to staff about the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
69. Staff was verbally reminded in person about the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
70. Staff was verbally reminded in groups about the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
71. Hardcopy reminders were sent to staff about the CLABSI initiative	1 2 3 4 Comments	1 2 3 4 Comments
72. Were there any additional Implementation Methods used on your unit that were not mentioned above?	1 2 3 4 Comments	1 2 3 4 Comments
73. If yes, please describe (optional)	1 2 3 4 Comments	1 2 3 4 Comments
SURVEY END		
Based on your experience with implementing practice changes within your clinical setting is there anything missing?	Yes no	If yes, suggestions are greatly appreciated
Other comments		

THANKS

Please return to Debra Ridling

Debra.ridling@seattlechildrens.org or Hard copy at NACHRI Faculty Retreat

Appendix C

Implementation Methods Survey Tool

Implementation Methods Survey (11/2/11)

Purpose: You are being asked to complete this survey as part of a research study supported by the University of Washington in Seattle, Washington.

Background: In 2001, the Committee on Quality in Health Care in America found it took 17 years for evidence from randomized controlled trials to be applied to practice. Not much has improved over the last decade, despite the national approach to package evidence-based practices into abbreviated formats.

Aims: The purpose of the study is to examine methods of implementation utilized by Pediatric Intensive Care Units (PICUs) participating in the National Association of Children's Hospitals and Related Institutions (NACHRI) collaborative to eliminate central line associated blood stream infections (CLABSI).
Survey data will be combined with existing NACHRI data, such as CLABSI rate.

Once the data is entered into an excel spreadsheet, your unit and hospital name will be removed and replaced with a code number so it is completely **de-identified**. The Researcher will keep a separate code sheet with the unit name and code number, in case there are questions about data integrity in the future. The data and the code sheet will be saved in separate electronic files, which will be password protected and only accessible by the principal investigator. Individual unit/hospital data will not be shared with your unit/hospital, NACHRI, or anyone else.

- When completing the survey, consider what was done in your individual unit/hospital
- Completing the survey is voluntary
- You may skip any question
- The survey should take approximately 15 minutes to complete
- We appreciate your candid responses
- Thank you in advance for your time

Implementation Methods Survey

Please answer these questions independently (do not discuss with your colleagues). This survey specifically focuses on activities associated with your work to reduce/eliminate CLABSI in YOUR unit. All information will be kept strictly confidential. Your hospital and unit name will be removed from the survey, and replaced with a code number once it is merged with already existing data from the NACHRI collaborative database. The code is only used in case there are questions about data integrity during analysis. Your responses will not be shared with anyone.

Hospital Name		Unit Name Be Specific	

Number of Beds: _____ Type of Unit: □PICU □CICU □PICU/CICU

Your Profession: □RN-ICU □ RN-Infection Prevention
□MD-ICU □ MD-Infection Prevention
□Other_____

Your Primary Role in the ICU: □Provider □Manager/Director □Educator □CNS □Direct care staff □Quality or outcomes manager □Other_____

Phase in Collaborative: 1☐ 2☐ 3☐ 4☐

Role in the NACHRI Collaborative: ☐ Project Lead ☐Participant ☐Champion

Please Circle Your Responses

Education and Training

1. Staff received didactic/lecture/on-line education about CLABSI since joining the collaborative (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

2. Staff received didactic/lecture/on-line education about CLABSI within the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

3. If staff received didactic/lecture/on-line education about CLABSI within the last year (Indicate the number of times).

N/A not done 1 2 3 4 > 4

4. Nursing Staff participated in interactive hands-on training related to central line maintenance in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

5. Nursing Staff performed return demonstration of alcohol scrub in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

6. Nursing Staff performed return demonstration of the cap change procedure in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

7. Nursing staff performed return demonstration of dressing change procedure in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

8. Physician and other staff who place central lines participated in interactive hands-on training about central line insertion in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

9. Physician and other staff who place central lines performed return demonstration of patient draping procedure in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

10. Physician and other staff who place central lines performed return demonstration of full sterile barriers in the last year (Indicate the percent)

0 < 50% 50% > 50% >90%

11. Physician and other staff who place central lines performed return demonstration of central line insertion procedure in the last year (Indicate the percent of staff)

0 < 50% 50% > 50% >90%

Audit and Performance Feedback

12. The NACHRI recommended maintenance audits were completed a minimum of weekly (Indicate the percentage of time)

0 < 50% 50% > 50% >90%

13. Every element of the NACHRI recommended maintenance audits were completed (Indicate the percentage of the time)

0 < 50% 50% > 50% >90%

14. NACHRI recommended maintenance audits were done by direct observation (for example, observation of the dressing change, line change, line entry, etc.) (Indicate the percentage of the time)

0 < 50% 50% > 50% >90%

15. NACHRI recommended insertion audits were completed for every central line was placed (Indicate the percentage of time)

0 < 50% 50% > 50% >90%

16. Every element of the NACHRI recommended insertion audits were completed (Indicate the percentage of the time)

0 < 50% 50% > 50% >90%

17. Audit results were discussed with direct care staff

never yearly few times year monthly every 1-2 weeks

18. Audit results were tailored for specific individuals/groups

never occasionally sometimes usually always

19. The NACHRI CLABSI reports were tailored (e.g. annotated or edited) to fit our unit

never occasionally sometimes usually always

Culture

20. A safety culture survey was conducted in the last 5 years (indicate number of times)

0 1 2-3 4 5

21. Direct care ICU staff received safety culture survey results in the last year (Indicate percent of staff)

N/A survey not done	0	< 50%	50%	> 50%	>90%

22. ICU leadership received safety culture survey results in the last year (indicate percent of staff)

N/A survey not done	0	< 50%	50%	> 50%	>90%

23. An action plan was made to improve at least one aspect of the ICU safety culture within the last year

strongly disagree disagree neutral agree strongly agree

24. Improvements were made in ICU safety culture in the last year

strongly disagree disagree neutral agree strongly agree

Cost Benefit Analysis

25. It was easy to obtain approval for the cost of joining the NACHRI CLABSI collaborative

strongly disagree disagree neutral agree strongly agree

26. When evaluating supplies to support adherence to the central line bundles, we considered the cost of supplies compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc)

strongly disagree disagree neutral agree strongly agree

27. When planning our education and/or training, we considered the cost of education and/or training compared to the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc)

strongly disagree disagree neutral agree strongly agree

28. Staff was educated on the cost of a CLABSI (e.g. morbidity, mortality, length of stay, etc) (Indicate the percent of staff)

0	< 50%	50%	> 50%	>90%

29. Direct care staff were offered incentives (money, salary, gift) to participate in the CLABSI initiative (indicate the percent of staff)

0 < 50% 50% > 50% >90%

30. If incentives were used for direct care staff, indicate the monetary one-year value given to each individual

N/A < $5 $6-$20 $21-$100 $100-$1,000 >$1000

31. Leaders were offered incentives (money, salary, gift) to participate in the CLABSI initiative (Indicate the percent of leaders)

0 < 50% 50% > 50% >90%

32. If incentives were used for leaders, indicate the monetary one-year value given to each individual

N/A < $5 $6-$20 $21-$100 $100-$1,000 >$1000

33. Units were offered incentives such as food, parties, or celebrations to participate in the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

Resources and Tools

34. Checklists were created to facilitate the implementation of the elements of the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

35. Tools such as reference cards, posters, visual cues, and/or other job aids were created to facilitate the implementation of the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

36. Toolkits (electronic or hard copy) were created for staff to access information related to the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

37. Carts and/or kits were created to facilitate CLABSI insertion bundle adherence

strongly disagree disagree neutral agree strongly agree

38. Carts and/or kits were created to facilitate CLABSI maintenance bundle adherence

strongly disagree disagree neutral agree strongly agree

39. Changes were made to our clinical on-line computer order entry system to facilitate compliance with the CLABSI initiative

N/A strongly disagree disagree neutral agree strongly agree

40. Changes were made to our clinical on-line computer documentation system to facilitate compliance with the CLABSI initiative

N/A strongly disagree disagree neutral agree strongly agree

41. Staff had in-person access (within 30 minutes) to a nurse skilled in central line maintenance to instruct and/or assist them whenever needed (Indicate percent of the time resource was available)

0 < 50% 50% > 50% >90%

42. Staff had phone or email access (within 30 minutes) to a nurse knowledgeable in performing central line maintenance to answer questions (Indicate percent of time the resource was available)

0 < 50% 50% > 50% >90%

43. The standard of care in the ICU matches the NACHRI CLABSI bundles

strongly disagree disagree neutral agree strongly agree

44. All written policies pertaining to central line care in the ICU reflect the NACHRI CLABSI bundles

strongly disagree disagree neutral agree strongly agree

Local Participation

45. Select staff was recruited to act as change champions/coaches to work with their peer group to facilitate compliance with the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

46. If change champions/coaches were used, what percent of shifts were covered?

N/A not used < 50% 50% > 50% >90%

47. Opinion leaders, who were direct care staff, were actively recruited to promote the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

48. Individuals that could collaborate effectively across multiple disciplines, such as groups of physicians, nurses, administrators, supply, and/or finance, were included in the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

49. When we first joined the collaborative, groups of staff met to discuss the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

50. Groups of staff meet regularly to discuss the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

51. Decisions about how to roll out the CLABSI initiative bundles were made by consensus

strongly disagree disagree neutral agree strongly agree

52. We met with key stakeholders before the CLABSI initiative bundles were rolled out

strongly disagree disagree neutral agree strongly agree

53. Elements of our CLABSI initiative bundle rollout were changed based on key stakeholder feedback

strongly disagree disagree neutral agree strongly agree

Communication and Marketing

When answering the following set of questions, consider the communication and marketing that originated from YOUR unit or hospital, not NACHRI

54. The communication about the CLABSI initiative was very visible

strongly disagree disagree neutral agree strongly agree

55. The communication about the CLABSI initiative was much more visible than the communication about other quality or safety initiatives

strongly disagree disagree neutral agree strongly agree

56. The communication about the CLABSI initiative was different or unique compared to the communication about other quality or safety initiatives

strongly disagree disagree neutral agree strongly agree

57. The communication about the CLABSI initiative was customized and individualized to a variety of different audiences

strongly disagree disagree neutral agree strongly agree

58. Our marketing department promoted the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

59. A “brand” or logo was created to make the CLABSI initiative recognizable

strongly disagree disagree neutral agree strongly agree

60. Patient specific stories were included when communicating about the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

61. The rationale and importance of the CLABSI initiative were included in the communication

strongly disagree disagree neutral agree strongly agree

62. CLABSI reduction was a hospital goal within the last 5 years (indicate the number of times)

0 1 2-3 4 5

63. The CLABSI initiative was marketed to physicians or other providers outside the hospital

strongly disagree disagree neutral agree strongly agree

64. The CLABSI initiative was marketed to insurers, competitors, or regulators outside the hospital

strongly disagree disagree neutral agree strongly agree

65. The CLABSI initiative was marketed to patients and families

strongly disagree disagree neutral agree strongly agree

66. Social media strategies, such as text messages, Twitter, Face book, or blogs were used as a means to promote the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

67. Groups, such as shared governance councils, committees, or other professional groups were engaged to promote the CLABSI initiative

strongly disagree disagree neutral agree strongly agree

68. Email reminders were sent to staff about the CLABSI initiative

never annually quarterly monthly weekly

69. Staff was verbally reminded in person about the CLABSI initiative

never annually quarterly monthly weekly

70. Staff was verbally reminded in groups about the CLABSI initiative

never annually quarterly monthly weekly

71. Hardcopy reminders were sent to staff about the CLABSI initiative

never annually quarterly monthly weekly

Other

72. Were there any additional Implementation Methods used on your unit that were not mentioned above?

Yes No

73. If yes, please describe

Thank You

Appendix D

CDC Criteria to Determine if Blood Stream Infection is Associated with a Central Line

Included below are the definitions and criteria published by the CDC (2010) that were used to determine if a blood stream infection was associated with a central line, or not. In order for a blood stream infection to be labeled as a CLABSI, it must have met the CDC criteria. The CDC definitions and criteria were used by all participants in the NACHRI PICU CLABSI collaborative, which represents the standard approach across the United States. The standard approach was in place prior to this research study and was not modified for the purposes of the study.

CDC Exact Language for Determination of CLABSI

Laboratory-confirmed bloodstream infection (LCBI): Must meet one of the following criteria:

> Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures and organism cultured from blood is not related to an infection at another site. (See Notes 1 and 2 below.)
>
> Criterion 2: Patient has at least one of the following signs or symptoms: fever (>38 ^{o}C), chills, or hypotension and signs and symptoms and positive laboratory results are not related to an infection at another site and common skin contaminant (i.e., diphtheroids [*Corynebacterium* spp.], *Bacillus* [not *B. anthracis*] spp., *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions.

Criterion 3: Patient < 1 year of age has at least one of the following signs or symptoms: fever (>38°C core) hypothermia (<36°C core), apnea, or bradycardia and signs and symptoms and positive laboratory results are not related to an infection at another site and common skin contaminant (i.e., diphtheroids [*Corynebacterium* spp.], *Bacillus* [not *B. anthracis*] spp., *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions. (See Notes 3, 4 and 5 below.)

NOTES:

1. In criterion 1, the phrase "one or more blood cultures" means that at least one bottle from a blood draw is reported by the laboratory as having grown organisms (i.e., is a positive blood culture).
2. In criterion 1, the term "recognized pathogen" does not include organisms considered common skin contaminants (see criteria 2 and 3 for a list of common skin contaminants). A few of the recognized pathogens are *S. aureus*, *Enterococcus* spp., *E. coli*, *Pseudomonas* spp., *Klebsiella* spp., *Candida* spp., etc.
3. In criteria 2 and 3, the phrase "two or more blood cultures drawn on separate occasions" means 1) that blood from at least two blood draws were collected within two days of each other.

March, 2010 4-3http://www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf

VITA

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