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The Effectiveness Of Interventions And Bundles For Central Line-Associated Bloodstream Infections In The Neonatal Intensive Care Unit

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THE EFFECTIVENESS OF INTERVENTIONS AND BUNDLES FOR CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTIONS IN THE NEONATAL INTENSIVE CARE UNIT

by

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ABSTRACT

Introduction: Central Line-Associated Bloodstream Infections (CLABSIs) are a major cause of increased mortality, morbidity and healthcare costs in neonatal intensive care units (NICUs) patients. Despite CDC's efforts to reduce infection rates, patients often suffer consequences. The objective of this study is to perform a systematic review of strategies utilized in the neonatal population and evaluate them with the current CDC's guidelines to assess the effectiveness of bundles in preventing CLABSI in NICUs.

Methods: A systematic literature search was conducted using CINAHL Plus with Text, Cochrane Database of Systematic Reviews and MEDLINE from January 2008 up to 2018. There were multiple search terms used and these included "neonate OR newborn OR infant", "CLABSI OR central line-associated bloodstream infection", "intervention OR prevention" and "bundle". The search solely focused on the outcome of infant patients. Therefore studies were excluded for the following criteria: being non-peer reviewed, being published before 2008, and being a case in which CLABSI was assessed in patients outside the NICU. See Table 4 and 5 for further information.

Results: Eight articles were eligible for inclusion all of which CDC's guidelines were implemented in their strategy of intervention. The systematic review showed that adherence to care bundles decreases infection rates drastically. All eight articles reported a significant decrease in CLABSI rates following the implementation of the bundle set by CDC with a two studies achieving a CLABSI rate of zero.

Author's Conclusion: Implementation of care bundles showed a success in reducing CLABSI rates in the NICUs; however none of the studies endorsed a specific bundle application utilized to achieve its intended goal. Some practices adopted CDC's guidelines more than others and those showed a greater decrease in infection rate. In addition, it is evident that nurses deliver the best care when preventing an infection. Further research is needed to assess the effectiveness of specific bundle element.

DEDICATION

This thesis is dedicated to the memory of a young vibrant CLABSI victim, Nora Boström. Nora passed away due to a preventable Central line infection at the age of three, a few days before her fourth birthday.

To all healthcare providers, using evidence-based practice to provide and uphold the standard of medicine.

To every patient who was a victim of hospital acquired infection and suffered a medical error.

To my parents, Souad Daloul and Walid Alhamwi, I would also like to express my deepest gratitude, without whom I would not have become the man I am today. Your continuous encouragement and strength through this tough time has shaped my future and I hope to always make you proud.

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INTRODUCTION

Central Line Associated Bloodstream Infection (CLABSI) is an infection that occurs when bacteria or viruses enter a patient's bloodstream through a central line catheter. A central line catheter is usually inserted by healthcare professionals to access a major vein to administer medications or fluid, or to collect blood. The catheter often remains in place for a long period of time, sometimes for weeks or months. If infected, there is a high chance that the patient will suffer major medical problems, which may even progress to death. Current studies show a great correlation between having a CLABSI bundle with 95 percent compliance rate and significate decrease in infection occurrences.

The objective of this study is to assess the adherence of different intervention methods used to reduce CLABSI rates in neonatal intensive care units and compare it with the most updated Centers for Disease Control (CDC) guidelines. Studies reported the range of CLABSI occurrences in neonates ranges from 3.2 to 2.1 CLABSIs per 1000 central line days (Folgori, Bielicki & Sharland, 2013). The disparity in the range possible reflects the various CLABSI bundle elements implemented in hospitals and therefore results in different infection rate. A care bundle is a structured package that aims to improve the process of care and patient outcome using evidence-based practices have been proved to be effective in reducing CLABSIs in adults ICUs; however, the bundle has shown an inconsistent results when used in the neonatal ICU and thus will be addressed in this study.

BACKGROUND

Health Care and Medical Error

In a study conducted by reviewing the medical records of patients treated in New York hospitals in 1984, it was estimated by the Institute of Medicine that each year up to 98,000 patients die from medical errors. This study was based on three decades of data, but an updated study estimates that more than 400,000 patients die annually from preventable errors in the United States (James, 2013).

The accuracy of these numbers is not what matters, but the alarming increase in mortality rates because of medical errors is what should raise people's concern (Klintworth et al, 2014). Moreover, the number of preventable errors is always on the rise despite these measures (Ista, et al, 2016).

Reporting a near-miss, sentinel event or even an adverse medical error involves creating a special report that meets a set of information standards such as the date and time of event, name of the staff, witnesses, location and description of the event, equipment involved, patient's pre and post condition, position and nature of injury and the treatment provided. These are the minimum information necessary to initiate an investigation that can lead to a conclusive explanation as well as a learning experience (Marschall, et al 2014).

Hospital Acquired Infections

Of the most common types of errors, Hospital Acquired Infections (HAIs) are a major cause of a significantly number of deaths in the U.S. HAIs are caused by bacterial, viral and fungal pathogens with the most common types being Surgical Site Infection (SSI), Urinary Tract Infection (UTI), Bloodstream Infection (BSI) and Pneumonia such as the Ventilator-associated Pneumonia (VAP) (CDC, 2010).

Healthcare-associated infections (HAIs) are the leading causes of considerable morbidity and mortality in the U.S. Four types of infections account for more than 75% of all HAIs in hospitals: UTI, 34%; SSI, 17%; BSI, 14% and lastly, Pneumonia is at 13% (CDC, 2010).

Two complementary HAI surveillance systems, the Emerging Infections Program Healthcare-Associated Infections – Community Interface (EIP HAIC) and the National Healthcare Safety Network (NHSN) routinely publish reports that are used to track the progress as well as target the areas that need assistance (CDC, 2010).

Nationally, there was a 2-11% decrease of specific HAI types in acute care hospitals within the U.S. between 2015 and 2016 (CDC, 2010). In the same period, the 2016 state performance shows that 38 states improved performance on at least two HAI types with only 10 states performing worse on two infections types. Although over the years there has been significant progress made in preventing some of these HIA, much more work still needs to be done. Expenses incurred in treating HAI are not reimbursed to the concerned healthcare organization and since they can run into thousands of dollars, the financial stability of the facility must always be considered

Central Line Associated Bloodstream Infections

Most Infections prevention experts and improvement teams rely on the CDC to define CLABSI and central lines. Approximately 70% of CLABSIs are preventable just by using the applicable and current CDC guidelines (CDC, 2010).

A central line is defined as catheter whose utmost tip terminates in a great vessel such as the aorta, inferior and superior vena cava, pulmonary artery, brachiocephalic, internal jugular, subclavian and external iliac veins, as well as common femoral veins. Other lines considered as catheters are the peripherally inserted central catheter (PICC) Pacemaker wires or other non-lumened devices are not considered as central lines.

There is an increasing use of central lines in inpatient and outpatient settings in the provision of long-term venous access but these lines also disrupt the integrity of a skin thus making bacterial or fungal infections possible (Dumyati, et al, 2014). The infection may then spread to the bloodstream causing hemodynamic changes and severe sepsis or organ dysfunction, which may lead to a death. It is estimated that about 90 percent of CLABSI occur with or because of the central lines.

The central line bundle is a collection of evidence-based interventions for intravascular central catheter patients that, if implemented together, they have better outcomes than when they are implemented individually. The central line bundle approach is made up of five key components namely: 1) hand hygiene, 2) chlorhexidine skin antisepsis, 3) maximal sterile barrier precautions, 4) optimal catheter site selection, and 5) daily review of line necessity.(Ista et al, 2016)

The central line bundle approach is most successful when all the mentioned elements are executed together and not singularly. The application of this approach has been demonstrated to reduced central line infections rates in many hospitals, with many ICUs that have implemented this multifaceted intervention having nearly eliminated CLABSI incidences (Marschall, et al, 2014). The success of the central line bundle approach has also been attributed to a combination of mindfulness that is developed when applying the key components mentioned above with particular reduction of bloodstream infections development resulting from the strict application of maximal sterile barrier precautions (Dumyati, et al, 2014).

- **Hand Hygiene**

The most effective method of decreasing the likelihood of a central line infection is proper hand hygiene. Whether washing the hands is done with water or with alcohol based waterless hand cleaners, both methods are helpful in preventing the contamination of central line sites and the attendant bloodstream infections (Weeks, Hsu, Yang , Sawyer & Marsteller, 2014).

Appropriate hand hygiene should be done before and after examining a catheter insertion site but not after an antiseptic application unless the antiseptic technique is maintained. Washing hands before and after inserting, accessing, fixing, or dressing a catheter is also of utmost importance (Dumyati, et al, 2014). In addition, hands should be washed as soon as a contamination is suspected or when the hands are obviously soiled as well as before and after any invasive procedure, before donning gloves and after removing them, after using the bathroom and between attending patients.

- **Chlorhexidine Skin Antisepsis**

This element of the central bundle line has been shown to provide better skin antisepsis than all other techniques, including use of povidone-iodine solutions. Prior to insertion many facilities use kits for catheter insertion that include antiseptic solutions and drops. The technique applied starts with preparing the skin with antiseptic chlorhexidine 2% in 70% isopropyl alcohol (Reagan, et al, 2015). After that, the operator holds the applicator down for the solution to saturate the pad, and then press the sponge against the skin of the patient before applying the chlorhexidine solution using the back-and-forth friction scrub for at least thirty seconds. Once done, the clinician should give the aseptic solution at least two minutes to dry completely before he or she punctures the site of insertion.

- **Maximal Sterile Barrier Precautions**

A key approach in decreasing the likelihood CLABI is the application of the maximal sterile barrier precautions when preparing for the central line insertion. The clinician inserting the line, as well as those assisting in the procedure, must strictly comply with maximal sterile barrier precautions, which involves wearing a sterile gown and gloves, a cap and a mask (Klintworth, et al, 2014).

The cap ought to cover the clinician's hair while the masks tightly cover the noses as well as the mouths. The patient should also be covered with a sterile drape from head to toe and that drape must have a small opening for the incision or the site of insertion. Maximal sterile barrier precautions are similar to other surgical procedures that come with risks of infections and safety care should be observed when applying this approach (Ista et al, 2016)

- **Optimal Catheter Site Selection**

The most commonly used central lines are the percutaneously inserted catheters as the femoral vein for a central venous access in adult patients are usually avoided since the site of insertion cannot alter the risk of the infection (Marschall, et al 2014). The site of insertion is not a risk factor for line infection if an experienced clinician inserts the catheter and strictly adheres to the sterile techniques.

The optimal site selection requires that every factor should be considered before deciding on where to place the catheter. These factors include catheter-operator skill, potential for mechanical complications and risk of subclavian vein stenosis (Weeks, Hsu, Yang , Sawyer & Marsteller, 2014). The clinician leading the operation must weigh the benefits as well as the risks involved in each selected site and should there be a discussion between the clinical team on the selected site and rationale documentation is necessary that provides the reasons for the selected vessel.

- **Daily Review of Line Necessity and prompt removal of any unnecessary lines**

This element prevents unnecessary delays in the removal of any line that is no longer needed for the care of the patient. Most of the time, the central lines are retained in place because they provide the clinical team with reliable access or because the personnel responsible have not made considerations of removing them. The risk of infection increases with the duration the line remains in place or decreases when the line is removed. CDC guidelines do not suggest replacing catheters at scheduled intervals because such a method does not reduce CLABSI incidences or

even lower the rates of the infections (Dumyati, et al, 2014). Routine replacement is not necessary for a catheter that is functioning and has no signs of local or systemic complications.

CLABSI in NICU

In the Neonatal Intensive Care Unit (NICU), central lines are frequently used especially for total parenteral nutrition (TPN), and for the administration of medications. The lines have the potential of causing harm or infections to vulnerable neonates. The neonates are especially susceptible to HAIs and these have the potential of causing serious and lasting harmful effects such as neurodevelopmental delays. Evidence shows that a compliance of 95 percent or greater with the central line bundle correlates with greater reduction of CLABSI occurrences in NICU (Abdelaziz, et al, 2017).

Frequent utilization of central lines in preterm infants for medication administration and nutritional support correlates with increased rates of CLABSIs and these three are the most common elements encountered in most NICUs (Barry, 2017). Even with zero CLABSI rates in some hospitals, there is a still heightened risk of these cases mainly due to knowledge deficits on current line maintenance policy, the absence of formal and up to date training for new employees on CLABSI prevention, and lack of ongoing audits.

With a goal to reduce infection rather than prevent CLABSIs, ongoing line audit practices and the implementation of formal CLABSI classes, as well as the promotion of such a culture, is essential. Despite the introduction of the central line bundle in July 2012, CLABSI has continued to pose a challenge in most NICUs (Hoang, et al, 2008). Central lines are an essential part in

neonatal care, yet neonatal CLABSI is still a significant cause of infant morbidity and mortality as well as increased costs of treatment and prolonged hospitalizations.

Long-term venous access is necessary for the provision of nutrition, medications, and fluids for NICU patients and since the 1980s, peripherally inserted central venous catheters (PICC) have been in widespread use. The advantages associated with PICCs are that they can be placed at the bedside without general anesthesia and thereafter can remain in place for days or even weeks with minimal mechanical complications (Zachariah, et al, 2014)

PICCs encompass larger proportions of the central lines inserted in NICUs and are intended for short-term vascular access. However, these catheters can remain in site for prolonged periods and this can become a factor for harmful after effects. PICCs can easily be complicated by the occurrence of CLABSI because of prolonged placement or maintenance issues (Payne, Hall, Prieto & Johnson 2018). A rough estimate of 80,000 CLABSIs occurs annually in the United States with attributable mortality rates ranging between 4% to 20%.

Extended durations of PICC line increases the risks of CLABSI for neonates and this risk outweighs the complications of replacing it. The findings of these studies further contend that after the 35th day of having a PICC in place, the risk of CLABSI incidence increases every day by approximately 33%. Several factors contribute to the origin and development of an infection in relation to catheters such as the age of the neonate, severity of an underlying illness and immunologic immaturity (Abdelaziz, et al, 2017).

There are also catheter-related and environmental factors, many of which can easily be prevented including prolonged catheterization, emergent catheter placement, size and type of

catheter material, the location of catheter, poor aseptic insertion technique, frequency of catheter manipulations and of system entry, number of lumens, type of insertion, and site dressing. As Payne, et al, (2018) attest, hand hygiene, chlorhexidine skin antisepsis, maximal barrier precaution, optimal catheter-site selection, and daily review of line necessity accompanied with prompt removal of any unnecessary lines are the best practices for preventing CLABSI even in NICU.

Preventive catheter replacement is recommended after 35 days as that can offer a maximum reduction in catheter-associated CLABSIs. There are risks involved in central line replacements such as subsequent infection from the new catheter, procedural costs, pain to the neonate, mechanical and consequent infectious complications. However, research studies suggest that CLABSI incidence rates in the replaced catheters are usually lower than in the primary PICCs (Barry, 2017).

Various research studies have identified that most CLABSIs in NICU populations are triggered by skin flora, such as the coagulase-negative staphylococci. Birth weights, gestational and chronological age, are also risk factors for CLABSI in neonates. Low birth weight and premature infants require the most days with the catheter and hence remain in NICU for longer durations (Pogorzelska, 2016). This increased exposure may place them at higher risks for CLABSI, and since this exposure time can modify the effects of other factors, most researchers fail to adjust it when assessing the risk factor associated with exposure time.

Even as the PICC remains as a fundamental component of NICU care, measures should be enhanced to reduce factors that can cause CLABSI or other related serious complications.

Catheter types and exposure time could also be the drivers of CLABSI rates in neonatal care units, even though little research exists that can expound more on this angle of correlation (Hoang, et al, 2008). Additional studies are required to identify the acceptable threshold for a PICC replacement that would outweigh the risk reduction and associated costs of replacement.

Nurses' Role

Nurses make positive impacts in reducing infections as well as in the provision of intensive care. Nurses are integral to the process of reducing CLABSI (Harris, Roussel & Thomas, 2016). For instance, when CLABSI reduction rates improve, the quality and safety of patients care to improve as well and this impacts favorably on the running and financial stability of the healthcare facility.

Even with a strict application of the central line bundle in addition to data collections, and surveillances as measures to prevent or reduce CLABSI, sometimes a team of dedicated nurses is all it takes to obtain the desired results. Trained and skillful nurses specifically assigned to oversee the process of inserting the central line and the maintenance procedures have been proved as the easiest and inexpensive ways of eliminating or reducing CLABSI incidences in hospitals and in the shortest times possible.

Devoted nurses at the University of Maryland Medical Center's surgical ICU have participated in a 25-week period survey which managed to sustain a zero rate CLABSI infection in that facility (Yokoe, et al, 2014). The nurses' role in that period helped to eliminate more than 14 infections as well as saved two lives. This saved the health facility more 200,000 dollars over a period of 6 months. In essence, nurses at the health center demonstrated and succeeded

tremendously by being the primary drivers of the anti-infection measures besides taking the measures directly at the patients' bedsides.

Nurses are the closest health care providers to the patients and when they are assigned the pivotal role of monitoring the infection prevention practices especially those that involve central line insertion and CLABSI, they possess the necessary educational components such as monitoring, maintenance, and care for the lines. Nurses are specifically trained to also check central line dressings on a daily basis and to ensure that they dry at all times and remain intact, which ensure that the integrity of those lines is maintained (James, 2013). Nurses are also champions in monitoring hand hygiene practices as they promptly call out any staff breaching the hand hygiene codes, easily notice any noncompliance and provide timely reminders where necessary.

Nurses are also responsible for monitoring the central line compliance as well as providing necessary feedback on the best practices. They also oversee environment management, which ensures that every room in the facility is not only clean but also free of clutter. Giving nurses complete control of the wards is a natural culture that has accrued exceptional benefits for the respective hospitals and this is one of the primary factors contributing to the reduction of CLABSI rates (Dumyati, et al, 2016).

Being proximate to the patients, nurses easily and promptly recognize the impact of averting or reducing chances of CLABSI. Where this practice is valued and enforced has turned it into a beneficial culture with CLABSI dropping to zero and that rate remains there for quite a long time (Harris, Roussel & Thomas, 2016). Traditionally, the dichotomy between doctors and

nurses is precarious with the latter not always responding positively when a nurse reminds them to wash their hands or to dress in the required and appropriate gowns, especially during a central line insertion. Surgeons and surgical care personnel who recognize the importance of nurses in CLABSI prevention have contributed tremendously to the successes as elucidated above.

PROBLEM

Fort eight percent of intensive care unit patients have the central lines and this account for approximately 15 million central-venous-catheter-days in ICUs per year (CDC, 2010). This is a large number and for this reason, some unforeseen or sometimes careless and reckless mistakes occur which can lead to a high number of infected patients. CLABSI infections cause considerable indisposition, high but preventable mortality and incur large health care costs.

It is estimated that in the U.S. alone, up to 82,000 CLABSI infections and around 28,000 attributable losses of lives occur in ICUs every year. CLABSIs prolong hospitalization, are costly, and cause the deaths of approximately 31,000 people in the U.S. annually. The prolonging of hospitalizations because of nosocomial bloodstream infections lasts as much as 7 days with the estimates of the attributable costs per each bloodstream infection ranging between 3,700 and 29,000 dollars (Reagan, et al 2015).

Each day, one in thirty-one patients has at least one type of hospital-acquired infection. In 2015 HAI prevalence survey, patients were 16% less likely to acquire HAI than the patients surveyed in 2011. In this regard, only approximately 3 percent of hospitalized patients had one or more HAI in the 2015 survey. Interestingly, an estimated 687,000 HAI cases in the United States' acute care hospitals occurred in 2015 and of these, 72,000 hospital patients who had acquired healthcare-associated infections died in the course of their hospitalizations (James, 2013).

PURPOSE AND SIGNIFICANCE

The objective of this study is to conduct an integrative literature review regarding patient outcomes of strategies used in care bundle to decrease CLASBI rates among neonates. The research will also discuss the efficacy of care bundle supported by the CDC.

This literature review is important because it will analyze current data pertaining to CLABSI prevention methods in NICUs. CLABSI rates are not increasing significantly but the mortality associated with each infection is alarming and is not deceasing (Yaseen, et al, 2016). A literature review of the effectiveness of bundle was tested and a decrease in infections was reported due to 90% compliance to insertion and sterilization procedures (Hoang, et al 2008). However, there is no updated summary the reviews the current prevention methods used and how the adherence to the care bundle affects infection rate. New prevention strategies which are being implemented by hospitals across the U.S. could potentially have better results in lowering infection rates in NICUs and this will be discussed in this research. Most available literature is a decade old and is not aligned with the CDC's most updated guidelines therefore a literature search from 2008 up to 2018 is reviewed to report the most up to date findings. The neonatal population was chosen over the adults due to the excessive number of literature research available which shows the success of care bundle in decreasing CLBSI rates with a 99% adherence rate to guidelines.

METHODS

Results from a literature research conducted in October 2018 for the purpose of this research were organized in the form of a literature review. Different databases were used: Medical Literature On-line (MEDLINE), The Cochrane Database of Systematic Reviews, and Cumulative Index to Nursing and Allied Health Literature Plus with Full text (CINAHL).

The literature research keywords included, "neonate OR newborn OR infant", "CLABSI OR central line-associated bloodstream infection", "intervention OR prevention" and "bundle". The search solely focused on the outcome of neonates. Inclusion criteria included any study published in the English language and in a United States' hospital where CLABSI was assessed in an NICU after January 2008. Both randomized controlled trails (RCT) and non-randomized interventional studies were included. Studies were excluded for the following criteria: articles not peer reviewed, articles published before 2008, and articles where CLABSI was assessed in patients outside the NICU. See Table 4 for further information. All retrieved articles that were excluded due to the above criteria can be found in Table 5 with the reason for exclusion.

Three steps were adopted to review related articles. In the first step, a strategy of researching keywords and reviewing article's titles by using virtual health library was implanted. The following exclusion criteria adopted: diagnostic studies; studies addressing only adult patients and studies pertaining to calculating attributable CLABSI cost. The final step; where inclusion criteria were applied, and the snowball method were used.

In 2017, guidelines have been developed by the CDC for all healthcare personnel who perform an intravascular catheter insertion as well as guidelines for persons overlooking

surveillance and control of infection in any healthcare setting. Table 1 presents a summary of categorized recommendations which will be used as a benchmark for each of the included studies.

Table 1: Summary of Recommendations:

Category	Description
Category IA	Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.
Category IB	Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (e.g., aseptic technique) supported by limited evidence.
Category IC	Required by state or federal regulations, rules, or standards.
Category II	Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.
No Recommendation	Represents an unresolved issue for which evidence is insufficient or no consensus regarding efficacy exists

Note: the table above was retrieved from the following link:
https://www.cdc.gov/infectioncontrol/guidelines/bsi/index.html

Data Analysis

Eight articles met the inclusion criteria and were identified for an integrative review. Data from each article were extracted by using a standardized template: author, year of publication, setting, sample size, intervention methods used/bundle element, and main findings along with the CDC's recommendation category to assess the effectiveness of the methods used. All eight article reported a significant decrease in CLABSI rate following the implementation of the bundle with a two studies achieving a CLABSI rate of zero (Kime, Mohsini, Nwankwo & Turner, 2011) (Ceballos, Waterman, Hulett & Makic, 2013). For example, Kime at al reported a zero CLABSI rate after implementing a three phase intervention which was a six month study. Kaplan, however, reported a little improvement in infection rate and it could be to a various reasons.

In the main finding section in Table 2, two set of calculations are provided to assess a more accurate finding: number of infection per thousand central line days and an improvement percentage. All of the articles have either one or both of the numbers. Level of Evidence section shows what that specific NICU used as an intervention method the CDC recommended guideline to prevent infection shown in Table 3. Each article implemented various methods to prevent or reduce infection and demonstrated its methods efficacy by the improvement rate. Some articles separated the methods used into sections (i.e.Wilder where he reported the following: two person PICC dressing change procedure, skin preparation, documentation and Education) and other reported the compliance percentage of each bundle element such as Ceballos.

Results

This paper reviewed eight articles. The first one is on flooring hospital for children at Tufts Medical center, Level IIIC NICU by Erdei, Mcavoy, Gupta, Pereira & Mcgowan (2015). In this particular studied article, the sample size taken was for a greater than 500 infants on a yearly basis. In terms of the interventions used, there would be policies, which would be implemented over a period of 5 years. The NICU staff would review the chart and re-educate the patients on the hand washing procedures. There will be a designated cart for the NICU CL. The patients should be provided with the education and training needed, impregnated port protectors, and the standardization of the nutrition advancement based on the feeding protocol.

The second study is based on the University of Colorado Hospital, Level IIIB NICU by Ceballos, et al (2013). In this particular study, there were 560 patients admitted in this facility with an average of 34 patients. The policies implanted over a period of 2 years included a compliance of 98% in hand hygiene. Before the start of this procedure, there occurred a time out of 96%. The checklist of the task was complied with at 99%. At the same time, there was a 92% skin preparation and a maintenance of a sterile field as the procedure continued. The documentation was completed at 99% and sterile drip procedure observed at 96%.

The third study was carried out at 24 Ohio NICUs whereby 1916 subjects were eligible according to Kaplan, Lannon, Walsh & Donovan (2011). The policies implanted over a period of one year involved the insertion of the catheter. Under observation included the maximal sterile barrier, the covering of the patient in full body drape and the wearing of the mask among others. In Fisher, Cochran, Provost, Patterson & Bristol (2013), this study will look at the 10 Level III

and 3 level II NICUs with 641 annual admission ranges. The policies covered a period of nine months. The main ones were the insertion for hand hygiene, the unit time out and the wearing of masks to name a few. The second one was the maintenance, touching on the cleansing for complete air-drying.

Kime et al (2011) carried out a study on the NICU in a Saginaw, Michigan Hospital. It was a level III where 100 infants were involved in the study. In the entire period of 6 months for the implementation of the policies, there was the first phase for the hand hygiene, the second for scrubbing the hub and the third for the central line tubing.

The study by Piazza, Brozanski, Provost, Grover & Chuo (2016) at the 17 level III ICUs for the number of patients greater than 25 and the 50 admissions annually. The study looked at the hand hygiene, the central line insertion, and the central line maintenance. The cleaning using a minimum of sterile gauze and a barrier is also included.

In a study conducted by Payne et al (2018), a systematic review of twenty four articles was conducted to assess the effectiveness of the care bundle in neonatal ICUs and compare it with its effectiveness in the pediatric population. The study included articles from the around the world and each component of bundle each NICU used to reduce CLABSI was reported. Five of the studies included were observational studies and the remaining 19 were before and after quality improvement studies. As reported in Table 2, the study found a significant decrease in CLABSI rate and a reduction percentage of 60, which also equates to a decrease from 0.51 to 0.31 per thousand central line days as calculated in the meta-analysis. Although a significant

decrease was noted due to the implementation of the bundle, the study was not able to answer its initial goal.

Lastly, this analysis looks at Level IV NICU in a Southwestern hospital according to Wilder, Wall, Haggard & Epperson (2016). There were 36 beds and the policies implanted covered a period of 4 years. The policies touched on the two-person PICC dressing change procedure, the skin preparation, documentation and education. In all these studies, there are main findings. For instance, according to Erdei et al (2015), there was a reduction of CLABSI rates by 77%. In the one by Ceballos et al (2013), The CLBSI reduced by 92%. The study Kaplan (2011) showed a reduction in the LOS rates by 20%. CLABSI reduced by 71% in the study by Fisher (2013). Kime (2011) on the other hand showed a reduction to 0 from 15.6 while that by Piazza (2016) was by 19.28. Lastly, the study by Wilder, 2016 had a reduction of 92% in the CLABSI rates.

Table 2: Reviewed Articles

Article	Setting/ NICU Level	Sample Size	Bundle Elements/ Intervention Used	Main Findings	Level of Evidence by CDC
Ceballos K, Waterman K, Hulett T, Makic MB (2013). Nurse-Driven Quality Improvement Interventions to Reduce Hospital-Acquired Infection in the NICU. Advances in Neonatal Care, 13(3), 164-165. doi:10.1097/anc.0b013e31829b6aaf	University of Colorado Hospital, Level IIIB NICU	560 yearly admission, average daily of 34 patients	(Policies implemented over two-year period) -98% hand hygiene compliance -96% time out occurred before start of the procedure -99% compliance with checklist task -92% skin preparation was observed -97% provider maintained sterile field throughout the procedure -99% documentation completed -96% sterile drape procedure directly observed	92% Reduction in CLABSI rates, 9.6 to 0 per thousand central line (84 fewer hospital days). Estimated cost savings of $348,000	IA_2 IA_4 IA_5 IA_8 IB_2 IB_3 IB_4 IC_2

Erdei, C., Mcavoy, L. L., Gupta, M., Pereira, S., & Mcgowan, E. C. (2015). Is Zero Central Line-Associated Bloodstream Infection Rate Sustainable? A 5-Year Perspective. Pediatrics, 135(6). doi:10.1542/peds.2014-2523	Tufts Medical center for children Level IIIC NICU	>500 infants yearly	(Policies implemented over five-year period) -Chart reviewed by NICU staff. -Reeducation on hand washing procedures -Designated NICU central line cart -Education and training was provided. -Training and reeducation of PICC line insertion team -usage of alcohol impregnated port protectors -Standardization of nutrition advancement per feeding protocol	77% Reduction in CLABSI rates. (decreased from 4.1 to 0.94 per thousand central line days)	IA_5 IB_2 IB_4

Fisher, D., Cochran, K. M., Provost, L. P., Patterson, J., Bristol, T., Metzguer, K., . Mccaffrey, M. J. (2013). Reducing Central Line-Associated Bloodstream Infections in North Carolina NICUs. Pediatrics, 132(6). doi:10.1542/peds.2013-2000	10 Level III and 3 level II NICUs	641 annual admission range	(Policies implemented over nine-month period) -Insertion: Hand hygiene, unit time out before procedure, all required supplies at the bedside. Face mask worn by those within 3ft of sterile field. procedure stopped is sterility compromised -Maintenance: cleansing solution allowed to air dry completely. Staff use sterile or clean barrier for tubing assembly.	71% reduction in CLABSI rates, 3.94 to 1.16 per thousand central line days	IA_3 IA_4 IA_6 IB_2

Kaplan, H. C., Lannon, C., Walsh, M. C., & Donovan, E. F. (2011). Ohio Statewide Quality-Improvement Collaborative to Reduce Late-Onset Sepsis in Preterm Infants. Pediatrics, 127(3), 427-435. doi:10.1542/peds.2010-2141	24 NICUs Level III NICUs in Ohio	1916 eligible infants	(Policies implemented over one-year period) Catheter Insertion included: -assessment of need for catheter insertion -use maximal sterile barrier -patient covered in full-body drape -inserter wears mask, hat and sterile gown -excellent hand hygiene before gloving -all supplies required accessible by bedside Safe Catheter maintenance included: -daily assessment -dressing integrity and site cleanliness assessed daily -Site care -use of closed system -catheter access -tubing care: staff wear clean gloves	20% Reduction in LOS rates after >90% compliance with catheter insertion components with at least one report of LOS	IA_1 IA_3 IB_1

Kime T, Mohsini K, Nwankwo MU & Turner B. (2011) Central line "attention" is their best prevention. Adv Neonatal Care. 08;11(4):242–248. doi:10.1097/ANC.0b013e318225668	Level III NICU in a Saginaw, Michigan hospital.	100 infants	(Policies implemented over six month period) -Phase 1: Hand Hygiene training. Hand Sanitizer on two walls in each nursery and at each bedside. -Phase 2: Scrub the hub; needleless connecter cleaned with 70% alcohol wipes, Chlorhexidine 2% solution used with friction 10-15 seconds -phase 3: central line tubing; clean technique, sterile at insertion point -phase 4: central line insertion, removal; standardized procedure for insertion of central line	CLABSI decreased from 15.6 to 0 per thousand central line days	IA[8] IA[9] IB[3] IB[4] IB[6]

Payne, V., Hall, M., Prieto, J., & Johnson, M. (2017). Care bundles to reduce central line-associated bloodstream infections in the neonatal unit: A systematic review and meta-analysis. Archives of Disease in Childhood - Fetal and Neonatal Edition, 103(5). doi:10.1136/archdischild-2017-313362	A review of 24 studies	131 NICUs evaluated	Elements used: -maximal standard barrier precautious -skin preparation -scrub the hub -daily line need assessment -closed IV tubing -peripherally inserted central catheter team -central line trolley/kit -dressing protocol -two person technique -alcohol impregnated port protectors Professional elements used: -educating and training -multidisciplinary team -opinion leaders -rewards -root cause analysis	60% Reduction in CLABSI rates, 0.31 to 0.51 per thousand central line day	IA3 IA5 IA7 IA8 IB5

Piazza, A. J., Brozanski, B., Provost, L., Grover, T. R., Chuo, J., Smith, J. R.,Pallotto, E. K. (2015). SLUG Bug: Quality Improvement With Orchestrated Testing Leads to NICU CLABSI Reduction. Pediatrics, 137(1) . doi:10.1542/peds.2014-3642	17 level III ICUs	>40 admissions annually >25 inpatient beds	-Hand hygiene: use of hand sanitizer immediately before or after patient contact -Central line insertion: dedicated teams, sterile barrier, site preparation and sterile dressing -Central line maintenance: 70% alcohol prep or chlorhexidine prep as per NICU protocol, sterile: minimum to include sterile gloves and mask with use of sterile barrier under the CVC OR Clean: minimum to include clean gloves with sterile gauze barrier under the CVC	19.28% Reduction in CLABSI rates, 1.333 to 1.076 per thousand central line day	IA_4 IB_1 IB_2

Wilder, K. A., Wall, B., Haggard, D., & Epperson, T. (2016). CLABSI Reduction Strategy. Advances in Neonatal Care,16(3), 170-177. doi:10.1097/anc.0000000000000259	Level IV NICU in a southwestern hospital	36 beds	(Policies implanted over four year period) -Two person PICC dressing change procedure: all dressing changes were done using sterile technique involved wearing gloves, gown and masks. -Skin preparation: Using friction, the team cleansed the area under the dressing with chlorhexidine gluconate 2% -Documentation in the electronic medical record: length of external catheter and site appearance. -Education: Provide parent/legal guardian education as appropriate.	92% Reduction in CLABSI rates, 3.9 to 0.3 per thousand central line day	IA_5 IA_7 IB_4 IB_7 IC_1

Table 3: Up to date guidelines set by CDC

Scientific Evidence	**Level of Evidence**
Educate healthcare personnel regarding the indications for intravascular catheter use	IA_1
Periodically assess knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of intravascular catheters.	IA_2
Designate only trained personnel who demonstrate competence for the insertion and maintenance of peripheral and central intravascular catheters.	IA_3
Avoid using the femoral vein for central venous access in adult patients.	IA_4
Avoid the subclavian site in hemodialysis patients and patients with advanced kidney disease, to avoid subclavian vein stenosis.	IA_5
Promptly remove any intravascular catheter that is no longer essential.	IA_6
Use a fistula or graft in patients with chronic renal failure instead of a CVC for permanent access for dialysis.	IA_7
Promptly remove any intravascular catheter that is no longer essential.	IA_8
Sterile gloves should be worn for the insertion of arterial, central, and midline catheters	IA_9
Ensure appropriate nursing staff levels in ICUs. Observational studies suggest that a higher proportion of "pool nurses" or an elevated patient–to-nurse ratio is associated with CRBSI in ICUs where nurses are managing patients with CVCs.	IB_1
Use a subclavian site, rather than a jugular or a femoral site, in adult patients to minimize infection risk for no tunneled CVC placement.	IB_2
Use a CVC with the minimum number of ports or lumens essential for the management of the patient.	IB_3
When adherence to aseptic technique cannot be ensured (i.e., catheters inserted during a medical emergency), replace the catheter as soon as possible, i.e., within 48 hours.	IB_4
Maintain aseptic technique for the insertion and care of intravascular catheters.	IB_5
Use a sterile sleeve to protect pulmonary artery catheters during insertion.	IB_6
Prepare clean skin with an antiseptic (70% alcohol, tincture of iodine, or alcoholic chlorhexidine gluconate solution) before peripheral venous catheter insertion	IB_7
Wear clean gloves, rather than sterile gloves, for the insertion of peripheral intravascular catheters, if the access site is not touched after the application of skin antiseptics.	IC_1
Wear either clean or sterile gloves when changing the dressing on intravascular catheters.	IC_2
Chlorhexidine-impregnated dressings are NOT recommended to protect the site of short-term, non-tunneled central venous catheters for premature neonates due to risk of serious adverse skin reaction	IC_3

The CDC has implemented changes to its recommended CLABSI guidelines as of July of 2017 and one of its major updates indicates that chlorhexidine impregnated dressings are not recommended to protect the site of short term catheters due to risk of serious adverse skin reactions (CDC 2017). All of the articles reported the importance of chlorhexidine in protecting the infant's skin, but the CDC suggests otherwise. For example, Wilder at al (2016) reported as part of skin preparation: Using friction, the medical team should cleanse the area under the dressing with chlorhexidine gluconate 2%. These studies did not implement CDC's update due to publication date.

In addition to examining CLABSI rates in patients as the major outcome, one study examined how preventing BSI also decreases cost. Ceballos et al (2013) reported a huge number of $348,000 in cost savings due to preventing infection by eliciting 84 few hospitalization days. This study was one of two that achieved a zero CLABSI rate and reported a significant reduction in the mean number of central lines placed. This study is important, because it not only shows the significant reduction rate in CLABSI but also it emphasis the important role of nurses in preventing infections. The study is mainly focused on nurse's effort in preventing infections and by following the procedure set forth by the CDC with a high compliance rate, that NICU team was able to achieve the desired result of zero infection.

DISCUSSION

This discussion will look at the evidenced based practice in the Central Associated Bloodstream Infections, otherwise known as CLABSI. Research shows that there are as many as four million children who die in the neonatal period, 70% of whom could be saved if there were a practice of safe delivery in the nursing care. According to Erdei et al (2015), a zero central line-associated blood stream infection rate can be sustainable. The background of the study was at the Floating Hospital for Children at the Tufts Medical Center. There were several methods used prior to the implementation of CLABIS in the NICU for the period from 2008 to 2013.

Following the adoption of the standardized care practices, which included the checklists and the bundles, there were significant reduction rates to zero for a period exceeding 370 days consecutively. The interventions led to the reduction in rates for a period of over 600 days. The key drivers to this success included, surveillance, ongoing training, better documentation, vigilance, and the catheter insertion. The conclusion of this study was that the high quality training, coupled with compliance to the evidence based guidelines and the documentation process played a key role in the reduction of the CLABIS. The case study provides proof that the blood stream infections in the neonatal period have a significant effect on the length of stay in hospital, the accompanying costs, the mortality as well as the morbidity. A further study shows that there is a strong correlation between the neonatal infections and the neurodevelopmental outcomes in preterm infants. The study concludes that the reduction in CLIBSI is not an easy undertaking. It calls for an intervention, a follow up data and team development. The specific goal is to ensure that there is sustenance of zero CLABIS rate for a period of not less than 1 year.

There is a way in which the nurse-driven quality improvement intervention could be used to reduce the hospital-acquired infections (HAIs) in the NICU according to Ceballos et al (2013). The study establishes that there are many cases of HAIs, which increase the morbidity in the neonatal intensive care settings. The Ventilator–associated Pneumonia (VAP) and the CLABSI are usually expensive to undertake and eradicate as far as the Center for Disease Control and Prevention is concerned. The research was carried out in the form of a quality control study. There was the development of the neonatal specific education modules for the nurses in the neonatal nurse heads with the aim being the reduction in the CLABSI rates. The initiation of the CLABSI checklist was designed with the aim of having standardized infection control practices. There was a need to carry out a compliance audit in order to validate the implementation of VAP bundle. On the overall, there was a reduction in the number of hospital days by a record of 84 days. The savings in the hospital cost to the tune of $ 348, 000 that represents a CLABSI reduction by 92%, the central line days also reduced by 27%, VAP by 72 fewer days in hospital, and vent days' reduction was by 31 days. Nurses play a critical role in the improvement of healthcare. The bundled intervention in particular offers nurses with the opportunity to improve systems, feedback and the intervention compliance. On the part of the feedback, the nurses will receive a real-time communication on the change of the policy and how in the end it would impact on the state of health care in the neonatal setting. The bedside nurse should be empowered on the matter of the bundle implementation as well as the increased ownership as well as compliance with the practice and the eventual patient outcomes.

In Ohio, there was state-wide quality-improvement, which was collaborative to reduce the late onset sepsis in the preterm infants according to Kaplan et al (2011). The objective of the study was to reduce the onset of the bacterial infections in infants aged between 22 and 29

weeks. The collaborative quality improvement method was in particular found to be effective when it came to the implementation of the evidence-based catheter care. The method of the study involved a time-interrupted series on 24 Ohio NICUs. There were selected sites for the implementation of the evidence-based catheter care. There was the collection of data on the indwelling catheter care. The other data collected was on the episodes of infection, the catheter days and the patient days.

The results show that the compliance with the catheter and components for the indwelling catheter had reached a record 80.4% in December 2009. It led to a reduction in the number of infants with a baseline of between 18.2% and 14.3%. In conclusion, the study confirms that the late onset infection reduction by 20% was a result of the compliance with the evidence-based indwelling catheters, which was less than 90%. It turns out that a third of the infections were not related to the catheter. As a result, the study leaves the door open for the attention in other areas such as nutrition and skin integrity. It also implies that collaboration is a crucial component when it comes to the reduction in the bacterial infections in infants. The study fails in its hypothesis that there would be a reduction in the nosocomial infections because at the end of the study, the magnitude was less than hypothesized, which is 20%. However, it left some room for improvement of the process.

In a study by Kime, et. al. (2011) it presents another angle to the discussion on the reduction of the central line associated blood infection. In particular, the study looks at the results following the implementation of the infection control measures at a level 3 neonatal intensive care unit. The study opens by acknowledging that there has been significant advancement in the neonatology for those who need the central lines. The study identifies the

micro-preemies. After this critical study, it was found that the presence of CLABSIs led to various negative outcomes. Some of these include the prolonged hospitalization, mortality, and morbidity to name a few. It was also found that the health care education led to the reduction in the cases of CLABSI, which was a positive aspect. The core of the study was the comparison of the period before and after the catheter. The use of the intravenous tubing led to the increase in CLABIS from a day to three days. The re-introduction of neonatal intensive care staff to the interlink and after the intervention, there was a decrease in CLABSIs compared to the period before the intervention. In one particular case, CLABSIs reduced from 4.4/1000 to 0/1000 in reference to the catheter days. The conclusion of this study confirms that the evidence-based intervention studies have the potential to reduce CLABSIs.

In conclusion, out of the various measures to be used in the reduction of the central-line associated blood stream infections rates, the one control measure that is effective is the level 3 neonatal intensive care unit. The authors of the study have established that CLBSIs can be drastically reduced with the evidence-based measures. The changes in the catheter care provide the basis for the determination one whether there would be a reduction in the CLABSIs rates or not.

Can the Central –line associated bloodstream infection (CLABSIs) be reduced to 15% over a period of a year in NICUs? The study by Piazza et al (2016) seeks to establish how this could be achieved. Through testing, it would be possible to establish the prevention practices, which would be ideal for the reduction of CLABSIs. There are a few approaches, which were used. They included the expert opinion, benchmarking, and literature review. The methods available include the use of central venous catheter access limitation, the hub care monitoring,

tubing change technique, and lastly, the central venous catheter removal monitoring. All these methods would come handy in checking the changes in the CLABSIs rates for all the 17 centers, which were part of the study. The aim was to find the one that would reduce CLABSIs the most.

The results showed that in 1000-line days, CLABSIs reduced by 19.28% and that a record 16 out of the possible 17 achieved compliance that was greater than 75%. Hub scrub compliance monitoring and sterile tubing change reduced the CLABSIs rates by 1.25 for 1000 line –days. The report showed that the six groups or centers had managed to reduce the infection rates by some reasonable margins. The conclusion of this study shows that there was generally a reduction in the CLABSIs rates where multicenter improvement collaborative is used. Secondly, the study establishes that the orchestrated testing led to the reduction in the infection rates through infection monitoring. Meanwhile, there was the sterile tubing change, which combined with the hub scrub compliance to enhance the efforts in reduction of the CLABSIs rates. Consequently, this report acknowledges that it is possible to make quality improvement through orchestrated testing, leading to the reduction in the CLABSIs rates. Evidently, there occurs a significant reduction in CLABSIs rates if the correct approaches are used.

There can be a CLABSI's reduction strategy as Wilder et al (2016) confirms in a study. This study considers the systematic central line quality improvement through the integration of the line-rounding principles as well as the team approach. The background study is based on CLABSIs as the main cause of Hospital Acquired Infections or HAIs. These infections cost hospitals millions of dollar every year. There is evidence-based literature, which has shown through a review that a systematic team method would provide an effective line maintenance would play an important role in the reduction of CLABSIs rates.

The purpose of the study was to evaluate how the quality improvement could be used to reduce the CLABSIs rates and especially in relation to the neonatal intensive care unit. In 2011, there was a reduction in the rates by at least a half, which are equivalent to 3.9 per every 1000 line days. The other suggested methods include the use of team members, competencies and techniques. There were specific criteria to be used in the performance of the daily line rounds in the case of sterile techniques.

The findings show that the central line–associated blood stream infection rate was significantly reduced with an improvement of 92%. This can also be expressed as a reduction from 3.9 to 0.3 for every 1000 line days in 2011 and 2014 respectively. The implication of the practice was to the effect that the dedicated CLABSIs team, which significantly impacted on the CLABSI rates in the neonatal intensive care units. Further, the research shows that there is more that needs to be done in order to establish, which team approach would be effective in the reduction of the hospital-acquired infections, the acquired ulcers and the UTIs. In conclusion, it is evident that the use of the CLABSIs reduction strategy should be adopted in the neonatal intensive care setting in order to reduce the hospital-acquired infections.

If the guidelines for the prevention of the intravascular infections were followed, there would be a reduction in the cases of these infections. According to O'Grady et al (2011), the health care personnel developed these guidelines for use. The aim is to reduce and control the infections common in the hospital environment. Various organizations made up the working group such as the American Society of Critical Care Medicine. Reports and studies show that there are as many as 15 million central vascular catheter days. These are equivalent to the number of days where all the patients are exposed to the CVCs. Studies have shown that the

CLABSIs tend to increase the number of hospital days as the cost of hospital charges. The morbidity is also an important aspect of these infections. The multidisciplinary efforts should be utilized by the health care professionals and especially in the areas of the insertion and removal of the central vascular catheter, otherwise known as the CVC.

An effective prevention program is one that would involve the reduction of the CLABSIs in all the patient care units. There is evidence to the effect that the application of this approach would help in further reduction of the CLABSIs through the use of strategies and technologies. The authors propose four main recommendations, the first one being the education of the health care professionals. This education would help in the maintenance of the CVC and in particular, when it comes to the control measures. The second one is periodically assessing the knowledge and adherence to the laid down guidelines. The third one is the designation of the trained personnel, who have demonstrated the relevant competence when it comes to the insertion of the CVC. Lastly, one should ensure that there is the appropriate nurse staffing at all levels in the Intensive care unit. There are already records to show that a high number of nurses in relation to the CRBSI in the intensive care unit and especially where nurses manage the CVCs.

In the choice of the catheters and sites, there are some standard rules to follow. Some examples include, the upper extremity is the one that is preferred for the insertion of the catheter. Either the upper and lower limit can be used for the infants and neonates. The catheters should be used for their intended purposes as well as the duration they will be used. Steel needles should be avoided and especially in the administration of fluids as well as the medication due to the high risk of necrosis in the tissues. The midline catheters are preferred to the short peripheral

catheters. Lastly, observe if the patient develops complications such as phlebitis, which is associated to the peripheral venous catheter.

Can the rate of bloodstream infection in patients be reduced to zero? According to Yaseen et al (2016), this is feasible; hence the project to reduce the rate of the line associated bloodstream infection in the ICU infections. The target, in this case, should be zero. The Central Venous Catheters have been found to be highly effective when it comes to saving the lives of patients in the Intensive Care Units since they enable them in the provision of medication as well as the fluids. After a team evaluated the compliance to the CL Bundle, it was found to have an impact on the rate of CLABSIs rate. It was observed that the CL Bundle attained the compliance of 98%; there was a reduction in the rate of CLABSIs. In the subsequent years, this increased to 100%. Eventually, the target of zero was achieved where the compliance was 100%. The implementation of CL Bundle would be necessary if one is to be able to reduce the CLABSIs to zero within a given period. However, as this study confirms, these catheters are usually not as safe as one might think. They could potentially cause life-threatening bloodstream infections. As a result, there is a need to ensure compliance to the Central Line Bundle

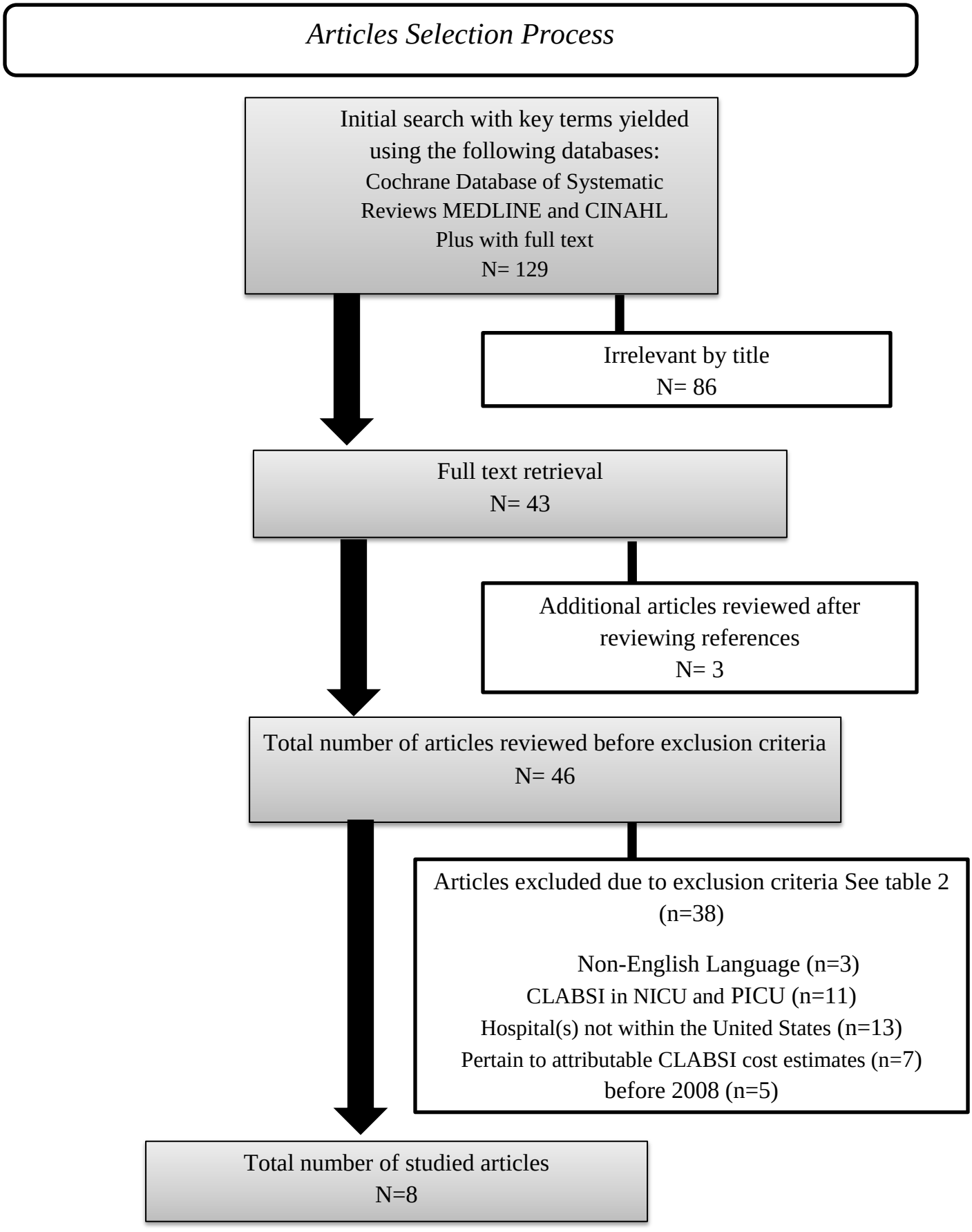
It was evident that CLABSI bundle found to be effective reducing infections significantly in adults but the study was not able to endorse a specific component that helped the most in reducing infection. However, it is suggested that future research should gear its focus into determining what specific process promote the effective implantation of prevention recommendation and moreover be able to recommend a specific bundle element that helped in the reducing rates the most.

Moreover, the study found the following bundle element to be most effective in reducing infection rates: 1) insertion technique, 2) maintenance and 3) collaborative action. Insertion techniques include: Specifically trained dedicated PICC team, Use of maximum sterile barriers and Chlorhexidine or povidone-iodine allowing the antiseptic to completely dry. Maintenance includes: Hub care; Disinfect using a vigorous 15-second scrub time with each subsequent entry, Allow the agent to dry before access, Standardized IV tubing changes with sterile technique and 2-person and Minimize add on-devices. Lastly, Collabrative Actions were found to be crucial in the process of reducing infection rats as it showed the most significant impact and includes: Bedside audits, Procedural checklist, ongoing discussion and education and Reporting compliance is associated with lower CLABSI rates

All eight articles studied the effectiveness of the bundle as a whole component and how there is a great correlation between the compliance rate and reduction rate. Further studies should shift its goal to assess the success of one particular bundle element. It is clear in the two studies that achieved a 0 infection rate have used more elements recommended by the CDC shown in Table 3. But one conclusion can be drawn from both studies is they both were heavy on reeducating the staff on all aspects of central line which was correlated to an increase in compliance rate. In order for hospitals to continue in maintaining CLABSI bundle compliance, a consistent audit and education for new hire must be strictly enforced and remain in place at all time. Preventing medical errors and hospital acquired infections in all patients' population is a crucial and essential to all hospitals, and the continuation of research about this topic is key to achieving patient safety in the neonatal intensive care units.

APPENDIX A: LIST OF FIGURES

Figure 1: Systematic Review Flowchart



APPENDIX B: LIST OF TABLES

Table 4: Abbreviations used in the text

Abbreviations	
BSI	Bloodstream infection
CDC	Centers for Disease Control and Prevention
CLABSI	Central line associated bloodstream infection
CL	Central line
CVC	Central venous catheter
DHHS	Department of Health and Human Services
EIP	Emerging Infection Program
HAI	Hospital acquired infection
LOS	Late onset sepsis
NHSN	National Healthcare Safety Network
NICU	Neonatal Intensive Care Unit
PICC	Peripherally inserted central catheter
SSI	Surgical Site Infection
TPN	Total Parenteral Nutrition
UTI	Urinary Tract Infection
VAP	Ventilator Associated Pneumonia

Tale 5: Exclusion Criteria

The following exclusion criteria were applied when searching for articles to be included in the review:

• Articles not peer reviewed were excluded
• Studies conducted in mixed patient group (eg, children's hospital) were excluded
• Articles published before 2008 were excluded
• Articles related to non-human subjects were excluded
• Articles published in a language other than English were excluded
• Articles where CLABSI was assessed in patients other than newborn were excluded
• Articled were CLABSI was assessed outside of NICU were excluded
• Articles conducted outside of the United States were excluded
• Studies pertaining to bloodstream infection that are not HAI were excluded

Tale 6: Excluded Articles

References (APA)	Reason for Exclusion
Almeida, C. C. de, Pissarra da Silva, S. M. S., Flor de Lima Caldas de Oliveira, F. S. D., Guimarães Pereira Areias, M. H. F., & Guimarães Pereira Areias, M. H. F. (2017). *Nosocomial sepsis: evaluation of the efficacy of preventive measures in a level-III neonatal intensive care unit. Journal of Maternal-Fetal & Neonatal Medicine*, 30(17), 2036–2041. https://doi-org.ezproxy.net.ucf.edu/10.1080/14767058.2016.1236245	Pertains to hospital(s) not within the United States
Aly, H., Herson, V., Duncan, A., Herr, J., Bender, J., Patel, K., & El-Mohandes, A. A. E. (2005). *Is bloodstream infection preventable among premature infants? A tale of two cities. Pediatrics*, 115(6), 1513–1518. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=https://search-ebscohost-com.ezproxy.net.ucf.edu/login.aspx?direct=true&db=cmedm&AN=15930211&site=eds-live&scope=site	Before 2008
Andersen, C., Hart, J., Vemgal, P., & Harrison, C. (2005). *Prospective evaluation* of a multi-*factorial prevention strategy on the impact of nosocomial infection in very-low-birthweight infants. The Journal Of Hospital Infection*, 61(2), 162–167. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=https://search-ebscohost-com.ezproxy.net.ucf.edu/login.aspx?direct=true&db=cmedm&AN=16240469&site=eds-live&scope=site	Before 2008
Arnts, I. J. J., Schrijvers, N. M., van der Flier, M., Groenewoud, J. M. M., Antonius, T., & Liem, K. D. (2015). *Central line bloodstream infections can be reduced in newborn infants using the modified Seldinger technique and care bundles of preventative measures*. Acta Paediatrica (Oslo, Norway: 1992), 104(4), e152–e157. https://doi-org.ezproxy.net.ucf.edu/10.1111/apa.12915	Pertains to hospital(s) not within the United States
Bradford, N. K., Edwards, R. M., & Chan, R. J. (2015). *Heparin versus 0.9% sodium chloride intermittent flushing for the prevention of occlusion in long term central venous catheters in infants and children. COCHRANE DATABASE OF SYSTEMATIC REVIEWS*, (11). https://doi-org.ezproxy.net.ucf.edu/10.1002/14651858.CD010996.pub2	Pertains to CLABSI in both NICU and PICU

Brooker, R. W., & Keenan, W. J. (2007). *Catheter related bloodstream infection following PICC removal in preterm infants. Journal of Perinatology*, (3). Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=https://search-ebscohost-com.ezproxy.net.ucf.edu/login.aspx?direct=true&db=edsgao&AN=edsgcl.183337775&site=eds-live&scope=site	Before 2008
Carraro, F., Cicalese, M. P., Cesaro, S., De Santis, R., Zanazzo, G., Tornesello, A., … Giacchino, M. (n.d.). *Guidelines for the use of long-term central venous catheter in children with hemato-oncological disorders. On behalf of supportive therapy working group of Italian Association of Pediatric Hematology and Oncology (AIEOP). ANNALS OF HEMATOLOGY*, 92(10), 1405–1412. https://doi-org.ezproxy.net.ucf.edu/10.1007/s00277-013-1794-1	Pertains to CLABSI in NICU and PICU
Vital signs: central line-associated blood stream infections--United States, 2001, 2008, and 2009. (2011). MMWR. Morbidity And Mortality Weekly Report, 60(8), 243–248. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=https://search-ebscohost-com.ezproxy.net.ucf.edu/login.aspx?direct=true&db=cmedm&AN=21368740&site=eds-live&scope=site	Pertain to calculated attributable CLABSI cost estimates
Chandonnet, C. J., Kahlon, P. S., Rachh, P., DeGrazia, M., DeWitt, E. C., Flaherty, K. A., … Agrawal, P. B. (n.d.). *Health Care Failure Mode and Effect Analysis to Reduce NICU Line-Associated Bloodstream Infections. PEDIATRICS*, 131(6), E1961–E1969. https://doi-org.ezproxy.net.ucf.edu/10.1542/peds.2012-3293	Pertains to CLABSI in NICU and PICU
Cosgrove, S. E. (2006). *Evidence that prevention makes cents: Costs of catheter-associated bloodstream infections in the intensive care unit. Critical Care Medicine*, 34(8), 2243–2244. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=https://search-ebscohost-com.ezproxy.net.ucf.edu/login.aspx?direct=true&db=cmedm&AN=16883193&site=eds-live&scope=site	Pertain to calculated attributable CLABSI cost estimates
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