An-Najah National University

Faculty of Graduate Studies

THE IMPACT OF THE PROTOCOL CENTRAL LINE BUNDLE CARE ON CATHETER RELATED BLOOD STREAM INFECTION

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Critical Care Nursing, Faculty of Graduate Studies, An-Najah National University, Nablus - Palestine.

2024

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Dedication

This thesis is dedicated to my family, friends, teachers, and colleagues.

To my family, whose unwavering support, love, and encouragement have been my greatest source of strength. Your belief in me has been my constant motivation.

To my friends, for your understanding, patience, and endless support throughout this journey. Your companionship has been invaluable.

To my teachers, especially Dr. Aidah Alkaissi, whose guidance, wisdom, and expertise have been instrumental in the completion of this work. Your dedication to my academic growth has been inspiring.

To my colleagues, for your collaboration, insights, and encouragement. Your contributions have enriched this research in countless ways.

Thank you all for being an integral part of my journey.

Safaa Awad

Acknowledgement

First and foremost, I would like to express my deepest gratitude to Dr. Aidah Alkaissi, my supervisor, for her invaluable guidance, support, and encouragement throughout the course of this study. Her expertise and dedication have been instrumental in the completion of this thesis.

I am profoundly grateful to my family for their unwavering support and understanding. Your constant encouragement and belief in my abilities have been a source of strength and motivation during this challenging journey.

To my friends, thank you for your patience, support, and for always being there when I needed you. Your encouragement and understanding have meant the world to me.

I would also like to extend my appreciation to my colleagues for their collaboration and support. Your insights and feedback have greatly contributed to the development and completion of this research.

A special thanks to all the participants and staff involved in this study. Without your cooperation and contribution, this research would not have been possible.

Finally, I would like to acknowledge everyone who has directly or indirectly supported me in this endeavor. Your help and encouragement have been invaluable.

Thank you all.

Safaa Awad

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

THE IMPACT OF THE PROTOCOL CENTRAL LINE BUNDLE CARE ON CATHETER RELATED BLOOD STREAM INFECTION

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **Safaa Awad**

Signature: safa awad

Date: 10. 9. 2024

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THE IMPACT OF THE PROTOCOL CENTRAL LINE BUNDLE CARE ON CATHETER RELATED BLOOD STREAM INFECTION

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Abstract

Background: Currently, there is a need to reduce central line-associated bloodstream infections (CLABSIs). The aim of this study was to determine whether the implementation of the evidence-based guideline-based care bundle protocol while applying and managing central venous catheters can reduce CLABSIs among intensive care unit patients in a Palestinian hospital.

Methods: The study utilized a quasi-experimental design. This design used retrospective and prospective approaches. The CLABSIs that occurred before the implementation of the evidence-based guideline-based care bundle protocol were collected retrospectively during a 12-month period (Control period: January 2022 to December 2022). The CLABSIs that were detected after Implementing the evidence-based guideline-based care bundle protocol were collected prospectively over a 12-month period (Intervention period: January 2023 to December 2023). The site of the study was an adult intensive care unit in the southern region area of the West Bank of Palestine.

Results: The study included 354 intensive care unit patients. Of those, 177 (50%) were in the control period and 177 (50%) were included in the intervention period. The adherence to the bundle care protocol was usually good, with most components ranging from (85.9% to 89.8%). The WBC count of the patients in the control period was significantly higher than that of the patients in the intervention period (p value < 0.001). Similarly, the percentage of monocytes of the patients in the control period was significantly higher than that of the patients in the intervention period (p value = 0.027). Moreover, the percentage of lymphocytes of the patients in the control period was significantly higher than that of the patients in the intervention period (p value < 0.001).

The CRP values of the patients in the control period were significantly higher than those of the patients in the intervention period (p value = 0.010). There was a statistically significant higher incidence of CLABSIs before implementing the bundle care protocol (control period) (n = 71, 40.1%) compared to the period after implementing the bundle care protocol (intervention period) (n = 41, 23.2%) (p < 0.001). Although there was a difference in the mortality rates between the period before implementing the bundle care protocol (n = 45, 25.4%) compared to the period after implementing the bundle care protocol (n = 33, 18.6%), however, this difference was not statistically significant (p = 0.158).

Conclusions: The results of this study showed that the use of the evidence-based guideline-based care bundle protocol significantly decreased the occurrence of CLABSIs in patients in the intensive care unit. Although compliance with the majority of aspects of the protocol was excellent, further efforts to improve adherence to daily line necessity evaluations should further optimize patient outcomes. Future research should prioritize investigating methods to maintain consistently high rates of adherence and examine the enduring effects of these regimens on patient morbidity and death.

Keywords: Bundle; Central venous catheter; Blood stream infection; Central line-associated bloodstream infections; Intensive care unit; Nurses.

Chapter One

Introduction and Theoretical Background

A central venous catheter (or a central line catheter) is an indwelling device inserted into a large, central vein located within the neck (internal jugular vein), chest (subclavian vein), arms (basilic vein or cephalic vein), or groin (femoral vein) of the patients (Card et al., 2023; Mavrovounis et al., 2020). Central venous catheters are often placed for a primary function of withdrawing blood, for total parenteral nutrition, administration of fluids, and/or administration of drugs.

During different medical/surgical procedures, central venous catheterizations are frequently performed for patients in the critical or intensive care units (Card et al., 2023). Those patients often have restricted peripheral access or are receiving vasoactive drugs. It is important to note that central line catheters can be inserted for either temporary or permanent purposes while caring for patients with conditions medical/clinical conditions including shock, decompensated heart failure, and/or pulmonary hypertension (Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022). In addition, central line catheters can be used for patients who are on hemodialysis, fluid resuscitation, and those who need monitoring of their hemodynamic parameters.

It is common that central venous catheters are placed for a long period of time. When the central venous catheters remain in place for a long period of time, this can increase the risk of bloodstream infections that are caused by pathogens that pass from the central venous catheters into the bloodstream (Card et al., 2023). These infections are referred to as CLABSIs. The Centers for Disease Control and Prevention (CDC) has offered guidelines, awareness materials, and recommendations aimed at preventing or minimizing the incidence of these CLABSIs (Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022).

Diseases acquired while patients are admitted to hospitals including CLABSIs can result in considerable morbidity and mortality in different hospitals around the globe (Chovanec et al., 2021). Furthermore, these infections have also led to a rise in healthcare costs. CLABSIs are often seen in hospitals and are frequently linked to substantial patient morbidity and fatality rates. (Chovanec et al., 2021).

Hospital-acquired infections are defined as the infections that are acquired after patients have been admitted to hospitals. Manifestations and indications of these illnesses often appear within 48 h after admission of the patients to hospitals (Mouajou et al., 2022). Different types of infections, like CLABSIs, (CAUTIs catheter-associated urinary tract infections), HAP (hospital-acquired pneumonia), SSIs (surgical site infections), CDI (Clostridium difficile infections), and VAP (ventilator-associated pneumonia) are closely monitored by the CDC's National Healthcare Safety Network (Monegro et al., 2021).

In modern healthcare systems, central venous catheters are essential medical equipment (Maria et al., 2021). According to the CDC, more than (50%) of patients in intensive care units in America need central venous catheters. This results in a total of 15 million central venous catheters being used on a daily basis each year (Hemberg et al., 2023; Zingg et al., 2023). Central venous catheters can be inserted to hemodynamic monitoring of patients, administration of fluids, administration of medications, infusion of blood derivatives, and providing parenteral nutrition (Böll et al., 2021; Hemberg et al., 2023; Zingg et al., 2023). There are many advantages of using central venous catheters. However, the use of central venous catheters can also be linked to potential risks that clinicians and healthcare providers should not underestimate. CLABSIs are one of these potential risks that were shown to be linked to the use of central venous catheters (Card et al., 2023).

Many previous studies have reported that bloodstream infections are prevalent among patients admitted to hospitals (Böll et al., 2021; Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022; Card et al., 2023; Chovanec et al., 2021). These bloodstream infections were confirmed using various laboratory testing methods. It is noteworthy mentioning that when the laboratory testing does not demonstrate the connection between the catheter and the infection, in most cases, the source of infection is attributed to the use of central venous catheters, i.e., CLABSIs. CLABSIs are often caused by bacteria that inhabit the skin, i.e., the normal bacterial flora of the skin. It has been proposed that these microorganisms contaminate the catheter insertion site, intravenous (IV) fluids, device connections, and may also spread via the bloodstream or by contact with healthcare staff's hands (Novosad et al., 2020; Star et al., 2024).

Researchers have established a correlation between the likelihood of contracting CLABSIs and some risk factors such as the type of infused solution, the duration of catheter use, training, skills, and expertise of the healthcare provider who inserts the central venous catheters (Alshahrani et al., 2023; Lafuente Cabrero et al., 2023; Moriyama et al., 2022).

The consequences of contracting CLABSIs can be significant, to the extent that the American Institute for Healthcare Improvement has included CLABSIs as one of the six primary initiatives in campaigns that aimed to save the lives of a hundred thousand patients initially and five million lives later (Chovanec et al., 2021; Mostafa et al., 2022; Pearlman, 2020). The campaigns sought to enhance patient care and prevent deaths by implementing straightforward and effective measures.

Currently, several techniques have been proposed to mitigate the risks of CLABSIs. The CDC has outlined specific strategies for preventing intravenous (IV) catheter-related infections in its recommendations, known as the recommendations for the prevention of IV catheter-related infections (Buetti et al., 2021; Van Den Bosch et al., 2022; Wu et al., 2020). The recommendations were developed to be implemented in clinical practice as a bundle. The Care Bundle Checklist for the Prevention of CLABSIs in Patients with a Central Line protocol (which were referred to as bundle in this thesis) is composed of measures that should be considered by the healthcare providers (physicians and nurses) while inserting central venous catheters. Adherence to the bundle is said to be crucial for ensuring the safety of the patients, and when the measures are implemented together, the bundle can significantly boost the outcomes of the patients (Salama et al., 2016). Adherence to the bundle needs continuous monitoring, education, and training of healthcare providers (physicians and nurses) on the best ways to insert central venous catheters. The continuous monitoring, education, and training should aim to prevent bloodstream infections including CLABSIs. No doubt, prioritizing adequate compliance with the recommended measures in the bundle and consistently applying them to the patients can ensure achieving optimal patient outcomes (Salama et al., 2016; Star et al., 2024).

Brachine, Peterlini, and Pedreira (2012) conducted an integrative review on the evidence-based measures that made up the bundle that was used to reduce CLABSIs in Brazil (Brachine et al., 2012). The review identified issues in translating and culturally

adapting key terms used to describe the bundle of measures that were used to reduce CLABSIs. It is noteworthy to mention that using appropriate and culturally relevant terminologies is essential for changing behaviors and adopting these measures in practice. The authors concluded that some researchers and clinicians often adopt the term of a "set of good practices" to describe the measures in the bundle (Brachine et al., 2012). Therefore, there has been some calls to establish a culturally specific synonym for its application in the approach.

To educate and train healthcare providers on implementing the bundle to reduce the incidence of CLABSIs, there were efforts made (Brachine et al., 2012). The type of catheter used, the prevalence of CLABSIs-causing bacteria among the patients, and the practical steps that could be taken to decrease the incidence of CLABSIs were discussed (Brachine et al., 2012).

The minimum number of measures or interventions was 3 while the maximum was 6 in most cases using the bundle (Atia, 2020; Brachine et al., 2012; Costa et al., 2020; Karapanou et al., 2020; Lin et al., 2017). According to most studies included in this integrative review, it was found out that applying a bundle led to significant reduction in rates of CLABSIs (Brachine et al., 2012).

The practice of hand washing, widely recognized as one of the primary preventive interventions against nosocomial infections, was referenced in the majority of the studies (Brachine et al., 2012; Burke et al., 2021; Jeong et al., 2013).

Aside from hand washing, using chlorhexidine gluconate as a skin antiseptic, implementing maximum barrier precautions (such as wearing a mask, cap, sterile apron, and sterile gloves, and maintaining a sterile field around the patient), and minimizing the use of the femoral vein for access wherever feasible were also suggested as preventive strategies (Burke et al., 2021; LeMaster et al., 2014; Madran et al., 2022).

Using an alcoholic solution of chlorhexidine gluconate with a concentration of at least (0.5%) as an antiseptic treatment for the skin before inserting a central venous catheter was strongly recommended based on well-designed randomized clinical studies (Denkel et al., 2022; Shah et al., 2016). This recommendation was supported by IA-level-of-evidence, indicating a high level of confidence (Brachine et al., 2012; Jeong et al., 2013;

Madran et al., 2022; Scheithauer et al., 2014). Alternatively, (70%) alcohol and tincture of iodine can also be used as antiseptics (Alhamwi, 2018; Brachine et al., 2012; DeVries, 2016). A previous study reported the use of tincture of iodine as an antiseptic for children's skin (Humar et al., 2000; Little et al., 1999). Nevertheless, the study did not provide statistically significant outcomes.

The use of maximal barrier precautions while inserting a central venous catheter was a recommendation made by the Infection Control and Barrier Precautions Committee (IB-level-of-evidence) (Brachine et al., 2012).

The site of catheter insertion had a crucial role in the occurrence of CLABSIs because it directly influenced the concentration of bacteria on the skin and the probability of thrombophlebitis (Marsh et al., 2020).

In interventional radiology, it is often recommended to avoid inserting central venous catheterization in the femoral vein of adult patients (Brachine et al., 2012). The subclavian vein is often considered more suitable site for central venous catheterization. On the other hand, femoral vein catheterization in children had a low incidence of mechanical obstacles as one part of Care Bundle Checklist for Prevention of CLABSIs in Patients with Central Line protocol (Brachine et al., 2012).

As one way of reducing the incidence levels of CLABSIs (IB-level-of-evidence), use multidisciplinary clinician consultation. During such kind meetings between multidisciplinary clinicians, there is often regular assessment done to ascertain whether there is need for central venous catheterization or not (Brachine et al., 2012). Compliance with the different measures in the bundle was shown to increase the safety of the patients, reduce the rates of hospital acquired infections, and improve the outcomes of the patients (Brachine et al., 2012).

In addition to these various steps, other approaches were outlined so as to prevent/minimize CLABSIs. These included; Chlorhexidine gluconate impregnated dressings, use of antibiotics or antiseptic impregnated catheters, central venous catheterization guided by ultrasound and modifying routine procedures for changing connectors and sets (Brachine et al., 2012).

Many recommendations have been made for training healthcare providers (physicians and nurses) in order to educate them about measures contained within a bundle (Brachine et al., 2012; Burke et al., 2021). Moreover, having a group of healthcare providers handle insertion of central venous catheters as well as bandaging can facilitate best practice and adherence to bundled recommendations. It could be useful if this staff adopted procedural checklists in order to follow-up on bundle compliance (Brachine et al., 2012; Burke et al., 2021).

The patients' safety was increased while hospital-acquired infection rates decreased as a result of different bundles' compliance (Lin et al., 2017; Salama et al., 2016). Measures in the package were approved by World Health Organization (WHO) and CDC but at the same time, they emphasized that their observance would play a crucial role in reducing hospital acquired infections like CLASBIs (Brachine et al., 2012; Burke et al., 2021; Lin et al., 2017; Salama et al., 2016).

Also worth noting is that there is no definitive evidence of the bundle's capability to prevent or lower cases of CLASBIs, and increase patient outcomes in different hospitals' intensive care units. However, there had been positive results earlier reported which suggested that compliance with measures and interventions within such a bundle had reduced the incidence of blood stream infections including CLASBIs when applied together as a bundle (Burke et al., 2021; Card et al., 2023; Chovanec et al., 2021; Lafuente Cabrero et al., 2023; Madran et al., 2022; Maria et al., 2021; Monegro et al., 2021; Mostafa et al., 2022; Mouajou et al., 2022; Star et al., 2024; Zingg et al., 2023).

The literature described the measures in the bundle as: practicing hand hygiene before handling the catheter, using chlorhexidine gluconate as a skin antiseptic, taking maximum precautions when inserting a central catheter, covering the device with a sterile transparent semipermeable dressing and replacing it whenever it becomes dirty, wet, or unattached, using catheters that are impregnated with antibiotics or antiseptics, reviewing the necessity of the catheter daily and removing it immediately when it is no longer necessary, educating staff members; and conducting procedure audits using a checklist (Burke et al., 2021; Card et al., 2023; Chovanec et al., 2021; Lafuente Cabrero et al., 2023; Madran et al., 2022; Maria et al., 2021; Monegro et al., 2021; Mostafa et al., 2022; Mouajou et al., 2022; Star et al., 2024; Zingg et al., 2023).

The literature provided different recommendations to prevent the incidence of CLABSIs in patients to whom central venous catheters were inserted. Among these recommendations, the bundle was suggested as the most effective in preventing the incidence of CLABSIs (Atilla et al., 2016; Burke et al., 2021; Entesari-Tatafi et al., 2015; Furuya et al., 2016; Galpern et al., 2008; Jeong et al., 2013; Lin et al., 2017; O'Neil et al., 2016; Tang et al., 2014). The bundle prioritized five essential components: chlorhexidine antiseptic, hand hygiene, catheter site selection, maximum sterile barrier, and daily assessment of the need for the central venous catheter. Once a central venous catheter device was inserted, nurses are supposed to provide evidence-based care and support measures (Jarding & Makic, 2021).

1.1 A brief review of the relevant literature

Gupta et al investigated the efficacy of various strategies and approaches in preventing the incidence of CLABSIs (Gupta et al., 2021). The treatments and methods consisted of introducing preventative bundles, providing healthcare personnel with training on simulations for central venous catheter insertions, and using standardized and real-time bundle monitoring via direct observations. The study reported that CLABSIs rates decreased to 0.4 per 1000 device-days after the implementation of the measures compared to 3.1 per 1000 device-days before the implementation of the measures (Gupta et al., 2021). In addition, applying the measures in the bundle and monitoring the process by directly observing the healthcare providers (nurses and physicians) yielded significant and long-lasting decrease in the rate of occurrence of CLABSIs among patients in the intensive care units. It is of note to mention that because randomized controlled clinical trials were not conducted, it was not possible to assess the efficacy of each measure in the bundle. Additionally, no control group was used. This precluded a conclusion on the efficiency of each measure separately. A large group of experts who had expertise in different domains were included. This facilitated the decision-making process and allowed generation of recommendations. Several concerns were identified by the diverse panel of experts who were included in the study. Recommendations were developed to address these concerns. The study concluded that the simulations were effective in enhancing the learning, training, and skills acquisition by the healthcare providers who could adhere to the recommended measures and reduce the incidence of CLASBIs (Gupta et al., 2021).

A quasi-experimental study was conducted by Marra et al (2011) that was aimed at reducing the incidence of CLABSIs in intensive care units (Marra et al., 2011). In this study, the researchers implemented different measures and interventions. It was ensured that all patients requiring central venous catheters received them according to Institute for Healthcare Improvement (IHI) central line bundles in the ICUs. The IHI central line bundle resulted in an incidence rate of 3.2 per 1000 catheter-days for CLABSIs as against a previous figure of 6.4 per 1000 catheter-days with a decline of up to half just after introduction (Marra et al., 2011). The study was conducted in two phases. The first phase was between 2005 and 2007 and the second phases was between 2008 and 2010. A total of 34 articles were included in the review. The articles were assessed and classified using an approach that was developed by the Joanna Briggs Institute. Different studies have used bundles of measures that included hand hygiene and strict barrier precautions. Additionally, catheters and bandages infused with antimicrobial agents were also used (Marra et al., 2011).

Pereira et al conducted a systematic review covering research studies conducted on management and maintaining central venous catheters (Pereira et al., 2024). The search was performed through such databases as PubMed, Scopus, Cinahl, Web of Science, Lilacs, Bdenf and Cochrane. The literature was searched in March 2021. A total of 34 articles were included in this review. Articles were then critically appraised and ranked using Joanna Briggs Institute criteria. Some studies have used bundles of measures including hand hygiene and strict barrier precautions. Catheters infused with antimicrobial agents have also been used as well as bandages. These measures were also coupled by active participation and engagement of the healthcare providers (physicians and nurses) who joined efforts to reduce the incidence of CLABSIs (Pereira et al., 2024). The review concluded that applying bundles of care, provision of educational sessions to healthcare providers, and supporting adherence to the measures in the bundles can successfully result in the reduction of CLABSIs rates among patients admitted to intensive care units (Pereira et al., 2024).

Another systematic review that was conducted by Frost et al that included studies investigating the efficacy of chlorhexidine bathing to reduce the risk of infections among intensive care unit patients (Frost et al., 2016). The review focused on the studies that included bloodstream infections, CLABSIs, infections caused by multi-drug

resistant bacteria, ventilator-associated pneumonia, and catheter-associated urinary tract infections. Cluster randomized cross-over studies and randomized controlled trials were included in the review. A comprehensive summary of the available evidence on the efficacy of chlorhexidine bathing to reduce the occurrence of hospital-acquired infections was generated using a trial sequential analysis (Frost et al., 2016). A total of 5 studies were included in the final analysis. Of those, 2 were randomized-controlled trials and the others were cluster-randomized-crossover trials. The review concluded that continuous use of chlorhexidine bathing on daily basis can reduce the incidence of bloodstream infections among the patients in the intensive care unit by about one-third, CLABSIs by about (40%), and infections caused by multi-drug-resistant bacteria by about (18%). The review also concluded that there was no significant decrease in the catheter-associated urinary tract infections or ventilator-associated pneumonia among the patients admitted to the intensive care units (Frost et al., 2016).

Mudd et al included the development of a survey by specialists in CLABSIs within the hospital's team responsible for epidemiology and infection management (Mudd et al., 2022). The survey was created using a Delphi approach. The survey used elements from the institution's evidence-based central venous catheter insertion and maintenance bundles in order to prevent/reduce CLABSIs. The survey was tested with individuals who were very focused on achieving infection control perfection, in order to ensure that it was clear and relevant to evidence-based procedures particular to hospitals. The feedback was casual. Qualtrics survey was sent to nurses and physician assistants employed at a single, prominent metropolitan academic medical institution via an email sent via a hospital email list. The study participants were requested to provide feedback on several aspects including central venous catheter insertion, maintenance, and daily procedures. Furthermore, the participants were requested to mention the obstacles to the implementation of evidence-based procedures for preventing CLABSIs. The questionnaires were delivered to about 220 advanced practice providers who worked in inpatient and specialist services and provided care for both adult and pediatric patients. The research team was unaware of any connection between the respondents and the survey findings. The results indicated that the majority of advanced practice providers (85%) that participated in the study do not use central venous catheters. The participants who performed central venous catheter insertions (n = 6) were requested to provide details on the components of the central venous catheter insertion bundle, which

encompasses the use of maximal barrier precautions and the selection of the most suitable site. Participants stated that they consistently used a central line insertion kit including sterile gowns, masks, full-body drapes, and other necessary items. They also expressed a high level of confidence and expertise in choosing the most suitable central venous catheter to limit the risk of CLABSIs (Mudd et al., 2022).

The central venous catheter maintenance bundle addressed various aspects, such as daily assessment of the need for the central line, administration of medications using peripheral or oral routes, using standardized tools to address line-related issues, identifying the duration of line placement, assessing the central venous catheter site, and daily chlorhexidine bathing treatments (Mudd et al., 2022). While the majority of respondents stated that they did not implant central venous catheters, a significant proportion (87.5%) of respondents did manage or treat patients with central venous catheters. Additionally, (40%) of respondents reported managing or treating patients with central venous catheters throughout every shift. Only (12.5%) of the respondents claimed that they had never managed or treated patients with central venous catheters. Regular assessment of the need of the line was a crucial element of the maintenance package. When questioned about a typical clinical day, (56%) of respondents who manage/treat patients with central venous catheters stated that the necessity for the central venous catheter was considered/discussed "sometimes", while (44%) stated it was considered/discussed "always" for each patient with a central venous catheter.

Participants were asked to indicate the predominant methods used for discussing the need of central venous catheter during rounds. Examples provided include Kamishibai cards (often referred to as K-cards), an algorithm, a tool, or other approaches that may be discerned in free-text replies (Gabriel et al., 2024). A total of sixteen replies were received. The majority (75%) of the participants stated that the conversation on the need for a central venous catheter occurred mostly via oral exchanges, either at patient presentations or when assessing and arranging daily care. There was no mention of any particular instrument. Four individuals (25%) reported use unit-based harm prevention, K-cards, or a rounding tool.

Advanced practice providers used several methodologies to ascertain the duration of their patients' central venous catheters (Huang et al., 2021). The majority (76%) of responders who managed/treated patients with central venous catheters used chart

review. Some individuals used a rounding tool (9%) or received notifications during interdisciplinary patient care rounds (9%). No responders have reported using a huddle board. Responders were given the opportunity to offer written replies, stating that conversations about the length of the line took place either during the transfer of responsibility between provider teams (3%) or via a mix of other approaches (3%). (55%) of respondents stated that shifting medications/fluids from central to peripheral or oral routes was discussed "always" on a normal clinical day for each patient with a central venous catheter. Forty-two percents claimed that this conversation "sometimes" happened, while (3%) reported that it "never" occurred. According to the advanced practice providers, they were the ones who started discussing about the need for central venous catheter and the administration of fluids or drugs. They initiated these conversations (38%) of the time and did so sometimes (63%) of the time. The central venous catheter dressing was directly examined by the advanced practice providers or a team member "always" (48%) of the time, "sometimes" (42%) of the time, and "never" (9%) of the time on a normal clinical day (Huang et al., 2021).

A prescription for daily chlorhexidine bathing treatments was necessary for patients with central venous catheters, unless there were contraindications such as age/weight limits or allergy (Martinez et al., 2020; Rupp et al., 2012; Tien et al., 2020). While central venous catheters were often included in standard order sets, they were not necessarily prescribed if a central venous catheter was already present at admission. Participants were queried about the frequency with which they verified the prescription of chlorhexidine for their patients with central venous catheters. Thirty-three percents of the respondents said that they never verify if chlorhexidine had been ordered, (39%) reported doing so occasionally, and (27%) reported usually confirming this.

When questioned about their comfort level in discussing the significance of chlorhexidine bathing treatments with patients, the majority of advanced practice providers who manage/treat patients with central venous catheters reported feeling either "extremely comfortable" (42%) or "somewhat comfortable" (30%) in engaging in these talks (Pasalioglu & Kaya, 2014). Fifteen percents of individuals got a "somewhat uncomfortable" feeling, while (12%) experienced an "extremely uncomfortable" feeling while discussing the significance of chlorhexidine bathing treatments with their patients.

Prakash et al conducted a study in a tertiary care hospital in South India (Prakash et al., 2017). The study's duration spanned from January 2016 to September 2016 and was divided into three distinct stages, with each phase lasting for a period of 3 months. While implementing, bundle care documents were introduced in all intensive care units and the intensive care unit personnel received fundamental instruction on the importance and effects of the bundle care strategy.

The incidence rates of device-associated infections, such as ventilator-associated pneumonia, CLABSIs, and catheter-associated urinary tract infections, were calculated over the whole duration of the study (Hassan et al., 2019; Prakash et al., 2017). The study findings demonstrate that the implementation of a care package approach has a substantial impact on reducing healthcare-associated illnesses (Hassan et al., 2019).

Rosenthal et al performed a research that examined the effectiveness of this approach in reducing incidence of CLABSIs and associated mortality (Rosenthal et al., 2010). The study included 86 intensive care units. The cumulative CLABSIs rates were compared between the baseline period (first 3 months) and subsequent 6-month intervals across a span of 24 months in a total of 53,719 individuals (with a combined total of 190,905 central line–days). Baseline surveillance findings were compared with data from the intervention period. The results demonstrated a (33%) reduction in CLABSIs incidence over the first 6-month period, with the number of CLABSIs per 1,000 central line-days decreasing from 14.5 to 9.7. During the first 24 months, there was a total decrease of (54%) from the starting point (from 16.0 to 7.4 CLABSIs per 1,000 central line–days). The relative risk was 0.46 (with a 95% confidence range of 0.33–0.63), indicating a significant reduction. The p-value was less than 0.001. There was a (58%) drop in the mortality rate among individuals with CLABSI. During the intervention period, there was a significant improvement in hand hygiene adherence, increasing from (50%) to (60%) (p-value <0.001). The percentage of intensive care units that used maximal sterile barriers at insertion also increased significantly, from (45%) to (85%) (p-value <0.001). Additionally, there was an increase in the adoption of chlorhexidine for antisepsis, from (7%) to (27%) (p-value = 0.018), and in the percentage of units that sought to remove unneeded catheters, from (37%) to (83%) (p-value = 0.004). Furthermore, the duration of central line placement decreased from 4.1 to 3.5 days (p-value <0.001). It was noted that authors of this article had a strong belief in the fact that

the use of education, performance feedback and monitoring of CLABSI rates would enhance infection control adherence. These findings indicated a reduction in the rate of CLABSIs by (50%) as well as decrease in number of patients who died from CLABSIs within first two years (Rosenthal et al., 2010).

The central line bundle comprises four essential components (Lee et al, 2018): 1) hand hygiene; 2) applying strict sterile barrier precautions; 3) using chlorhexidine; and 4) selecting the appropriate venous access site (Lee et al., 2018). This study took place between January2013 and December2016 with a total of 1672 patients enrolled during that time frame to assess adherence to central line bundling protocol and incidence of CLABSIs across intensive care unit, emergency room, general ward and operation room. During this period there were one thousand six hundred seventy-two patients. The study found out that there were twenty-nine cases of CLABSIs which occurred at an incidence rate of (1.73%) (Lee et al., 2018). About half or slightly more than half (49%) followed the central lines bundle simultaneously while others did it differently. In addition, compliance with practice varied among different wards within the hospital such as: emergency room (22.3%), ICU (28.5%), general ward (36.5%), operating room (84.6%) (Lee et al., 2018).

Wei et al performed a systematic review with meta-analysis of studies that evaluated use of chlorhexidine-impregnated dressing in preventing CVC associated infections (Wei et al., 2019). Main databases were searched to identify articles included in this systematic review with meta-analysis. The search was conducted up to 2018. The fixed-effects and random-effects models were used to estimate the pooled odds ratio (OR) and mean differences along with their (95%) confidence intervals (CI). Total of twelve randomized controlled trials were included in the review, which involved six thousand twenty-eight patients. According to this review, chlorhexidine-impregnated dressings reduced the odds of catheter colonization (OR = 0.46, 95% CI: 0.36 to 0.58) as well as reduced the odds of incidence of CLABSIs (OR = 0.60, 95% CI: 0.42 to 0.85) (Wei et al., 2019). Chlorhexidine-impregnated dressings showed a decrease in the occurrence rate of catheter colonization and CLABSIs among randomized controlled trials that had at least two hundred participants when subgroup analysis was carried out; however, there was no significant decrease in the occurrence rate of catheter colonization when the sample size was below two hundred participants. The review concluded that using

chlorhexidine-impregnated dressings can reduce the incidence of catheter colonization and CLABSIs (Wei et al., 2019).

In clinical practice, adherence is defined as the degree to which the healthcare provider's actions align with the advice given by the healthcare professional or the established procedure. Protocol adherence is often defined as the ratio of suggested actions that are actually executed. While all studies included data on adherence to the central line bundle guidelines, there was significant variation in the number of bundle components reported and the stated levels of adherence. None of the studies examined compliance with all 14 recommendations of the central line bundle checklist. Five studies documented existing procedures and conducted a comparative analysis with proposed recommendations (Brachine et al., 2012). Various research included adherence to the bundle with other treatments such as knowledge evaluation, teaching, feedback, and monitoring. Two research used direct observations to document adherence to rules, together with sample demographics and other observed details, in order to identify factors that predict compliance or non-compliance. Furuya et al replicated their 2011 research with a minor adjustment by examining both the overall compliance of bundles and the compliance of individual bundle items (Furuya et al., 2016). The purpose was to investigate the correlation between compliance with individual bundle items and overall compliance, as well as its impact on CLABSIs rates.

1.1.1 Inadequate compliance with guidelines

None of the studies documented full adherence to all of the components of the bundle (Brachine et al., 2012). The most often reported aspects were the components of hand cleanliness, selection of the optimal location for insertion, skin preparation using a solution containing more than (0.5%) chlorhexidine and alcohol before to insertion, and the use of dressings (Humar et al., 2000).

1.1.2 Hand cleanliness

The most often documented adherence item was the performance of hand cleanliness before central line placement. The level of adherence in non-interventional trials varied between (53% and 100%) (Brachine et al., 2012).

1.1.3 Location of insertion

Eleven studies indicated inconsistent selection of either the subclavian or internal jugular vein for inserting a central line (Brachine et al., 2012). The adherence to optimal site selection, as indicated by individuals, varied from (39% to 100%) in surveys. The before and post intervention investigations found that one intervention resulted in a (62%) compliance rate after the intervention, while the other intervention resulted in a (97%) compliance rate. Observational studies documented the greatest level of adherence, ranging from (94% to 100%).

1.1.4 Preparation of the location for insertion

The adherence to the preparation of the insertion site before placing the central line using a solution containing more than (0.5%) chlorhexidine and alcohol ranged from 4% to 100% (Brachine et al., 2012; Humar et al., 2000; Tien et al., 2020). There was significant variation in adherence levels across different countries. Two studies done in the United States provided data on adherence rates, which ranged from (53% to 64%) for always, (16% to 83%) for frequently, (1.6% to 85%) for occasionally, and (23.2%) for rare, never, or not responded (Furuya et al., 2011; Furuya et al., 2016). Two before and after intervention trials reported adherence rates of (40% and 99.6%) respectively (Jeong et al., 2013; Tang et al., 2014).

1.1.5 Maximal barriers to precaution

Some studies assessed the usage of maximum barrier precautions for central line insertion as a single overall item, whereas others measured each individual item (mask, cap, gown, sterile gloves, and sterile whole-body drape) separately (Brachine et al., 2012). The adherence to comprehensive maximum barrier precautions was found to be between (93% and 96%) in a major online study that compared high-income and middle-income nations. Adherence rates were reported as follows: (54%-56%) always, 16%-18% generally, (1.6%-85%) occasionally, and (23.3%) rare, never, or not measured (Burke et al., 2021). The studies that provided separate data for each item were conducted in Australia, Brazil, Egypt, and Yemen (Brachine et al., 2012; Burke et al., 2021). The use of a sterile full body drape exhibited the least adherence in all nations, ranging from (28% to 92%). This was followed by the cap, with compliance rates ranging from (32% to 96%). The gown had adherence rates between (52% and

97%), while the mask showed rates between (60% and 84%). On the other hand, sterile gloves shown the greatest compliance, ranging from (93% to 100%) (Burke et al., 2021). It is worth noting that no one country had the lowest or maximum adherence across all items.

1.1.6 Dressing

Out of the 19 trials, five reported using either gauze or clear semipermeable dressing after insertion, with adherence rates ranging from (0% to 100%) (Burke et al., 2021). A study found that there was no adherence to dressing standards after insertion, and all insertions were done in the operating room. The reported success rate for promptly replacing a wet, dirty, or dislodged dressing ranges from (73% to 99.7%) (Aloush & Alsaraireh, 2018). Only one research gathered data on adherence to aseptic technique during central line dressing changes. The study found that compliance ranged from (59% to 84%) (Burke et al., 2021). The adherence to recommended time intervals for changing dressings was seen to range from (4% to 90%) for gauze dressings, and from (22% to 85%) for semipermeable dressings.

According to the current recommendations from the CDC, it is recommended to use dressings with chlorhexidine gluconate-impregnated sponge for all short-term, nontunneled central venous catheters in patients who are 18 years old or older (Wei et al., 2019). While the recommendations did not explicitly mention the specific kind of dressing for artery catheters, many randomized studies have examined the impact of transparent dressings and chlorhexidine gluconate-impregnated sponge dressings on the incidence of arterial CLABSIs. A small-scale investigation was conducted to analyze 63 instances of radial artery cannulations. The research involved comparing two techniques, the control group of which used iodophor-based skin preparation and opaque elastic adhesive bandage while the intervention group used transparent dressing containing Triclosan, a bactericide, along with an adhesive dressing made of plastic (Wei et al., 2019). Although there were no statistically significant differences between the two groups as regards frequencies of clinically detected local infection or CLABSIs; it was noted that the intervention offered advantages such as fewer number of steps and continuous visual access to cannulation site. The efficacy of a transparent dressing impregnated with silver ions was evaluated against clear polyurethane dressings in a small clinical trial involving 31 patients from an intensive care unit. Even though

Arglaes dressing has been associated with numerous antimicrobial properties due to its content of silver ions, this study showed that there were similar rates of bacterial growth from catheter tips and skin swabs amongst both groups. The authors hypothesized that the aseptic application of the dressing had a more significant impact than the dressing itself (Wei et al., 2019).

There have been a few clinical trials conducted at different centers with more number of patients that showed the usefulness of chlorhexidine gluconate-impregnated dressings in reducing arterial CLABSIs (Entesari-Tatafi et al., 2015; Reynolds et al., 2024). In these trials the researchers compared standard Tegaderm dressings to Tegaderm with chlorhexidine gluconate-impregnated dressings in 1,727 arterial catheters out of 3,778 total catheters including central venous catheters and arterial catheters. These three figures for the control group were: catheter colonization rate at (11.5%), major CRBSI rate at (1.2%) and CLABSI rate at (0.9%). Despite low baseline infection rates, the risk of major CLABSIs reduced by (60%) [HR =0.39 (95 % CI =0.17–0.93; p=0.03)] among patients using chlorhexidine gluconate-impregnated dressing as an intervention group compared to placebo (standard dressing). In another randomized study comparing chlorhexidine gluconate CHG on major CLABSIs and catheter colonization between highly adhesive dressings HP Transparent Film Dressing; 3M), chlorhexidine gluconate impregnated dressings Tegaderm CHG; and standard ones Tegaderm Transparent Film Dressing; 3M) on major CLABSIs and colonization over arteries for which there were a total of four thousand one hundred sixty-four three central venous lines plus any artery line implanted two thousand two hundred one formative years ago when babies are most available during delivery between those 4 thousand and more which included such lines. Major central line-associated blood stream infections (CLABSIs) decreased by (67%) (HR 0.328; 95% CI, 0.174-0.619; p = 0.0006), and the rate of CLABSI fell by (60%) (HR 0.402; 95% CI, 0.186-0.868; p = 0.02) when dressed with chlorhexidine gluconate impregnated dressings as compared to non-chlorhexidine gluconate impregnated ones according to a recent study conducted in an ICU setting [16]. On the other hand, these researchers also found that highly adhesive dressings increased skin colonization rate considerably ($p < 0.0001$) and catheter colonization rates ($p = 0.0016$). In addition, it is worth noting that the collective data for arterial catheters and central venous catheters were provided without separating the findings for arterial catheters alone (Entesari-Tatafi et al., 2015; Reynolds et al., 2024).

1.1.7 Administration sets

Two studies examined the adherence to changing administration sets, and the observed rates of compliance were (12%-100%) for continuous infusion sets, (28%-71%) for blood or blood products or fat emulsions and (14%-36%) for propofol administration (Ananya, 2018; Burke et al., 2021). Of the three studies that did not mention what kind of sets were used, two were cross-sectional observational studies where reported compliance ranged between (73% and 100%). The remaining study was a prospective surveillance before and after cohort study with a pre-compliance of (33%), post-compliance was at (39%) (Ananya, 2018; Burke et al., 2021; Burton, 2023).

1.1.8 Daily audits

The results of a comprehensive survey conducted in 984 adult intensive care units in the United States revealed that the performance of daily audits to evaluate the ongoing need for central lines was reported as follows: (30.4%) always, (25.3%) usually, (6.7%) sometimes, and (25.5%) rarely, never, or not monitored (Burke et al., 2021). Additionally, a cross-sectional observational study found that (58%) of the units performed these audits. In a prior and post interventional trial, the frequency of daily audits increased significantly from (67.5% to 98.9%). However, in a pre and post intervention quality improvement study, the audits declined somewhat from (13%) to (11%) (Burke et al., 2021).

1.1.9 Access ports

The act of vigorously cleaning the access port or hub using friction and an adequate antibiotic before each usage varied in effectiveness, ranging from (12.7% to 100%) (Burke et al., 2021; Novosad et al., 2020). A study indicated the use of only sterile devices for accessing catheters, with a compliance rate of (73%) in medium income nations and (59%) in high income countries (Valencia et al., 2016).

1.1.10 Bathing on a daily basis

The 2011 CDC recommendations for managing and preserving central lines suggest that adult patients should undergo daily washing with chlorhexidine (Jeong et al., 2013). Not a single one of the studies included in the analysis indicated adherence to this advice. The study found that the central line checklist was used in (62% to 84%) of cases,

according to further data (Burke et al., 2021; Ista et al., 2016). Other studies conducted surveillance of adherence to the central line bundle, but did not provide precise data.

Arterial catheters are often used to continuously evaluate hemodynamics and respiratory status throughout the perioperative period and in critical illness. Approximately 8 million air conditioners are installed in the United States annually (Madhani et al., 2024). CLABSIs have been recognized as a significant cause of illness. However, clinicians may underestimate the contagiousness of arterial CLABSIs in comparison to CLABSIs, and their adherence to the guidelines advised by the CDC was not constant (Abbady et al., 2019; Burke et al., 2021; Scheithauer et al., 2014). While the CDC routinely monitors CLABSIs rates, estimating that over 30,000 CLABSIs occur in the United States each year, arterial CLABSIs rates are not monitored as extensively (Gadala, 2021; Harris-Hall, 2020). The objective of this narrative review is to provide a concise overview of the existing information on the frequency of arterial CLABSIs, as well as therapies aimed at mitigating the risk of such infections. The authors first examine the frequency of arterial CLABSIs in relation to CLABSIs. They did a detailed analysis of the data on therapies that are protocolized to decrease arterial CLABSIs. Ultimately, they tackle the deficiencies in existing information and deliberate on prospective future avenues.

While recommendations and regulatory authorities often pay less attention to arterial CLABSIs compared to CLABSIs, recent research indicates that arterial catheters have a greater risk of iatrogenic bloodstream infections than previously believed (Abbady et al., 2019). Observational and randomized studies have examined the frequencies of catheter tip colonization and catheter-related infections in both arterial catheters and central venous catheters. The study indicated that arterial catheters were a source of CLABSIs that were not widely acknowledged. In a 2006 systematic analysis conducted by Maki et al., it was shown that the occurrence of arterial CLABSIs was 1.7 per 1,000 catheter days (Maki et al., 1997). This rate was lower compared to the rate of 2.7 per 1,000 catheter days for short-term, noncuffed central venous catheters. In 2014, a meta-analysis found that the pooled incidence of arterial CLABSIs was 0.96 per 1,000 catheter days in studies where arterial catheters were cultured in instances of suspected infection (Chopra et al., 2015). Nevertheless, the incidence of arterial CLABSIs was significantly elevated, reaching 1.26 per 1,000 catheter days in the studies that included

all arterial catheters. These data indicate that arterial catheters impose a substantial cost on healthcare. In 2011, the CDC released revised recommendations for the Prevention of Intravascular Catheter-Related Infections (Mermel, 2000). These recommendations were developed via a cooperation with numerous societies from different clinical specialties. Three Notwithstanding these recommendations, arterial catheters persistently remain undervalued as a possible cause of substantial CLABSIs in clinical practice. A comprehensive survey revealed that clinicians underestimated the risk of arterial CLABSIs by a factor of 3. Additionally, only (44%) of clinicians reported adhering to the CDC-recommended practices for arterial catheter insertion (Chopra et al., 2013; Harris-Hall, 2020; Mermel, 2000). The authors of the study suggest that the inconsistent compliance with CDC guidelines may be due to misconceptions about the risk of arterial CRBSIs and a lack of awareness of the updated 2011 guidelines.

1.1.11 Barrier Precautions

The CDC advises implementing different degrees of barrier measures based on the specific kind of catheter being implanted. The recommendations distinguish between central arterial catheters, which include the insertion of catheters into the axillary and femoral arteries, and peripheral arterial catheters. As minimum measures, sterile gloves, surgical masks, surgical covers, and tiny sterile fenestrated drape are recommended to be used when inserting peripheral catheters (Harris-Hall, 2020). Alternatively, maximum sterile barrier precautions include use of sterile gloves, sterile gown, surgical coverings and masks along with complete body drape during central line placement. It is also recommendable to follow these principles when inserting either a central venous catheter or a central catheter. These were performed already in 2 other studies. Two previous studies assessed the effects of using barrier precautions on the incidence of CLABSIs while inserting central catheters (Burke et al., 2021; Harris-Hall, 2020). In the study, 272 patients were randomized. They were to undergo strict barrier precautions including sterile gloves and maximum sterile precautions during central catheter insertion. The study findings showed that there was no variance in rates of catheter colonization and CLABSIs between these groups. Therefore, the results have shown that implementing broad-based barriers may fail to prevent catheter colonization or CLABSI. It is worth noting that few RCTs have been conducted to assess the efficacy of barrier precautions on controlling incidence of CLABSI. Furthermore, the studies

were characterized by small sample sizes and low statistical power (Star et al., 2024). It has been estimated that this would require inclusion of about 2,200 patients in order to demonstrate halving of CLABSI cases (Star et al., 2024). For instance, a recent study reported mean costs per case as $1,111; given expected 5 million cases per year this will be $5 billion/year. The other group had maximum sterile precautions during central venous catheterization (CVC) for about 618 patients. Moreover, the impact of using minimal barrier precautions (sterile gloves and big sterile drape) while inserting central catheters was investigated among 321 patients (Star et al., 2024). On the other hand, maximum sterile barrier precautions (sterile gloves, gown, large drapes, mask, and cap) were used while inserting central catheters for 618 patients. There were no detectable differences in the rates of catheter colonization and CLABSIs among the patients in the two groups. Together, these findings indicated that using minimal barrier measures was not enough to reduce the incidence of catheter colonization and CLABSIs.

1.1.12 Cutaneous Antisepsis

The CDC recommends the use of antiseptic solutions containing chlorhexidine for disinfection of catheters and during dressing removal before insertion of a central catheter (Ferguson et al., 2003). Chlorhexidine's mode of action is based on alteration bacterial cell wall structure. The bactericidal effect of this could act upon diverse strains of bacteria that cause CLASBIs (Ferguson et al., 2003). There were randomized controlled trials (RCT) and meta-analysis reports to show its efficacy. Randomized controlled trial was done by inserting 492 central catheters and 176 central venous catheters, comparing the efficacy of three different solutions: povidone-iodine (10%), isopropyl alcohol (70%), aqueous chlorhexidine gluconate (2%) (Ferguson et al., 2003). In this randomized controlled trial, the results showed that chlorhexidine was more effective at reducing local catheter-related infections than either povidone-iodine or isopropyl alcohol. On comparison, in the group where chlorhexidine was used there were 2.3 local catheter-related infections per 100 catheters. However, the group in which alcohol was used had 7.0 local catheter-related infections per 100 catheters whereas, when povidone-iodine was used there were 0.3 local catheter-related infections per 100 catheters (Ferguson et al., 2003).

The possibilities of patients getting catheter-related infections was 0.32 (95% CI: 0.10-0.86, p value = 0.02) for those who used chlorhexidine as compared to others who did not use it. In another study conducted in the year 1996, the patients were randomly assigned into two groups; one group received a chlorohexidine-based antiseptic solution which contained (0.25%) chlorohexidine gluconate, (0.025%) benzalkonium chloride and 4% benzyl alcohol while the other received (10%) povidone iodine during insertion of their central venous catheters which numbered at the total of one hundred fifty eight; and central catheters numbering one hundred fifty seven .Unlike the previous trial in 1991, this study used catheter related sepsis as its primary outcome measure. Catheter-related sepsis is defined as a positive catheter culture with either fever or sustained decrease in temperature, consistent with present criteria for systemic inflammatory response syndrome (SIRS). The current research indicated that colonization per thousand days among central catheters were significantly higher in povidone iodine group than in chlorhexidine group. The relative risk of colonization among central catheters of chlorhexidine versus iodine was found to be equal to 0.5 with confidence interval of (0.1–1) and P value=0.05. Given that the rate had been calculated as eight episodes per every 1000 days catheter usage by using pervious data from this hospital population (Ferguson et al., 2003).

1.1.13 Insertion Site

A randomized controlled study and a systematic review involving studies done between 1978 and 2001 have been carried out and they showed that significant differences in CLASBI rates occurred when catheters were put through the radial or femoral sites (Ferguson et al., 2003). Of note, it is difficult to apply the results of these studies at present because modern day practices have introduced more advanced antiseptic solutions that contain chlorhexidine and extensive use of barrier procedures (Ferguson et al., 2003; O'Horo et al., 2014). According to O'Horo et al (2014), a meta-analysis that was done revealed that there is a bigger risk of CLASBIs when using the femoral site (O'Horo et al., 2014). The rate of incidence for CLABSIs with femoral sites was instead given as "one point five percent" (95% CI: 0.8% to 2.2%). However, "the rate of CLABSIs at radial locations was given as "0.3%" (95% CI: 0.1% to 0.4%) (O'Horo et al., 2014).

When subgroup analysis was performed, studies which compared direct radial access location versus femoral access location suggested that CRIs were 1.94 times higher in cases with femoral than with radial (95% CI: 1.32-2.84; p = 0.001). These findings have been consistent with other reports from different sources and are in line with the guidelines made by the CDC to use radial, brachial, or dorsalis pedis sites for insertion, rather than femoral or axillary sites (O'Horo et al., 2014).

However, it is of note to mention that some observational studies have failed to demonstrate similar results (O'Horo et al., 2014). For example, researchers performed a retrospective analysis of 3 multicenter randomized controlled trials that had larger sample sizes (a total of 6,373 patients were included) to compare to the study of O'Horo et al (O'Horo et al., 2014). Because there was no randomization while choosing the insertion site, the researchers used a propensity score weighting approach to estimate whether the patients would have radial or femoral artery catheterization. Using this weighting, they then used Cox proportional hazard models to assess the risk of CLABSIs. The study found that there was no significant difference in the hazard risk for CLABSIs (HR 1.01; 95% CI, 0.50-2.05; p = 0.98) and severe catheter-related infections (CRI) hazards (HR, 1.04; 95% CI, 0.57-1.89; p = 0.91) between the femoral and radial insertion site groups. Nevertheless, the Cox proportional hazard analysis revealed a greater likelihood of catheter colonization for femoral catheters (HR, 1.63; 95% CI, 1.34-1.97; p < 0.0001) (O'Horo et al., 2014). Due to the conflicting results of these studies, it is uncertain if the placement of central catheters has an effect on the occurrence of CLABSIs. To resolve this problem, more randomized data is required.

1.1.14 Duration of Indwelling central catheters

Recommendations presently in effect discourage a policy of routine replacement of central catheters to prevent catheter related infections, only replacing them when clinically indicated. These findings support the present guidelines from a retro-pre post study on 1672 patients (with 3247 catheters) that compared infection rates between patients whose scheduled central catheter got replaced every five days pre-2000 according to the hospital's institutional policy and those with only clinically-indicated replacements (in the period after 2000) (Card et al., 2023). In addition, this research discovered no significant differences in terms of colonization rates between the two groups (14.2% before 2000 vs 16.4% after 2000; p = 0.1). Moreover, it was noted that

the CRI rate was significantly higher among pre-2000 patients who had scheduled replacements than among those who had such changes only when needed (1.4% before 2000 vs 0.6% after 2000; p = .01). Only one randomized trial has been conducted assessing how long an indwelling central catheter may be associated with infectious risk till now. In this regard, another survey evaluated the incidence of infectious risks through three methods of Central catheter maintenance in one hundred twelve participants as follows: (a) percutaneous puncture using new sites for each seven-day change; (b) selection for exchange or removal if necessary; or (c) guidewire exchange while changing every seventh day at same site (Card et al., 2023). This study demonstrated that there were no significant differences in rates of catheter colonization or CLABSIs among the 3 groups. Consequently, authors suggested in this research no change of catheters without indication, a support for the present CDC directives.

Alternatively, two prospective observational studies study found that routine replacement of central catheters reduces infection associated with these devices (Bregenzer et al., 1998; Pirracchio et al., 2011). However, sample size, design and outdated data not representing modern critical care practices limited these two studies. The first one was done in 1988 and involved 56 patients in ICU. There was a comparison of the colonization rates on the skin between <96 hours and >96 hours' catheter use (75 central catheters). None of the catheters that were used for less than 96 hours showed skin colonization whereas (27%) of them utilized for more than 96 hours indicated skin colonization. This study found evidence that longer indwelling arterial duration is associated with infectious risk, yet it did not examine whether replacement influenced the rate at which patients acquire infections through their line. It is also possible that there would have been no difference in infection rates as patients requiring a central catheter for greater than 96 hrs most likely had an underlying clinical condition that predisposed them to infection. The second was a 1993 observational study of 71 central catheters that examined duration of indwelling central catheter as a predictor of catheter-related infections, and found an overall catheter colonization rate of (15%) and CLABSIs rate of (5.5%). Among these eleven local infections and four CLABSIs detected post-catheter placement, all happened after day four ($p < 0.05$). Nevertheless, this study may have been affected by its population under study which consisted only critically ill cancer patients. Also, this study was limited by lack of appropriate comparator group (standard replacement) (Pirracchio et al., 2011).

1.2 Summary of the literature

Hospital acquired infections are a major public health concern because of their impacts on morbidity, hospital stay, and additional healthcare costs. Central venous catheters account for about 90 percent of catheter-related bloodstream infections (Adal & Farr, 1996; Kim et al., 2011; Peng & Lu, 2013). Despite the benefits of central venous catheters, they also serve as potential portals for localized and systemic blood stream infections. This procedure is generally performed with ultrasound guidance (Rothschild, 2001). Despite the general overall safety of this procedure, complications prevalence still occurs. This research focuses on the complications of line placement and maintenance.

1.3 The Palestinian healthcare system

In Palestine, patients receive healthcare from governmental (public), private, and charity hospitals. Government hospitals are core in the majority of health care delivery services extending from the West Bank to the Gaza Strip. These hospitals treat a variety of diseases, often using modern technology, and offer complex services in a specialized manner. Governmental and charity hospitals often receive funding from various sponsors in order to provide patients with effective health care services.

A critical focus across the governmental/public, private, and charity hospital sectors has been the minimization of hospital-acquired infections, which pose a considerable challenge that limits the safety of patients. Efforts to combat hospital-acquired infections include adoption of evidence-based protocols to control the spread of infections, staff training in infection prevention, and rigorous hygiene standards. Governmental/public, private, and charity hospitals have implemented regular sanitation practices, sterilization procedures, and patient isolation measures when necessary. Furthermore, several hospitals in Palestine have obtained accreditation from the prestigious Joint Commission International. These accreditations highlighted commitment of these hospitals to ensuring high standards of healthcare quality and safety. These accreditations reflected a serious drive toward enhancing the outcomes of patients and aligned with the evidence-based practices followed internationally to reduce infections and improve the overall health outcomes of the patients.

1.4 Problem statement

It has been emphasized that additional research was needed to determine the effectiveness of the measures in the bundle on preventing/minimizing the incidence of CLABSIs in clinical practice. Because nurses are often responsible for inserting central venous catheters, the idea behind such research was relevant to the nursing practice.

At Al Mezan Hospital, an infection control committee was formed. The roles of the infection control committee include designing and recommending measures to minimize infections, rationalize the use of antibiotics, analyze the infections and characterize the causative agents.

So far, there has been no study to assess the impact of measures that can be implemented on the incidence of CLABSIs, notably in the ICU. Therefore, study aimed to assess the impact of implementing an evidence-based practice guideline-based care bundle on the incidence of catheter-related bloodstream infections in patients undergoing follow-up and treatment in an intensive care unit of a main hospital in the southern region of the West Bank of Palestine. The focus was specifically on the administration and management of central venous catheters. The CDC's bundle was developed to help healthcare providers including physicians and nurses to preventing/minimizing the incidence of CLABSIs in clinical practice.

1.5 Objectives

The aim of this study was to determine how the evidence-based guideline-based care bundle affected catheter-related bloodstream infections during the application and management of central venous catheters in patients receiving follow-up and therapy in intensive care units.

The specific objectives of this study were:

- To assess how a central line care bundle affected bloodstream infections caused by catheters at Al Mezan Hospital.
- To assess the impact of the central line care bundle on patient mortality rates.
- To assess the impact of central line care bundle implementation on morbidity.

- To assess the impact of central line care bundle implementation on hospital stay.

1.6 Hypotheses

- There was no significant relationship at 0.05 level between implantation of central line care bundle and the rates of catheter related blood stream infection.
- There was no significant relationship at 0.05 level between implantation of central line care bundle and mortality rate of the patient.
- There was no significant relationship at 0.05 level between implantation of central line care bundle and morbidity.
- There was no significant relationship at 0.05 level between implantation of central line care bundle and hospital stay.

1.7 Importance of the study

There are several risk factors that are associated with CLABSIs. These include the length of time the catheter is in place, the number of lumens in the catheter, using the femoral access site, excessive manipulation of the central venous catheter, receiving total parenteral nutrition, bacterial colonization at the site where the catheter is inserted, prolonged hospitalization, and other risk factors. One of the most successful ways for preventing CLABSIs is the use of bundles, as highlighted by Sun et al. (Sun et al., 2020). Bundles are a methodical application of a group of evidence-based procedures, often consisting of three to five, that, when executed correctly and together, may enhance patient outcomes.

As far as we know, there have been no studies conducted in Palestine to examine the impact of early prediction identification and intervention on patients. The main goal of this research was to establish a highly efficient and effective bundle designed to assess the effects of these specialized care steps on patients in the intensive care unit.

Chapter Two

Methods

2.1 Study design

The study utilized a quasi-experimental research design, involving both retrospective analysis of the incidence of blood stream related central line infections and prospective implementation of evidence-based professional guidelines to prevent central line associated blood stream infections in adult ICU patients at Al Mezan hospital.

A doctor implanted the central line, and a nurse cleaned the insertion site of the central line using either povidone iodine or (0.5%) chlorhexidine with alcohol, (70%). Nurses monitored the central line for signs of infection while administering treatment.

The study encompassed both a retrospective and experimental approach. The research included patients who received treatment in the critical care unit of Al-Mezan Hospital from January 2022 to December 2023. The patients had a central line inserted by the hospital personnel in the units and needed to keep the central line in place for a minimum of 48 hours. The experimental cohort included patients selected from the research community, commencing in June 2022. The researcher supervised the delivery of the guideline-based application and care package in the critical care units. The patients were assessed daily for bloodstream infection.

2.1.1 Patient classified into two groups

- **Experiment group (n=170):** prospective with implemented evidence based professional guideline in the period of January 2023 to December 2023 (12 months prospective)

- **Control group (n=170):** retrospective with routine care without guideline in the period of January 2022 to December 2022 (12 months retrospective).

2.2 Population

All patients admitted to the intended ICU ward who were willing to participate in this study during the period of data collection.

The bed capacity of ICU was 10. Four doctors and twenty nurses were employed in the unit. A physician inserted the central line, while a nurse performed the care of the insertion site of the central line using chlorhexidine solution at (0.5%) strength. During care, nurses looked for any infection present in the central line.

2.2.1 Inclusion criteria

- All adult patients in ICU with a central line inserted within the unit in the period of January 2023 to December 2023 in the experimental group.
- All adult patients in ICU departments with a central line inserted within the unit in the period of January 2022 to December 2022 in the control group.

2.2.2 Exclusion criteria

- Any patient with a central line that was not inserted within unit.
- Patients who were less than 18 years or older than 80 years old.
- Patients who were pregnant, transferred with a central line from another unit or center to the intensive care unit, or who had previously been diagnosed with CLABSI, or in whom a central line was inserted or central line care was given in other units were excluded from the study.

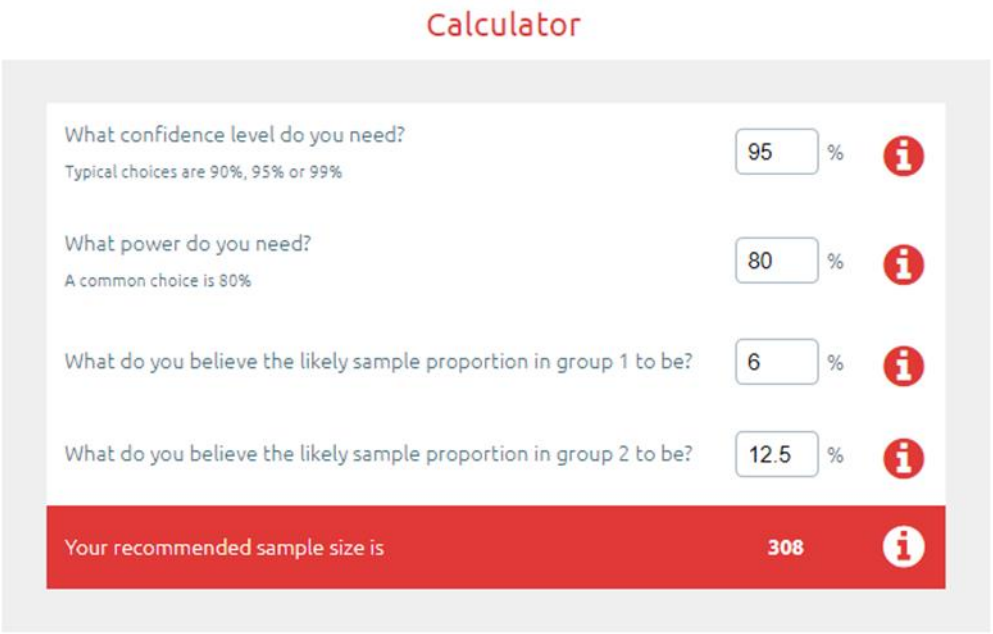
2.3 Sample size and sampling method

The sample size for this research was determined based on the data obtained from a prior study conducted by Süha and Karagözolu (Süha & Karagözoğlu, 2019). The Sample Size Calculator was used to make a comparison between two proportions (Campbell et al., 2004). To determine the necessary sample size for identifying a discrepancy between two proportions the sample size calculator was used (Figure 1). In the control group, (12.5%) of patients (33 out of 264) had CLABSIs, whereas in the intervention group, only (6%) (4 out of 58) had such infections. A total of 308 patients were needed. An additional of about (20%) of the sample size were included to

compensate for any dropouts. The sample consisted of 354 patients. The 354 patients included in this study were divided into two groups. Every group consisted of 177 patients.

Figure 1

Sample size calculator



2.4 Study variables

2.4.1 Independent variable (intervention)

- Use of central line bundle

2.4.2 Dependent variables

- Rate of CLABSIs
- Morbidity
- Mortality rate
- Hospital length of stay
- Vital signs and lab test

2.4.3 Independent variables

- Past medical history
- Demographic data

2.5 Procedure

The CDC's protocol for prevention of CLABSIs was used in this study. A meeting with the clinical staff, including nurses and doctors was held in a meeting room located in the Intensive Care Unit at the beginning of the study. The purpose of this meeting was to enhance their adherence to the care bundle. The meeting was repeated numerous times with the same participants. During the meetings, the importance of adhering to the bundle was repeated.

During the meetings, the participants received detailed information on the care bundle described in the guidelines, including the purpose and significance. The participants were informed that lack of adherence to the 5 recommendations outlined in the care bundle would result in negative consequences on the patients including higher incidence of CLABSIs.

Throughout the study, the physicians and nurses were monitored and assisted whenever needed to adhere to aseptic techniques while inserting the central lines.

2.6 Data collection and study tools

The Care Bundle Checklist for the Prevention of CLABSIs in Patients with a Central Line was used. The data were collected using standardized data collection forms that were separately developed for the retrospective period and prospective period. The data collection forms were based on the "Daily Evaluation Form of Patients with a Central Line", "6-Month Data Checklist Regarding the CLABSI," and the tools produced by the Infection Control Committee (Al-Abdely et al., 2017; Jeong et al., 2013; Kanj et al., 2012; Larsen et al., 2019; Latif et al., 2015; Ling et al., 2016; McMullan et al., 2013; Quan et al., 2016; Sacks et al., 2014).

The Infection Control Committee diagnoses CLABSI by using the diagnostic criteria for Blood Stream Infections, which are confirmed by the CDC's laboratory. This diagnosis is made in individuals who exhibit signs and symptoms of infection. Data on CLABSIs were collected on a daily and throughout the study.

The Daily Evaluation Form of Patients with a Central Line consisted of 6 primary and 5 secondary components. These components inquired about the proper hand hygiene, the use of maximum barrier precautions, the appropriate selection of central line sites, skin antisepsis with chlorhexidine, and adherence to aseptic techniques during central line insertion and post-administration hand hygiene. All of these components were recommended by the CDC and healthcare infection control practices advisory committee (HICPAC, 2017).

The other tool consisted of 10 main questions and 5 sub-items. These questions inquired about the duration of the infusion set, the occurrence of blood transfusion, the closure of unused lumens, the performance of central line dressing care, the cleaning of hubs with alcohol before medication was administered, the types and quantity of blood products received through the central catheter, the amount of parenteral nutrition, the evaluation of the daily requirement for the central line in hemodialysis therapy, the removal of the central line if it was unnecessary, and the presence of local infections in the catheter area.

The "6-Month Data Checklist Regarding the CLABSI" was developed by the Infection Control Committee. The tool has six questions that inquired about the number of central line insertions, the duration of central venous catheter (CVC) use, the rate of central line-associated bloodstream infections (CLABSIs), the total number of patient days, the number of patients, and the incidence of CLABSIs.

2.7 Statistical Analysis Methods

The data collected were analyzed using Statistical Package for Social Sciences (SPSS) v 21.0. Descriptive data including frequencies (n) and percentages (%) were generated. The categorical data were compared using Chi-Square/Fisher’s exact test and the continuous data were compared using t-tests. A p value of < 0.05 was considered as statistically significant.

2.8 Ethics and approvals

This study was approved by the Faculty of Graduate Studies, An-Najah National University and the ethical committee of Al Mezan Hospital.

Additionally, the Institutional Review Board (IRB) of An-Najah National University also approved the study.

Chapter Three

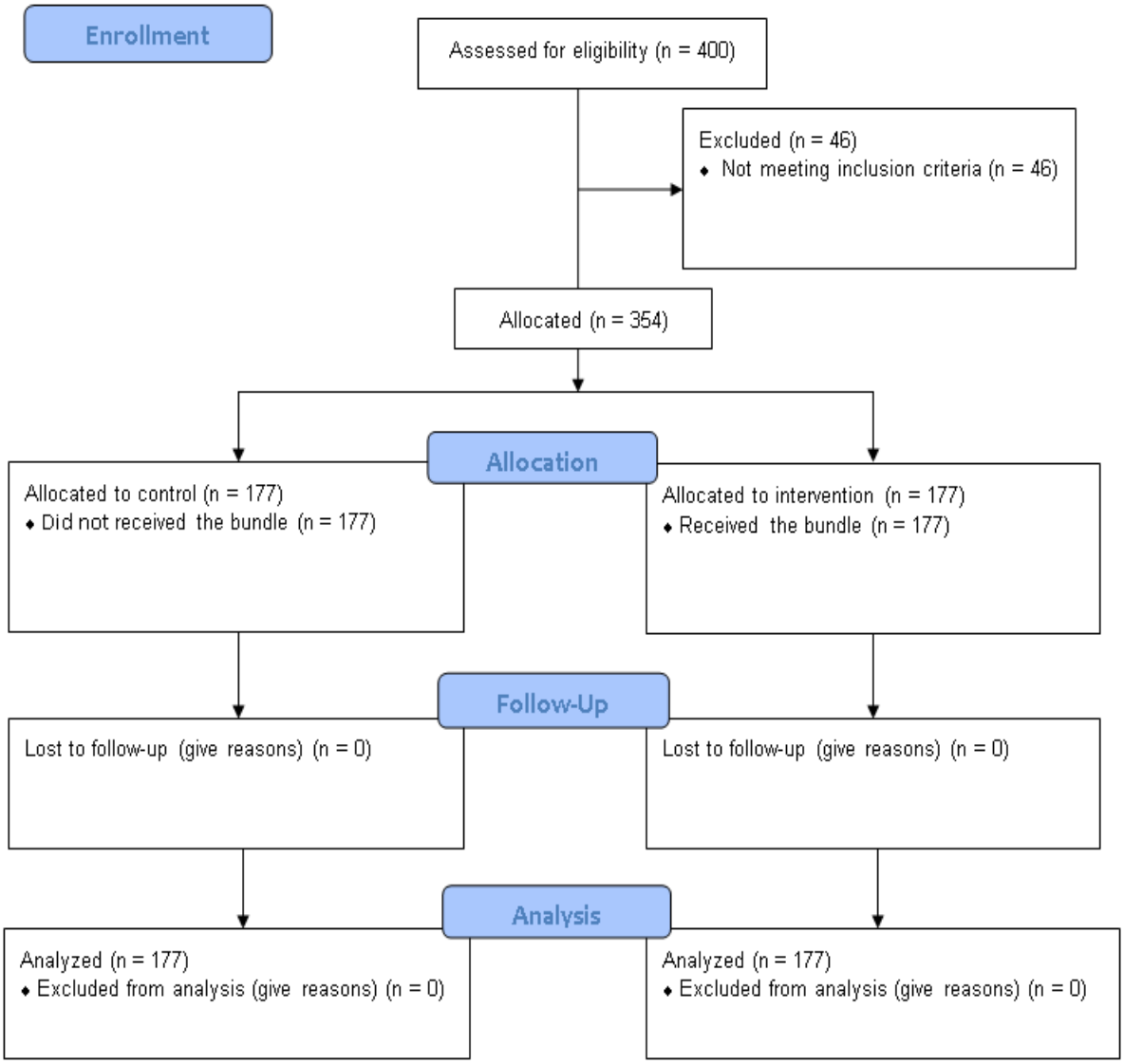
Results

3.1 Selection of the patients

In this study, a total of 400 patients were assessed for eligibility. Of those, 46 were excluded due to not meeting the inclusion criteria and a total of 354 were allocated to the control and intervention groups. Of the patients, 177 (50%) were allocated to the control group and 177 (50%) were allocated to the intervention group as shown in Figure 2.

Figure 2

Allocation of the patients into the control and intervention groups



3.2 Characteristics of the patients

There were no statistically significant differences in the rationale for obtaining CVC and placement of CVC between the patients in the control and intervention groups in this research (p value > 0.05). Similarly, there were no statistically significant changes in the prevalence of diabetes mellitus and asthma as comorbid illnesses between the patients in the control and intervention groups (p value > 0.05). In contrast, the control group had a higher number of male patients compared to the intervention group (p value = 0.021). Furthermore, the intervention group had a higher number of patients with shock, hemorrhage, or cardiac arrest compared to the control group (p value < 0.001). The control group exhibited a higher prevalence of concomitant hypertension compared to the intervention group (p value = 0.002), and a higher prevalence of COPD compared to the intervention group (p value = 0.010). These differences are shown in Table 1.

Table 1

Characteristics of the patients in the control and intervention groups

	Control		Experimental		
Characteristic	n	%	n	%	p value
Sex					
Male	122	68.9	100	56.5	0.021
Female	55	31.1	77	43.5	
Diagnosis					
Cerebral vascular accident	60	33.9	30	16.9	< 0.001
Asthma/COPD exacerbation/respiratory arrest	48	27.1	47	26.6	
Shock/bleeding/cardiac arrest	47	26.6	91	51.4	
Decompensated heart failure	22	12.4	9	5.1	
Comorbidities					
Hypertension					
Yes	133	75.1	105	60.0	0.002
No	44	24.9	72	40.0	
Diabetes mellitus					
Yes	98	55.4	96	54.2	0.923
No	79	44.6	81	45.8	
Asthma					
Yes	17	9.6	28	15.8	0.110
No	160	90.4	149	84.2	
COPD					
Yes	50	28.2	29	16.4	0.010
No	127	71.8	148	83.6	
Cardiovascular disease					
Yes	108	61.0	87	49.2	0.032
No	69	39.0	90	50.8	
Site of CVC					
Internal jugular	98	55.4	116	65.5	0.107
Subclavian	72	40.7	53	29.9	
Femoral	7	4.0	8	4.5	
Reason for CVC					
TPN	3	1.2	3	1.7	0.979
IV medications	91	52.0	93	52.3	
Poor IV access	53	30.1	54	30.1	
Hemodynamic monitoring	30	16.8	27	15.9	

In this study, there was no statistically significant difference in the duration of ICU stay between the patients in the control and intervention group (p value = 0.731). Similarly, there was no statistically significant difference in the duration of CVC between the patients in the control and intervention group (p value = 0.903). Moreover, there was no statistically significant difference in the number of patient's days between the patients in

the control and intervention group (p value = 0.801). During their stay, there was no statistically significant difference in the temperature values between the patients in the control and intervention group (p value = 0.141). In addition, there was no statistically significant difference in the diastolic blood pressure readings between the patients in the control and intervention group (p value = 0.950) (Table 2).

On the contrary, patients in the control group were significantly older than the patients in the intervention group (p value = 0.029). Moreover, systolic blood pressure values of the control group were significantly elevated compared to the patients in the intervention group (p value = 0.017). Again, the heart rate values of the patients in the control group were significantly elevated compared to those of the patients in the intervention group (p value < 0.001). The SpO_2 of the patients in the control group was significantly higher than that of the patients in the intervention group (p value < 0.001). The WBC count of the control group was significantly higher than that of the patients in the intervention group (p value < 0.001). Similarly, the percentage of monocytes of the patients in the control group was significantly higher than that of the patients in the intervention group (p value = 0.027). Moreover, the percentage of lymphocytes of the patients in the control group was significantly higher than that of the patients in the intervention group (p value < 0.001). On the other hand, the percentage of neutrophils of the patients in the control group was significantly higher than that of the patients in the control group (p value = 0.041). The CRP values of the patients in the control group were significantly higher than those of the patients in then intervention group (p value = 0.010). On the other hand, there was no statistically significant difference in the percentages of the basophils and eosinophils of the patients in the control and intervention groups (p value > 0.05). These differences are shown in Table 2.

Table 2

Difference in the age, duration of hospital stay, CVC, vital signs, and laboratory findings between the patients in the control and intervention groups

	Control		Experimental		
Characteristic	Mean	SD	Mean	SD	p value
Age (years)	55.3	13.8	51.8	15.6	0.029
Duration of ICU stay (days)	35.4	10.9	34.9	17.9	0.731
Duration of CVC	26.6	8.8	26.8	14.9	0.903
Patient's days (days)	43.5	14.2	43.0	23.2	0.801
Temperature (°C)	37.9	1.6	37.7	1.6	0.141
Systolic blood pressure (mmHg)	127.6	18.4	118.8	22.5	0.017
Diastolic blood pressure (mmHg)	67.8	12.1	68.0	12.8	0.950
Heart rate (beats/min)	81.9	13.4	91.1	14.0	< 0.001
SpO_2 (%)	95.1	1.3	93.9	2.0	< 0.001
WBCs ($\times 10^9$/L)	14.3	5.5	11.3	5.7	< 0.001
Monocytes (%)	5.8	4.2	7.3	3.2	0.027
Basophils (%)	1.4	0.9	1.2	0.9	0.384
Lymphocytes (%)	33.3	12.3	19.6	9.1	< 0.001
Neutrophils (%)	55.1	15.7	60.7	15.4	0.041
Eosinophils (%)	3.5	2.4	3.0	2.2	0.196
CRP (mg/dL)	69.5	74.3	50.6	61.6	0.010

3.3 Compliance to the central line bundle care protocol during the study period

The compliance and noncompliance rates of the different items in the central line bundle care protocol are shown in Table 3. As shown in Table 3, the highest noncompliance rates were reported for the daily review of line necessity with prompt removal of unnecessary lines.

Table 3

Compliance and noncompliance rates to the central line bundle care protocol

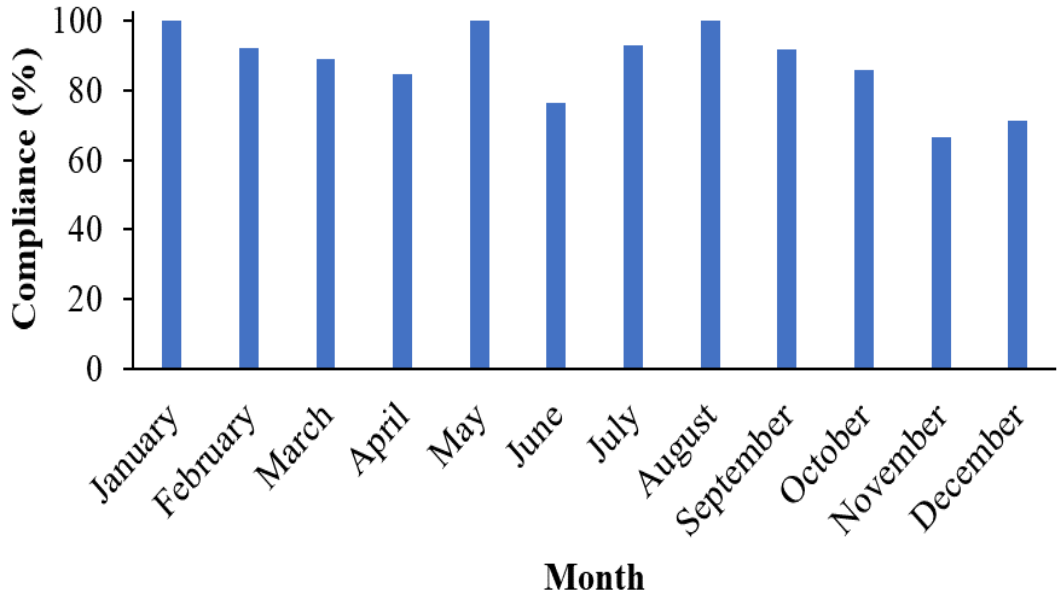
		Compliance		Noncompliance		Total	
#	Bundle item	n	%	n	%	N	%
1	Perform hand hygiene before insertion	157	88.7	20	11.3	177	100
2	Maximal barrier precautions upon insertion	157	88.7	20	11.3	177	100
3	Chlorhexidine skin antiseptic upon insertion	159	89.8	18	10.2	177	100
4	Optimal catheter site selection	152	85.9	25	14.1	177	100
5	Daily review of line necessity with prompt removal of unnecessary lines	131	74.0	46	26.0	177	100

3.3.1 Perform hand hygiene before insertion

Although there was a variability in the compliance rates to performing hand hygiene before insertion over the period from January to December as shown in Figure 3, the variability in the compliance/noncompliance rates was not statistically significant (p value = 0.095).

Figure 3

Compliance rates to performing hand hygiene before insertion over the period from January to December

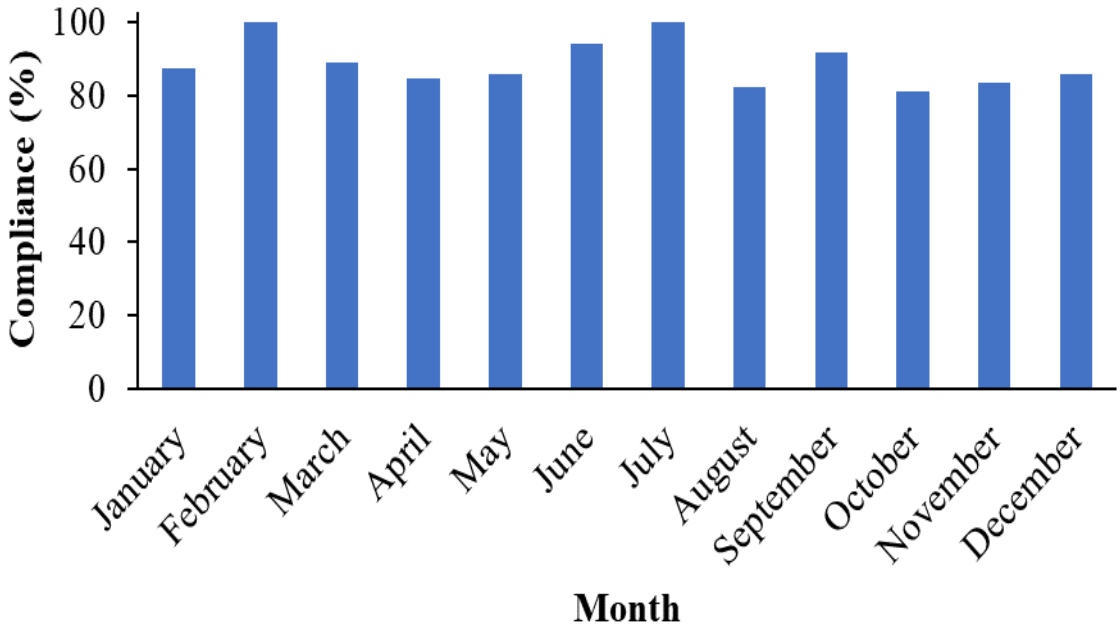


3.3.2 Maximal barrier precautions upon insertion

Although there was a variability in the compliance rates to applying maximal barrier precautions upon insertion over the period from January to December as shown in Figure 4, the variability in the compliance/noncompliance rates was not statistically significant (p value = 0.810).

Figure 4

Compliance rates to applying maximal barrier precautions upon insertion over the period from January to December

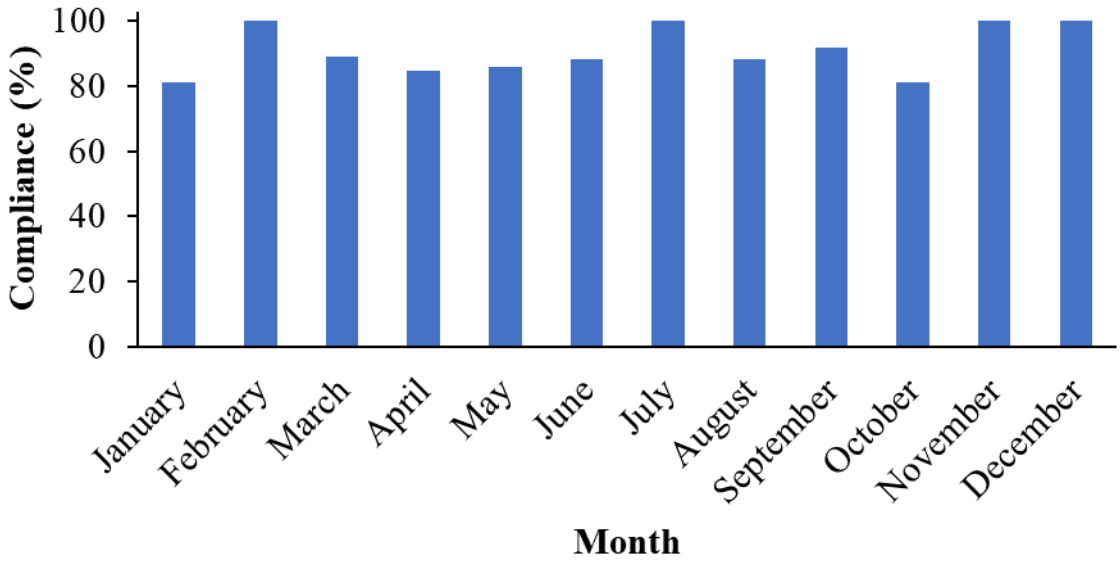


3.3.3 Chlorhexidine skin antiseptic upon insertion

Although there was a variability in the compliance rates to using chlorhexidine skin antiseptic upon insertion over the period from January to December as shown in Figure 5, the variability in the compliance/noncompliance rates was not statistically significant (p value = 0.608).

Figure 5

Compliance rates to using chlorhexidine skin antiseptic upon insertion over the period from January to December

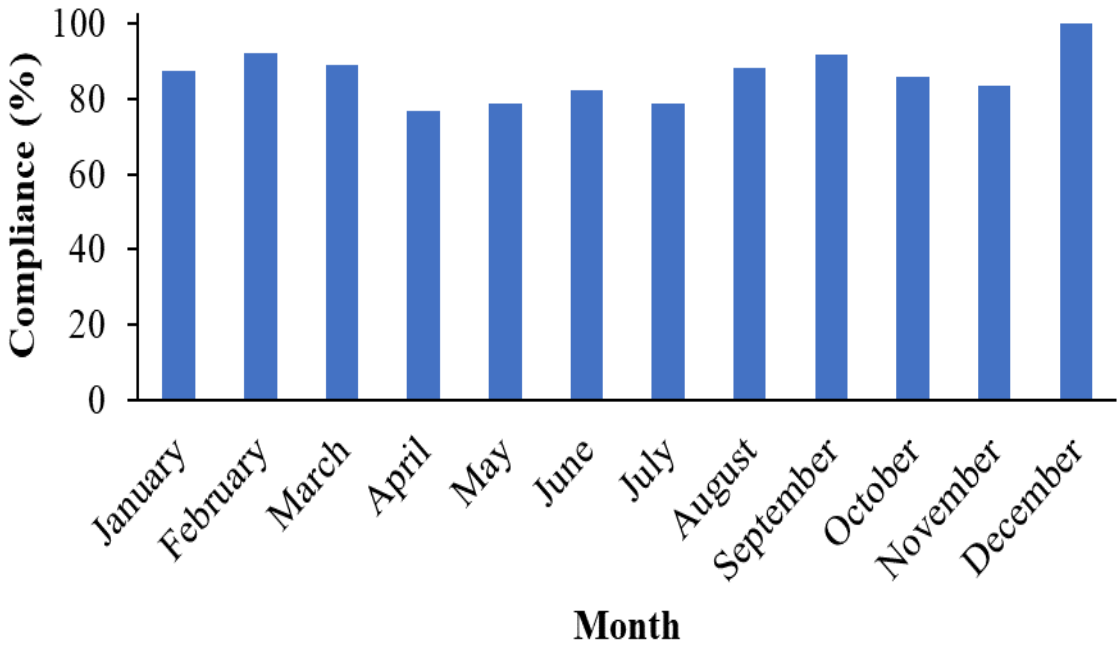


3.3.4 Optimal catheter site selection

Although there was a variability in the compliance rates to applying optimal catheter site selection over the period from January to December as shown in Figure 6, the variability in the compliance/noncompliance rates was not statistically significant (p value = 0.942).

Figure 6

Compliance rates to applying optimal catheter site selection over the period from January to December

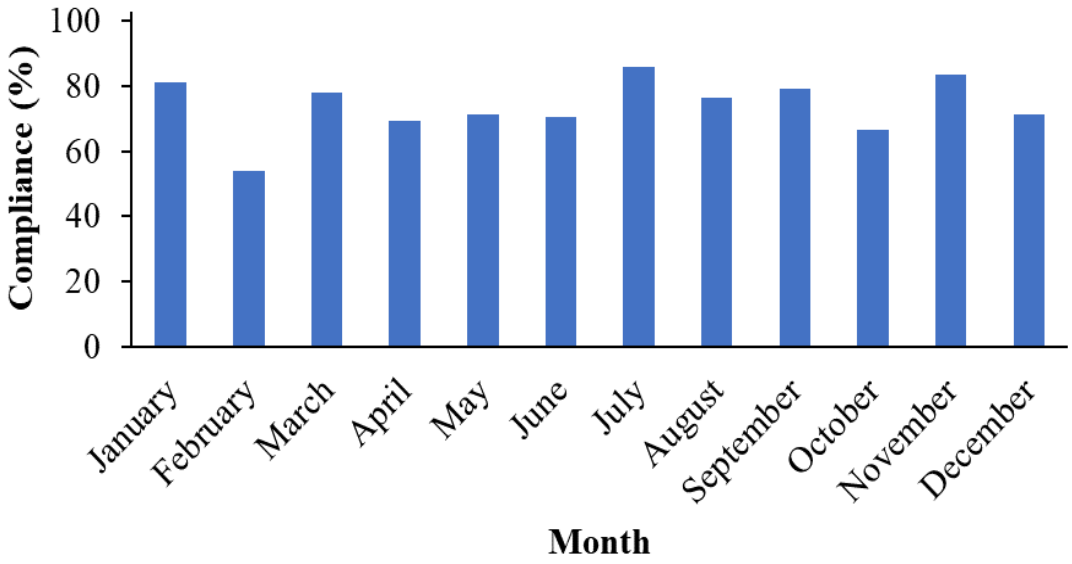


3.3.5 Daily review of line necessity with prompt removal of unnecessary lines

Although there was a variability in the compliance rates to performing daily review of line necessity with prompt removal of unnecessary lines over the period from January to December as shown in Figure 7, the variability in the compliance/noncompliance rates was not statistically significant (p value = 0.867).

Figure 7

Compliance rates to performing daily review of line necessity with prompt removal of unnecessary lines over the period from January to December



3.4 Incidence of catheter-related bloodstream infections and death rates

In this study, there was a statistically significant difference in the incidence of catheter-related bloodstream infections before and after implementing the bundle care protocol. There was a statistically significant higher incidence of catheter-related bloodstream infections before implementing the bundle care protocol compared to the period after implementing the bundle care protocol ($p < 0.001$). Although there was a difference in the mortality rates between the periods before implementing the bundle care protocol compared to the period after implementing the bundle care protocol, however, this difference was not statistically significant ($p = 0.158$). These differences are shown in Table 4.

In the period before implementing the bundle care protocol, there was a comparatively high incidence of catheter-related bloodstream infections caused by *Klebsiella pneumoniae*, Methicillin-resistant *Staphylococcus aureus*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Staphylococcus epidermidis*. The incidence rates of these catheter-related bloodstream infections are shown in Table 4.

Table 4

Differences in the incidence of catheter-related bloodstream infections and death rates

	Control		Experimental		
Variable	n	%	n	%	p value
Isolation of microorganism from blood					
Negative	106	59.9	136	76.8	0.001
Positive	71	40.1	41	23.2	
Microorganism					
Klebsiella pneumoniae	20	28.2	9	22.0	
Acinetobacter baumannii	7	9.9	3	7.3	
Pseudomonas aeruginosa	6	8.5	1	2.4	
Escherichia coli	4	5.6	5	12.2	
Enterococcus faecalis	6	8.5	1	2.4	
Candida spp.	0	0.0	2	4.9	
Staphylococcus epidermidis	6	8.5	7	17.1	
Proteus mirabilis	1	1.4	0	0.0	
Methicillin-resistant *Staphylococcus aureus*	12	16.9	8	19.5	
Stenotrophomonas maltophilia	2	2.8	1	2.4	
Enterobacter cloacae	4	5.6	4	9.8	
Citrobacter koseri	3	4.2	0	0.0	
Death					
No	132	74.6	144	81.4	0.158
Yes	45	25.4	33	18.6	

Chapter Four

Discussions and Conclusions

4.1 Summary of the main results

The investigation uncovered numerous crucial findings. Initially, there were differences in patient characteristics between the control and intervention groups. The control group had a greater number of male patients and a higher occurrence of hypertension and COPD, while the intervention group had a larger number of patients with shock, hemorrhage, or cardiac arrest. The adherence to the bundle care protocol was usually good, with most components ranging from (85.9% to 89.8%). However, the compliance rate for the daily check of line need was lower at (74.0%). The introduction of the bundle care strategy resulted in a substantial decrease in the occurrence of CLABSIs ($p < 0.001$). The clinical results revealed no statistically significant disparities in the length of stay in the intensive care unit, duration of central venous catheterization, or number of patient days between the two groups. Nevertheless, the control group had elevated systolic blood pressure, heart rate, SpO_2, WBC count, and CRP levels, suggesting a more pronounced state of illness. There was a significant drop in infections caused by pathogens such as *Klebsiella pneumoniae*, Methicillin-resistant *Staphylococcus aureus*, and *Acinetobacter baumannii* after the deployment of measures to reduce pathogens. While the execution of the strategy resulted in a drop in death rates, this reduction did not reach statistical significance ($p = 0.099$).

The data revealed that clinically-founded central line bundle care bundles has a huge impact on the safety of patients in critical care units. The reduced incidence of CLABSIs illustrates how effective the protocol is in preventing infections and improving clinical outcomes. The high rates of adherence suggest that these guidelines can easily be incorporated into their daily routines by medical personnel leading to improved disease control and patient management. This drop in major pathogenic microorganisms indicates the role of the protocol in reducing chances of getting serious diseases. However, the less-likely compliant percentage for daily line need checks shows the need for continuous training and focus in this area to ensure strict observance to protocols. Therefore, these findings are helpful for guiding future investigations aimed at maintaining strong compliance as well as exploring long-lasting benefits

associated with such treatment regimens. In addition, these discoveries may provide insights to healthcare policy-making and uniform approach development that could aid in decreasing CLABSIs and enhancing patient outcomes across various health care settings.

4.2 Discussion of the main findings

4.2.1 Characteristics of the patients

A total of 354 patients were recruited for the trial, with an equal distribution between the control and therapeutic groups. The baseline characteristics showed some differences, since the control group had a greater number of male persons, higher incidence of hypertension and COPD while the intervention group had more patients suffering from diseases like shock, bleeding or cardiac arrest. These disparities underscore the importance of factoring in patient demographics and comorbidity profiles when assessing therapy efficacy (Monegro et al., 2021; Salama et al., 2016). When comparing trial data with other studies, paralleled trends and discrepancies are identifiable if one looks at baseline parameters; e.g., effects on therapy outcome (Hemberg et al., 2023; Jeong et al., 2013; Karapanou et al., 2020; Karlnoski et al., 2019; Lafuente Cabrero et al., 2023). In the case where categorizing certain ailments such as hypertension or COPD is dependent on specific demographic features typical among control subjects; there may be differences in terms of acute illnesses including shock or cardiac arrest which could not be so accentuated in different researches concentrated on separate therapeutic approaches or patient characters but have been underlined by this investigation. The literature often highlights the need of accounting for initial variations to appropriately evaluate the effectiveness of a therapy, which aligns with the trial's acknowledgement of these discrepancies. Examining the extent to which these fundamental features correspond or deviate from previous studies helps in placing the results of this study within the wider scientific understanding of patient demographics and illness profiles in therapeutic treatments.

4.2.2 Efficacy of the bundle care protocol

The main finding of this study was the significant decrease in the occurrence of catheter-related bloodstream infections after the adoption of the bundle care strategy. This result was consistent with other studies, which suggest that following complete

care packages may significantly decrease infection rates (Alhamwi, 2018; Assis et al., 2018; Brachine et al., 2012; Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022; Burke et al., 2021; Card et al., 2023; DeVries, 2016; Gabriel et al., 2024; Gupta et al., 2021; Humar et al., 2000; Jeong et al., 2013; Karlnoski et al., 2019; LeMaster et al., 2014; Maria et al., 2021; Marra et al., 2011). The favorable result was achieved by the implementation of many components of the procedure, including hand cleanliness, maximum barrier measures, chlorhexidine skin antisepsis, appropriate catheter site selection, and daily check of line requirement.

The majority of components in the bundle had strong compliance rates, ranging from (85.9% to 89.8%). However, the daily evaluation of line need had a lower compliance percentage of (74.0%). This discovery means that though healthcare providers generally performed well, there may be room for continuous assessment of central line necessity and prompt removal of unnecessary ones.

These results show a significant decline in CLABSI rates when full care bundles are introduced. This finding is consistent with other researches demonstrating that implementing such measures immensely reduces infection rates (Alhamwi, 2018; Assis et al., 2018; Brachine et al., 2012; Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022; Burke et al., 2021; DeVries, 2016; Gabriel et al., 2024; Gupta et al., 2021; Humar et al., 2000; Jeong et al., 2013; Karlnoski et al., 2019; LeMaster et al., 2014; Marra et al., 2011). The successful outcome can be assigned to some key elements in the protocol like strict compliance with hand hygiene, complete barrier precautions during catheter insertion, using chlorhexidine skin antisepsis, careful placement of catheters, and periodic review of their necessity (Brachine et al., 2012; Frost et al., 2016; Oliveira et al., 2016). However, areas within the bundle had variable compliance as indicated by this study. Most aspects had a high rate of adherence whereas the compliance rate for daily evaluations of line need was (74.0%). Thus, even if they have good observance on other bundle parts personnel should always check regularly and remove unnecessary tubes as soon as possible. Comparisons with previous studies indicate that care bundles are helpful in lowering CLABSIs. However, there are some areas, such as daily line reviews, where improvement methods may be focused on to increase the effectiveness of protocols and ensure patient safety.

4.2.3 Impact on clinical outcomes

In addition to decreasing infection rates, the research also analyzed different clinical outcomes. There was no statistically significant disparity in the length of ICU stay, CVC duration, or patient days between the control and intervention groups. Nevertheless, significant disparities were seen in physiological indicators and laboratory data. Patients in the control group had elevated systolic blood pressure, heart rate, SpO_2, WBC count, and CRP levels, suggesting the presence of more severe underlying diseases or a heightened inflammatory response.

Hence, the program achieved a significant drop in the occurrence of CLABSIs ($p < 0.001$), showing that it is efficient. Prior to the intervention, Klebsiella pneumoniae, Methicillin-resistant Staphylococcus aureus and Acinetobacter baumannii were frequently reported as the most common pathogens. After the intervention, one can observe a steep fall in these pathogen-associated infections which indicates that this bundle care regimen was able to minimize chances of catching such diseases.

The findings prove that strict implementation of care bundle protocols considerably reduces CLABSI rates thereby supporting previous studies that have shown its efficacy. Several components are responsible for its effectiveness among them being; strict hand hygiene, barrier precautions, skin antisepsis, proper catheter site selection and daily line checks when necessary (Assis et al., 2018; Brachine et al., 2012; Buetti, Marschall, Drees, Fakih, Hadaway, Maragakis, Monsees, Novosad, O'Grady, et al., 2022; Burke et al., 2021; DeVries, 2016; Humar et al., 2000; Karlnoski et al., 2019; LeMaster et al., 2014; Marra et al., 2011; Mostafa et al., 2022; Pearlman, 2020; Prakash et al., 2017; Reyes et al., 2017; Salama et al., 2016; Scheithauer et al., 2014; Wallace & Macy, 2016; Wu et al., 2020; Zingg et al., 2023). However, this analysis indicates variability across elements with particular emphasis on non-compliance with daily line checks. In order to achieve better results, healthcare practitioners should prioritize the improvement of adherence to all components of the bundle, particularly by implementing focused interventions to guarantee consistent and timely evaluation of the requirement of catheters. Suggested actions based on these results include continuous education and training for healthcare personnel, establishing reminder systems for daily evaluations, and cultivating a culture that gives high importance to infection prevention procedures.

These initiatives may enhance compliance with treatment procedures and maintain decreases in CLABSIs, thereby enhancing patient safety and healthcare results.

4.2.4 Mortality rate

The introduction of a bundle care regimen did not produce significantly reduced death rates ($p = 0.099$). This means that although the bundle care protocol is successful in reducing infection rates, its overall impact on mortality could be affected by other factors such as the severity of underlying diseases and comorbidities.

These results show that although adoption of an all-inclusive treatment strategy reduces CLABSIs, it has no significant effect on overall death rates. This suggests that infection prevention alone may not be the only determinant for patient outcomes because other factors like underlying disease severity and co-morbidity might play a role. This finding was consistent with earlier research which has shown that infection control methods do not always translate into reduction in mortality directly, especially in critically ill patients with complicated medical conditions (Karapanou et al., 2020; Monegro et al., 2021). Some implications drawn from these findings include continued emphasis on adherence to infection prevention policies while also looking at broader areas of patient care including better management of underlying diseases and improving delivery of healthcare generally. Additional studies should investigate more treatments or alterations to the bundle care protocol in order to increase its efficacy in improving overall patient outcomes beyond infection rates.

4.3 Limitations of the study

It is important to take into account several constraints while analyzing the findings of this research. The use of a non-randomized design in this study may lead to selection bias, and the variations in baseline characteristics between the control and intervention groups might potentially affect the accuracy of the findings. Furthermore, the study's restriction to a single healthcare facility hinders the capacity to apply the results to other healthcare settings that have diverse patient groups and healthcare methods.

4.4 Implications

Based on the findings, this study has the following implications:

- **Minimizing the incidence of CLABSIs**

In the ICU, the incidence of CLABSIs can be effectively minimized by the implementation of an evidence-based care bundle protocol.

- **Improved clinical indicators**

Implementing the bundle can markedly improve WBC count, monocyte percentage, lymphocyte percentage, and CRP values. This indicates that the infection and inflammation among patients have diminished.

- **Protocol adherence**

Such statistics prove that these protocols can be implemented successfully in ICU settings through training and education (85.9% to 89.8% adherence rates for care bundle protocol components).

- **Mortality rate**

Nevertheless, while there was a decrease on mortality rates following the care bundle protocol being implemented, such difference did not reach statistical significance thereby indicating the need to further investigate factors influencing mortalities as well as consider more interventions that can help reduce them.

- **Daily line necessity evaluations**

This aspect of the protocol needs to be better followed because improving adherence to daily line necessity evaluations is one way to continue optimizing patient outcomes.

- **Future research directions**

It is imperative that future research focus on promoting and keeping up with high adherence to clinical care protocols alongside the review of long-term effects of these protocols on patient morbidity and mortality.

- **Healthcare policy and practice**

This study supports the decision to introduce evidence-based-guideline- based-care-bundle protocols in ICU settings aimed at improving patient outcomes and reducing CLABSIs, thereby influencing healthcare policy decisions and practice concerning infection control.

- **Training and education**

The findings demonstrate the significance of on-going training and education for healthcare professionals on compliance with care bundle protocols so as to maintain a consistent improvement in patient's service quality.

4.5 Recommendations

Given the reported data, it is possible to make various suggestions to enhance the efficiency of the bundle care regimen and enhance patient outcomes:

- **Improve Compliance with Bundle Components**

Although there are normally good rates of adherence, especially with hand cleanliness, maximum barrier measures, and chlorhexidine skin antiseptic, there is still potential for improvement in doing daily assessments of the requirement of lines. Implementing focused strategies such as frequent audits, feedback sessions, and instructional initiatives for healthcare personnel may effectively enhance compliance with this crucial element, hence assuring timely removal of superfluous central venous catheters and reducing the risk of infections.

- **Addressing the demographics and comorbidities**

Examine the patient's demographic information and any existing medical conditions they may have. Observe the disparities in the fundamental features of the control and intervention groups, namely the elevated occurrence of male patients, shock, hemorrhage, and cardiac arrest in the intervention group. These variables have the potential to impact results and should be taken into account while choosing patients and implementing protocols. Additional study or subgroup analysis might investigate if customized techniques are necessary for certain patient populations in order to maximize results.

- **Monitor and Adjust Clinical Practices**

Consistently observe and analyze infection and death rates to evaluate the continuing influence of the bundle care strategy. Although there was a notable decrease in catheter-related bloodstream infections, the death rates did not show a statistically meaningful change after the introduction of the approach. This indicates the need for continuous assessment and perhaps modifying the procedure based on up-to-date clinical data and input from healthcare professionals.

- **Microbiological Surveillance and Antibiotic Stewardship**

To address the presence of harmful bacteria, namely drug-resistant organisms such as Klebsiella pneumoniae and Methicillin-resistant Staphylococcus aureus (MRSA), it is advisable to establish effective monitoring systems for microorganisms and procedures that promote the responsible use of antibiotics. These endeavors may aid in the prompt identification of infections, suitable administration of antimicrobial treatment, and reduction of resistance patterns, hence improving patient safety and treatment results.

4.6 Conclusion

This research shows that the use of a central line bundle care strategy based on evidence substantially decreases the occurrence of CLABSIs in patients in the intensive care unit. The adherence to the bundle care protocol was usually good, with most components ranging from (85.9% to 89.8%). Although compliance with the majority of aspects of the protocol was excellent, further efforts to strengthen adherence to daily line necessity evaluations should further optimize patient outcomes. Future research should prioritize investigating methods to maintain consistently high rates of adherence and examine the enduring effects of these regimens on patient morbidity and death.

List of Abbreviations

Abbreviation	Meaning
CAUTIs	Catheter-Associated Urinary Tract Infections
CDC	Centers For Disease Control and Prevention
CDI	Clostridium Difficile Infections
CI	Confidence Interval
CLABSIs	Central Line-Associated Bloodstream Infections
CRBSIs	Catheter-Related Bloodstream Infections
CRI	Severe Catheter-Related Infection
CRP	C-Reactive Protein
CVC	Central Venous Catheterization
HAP	Hospital-Acquired Pneumonia
HR	Hazard Ratio
ICU	Intensive Care Unit
IHI	Institute For Healthcare Improvement
IRB	Institutional Review Board
IV	Intravenous
OR	Odds Ratio
RCT	Randomized Controlled Trial
SIRS	Systemic Inflammatory Response Syndrome
SpO_2	Oxygen Saturation
SPSS	Statistical Package for Social Sciences
SSIs	Surgical Site Infections
VAP	Ventilator-Associated Pneumonia
WBCs	White Blood Cells
WHO	World Health Organization

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Appendices

Appendix A

IRB approval

An-Najah National University
Faculty of Medicine & Health Sciences
Institutional Review Board

جامعة النجاح الوطنية
كلية الطب وعلوم الصحة
لجنة الخلاقيات البحث العلمي

Ref: Mas.. Feb. 2023/22

IRB Approval Letter

Title of Research:

The Impact of the Protocol Central line Bundle Care on Catheter Related Blood Stream Infection

Submitted by:
Safa Mosa Isaa Awad.

Supervisor:
Aidah Alkaissi

Approved:
26th Feb. 2023

Your Study Title "**The Impact of the Protocol Central line Bundle Care on Catheter Related Blood Stream Infection"** reviewed by An-Najah National University IRB committee and was approved on 26th Feb. 2023

Hasan Fitian, MD

IRB Committee Chairman

IRB
Institutional Review Board

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Appendix B

Checklist for prevention of central line associated blood stream infections

Checklist for Prevention of Central Line Associated Blood Stream Infections

Based on 2011 CDC guideline for prevention of intravascular catheter-associated bloodstream infections:
https://www.cdc.gov/infectioncontrol/guidelines/bsi/index.html
Strategies to Prevent Central Line–Associated Bloodstream Infections in Acute Care Hospitals: 2014 Update
http://www.jstor.org/stable/10.1086/676533

For Clinicians:

Follow proper insertion practices

☐ Perform hand hygiene before insertion.
☐ Adhere to aseptic technique.
☐ Use maximal sterile barrier precautions (i.e., mask, cap, gown, sterile gloves, and sterile full body drape).
☐ Choose the best insertion site to minimize infections and noninfectious complications based on individual patient characteristics.
- Avoid femoral site in obese adult patients.

☐ Prepare the insertion site with >0.5% chlorhexidine with alcohol.
☐ Place a sterile gauze dressing or a sterile, transparent, semipermeable dressing over the insertion site.
☐ For patients 18 years of age or older, use a chlorhexidine impregnated dressing with an FDA cleared label that specifies a clinical indication for reducing CLABSI for short term non-tunneled catheters unless the facility is demonstrating success at preventing CLABSI with baseline prevention practices.

Handle and maintain central lines appropriately

☐ Comply with hand hygiene requirements.
☐ Bathe ICU patients over 2 months of age with a chlorhexidine preparation on a daily basis.
☐ Scrub the access port or hub with friction immediately prior to each use with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol).
☐ Use only sterile devices to access catheters.
☐ Immediately replace dressings that are wet, soiled, or dislodged.
☐ Perform routine dressing changes using aseptic technique with clean or sterile gloves.
- Change gauze dressings at least every two days or semipermeable dressings at least every seven days.
- For patients 18 years of age or older, use a chlorhexidine impregnated dressing with an FDA cleared label that specifies a clinical indication for reducing CLABSI for short-term non-tunneled catheters unless the facility is demonstrating success at preventing CLABSI with baseline prevention practices.

☐ Change administrations sets for continuous infusions no more frequently than every 4 days, but at least every 7 days.
- If blood or blood products or fat emulsions are administered change tubing every 24 hours.
- If propofol is administered, change tubing every 6-12 hours or when the vial is changed.

Promptly remove unnecessary central lines

☐ Perform daily audits to assess whether each central line is still needed.

For Healthcare Organizations:

☐ Educate healthcare personnel about indications for central lines, proper procedures for insertion and maintenance, and appropriate infection prevention measures.
☐ Designate personnel who demonstrate competency for the insertion and maintenance of central lines.
☐ Periodically assess knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of central lines.
☐ Provide a checklist to clinicians to ensure adherence to aseptic insertion practices.
☐ Reeducate personnel at regular intervals about central line insertion, handling and maintenance, and whenever related policies, procedures, supplies, or equipment changes.
☐ Empower staff to stop non-emergent insertion if proper procedures are not followed.
☐ Ensure efficient access to supplies for central line insertion and maintenance (i.e. create a bundle with all needed supplies).
☐ Use hospital-specific or collaborative-based performance measures to ensure compliance with recommended practices.

Supplemental strategies for consideration:

☐ Antimicrobial/Antiseptic impregnated catheters
☐ Antiseptic impregnated caps for access ports

Appendix C

Data collection form for the retrospective period

Data sheet

Question										
Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
1. Age of patients (year)										
2. Sex					Male Female					
3. Diagnosis										
4. Previous history					1. Hypertension			Yes		No
					2.Diabetes			Yes		No
					3.Asthma			Yes		No
					4.COPD			Yes		No
					5.cardiovascular			Yes		No
5. Duration of ICU stay (day)										
6. Site of central venous catheter					1.Internal jugular 2.Subclavian 3.Femoral					
7. Days' duration of CVC										
8. Patients' days										
9. Reason for CVC					1.TPN treatment 2.IV medications 3.Poor IV access 4.Hemodynamic monitoring					

10.Initial vital sign (indicate to draw culture)

Temp		Bp	
HR		Spo2	

11.Laboratory study (indicate to draw culture)

A.CBC

WBC		**Monocyte**		**Basophile**	
Lymphocytes		**Neutrophil**		**Eosinophil**	

B. CRP titer (Initial)					
C. The isolated organism(s) From blood			**Negative**	**Positive**	
If positive type of organism(s)					
Klebsiella pneumoniae	Yes	No	Proteus mirabilis	Yes	No
Acinetobacter baumannii	Yes	No	MRSA	Yes	No
P. aeruginosa	Yes	No	Stenotrophomonas maltophilia	Yes	No
E. coli	Yes	No	Serratia marcescens	Yes	No
Enterococcus faecalis	Yes	No	Enterobacter cloacae	Yes	No
Candida spp.	Yes	No	Citrobacter koserii	Yes	No
S. epidermidis	Yes	No			
12. Percentage of death					

Appendix D

Data collection form for the prospective period

The effects of the central line bundle care protocol on catheter-related bloodstream infection

Data sheet

CLABSI is a laboratory-confirmed bloodstream infection (LCBI) where the central line (CL) was in place for >2 calendar days on the date of the event, with the day of device placement being Day 1, and the CL was in place on the date of the event or the day before. The CLABSI rate was calculated as the number of all CLABSI per 1000 CVC days

Question										
Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
1. Age of patients (year)										
2. Sex					Male Female					
3. Diagnosis										
4. Previous history					1. Hypertension			Yes		No
					2.Diabetes			Yes		No
					3.Asthma			Yes		No
					4.COPD			Yes		No
					5.cardiovascular			Yes		No
5. Duration of ICU stay (day)										
6. Site of central venous catheter					1.Internal jugular 2.Subclavian 3.Femoral					
7. Days' duration of CVC										
8. Patients' days										
9. Reason for CVC					1.TPN treatment 2.IV medications 3.Poor IV access 4.Hemodynamic monitoring					

10.Initial vital sign(indicate to draw culture)

Temp		Bp	
HR		Spo2	

11.Laboratory study(indicate to draw culture)

A.CBC

WBC		**Monocyte**		**Basophile**	
Lymphocytes		**Neutrophil**		**Eosinophil**	

B. CRP titer (Initial)		
C. The isolated organism(s) From blood	**Negative**	**Positive**

If positive type of organism(s)

Klebsiella pneumoniae	Yes	No	Proteus mirabilis	Yes	No
Acinetobacter baumannii	Yes	No	MRSA	Yes	No
P. aeruginosa	Yes	No	Stenotrophomonas maltophilia	Yes	No
E. coli	Yes	No	Serratia marcescens	Yes	No
Enterococcus faecalis	Yes	No	Enterobacter cloacae	Yes	No
Candida spp.	Yes	No	Citrobacter koserii	Yes	No
S. epidermidis	Yes	No			

12. Answer this question yes or no recording to daily maintain central line catheter.

1. Perform hand hygiene before insertion	Yes	No
2. Maximal barrier precautions up on insertion	Yes	No
3. Chlorhexidine (2% in 70%isopropyl alcohol) skin antisepsis upon insertion.	Yes	No
4.Optaminal catheter site selection (with avoidance of femoral vein for central venous access in adult patient.	Yes	No
5. daily review of line necessity with prompt removal of unnecessary lines	Yes	No

13. Percentage of death

جـامعـــة النجاح الوطنية

كليـــة الدراســـات العليـــا

أثر بروتوكول العناية بالقسطرة الوريدية على عدوى مجرى الدم المتعلقة بالقسطرة

إعداد

صفاء عوض

إشراف

د عائدة القيسي

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في تمريض العناية المكثفة، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2024

أثر بروتوكول العناية بالقسطرة الوريدية على عدوى مجرى الدم المتعلقة بالقسطرة

إعداد

صفاء عوض

إشراف

د عائدة القيسي

الملخص

خلفية الدراسة: حالياً، هناك حاجة للحد من التهابات مجرى الدم المرتبطة بالخط المركزي (CLABSIs). الهدف من هذه الدراسة هو تحديد كيفية تأثير حزمة الرعاية القائمة على الإرشادات القائمة على الأدلة على خطر الإصابة بعدوى مجرى الدم المرتبطة بالقسطرة أثناء تطبيق وإدارة القسطرة الوريدية المركزية في المرضى الذين يتلقون المتابعة والعلاج في وحدات العناية المركزة.

منهجية الدراسة: استخدمت الدراسة تصميما بحثيا شبه تجريبي، يتضمن تحليلا بأثر رجعي لحدوث التهابات الخط المركزي المرتبطة بمجرى الدم والتنفيذ المستقبلي للإرشادات المهنية القائمة على الأدلة لمنع التهابات مجرى الدم المرتبطة بالخط المركزي في مرضى وحدة العناية المركزة البالغين في مستشفى الميزان. مجموعة تجربة مستقبلية مع إرشادات مهنية قائمة على الأدلة المنفذة في الفترة من يناير 2023 إلى ديسمبر 2023 (12 شهراً محتملاً) وكانت المجموعة الضابطة بأثر رجعي مع الرعاية الروتينية بدون إرشادات في الفترة من يناير 2022 إلى ديسمبر 2022 (12 شهرا بأثر رجعي).

نتائج الدراسة: من بين المرضى، تم تخصيص 177 (50٪) لمجموعة التحكم و177 (50٪) لمجموعة التدخل. كان عدد كرات الدم البيضاء للمجموعة الضابطة أعلى بكثير من عدد المرضى في مجموعة التدخل (قيمة $p < 0.001$). وبالمثل، كانت النسبة المئوية للوحيدات للمرضى في المجموعة الضابطة أعلى بكثير من نسبة المرضى في مجموعة التدخل (قيمة $p = 0.027$). علاوة على ذلك، كانت النسبة

المئوية للخلايا الليمفاوية للمرضى في المجموعة الضابطة أعلى بكثير من تلك الخاصة بالمرضى في مجموعة التدخل (قيمة $p < 0.001$ كانت قيم CRP للمرضى في المجموعة الضابطة أعلى بكثير من قيم المرضى في مجموعة التدخل آنذاك (قيمة $p = 0.010$). كان هناك ارتفاع ذو دلالة إحصائية في حدوث التهابات مجرى الدم المرتبطة بالقسطرة قبل تنفيذ بروتوكول الرعاية التجميعية مقارنة بالفترة التي تلت تنفيذ بروتوكول الرعاية التجميعية ($p < 0.001$). على الرغم من وجود اختلاف في معدلات الوفيات بين الفترات التي سبقت تنفيذ بروتوكول الرعاية التجميعية مقارنة بالفترة التي تلت تنفيذ بروتوكول الرعاية التجميعية ، إلا أن هذا الاختلاف لم يكن ذا دلالة إحصائية ($p = 0.099$).

إستنتاجات الدراسة: يظهر هذا البحث أن استخدام استراتيجية رعاية حزمة الخط المركزي بناء على الأدلة يقلل بشكل كبير من حدوث التهابات مجرى الدم المرتبطة بالقسطرة (CRBSIs) في المرضى في وحدة العناية المركزة (ICU). على الرغم من أن الامتثال لغالبية جوانب البروتوكول كان ممتازاً، إلا أن بذل المزيد من الجهود لتعزيز الالتزام بتقييمات الضرورة اليومية للخط يجب أن يزيد من تحسين نتائج المرضى. يجب أن تعطي البحوث المستقبلية الأولوية لطرق التحقيق للحفاظ على معدلات عالية باستمرار من الالتزام ودراسة الآثار الدائمة لهذه الأنظمة على مراضة المرضى ووفاتهم.

الكلمات المفتاحية: حزمة، قسطرة وريدية مركزية، عدوى مجرى الدم، عدوى مجرى الدم المرتبطة بالخط المركزي، وحدة العناية المركزة، الممرضات.