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The Effectiveness of Using CLABSI Prevention-Education Based Intervention on Nurse Competency in Central Line Maintenance and Patient Care Outcomes in Intensive Care Units in Palestine: A Quasi-Experimental Study

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Declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is substantially my own work and has not been submitted for any other degree at the Arab American University or any other institution.

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Dedication

I dedicate this work to anyone who believes that this work is neither the beginning nor the end, but rather one of the stations for challenging oneself, confronting reality, and breaking the barrier of incapacity.

To everyone who embraces peace and love, and remains steadfast in resistance and perseverance against need, weakness, injustice, and obstacles.

This work is a heartfelt dedication to all those who have loved me, enveloped me in their immense trust, and believed in my ability to accomplish this task, seeing it as a fundamental building block for changing even a small part of reality.

It is the culmination of the hard work and effort of a complete team, starting with my parents, brothers, and sisters, and the swallows that used to fly at dusk in front of my balcony, where I spent long hours reminiscing, rephrasing sentences and vocabulary, and exchanging ideas. Joining this struggle are the voices of my dear supervisor, Dr. Ayman Mansour, Dr. Emad Fashafsheh, my honest friends and colleagues Dr. Nizar Al Sayed, Aseel Al Sayed, Israa Sakhleh, Mohammed Zapn, Nariman Nassar, as well as my colleagues and the unwavering support of Dr. Imad Abu Khader, Dr. Mohammed Qutait, Dr. Hisham Zahran, Dr. Loai Zabin, and Dr. Farid Abu Lil.

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Abstract

Central line-associated bloodstream infection (CLABSI) is a serious but preventive hospital-acquired infection. This study aimed to assess the effectiveness of providing an education-based CLABSI prevention intervention on nurses' competency in maintaining central lines and patient mortality rate and length of stay.

The study was conducted in intensive care units of the Ministry of Health Hospitals in the northern provinces of Palestine between September 2023 and March 2024. A quasi-experimental design was applied. The sample was convenient and nurses were allocated randomly to either a control group or an experimental group at hospital levels based on the bed capacity of the ICUs from where nurses were recruited. The knowledge was assessed using a translated, self-completed questionnaire. The nurses' skills were observed using a short version of the Ebru Kazan and Gulnur Kar checklist. Regarding the mortality rate and length of stay, a baseline measurement was performed retrospectively for three months before initiating the intervention and then monthly through the study.

A total of 98 intensive care nurses were involved in the study. The results indicated that was no significant difference in the baseline knowledge ($t = -0.61$, $p = 0.537$) and practice ($t = -0.376$, $p = 0.708$) of central lines' safe handling and maintenance between the two groups. The experimental group had their knowledge improved their practice level enhanced and the improvement maintained during the post-intervention period ($F_{(1, 41)} = 4485.58$, $p < 0.001$). Regarding the patient outcomes, there was no significant effect of the intervention on the mortality rate ($t = -1.85$, $p = 0.138$) and length of stay ($t = 177$, $p = 0.151$) in both groups.

Due to the effect of the educational intervention of this study in improving the intensive care nurses' competencies of central line care, it is recommended to apply ongoing education and in-service training in the infection control field to promote and maintain nurses' competencies of safe handling of central lines and preventing CLABSI.

Also, it is recommended to standardize policies for safe and efficient central line maintenance and Safe handling.

Keywords: Central line, knowledge, Nursing, skills, infection

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List of Definitions of Abbreviations

Abbreviations	Title
AAUP	Arab American University of Palestine
AHQR	Agency for Healthcare Research and Quality
ANCC	American Nurse Credentialing Center
ANOVA	Analysis of Variance
CDC	Center of Disease Control and Prevention
CHC	Chlorhexidine gluconate
CLABSI	Central Line Associated Blood Stream Infection
CRBSI	Catheter-Related Blood Stream Infection
CVC	Central Venous Catheter
CVI	Content Validity Index
CVR	Content Validity Ratio
EQUATOR	Enhancing the Quality and Transparency of Health Research
GCC	Gulf Cooperation Council
HAI	Health Care-Associated Infections
IBM	International Business Machines Corporation
ICU	Intensive Care Unit
INICC	The International Nosocomial Infection Control Consortium
IRB	Institutional Review Board
JBI	The Joanna Briggs Institute;
JCI	Joint Commission International
LOS	Length of Stay
M	Mean
MDROS	Multi-drug resistance Organism
MOH	Ministry of Health

Abbreviations	Title
NHSN	National Healthcare Safety Network
NO.	Number
PICU	Pediatric Intensive Care Unit
PPE	Personal Protective Equipment
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Scoping Review
PSFHI	Patient Safety Friendly Hospital Initiative
SD	Standard Deviation
SHEA	The Society for Healthcare Epidemiology of America
SIR	Standardized Infection Rate
SPSS	Statistical Package for the Social Sciences
TPN	Total Parenteral Nutrition
USA	United States of America
VAD	Venous Access Device
WHO	World Health Organization

Chapter One: Introduction

1.1 Background

Using central lines or central venous catheters (CVCs) in intensive care units (ICUs) is common; however, complications are issues to be concerned about. Pneumothorax, bleeding, and arrhythmia are examples of these complications; hence, catheter-related bloodstream infection (CLABSI) is the most common complication that has serious adverse effects (Ilyas et al., 2019; Van Den Bosch et al., 2022). CLABSI is a healthcare-associated infection (HAI) that occurs in five to ten percent of patients worldwide (Voidazan et al., 2020). It is also considered a serious infection and complication of improper insertion or maintenance of CVCs (Glover et al., 2022), especially if combined with immunosuppression and comorbidity (Blot et al., 2022; Monegro et al., 2023).

The reports indicated that critical care patients in low- and middle-income countries have a greater chance of acquiring CLABSIs than do those in high-income countries (Latif et al., 2024; Rosenthal et al., 2024). In Palestine, for instance, a study found that the average CLABSI rate was 3.7 per 1,000 device days, which was twice as high as the incidence reported internationally (Sabateen et al., 2022). This high level of CLABSI makes those patients vulnerable to further complications and devastating impacts (World Health organization, 2022), may prolong the length of stay by at least seven days (J. Lowery et al., 2022), and may cause more than 28000 deaths annually (Gupta et al., 2021; Haddadin et al., 2023).

CLABSI costs the healthcare system billions of dollars in both developed and resource-limited countries, with significant variation in cost among hospitals and countries (H. Toor et al., 2022). CLABSI is the costliest HAI, costing 31,000–65,000 per case and increasing costs by approximately 70% (Agency for Health care Research and Quality, 2022). Despite having a significant burden on healthcare systems, patients, and health institutions, CLABSIs are still highly preventable (Almahmoud et al., 2020). Nurses can reduce and prevent the occurrence of CLABSIs by enhancing their compliance with international recommendations for preventative practices and

improving their competence in CVC maintenance (S. Mohapatra et al., 2020; H. Toor et al., 2022).

Many studies across the world have assessed the competency level of CLABSI prevention and CVC maintenance among intensive care nurses to detect current practices and how they affect the CLABSI rate. ICU nurses have different levels of knowledge and practices related to CVC maintenance and safe handling among nations. In a study conducted in Malaysia, ICU nurses reported a good level of knowledge and practice (Azlan & Aung, 2021), and a satisfying level of practice was detected among intensive care nurses in Jordan (Aloush & Alsaraireh, 2018). However, intensive care nurses in Poland, China, and Egypt reported an insufficient level of knowledge and practice of the CLABSI bundle (Chi et al., 2020; Dyk et al., 2021).

Unfamiliarity with CLABSI prevention bundles and evidence-based practices to maintain and safely handle CVCs is a barrier to controlling CLABSI occurrence and optimizing the quality of care related to CLABSIs (Bae et al., 2022; Oncology Nurse Advisor, 2022). Therefore, numerous interventions have been delivered globally to increase nurses' competence in CVC maintenance and safe handling, especially in ICUs (R. Acharya et al., 2019; Alkhawaja et al., 2020; Rosenthal et al., 2010). In studies conducted in Saudi Arabia, the CLABSI rates decreased by 0.66 CLABSIs per 1000 device days, whereas nurses' competency levels improved after education-based training was applied (Waleed A Mazi et al., 2021; Perumal et al., 2022). Enhancing nurses' competency in CVC maintenance and adopting CLABSI preventive strategies also play a vital role in decreasing the CLABSI rate, hospitalization rate, and mortality rate threefold among patients with CVC (Chovanec et al., 2021; Hsieh et al., 2023; S. Mohapatra et al., 2020; Poh et al., 2020).

Several factors have been reported to affect the effectiveness of CLABSI prevention interventions in improving nurses' competency and eliminating the undesired effects of CLABSIs on patients and healthcare systems (Hebbar et al., 2015a; F. A. Mostafa et al., 2022). For example, the infrastructure and accessibility of necessary equipment and supplies are crucial for encouraging nurses' adherence to evidence-based guidelines for CLABSI eradication and providing best practices when handling CVCs (Garcia et al., 2022). Another factor that negatively affects nurses' compliance is having a high nurse-patient ratio, which can impair nurses' ability to work efficiently and

diminish their compliance with the CLABSI prevention bundle (Shang et al., 2019). Moreover, higher compliance is observed in nurses who have engaged in previous training sessions, who have more clinical experience, and who have a higher level of education (Aloush & Alsaraireh, 2018; B. Badparva et al., 2023; Chi et al., 2020; Dyk et al., 2021). The literature also shows that ongoing observations, surveillance, continuing in-service training, and standardization of nurses' practices are essential to preserve and maintain the effect of CLABSI preventative intervention on nurses' competency level and to prevent the detrimental effects of CLABSIs (Foka et al., 2021; Mathew et al., 2020).

The accumulated knowledge and literature suggest that this study mainly attempted to address issues related to CLABSI prevention in Palestinian ICUs. Nurses need to be aware of the CLABSI bundle and the principles of safe handling of CVCs and to recognize that patients' healthcare outcomes are significant indicators of the effectiveness of their care. This may require nurses to receive ongoing education and remain aware of the skills and knowledge needed to maintain patients' safety measures and improve the quality of their care to sustain a healthcare environment free of infection. In addition, they should be trained and tutored in evidence-based recommendations and guidelines.

1.2 Problem Statement

Healthcare-associated infection is considered among the key performance indicators of quality of health care, where CLABSI rate is one of these indicators, that affect the quality of care provided in healthcare settings (Scheinker et al., 2020). The prevalence of CLABSIs in low- to middle-income countries is three to five times greater than that reported in high-income countries (Alp et al., 2019). Palestine is one of low income countries in which there is a lack of national program to fight CLABSI.

In an attempt to improve the infection control practices and subsequently the patient outcomes, some health care agencies in Palestine actively participate in initiatives and accreditation programs which addressed the importance of maintaining an infection-free patient environment. For example, the Patient Safety Friendly Hospital Initiative (PSFHI) has been carried out to improve patient safety practices in Palestine (Siddiqi et

al., 2012). Another example is the Accreditation from the Joint Accreditation International (JCI) institution, which emphasizes the importance of HAI prevention as a fundamental patient safety goal and struggles to promote high-quality care and maintain the efficacy of healthcare services provided in hospitals (Joint Commision International JCI, 2022).

Unfortunately, the initiatives were temporarily implemented and targeted mainly the Palestine medical complex, while the JCI accreditation was attainable for only a few non-governmental hospitals. This indicates an inequality in improvement opportunities between these hospitals and the remaining MOH hospitals where there were insufficient financial resources. Consequently, a huge disparity the infection control practices, health care provider's competencies, and the reliability and availability of related data regarding infection prevention and patient outcomes indicators. In other words, efforts to control HAIs, especially CLABSIs, are still weak, fragmented, and target specific health institutions in Palestine.

Many obstacles are encountered by the healthcare system in Palestine. They are related primarily to the Israeli occupation. Restrictions on movements, frequent geographic separation, and frequent attacks by the Israeli military make life-saving procedures and interventions a priority. This condition results in a lack of adequate numbers of nurses, inequality in their distribution, and migration of healthcare providers, which contributes to jeopardizing healthcare services in Palestine (WHO, 2023).

Instability in the West Bank and fragmented health services have hindered the efforts to assess the current national prevalence of CLABSIs and to evaluate the effectiveness of infection control efforts. There is no reliable and valid data concerning the national CLABSI rate or standardized tracking of the quality of care provided to prevent CLABSIs and improve patients' and hospital outcomes. Moreover, the overload on the healthcare system coupled with limited resources delays the establishment of standardized CLABSI prevention programs and limits the ability to assess the healthcare providers’ awareness and compliance with CLABSI preventive approach and the outcome of their care (Willemsen et al., 2022).

The financial status further magnifies the problem. In other words, the financial resources for the Ministry of Health (MOH) are very limited and controlled by occupation, which decreases the availability of essential medical supplies in the market

(Ibrahim Salem, 2020). Importing essential medical materials requires permission from the Israeli government and is affected by political conditions that vary from time to time (Issa Noursi, 2022). In addition, there is a very limited budget for continuous training and education programs. Therefore, Palestinian nurses must provide care under stressful, demanding, and resource-limited work conditions.

In light of these findings, this study helps improve practices for preventing CLABSIs by educating and training nurses in the northern provinces of the West Bank. This education and training focused on applying the best evidence-based practices of CVC maintenance while utilizing the available equipment and materials. In addition, this study offers a valuable opportunity to assess the actual level of ICU nurses' competence in CVC care and maintenance and to improve this level, in addition to evaluating how improvements in nurses' competency level affect the quality of nursing care in terms of the mortality rate and length of stay.

1.3 Significance

This study is emphasizing care of patients admitted to ICUs. Enhancing nurses' awareness of the seriousness of CLABSIs and the importance of the CLABSI bundle encourages them to provide the most effective, prompt, and efficient CVC maintenance practices (Ibrahim Salem, 2020). This study played a crucial role in minimizing the gap between evidence-based recommendations and actual nurses' practices and assisted in delivering the best practices for patients (Almahmoud et al., 2020). Sufficient knowledge and practices can increase nurses’ competence and enhance their sense of responsibility toward patients with CVC (Dumont & Nesselrodt, 2012).

An additional favorable outcome of this study would be the effect of nurses' competency on patients' outcomes in terms of length of stay and mortality rate. This study inspired nurses to work collaboratively to promote the quality of their care in the safe handling and maintenance of CVCs. Promoting the quality of care could decrease the risk of CLABSIs, minimize the hospitalization time, prevent further infections, and minimize the probability of mortality (Sedrak et al., 2019), which in turn reduce both the cost of care and the economic burden on patients and health institutions (Phan et al., 2018).

Researchers, academics, and policymakers can also benefit from this study. The application of CLABSI prevention interventions in extremely poor infrastructure and limited resource environments provides a rich environment for research. Additionally, the effect of this study on patient safety would encourage academics to integrate evidence-based practices in their programs to be up-to-date with the universal concerns of patient safety. Policy makers, from their perspective, may be encouraged to modify or settle regulations that support the presence of a standardized surveillance system to better track CLABSI incidence, promote healthcare providers' capabilities and qualifications, and support managers of health care institutions in creating their own CLABSI prevention programs that move in synchrony with verifying the competencies of health care providers, especially in infection prevention.

Therefore, this study provides a distinguished opportunity to explore the exceptional relationships among nurses' competencies, the quality of care, and institutional patient safety outcomes and how they would be affected by the application of education-based interventions in the Palestinian health environment.

1.4 Statement of Purpose

The purpose of this study was to assess the effectiveness of using an education-based CLABSI prevention intervention on nurses' competency to maintain central lines and patient care outcomes (mortality rate and length of stay) among patients admitted to intensive care units in the northern region of Palestine.

1.5 Research Questions

The study was conducted to improve nurses' and patients' outcomes and to answer the following questions:

1.5.1 Primary Questions

1.5.1.1 Question One

What is the effect of a CLABSI prevention education-based intervention on nurses' competency in central lines' maintenance and safe handling among patients in intensive care units in the northern region of Palestine?

1.5.1.2 Question Two

What is the effect of a CLABSI prevention education-based intervention on patient care outcomes (mortality rate and length of stay) among patients in intensive care units in the northern region of Palestine?

1.5.2 Secondary Question

What are the differences in nurses' competency in central lines' maintenance and safe handling in relation to their demographic and institutional factors at baseline?

1.6 Research Hypothesis

The hypotheses for this study are as follows:

1.6.1 Hypothesis One

There is a positive effect of using education-based intervention for CLABSI prevention and central lines' maintenance on nurses' competency level in maintaining CVC among patients admitted to intensive care units compared to control group.

1.6.2 Hypothesis Two

There is a positive effect of using education-based intervention for CLABSI prevention and central lines' maintenance on length of stay and mortality rate intensive care units compared to control group.

1.7 Theoretical Framework

The American Nurse Association of Critical Care Nurses (AACN) Synergy Model for Patient Care is a widely used framework that aligns patient needs with nurse competencies. This model reflects the nurse-patient unique reciprocal relationship that leads to a safe patient care journey, as illustrated in Figure 1.1. Nurses' competencies protect patients from medical errors and harm (American Nurse Association of Critical Care Nurses, 2022), and these competencies are determined by the needs of the patients. Synergy and optimal patient outcomes occur when nurses' competencies correspond to patients' needs and consider the unique characteristics of patients. This will lead to the synergetic effect (Cordon et al., 2021).

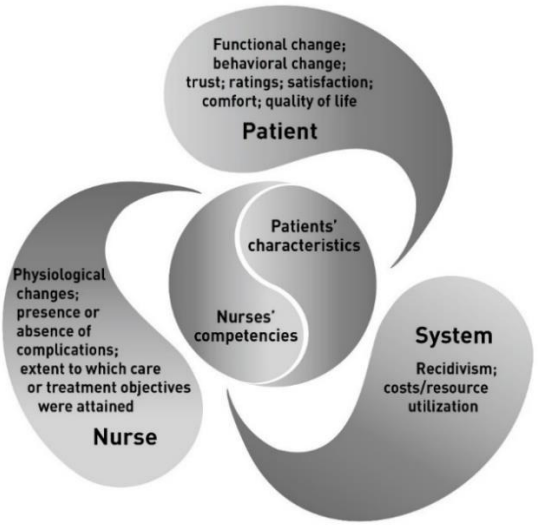


Figure 1.1 AACN Synergy Model for Reciprocal Relationships between Patients' Needs and Nurses' Competencies

The synergy model pays attention to what nurses collectively can achieve for patients and what patients collectively want. Nurses are frequently the voice of patients who are unable to express themselves. This reflects the unique relationships among nurses, patients, and their families. Competent nurses safeguard the rights of patients, sustain patient safety, and protect them from HAIs (Mohamed Ahmed, 2018). The synergy model states that when patient characteristics and nurse competencies synergize, optimal patient outcomes are achieved.

Nursing competencies are also described in terms of essential continuums. The synergy model describes eight dimensions of nursing practice that span the continuum from competent to expert. These competencies reflect a dynamic integration of the knowledge, skills, experience, and attitudes needed to meet patient needs and optimize patient outcomes (Swickard et al., 2014).

In the field of infection control, the synergy model could be a convenient model to explain the reciprocal relationship between nursing competencies and the incidence of CLABSI. Hospitalized patients have a right to zero infections, so keeping them safe and healthy through effective and efficient care is considered the ultimate purpose of all healthcare services. HAIs are among the primary risk factors for prolonged patients' hospitalization, and increase patients' vulnerability to more severe complications, disabilities, and even death. As a result, preventing the spread of infections, adhering to infection control precautions, and committing to Center of Disease Control and

Prevention (CDC) recommendations to prevent CLABSIs are vital requirements. On the other hand, patient-centered care focuses on delivering evidence-based procedures by competent healthcare providers, whose competencies are upheld by in-service training and ongoing education.

The concept of the Synergy model represents the cornerstone of this study. Throughout this study, intensive care nurses in the northern region of Palestine had an exceptional chance to advance their expertise in CVC care and CLABSI preventive procedures. The educational intervention of this study was structured on the basis of the baseline competence level of the intensive care nurses and the care outcomes of the ICU-admitted patients in terms of mortality rate and length of stay. This process defines the concept of synchrony between what patients need and what can be improved in nursing practices to obtain the desired patient outcome. The following hypothesized model illustrates the relationships between the study variables (see Figure 1.2).

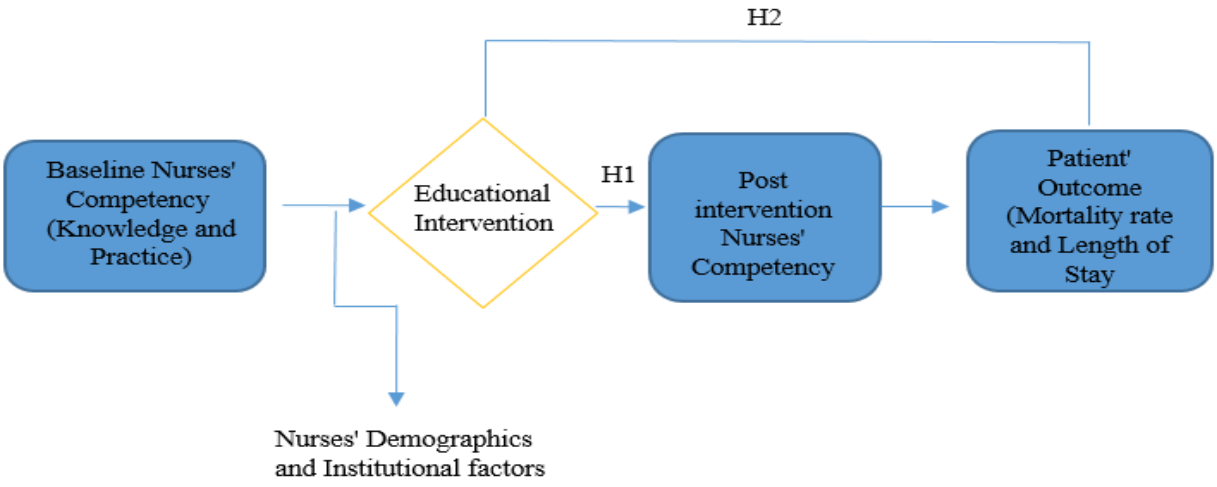


Figure 1.2 Hypothesized Model

1.8 Variables of the Study

1.8.1 Nursing Competency

1.8.1.1 Conceptual Definition

Competence is a noun (in doing something), the ability to perform something well, whereas competency refers to a skill that one needs in a specific job or for a particular condition (Oxford Learner's dictionaries, 2022). In a profession, competence refers to the personal ability to understand and perform needed tasks safely and effectively and is consistent with the expectations for a person equipped with education and training in a profession or specialty (Falender & Shafranske, 2007). In nursing, knowledge alone is not enough. It should be coupled with clinical competencies to guarantee effective and safe practices, and it is highly recommended and pivotal for nurses to be competent before providing direct care to patients (APSIC, 2017).

1.8.1.2 Operational Definition

In this study, nurse competency refers to the level of knowledge and practice of CVC maintenance and safe handling. Nursing knowledge of the CLABSI definition, Bundle, and principles of safe maintenance was addressed via a self-completed pretest and posttest questionnaire (see Appendix A). For this study, the pretest, posttest questionnaire was modified from the previous work of Humphrey (2015) and Ahmed.S (2021) to suit the available resources in Palestinian health institutions and to be convenient with the most recent evidence-based recommendation.

Practice and nursing skills were assessed by using an observational checklist developed by Gulnur and KAZAN (2021). This checklist was reviewed by a panel of experts from JCI-accredited hospitals. The checklist was used to observe and evaluate intensive care nurses' performance when CVC care was applied.

1.8.2 Central lines or CVC Maintenance

1.8.2.1 Conceptual Definition

Maintenance refers to keeping something working well (Elizabeth Walter, 2023), and CVC refers to applying sterile dressing over the insertion site frequently according to the CDC recommended, safely accessing ports, scrubbing the hubs, changing the infusion sets for intravenous fluid and blood and flushing the lumens as per the CDC and local policies (Bell & O'Grady, 2017; Quadros et al., 2022).

1.8.2.2 Operational Definition

The observational checklist of central line maintenance was developed by (Gulnur & KAZAN, 2021) used to assess the following practices of the intensive care nurses in this study:

- Sterile dressing was applied over the insertion site.
- Dressing changes were performed according to the instructions provided in the intervention of the study and based on the CDC recommendations.
- Scrubbing the hub via a non-touch technique.
- Accessing and flushing the CVC ports.
- The infusion sets were changed according to the type of solution administered.

1.8.3 Crude Mortality Rate

1.8.3.1 Conceptual Definition

The mortality rate is defined as the ratio between dead and living individuals in a particular population and within a specific period of time expressed per 1000 or 100,000 people. (Merriam Webster, 2024). Additionally, it can be defined as the number of deaths among a specific population related to a specific cause, age group, place, or over a defined period of time. The crude mortality rate is a general death rate in a population at specific times, regardless of the cause(Cambridge Dictionary, 2024; World Health Organization, 2024).

1.8.3.2 Operational Definition

In this study, the crude mortality rate was calculated according to the following formula (Centers for Disease Control and Prevention, 2012): the number of deaths divided by the total population size at a specific period of time multiplied by 10^3. The applied formula was as follows:

(No. of deaths/No. of population $*10^3$)

1.8.4 Length of Stay

1.8.4.1 Conceptual Definition

The average number of days patients spend during their hospital stay at a specific period of time (National Health Care Safety Network, 2023).

1.8.4.2 Operational Definition

The length of stay refers to the total number of occupied beds in a department at a specific time divided by the number of discharged patients in that department (World Health Organization, 2023a). The applied formula was as follows:

$\sum$ (Date of discharge - Date of admission)/number of discharges

1.9 Summary

This chapter highlight the crucial role of nursing competency in preventing CLABSI in Palestine. Educational intervention could improve nurses' competencies and enhance patients' outcomes.

Chapter Two: Literature Review

2.1 Introduction

Central line-associated blood stream infection (CLABSI) is among the life-threatening infections acquired during patient hospitalization. It has a negative effect on patient outcomes and places a high burden on the cost of care provided. Nurses are the guardians of patients during hospitalization, and they strive to deliver highly safe and efficient care and to maintain an infection-free environment. Many interventions are recommended to maintain zero CLABSIs and preserve patient safety. These interventions take many forms and vary among healthcare institutions, as does their effectiveness in fighting CLABSIs. This study sheds light on one of these interventions, which involves torturing nurses on the proper approach to CVC maintenance and how this training could improve their competencies and subsequently improve patients' outcomes.

This chapter delves in depth into the existing body of knowledge and evidence, delineates the extant literature, analyzes them to detect gaps in knowledge and inconsistencies in interventions, and synthesizes the available resources to highlight areas of improvement and future research opportunities. The detected gap within the literature is explicitly articulated to robustly justify conducting this study and the valuable and unique contribution of this study to the overall body of healthcare practices. In particular, this review of the literature endeavors to shed light on the realm of nursing competencies in the context of the maintenance of CVCs and their efficacy in promoting patient outcomes.

A comprehensive review of the relevant literature was executed to cover the following headings: the definition of CLABSI, its prevalence worldwide and in ICUs, modifiable and nonmodifiable factors contributing to CLABSIs, the impact of CLABSIs on patient and hospital outcomes, recommended preventive measures, the role of nursing in prevention and how nursing knowledge and practice are influenced by preventive interventions. In addition, this review searched literatures in education-based interventions aimed at preventing CLABSIs in ICUs and their influence on enhancing nurses' competency in CVC maintenance and patients' outcomes.

2.2 Search Strategy

After the main components or themes of the literature review were determined, key terms were selected and searched through the following databases: EBSCO host, Scopus, Science Direct, PubMed, Wiley Online Library, Medline through EBSCO host, and CINAHL Complete through EBSCO host.

2.3 Part One: General View of CLABSI Prevention-Related Issues

2.3.1 Definition, Types, Indications, and Pros and Cons of Different Central Lines

The central line is a medical device inserted peripherally or centrally (through the internal jugular, subclavian, or femoral vein) and advanced to terminate near the right atrium of the heart at the end of the inferior vena cava or superior vena cava. The central line has many synonyms, such as a central line, and a central venous access

There are many types of CVCs. They can be categorized according to the longevity of being in suit or their duration of treatment: short-term and long-term (or tunneled and non-tunneled). Short, non-tunneled catheters are the most commonly inserted, whereas tunneled catheters are indicated for patients who need prolonged treatment such as chemotherapy or dialysis (Tolbert & Morrall, 2019). Other classifications of CVCs are also used. The CVC could be permanent, such as tunneled or implanted ports, and temporary non-tunneled catheters (Ling et al., 2022). The selection depends on many factors, especially the indication of CVC.

In many circumstances, the medical team related to the CVC based on the insertion site. Internal jugular, subclavian, and femoral site CVCs are types of insertion sites (Pitiriga et al., 2020). Each site has advantages and disadvantages, and the preference depends on the patient's condition and the urgency of treatment (Heidenreich et al., 2022)..

2.3.2 Indications for CVC Insertion

CVC insertion is considered an essential medical procedure that is utilized for a variety of medical indications. First, the CVCs are essential for frequent and accurate

hemodynamics readings, such as central venous pressure which is crucial for proper fluid management in critical care patients (Audrey Tse; Michael A. Schick, 2022). Another primary indication for CVC is the administration of incompatible medications, infusions, and intravenous treatment that requires a prolonged period (Centers for Disease Control and Prevention, 2023). Total parenteral nutrition (TPN) is another frequent indication for CVC insertion in ICUs (Dube et al., 2020).

In addition, CVCs play a crucial for many invasive procedures like hemodialysis and plasmapheresis, which require frequent venous access for blood exchange, and pacemaker placement (Dube et al., 2020; Kolikof et al., 2023). In intensive care settings, many prescribed medications and infusions are vesicants and irritants, such as vasoactive medications and highly concentrated glucose. These can be incompatible with peripheral access and may cause phlebitis and extravasation; Therefore, CVCs are the first choice for intravenous access (Audrey Tse; Michael A. Schick, 2022).

Furthermore, CVCs are recommended for patients with oncological and hematological disorders (Raimbault et al., 2023). These patients often need frequent venipuncture for obtaining blood samples and cultures (Heidenreich et al., 2022), which makes their peripheral veins fragile, traumatized, and difficult to access. CVCs provide accessible and reliable for handling these problems and protecting patients from pain and unintentional complications (Larcher et al., 2023).

Chemotherapy administration is an additional challenge for patients with cancer. These agents are vesicant and irritant chemicals that may cause necrosis in blood vessels and worsen patients' condition in many cases (He et al., 2021). Chemotherapy administration through peripheral access is contraindicated (Utsu et al., 2021). Therefore, CVC is the access of choice (Sapkota et al., 2020). Moreover, CVCs could improve the quality of life and minimize pain in patients undergoing bone marrow transplantation or requiring frequent blood and blood component administration (He et al., 2021; Kolikof et al., 2023).

2.3.3 CLABSI Definition, Causes, and Risk Factors

CLABSI or catheter-related bloodstream infection (CRBSI) is defined as an infection of the bloodstream that results from a violation of aseptic technique during insertion and/or maintenance of CVC (Centers for Disease Control and Prevention,

2022b) and it is detected by laboratory studies within 48 hours of CVC insertion (Haddadin et al., 2022).

The CDC redefined the CLABSI to be an infection that occurs in patients with a CVC inserted for more than two calendar days or after the third day of CVC placement, just before a positive culture result is obtained (National Health Care Safety Network, 2024). Alternatively, an infection may be recognized in patients whose CVC was removed the day before confirming the results. Importantly, CLABSI is specific to inpatient settings during the current admission and following the initial access of the CVC (Chopra Vineet, 2024).

CLABSIs may occur via the migration of commensal bacteria into the bloodstream. Migration can occur via two common routes: intraluminal or extraluminal (Haddadin et al., 2023). The extraluminal movement of pathogens results from improper insertion site dressing and inadequate skin antisepsis and occurs within seven days of inserting the CVC. Pathogens may be transmitted from health-care providers' hands through the skin entry site to the external surface of the CVC's lumens toward the distal tip of the CVC (Chopra Vineet, 2024). Tunneled CVC has a cuff under the skin in which fibrinogen accumulates and prevents the migration of bacteria along the external surface (Haddadin et al., 2023)

On the other hand, intraluminal transmission mainly results from nonadherence to hub scrubbing before accessing, which results in port contamination and unsterile access to CVCs (Chopra Vineet, 2024). In this case, CLABSI occurs seven days after the CVC is inserted as a result of bacterial colonization inside the lumens of the catheter (Haddadin et al., 2023). Improper flushing of the CVC lumens facilitates bacteria migration into the bloodstream. A common source of infection is contaminated hands or intravenous fluid or medications, which can contaminate the insertion site or the hub of the catheter (Ling et al., 2022; Wei et al., 2021).

2.3.4 Causes and Risk Factors Contributing to CLABSIs

Given the multifaceted nature of CLABSI, it is crucial to consider and recognize various factors that may contribute to the occurrence of CLABSI, such as patient

attributes, healthcare practices, and environmental elements. These factors can be classified as intrinsic (nonmodifiable), or extrinsic (modifiable).

Modifiable risk factors are the target of many initiatives and preventive programs (Selby et al., 2021). Examples of these factors include the sociodemographic characteristics of the patient, such as age, sex, previous medical and surgical history (de Quadros et al., 2022); type of CVC inserted and site of insertion; the unit in which the patient was admitted (Dsilva et al., 2022a); healthcare providers' demographic characteristics, such as age, sex and educational level; and institutional factors, such as the number of years of experience and receiving education or training on CVC maintenance (Aloush & Alsaraireh, 2018). Contradictory findings exist regarding the effects of nonmodifiable factors on the occurrence of CLABSIs (Lafuente Cabrero et al., 2023).

2.3.5 CVC–Related Factors

The number of central catheter days, the dwell time of the CVC, and the prolonged catheter in situ are modifiable risk factors that increase the CLABSI rate (DiPietro et al., 2020; Khieosanuk et al., 2022; Mermel, 2020; Nielsen et al., 2022; Rabie et al., 2022; Scheier et al., 2021). Multiple-lumen CVCs (Torre et al., 2018), the use of a silicon-type catheter (Khieosanuk et al., 2022), frequent CVC access, improper reopening of occluded CVCs and CVC insertion in the operating room are also risk factors (Park et al., 2021). Furthermore, CVC with a large lumen diameter above seven Fr (van den Bosch et al., 2019) and inserting a CVC in the internal jugular or femoral vein are also risk factors (Heidenreich et al., 2022; Moriyama et al., 2022; Scheier et al., 2021).

2.3.6 Institutional and Health Care Providers' Related Factors

At the institutional and healthcare provider level, several factors contribute to CLABSI. The absence of standardized CLABSI preventive strategies and protocols, fragile systems, and inadequate resources, such as a lack of maximal sterile barriers (Joint Commision International JCI, 2022), insufficient surveillance and quality control monitoring (O'Grady, 2023), and limited leadership involvement of staff (Odada et al., 2023) are significant institutional factors linked with CLABSI.

The nonadherence of healthcare providers to established policies and guidelines at both the institutional and national levels is widely recognized as a prominent

contributing factor to CLABSIs (Hamza et al., 2022). Suboptimal staffing levels, exemplified by a high nurse-to-patient ratio, lead to insufficient time for essential tasks, such as the thorough evaluation of CVCs and add-on devices; these conditions have also been identified as key challenges (O'Grady, 2023; Odada et al., 2023).

Moreover, a high nursing turnover rate (Monsees et al., 2019) and deficient knowledge and skills in maintaining CVC stemming due to inadequate continuing education activities (Patil et al., 2022) significantly contribute to issues such as improper catheter insertions and substandard hand hygiene practices, thereby increasing the vulnerability of CLABSIs (Elgowainy, 2020).

2.3.7 Prevalence of CLABSIs Worldwide and in ICUs

Central Line-Associated Blood Stream Infection (CLABSI) is an issue of great concern at the global scale, as its incidence varies across different international and national regions. A multicenter study encompassing 281 intensive care units located within 95 hospitals across nine Asian countries revealed a pooled CLABSI rate of 5.08 per 1000 central venous device days. Notably, the highest CLABSI rate is linked with femoral catheters, temporary dialysis catheters, and jugular catheters (V. D. Rosenthal et al., 2023). Another multinational study involved 728 ICUs from 286 hospitals spread across 147 cities in 41 low- to middle-income countries recorded CLABSI rate of 4.82 CLABSIs per 1,000 catheter days in the ICUs which surpassed the rates reported by the CDC and the National Healthcare Safety Network (NHSN) (Victor Daniel Rosenthal et al., 2023).

In the United States, CLABSI incidence was evaluated in 448 ICUs and 677 medical-surgical units. The prevalence of CLABSIs in ICUs is approximately 0.87 per 1,000 catheter days (H. Toor et al., 2022). This rate was aligned with the National Standardized Infection Rate (SIR) of 0.84 reported by the CDC in 2022, which was based on data from 3,728 general acute care hospitals in the United States of America (USA) (Centers for Disease Control and Prevention, 2022a).

In the USA, a retrospective cohort study conducted in southern California reported CLABSIs rate of 1.7 per 1000 catheter days in the ICUs compared with 2.8 per 1000 days reported in inpatient wards. Notably, the rate of CLABSIs was particularly higher in patients having femoral and hemodialysis catheters (Harjyot Toor et al., 2022).

Conversely, in community hospitals within the same state, the incidence of CLABSIs was recorded as 1.09 (Nelson et al., 2022).

In the context of Southeast Asian countries with low to middle incomes, a variation in the rate of CLABSIs was observed. A study conducted in a single center in North India reported a CLABSI incidence rate of 9.3 per 1000 catheter days (Maqbool & Sharma, 2023). Moreover, a nationwide investigation in China examined the prevalence of CLABSIs among 38,212 patients admitted to ICUs. The average incidence rate was 1.50 per thousand catheter days, with the lowest incidence observed in the pediatric intensive care unit (PICU) and the highest in the cardiac intensive care unit (Zeng et al., 2021).

In South Africa, an academic hospital reported an incidence of 26.3 per 1000 CVC days (Glover et al., 2022), whereas a 400-bed teaching hospital in Slovakia reported a 2.81 CLABSI rate per thousand catheter days (S. Hlinkova et al., 2023), while in Switzerland, a seven-year study reported that CLABSIs rate of 2.20 CLABSIs per 1,000 catheter days (Paioni et al., 2020).

In the Arab region, numerous investigations have been carried out to explore issues related to CLABSIs. A study conducted in Saudi Arabia examined the CLABSI incidence in ICUs of 106 hospitals over two years revealed a rate of 3.24 per 1,000 catheter days (Alanazi et al., 2021). Another study conducted at King Fahad Hospital of the University in Saudi Arabia reported CLABSI incidences of 4.97, 2.99, and 4.56 per 1,000 catheter days in the medical, surgical, and PICUs, respectively (Alwazzeh et al., 2023).

In addition, the infection rate was found to be 0.63 per thousand central line days in the 27-bed medical-surgical ICU of King Faisal Medical Complex (W. A. Mazi et al., 2021). Another prospective surveillance study reported a CLABSI rate of 3.24 per 1,000 catheter days, which aligned with the standardized infection ratios reported in Gulf Cooperation Council (GCC) hospitals but exceeded those reported in NHSN hospitals and fell below the rates reported in International Nosocomial Infection Control Consortium (INICC) hospitals (Alanazi et al., 2021).

On the other hand, in Oman, the estimated average incidence was 8.6 per 1,000 catheter days over two years (Al-Shukri et al., 2022), whereas a prospective study for the Kingdom of Bahrain estimated that the average CLABSI incidence was 3.2 per thousand

catheter days (Al-Khawaja et al., 2021). In Jordan, a study conducted in three hospitals reported that the CLABSI rate among ICU-admitted patients was 1.98 per thousand catheter days (Matlab et al., 2022), whereas a single study conducted in Augusta Victoria Hospital in Palestine reported that the CLABSI rate was seven times greater than that reported in Jordanian hospitals (Sabateen et al., 2022).

2.3.8 The Impact of CLABSIs on Patient and Hospital Outcomes

Health care-associated infections (HAIs) including CLABS increase mortality and morbidity rates. Every year, more than a million HAIs harm one out of every 31 hospitalized patients in the USA, adding billions of dollars to healthcare costs (Agency for Health care Research and Quality, 2022). One of the most commonly reported HAIs is CLABSIs, which impose a significant burden on hospital and patient outcomes(Maqbool & Sharma, 2023). As reported by Niccolò Buetti et al. (2022), CLABI prolonged the length of hospital stay (LOS) (Alshahrani et al., 2023) and added nearly 30,000 dollars to the cost of care (Niccolò Buetti et al., 2022). A study by Al-Khawaja et al. (2021) also revealed that patients with CLABSIs had increased LOSs and mortality rates (Al-Khawaja et al., 2021).

The mortality rate in patients with CLABSIs is dramatically increased on the basis of the type of CVC and the insertion site used (Alwazzeh et al., 2023). A study conducted in six ICUs in China revealed that the attributed effect of CLABSIs on health costs was double the cost required for patients with the same conditions but without CLABSIs, as was the effect of CLABSIs attributed to an additional 20 days on the LOS (Zhang et al., 2023). In Germany, a study by Baier et al. (2020) revealed that patients with CLABSIs had a twofold longer attributable LOS than patients without CLABSIs did, and CLABSIs were independently associated with increased costs (Baier et al., 2020).

A positive correlation between LOS and CLABSI occurrence was identified in a study conducted in Saudi Arabia between 2016 and 2018 (Alotaibi et al., 2020). Another study from Nairobi reported that patients who developed CLABSIs had prolonged LOSs, mortality rates, and subsequent increases in healthcare costs (Kiroro & Twahir, 2018). The previous effects of CLABSIs were also confirmed in a long-term prospective study conducted in Taiwan from 2011 to 2020, in which patients with CLABSIs stayed ten days longer than patients without CLABSIs did (Liu et al., 2023).

2.3.9 Preventive Measures and Intervention to Eliminate CLABSIs

The above sections showed that CLABSIs are a serious health problem in ICUs, imposing a substantial threat to patients' and hospitals' outcomes. It prolongs the LOS, increases morbidity and mortality rates, and presents a serious economic burden. Therefore, adopting and executing diverse preventive interventions is vital to achieve zero CLABSI.

The CDC has implemented many initiatives and efforts to decrease and even prevent CLABSIs. They developed reliable evidence-based guidelines and toolkits, defined CLABSIs, standardized the CLABSI incidence calculation, and published recommendations to improve healthcare providers' practices and to assist organizations and healthcare systems in eradicating CLABSIs (Centers for Disease Control and Prevention, 2023).

The CLABSI prevention bundle is an example of a CDC toolkit. This was the result of a large study including 1,000 ICUs that participated in the *On the CUSP: Stop BSI* project (Agency for Health care Research and Quality, 2018). The CLABSI bundle is a group of simple, feasible, and evidence-based practices used to properly insert and maintain various types of CVCs in different healthcare settings and patient populations (Brunner et al., 2023; Hussain et al., 2020). The bundle is a multidisciplinary approach that is essential for ensuring patient safety, maintaining high-quality care, and ensuring an infection-free environment. For ultimate benefit, the components of the bundle should be applied collectively to achieve the desired outcomes (Doellman, 2023).

Many healthcare institutions have adopted the CLABSI bundle as a strategic plan to maintain zero CLABSI, guarantee consistency in delivering the best care for all patients with CVC, and monitor the compliance of healthcare providers (Hamza et al., 2022; Waleed A Mazi et al., 2021). This bundle encompasses five essential practices to protect patients from CLABSIs: hand hygiene at five points (hygiene must be performed before and after palpation of the insertion sites and before and after insertion, dressing, accessing, or any other form of manipulation of the CVC, using chlorhexidine (CHC) 2% in 70% alcohol antiseptic, maximum barrier precaution for CVC insertion, optimal insertion site selection and finally a daily review of CVC necessity (Lin et al., 2018; Veer & Sharma, 2023).

The Society for Healthcare Epidemiology of America (SHEA) recommends additional essential practices to maintain CVC. These evidence-based interventions are integral parts of the CDC bundle (The Society for Healthcare Epidemiology of America (SHEA), 2022). These practices encompass: scrubbing the hub for an average of 15 seconds using CHC 2% in Isopropyl Alcohol or Alcohol 70%, disinfecting all needleless connectors, flushing with syringes with a minimum size of 10 ml for each lumen, changing the heparin lock when needed, changing gauze dressing every 24 to 48 hours and the transparent dressing at least weekly (The Society for Healthcare Epidemiology of America (SHEA), 2022).

Additionally, the intravenous tubing should be replaced every 72–96 hours, the blood and TPN administration sets to be replaced every 24 hours, and the tubing used for administering Intralipid should be replaced every 8 hours (Alkhawaja et al., 2020; N. Buetti et al., 2022; The joint Comission International, 2024; The Society for Healthcare Epidemiology of America (SHEA), 2022).

Many healthcare institutions adopt the bundle and the SHEA recommendations as the core of their quality and infection control programs and the skeleton of any improvement initiatives to maintain a CLABSI-free health environment. Most programs are multidisciplinary and apply a range of interventions supported by education, which is a key factor for eliminating CLABSIs (Engel et al., 2023).

The majority of the education-based interventions targeted healthcare providers involved in inserting and maintaining the CVC. The desired outcome of these programs was to enhance nurses' competencies (knowledge and practice) in handling CVCs and to improve their compliance with the most updated evidence-based practices essential to sustaining zero CLABSIs (Ling et al., 2022).

Education-based interventions take several forms and integrate multiple teaching methods (Aloush & Alsaraireh, 2018). PowerPoint presentation, classroom discussions, leaflets, videos, and memorizing cards are supportive materials to enhance the effectiveness of the education process (Negm et al., 2021). Another pivotal approach is simulation-based training (Gauntt et al., 2022) which torture healthcare providers in the proper technique of CVC maintenance and enhance healthcare providers' competencies (de Quadros et al., 2022; Hernández-Aceituno et al., 2020). Some programs also employ computer-based education and e-learning modules to increase healthcare providers'

knowledge of CVC maintenance and CLABSI prevention (Adawee et al., 2023). In other programs, education took the form of enduring lectures and frequent learning sessions during rounds (Centers for Disease Control and Prevention, 2023).

Compliance and adherence with CLABSI bundles are pivotal for eliminating CLABSIs and are complementary to education-based interventions. To maintain adherence to best practices guidelines and policies to prevent CLABSIs, it is imperative to establish a strong surveillance system and follow-up plans to monitor healthcare providers during CVC insertion and maintenance (El-Sadek et al., 2022).

The CDC developed bundle-based checklists to systematically monitor and assess compliance (Centers for Disease Control and Prevention, 2023). Many healthcare facilities depend on these checklists to ensure that healthcare providers adhere to CLABSI prevention policies and to assess the effectiveness of educational programs (Çavdar & Akyol, 2022). Many surveillance systems rely heavily on CDC definitions and checklists (National Health Care Safety Network, 2024) as standardized surveillance is a cornerstone in preventing CLABSIs (Haddadin et al., 2023; Saleem et al., 2019).

Surveillance systems are essential for detecting CLABSIs and evaluating the effectiveness of preventive strategies (Rai et al., 2023). However, applying a standardized surveillance system alone cannot eliminate CLABSIs (National Healthcare Safety Network, 2024); instead, these systems are commonly applied as integral components of initiates, awareness campaigns, and infection control programs side by side with on-the-job training and continuing education activities. (Centers for Disease Control and Prevention, 2023).

Effective surveillance should be initiated and executed by a qualified and specialized team that is competent to apply surveillance and to observe and report the competence of healthcare providers in maintaining CVC(Hill et al., 2022; Welter & Villanueva, 2022). A further discussion of CLABSI preventive interventions is provided in the next review section.

2.3.10 Global and Regional Barriers and Obstacles to CLABSI Prevention

Many obstacles interfere with preventing CLABSIs. These challenges have been recognized in global, regional, and local settings and categorized as institutional and individual obstacles.

At the regional level, healthcare systems in many countries are immature, lack standardized policies, do not utilize CLABSI bundles and toolkits, and there are no uniform surveillance systems or inconsistencies in reporting CLABSIs (Aloush et al., 2018). This makes it difficult to identify the magnitude of the CLABSI burden on the health system of these countries, and it is difficult to compare the CLABSI incidence and impact to an agreed-upon benchmark.

In addition, limited resources and low income lead to the inaccessibility of essential supplies such as personal protective equipment (PPE), disinfectants, semipermeable dressings, and antiseptic solutions most of the time (Cameron et al., 2021). Furthermore, the infrastructures of healthcare institutions have a great impact on eliminating CLABSIs. Crowding patients' rooms in combination with poorly distributed sanitation areas discourages nurses from doing hand hygiene and facilitates the spread of CLABSIs (Maki & Zervos, 2021).

Many low-income countries complain of a shortage of qualified and competent nurses, high turnover, and heavy workloads. These factors limit direct interaction between patients and healthcare providers, consequently leading to a decline in the ability to adhere to CVC maintenance guidelines (Matlab et al., 2022). Noncompliance with regulations by healthcare providers is often attributed to insufficient continuous professional development and training in infection control principles (Nasiri et al., 2023). Nurses working in such facilities also lack adequate exposure to evidence-based guidelines, resulting in a lack of awareness and comprehension of the current protocols (El-Sadek et al., 2022). This challenge is exacerbated by disparities in resources and surveillance systems at the regional level (N. Buetti et al., 2022).

The presence of patient safety culture within organizations is a leading factor for sustaining patients' safety and zero CLABSI environments (Zabin et al., 2022). It is aground for effective teamwork work and positive attitudes toward high-quality patient-centered care (Richter & McAlearney, 2018). The lack of this cultural aspect leads to a substandard level of dedication to ensuring patient safety principles along with noncompliance with infection control principles and disbelief in the ability of bundles and toolkits to reduce CLABSIs (Harlan et al., 2022).

On the other hand, patients and their families are the principal factors in decreasing the CLABSI level. Patient and family participation in care helps improve

compliance with infection control regulations (Lin et al., 2024). However, poorly educated, health-illiterate patients face challenges in adhering to hand hygiene practices, personal hygiene, and isolation precautions. The absence of efficient health education about CLABSI prevention and patient acuity makes patients and their families uncooperative and unable to report symptoms of infections; therefore, many initiatives focus on educating patients and improving their awareness of infection control precautions (Suttle et al., 2019).

2.3.11 Context of the West Bank

Conducting research in the West Bank represents significant challenges, particularly in the field of healthcare. The occupation and political conflicts in the region have had a profound impact on the Palestinian healthcare system and scientific research, resulting in detrimental constraints and limitations on various components of the system, including healthcare providers, clients, administrative systems, resources, and infrastructure (Abu Moghli, 2023).

Access to healthcare facilities and services is often restricted owing to the establishment of unplanned, permanent, or temporary checkpoints by the occupation's military. Additionally, sudden invasions and attacks on cities and the countryside areas further exacerbate limitations on freedom of movement. Consequently, healthcare services become fragmented, placing both patients and healthcare providers under high-pressure conditions (Mosleh et al., 2018). Both of them struggle to reach hospitals and healthcare centers, and when they do, they encounter highly stressful environments that negatively impact all aspects of care. These conditions are time-consuming, financially burdensome, and have psychological consequences (United Nations Population Fund, 2024).

Healthcare researchers are greatly affected by these challenging circumstances. They require additional time and more financial support to reach their target populations, including patients, administrators, and individuals who encounter difficulties in accessing healthcare facilities (Director-General, 2024). Many of those nurses become uncooperative with researchers, as their priority is to seek care and return home, prioritizing their immediate needs.

The pressurized work environment indirectly hampers the quality of healthcare and contributes to the spread of infections, including hospital-acquired infections such as CLABSIs. These issues are further magnified by fragile infrastructure, which is a consequence of unstable political conditions and immature strategic planning (N. Buetti et al., 2022). Additionally, there is a shortage of qualified and specialized healthcare providers, as many have migrated outside the country (Anera, 2020). Despite the Ministry of Health's efforts to standardize policies and regulations, these efforts remain insufficient.

Nongovernmental hospitals often precede the MOH in adopting new services, establishing policies, and seeking accreditation from international associations in an attempt to fill the gaps in services provided. However, there is still a lack of national, standardized policies and surveillance systems to track the effectiveness and efficiency of healthcare services, including infection control efforts (Kheir-Mataria, 2019). This creates a significant gap in the quality of care and the distribution of healthcare services, as well as a lack of valid and reliable evidence-based data on health conditions in the West Bank. Nevertheless, these obstacles are rich environments for research.

Economic conditions have a devastating effect on the healthcare system. The occupation restricts financial transactions, particularly to the MOH (M. Koussa, 2023). This situation has been compounded by years of fighting COVID-19, and now, financial support has been completely blocked due to (Tawafan Al Aqsa). For many years, healthcare providers in all Ministry of Health hospitals have been earning only 60% or less of their salary, leading to many retirements due to financial strain. This compels administrators to declare an emergency state, leading to health services being provided at minimal staffing levels, which further disturbs the delivery of care.

This notable shortage of healthcare providers became even more pronounced during the war in Gaza, where the siege on cities coincided with the absence of salaries. This is a crisis regarding quality of care, and from the research perspective, researchers may be unable to contact participants within the time frame of their studies.

The occupation exacerbates the current conditions by constricting trade preventing procurement, importing, and accessing essential medical equipment and supplies to provide accepted quality health care, which may lead to increasing the spread

of hospital-acquired infections, worsening hospital and patient outcomes and complicating the existing conditions (Rosenbloom & Leff, 2022). From the research perspective, the lack of necessary equipment and materials hampers the ability to conduct many research studies.

Economic restraint hinders the ability to allocate resources essential for effective health services. This affects salary offerings and exacerbates disparities in the workforce. These conditions heavily hamper steps toward promising hospital and patient outcomes and research efforts and delay the implementation of professional development programs across healthcare facilities (N.Shiraz, 2021).

2.3.12 Conclusion

CLABSI continues to pose a significant challenge in healthcare settings. Despite the enormous effort to eliminate CLABSIs, various challenges and obstacles hamper the effectiveness of these efforts and initiatives. Addressing these obstacles through research could help control them and enhance adherence to evidence-based guidelines. Education-based intervention is an essential part of any preventive strategy. Creating a safety culture is key to maintaining an infection-free environment and improving nurses' competencies in the West Bank, the condition is more complex and challenging, and any single step can make a difference in controlling infections.

2.4 Part Two: Central Line-Associated Blood Stream Infection Preventive Interventions in Intensive Care Units: Scoping Review

2.4.1 Introduction

CLABSI is among the most serious hospital-acquired infections and is associated with devastating effects on patient and hospital outcomes, especially in low-income countries (Alkhawaja et al., 2020). It increases the mortality rate, prolongs hospital stays, and increases the health care costs (Fadwa Abu Mostafa et al., 2022). There are many leading factors for CLABSIs, such as deficiencies in essential medical materials and equipment, patient morbidity and health conditions, and hospital-related causes, such as a lack of policies and in-service training, and the absence of a dedicated infection control team (Bita Badparva et al., 2023).

CLABSI preventive interventions usually target the contributing factors of CLABSIs (Hamza et al., 2022). Although the outcome is to prevent CLABSIs, these interventions take many forms and may differ in their specific goals, the target group, the strategies adopted, and the time frames. Some interventions focus on a single approach, such as training and education on the CLABSI prevention bundle, while others adopt a multifaceted approach such as establishing a specialized infection control team, with modifying policies and guidelines(Arrieta et al., 2019; Bierlaire et al., 2021).

Despite the promising effects of many interventions in decreasing the incidence of CLABSIs, the optimal efficacy, effectiveness, reliability, and applicability of these interventions are still unclear (Lazarus et al., 2023). There is a need to explore and examine the scope, extent, and range of available intervention-based studies to prevent CLABSIs and to comprehend the existing evidence on this topic.

The scoping review approach is preferred for systematically mapping the literature that underpins the various types of intervention approaches applied in the field of CLABSIs. For these reasons, this scoping review was conducted to address the different types of interventions that have been applied to reduce the CLABSI rate, to identify the target group of these studies, the outcomes desired from conducting these interventions, the methods of measurements, and to identify any gap in the literature. Therefore, this scoping review was conducted to answer the following questions:

- What evidence exists in the literature regarding education-based interventions that aim to increase intensive care nurses' competencies in the maintenance of central lines and the prevention of CLABSIs?
- What is known about intensive care nurses’ competency of central line maintenance and CLABSI prevention?
- What is the effect of applying education-based interventions on nurses' competencies in central lines' maintenance and safe handling, as reported by the reviewed articles?
- What are the main gaps regarding CLABSI preventive interventions in the literature, and what are the most urgent recommendations for future research?

2.4.2 Methods

2.4.2.1 Protocol and Registration

This scoping review was conducted on the basis of the framework of the Joanna Briggs Institute (JBI) and was reported by the Preferred Reporting Items for Systematic Review and Meta-Analyses-Scoping Review Extension for Scoping Review guidelines (PRISMA-ScR), which was developed according to published guidance by the Enhancing the Quality and Transparency Of Health Research (EQUATOR) Network for the development of reporting guidelines (Levac et al., 2010; McGowan et al., 2020). A research team revised the protocol.

2.4.2.2 Eligibility Criteria

The inclusion criteria of this review are illustrated in Table 2.1 and follow the mnemonic described by (population, concept, and context) in addition to the design, date, language, and type of sources. The inclusion criteria were tested by two independent reviewers (MW and SI) before initiating the study selection process.

Table 2.1 Inclusion and Exclusion Criteria: Population, Concept, and Context

Category	Inclusion	Exclusion	Rational
Population (Intensive Care Nurses)	Studies targeted nurses who provide direct care to patients in ICUs despite being the targeted population or being a part of a multidisciplinary team targeted by the study.	Studies that targeted nursing students and healthcare providers other than nurses.	

Category	Inclusion	Exclusion	Rational
Concept (Education-based intervention)	Structured training or education-based interventions that take one or more of the following formats: lecture-based learning, PowerPoint sessions, seminars, clinical training, simulations, sharing memorizing cards, e-learning modules, blended learning approach, learning during rounds ...etc.	Interventions that depend on self-reported or monitored practices	This review was intended to explore the effect of educational intervention on nurses' competence using well-defined objective criteria. Using a self-assessed tool increases the bias and subjectivity of the results.
Context (Intensive Care Units)	Different types of Intensive Care Units.	Neonatal Intensive Care Units	The NICUs were excluded because the neonatal population has exceptional guidelines, policies, and regulations for CVC insertion and maintenance.
Language	Only English- based peer-reviewed research was retrieved	Any other Language	English is the most commonly used language and the only understood by the research team.
Design	The eligible designs included but were not limited to quantitative and pre-post, quasi-experimental, experimental, and control group designs.	Qualitative and Descriptive designs	Qualitative and descriptive were excluded because their design could not measure the effects of

Category	Inclusion	Exclusion	Rational
			the interventions and just reflect the situation at the time of data collection, also this design would not help answer the review questions.
Date Range	2013-2023		To guarantee the synthesis of a variety of updated evidence.
Type of source of evidence	Peer-reviewed research articles	Gray studies, Review studies, and qualitative studies	To control for the quality of studies involved.

2.4.2.3 Data Sources and Search

The investigator initially searched for key studies in Google Scholar and PubMed to use them as seed documents. They assisted in identifying further studies and essential keywords and formulating a search strategy. For a rigorous and relevant search process, the investigator conducted an initial search, after which the search criteria were iteratively developed until the search team became satisfied with the strategy and the keywords were convenient for answering the review questions.

After conducting a peer review of the search strategy, an agreement was reached to determine and refine the key terms and synonyms; then, they carried out a systematic search for relevant research articles in the following databases: EBSCO host, Scopus, Science Direct, Pub Med, Wiley Online Library, Medline through EBSCO host, and CINAHL Complete through EBSCO host from January 2013 to September 2023.

The research team utilized the following keywords: central line infection, central line-related bloodstream infection, central venous catheter-associated bloodstream

infection, central venous catheter-related bloodstream infection, central venous access device-related infection, central venous access device-associated infection, central venous access-related bloodstream infection, central line-associated bloodstream infection, intervention, treatment, program, education, and training.

Boolean operators such as "OR " and "AND" were applied to form composite expressions to enhance the search process. Also, the research team applied filters for publication date and article type. The search strategy was limited to research articles published from 2013 to 2023 and in English. Following that, the investigator exported the extracted articles into End Note and removed duplicates. The electronic database search was performed through the AAUP and An-Najah National University e-libraries. The final search strategy for PubMed is displayed in Appendix B.

2.4.2.4 Data Charting and Calibration

The main author created a Microsoft Excel Charting Form or Matrix to help standardize the capture and charting of relevant variables and sources of evidence. A panel of three experts in research jointly reviewed the matrix and the extraction process. The matrix and the charting procedure were amended accordingly before commencing the screening. The three experts and investigators screened the same studies to increase the consistency in screening the data.

Based on relevancy and eligibility, the team first evaluated the titles, the abstracts, and then the full-text articles. After completing the screening, they met to compare the final extracted articles, but there were disagreements on several studies; therefore, an external expert was consulted to reach a consensus. Some of these articles were excluded, and others were included in the final study. The search team members independently recorded the variables on the matrix and the main author continuously updated the matrix iteratively. The final matrix is illustrated in Appendix C.

2.4.2.5 Data Synthesis

The characteristics of the agreed-upon studies were tabulated and narratively summarized on the basis of the purpose, country of origin, design, intervention, tool of measurement, and findings. Finally, implications were retrieved for future research, education, and administration.

2.4.3 Results

2.4.3.1 Study Selection

In this scoping review, the investigator retrieved 4471 studies from seven databases during the initial search, as shown in Figure 2.1. Among them, 1260 were removed as duplicates. A total of 3211 studies underwent a review of their titles and abstracts. Based on the titles and abstracts, 2427 studies were excluded because of irrelevancy. The systematic review, meta-analysis integrative review, qualitative review, and blueprints were removed.

After that, 280 studies were retrieved and assessed for eligibility. The remaining studies underwent further review. Those studies with descriptive designs or targeted physicians only and those that applied the intervention to the neonate population were all removed. At the end of the screening process, 29 studies were considered eligible for review. The studies were published between 2013 and 2023.

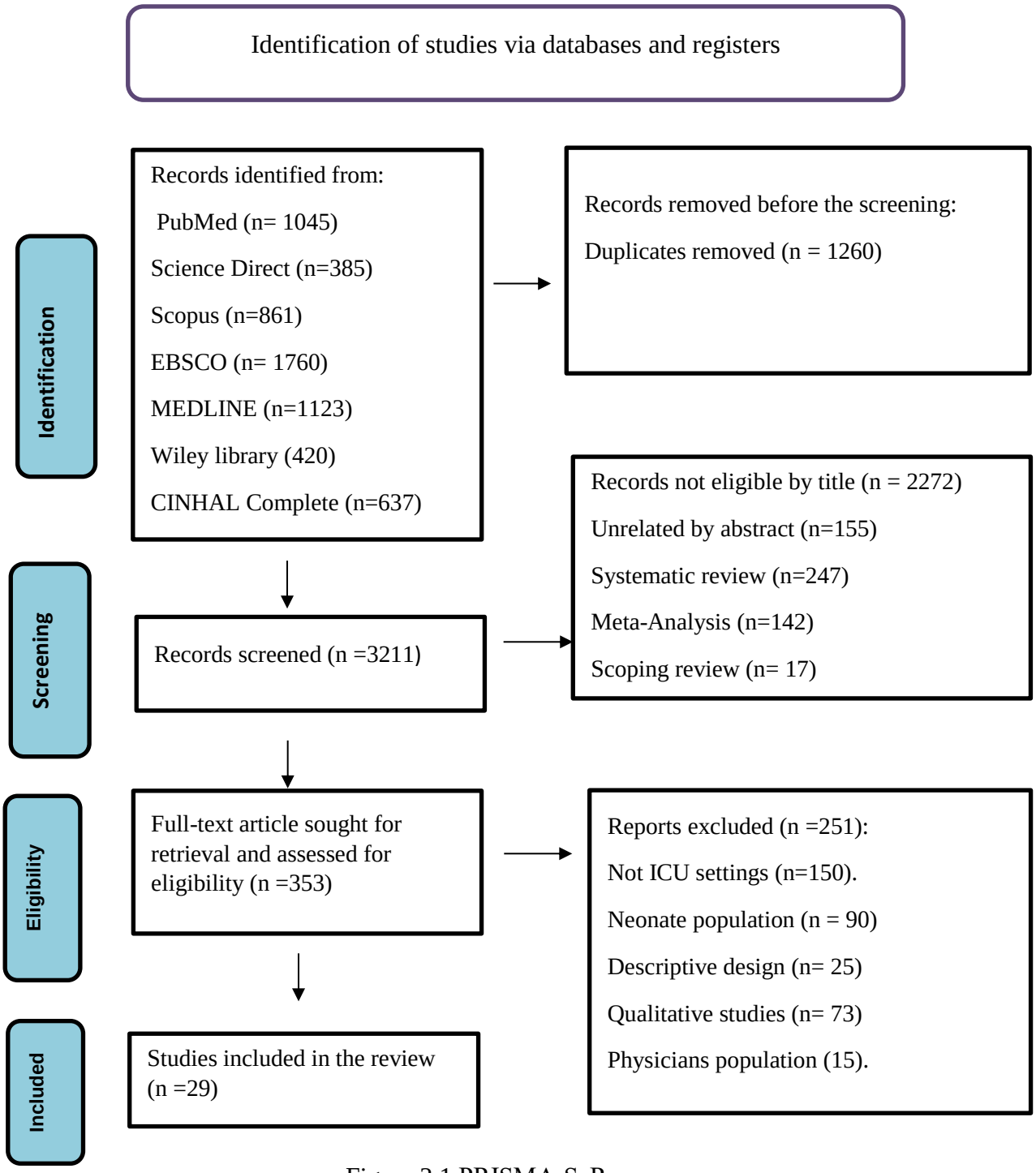


Figure 2.1 PRISMA-ScR

2.4.3.2 Study Characteristics

The characteristics of the 29 reviewed studies are summarized in Appendix C. The included studies are summarized on the basis of the date of publication, the country

of origin, the aim of the study, the targeted sample, the setting, the study design, the type of intervention, the educational approach, the method and tools for data collection, and the findings and outcomes.

The included studies were conducted in different countries. Six studies were conducted in the Middle East region, one in Jordan (Aloush, 2018), four in Saudi Arabia (Khalid et al., 2013; Mazi et al., 2014; Waleed A. Mazi et al., 2021; Fadwa Abu Mostafa et al., 2022), one in Egypt (Negm et al., 2021), one in Bahrain (Alkhawaja et al., 2020), and one in Turkey (Leblebicioglu et al., 2013).

In the United States of America (USA) eight studies were identified (Exline et al., 2013; Gauntt et al., 2022; Hebbar et al., 2015b; Hong et al., 2013; Humphrey, 2015; Jessica Lowery et al., 2022; Scholtz et al., 2013; Walz et al., 2015). There was one study from Argentina (Rosenthal et al., 2018), one from Brazil (de Quadros et al., 2022; Melo et al., 2022), and one from Canada (Paquet et al., 2021).

In Europe, there was one multinational study (van der Kooi et al., 2018), one originating from England (Burt & Spowart, 2021), one from Geneva (Zingg et al., 2014), one from Germany (Hansen et al., 2014), and one from Italy (Musu et al., 2017). Four studies were conducted in India (Ranjita Acharya et al., 2019; Dsilva et al., 2022b; Jaggi et al., 2013; Sarita Mohapatra et al., 2020).

2.4.3.3 The Target Group of the Studies

The reviewed studies incorporated several types of interventions that aimed to decrease the CLABSI rate. They vary in the types of interventional approaches, the targeted group, and the setting where the study was conducted. Concerning the targeted trainees, thirteen studies focused on nurses only as their samples. The number of nurses who participated in these studies ranged from 34 to 536 intensive care nurses (Ranjita Acharya et al., 2019; Aloush, 2018; Burt & Spowart, 2021; Dsilva et al., 2022b; Hebbar et al., 2015b; Humphrey, 2015; Jessica Lowery et al., 2022; Sarita Mohapatra et al., 2020; Paquet et al., 2021; Scholtz et al., 2013), whereas three studies did not mention the actual number of involved nurses (Alkhawaja et al., 2020; Khalid et al., 2013; Mazi et al., 2014).

The remaining studies utilized interventions to involve multidisciplinary teams, including intensive care nurses and physicians (de Quadros et al., 2022; Exline et al.,

2013; Gauntt et al., 2022; Hansen et al., 2014; Hong et al., 2013; Jaggi et al., 2013; Leblebicioglu et al., 2013; Waleed A. Mazi et al., 2021; Melo et al., 2022; Fadwa Abu Mostafa et al., 2022; Musu et al., 2017; Negm et al., 2021; Rosenthal et al., 2018; Zingg et al., 2014).

2.4.3.4 The Presence of Hypothesis

Among the reviewed studies, only 14% adopted hypotheses. Hebbar et al. (2015b) hypothesized that simulation-based training could increase nurses' compliance with CVC maintenance. Negm et al. (2021) suggested that bundle-based training decreases the CLABSI rate. The hypothesis of the study of Scholtz et al. (2013) was that education-based training in CVC maintenance would improve nurses' knowledge and competence and subsequently decrease the CLABSI rate. Exline et al. (2013) hypothesized that the use of obligatory in-service education and demonstration returns would decrease the CLABSI rate by half (Exline et al., 2013; Hebbar et al., 2015b; Negm et al., 2021; Scholtz et al., 2013).

2.4.3.5 Desired Outcomes of the CLABSI Prevention Intervention

Concerning the aims of the involved studies, achieving zero CLABSI was the outcome of many adopted interventions; however, the specific aims of the studies varied. Some of these interventions focused on healthcare workers who maintain venous access devices, while other interventions targeted policies and procedures; or applied a multimodal approach.

Nine of the included studies applied education-based interventions to improve nurses' level of knowledge and compliance with CLABSI preventive interventions and compliance with recommended CVC maintenance practices (Aloush, 2018; Burt & Spowart, 2021; de Quadros et al., 2022; Dsilva et al., 2022b; Hebbar et al., 2015b; Humphrey, 2015; Sarita Mohapatra et al., 2020; Negm et al., 2021; Scholtz et al., 2013).

One study aimed to improve compliance with hand hygiene practices to indirectly decrease the CLABSI rate (van der Kooi et al., 2018), and the remaining studies explicitly investigated the effects of their interventions in decreasing the incidence of CLABSIs (Ranjita Acharya et al., 2019; Alkhawaja et al., 2020; Exline et al., 2013; Gauntt et al., 2022; Hansen et al., 2014; Hong et al., 2013; Jaggi et al., 2013; Khalid et

al., 2013; Leblebicioglu et al., 2013; Jessica Lowery et al., 2022; Mazi et al., 2014; Waleed A. Mazi et al., 2021; Melo et al., 2022; Fadwa Abu Mostafa et al., 2022; Musu et al., 2017; Paquet et al., 2021; Rosenthal et al., 2018; Walz et al., 2015; Zingg et al., 2014).

2.4.3.6 Intervention Strategies

The reviewed studies utilized diverse interventional approaches to directly or indirectly decrease the CLABSI rate. Education and training were the core elements. Seventeen studies utilized only training and education-based interventions. Some studies (Aloush, 2018; Hansen et al., 2014; Khalid et al., 2013; Negm et al., 2021; Paquet et al., 2021) used PowerPoint-based lectures and educational sessions varied in duration from 15 minutes to three hours and in frequency of provision, whereas five studies applied simulation-based training, in which skills are demonstrated on specialized mannequins with several types of CVCs inserted into the chest or arms (de Quadros et al., 2022; Gauntt et al., 2022; Hebbar et al., 2015b; Humphrey, 2015; Scholtz et al., 2013).

On the other hand, some studies used a mixed approach, incorporating hands-on demonstrations, simulations, and lectures. Three studies combined lectures and hands-on training and demonstrations, one focused on hand hygiene (Sarita Mohapatra et al., 2020); one aimed to improve hand hygiene practices and CVC care (Ranjita Acharya et al., 2019); and the third aimed to enhance nursing skills in maintaining CVC, performing hand hygiene and proper blood culture techniques (Mazi et al., 2014).

Two studies applied competency-based simulation and demonstration returns supported by educational sessions (Burt & Spowart, 2021; Exline et al., 2013). Musu et al. (2017) emphasized evidence-based practices for maintaining CVC through lectures supported by demonstration returns, video illustrations, discussions, and the distribution of posters and factsheets. Additionally, two studies relied on self-directed, self-paced education through utilizing E-learning module systems and the distribution of special booklets (Dsilva et al., 2022b; Jessica Lowery et al., 2022). One study did not provide details about the nature of the educational intervention (Hong et al., 2013).

The remaining studies utilized multimodal interventions, including standardizing CVC maintenance policies and procedures, applying CLABSI prevention bundles, and

establishing specialized infection control teams fostered by workshops and demonstration returns (Alkhawaja et al., 2020; Jaggi et al., 2013; Leblebicioglu et al., 2013; Melo et al., 2022; Fadwa Abu Mostafa et al., 2022; Rosenthal et al., 2018; van der Kooi et al., 2018; Walz et al., 2015; Zingg et al., 2014).

2.4.3.7 The Instruments of Data Collection

Different tools and instruments have been used to assess nurses' knowledge and compliance with evidence-based practices to maintain CVCs and prevent CLABSIs; however, the CDC utilizes a standardized method to evaluate the CLABSI rate and prevalence. In this review, twenty studies relied on surveys to measure the effectiveness of the interventions. The remaining nine studies used questionnaires and checklists to assess nurses' knowledge and practices. Hansen et al. (2014) used a multiple-choice questionnaire and survey.

Hebbar et al. (2015b) utilized a 17-item checklist to assess nurses' compliance with the CLABSI bundle. Jessica Lowery et al. (2022) assessed the level of knowledge by using a questionnaire disseminated by an e-learning module. Humphrey (2015) also used a 16-question test. Scholtz et al. (2013) relied on a self-completed questionnaire and a written exam to assess knowledge. de Quadros et al. (2022) used a four-domain checklist to observe the nurses’ compliance. The six previous studies did not provide further details about the tools.

Among the reviewed studies, three provided the psychometric properties of the instruments utilized for data collection (Aloush, 2018; Dsilva et al., 2022b; Negm et al., 2021). Aloush (2018) reported that the questionnaire used had good internal consistency and reliability, with a Cronbach’s alpha of 0.82, while Dsilva et al. (2022b) revealed that both the questionnaire and the checklist utilized in the study were valid and reliable, and reported the content validity index (CVI) for both of them. Negm et al. (2021) reported the reliability coefficient for the questionnaire used to assess the level of nurses' knowledge.

2.4.3.8 Findings and Outcomes

Most of the findings of the reviewed studies revealed that the CLABSI rate decreases after the interventions, including education-based interventions. Two studies

focused only on differences in the level of knowledge and skills. They indicated that education-based interventions enhanced nurses' knowledge and practice of CVC maintenance principles (Dsilva et al., 2022b; Humphrey, 2015). Another two studies mentioned the concept of competency in their results and reported that participants' competencies were improved after receiving education and training (Aloush, 2018; Scholtz et al., 2013).

On the other hand, the findings of six studies were dual; they revealed that interventions affected both the CLABSI rate and nurses' knowledge and that any enhancement in nurses' knowledge of CLABSI bundle would significantly decrease the CLABSI rate (Ranjita Acharya et al., 2019; Burt & Spowart, 2021; Hansen et al., 2014; Jessica Lowery et al., 2022; Sarita Mohapatra et al., 2020; Negm et al., 2021).

Seventeen studies reported only the difference in the CLABSI rate after applying the interventions, and in all of them, the rate declined significantly, and in some studies, this decline was maintained for an extended time (Exline et al., 2013; Gauntt et al., 2022; Hebbar et al., 2015b; Hong et al., 2013; Jaggi et al., 2013; Khalid et al., 2013; Leblebicioglu et al., 2013; Mazi et al., 2014; Waleed A. Mazi et al., 2021; Melo et al., 2022; Fadwa Abu Mostafa et al., 2022; Musu et al., 2017; Paquet et al., 2021; Rosenthal et al., 2018; van der Kooi et al., 2023; Walz et al., 2015; Zingg et al., 2014).

Regarding simulation-based training, de Quadros et al. (2022) reported that simulation could improve nurses' adherence to evidence-based practices. While the study conducted by Alkhawaja et al. (2020) revealed that their intervention, including education, led to decreases in the CLABSI rate, cost, and length of stay (Alkhawaja et al., 2020), and the intervention of one study led to decreases in the CLABSI rate and mortality rate (Jessica Lowery et al., 2022).

2.4.4 Discussion

2.4.4.1 Summary of Evidence (Main Finding)

This scoping review analyzed 29 studies published between 2013 and 2023 that focused on interventions to prevent CLABSIs. The interventions focused on improving healthcare providers' competencies, equipment availability, and surveillance systems.

Most studies have targeted different healthcare providers and specialties, including nurses. They integrated different approaches to execute their goals.

The primary objective that was commonly shared among the reviewed studies was reducing the CLABSI rate. However, only 17% of the studies focused on improving nurses' understanding of and proficiency in CVC maintenance. The majority of the studies used checklists and surveys developed at the institutional level and were based on the CDC's recommendations. Some studies have used questionnaires and written exams to detect changes in participants' knowledge or competency levels after receiving educational interventions. However, few studies have reported the psychometric properties of their applied questionnaires and checklists.

2.4.4.2 The Identified Gaps in the Literature

Many gaps emerged after reviewing the interventional studies to prevent CLABSIs. The methodologies were inconsistent across many reviewed studies, which hindered the ability to compare the results, and the employed methodologies did not mention the design (Gauntt et al., 2022). Few studies explicitly described the sampling technique, sample size, sampling size calculations, inclusion and exclusion criteria, methods of data collection, and analysis process (Khalid et al., 2013). This makes the quality, reliability, and validity of the reviewed interventional studies questionable.

In addition, even if the sample size was mentioned, many of the studies had relatively small sample sizes. All these limitations compromise the ability to generalize the results and outcomes of these studies, and future studies on this topic should adopt more standardized guidelines to yield more valid and reliable findings.

Furthermore, while most of the studies included education and training in their intervention, they did not provide a baseline knowledge or practice of CVC maintenance and CLABSI prevention (Waleed A. Mazi et al., 2021). Therefore, the improvement in nurses' knowledge or competency level was difficult to detect and compare in terms of participants' demographics and institutional background. This compromised the ability to attribute the improvement to the efficacy of the interventions in isolation of other factors and subsequently, efficient CLABSI reduction. The only reported baseline data was the CLABSI rate, which was not the core outcome of many studies.

A variety of the included studies insufficiently described the applied education and training (Hong et al., 2013; Walz et al., 2015), and many of the studies described multimodal approaches generally without providing a full explanation of the specific phases (Alkhawaja et al., 2020). This hinders the ability to understand the interventions, limits the replicability of the studies, and hinders the ability to assess the effects of the interventions accurately and to what extent these interventions or their components influence the achievements of the desired outcomes. This is challenging for those who desire to conduct similar studies. They may encounter many questions regarding the context of providing these interventions, such as the proper time to execute these programs and the required supplements, equipment, and legislation.

The lack of standardized instruments to assess the competency of CVC maintenance is considered a challenge for future research and for the interpretation of the existing data (Burt & Spowart, 2021; Hansen et al., 2014; Hong et al., 2013; Melo et al., 2022). This may impede the synthesis of evidence and restrict the ability to provide robust recommendations or guidelines. Furthermore, using different measurement tools to assess knowledge and practice levels poses challenges for drawing meaningful comparisons or identifying trends across the literature. This further hinders the ability to identify gaps and areas for improvement.

Through close examination of the identified gaps, one possible explanation has emerged. Many of the reviewed studies implemented their intervention as part of larger quality improvement projects rather than a well-defined interventional study. These projects focused on combating CLABSIs instead of addressing the key factors that may contribute to CLABSIs, which further elucidates the current deficiency in the methodology of the included studies.

Moreover, the primary causes of many of the aforementioned gaps, even in Palestine, may be related to the absence of a clear national definition of CLABSI, the lack of national surveillance, the absence of standardized policies and guidelines to regulate and monitor nurses' performance and compliance with the CLABSI bundle, and underdeveloped continuing educational programs and infection control teams or programs at the national level. All of these factors result in fragmented projects.

In Palestine, for example, no research has been conducted regarding CLABSI prevention and enhancing nurses' knowledge and competency in CVC care. This is primarily due to the absence of a national survey to identify and measure the actual rate of CLABSIs; consequently, there are no available data on the prevalence of CLABSIs and the extent to which nurses' knowledge and performance may contribute to this critical issue. Additionally, CLABSI has many contributing factors making it a complex issue. Therefore, a comprehensive understanding of CLABSI prevention and the quality of care provided by healthcare providers requires extensive research and investment.

2.4.4.3 Limitations

This scoping review has several limitations. First, owing to the inclusion and exclusion criteria, the review included only peer-reviewed studies published in English and excluded studies that targeted the neonate population. Second, the currency of the reviewed literature may be affected, as many studies were published after the date of our review. These limitations might lead to the absence of relevant studies.

2.4.4.4 Implications

The results of this scoping review underscore the need for further focused research to rigorously evaluate the influence of different intervention approaches on reducing CLABSIs and improving healthcare professionals, including nurses' competencies. This study would aid in the adoption of more effective evidence-based practices. From the standpoint of continuous education, hospital administrators need to support these programs and use well-designed instruments to assess and reassess the competencies of healthcare practitioners, as this is essential for eradicating CLABSIs.

Chapter Three: Methodology

3.1 Introduction

This chapter delineated the methodology through the following sections: study design, setting, population, sample, study measurement tools, data collection methods, data analysis plans, and ethical aspects.

3.2 Study Design

This study applied a quasi-experimental, pretest-posttest repeated measure design. time series design. There were four points of measurement: baseline assessment (T_0), assessment directly after the intervention (T1), assessment four weeks after the intervention (T_2), and assessment eight weeks after the intervention (T_3). There were two groups; the interventional and the control group. The study extended over five months from the baseline data assessment to the last set of post-interventional observations (see Appendix D).

Furthermore, this design is convenient for assessing the longitudinal effects of the intervention on the mortality rate, length of stay, and intensive care nurses' competency in addition to analyzing the patterns and changes in these variables over time. The data were collected at different times, pre and post-intervention. The competence level (knowledge and practice) and quality of care measurements (length of stay and mortality rate) were assessed at four points in time: baseline assessment (T_0), directly after the intervention (T1), four weeks after the intervention (T_2), and eight weeks' post-intervention (T_3).

3.3 Settings

The study took place in the ICUs of the MOH hospitals in the northern provinces of the West Bank. In the west bank there are 18 MOH hospitals with a capacity of 1,948 beds, among them the number of intensive care beds available for adult is 110. In the

north provinces there are seven hospitals, Khalil Suleiman in Jenin, Tubas Turkish Hospital in Tubas, Thabit Thabit in Talkarem, Alwatani and Rafedia in Nablus, Darweesh Nazzal in Qalqiliya, and Yasser Arafat hospital in Salfit. The bed capacity among these hospitals varies; the lowest bed capacity is reported in Salfeet Hospital, with six beds for every 10,000 people, and eight beds per 10,000 people in Tubas Turkish Hospital, whereas the highest bed capacity reported in Rafedia and Al Watani Hospitals, with 15 beds serving 10,000 people. Jenin has 10.4 beds per 10,000 people, and the bed capacity of Talkarem hospitals is 8.4 beds per 10,000 people (Palestinian Ministry of Health, 2023).

The adequacy of intensive care services also differs among these hospitals. Darwish Nazzal Hospital has three ICU beds; Tubas and Salfeet each have four ICU beds, whereas Rafedia and Al-Watani hospitals have 12 and 11 beds, respectively. This reflects unequal health care capabilities, in which lower ICU bed numbers and density are associated with more limited specialties, inadequate resources, and health care services. This increases the need to transfer patients to other hospitals seeking more efficient and specialized intensive care, leading to further unequal distributions of patients and workload. Bed capacity was used to allocate nurses to either control and experimental group with hospitals with the lowest bed density and ICU bed capacity were excluded to make a meaningful comparison of the effect of the education-based intervention between the control and intervention groups.

According to the allocation criteria, the study was conducted on the ICUs in Talkarem, Jenin, and Nablus. Khalil Suleiman has 223 beds with an average of 2.7 length of stay, Thabit Thabit has 129 beds with 2.4 length of stay, Alwatani has 62 beds and 5.6 length of stay, whereas Rafedia has 207 beds and a length of stay of 3.2. These hospitals have characteristics that match the purpose of the study. They have to encounter forced challenges and strains on resources which restrict their ability to offer equal and efficient health services.

Despite the limited infrastructure of MOH hospitals, the majority of patients and their families seek out nursing and medical care at these hospitals because of their relatively inexpensive treatment compared with other hospitals, especially since many of these families have low incomes (Civil Society Team for Enhancing Public Budget

Trasnperancy, 2020; Palestine Monetary Authority, 2022). These factors increase workload, place nurses in a high-pressure and stressful work environment, hinder their capacity to deliver timely, safe, and effective care, and restrict their ability to engage or participate in workshops and learning activities that may be offered outside their institutions. All these conditions reduce the equality of opportunities for nurses to enhance their competencies.

In light of this, the study provided education-based interventions for intensive care nurses in their place of employment at MOH hospitals in an attempt to bypass these constraints and ensure equal training opportunities. In addition, planning the education sessions considered the availability of resources and was sensitive enough to suit intensive care nurses' working time.

3.4 Study Population

The target population of this study consisted of all qualified nurses registered with the Palestinian Nursing Association and authorized to provide care to critically ill patients who are admitted to MOH Hospital in the northern region of Palestine. Approximately 2,728 nurses work in MOH hospitals in the northern provinces of Palestine. The accessible population were 109 nurses who were working in included ICUs in this study (Palestinian Ministry of Health, 2023).

3.5 Sample and Sampling

All nurses and patients in the targeted units were invited to participate in the study. Nurses were subject to intervention, but patient information was the only involvement of patients through medical records. The sample was convenient for nurses because of the political and military instability in the region, and the sudden and unexpected restrictions on movement. These conditions impeded the reachability of the study sample in addition to the willingness to participate and to continue through the study.

All intensive care nurses (N=109) from the MOH hospitals of Jenin, Talkarem, and Nablus were approached and recruited for this study. However, the final sample size was 98 intensive care nurses allocated to either the control group (56 nurses) or the experimental group (42 nurses). A random recruitment process based on the ICU bed

capacity was used to assign the nurses to either the intervention or control arm. Figure. 3.1 illustrates the sampling procedure

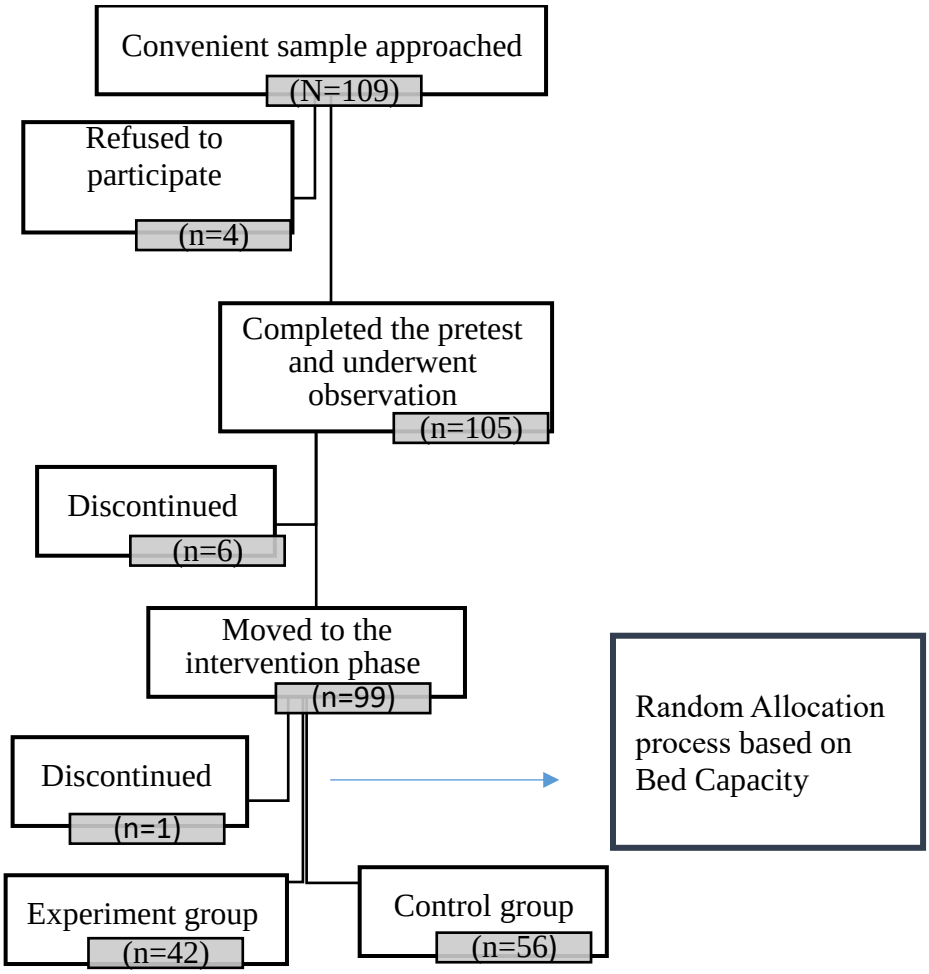


Figure 3.1Sampling Procedure

3.6 Attrition Prevention Techniques

Several strategies were executed to minimize the attrition. Open communication channels were maintained by creating WhatsApp groups to easily reach and contact the participating nurses, the head nurses, and the chief nursing officers of the concerned hospitals. Frequent constructive feedback and advice were also provided to the participating nurses at the individual level to encourage the continuity of their participation. In addition, direct contact with the chief nursing officers was maintained to obtain their support, collaboration, and cooperation, and to keep them aware of the study's progress.

3.7 Intervention

The intervention of this study was a CLABSI prevention education that aimed to improve intensive care nurses' knowledge and skills of safe handling and maintenance of CVCs. The theoretical section was prepared to enrich the nurses' knowledge of the CLABSI definition, clinical detection, complications, risk factors, regional and worldwide prevalence, components of the CLABSI bundle, and strategies for effective CVC maintenance. The clinical demonstration sessions aimed to train nurses on the proper and safe applications of the instructions and clinical guidelines tortured in the theoretical part of the program. The content of the theoretical part of the educational program is illustrated in Appendix E.

The investigator prepared and delivered the educational material for the study. It was prepared under the recommendations and toolkits of the CDC (Centers for Disease Control and Prevention, 2022b, 2023) and Agency for Healthcare Research and Quality (AHQR) (Ageny for Health care Research and Quality, 2018) and reviewed by a panel of experts to ensure that the content is valid and evidence-based. In addition, the educational course later received the American Nurse Credentialing Center (ANCC) accreditation which enhanced its quality and effectiveness.

A blended learning approach was applied in this study. This approach combined a virtual learning method via Zoom meetings, video recordings shared via the WhatsApp group, and hands-on training in the clinical area. The Zoom application was used to deliver a three-hour PowerPoint presentation covering the theoretical part of the intervention. In addition, the nurses in the experimental group received a video recording of the presentation via the unit-based WhatsApp group. Following this, they received hands-on training and demonstrations in their clinical area to optimize the effectiveness of the intervention and foster their active engagement.

The demonstration and hands-on sessions were provided individually and focused on key procedures such as performing the CVC's insertion site dressing, scrubbing the hub, accessing the CVC, and flushing lumens between uses (Centers for Disease Control and Prevention, 2023). The demonstration utilized a plastic model that resembled the human chest with the CVC inserted, after which the hands-on training was applied to real patients as a part of their routine care.

The participants used the available medical materials and equipment at the MOH hospitals, which was sufficient to maintain infection-free practices. These sessions were provided in collaboration with competent clinical nurses from JCI-accredited hospitals, where the CLABSI Bundle had been implemented for at least four years. This step ensured that the clinical nurses had the necessary competencies to transfer their experience to the trainees.

During the demonstration session, each trainee had the opportunity to perform the entire procedure and to repeat the steps as often as he or she felt satisfied or the instructor deemed the participant to perform the procedures safely. This approach minimized the variability resulting from the confounding factors of participants' interactions.

The demonstration sessions were conducted individually with a maximum capacity of two to three nurses per session. At the end of each session, the nurses reflected on what went well and what they could do better. In all sessions, nurses were invited to engage in open discussions and to benefit from the ask-and-answer opportunities.

3.8 Data Collection Procedure

The investigator followed some essential steps before commencing the data collection process. The investigator submitted the proposal for this study to the Institutional Review Board (IRB) of AAUP to guarantee that the ethical aspects were protected. Then, after obtaining the IRB approval with the number of 2023/A/116/N (see Appendix F), three official letters were sent, the first of which was sent to the Education in Health and Scientific Research Unit at the MOH to request permission to start the assessment process and apply the intervention for nurses. The second and third letters were sent from the Education in Health and Scientific Research Unit to the assistant undersecretary of the Hospital and Emergency Affairs Office and then to the General Administration of Information and Communication Technology. Appendix G displays the letter sent to obtain access to the patient information system at the MOH.

3.8.1 Phases of Data Collection

The actual data collection process was executed over 20 weeks at the following points in time: pretest (T_0), posttest directly after applying the intervention (T1), four-

week follow-up posttest (T_2), and eight-week posttest (T_3). It was executed over 20 weeks and was divided into the following main phases:

3.8.2 The Pretest Phase

Once permission was received, the investigator contacted the Chief Nurse Officers of the MOH-targeted hospital to illustrate the study title, purpose, and the anticipated time frame for the entire study, and to discuss several educational and training approaches that could be convenient for nurses and their workflow.

After that, the investigator met with the head nurses of the concerned units to explain the aim and desired outcomes of the intervention. The investigator provided them with a written document that contained detailed information about the author, the purpose of the study, and the nature of the intervention along with a section explaining how confidentiality and anonymity would be protected. At the end of the meetings, the investigator answered any emerging questions about the study and asked for permission to create a WhatsApp group for each unit to easily contact nurses and follow them in the next steps of the study.,

In this phase, two sets of baseline data were collected for the first time (T0), the patient-related data and nurses' baseline data. A retrospective baseline assessment of patients' outcomes (mortality rate and length of stay) was conducted for the three months preceding the intervention. Regarding the baseline practice level, it was assessed by observations. The observations were conducted by external research assistants who were specially trained nurses with at least two years of experience in intensive care units at a JCI-accredited hospital. The observations were performed via a special checklist.

After completing the observations, the research assistants distributed a special questionnaire to assess the nurses' knowledge. The questionnaire comprised two sections: the first concerned demographics and institutional factors, while the second section included the pretest questions intended to assess nurses' baseline knowledge of CVC maintenance and safe handling.

The participants were asked to register the first letter of their first name and family name with the last two digits of their employment number on the questionnaires. This was performed to easily refer them back to them in the post-intervention phase of the study. The participating nurses were assured that their identities would not be exposed and that their anonymity would be preserved. They were supplied with a contact number

and details of the investigator for any questions. After completing the assessment of the baseline competency level (knowledge and practice), the investigator divided the participants into two groups: the control and experimental groups.

The investigator created WhatsApp groups to explain the purpose and significance of the research and the nature of the educational intervention. This step also assured all invited intensive care nurses of the experimental group that they had the right to withdraw from the study at any time without penalty, and that their confidentiality would be maintained. The continuation of the study process was considered approval to participate in the study. The method of education and training was also discussed directly with the participating nurses to employ the most convenient method for the majority.

In this phase, the investigator focused on controlling the Hawthorne effect which poses a threat to the internal validity of any observational research design (Ghorbanmovahhed et al., 2023; Gomarverdi et al., 2019; Goodwin et al., 2017); thus, to minimize this effect, the participants were not exposed to the real purpose of the observation. They only knew that the observers were going to document different nurses' practices regarding CVC and what the responses of the patients were.

Furthermore, the research assistants who conducted the observations were instructed to visit the unit several times to become familiar with the work environment and the participants. This gave a sense of security and encouraged them to behave normally as much as possible.

Second, to control for interrater and intrarater reliability and to maintain the actuality and accuracy of the observations (Gulnur & KAZAN, 2021), the investigator provided refreshing training sessions to the observers on CVC care and maintenance. In these sessions, the investigator explained the observational checklist along with instructions on how to complete it. To verify the observers' performance, the investigator, trained, observed, and scored their practices while they performed CVC care on a planned CVC procedure several times via the checklist. This step was performed before commencing the study and after IRB permission was obtained.

3.8.3 Intervention phase

In this phase, the investigator delivered the education-based intervention to the intensive care nurses in the experimental group who agreed to continue in the study.

However, the nurses in the control group did not receive any education or instructions throughout the study.

3.8.4 Posttest Phase

- The data collection in the posttest phase was carried out prospectively at T1 and followed up at T2 and T3 intervals.
- After completing all the educational sessions, the nurses in both groups filled out the posttest questionnaire at three points in time: directly after completing the educational sessions, in the fourth week, and in the eighth week after the intervention phase. The research assistants distributed the knowledge questionnaire in synchrony with observing the practices of the nurses in both groups at T1, T2, and T3 after the education process was completed by the investigator.
- The observations were performed during day shifts. There was a high level of coordination and collaboration between the research assistants and the targeted nurses to minimize interruptions of the nurses' work routines.
- The mortality rate and length of stay were measured prospectively on a monthly basis from the beginning of the intervention until the end of the study.

3.9 Effects of Maturation and Contamination

The contamination and maturation effects between the control and experimental groups were minimized by performing the following steps:

- First, the groups allocation process guaranteed that the nurses in each group were recruited from different hospitals.
- Second, the research assistants were blindly assigned to follow up with the participants in both groups. There was no interaction between the two groups of research assistants.
- Third, the communication was through creating a separate WhatsApp group for each ICU, even those who belong to the same group.
- Fourth, the investigator collaborated with the head nurses of the involved units to arrange the participants' schedules so that the majority could be reached within a maximum period of one week to assess their knowledge and observe their practices at each phase of the study.

These arrangements assisted in minimizing the maturation effect, to avoid additional interruptions, and lessen the load on the participating nurses' work conditions.

3.10 Study Measurement

In this study, two sets of data were measured: nurses' knowledge, which was assessed via a self-report questionnaire, and their practice level were evaluated by using an observational checklist. Patient care outcomes (mortality rate and length of stay) were measured after retrieving the required data from the health information system via a Microsoft Excel sheet.

3.10.1 Demographics

The first section of the knowledge pretest questionnaire is concerned with sociodemographic and institutional factors and composed of the following:

- Age. Age of the intensive care nurses in years
- Sex. Being male or female.
- Income. Monthly salary in Shekel.
- Educational level. Being certified at an associate degree, a bachelor's degree, or a postgraduate level.
- Graduation country. Being graduated from Palestine or other countries.
- Year of experience: How many years did the nurses spend in the ICUs?
- Work nature. Being working at a full- or part-time contract.
- Shift system. Being work at only a morning shift or at three-shift systems.

3.10.2 Assessment of Nurses' Knowledge of CVCs' Safe Handling and Maintenance

A bilingual self-report questionnaire was used to assess nurses' knowledge of CVC's safe handling and maintenance. The questionnaire utilized a true/false format (Oermann & Gaberson, 2016). Questions were modified from tools previously developed by Humphrey (2015) and Ahmed et al. (2021), and were translated into Arabic on the basis of the World Health Organization (WHO) guidelines.

The knowledge score ranges from 0 to 26, with the correct answer worth one point. The total knowledge score was then converted to a score of 100% , classified as high for scores ranging from 80% to 100%, moderate if the score ranged from 60% to 79%, and poor if the score was less than 60% (Alzahrani et al., 2022). The reliability of the Humphry questionnaire reported as Cronbach's alpha value of -0.37 for the pretest and 46 for the posttest (Humphrey, 2015)

3.10.3 The Observational Checklist of Nursing Practices for CVC Care and Maintenance

The nurses' practices were observed by using the short version of the observational checklist developed by Ebru Kazan and Gulnur Kar (Gulnur & KAZAN, 2021). The English stem checklist consists of 25 items, each has three response choices: "Performed completely and accurately = two marks", "Performed but not completely or accurately = one mark", and "Not Performed = 0 marks".

The minimum practice score is 0, and the maximum score is 50. A practice score of 25 or above was categorized as "competent/full compliance", and a score below 25 reflects "incompetent or insufficient compliance" (Al-Shukri et al., 2022; Aloush & Alsaraireh, 2018). The content validity of the original checklist items was sufficient, with a content validity index (CVI) > 0.80 (Gulnur & KAZAN, 2021). The Observational Checklist is displayed in Appendix H.

3.10.4 Face and Content Validity of the Knowledge Assessment Questionnaire

3.10.4.1 Translation Process and Face Validity

The first step before assessing facial and content validity was to translate the aforementioned questionnaire to facilitate the process of self-reporting of knowledge. The translation was performed from English to Arabic based on the WHO guidelines for forward-backward translation (World Health Organization, 2023b). Bilingual experts did the translation and back translation by using a blind approach. The investigator contacted each expert individually to explain the aim of the study, the target group and what would be measured by the questionnaire. One expert translated the questionnaire from English (the original) to Arabic, while the second expert translated it back to English.

The final version of the questionnaire was compared with the original by a panel of three experts in the fields of infection control and education. They were visited in their workplace and provided with a full explanation of the study's purpose and target group.

The experts compared the questionnaire item by item to assess the equivalent meanings and evaluated face validity by providing constructive feedback about relevancy, clarity, understandability, and appropriateness based on their field experience and CDC recommendations. Their comments and recommended modifications were taken into consideration.

3.10.4.2 Content Validity Ratio and Index

To assess the validity of the knowledge questionnaire, a panel of seven subject matter experts from a JCI-accredited hospital were invited to assess the translated questionnaire. The panel composed of the head of the quality department, three nurses specializing in infection control, a clinical educator, and two senior oncology nurses who were responsible for competency verification for their colleagues and members of the internal venous access device (VAD) team.

The panelists were contacted via email and provided with a description of the study's purpose and a content validity assessment form. They were asked to evaluate each item for necessity and relevancy in reference to the CDC recommendations. The necessity of each item was assessed via a three-point Likert scale: one indicated that the item was not essential, two indicated that the item was useful but not essential, and three indicated that the item was essential. Relevancy to the construct was assessed via a four-point Likert scale, one indicated that the item was not relevant, two indicated that the item needed some revision, three suggested that the item needed minor revision, and four indicated that the item was highly relevant.

Necessity was computed via the Content Validity Ratio (CVR) according to the Lawshe's test to determine if the item is essential for measuring the construct. The following formula was used to calculate CVR:

$$CVR = (Ne-N/2)/N/2,$$

where *Ne* represents the number of panelists who agreed that the item was essential, and *N* refers to the total number of panelists. The minimum CVR (critical value) needed to retain the items was 0.75 while the average CVR for the utilized tool was 0.86.

Relevancy was calculated by using the average scale CVI. For this purpose, the item CVI was calculated by using the following formula:

$$\text{CVI}= \frac{\text{number of experts agreed on the item (rated as very relevant or needing minor revision)}}{\text{total number of experts}}$$

The average CVI of the scale (S-CVI/Ave) was calculated through the following formula:

$$\text{S-CVI / Ave} = \frac{\sum I-CVI}{total\ number\ of\ item}$$

The S-CVI/Ave found to be 0.98. The expert comments were considered, and the necessary amendments were made (see Appendix I).

3.10.4.3 Reliability

The internal consistency of the utilized tools was measured by the Cronbach's alpha coefficient. The alpha coefficient for the knowledge questionnaire was 0.739, whereas the alpha coefficient for the observational checklist was 0.732. According to the accepted threshold of Cronbach's alpha for this study ≥ 0.70, both tools have good reliability (Fuller, 2021; Taber, 2018).

3.11 Pilot Study

A pilot study was carried out with 10 intensive care nurses to test the validity and reliability of the observational checklist and the knowledge questionnaire. The participating nurses provided further constructive feedback on the readability and clarity of the translated questionnaire, and therefore some items were modified according to the feedback.

Additionally, the nurses provided feedback on the clarity of wording and suitability of the educational material for the participants. They also assisted in evaluating the amount of time needed for delivering the training program, and for assessing nurses' relevant data by using the questionnaire and the observational checklist.

Furthermore, the pilot testing determined the obstacles that might be encountered later during the data collection phase. These obstacles and challenges were discussed with head nurses in the relevant ICUs before the study commenced. The nurses involved in the pilot study were reached before commencing the study and excluded from the main study.

3.12 Ethical Considerations

This section focused on the following areas: approval from the IRB; informed consent; voluntary participation; protection from mental, psychological, and physical harm; and confidentiality, anonymity, and privacy before commencing the training program.

Before commencing the study, the IRB approval and permissions were obtained from all concerned institutions, as mentioned before in the procedure section to approach nurses and obtain access to patients' data. Also, all ethical approval for using the tools were obtained from the original authors. The next step was to invite nurses to participate in the study. Those who were willing to participate were provided with informed consent (see Appendix J). Informed Consent and Voluntary Participation

The informed consent outlined the study's title and objectives, anticipated psychological and social threats, the time frame needed to complete the educational intervention, and the fact that the participation was voluntary. The participating nurses were also informed that they could withdraw from the study at any time without penalties. The informed consent captured the initial page of the pretest knowledge questionnaire, so the participants could decide to commence the study or withdraw at any time. The completion of the pretest indicated the nurses' agreement to join the study.

This study was designed to have no threats to the participants' rights, and this was ensured by informed consent. However, there were minimum psychological threats, some nurses experienced stress and anxiety, as they had to set for lectures, hands-on training, and evaluation upon completing the training sessions. Voluntary participation and the freedom to withdraw at any time helped ensure a non-pressurized approach.

3.12.1 Anonymity and Confidentiality

Throughout the study phases, nurses were assured that their anonymity and confidentiality would be protected and maintained. They were not requested to disclose personal data or even their names in such a way that their data could not be linked with their identities. The completed questionnaires were securely stored in a special closed cabinet, while the observational checklists in electronic form data were kept on the personal Google Drive of the investigator. The data access was restricted just to the investigator and discarded after the study was completed.

3.13 Statistical Analysis

Statistical analysis was conducted to compare the mean scores of knowledge levels, competency level, the mortality rate, and the length of stay before and after completing the intervention at T0, T1, T2, and T3, to detect any improvement. The results of the pretest, posttest, and observational checklists were emptied into a Microsoft Excel spreadsheet to be coded, cleaned, and organized. Data analysis then was performed by using the International Business Machines Corporation (IBM) Statistical Package for Social Science program version (SPSS) 28 to detect changes and assess differences.

3.13.1 Descriptive Statistics

The demographic and institutional factors were analyzed via descriptive statistics. Percentages and frequencies were used to express categorical variables, such as educational level and graduation country. Continuous variables, such as age and years of experience, were described by using central tendency and dispersion measurements in terms of means (M) and standard deviations (SD). Additionally, the knowledge and practice of the safe handling and maintenance of CVCs were calculated and described using means, standard deviations, and interquartile equations via a dispersion test.

3.13.1.1 Inferential Statistics

The demographic characteristics of the control and experimental groups were compared using independent sample t-tests for continuous variables and chi-square tests for categorical variables. The differences in knowledge and practice scores were compared between the experimental and control groups via the independent sample t-test.

The effect of the provided educational intervention on nurses' knowledge and practices was analyzed via one-way repeated-measures analysis of variance (ANOVA), whereas the effect of the intervention on patients’ outcomes (mortality rate and length of stay) was examined via paired sample t-tests. The differences in mortality rates and lengths of stay between the groups were tested by the independent sample test. Finally, differences in knowledge and practice levels with respect to nurses' demographics were analyzed using one-way ANOVA for categorical variables, and Pearson’s r correlation was used for continuous demographic variables.

The assumption of normality of distribution was tested using skewness to verify whether the knowledge and practice scores for the four assessment points of time were normally distributed (Kim, 2013; Mishra et al., 2019). The acceptable skewness value to confirm normality distribution was between (-1) and (1) (Cooper et al., 2020; Mishra et al., 2019). The normality assumptions for all dependent variables were not violated, with skewness scores within this range. Concerning the sphericity assumption, Mauchly's test was used to verify the assumption that all the variances of the different time points are homogenous. The significance level for all the statistical tests was set at an α-error level < 0.05. The data analysis plan is summarized in Table 3.1.

Table 3.1 Summary of the statistical test used to test the hypothesis and answer the research questions

Main research hypothesis and questions	Statistical tests
Demographic characteristics and Institutional factors	Mean, standard deviation, frequencies and percentages
Hypothesis one	
Providing education-based intervention for CLABSI prevention and central lines maintenance will positively improve nurses' competency level in maintaining CVC, among patients admitted to intensive care units compared with the control group in the northern region of Palestine.	One-way repeated measure ANOVA test
Hypothesis two	
Providing education-based intervention for CLABSI prevention and central line maintenance will lower the mortality rate and shorten the length of stay among patients in intensive care units compared to the control group in the northern region of Palestine.	Paired-sample t-test was performed to assess differences between the three months before the intervention and the three months after the intervention for both

Main research hypothesis and questions	Statistical tests
	groups (the control and the experimental) Independent t test to measure differences in the Post-Intervention Length of Stay and Mortality Rate between the Control and Experimental Groups
Secondary research question	
What are the differences in nurses' competence level of central lines' maintenance and safe handling in relation to their demographics and institutional factors?	One-way ANOVA test and Pearson r correlation

3.14 Summary

This is a quasi-experimental study that involved all intensive care nurses in four MOH hospitals in the northern region of Palestine. The final samples were randomly allocated to either the control or experimental group based to the bed capacity. A total of 42 nurses in the experimental group received education on the safe handling and maintenance of CVCs. Both groups had their practices observed, and their knowledge assessed at baseline, directly after the intervention and at the fourth and eighth weeks following the intervention.

Data were entered and analyzed via SPSS 28. The effects of the education-based intervention on nurses' knowledge and skills and the differences between the two groups were analyzed via one-way repeated-measures ANOVA. The assumptions of normality and sphericity were tested for the dependent variables. The significance level was set at $\alpha < 0.05$.

Chapter Four: Results

4.1. Introduction

This chapter presents the key findings derived from the quantitative analysis of the data. The dataset consists of intensive care nurses' knowledge assessed by disseminated questionnaires, their level of practice evaluated by direct observation, and patients' outcomes in terms of length of stay and mortality rate, which were determined by referencing the governmental health information system.

Furthermore, this section comprises several subsections, including the introduction, data cleaning, intensive care nurses' socio-demographic characteristics and institutional factors, a comparison between the control and experimental groups in terms of their demographic and institutional factors, nurses' knowledge and practices of the safe handling and maintenance of CVCs, and the effects of education-based interventions on nurses' and patients' outcomes.

4.2. Data Cleaning

Data cleaning is a crucial step in preparing reliable data for statistical analysis (Pilowsky et al., 2024). The data-cleaning process began early in the research process. This occurred during the study design structuring and throughout the data gathering to minimize errors and enhance the quality of the collected data, ensuring that it was appropriate to address the research questions. Data entry is another pivotal step in the data-cleaning process (Um et al., 2022).

In this study, the data-cleaning process encompassed the following steps:

- The literature was reviewed to identify the data possibly required to answer the research questions and to define the selected variables. The variables and their definitions are recorded in the methodology section.

-The identified variables were prepared for data collection. The measured variables were entered into a Google Drive Excel sheet to standardize the data collection and data entry process for the research assistants, who received training on the data collection procedure.

- After completing the data collection process, the dataset was scanned to identify any incompleteness, inconsistency, or duplicates and to remove any such entries. For example, in the dataset containing the nurses' responses to the knowledge test, nurses who did not complete the post-intervention knowledge assessment test were excluded from the data analysis. The same approach was applied to the patient-related data, and any missing or inappropriate entries that may interrupt the calculation of the mortality rate or the length of stay were removed.

- Following the initial data cleaning, the author entered and coded the data in the SPSS program in a manner that facilitated data analysis and properly answered the research questions. For example, the nurses' related knowledge and practice scores were grouped by adding a new variable named "group" to assist in data entry and prevent missing data related to an equal distribution of nurses in each group.

- Before conducting the analysis, the variables were assessed for any missing data via the frequency test, and the continuous variables were also assessed for skewness to determine if there were outliers and to select the appropriate analysis test.

4.3. Demographic Data

4.3.1. Intensive Care Nurses' Sociodemographic Characteristics and Institutional Factors

This study involved 98 intensive care nurses recruited from four MOH hospitals in the north of West Bank. A total of 109 ICU nurses were approached and invited to join this study, with 98 agreed to participate in all phases of the study. The sample was convenient, with a good response rate of 89.9%. The control group consisted of 57.1% of the intensive care nurses recruited from Control Hospitals One and Two (n = 56), while

42.8% (n = 42) of the intensive care nurses were working at Experimental Hospitals One and Two (see Table 4.1.).

Table 4.1 Sample distribution according to the setting of recruitment (N=98)

Hospital	*N*	*%*
Contro1 hospital 1	27	27.6
Control hospital 2	29	29.6
Experimental hospital 1	26	26.5
Experimental hospital 2	16	16.3

Table 4.2 Compares the Intensive Care Nurses' Sociodemographic Characteristics and Institutional Factors between the Control and Experimental Groups.

More than half of the intensive care nurses in the control group were male (n = 34). Among these nurses, 69.6% held bachelor's degrees in nursing (n = 39), and all of them had graduated from Palestine. The majority worked in three-shift systems (n = 54). The mean age of the intensive care nurses was 29.3 years (SD = 5.32), with a mean income of 3658 Shekels (SD = 627.2) and an average of 6.64 years of experience in intensive care units (SD = 3.97).

In terms of sex, 66.7% of the nurses in the experimental group were males (n = 28). The majority held bachelor's degrees in nursing (n = 36), and 92.9% of them had graduated from Palestine (n = 39). Only two nurses (4.8%) worked on a single morning shift. The average age of the intensive care nurses in this group was 32.43 years (SD = 6.91), with an average income of 3843 Shekels (SD = 824.4). Their mean number of years of experience was 8.71 years (SD = 5.30).

The two groups were compared on the basis of their demographic characteristics. Categorical variables such as sex, educational level, employment status, and working in the shift system were compared via the chi-square test, while the independent sample t-test was used to examine the relationships between continuous variables such as age and income. The continuous variables were tested for normality via skewness, with scores ranging between -1 and 1 for all the variables.

The chi-square test revealed that there was no statistically significant association between any of the categorical demographics of the control and experimental groups, except for educational level (X^2 =7.5, p = 0.023) and graduation country (X^2 = 4.13, p = 0.042), and the independent samples t-test showed that there was a statistically significant difference in age (t = - 2.529, p = 0.013) and years of experience (t = - 2.210, p = 0.029) between the two groups. The results indicate that random distribution of the samples was not achieved between the control and experimental groups.

Table 4.2 Comparison of Intensive Care Nurses' Sociodemographic Characteristics and Institutional Factors between the Control and Experimental Groups

Demographic characteristics		Control Group (n= 56)		Experimental Group (n= 42)		Statistical test	
Variables	Categories	*N*	%	*n*	%	X^2	p value
Sex	Male	34	60.7	28	66.7	0.366	0.55[a]
	Female	22	39.3	14	33.3		
Educational level	Associate degree	5	8.9	5	11.9	7.58	0.02[a]
	Bachelor degree	39	69.6	36	85.7		
	Postgraduate degree	12	21.4	1	2.4		
Graduation Country	Palestine	56	100	39	92.9	4.13	0.04[a]
	Others	0	0	3	7.1		
Shift system	Morning shift	2	3.6	2	4.8	0.087	0.77[a]
	Three shifts	54	96.4	40	95.2		
Employment status	Full time	55	98.2	38	90.5	2.97	0.09[a]
	Part-time	1	1.8	4	9.5		
Continuous variables		M	SD	M	SD	T	p
Age		29.3	5.32	32.43	6.91.00	-2.529	0.013[b]
Income		3658	627.2	3843	824.4	-1.264	0.209[b]
Number of years of experience		6.64	3.97	8.71	5.3	-2.21	0.029[b]

Note. [a] p value derived from the Pearson chi-square test; the significance was set at $p < 0.05$.

[b] p value derived from the independent samples t-test,

Statistically significant at $p < 0.05$

4.4 Differences Between the Control and Experimental Groups in Terms of Knowledge of the Safe Handling and Maintenance of CVCs

To assess the differences between the control and experimental groups in terms of knowledge of the safe handling and maintenance of CVCs, the independent sample t-test was used, with a significance level of $\alpha \leq 0.05$. The results in Table 4.3 reveal that there is no significant difference at baseline between the control and experimental groups ($t = -0.61$, $p = 0.537$).

At T1, the mean knowledge score for the control group was 68.51 (SD = 20.93), while the experimental group had a significantly higher mean score of 80.85 (SD = 13.96). The t-test revealed a significant difference between the groups ($t = -3.30$, $p = 0.001$), suggesting that the educational intervention had a positive effect on the experimental group's knowledge.

At T2, the mean knowledge score for the control group remained at 68.51 (SD = 20.62), whereas the experimental group's mean score was 80.33 (SD = 14). The t-test again revealed a significant difference between the two groups ($t = -3.19$, $p = 0.002$), indicating that the experimental group maintained their improved knowledge level four weeks after the educational sessions.

At T3, the mean knowledge score for the control group was 69.53 (SD = 20.61), whereas the experimental group had a mean score of 79.95 (SD = 14.08). The t-test revealed a significant difference between the groups ($t = -2.81$, $p = 0.006$), suggesting that the experimental group continued to have a higher level of knowledge than the control group eight weeks after the educational sessions.

Table 4.3 Differences between the control and experimental groups in terms of knowledge of the safe handling and maintenance of CVCs

Time	Group	Descriptive Statistics		t-test	
		M	SD	t	P
Baseline	Control	67.87	20.94	-0.61	0.537

	Experimental	70.33	17.26		
T1	Control	68.51	20.93	-3.30	0.001
	Experimental	80.85	13.96		
T2	Control	68.51	20.62	-3.19	0.002
	Experimental	80.33	14		
T3	Control	69.53	20.61	-2.81	0.006
	Experimental	79.95	14.08		

4.5 Differences Between the Control and Experimental Groups in CVC Care and Maintenance Practices

To assess the differences between the control and experimental groups in terms of nursing practices related to CVC care and maintenance, the independent sample t-test was used, with the significance point was set at $\alpha \leq 0.05$. Table 4.4summarizes the results, which revealed that there was no significant difference between the control and experimental groups in terms of nursing practices related to CVC care and maintenance at baseline ($t = -0.376$, $p = 0.708$).

However, at T1, the t-test revealed a significant difference between the control and experimental groups in nursing practices of CVC care and maintenance ($t = -13.01$, $p < 0.001$). The mean practice score for the control group was 32.87 (SD = 5.77), whereas the experimental group had a significantly higher mean score of 46.66 (SD = 4.28). This implies that the educational intervention had a positive effect on the experimental group's practices.

At T2, the mean practice score for the control group was 32.67 (SD = 5.55), whereas the experimental group's mean score was 46.35 (SD = 4.29). The t-test revealed a significant difference between the groups ($t = -13.24$, $p < 0.001$), indicating that the experimental group maintained their improved practice level four weeks after the educational sessions.

At T3, the mean practice score for the control group was 32.69 (SD = 5.57), while the experimental group had a mean score of 46.19 (SD = 4.42). The t-test revealed a significant difference between the groups ($t = -12.91$, $p < 0.001$), suggesting that the

experimental group continued to have a higher level of practice than the control group eight weeks after the educational sessions.

Table 4.4 Differences in CVC care and maintenance practices between the control and experimental groups

Time	Group	Descriptive Statistics		Independent Samples T test	
		M	SD	t	p*
Baseline	Control	32.85	5.70	-0.376	0.708
	Experimental	33.30	6.15		
T1	Control	32.87	5.77	-13.01	< 0.001
	Experimental	46.66	4.28		
T2	Control	32.67	5.55	-13.24	< 0.001
	Experimental	46.35	4.29		
T3	Control	32.69	5.57	-12.91	< 0.001
	Experimental	46.19	4.42		

Note. * The significance level is set at a p-value < 0.05

4.6 The Effect of a CLABSI Prevention Education-Based Intervention on Intensive Care Nurses' Competency in CVC Maintenance

To answer the first research question, “What is the effect of a CLABSI prevention education-based intervention on nurses' competency in central lines' maintenance among patients in intensive care units in the northern region of Palestine?”, two one-way repeated-measures ANOVA models were performed, with the significance level set at $\alpha \leq 0.05$. All outcome measures were at the ratio data level, normally distributed (skewness ranged between – 0.013 and -1.039), and had a significant linear relationship.

4.6.1 The Effect of a CLABSI Prevention Education-based Intervention on Nurses’ Knowledge of the Safe Handling and Maintenance of CVCs in the Control Group

Mauchly's test was performed to assess possible violation of the sphericity assumption, i.e., the assumption that all the variances of the different time points are homogenous. Mauchly’s test was significant (i.e., the sphericity assumption was

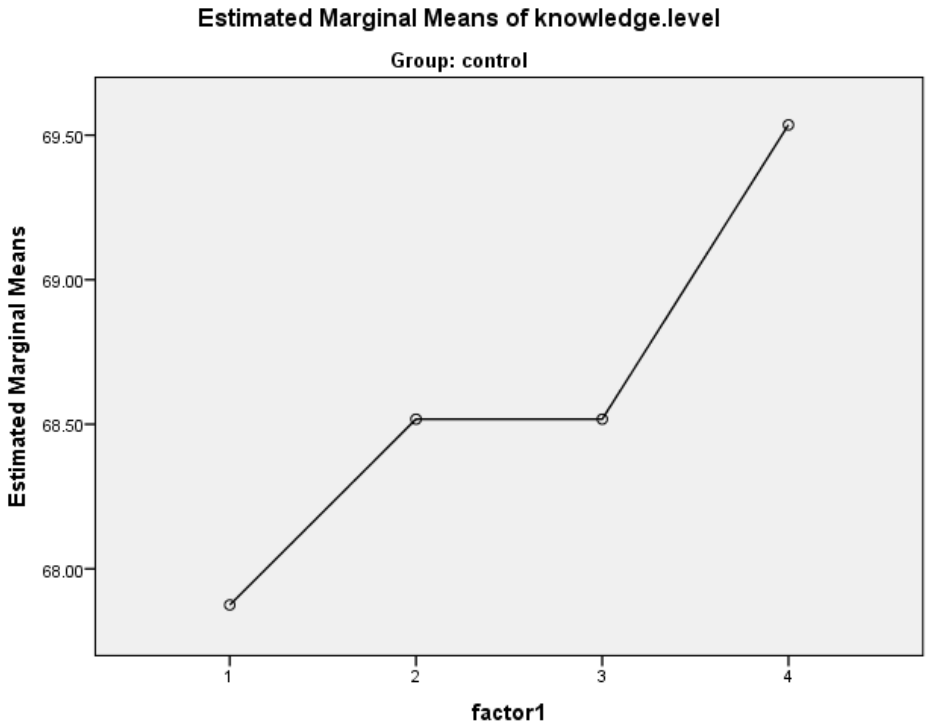
violated) W = 0.47, X^2 = 40.68, p < 0.001. The Green House epsilon was Ɛ = 0.66. A Greenhouse – Geisser correction was used to reduce the effect of type-1 error.

The overall F ratio for the difference in nurses' knowledge of the safe handling and maintenance of CVCs among the control group was significant, $F_{(1, 55)}$ = 618.73, p < 0.001, with a corresponding effect size of η^2= 0.91. This significant F test indicates that there are differences or changes across the four-time points. However, a pairwise comparison (Table 4.5) revealed that there was no specific significant difference in nurses' knowledge of CVCs' safe handling and maintenance at any of the time points. (see Figure 4.1)

Table 4.5 Pairwise Comparison of Intensive Care Nurses' Knowledge of CVCs' Safe Handling and Maintenance among the Control Group

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	P [b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	-0.64	0.3	0.665	-1.72	0.44
	3	-0.64	0.56	1	-2.18	0.90
	4	-1.66	0.68	0.11	-3.54	0.22
2	1	0.64	0.39	0.66	-0.44	1.72
	3	0	0.42	1	-1.16	1.16
	4	-1.01	0.59	0.548	-2.63	0.60
3	1	0.64	0.56	1	-0.90	2.18
	2	0	0.42	1	-1.16	1.16
	4	-1.01	0.41	0.10	-2.15	0.12
4	1	1.66	0.68	0.11	-0.22	3.54
	2	1.018	0.592	0.548	-.604	2.639
	3	1.018	0.416	0 .106	-.121	2.156

Note. b: Adjustment for multiple comparisons: Bonferroni test.



Note. Factor 1: Time

Figure 4.1 Changes in intensive care nurses' knowledge of CVCs' safe handling and maintenance among the control group over time

4.6.2 The effect of a CLABSI Prevention Education-Based Intervention on Intensive Care Nurses' Knowledge of CVCs' Safe handling and Maintenance in the Experimental Group.

Mauchly's test was performed to assess the possible violation of the sphericity assumption, i.e., the assumption that all the variances among the different time points are homogenous. Mauchly's test was significant indicating that the sphericity assumption was violated ($W = 0.100$, $X^2 = 91.64$, $p < 0.001$). The Green House epsilon was $\varepsilon = 0.458$**.** A Greenhouse – Geisser correction was used to reduce the effect of type-1 error.

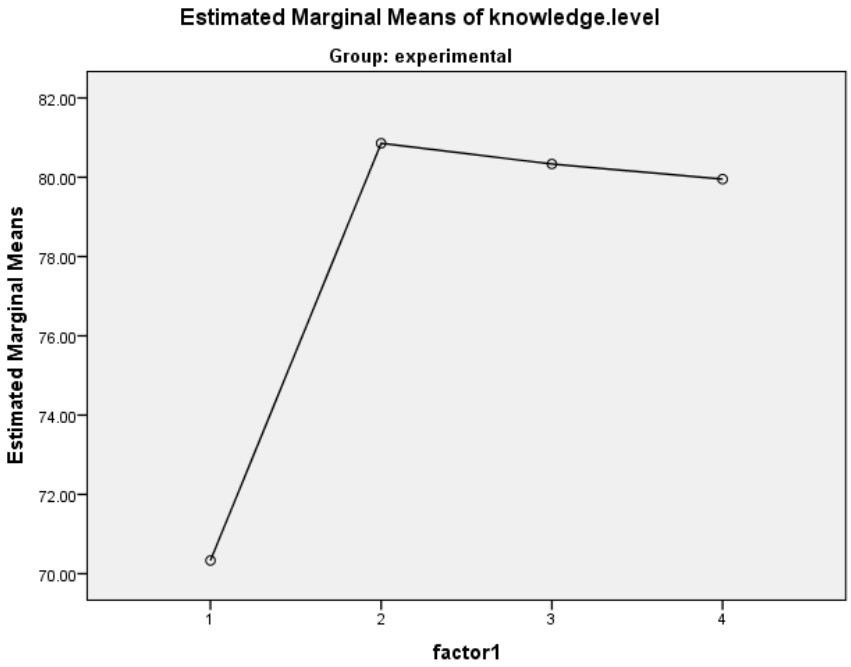
The overall F ratio for the difference in nurses' knowledge of the safe handling and maintenance of CVCs among the control group was significant, ($F(1, 41) = 1214, 63$, $p < 0.001$), with a corresponding effect size of $\eta 2 = 0.967$. A significant F test indicates that there are differences or changes among the four-time points. Table 4.6

shows that a significant change took place in the experimental group's knowledge of the safe handling and maintenance of CVCs between baseline and T1, between baseline and T2, and baseline and T3. The reduction was negatively good at -10.52, -10, and -9.61, respectively. However, there was no difference in nurses' knowledge of the safe handling and maintenance of CVCs among the experimental groups at T1, T2, and T3. (see Figure 4.2)

Table 4.6 Pairwise Comparison of Intensive Care Nurses' Knowledge of CVCs' Safe Handling and Maintenance across the Experimental Groups

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	p[b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	-10.52	1.140	< 0.001	-13.68	-7.36
	3	-10	1.173	< 0.001	-13.25	-6.74
	4	-9.61	1.189	< 0.001	-12.91	-6.32
2	1	10.52	1.140	< 0.001	7.36	13.68
	3	0.52	0.30	0.52	-0.30	1.35
	4	0.90	0.45	0.30	-0.34	2.15
3	1	10	1.17	< 0.001	6.74	13.25
	2	-0.52	0.30	0.52	-1.35	0.30
	4	0.38	0.50	1	-1	1.76
4	1	9.61	1.18	< 0.001	6.32	12.91
	2	-0.90	0.45	0.30	-2.15	0.34
	3	-0.38	0.50	1	-1.76	1

Note: b: Adjustment for multiple comparisons: Bonferroni.



Note. Factor 1: Time

Figure 4.2 Changes in Intensive Care Nurses' Knowledge of CVCs' Safe Handling and Maintenance among the Experimental Group Overtime

4.6.3 The effect of a CLABSI Prevention Education-Based Intervention on CVC Care Practices and Maintenance in the Control Group

Mauchly's test was performed to assess possible violation of the sphericity assumption, i.e., the assumption that all the variances of the different time points are homogenous. Mauchly's test was not significant (i.e., the sphericity assumption has been met) $W = 0.87$, $X^2 = 7.47$, $p = 0.18$. The Green House epsilon was $\varepsilon = 0.91$. Because the Greenhouse–Geisser ε value was close to 1.00, no correction was made to the degrees of freedom used to evaluate the significance of the F ratio. The overall F ratio for the difference between nurses' practice of safe handling and maintenance in CVCs in the control group was significant ($F_{(1, 55)} = 1902.94$, $p < 0.001$), and the corresponding effect size was $\eta^2 = 0.97$.

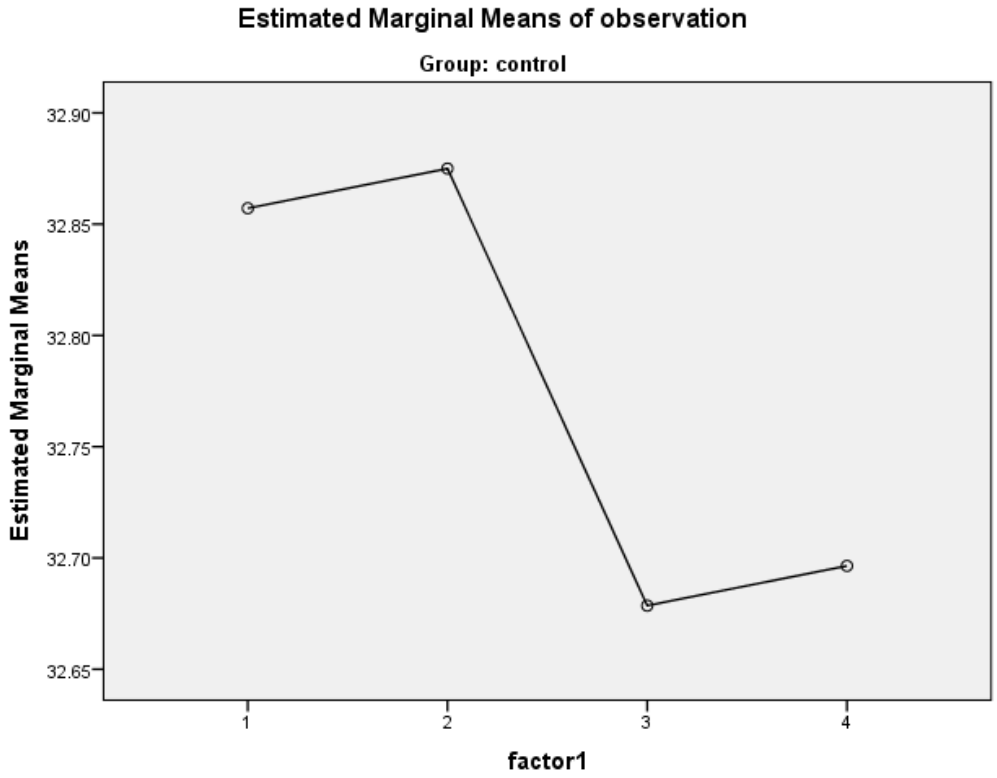
A significant F test indicates that there are differences or changes between the four time points. However, the pairwise comparison summarized in Table 4.7 shows that

there was no specific significant difference in nurses' practice of safe handling and maintenance of CVCs between any of the time points. (see Figure 4.3).

Table 4.7 Pairwise Comparison of CVC Care and Maintenance Practices among the Control Group

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	p[b]	95% Confidence Interval for differences	
					Lower Bound	Upper Bound
1	2	-0.01	0.11	1	-0.31	0.28
	3	0.17	0.12	0.90	-0.15	0.51
	4	0.16	0.14	1	-0.22	0.54
2	1	0.01	0.11	1	-0.28	0.31
	3	0.19	0.13	0.83	-0.16	0.55
	4	0.17	0.14	1	-0.22	0.58
3	1	-0.17	0.12	0.90	-0.51	0.15
	2	-0.19	0.13	0.83	-0.55	0.16
	4	-0.01	0.13	1	-0.37	0.34
4	1	-0.16	0.14	1	-0.54	0.22
	2	-0.17	0.14	1	-0.58	0.22
	3	0.01	0.13	1	-0.34	0.37

Note. b: Adjustment for multiple comparisons: Bonferroni test.



Note. Factor 1: Time

Figure 4.3 Changes in CVC Care Practices and Maintenance Among the Control Group Over Time

4.6.4 The Effect of a CLABSI Prevention Education-Based Intervention on CVC Care Practices and Maintenance in the Experimental Group.

Mauchly's test was performed to assess possible violation of the sphericity assumption, i.e., the assumption that all the variances of the different time points are homogenous. Mauchly's test was significant so the sphericity assumption was violated ($W = 0.01$, $X^2 = 169.05$, $p < 0.001$). The Green-House epsilon was $\varepsilon = 0.36$ and the Greenhouse–Geisser correction was used to mitigate the effect of type-1 error.

The overall F ratio for the difference in nurses' practices of safe handling and maintenance in CVCs in the experimental was significant, $F_{(1, 41)} = 4485.58$, $p < 0.001$, with a corresponding effect size of $\eta^2 = 0.99$. The significant F test indicates that there were differences or changes across the four-time points. Table 4.8 shows that a significant change in nurses' practices of CVC care and maintenance occurred in the experimental

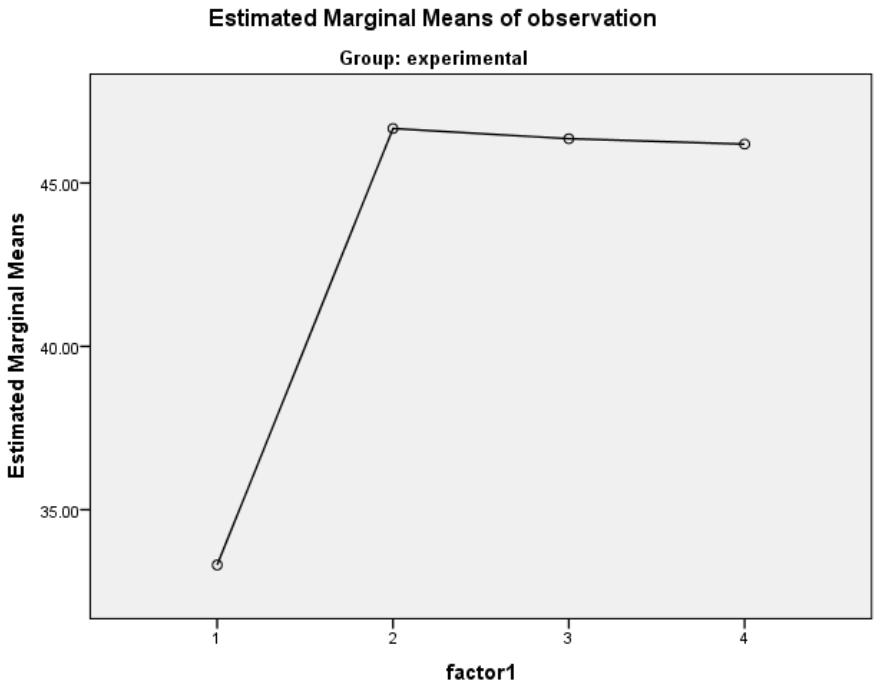
group between baseline and T1, baseline and T2, and baseline and T3. The reduction was negatively good at -13.35, -13.04, and -12.88, respectively. However, there was no difference in nurses' safe handling and maintenance of CVCs among the experimental groups at T1, T2, and T3.

The overall results supported the hypothesis that providing education-based interventions for CLABSI prevention and CVC maintenance would improve nurses' competency level in maintaining CVC among patients in intensive care units compared with the control group. (see Figure 4.4)

Table 4.8 Pairwise Comparison of the Practices or Competency of CVC Care and Maintenance among the Experimental Groups

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	p[b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	-13.35	0.85	< 0.001	-15.73	-10.98
	3	-13.04	0.87	< 0.001	-15.46	-10.63
	4	-12.88	0.87	< 0.001	-15.30	-10.45
2	1	13.35	0.85	< 0.001	10.98	15.73
	3	0.31	0.16	0.37	-0.13	0.75
	4	0.47	0.16	0.04	0.01	0.94
3	1	13.04	0.87	< 0.001	10.63	15.46
	2	-0.31	0.16	0.375	-0.75	0.13
	4	0.16	0.17	1	-0.30	0.63
4	1	12.88	0.87	< 0.001	10.45	15.30
	2	-0.47	0.16	0.04	-0.94	-0.01
	3	-0.16	0.17	1	-0.63	0.30

Note: b: Adjustment for multiple comparisons: Bonferroni.



Note. Factor 1: Time

Figure 4.4 Changes in CVC Care and Maintenance Practices among the Control Group Over Time

4.7 Effect of a CLABSI Prevention Education-based Intervention on Patient Mortality Rate and Length of Stay

A paired-sample t-test was performed to assess differences between the three months before the intervention and the three months after the intervention for both groups (the control and the experimental). Normality was tested by assessing the skewness, which ranged from – 1.21 to 1.07, and the homogeneity was assessed by conducting Leven's test. The results indicated that the equal of variance met with p = 0.782.

For the experimental group, the results indicated no statistically significant difference in the length of stay before (M = 3.98, SD = 0.54) and after the intervention was conducted (M = 3.75, SD = 1.43, (t = 0.32, p = 0.78)). Similarly, there was no statistically significant difference in the mortality rate between the pre-intervention (M = 28.33, SD = 10.21) and post-intervention (M = 30.00, SD = 11.00) periods in the same group (t = -0.139, P = 0.903).

In the control group, in contrary, the difference in length of stay before and after providing the intervention was statistically significant, with a greater mean length of stay in the post-intervention period with a difference of 2.63, CI= [- 4.46, - 0.81], t = - 6.20, p = 0.025. However, the mean mortality rate showed no statistically significant difference between the two periods (pre-intervention: M = 27.00, SD = 6.93; post-intervention: M =13.00, SD =11.53) (t = 1.32, P = 0.317), with the mean post-intervention mortality rate was higher than that in the pre-intervention period (see Table 4.9).

Table 4.9 Differences in the Mortality Rate and Length of Stay Before and After the Education-based Intervention

Variables		Descriptive Statistics		Paired Sample *T*-test			
Experimental group		M	SD	Paired Mean difference	SD	t	p *
Pair 1	Length of stay (pre-intervention)	3.98	0.54	0.23	1.24	0.32	0.779
	Length of stay (post-intervention)	3.75	1.43				
Pair 2	Mortality Rate (pre-intervention)	28.33	10.21	-1.66	20.84	-0.14	0.903
	Mortality Rate (post-intervention)	30	11				
Control group		M	SD	Paired Mean difference	SD	t	p *
Pair 1	Length of stay (pre-intervention)	2.77	0.16	-2.63	0.73	-6.2	0.025
	Length of stay (post-intervention)	5.4	0.76				
Pair 2	Mortality Rate (pre-intervention)	27	6.93	14	18.35	1.32	0.317
	Mortality Rate (post-intervention)	13	11.53				

Note. M: mean, SD: standard deviation,

*significance level at $p < 0.05$

Additionally, an independent-sample t-test (see Table 4.10) was performed to evaluate differences in the length of stay and mortality rate between the control and experimental groups in the period after the intervention. The results revealed no statistically significant difference in the means of the mortality rate ($t = -1.848$, $p = 0.138$) or length of stay ($t = 177$, $p = 0.151$) between the control and experimental groups. These results support the null hypothesis that providing education-based interventions for nurses did not affect the mortality rate or length of stay.

Table 4.10 Differences in the Post-Intervention Length of Stay and Mortality Rate between the Control and Experimental Groups

Variables	Independent - Samples T-test	
	T	p*
Length of stay (pre-intervention)	-3.71	0.021
Length of stay (post-intervention)	1.77	0.151
Mortality Rate (pre-intervention)	-0.187	0.861
Mortality Rate (post-intervention)	-1.848	0.138

Note. *The significance level at $p < 0.05$

4.8 Differences in the Baseline Competence Level of CVC Maintenance Concerning the Intensive Care Nurses' Demographics and Institutional Factors.

This section addresses the secondary question of the study. The results of the independent sample t-test in Table 4.11 show that there was no statistically significant difference in the baseline knowledge and practice of safe CVC handling and maintenance among the categorical demographic variables, including sex, graduation country, working in shift systems, and employment status ($p > 0.05$). One-way ANOVA also revealed no statistically significant difference in the baseline knowledge and practice of safe CVC handling and maintenance among the different educational levels, with p-values of 0.124 and 0.741, respectively.

Table 4.11 Differences in the Baseline Competency Level of CVC Maintenance Based on Intensive Care Nurses' Demographics

Demographic characteristics		Level of Knowledge (Baseline)			Level of practice (Baseline)		
Variable	Categories	M (SD)	t	p[a]	M (SD)	t	p[a]
Gender	Male	70.64 (18.99)	1.152	0.252	32.83 (5.90)	-0.46	0.641
	Female	65.97 (19.99)			33.41 (5.88)		
Graduation Country	Palestine	68.35(19.34)	-1.653	0.102	33.23 (5.85)	1.729	0.087
	Others	87.00 (12.28)			27.33 (3.21)		
Shift variation	Only morning shift	74.00 (20.24)	0.532	0.596	31.00 (2.16)	-0.711	0.143
	Three shifts	68.71 (19.44)			33.13 (5.97)		
Work nature	Full time	71.60 (20.84)	0.315	0.754	35.80 (7.49)	1.075	0.285
	Part-time	68.78 (19.43)			32.90 (5.79)		
Variable	Categories	M (SD)	*F*	P[b]	M (SD)	*F*	P
Educational level	Associate degree	63.20 (25.45)	2.1	0.124	32.2 (5.92)	0.741	0.479[b]
	Bachelor degree	68.04 (18.08)			33.44 (5.79)		
	Postgraduate degree	78.46 (20.20)			31.46 (6.41)		

Note. M: mean, SD: standard deviation, [a] p-value derived from the independent-sample t-test, the significance level at $p < 0.05$

b p-value derived from the ANOVA test; the significance level was set at a p-value < 0.05.

Furthermore, Pearson's r correlation was used to test the relationships between the baseline level of knowledge and practices with age, income, and number of years of experience. The three independent variables are normally distributed, with skewness values of 0.88, 0.174, and 1.25. Table 4.12 reveals that there was no significant

relationship between age, income, or number of years of experience and the baseline level of knowledge and practice ($p > 0.001$).

Table 4.12 Correlations among baseline level of knowledge and practice of CVC safe handling with age, income, and years of experience (N = 98)

Continuous variables	Age	Income	No. of years of experience	Baseline level of knowledge	Baseline level of practice
Age	-	-	-	-	-
Income*	0.526**	-	-	-	-
No. of years of experience	0.796**	0.624**	-	-	-
Baseline level of knowledge	-0.019	-0.015	0.011	-	-
Baseline level of practice	-0.187	-0.049	-0.19	0.028	-

Note. *Income in Shekels, ** Correlation is significant at $p < 0.01$ (two-tailed)

4.9 Summary

This chapter presents the results of various statistical tests used to address the research questions. The study involved 98 intensive care nurses from four hospitals north of the West Bank. The sociodemographic characteristics and institutional factors varied among the intensive care nurses in the control and experimental groups.

The analysis via repeated-measures ANOVA indicated that the education-based intervention significantly improved the intensive care nurses' knowledge and practices of CVC maintenance and safe handling compared with their baseline levels and in contrast to the control group. This improvement was maintained at T2 and T3.

On the other hand, the education-based interventions did not affect the mortality rate or the length of stay for patients admitted to intensive care units in hospitals in the

experimental group, with no significant difference compared with those in the control group.

Chapter Five: Discussion

5.1 Introduction

This chapter highlights the significance of the key findings of this dissertation, compares these findings with the available literature, and underscores the importance of these findings and their implications in many aspects. This study investigated the effects of a CLABSI prevention education-based intervention on nurses' competency in CVC maintenance and patients' care outcomes in intensive care units in the participating MOH hospitals in Palestine.

5.2 The Effect of a CLABSI Prevention Education-Based Intervention on Nurses' Competency in CVC Maintenance

To assess the effectiveness of the provided educational intervention on ICU nurses' competence in maintaining and safely handling CVCs in intensive care units, we hypothesized the following:

"Providing education-based intervention for CLABSI prevention and central lines' maintenance would positively improve nurses' competency level in maintaining CVC, among patients admitted in intensive care units compared with the control group in the northern region of Palestine".

The results revealed that the knowledge and safe handling skills of nurses improved after education was provided. Improvements in knowledge and practice were observed across the three points of measurement after the intervention was conducted: times I to III. Additionally, this improvement favored the experimental group over the control group. In other words, compared with the control group, the experimental group presented a greater level of knowledge and improved level of practice at Times II and III.

Furthermore, the experimental group maintained higher levels of knowledge and practice over the eight weeks after receiving the education. The control group maintained almost the same level of practice across the three points of measurement. This infers that the hypothesis was valid, as CLABSI prevention and safe handling of CVC-based

education were found to be effective interventions and contributed to improving ICU nurses' competencies and knowledge of CLABSI prevention principles and practices related to the safe handling and maintenance of CVC.

Additionally, an essential component of the synergy model is that education-based interventions could enhance knowledge and practices, which together create competent nurses who integrate knowledge and skills to provide safe care (American Nurse Association of Critical Care Nurses, 2022).

The improvement in knowledge and practice among the experimental group can be related and explained in various forms. One explanation could be related to the content of the education-based intervention. The intervention was much beyond providing spoon-feeding education; rather, it actively engaged the targeted nurses in the training. This hands-on teaching approach was found to be effective, as it allowed nurses to address and constantly improve their knowledge and practices by discovering areas of weakness in their practices and gaps in knowledge.

Nurses' involvement is considered essential for maintaining changes; thus, hands-on education and training allow nurses to improve their knowledge and practices (George & Massey, 2020). Additionally, assessing knowledge and practice repeatedly at four points in time increases the precision of the results, reflecting the essence of the robustness of the intervention and knowledge retention and practice (Clifford et al., 2021). Furthermore, the improvement in practice and knowledge may be evidence that the components of the educational intervention were tailored to the diversity of the ICU nurses' demographics and work conditions, which increased the effectiveness of the intervention (Abu Sharour et al., 2018).

In addition, having an evidence-based educational intervention that was developed according to the CDC recommendations helped promote the acceptance of the shared concepts and principles because the CDC recommendations are considered a valid and reliable source for the MOH infection control program and the main sources of knowledge for nurses and health practitioners.

Another important point that deserves discussion is that the nurses in both groups were working in almost identical political, financial, social, and work environments and that their demographics and institution-related factors did not significantly affect their baseline knowledge and practices. Thus, the increase in ICU nurses' competency to

maintain CVC in the experimental group may be related, in particular, to the content and method of providing education-based interventions. This has led to a significant improvement in ICU nurses' knowledge and practice of CVC safe handling from the baseline and during the follow-up periods after the intervention was conducted. However, the ICU nurses in the control group did not experience any improvement in baseline knowledge or practice across the measurement times.

Concerning the effect of education-based interventions on ICU nurses' competency, the results of the current study are in line with and supported by several studies. For example, in the study of Dsilva et al. (2022b), nurses demonstrated that enhancing their knowledge and competencies in the safe handling of CVC after receiving education in safe CVC handling enhanced their knowledge and practices of CLABSI prevention. The majority have maintained their ability to maintain CVCs over time (Dsilva et al., 2022b).

Moreover, the applied quasi-experimental time series design was effective in controlling for confounding factors. This enhanced the effectiveness of the provided intervention in improving knowledge and practice and in sensitively detecting change over time. This finding aligns with several studies that demonstrated the effectiveness of their methodologies in assessing the effect of the provided educational intervention while controlling for confounders. R. Acharya et al. (2019), for example, applied a quasi-experimental design and reported that receiving education about CLABSI prevention and CVC maintenance improved nurses' knowledge and practices and that the improvement was maintained over time compared with the baseline period. Similarly, Negm et al. (2021) and E. Khalifa et al. (2022) enhanced and maintained improvements in nurses' knowledge and practices of safe CVC handling after providing training programs, utilizing a quasi-experimental design.

Furthermore, the current study adopted a pretest-posttest design. This design assisted in comparing the outcome of providing educational intervention to baseline data and thus helped detect the effectiveness of the intervention. This finding was in accordance with the pretest-posttest design studies of S. Mohapatra et al. (2020) and Prathiba et al. (2022), in which the participating nurses showed improved levels of knowledge and practice after receiving educational programs for CVC maintenance and CLABSI prevention compared with their pretest level of knowledge and practice.

Similarly, the pretest-posttest study by Olajuyigbe (2021) revealed that nurses' knowledge of safe CVC handling improved after receiving CLABI prevention and educational intervention, which was further in line with the findings of Burt and Spowart (2021).

5.3 Effect of a CLABSI Prevention Education-based Intervention on Patient Mortality Rate and Length of Stay

According to the AACN Synergy Model, promoting nurses' ability to maintain CVCs and enhance their knowledge would improve patients' outcomes; thus, concerning the indirect effects of providing education-based interventions on the length of stay and mortality rate of patients admitted to the ICU, the following hypothesis was adopted:

"Providing education-based intervention for CLABSI prevention and central lines' maintenance would lower the mortality rate and shorten the length of stay among patients in intensive care units compared to the control group in the northern region of Palestine".

The results did not reveal any decline in the mortality rate or length of stay of the patients admitted to the ICU during the period of intervention. The mortality rate and length of stay were unaffected through the three points of measurement, times 1 to 3, and there was no advantage for the ICU patients in the experimental group in comparison with those in the control group. Accordingly, the second hypothesis was rejected.

The provided results might have several rationales. The time duration allocated to execute the study might limit the ability to detect the effect of improving the knowledge and practice of ICU nurses on patient outcomes. Throughout the study period, the West Bank experienced challenging conditions. The occupation increased his bloody military attacks and aggression, consequently leading to a significant increase in the number and severity of injuries. This situation triggered the displacement of experienced healthcare providers and resources, which imposed unexpected and intense pressure on the MOH hospitals. These hospitals had already complained of a shortage of resources and human power because of forced constraints on movement across regions and on the procurement of medical supplies (Ministry of Health of Plestine Ministrer's ofice, 2024).

Additional contributing factors might be the variability in the morbidities and the severity of health conditions among patients admitted during the study time frame. As highlighted in the study of Negm et al. (2021), patients' comorbidities prolonged the length of stay and increased mortality rates, masking the effect of increased nurses' competencies on patient outcomes. Moreover, the ICUs within the participating hospitals were the first choice for receiving a high volume of injured patients. Most of these injuries stemmed from rocket explosions and gunshots, explaining the prolonged length of stay in the post-intervention period, during which the intensity and severity of aggressive attacks increased. These facts impede the ability to detect the effect of improving nurses' competency in caring for CVCs on patients' outcomes. In addition, this could explain why the ICUs that admitted patients who received care from ICU nurses in the control group stayed longer in the post-intervention period than did those admitted before the intervention was conducted because of the increase in the severity of the attacks.

Prolonged follow-up, as recommended by Sarita Mohapatra et al. (2020), may provide more opportunities to capture the changes in mortality rates and lengths of stay after providing educational interventions for nurses. In contrast, two studies have shown that receiving educational interventions for CVC maintenance could positively affect patient outcomes (Alkhawaja et al., 2020; Jessica Lowery et al., 2022).

The current study revealed many challenging factors that mask the effect of educating ICU nurses and enhancing their competency in proper CVC care to improve patients' outcomes. Longer-term follow-up may help explore the effect of enhanced nurses' competencies on patients' outcomes in the intensive care unit (ICU) setting.

5.4 Differences in the Baseline Competence Level of CVC Maintenance Concerning Intensive Care Nurses' Demographics and Institutional Factors

The secondary focus of this study was the influence of ICU nurses' demographics and institutional factors on their level of knowledge and practice of proper maintenance of CVCs. The effect was evaluated at baseline to examine whether the demographic and institutional factors would have influenced the subsequent measurements of knowledge

and practice (Bertola et al., 2022). The results revealed that ICU nurses' knowledge and practices were not affected by their demographics or institutional factors.

These outcomes can be explained by a variety of factors. Initially, the provided educational intervention was well structured to tailor the nurses' attributes. Additionally, the blended learning approach, which consists of lecture-based learning, group discussions, hands-on training, and individual follow-up, encouraged the active involvement of ICU nurses and promoted their adherence.

The monthly income in this study appeared to have no effect on nurses' knowledge of and practices related to CLABSI prevention and CVC maintenance. This could be due to the feasibility of the administered interventions. The participating nurses were reached at their workplace, eliminating the need for financial resources to access training or attend educational sessions. Similarly, the absence of differences between males and females in their knowledge and practice of CVC maintenance and CLABSI prevention in the current study may imply the equality of opportunities and unbiased provision of training and education on the basis of sex.

The results align with those of some studies and contradict those of others. For example, Al Qadire and Hani (2022) reported that the level of knowledge of CLABSI prevention was not affected by sex, age, or years of experience; however, nurses with postgraduate certificates presented greater knowledge. This finding is consistent with the current study, except for the effect of education level. Conversely, a study by Al Maliki and colleagues revealed that older nurses, those with master's degrees in nursing, and those with more experience in ICUs were more knowledgeable and skillful, whereas sex did not differ (Almalki et al., 2023), which is partially inconsistent with the current findings. On the other hand, a study from Jordan indicated that sex, working on a shift system, and higher education had no effect on nurses' knowledge or competency level (Matlab et al., 2022) which in line with the current study.

With respect to the ICU nurses' demographics and institutional factors, the findings indicated no effect on their knowledge and practice of CVC maintenance. This may be due to the well-structured educational intervention and the use of blended learning strategies that encourage the active engagement of learners in educational sessions. Further studies are needed to fully explore the associations between demographic and institutional factors and nurses' competencies.

5.5 Strengths and Limitations

5.5.1 Strengths

This study is novel, as it is the first interventional study concerning CLABSI prevention and central lines' maintenance in Palestine. It provides holistic, standardized, evidence-based educational interventions that have distinguished contributions to enhancing nurses' competencies and adding valuable knowledge to the existing body of knowledge and research in Palestine.

In addition, it could facilitate the application of standardized nursing practice in caring of central line. Also, using the control group and time series design enhances the robustness of the study by controlling for confounding factors and measuring improvement through different points of measurement. This study provides valuable guidance for developing and providing education-based interventions to enhance nurses' ability to handle CVC safely and consequently improve patients' safety.

5.5.2 Limitations

One of the limitations encountered during conducting the study was the inability to measure the CLABSI rate due to the lack of national standardized documentation and archiving system which lead to inconsistency in recording patients' information, especially regarding central lines' insertion, maintenance, and removal, and disparity in assessing signs and symptoms of CLABSIs.

5.5.3 Implication for Health Education

This study provides effective, evidence-based educational interventions. This educational material can be pivotal to the Health Education and Scientific Research Department within the MOH. It can be used to build an e-learning module that serves as an integral part of the continuing education program. This module helps disseminate knowledge, guidelines, and international recommendations in favor of CVC maintenance and infection control principles. This integration could promote a safe culture and safe patient care.

5.5.4 Implications for Scientific Research

This study could encourage researchers to duplicate this study in different settings, including nongovernmental hospitals, and to target various healthcare providers' specialties, such as nurses in hemodialysis units and oncology departments

5.5.5 Implications for Policy Makers

The outcome of this study could inform the necessity of revising existing policies and programs concerning infection control practices, specifically the CVC care and CLABSI measurement. It is imperative to highlight the importance of supporting existing policies through clear procedures to monitor the competencies of healthcare providers and to measure infection control key performance indicators (KPIs), such as CLABSIs. The provided educational program could serve as a valid reference for developing more standardized policies and procedural guideline

5.5.6 Implications for Nurse Managers

The tools utilized in this study can be used to objectively assess and verify nurses' competency and ensure that safe and high-quality care is provided. Nursing managers could integrate these tools with the annual appraisal process and use them to evaluate compliance with patient safety practices, especially among newly hired nurses. Their usage could assist managers in capturing any existing gaps in practice.

5.6 Recommendations

The ultimate goal of this study was to improve nurses' competency in central lines 'maintenance and safe handling. Based on the key findings, the following recommendations emerged:

The CLABSI rate should be included as a study variable in future research. Prospective studies could be conducted to detect CLABSI rate and provide national prevalence of CLABSI, along with risk factors including health care providers' practices patients' health condition. Therefore, it is important to create high-level collaboration among researchers, infection prevention offices, and the quality and patient safety departments at the MOH hospitals This collaboration represents a golden step toward standardizing the CLABSI assessment and prevention approach and establishing agreed

upon guidelines and protocols to control health care providers' practices and setting up a clear method for CLABSI measurements

For future research, providing educational interventions in a classroom setting to minimize distraction and ensure that nurses are off duty on the day of training is recommended. The training sessions should be conducted according to the trainees' convenient time to avoid interrupting their routine schedule. This would encourage active engagement in discussion and assist the educator to provide individual feedback in a comfortable manner.

5.7 Conclusion

Nurses are the gatekeepers of patient safety. Their competency level determines their ability to maintain an infection-free environment and improve patient outcomes. This study provides an opportunity to assess the effect of education-based interventions on the safe handling of CVC. Nurses became more knowledgeable and competent in maintaining CVCs. Some support the results of this study, whereas others contradict them, which may be related to many factors. Managers at the MOH need to motivate nurses to keep up to date with evidence-based guidelines and recommendations.

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Appendices

Appendix A

Self-completed pretest and posttest questionnaire

الجزء الأول: المعلومات الشخصية

- اسم المستشفى:
- رمز الموظف:
- الجنس: ذكر أنثى
- العمر بالسنوات:
- الشهادة الجامعية: دبلوم بكالوريوس
  دراسات عليا
- دولة التخرج:
- عدد سنوات الخبرة بالعناية المكثفة:
- الدخل الشهري بالشيكل:
- العمل بنظام الورديات: وردية صباحية فقط وردية مسائية فقط
  ورديات منوعة
- نظام العمل: عقد دائم دوام جزئي

الجزء الثاني: الامتحان القبلي لقياس مدى المعرفة بالممارسات الوقائية لمنع عدوى مجرى الدم المرتبطة بالقثطار الوريدي المركزي

ارجو الإجابة باختيار أحد الخيارات التالية: صحيح ان كانت المعلومة صحيحة من وجهة نظرك، خاطئ ان كانت المعلومة خاطئة من وجهة نظرك ولا أعلم انت كنت لا تعلم مدى صحة المعلومة. قم بتعبئة البيانات بوضع إشارة (√) في مربع الإجابة المناسب

#	البند	صحيح	خاطئ	لا أعلم
1	تعرّف عدوى مجرى الدم المرتبطة بالقثطار الوريدي المركزي)) على انها عدوى مؤكدة في مختبر الدم خلال يومان تقويميان من ***CLABSI*** ، وهي مصحوبة بالقشعريرة، ***CVAD***ادخال الوريد بالقثطار المركزي (وارتفاع درجة الحرارة، وانخفاض ضغط الدم، وتسارع في دقات القلب والذي ليس مرتبطا بعدوى من مكان اخر A laboratory-confirmed infection where a CVAD is in place for >2 calendar days before a positive culture and is also in place the day of or the day before the culture and combined with chills, fever, hypotension, and tachycardia that is not related to an infection from another site			

#	البند	صحيح	خاطئ	لا أعلم
2	يجب التحقق من مكان إدخال جهاز القسطرة ال وريديةCVAD يوميا على الأقل. The insertion site of CVAD should be assessed at least once a day.			
3	بعد غسل أنبوب التغذية الوريدي المركزي (CVAD)، من الضروري إغلاق المشبك والفتحة عند آخر واحد ملليلتر من المحلول الملحي، لأن الضغط الإيجابي يمنع ارتجاع الدم داخل الأنبوب ويزيد من صلاحية استخدام الأنبوب الوريدي. After flushing the CVAD lumens, it is important to close the clamp and lock the lumen at the last 1 ml of normal saline 0.9% because Positive pressure prevents the backflow of blood into the lumen and can increase the patency of lumen.			
4	يجب تغيير ضماد الكلوروهيكسيدين الشفاف الذي يوضع فوق موقع إدخال القثطار الوريدي المركزي كل سبعة أيام أو عندما تقتضي الحاجة لذلك. The transparent chlorohexidine dressing over the central line insertion site must be changed every seven days and when needed.			
5	يعتبر محلول الكلوروهيكسيدين 2% الموجود في الكحول تركيز 70%، هو المحلول المطهر الموصي باستخدامه عند تغيير ضمادة القثطار الوريدي المركزي CVAD Chlorohexidine 2% in 70% alcohol is the recommended disinfectant solution for CVAD dressing			
6	على المريض ارتداء قناع الوجه عند التعامل او فتح القثطار الوريدي المركزي (CVAD)			
	When accessing the lumen of the CVAD, the patient should wear a mask.			
7	تقنية عدم اللمس هي التقنية الأكثر توصية عند فتح او التعامل مع القثطار الوريدي المركزي ((CVAD.			

#	البند	صحيح	خاطئ	لا أعلم
	The non-touch technique is the most recommended to access the CVAD.			
8	يوصى باستخدام الكلوروهيكسيدين عوضا عن الكحول عند العناية بموقع إدخال القثطار الوريدي المركزي، وذلك لأن فعاليته تدوم لأكثر من 12 ساعة بعد تطبيقه. Chlorhexidine is recommended over alcohol to care for the CVAD insertion site because it has more than 12 hours of residual activity after application.			
9	ان الالية الصحيحة لتغيير الضماد او الغيار الطبي عن موقع إدخال القثطار الوريدي المركزي ((CVAD هو عن طريق استخدام الحركات الخلفية والأمامية والفرك لمدة ثلاثين ثانية. The correct mechanism to do dressing over the CVAD insertion site is by using the backward, forward and friction for 30 seconds.			
10	عند إزالة انبوب الوصول الوريدي من جهاز القثطار الوريدي المركزي ((CVAD، يصبح تعقيم اليدين اجباريا باستخدام تقنية عدم الملامسة. When discontinuing an IV line from the CVAD lumen, Hand Hygiene is obligatory with using the non-touch technique.			
11	يجب تنظيف وفرك نهايات مخارج انبوب القثطار الوريدي المركزي لمدة 15 ثانية بالكحول 70% The CVAD hub must be scrubbed for 15 seconds using alcohol 70%.			
12	يجب تغيير الغطاء الخاص بنهايات مخارج القثطار الوريدي المركزي مع كل غيار للضمادة او الغيار الطبي وعند الحاجة. The lure lock adapter (Cap) of the CVAD hub must be changed with every dressing and when needed.			

#	البند	صحيح	خاطئ	لا أعلم
13	يستخدم الغطاء الخاص بنهايات القثطار الوريدي المركزي لمرة واحدة فقط ويجب التخلص منه في حال فصله عن القثطار The luer lock adapter (Cap) of the CVAD hub is a single-used apparatus.			
14	ان الحجم المناسب للحقنة لتنظيف وتصريف أو سحب عينات الدم من القثطار الوريدي المركزي (CVAD) هو حقنة سعتها 10 مل. The proper syringe size to flush or withdraw blood samples from CVAD is a 10 ml syringe.			
15	تعتبر عملية ادخال السائل الملحي لتصريف القثطار الوريدي المركزي والحفاظ على نفاذيته (الدفع والتوقف بشكل متتابع) باستخدام حقنة حجم 10 مل هي التقنية المناسبة لجميع أنواع جهاز القثطار الوريدي المركزي (.CVAD) A pulsatile push pause mechanism using a 10 ml syringe size is the proper flushing technique for all CVAD types.			
16	يجب تغيير وتبديل الانابيب الطبية المستخدمة لتقديم السوائل الوريدية بشكل مستمر كل اربعة الى سبعة أيام The administration sets for continuous infusions shall be changed no more frequently than every 4 days, but at least every seven days.			
17	يجب تغيير الانابيب الطبية المستخدمة لإعطاء محاليل تحتوي على الدهون المستخدمة للتغذية الوريدية كل 24 ساعة The administration sets for fat emulsions should be changed every 24 hours.			
18	الأنابيب الوريدية المستخدمة للإعطاء الدم عبر القثطار الوريدي المركزي يجب أن يتم تبديلها كل 24 ساعة The administration sets for blood should be changed every 24 hours.			

#	البند	صحيح	خاطئ	لا أعلم
19	بعد اعطاء الدم عبر القثطار الوريدي المركزي يجب تصريف وغسل الانبوب بالمحلول الوريدي الملحي بتركيز 0.9% After medication administration through CVAD, the lumen must be flushed with Normal Saline 0.9%.			
20	يجب سحب والتخلصان الدم الموجود في المساحة الفارغة في انابيب القثطار الوريدي المركزي قبل جمع عينة زراعة الدم. A dead space must be withdrawn and discarded before collecting blood culture.			
21	عند سحب عينة زراعة دم بوجود القثطار الوريدي المركزي، يجب سحب عينة زراعة دم طرفية بالبداية ثم المركزية من القثطار الوريدي المركزي The peripheral blood culture should be withdrawn first then the central culture for patients with CVAD.			
22	عند اخذ عينة زراعة دم من القثطار الوريدي المركزي يمكن اخذ عينة الدم مدم جميع انابيب القثطار ووضعها في انبوبة زراعة دم واحدة The blood collected for culture from CVAD MUST be collected from each lumen in one bottle.			
23	عند سحب عينة دم عادية من انابيب القثطار الوريدي المركزي الموصولة بسوائل وريدية يتم اعطاؤها للمريض بشكل مستمر عبر القثطار، يجب وقف هذه السوائل لمدة دقيقتين أو ثلاثة قبل سحب الدم When withdrawing a blood sample from CVAD, all lumens with continuous fluid infusion must be closed for 2-3 minutes before the procedure.			
24	يجب عدم ايقاف الادوية القابضة للأوعية الدموية الموصولة عبر القثطار الوريدي المركزي في حال الحاجة لسحب عينة دم من انابيب القثطار The lumen with vasopressor infusion shall not be clamped for blood sampling from CVAD.			

#	البند	صحيح	خاطئ	لا أعلم
25	الدم المسحوب من القثطار الوريدي المركزي بعد تركيبه مباشرة يصلح لأخذ عينة دم عادية طرفية The blood that is withdrawn directly from the central line just after insertion is considered a peripheral blood sample.			
26	تتكون حزمة العناية بالقثطار الوريدي المركزي من غسل اليدين واستخدام مادة الكلوروهيكسيدين 2% والمراجعة اليومية للحاجة لوجود القثطار المركزي واختيار المكان الانسب لإدخال القثطار الوريدي المركزي ولبس كامل المستلزمات عند ادخال القثطار المركزي The CVAD bundle contains hand hygiene, using Chlorhexidine 2% in 70% alcohol, daily review of necessity, site selection for insertion, and maximum barrier precaution.			

Appendix B

Final search strategy from Pubmed

Search: central line infection OR central line-related infection OR central line-related bloodstream infection OR central venous catheter-associated bloodstream infection OR central venous catheter-related bloodstream infections OR central venous catheter-related infection OR central venous access device-related infection OR central venous access device-associated infection OR central venous access-related bloodstream infection OR central line-associated bloodstream infections AND (intervention OR treatment OR program OR education OR training) Filters: Clinical Trial, Controlled Clinical Trial, Observational Study, Randomized Controlled Trial, Systematic Review, in the last 10 years, English ((((("central venous catheters"[MeSH Terms] OR ("central"[All Fields] AND "venous"[All Fields] AND "catheters"[All Fields]) OR "central venous catheters"[All Fields] OR ("central"[All Fields] AND "line"[All Fields]) OR "central line"[All Fields]) AND ("infect"[All Fields] OR "infectability"[All Fields] OR "infectable"[All Fields] OR "infectant"[All Fields] OR "infectants"[All Fields] OR "infected"[All Fields] OR "infected"[All Fields] OR "infectibility"[All Fields] OR "infectible"[All Fields] OR "infecting"[All Fields] OR "infection s"[All Fields] OR "infections"[MeSH Terms] OR "infections"[All Fields] OR "infection"[All Fields] OR "infective"[All Fields] OR "infectiveness"[All Fields] OR "infectives"[All Fields] OR "infectivities"[All Fields] OR "infects"[All Fields] OR "pathogenicity"[MeSH Subheading] OR "pathogenicity"[All Fields] OR "infectivity"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND "line-related"[All Fields] AND ("infect"[All Fields] OR "infectability"[All Fields] OR "infectable"[All Fields] OR "infectant"[All Fields] OR "infectants"[All Fields] OR "infected"[All Fields] OR "infecteds"[All Fields] OR "infectibility"[All Fields] OR "infectible"[All Fields] OR "infecting"[All Fields] OR "infection s"[All Fields] OR "infections"[MeSH Terms] OR "infections"[All Fields] OR "infection"[All Fields] OR "infective"[All Fields] OR "infectiveness"[All Fields] OR "infectives"[All Fields] OR "infectivities"[All Fields] OR "infects"[All Fields] OR "pathogenicity"[MeSH Subheading] OR "pathogenicity"[All Fields] OR "infectivity"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND "line-related"[All Fields] AND ("sepsis"[MeSH Terms] OR "sepsis"[All Fields] OR ("bloodstream"[All Fields] AND "infection"[All Fields]) OR "bloodstream infection"[All Fields])) OR (("central venous catheters"[MeSH Terms] OR ("central"[All Fields] AND "venous"[All Fields] AND "catheters"[All Fields]) OR "central venous catheters"[All Fields]

OR ("central"[All Fields] AND "venous"[All Fields] AND "catheter"[All Fields]) OR "central venous catheter"[All Fields]) AND ("associate"[All Fields] OR "associated"[All Fields] OR "associates"[All Fields] OR "associating"[All Fields] OR "association"[MeSH Terms] OR "association"[All Fields] OR "associations"[All Fields]) AND ("sepsis"[MeSH Terms] OR "sepsis"[All Fields] OR ("bloodstream"[All Fields] AND "infection"[All Fields]) OR "bloodstream infection"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "venous"[All Fields]) AND "catheter-related"[All Fields] AND ("sepsis"[MeSH Terms] OR "sepsis"[All Fields] OR ("bloodstream"[All Fields] AND "infections"[All Fields]) OR "bloodstream infections"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "venous"[All Fields]) AND ("catheter related infections"[MeSH Terms] OR ("catheter-related"[All Fields] AND "infections"[All Fields]) OR "catheter related infections"[All Fields] OR ("catheter"[All Fields] AND "related"[All Fields] AND "infection"[All Fields]) OR "catheter related infection"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "venous"[All Fields]) AND ("access"[All Fields] OR "accessed"[All Fields] OR "accesses"[All Fields] OR "accessibilities"[All Fields] OR "accessibility"[All Fields] OR "accessible"[All Fields] OR "accessing"[All Fields]) AND "device-related"[All Fields] AND ("infect"[All Fields] OR "infectability"[All Fields] OR "infectable"[All Fields] OR "infectant"[All Fields] OR "infectants"[All Fields] OR "infected"[All Fields] OR "infecteds"[All Fields] OR "infectibility"[All Fields] OR "infectible"[All Fields] OR "infecting"[All Fields] OR "infection s"[All Fields] OR "infections"[MeSH Terms] OR "infections"[All Fields] OR "infection"[All Fields] OR "infective"[All Fields] OR "infectiveness"[All Fields] OR "infectives"[All Fields] OR "infectivities"[All Fields] OR "infects"[All Fields] OR "pathogenicity"[MeSH Subheading] OR "pathogenicity"[All Fields] OR "infectivity"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "venous"[All Fields]) AND ("access"[All Fields] OR "accessed"[All Fields] OR "accesses"[All Fields] OR "accessibilities"[All Fields] OR "accessibility"[All Fields] OR "accessible"[All Fields] OR "accessing"[All Fields]) AND "device-associated"[All Fields] AND ("infect"[All Fields] OR "infectability"[All Fields] OR "infectable"[All Fields] OR "infectant"[All Fields] OR "infectants"[All Fields] OR "infected"[All Fields] OR "infecteds"[All Fields] OR "infectibility"[All Fields] OR "infectible"[All Fields] OR "infecting"[All Fields] OR "infection s"[All Fields] OR "infections"[MeSH Terms] OR

"infections"[All Fields] OR "infection"[All Fields] OR "infective"[All Fields] OR "infectiveness"[All Fields] OR "infectives"[All Fields] OR "infectivities"[All Fields] OR "infects"[All Fields] OR "pathogenicity"[MeSH Subheading] OR "pathogenicity"[All Fields] OR "infectivity"[All Fields])) OR (("central"[All Fields] OR "centrally"[All Fields] OR "centrals"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "venous"[All Fields]) AND "access-related"[All Fields] AND ("sepsis"[MeSH Terms] OR "sepsis"[All Fields] OR ("bloodstream"[All Fields] AND "infection"[All Fields]) OR "bloodstream infection"[All Fields])) OR (("central venous catheters"[MeSH Terms] OR ("central"[All Fields] AND "venous"[All Fields] AND "catheters"[All Fields]) OR "central venous catheters"[All Fields] OR ("central"[All Fields] AND "line"[All Fields]) OR "central line"[All Fields]) AND ("associate"[All Fields] OR "associated"[All Fields] OR "associates"[All Fields] OR "associating"[All Fields] OR "association"[MeSH Terms] OR "association"[All Fields] OR "associations"[All Fields]) AND ("sepsis"[MeSH Terms] OR "sepsis"[All Fields] OR ("bloodstream"[All Fields] AND "infections"[All Fields]) OR "bloodstream infections"[All Fields]))) AND ("intervention s"[All Fields] OR "interventions"[All Fields] OR "interventive"[All Fields] OR "methods"[MeSH Terms] OR "methods"[All Fields] OR "intervention"[All Fields] OR "interventional"[All Fields] OR ("therapeutics"[MeSH Terms] OR "therapeutics"[All Fields] OR "treatments"[All Fields] OR "therapy"[MeSH Subheading] OR "therapy"[All Fields] OR "treatment"[All Fields] OR "treatment s"[All Fields]) OR ("program"[All Fields] OR "program s"[All Fields] OR "programme"[All Fields] OR "programed"[All Fields] OR "programs"[All Fields] OR "programming"[All Fields] OR "programmability"[All Fields] OR "programmable"[All Fields] OR "programmable"[All Fields] OR "programme"[All Fields] OR "programme s"[All Fields] OR "programmed"[All Fields] OR "programmer"[All Fields] OR "programmer s"[All Fields] OR "programmers"[All Fields] OR "programmes"[All Fields] OR "programming"[All Fields] OR "programming"[All Fields] OR "programs"[All Fields]) OR ("educability"[All Fields] OR "educable"[All Fields] OR "educates"[All Fields] OR "education"[MeSH Subheading] OR "education"[All Fields] OR "educational status"[MeSH Terms] OR ("educational"[All Fields] AND "status"[All Fields]) OR "educational status"[All Fields] OR "education"[MeSH Terms] OR "education s"[All Fields] OR "educational"[All Fields] OR "educative"[All Fields] OR "educator"[All Fields] OR "educator s"[All Fields] OR "educators"[All Fields] OR "teaching"[MeSH Terms] OR "teaching"[All Fields] OR "educate"[All Fields] OR "educated"[All Fields] OR "educating"[All Fields] OR "educations"[All Fields]) OR ("education"[MeSH Subheading] OR "education"[All Fields] OR "training"[All Fields] OR "education"[MeSH Terms] OR "train"[All Fields] OR "train

s"[All Fields] OR "trained"[All Fields] OR "training s"[All Fields] OR "trainings"[All Fields] OR "trains"[All Fields])))) AND ((y_10[Filter]) AND (clinical trial[Filter] OR controlled clinical trial[Filter] OR observational study[Filter] OR randomized controlled trial[Filter] OR systematic review[Filter]) AND (English [Filter]))

Appendix C

Final matrix ‘’ characteristics of the reviewed studies’’

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings

(Dsilva, Mathew, & Joseph, 2022)	The effectiveness of a Self-instructional Module on Knowledge and Observed Practices of Nurses concerning Prevention of Central Line–Associated Blood Stream Infection: A Before–After Intervention Study	India	To assess the baseline knowledge among critical care nurses concerning CLABSI prevention principles. To assess the critical care nurses' level of practice in maintaining central lines. To examine the effect of providing a self-paced educational module on the level of knowledge and	A quasi-experimental pre-post-test design	51 critical care nurses.	ICUs in Tertiary care hospitals.	Education-based intervention using a self-reading booklet and educational module.	A questionnaire composed of 28 items in the form of multiple-choice questions (MCQ) and fill in the blank. Observational Checklist.	The knowledge and practice levels were significantly enhanced.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
			practice of caring for central line and preventing CLABSI.						
(Hong et al., 2013)	Decreasing Central-Line–Associated Bloodstream Infections in Connecticut Intensive Care Units	USA	This study was to determine if the Michigan Keystone program could be implemented in Connecticut and to assess the effect of the program on decreasing the CLABSI rate in ICUs.	Pre-Post-test design	Multidisciplinary intensive care health care providers.	17 ICUs from 14 hospitals.	The intervention was educational. (Not mentioned clearly)	Checklists	The overall CLABSI rate decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Muse et al., 2017)	Controlling catheter-related bloodstream infections through a multi-Center educational program for intensive care units	Italy	To assess the effect of providing education to health care providers and monitoring adherence with evidence-based interventions on decreasing the CLABSI rate.	Quasi-experimental study with interrupted time series	Six intensive care nurses and physicians.	Five MICU and SICU from five hospitals with different affiliations.	An education-based intervention involving lectures and skill demonstration.	Surveillance and observational checklist.	Hand hygiene compliance improved. CLABSI rate significantly reduced

(Scholtz, Monachino, Nishisaki, Nadkarni, & Lengetti, 2013)	Central Venous Catheter Dress Rehearsals Translating Simulation Training to Patient Care and Outcomes	Philadelphia, USA	To examine the impact of simulation sessions on nurses' knowledge, confidence, and performance. To evaluate the impact of training on nurses' competency while performing procedures on real patients. To evaluate the relationship between the improvement in confidence and skills and the CLABSI rate.	A prospective pre and post-test, timed series study	524 nurses.	MIC, SICU, operating rooms, the post-anaesthesia care unit, and the outpatient oncology clinic at a tertiary hospital.	Education-based intervention using simulation-based training.	Self-assessed questionnaire. a written knowledge tests Standardized checklist to assess the psychomotor skills.	The level of knowledge, self-confidence, and skill of dressing improved after the training. The level of competence in performing the dressing on real patients also improved. The overall CLABSI rate decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(de Quadros et al., 2022)	Adherence to central venous catheter maintenance bundle in an intensive care unit.	Brazil	To assess the effect of an educational program on the intensive care nurses' adherence to central line maintenance.	A descriptive-exploratory study, with a quantitative approach.	63 nurses and technicians.	Adult ICU of a public teaching hospital.	The intervention was a simulation-based training.	Checklist	The compliance and adherence with the observed bundle domains were improved. The adherence with documenting the indication of central line insertion improved by 8%, The adherence to the aseptic technique in catheter maintenance improved. The adherence to the maintenance of the infusion sets and dressing improved.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Burt & Spowart, 2021)	Assessing the impact of a new central venous access device training program for nurses: A quasi-experimental evaluation study	England	To assess the impact of applying educational intervention on improving the nursing knowledge and skills of managing the central line.	Retrospective quasi-experimental design.	112 registered nurses (RNs).	Two surgical wards, and one SICU.	The intervention was educational-based applying interactive lectures, demonstration return, and simulation activities	Not specified	45% of the trainees reported that they became more confident in their knowledge and skills after joining the training and they could disseminate knowledge. 82% of the nurses reported that they would change their skills and reflected this in the real practices. The CLABSI rate was reduced by 83 % in the six months after the education compared with the previous six months.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Exline et al., 2013)	Beyond the bundle - a journey of a tertiary care medical intensive care unit to zero central line-associated bloodstream infections	USA	To decrease the CLABSI rate below 1 per 1000 catheter days over two years.	Observational cohort study with historical controls approach.	Intensive care physicians and nurses.	A 25-bed capacity ICU at a tertiary academic hospital	Multimodal intervention that included educational sessions and skill demonstrations.	Surveillance and observational checklists.	The CLABSI rate decreased. The compliance with central line insertion and maintenance practices improved.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Mohapatra et al., 2020)	Impact of Continuous Education and Training in Reduction of Central Line-associated Bloodstream Infection in Neuro-I intensive Care Unit	India	To assess the impact of continuous education on adherence to CLABSI bundle, hand hygiene, and scrubbing the hub to prevent CLABSI in Neuro-ICUs.	A prospective observational before and after design.	50 intensive care nurses	NICU	Education-based intervention that applied continuous educational sessions in the form of lectures and skill stations.	Tests and Observations	The nursing knowledge and skills improved. The CLABSI rate decreased.

(Walz et al., 2015)	The Bundle "Plus": The Effect of a Multidisciplinary Team Approach to Eradicate Central Line-Associated Bloodstream Infections	USA	The study aims to decrease and sustain the incidence of CLABSI by implementing a multidisciplinary approach To implement CLABSI prevention bundle and practices. To create best practice guidelines for the insertion of the internal jugular central line. To improve the education on	Before and after design.	Nurses and Physicians	Seven adult ICUs.	Multimodal approach intervention including education.	Checklists, reports, and electronic systems.	The CLABSI incidence decreased. The insertion of a short-term central line decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
			obtaining blood culture. To do root cause analyses of all CLABSIs To use chlorhexidine dressings and minocycline/revamping catheters to prevent CLABSIs.						

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Paquet, Morlese, & Frenette, 2021)	Use of dry dressings for central venous access devices (CVCs) to decrease central line-associated bloodstream infections (CLABSI) in a trauma intensive care unit (ICU)	Canada	The aim of this study was not mentioned directly but the study was conducted to reduce the incidence of CLABSI and improve adherence with proper dressing practices.	Pre-post study design	84 intensive care nurses.	MICU, SICU at a university teaching hospital.	The intervention was in-service education-based sessions and audits performed weekly and twice a month.	Checklists	The adherence to dressing change was enhanced. The CLABSI rate was Zero during the study period.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
Hansen, S., Schwab, F., Schneider, S., Sohr, D., Gastmeier, P., & Geffers, C	Time-series analysis to observe the impact of a centrally organized educational intervention on the prevention of central-line-associated bloodstream infections in 32 German intensive care units.	German	To examine the impact of the program on the implementation of patient care practices and the occurrence rates of central line-associated bloodstream infections (CLABSI) in the involved Intensive Care Units (ICUs).	Not mentioned	32 health care providers.	107(ICUs).	The healthcare providers in the ICU received training and education during the intervention period over one period. The staff received two lectures held six months apart	Surveys. Multiple-choice questionnaire	Significant decrease in CLABSI prevalence Healthcare providers exhibited enhancement in their knowledge and awareness of CLABSI preventive intervention.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Gauntt et al., 2022)	Sustaining Improvements in CLABSI Reduction in a Pediatric Cardiac Intensive Care Unit	Columbus, Ohio, USA	To mitigate the CLABSIs prevalence in Pediatric intensive care units. To maintain the reduction in CLABSI rate for one year.	Quasi-experimental	Multidisciplinary team of health care providers	CICU	Simulation-based training twice per year.	Using a K-Card for audit	Reduction in the prevalence of CLABSI and the reduction sustained over two years.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Mazi et al., 2021	Sustained Low Incidence Rates of Central Line-Associated Blood Stream Infections in the Intensive Care Unit	Saudi Arabia	To assess the impact of applying SHEA based preventive program of CLABSI on reducing CLABSI rate.	Prospect ive study.	Multidisciplinary healthcare providers	MICU and SICU.	Establishment of a specialized infection control team. In-service Education Monitoring the compliance with hand hygiene based on the WHO five moments Monitoring the compliance with CLABSI bundle.	Surveillance Observation Checklist.	The compliance with the CLABSI bundle is maintained at 100%. The CLABSI rate declined. The hand hygiene compliance rate sustained above 70%.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Melo et al., 2022)	Success factors of a collaborative project to reduce healthcare-associated infections in intensive care units in North-eastern Brazil.	Brazil	To explain the implementation and outcomes of a joint initiative named PROADI-SUS that was put in place to minimize HAIs brought on by the use of devices and to pinpoint potential contributing variables in five ICUs in Recife during the first 18 months of the nationwide project.	Prospective observational	Multidisciplinary team	Five ICUs.	Multimodal approach with Monthly virtual learning sessions (VLs) and five live learning sessions throughout this time.	Performance of tests. Monitoring indicators; reports and sharing feedback	HAIs reduced in all ICUs.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Hebbar, Cunningham, McCracken, Kamat, & Fortenberry, 2015)	Simulation-based Pediatric intensive care unit central venous line maintenance bundle training	USA	To enhance the knowledge and compliance with the central venous catheter maintenance bundle.	prospective cohort comparison	79 nurses	PICU	Simulation-based training with continuous refresh at three, six, and twelve months.	Tests and Observation using a 17-item bundle checklist	Compliance with the CLABSI bundle significantly increased.
(Mostafa et al., 2022)	Reducing Central-Line-Associated Bloodstream Infections (CLABSI): An Improvement Project in a Specialized Tertiary Hospital.	Saudi Arabia	To decline the CLABSI rate by 30% during the study period	Pre-Post Design	Physician and Nurses	Inpatient wards and ICUs	Standardizing the policies and procedures. Simulation-based training. Conducting workshop	Competency checklist. Surveillance for CLABSI. Checklist	The CLABSI rate decreased. The average compliance rate of hand hygiene increased The CLABSI rate was Zero in ten ICUs.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(AL Khawaja et al., 2020)	Impact of International Nosocomial Infection Control Consortium's Multidimensional Approach on central line-associated bloodstream infection rates in Bahrain	Bahrain	To assess the effect of multimethod intervention and the utilization of the INICC Surveillance Online System (ISOS) on reducing the CLABSI rates in ICUs in Bahrain.	This study applied a prospective, pre-test, and post-test surveillance-based study	Infection control nurses and critical care nurses	ICU of INNICC member hospital.	In-service education. Development of checklist for central line insertion and care. Introducing new material according to the SHEA and CDC.	Surveillance system	The CLABSI rate decreased by 90%. The length of stay for CLABSI cases decreased by 367 days. The cost of hospitalization for patients with CLABSI decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Negm et al., 2021)	Impact of a comprehensive care bundle educational program on device-associated infections in an emergency intensive care unit.	Egypt	To assess the effect of the provided education program Comprehensive Care Bundle Educational Program CCBEP on decreasing CLABSI rate, shortening the mortality rates, and enhancing nurses' knowledge and compliance with the CLABSI bundle.	A quasi-experimental	70 multidisciplinary health care providers	Emergency ICU	The education-based intervention was applied, supported by posters, leaflets, and videos about central line maintenance.	Checklists and Questionnaire.	The compliance with the CLABSI bundle improved. The CLABSI incidence decreased. The mortality rate decreased. The healthcare providers' knowledge enhanced

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Aloush, 2018)	Educating intensive care unit nurses to use central venous catheter infection prevention guidelines: effectiveness of an educational course.	Jordan	To assess the effect of CLABSI prevention educational course on improving critical care nurses' knowledge of CLABSI prevention principles	An experimental, randomized controlled trial.	128 Critical care nurses.	MICU and SICU at 10 hospitals that had continuous education and infection control programs.	Education-based intervention in the form of lectures.	Questionnaire. Multiple choice exam	Pre-test knowledge scores were poor for all participants. The experimental group showed significant improvement in knowledge after the course. The control group showed no significant change in knowledge. Participants with 5 years of experience in the control group showed better improvement. No significant difference in knowledge scores based on gender.

(W. Mazi et al., 2014)	Central line-associated bloodstream infection in a trauma intensive care unit: Impact of implementation of Society for Healthcare Epidemiology of America/Infectious Diseases Society of America practice guidelines	Saudi Arabia	To evaluate the impact of multimodal intervention based on the recommendations of the Basic Society for Healthcare Epidemiology of America/Infectious Diseases Society of America (SHEA/IDSA) in reducing (CLABSI) incidence in intensive care units (ICUs).	Prospective, pre and post-design studies conducted over one year.	ICU nurses.	A trauma ICU.	The intervention was multimodal, including education and training Implementation of the monitoring system Assembling special kit for central line insertion. Monitoring of compliance with hand hygiene.	Surveillance	The CLABSI decreased significantly Three risk factors were identified and addressed for improvement including education. Hand hygiene compliance improved by 31%

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Khalid et al., 2013)	Itemizing the bundle: Achieving and maintaining “zero” central line-associated bloodstream infection for over a year in a tertiary care hospital in Saudi Arabia	Saudi Arabia	To assess the effects of a quality improvement initiative based on prevalent guidelines to achieve “Zero CLABSI”.	Not clear	Nurses from MICU and SICU	MICU SICU.	Education-based intervention, conducting audits to monitor hand hygiene, and central line bundles.	Intermittent audits	The CLABSI rate declined. The Zero CLABSI rate was maintained for fifteen months. Compliance with hand hygiene and central line maintenance improved

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Lowery et al., 2022)	Reducing central line-associated bloodstream infection (CLABSI) rates with cognitive science-based training	USA	This study aimed to assess the effect of applying web-based training grounded in cognitive science on the prevalence of CLABSI.	Pre-post-test design with one control group.	541 registered nurses.	ER, MICU, and SICUs.	Education-based intervention utilizing a learning module system (LMS) for training.	Pertest post-test vial LMS and the same system sent feedback to the learners.	The nurses' knowledge and practice improved CLABSI rate reduced for 8 months The mortality rate decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(van der Kooi et al., 2018)	Prevention of hospital infections by intervention and training (PROHIBIT): results of a pan-European cluster-randomized multicentre study to reduce central venous catheter-related bloodstream infections	Europe	To improve central line insertion and hand hygiene practices to decrease the CLABSI.	Stepped-wedge cluster randomized controlled multicentre intervention study	Multidisciplinary team	Adult ICUs from 14 hospitals in 11 European countries.	Multimodal intervention is composed of developing and applying a strategy for central line insertion, establishing an improvement approach for hand hygiene according to the WHO, and applying educational and bedside training sessions	Observational checklist	The CLABSI incidence decreased significantly among the three arms. Hand hygiene compliance improved. The CLABSI incidence declined as hand hygiene compliance improved.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Humphrey, 2015)	Improving Registered Nurses' Knowledge of Evidence-Based Practice Guidelines to Decrease the Incidence of Central Line-Associated Bloodstream Infections: An Educational Intervention	USA	To assess the baseline level of knowledge of critical care nurses about contributing factors for CLABSI and to evaluate the effect of education-based intervention on the nurses' knowledge;	A pre-post-test design.	64 critical care nurses.	ICUs in regional hospitals.	Education-based intervention in the form of 30-minute educational sessions, interactive training sessions, and hands-on training.	Questionnaire.	The nurses' knowledge of CVC maintenance improved by twofold after applying the education-based intervention.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Rosenthal et al., 2018)	Impact of the International Nosocomial Infection Control Consortium (INICC)'s Multidimensional Approach on Rates of Central Line-Associated Bloodstream Infection in 14 Intensive Care Units in 11 Hospitals in 5 Cities in Argentina	Argentina	This study aimed to assess the effect of the INICC multimodal approach and surveillance online system (ISOS) to decrease CLABSI rates.	Prospective, cohort, pre-and post-test design.	Healthcare providers of different specialties	14 adult ICUs in 11 hospitals members at INICC in Argentina.	Multimodal intervention included applying the CLABSI bundle and providing monthly educational sessions to health care providers.	Surveillance and observational checklists	The CLABSI rate declined.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Acharya, Mishra, Ipsita, & Azim, 2019)	Impact of Nursing Education on CLABSI Rates: An Experience from a Tertiary Care Hospital in Eastern India	India	To assess the effect of the educational intervention on increasing compliance with Hand Hygiene and decreasing the CLABSI rate.	A quasi-experimental design	34 nurses.	MICU in Ten a tertiary care hospital.	Education-based intervention composed of 30-minute lectures and skill demonstrations.	Checklist and test	The level of knowledge improved directly after the intervention. The CLABSI rate significantly decreased.

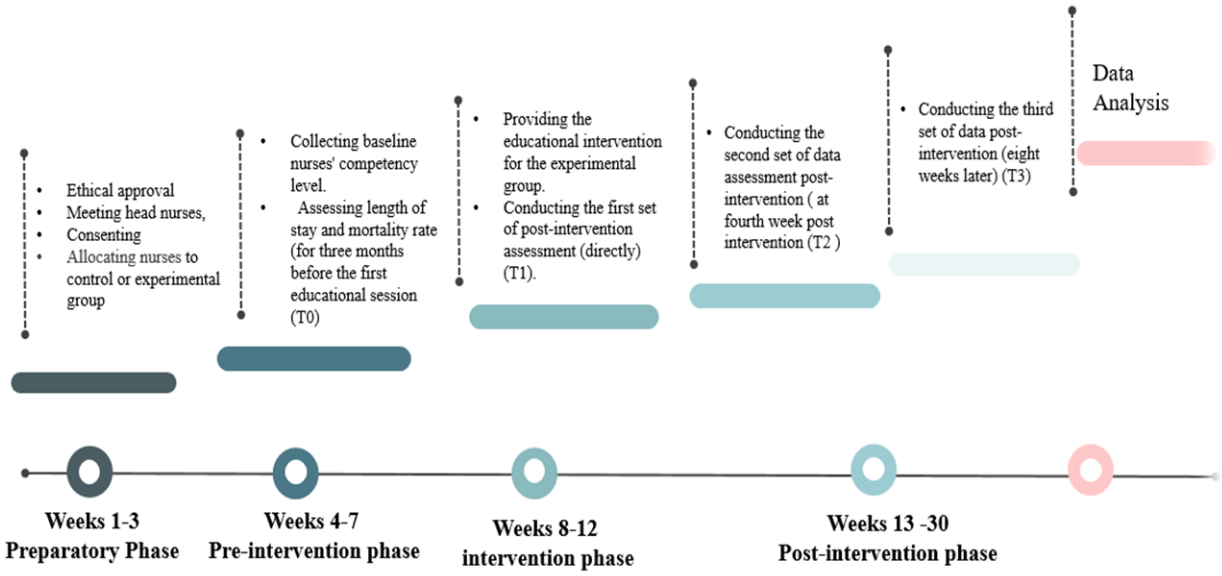
Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Zing et al., 2014)	Hospital-Wide Multidisciplinary, Multimodal Intervention Programme to Reduce Central Venous Catheter-Associated Bloodstream Infection	Geneva, Switzerland,	To assess the effectiveness of a multimodal intervention in decreasing the CLABSI rate.	A pre and post-test prospective design.	146 physicians and 1274 nurses	ICUs and medical-surgical departments at the University Hospitals	Multimodal intervention that included updating protocols for central line insertion and maintenance, providing educational intervention via eLearning module and live workshops, and introducing single-use kits	Surveillance.	The CLABSI rate significantly decreased.

(Leblebicioglu et al., 2013)	Impact of a multidimensional infection control approach on central line-associated bloodstream infection rates in adult intensive care units of 8 cities of Turkey: findings of the International Nosocomial Infection Control Consortium (INICC)	Turkey	To decrease the CLABSI rate in ICUs	A before and after prospective design	Multidisciplinary Health care providers.	Eight ICUs at 13 hospitals in eight Turkish cities. All hospitals were INICC members,	Multidimensional infection control-based interventions were applied including education and training.	Surveillance.	The CLABSI rate decreased.

Author	Title	Country	Research Question /Purpose	Design	Participants (n)	Setting	Intervention	Measurement instruments	Main findings
(Jaggi et al., 2013)	Impact of an International Nosocomial Infection Control Consortium Multidimensional approach on central line-associated bloodstream infection rates in adult intensive care units in eight cities in India	India	To evaluate the impact of multi-approaches intervention on decreasing CLABSI rate.	The design was pre and post-intervention, cohort, and prospective.	Physicians and nurses.	16 ICUs in 11 hospitals in eight Indian cities. These hospitals were members of INICC.	The intervention was multimodal including the application of the CLABSI bundle, monthly education sessions, and using a surveillance system to detect CLABSI. 3	Surveillance system	The CLABSI rates decreased by half. Hand hygiene compliance improved.

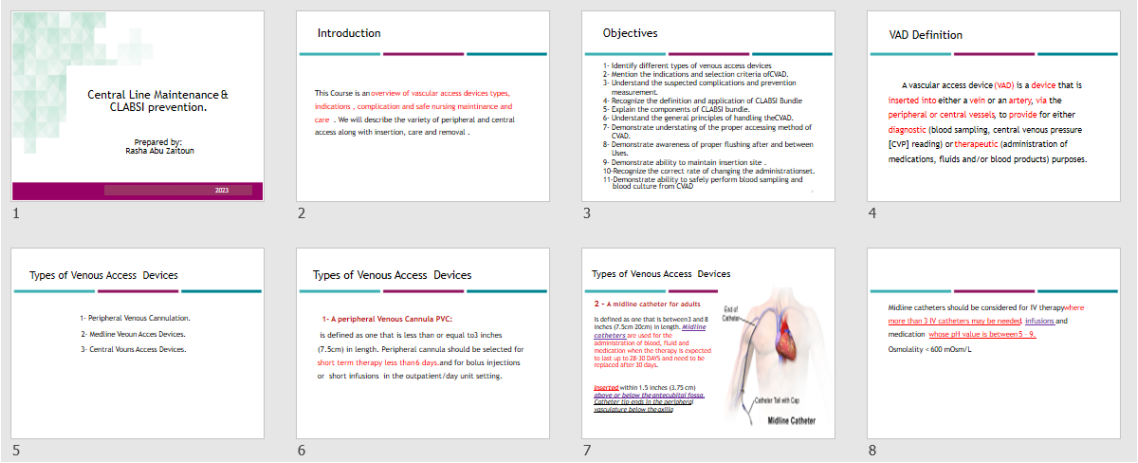
Appendix D

The study design and data collection Process



Appendix E

The content of the theoretical part of the educational program



5- Hemodialysis catheter

The catheter used for hemodialysis is a tunneled catheter because it is placed under the skin. There are two types of tunneled catheters:

cuffed or non-cuffed.

Non-cuffed tunneled catheters are used for emergencies and for short periods (up to3 weeks).

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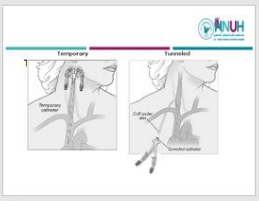

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TempCath Hemodialysis Catheter

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Complication and risk of CVC

- Bleeding
- Discomfort during placement.
- Blocking or kinking
- Collapsed lung: This is called a Pneumothorax
- Infection: CLABSI (Central Line-associated Bloodstream infection)

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Mechanism of CLABSI occurness

- More Common Mechanisms
  - Extraluminal: Pathogens migrate along the external surface of the catheter
    - More common in the early period following insertion, < 7 days
  - Intraluminal: Hub contamination, migration along the internal surface
    - More common >7 days, intraluminal colonization
- Less Common Mechanisms
  - Hematogenous seeding from another source
  - Contaminated Infusates.

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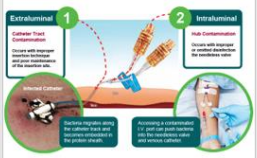

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The goal of an effective prevention program should be the elimination of CRBSI from all patient-care areas.

- So that the CDC DEVELOP A BUNDLE to control infection and guides the professional practice regarding venous access devices.

Institute for Healthcare Improvement CDC Centers for Disease Control and Prevention

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What is a Bundle?

- Introduced by the Institute for Healthcare Improvement(IHI).
- Groups of practices with high-level clinical evidence- effectiveness
- When applied together, improvements synergistically greater benefits of a Bundle.
- Treatment variation is minimized.
- Reliability is enhanced.

The whole is greater than the sum of its parts!

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IHI Bundle Components

- Hand Hygiene.
- Maximal barrier precautions.
- Chlorehexidine skin antisepsis.
- Optimal catheter site selection.
- Daily review of line necessity.

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1. Hand Hygiene
   - Before and after palpating* catheter insertion sites
   - Before and after inserting, replacing, accessing, repairing, or dressing a catheter
   - When hands obviously soiled or contamination suspected
   - Before and after invasive procedures between patients
   - Before donning and after removing gloves

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2. Maximal barrier precautions
   - Wear cap, mask, sterile gown and sterile gloves , STERILE DRAPE

   Both the line inserter AND immediate assistant
   - Cover patient from head to toe with sterile drape with small opening for site of insertion

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Operator & supervisor (or anyone at risk for crossing the sterile field)	For the Patient	For the Assistant
•Hand hygiene •Non-sterile cap and mask •All hair should be under cap (includes beard and mustache) •Mask should cover nose and mouth tightly •Sterile gown •Sterile gloves	•Cover patients head and body with a large sterile drape	•Hand hygiene •Non-sterile cap and mask •All hair should be under cap (includes beard and mustache) •Mask should cover nose and mouth tightly •Sterile gown •Sterile gloves

Note: people in the same room who are not involved with the procedure (and who are not at risk for crossing the sterile field) do not need to wear maximal barrier precautions

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3. Chlorhexidene skin antisepsis
   - Allow time to dry completely before puncturing site2 MINUTES
4. Optimal catheter site selection
   - Subclavian vein the preferred site for nontunneled catheters in adults

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The femoral site should be avoided.

in a clinical trial of ICU patients randomized to femoral or subclavian lines there were:

- Higher rate of infectious complications (colonization and BSI combined) in femoral grp: 79.8% vs 4.5% (p < .001)
- Higher rate of thrombotic complications in femoral grp: 21.5% vs. 1.9% (p = .001); complete thrombosis 6% vs 0%

The preferred order of preference:

1) Subclavian → 2) Internal Jugular → 3) Femoral

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Background: Epidemiology Modifiable Risk Factors

Characteristic	Risk Factor Hierarchy
Insertion circumstances	Emergency > elective
Skill of inserter	General > specialized
Insertion site	Femoral > subclavian
Skin antisepsis	70% alcohol, 10% povidone-iodine > 2% chlorhexidine
Catheter lumens	Multilumen > single lumen
Duration of catheter use	Longer duration of use greater risk
Barrier precautions	Submaximal > maximal

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5. Daily review of central line necessity with prompt removal of unnecessary lines
   - Risk of infection increases with duration of line
   - Examples of appropriate uses: receipt of TPN, chemotherapy, extended use of antibiotics, or hemodialysis

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Empower nurses and others to

"STOP THE LINE"

If any of bundle components are missing

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CLABSI Prevention Strategies

Core (ALWAYS, every time)

- Remove unnecessary central lines
- Proper insertion practices
- Hand hygiene
- Skin antisepsis
- Lower risk insertion sites
- Hub and access port disinfection.
- Educate on central line insertion and maintenance.

Supplemental

- Chlorhexidine bathing
- Antimicrobial-impregnated catheters
- Chlorhexidine-impregnated dressings

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Catheter Type	Duration of Use	Insertion	CLABSI Risk
Nontunneled	Short-term use	Percutaneous insertion	Accounts for most CLABSIs
Tunneled CVC	Long-term use	Requires surgical insertion	Lower rate of CLABSI compared with nontunneled
Implantable ports	Long-term use	Requires surgical insertion and removal	Lowest risk of CLABSI
Peripherally inserted central catheters	Short to intermediate use	Inserted at bedside	Lower rate of infection than nontunneled CVCs

Abbreviations: CLABSI, central-line-associated bloodstream infection; CVC, central venous catheter.

Data from The Joint Commission. Preventing central line-associated bloodstream infections: a global challenge, a global perspective. Oak Brook (IL): Joint Commission Resources; 2012. Available at: http://www.PreventingCLABSIs.pdf.

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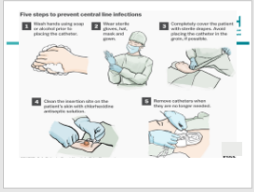

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Principles of Care

- General Principles
- Accessing the Catheter
- Flushing After and Between Uses (except Neonates).
- Care of the Exit Site (Except Neonates)

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General Principles

Accessing the Catheter

Flushing After and Between Uses (except Neonates)

Care of the Exit Site (Except Neonates)

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Before insertion

Skin preparation:

The skin should be cleansed with alcoholic(70%)/ Chlorhexidine (2%) prior to CVC insertion using scrub technique (backward forward motion) for 30 seconds and allow to dry(for 30-60 seconds) for the patients older than two months.

If femoral vein site is selected for CVC insertion, the area should be scrubbed for 2 minutes prior insertion and allow to dry.

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Use an aseptic technique:

- Wear sterile gloves when carrying out dressingchanges
- 'Scrub the Hub' - all needle-free access devices (bungs) should be cleaned for 15 seconds using chlorhexidine 2% in 70% and then allowed to air.

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- Monitor temperature, pulse, blood pressure, resp. rate and O saturations at least a minimum of 4 hourly
- Do not allow air to enter the catheter.

  All syringes and intravenous administration sets must be carefully primed. *To prevent air embolism.*
- Cap off the catheter with a needlefree access device when not in use.This will minimize interruptions to the closed system. Unless manufacturer's instructions vary, this should be changed every 7 days or every 200 uses,

50

- Whenever the cap /access device is removedfrom the catheter then it must be replaced with a new, needleless access device/bung. *To prevent infection.*
- If the catheter possesses an integral clamp, keep it closed whenever the cap is removed
- Clamping should always take place at the designated area and never at the thickened area near the hub (
- Always take signs of systemic or local infection seriouslyand refer to the medical team

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- The practice of administering prophylactic antibioticsat the time of CVC insertion should NOT be routinely followed.
- The practice of administering prophylactic minidose Warfarin to patients with CVCs should NOT be followed
- Should the catheter fracture or be accidentally cut clamp it without delay proximal to the break. Specialist advice should be sought immediately to consider removal or repair.

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•General Principles

•Accessing the Catheter

- Flushing After and Between Uses (except Neonates)
- Care of the Exit Site (Except Neonates)

53

Methods for maintaining patency

Patency is defined as the ability to infuse through and aspirate blood from a VAD .

It is important for the patency of the device to be maintained at all times. Blockage predisposes to device damage, infection, inconvenience to patients and disruption to drug delivery.

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Methods for maintaining patency

Occlusion of the device is usually the result of:

- Clot formation due to:
  - an administration set or electronic infusion device being turned off accidentally and left for a prolonged period; or
  - insufficient or incorrect flushing of the device when not in use.

Thrombotic occlusions are responsible for58% of all occlusions.

- Precipitate formation due to;

  Inadequate flushing between incompatible medications .
- Kinking or pinch-off syndrome may also impair patency of the device.

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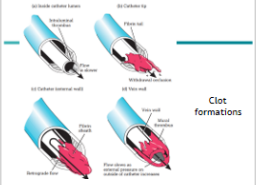

Clot formations

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There are two types of thrombotic occlusion:

1- Partial withdrawal occlusion (PWO) :

this is usually caused by fibrin sheath formation and identified by absent or sluggish blood return whilst fluids can be infused .

2- Total occlusion:

when there is an inability to withdraw blood or infuse fluids or medications. This can be resolved by instillation of a thrombolytic agent .

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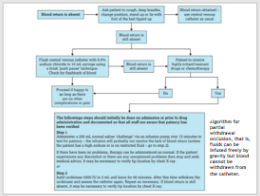

algorithm for partial withdrawal occlusion, that is, fluids can be infused freely by gravity but blood cannot be withdrawn from the catheter.

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-Before it is used for administering therapeutic drugs or fluids, thepatency and correct functioning of the catheter should be established.

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•General Principles

Accessing the Catheter

Flushing After and Between Uses (except Neonates)

Care of the Exit Site (Except Neonates)

60

Flushing Solutions

- Two main types of solutions are used to maintain patency in VADs

  Heparin and 0.9% sodium chloride. All devices should be flushed with 10 20 mL 0.9% sodium chloride after blood withdrawal followed by the appropriate flushing.

- Maintaining patency can be achieved by:

  1- a continuous infusion to keep the vein open (KVO), either by the patient being attached to an infusion of0.9% sodium chloride,

  2- intermittent flushing (previously known as a 'heparin lock').

61

Heparinized saline is still the accepted solution for maintaining the patency of CVCsfor intermittent use or infrequent use ,but due to the risk of errors with heparin, its use must be considered carefully .

Use of 0.9% sodium chloride alone is widespread with certain CVADs, e.g., Flushing regimens, ranging from once daily to once weekly, have been found to be effective.

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- Excessive force should never be usedwhen flushing devices. When a catheter lumen is totally patent, internal pressure will not increase during flushing . However, if resistance is felt (due to partial occlusion) and a force is applied to the plunger, particularly with a smallvolume syringe, high pressure could result within the catheter, which may then rupture .

  It is therefore recommended that the device is checked firstwith a 10 mL or larger syringe containing0.9% sodium chloride . However, smaller syringes should only be usedto administer drugs where there is no pressure or occlusion and where it is not possible to further dilute drugs and administer in a large syringe.

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Flushing Technique and process

1- Using a pulsated (push-pause) flush to create turbulent flow when administering the solution, regardless of type and volume. This removes debris from the internal catheter wall.

2. The procedure is completed using thepositive pressure technique. This is accomplished by maintaining pressure on the plunger of the syringe while disconnecting the syringe from the injection cap, which prevents reflux of blood into the tip, reducing the risk of occlusion

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-Where possible, do not use syringes smaller than10 ml for infusion into the catheter

-Use a brisk 'push-pause' flushing technique routinely when flushing the catheter

-If the catheter possesses a clamp, clamp the line while the final ml of the flush is being injected

- Do not routinely withdraw and discard blood from the catheter before flushing except Renal Dialysis Catheters

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Frequency of flushing and flushing solutions:

This varies depending on the device

Please note that Hepsal and Heparinised Saline must be prescribed.

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General Principles

Accessing the Catheter

Flushing After and Between Uses (except Neonates)

Care of the Exit Site

67

➢ Types of dressings

Sterile gauze and transparent dressings

- The recommendation for a central venous access device site is an intact dry adherent transparent semiocclusive dressing.
- These dressings allow observation of the exit site without the need to remove the dressing. They are also moisture permeable, thereby reducing the collection of moisture under the dressing.

68

➢ Types of dressings

- Newer products include a chlorhexidine gluconate antimicrobial transparent dressingwhich contains a chlorhexidine gel pad which is integral to the dressing and has been shown to allow visualization of the site, facilitating absorption of fluid under the dressing.

69

➢ Types of dressings

It has been shown to prevent the regrowth of microbial skin flora .This can also be achieved by attaching a hydrophilic polyurethane absorptive foam patch impregnated with CHG under the transparent dressing, which has been shown to reduce the rate of catheter colonization and demonstrated significant reductions in the associated rate of catheter-related bloodstream infection.

However, the foam patch does not enable insertion site visualization.

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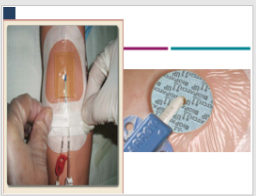

71

a) Dressings immediately post insertion:

The exit site should ideally be left undisturbed for1-2 days most exit sites bleed to some extent following insertion. If this leads to "strike-through" on a dry dressing, (i.e. exudate/blood/serous fluid observed on the outside of a dry dressing) it should be changed immediately since a wet surface provides "a liquid pathway for bacteria to travel" to the wound.

72

Dressings immediately post insertion:

The ideal dressing immediately postinsertion is a dry dressing covered and sealed with a transparent dressing (Tegaderm).

If a dry dressing alone is used postinsertion, it should again ideally be left undisturbed for 1 - 2 days but should always be changed as soon as any"strike-through" occurs using an aseptic technique.

73

If bleeding is excessive the dressing should be changed every time strike-through occurs and replaced with a more absorbent or thicker dressing

It is not acceptable to add more dressings on top of blood soaked dressings which have been in contact with a moist outer surface, because of the infection risk

74

B) On-going Dressing Regimes after the first1-2 days:

As a general principle, where a dressing is used it should be :

Inspected regularly and renewed immediately should it become soiled, wet or detached

75

If the exit site is reddened, painful,exudating or infected, :

Increase the frequency of dressing change depending on the amount of exudates.

76

The main options for dressings are

- IV-dedicated occlusive transparent dressing changed every 7 days.

Except patients on dialysis and neonates.

-Sterile dry dressing taped in situ, changed at least twice a week

- No dressing. This may be suitable for some patients withTunnelled CVCs

.

from 21 days post insertion once the tissues havefibrosed around the cuff and in the absence of exudate or signs of infection. "

77

CiCleaning of Exit Site:

-At dressing changes, the exit site should be cleaned using chlorhexidine 2% in 70% Isopropyl Alcohol (IPA) (Sanicloth%CHG) using an outward spiral (Friction) motion to avoid transferring bacteria to the exit site.

- Cleaning should be carried out using an aseptic technique.

78

➢ Principles of care/ Cleaning solutions

- Most transient flora can be removed from the skin with soap and water using mechanical friction. It is also important to remove dirt as antiseptic solutions are not as effective as they cannot penetrate surface dirt .
- Chlorhexidine 2% in 70% alcohol has been shown to be the most effective agent for skin cleaning around the VAD insertion site prior to insertion and between dressing changes .

79

Seventy percent alcohol acts by denaturing protein and so has excellent properties for destruction of grampositive and -negative bacteria, as well as being active against fungi and viral organisms.

- Alcohol concentration between70% and 92% provides the most rapid and greatest reduction in microbial counts on skin but does not have any residual activity .
- This is where chlorhexidine has an advantage over alcohol used alone, as it has excellent residual activity for4-6 hours after application. It is important to be aware of patient sensitivity to chlorhexidine gluconate..

80

- Solutions should be applied withfriction in back-and-forth strokes for at least 30 seconds and allowed to air dry for 30-60 seconds.
- It has been found that 1 minute of application with alcohol is as effective as 12 minutes of scrubbing and reduces bacterial counts by 75%. However, a quick wipe fails to reduce bacterial counts prior to peripheral cannulation.
- Allowing any cleaning solution to dry is vital in order for disinfection to be completed and, in the case of alcohol, which is a plasticizer, it ensures that plastic equipment will not'glue together'.

81

- Loose blood, exudates or other debriswhich might provide a focus or infection or might impair inspection of the wound may be gently removed bycleaning in the above manner with sterile 0.9% sodium chloride prior to cleaning with Chlorhexidine 2% (Sanicloth2%).

82

D) Removal:

If a short-term CVC has not been used for <24 hours consideration should be given to its removal.

Some CVCs are simple and relatively safe to remove. With others, there is high risk of air embolism and so removal requires a higher level of training and skill

83

1-Care of Centrally-Inserted, Non- Tunnelled CVCs.

84

Most commonly found in acute settings They are not suitable for long-term use because they rarely remain free of infection for longer than7 - 10 days.

The catheter is usually inserted via thesubclavian, jugular or femoral veins.

Non-tunnelled CVCs may have single or multiple lumens

Each lumen is equipped with an integral clamp.

85

Care of Centrally-Inserted, Non-Tunnelled CVCs

Flushing

Exit site Care

Removal

86

Before flushing: If there are infusion vasoactive drugs in the lumen, withdraw prior to flushing to avoid bolus dose

Technique:

Brisk push-pause technique with positive pressure finish

87

What to flush with:

- 0.9% sodium chloride between incompatible drugs / infusions and after blood sampling (if sodium chloride 0.9% incompatible use suitable alternative).
- Lock with 10ml 0.9% sodium chloride if catheter is to be accessed again within 1 day.
- Lock with 5ml i(heparin saline 10 U/ml if catheter not to be used again within 1 day.

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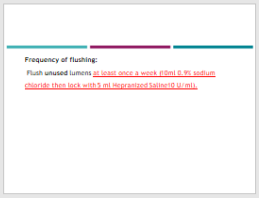

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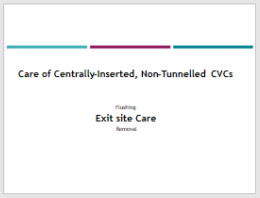

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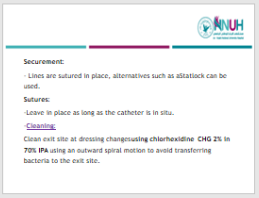

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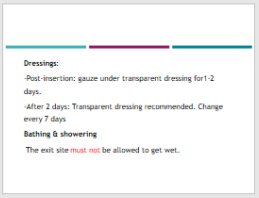

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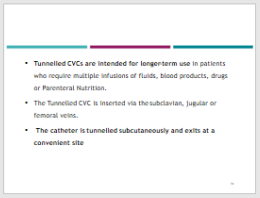

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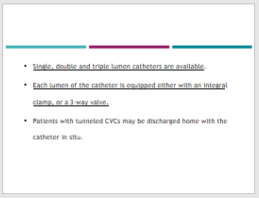

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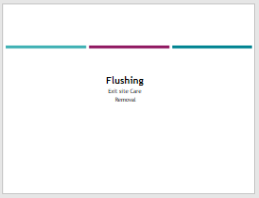

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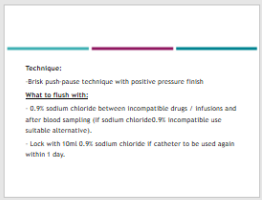

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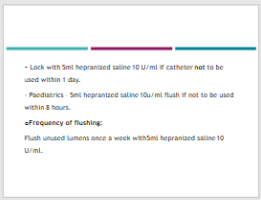

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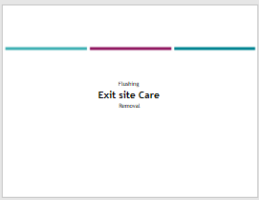

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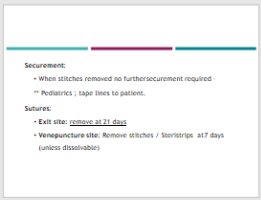

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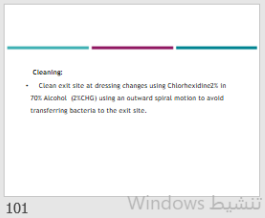

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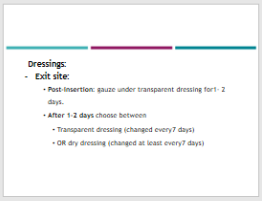

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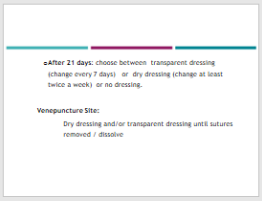

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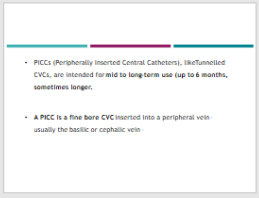

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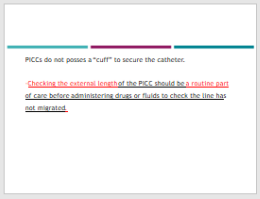

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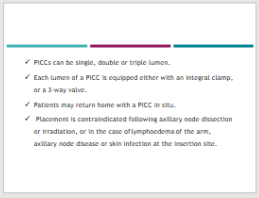

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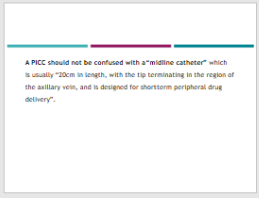

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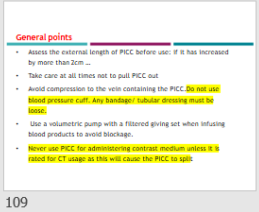

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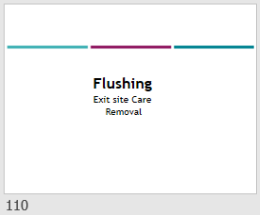

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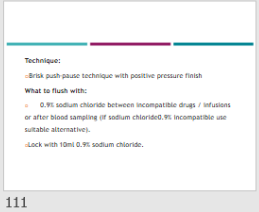

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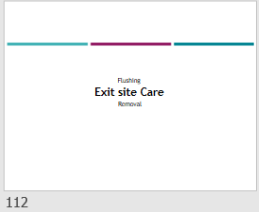

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Securement:

- Always fix catheter firmly to patient's skin (dedicated device e.g. Statlock.)

Cleaning:

- Clean exit site at dressing changes with **Chlorhexidine 2%** in **70% Alcohol** using an outward spiral motion to avoid transferring bacteria to the exit site.

113

Dressings:

- **Post-insertion:** gauze under transparent dressing for 1- 2 days.
- **After 1- 2 days:** transparent dressing (change every 7 days including any dedicated fixing device e.g.Statlock dressing)

114

4 - Care of Implantable Ports (TIVAD / Portacaths).

115

A Totally Implantable Venous Access Device (TIVAD) is similar to a **Tunnelled CVC** but instead of protruding from the patient's chest, the catheter terminates in a self-sealing injection port which is implanted under the skin. **There are therefore no external parts**

116

Ports require less maintenance when not in use than other types of catheter.

suitable for patients who require **long-term frequent and intermittent venous access.**

Dual lumen devices are available

Ports may also be used **as an alternative to subcutaneous administration** of long-term maintenance therapies

117

General Points

Following insertion there may be edema and tenderness around port

If patient undergoes MRI scan, inform scanning personnel about the port.

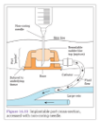
If patient requires defibrillation do not place paddles directly over the port.

Never use port for administering contrast medium as this may cause the catheter to split.

Sometimes it is not possible to bleed back ports despite easy flushing.

118

Porta-cath Needle Insertion



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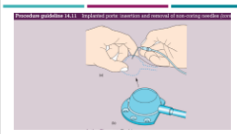
Technique:

- Use Aseptic Technique
- Numb skin over the port
- Prepare skin over the port using CHG2% and allow to dry.
- Prime needle and/or giving set with0.9% sodium chloride.
- Hold port firmly with thumb and two fingers
- Insert needle firmly

120



121

Flushing

Exit site Care

Removal

122

□Non-accessed ports:

Flush at least every four to six weeks with 10ml-20ml 0.9% sodium chloride for adult and5-10ml for pediatric and lock with 250International units/2.5ml-5ml (100 international unit each 1 ml NS 0.9%)

□ Accessed ports:

Technique:

- Brisk push-pause technique

123

What to flush with:

-0.9% sodium chloride 5ml between incompatible drugs / infusions or after blood sampling (if sodium chloride0.9% incompatible use suitable alternative).

If needle to be removed: lock with 250International units/2.5ml-5ml (100 international unit each 1 ml NS 0.9%)

If needle to remain in situ and port to be used within1 day: lock with 10ml 0.9% Sodium chloride and follow with5ml heparinized Saline(10U/ml.

124

Flushing

Exit site Care

Removal

125

Accessed ports:

- Pad needle with sterile gauze if necessary and cover with transparent iv dedicated dressing. Needle site should be visible for inspection.
- Tape tubing firmly to skin to prevent pulling on the needle.
- Inspect needle entry site at least daily.
- Advise patient to report any discomfort or swelling at the puncture site immediately.

126

Bathing, showering & swimming

□Non-accessed ports:

- Patient may bath, shower or swim freely once wound has healed.

□Accessed ports:

- Bathing: Patient should not submerge exit site in bathwater
- Showering: Patient may shower if needle site is completely covered with an occlusive dressing, taking care not to dislodge needle - confirm with Clinical Nurse Specialist.
- Swimming: not advised while needle is in situ.

127

Blood culture from CVC

Guidelines:

- ✓ The Doctor order should be written for blood culture.
- ✓ Blood culture for patient with central venous catheter should include one venipuncture plus central line cultures .
- ✓ Blood Culture Should only be taken when there is reason to suspect an infection :

*** Blood Culture Clinical Decision Rule:**

Either 1 major criterion or ≥ 2 minor criteria meet an indication of blood culture . If these are not present blood culture is not indicated by the rule

128

Major criteria	Minor Criteria
Temperature > 38	Immunosuppression
Known or suspected infection such as:	Central venous device
Febrile neutropenia	Hypotension < 90 mm Hg
Endocarditis	White blood cell count
Sepsis	WBC > 18, 000 cells/ mm³
Septic arthritis	WBC < 4,000 cells/ mm³
Meningitis	Platelets < 150,000 cells/ mm³
Osteomyelitis	Chills /rigors
Peritonitis	Age > 65 years
Pneumonia in ICU	Glycemia > 2.0 mg/ dl
ICU patient with cellulitis , necrotizing fasciitis or with comorbidities (diabetes, IV drug use.)	

129

- ✓ Cultures of peripheral and central access must be drawn within15 minutes.
- ✓ The volume of blood obtained from the peripheral vein and from the CVC MUST match.
- ✓ The peripheral blood should be obtained first to determine the blood amount for CVC sample.
- ✓ Blood cultures drawn at the time of line insertion can be considered 'venipunctures'.
- ✓ If a patient is hypotensive or in shock, do not delay blood culture sampling while awaiting line placement. Obtain two peripheral cultures and start antibiotics STAT.

130

- ✓ Arterial sample is acceptable alternative to peripheral samples.
- ✓ Do not draw from a line that had antibiotic administered through it during the previous hour.

131

- ✓ Avoid drawing from the lumen with vasoactive medications for patient safety.
- ✓ If continuous infusion of IV fluids in any lumen, STOP all intravenous solution for 2-3 minutes prior to obtain samples .
- ✓ Anaerobic sample should be sent only in the following conditions:

Immunodeficiency, malignancy BMT, gastrointestinal disorder or per doctor order.

132

Procedure:

1. The doctor order should be verified.
2. Clean hand and don clean gloves .
3. The tubing and cap junction should be scrubbed by alcohol prep(70% or chlorhexidine 2%in 70% alcohol (apply friction for account of 15). Allow to dry air .
4. Remove the plastic cap of each bottle and scrub the top with alcohol70%
5. Disconnect tubing and cap and attach syringe evacuatainer to the CVC Lumen hub. Use Aseptic Non Touch Technique ANTT
6. Withdraw the recommended blood amount
7. Flush CVC line with 10 ml normal saline0.9%using push pause technique for pediatric (5 ml flush)

Do not aspirate a discard volume.

133

Collection Volume :

Weight	Volume
1-5kg	1ml for each bottle
5-17 kg	1.5 ml for each bottle
17-40 kg	3ml for each bottle
>40 kg	5 ml for each bottle

134

8. If using syringe fill the aerobic first, then the anaerobic. Gently invert to mix.
9. Place bottles in a bag (one sets per bag) with the requisition.
10. Each bottle must be labeled with patient name , site specification and lumen specification (peripheral RT hand , CVC R.L.)
11. The procedure must be documented in the medical and nursing notes (date, time venipuncture site, indication .)

135

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Appendix F

The approval of the Institutional Review Board of the Arab American University of Palestine

Arab American University- Palestine
Deanship of Scientific Research
IRB committee
Tel: 04-241-6888, ext 1196
E-mail: irb.aaup@aaup.edu

الجامعة العربية الامريكية- فلسطين
عمادة البحث العلمي
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البريد الالكتروني: irb.aaup@aaup.edu

IRB Approval Letter

Study Title: The Impact of Using CLABSI Prevention Educational Program on Nurses' Knowledge and Practices, and CLABSI Rate in Palestine

Submitted by: Rasha Subhi Abdekfattah Abu Zaitoun

Date received: 15th May 2023

Date reviewed: 12th June 2023

Date approved: 12th June 2023

Your Study titled "**The Impact of Using CLABSI Prevention Educational Program on Nurses' Knowledge and Practices, and CLABSI Rate in Palestine**" With archived number 2023/A/116/N was reviewed by the Arab American University IRB committee and was approved on 12th June 2023

Reham Khalaf-Nazzal, MD, PhD
IRB committee chairman
Arab American University of Palestine

IRB
ARAB AMERICAN UNIVERSITY

General Conditions:

1. Valid for 8 months from date of approval.
2. It is important to inform the committee with any modification of the approved study protocol.
3. The committee appreciates a copy of the research when accomplished.

لجنة أخلاقيات البحث العلمي في الجامعة العربية الامريكية

IRB at Arab American University

Appendix G

The official permission of Education in Health and Scientific Research Unit

State of Palestine
Ministry of Health
ation in Health and Scientific Research Unit

دولة فلسطين
وزارة الصحة
وحدة التعليم الصحي والبحث العلمي

الرقم: ...
التاريخ: ...

عطوفة الوكيل المساعد لشؤون المستشفيات والطوارئ المحترم،،،
تحية واحترام،،،

الموضـــوع: تسهيل مهمة بحث دكتوراه

يرجى تسهيل مهمة الطالبة: رشا صبحي ابو زيتون – برنامج الدكتوراه في التمريض- الجامعة العربية الامريكية، بعنوان:

" The effectiveness of CLABSI Prevention - Education Based Intervention on Nurses Competency in Central Line Maintenance, CLABSI Rate, Mortality Rate and Length of Stay of Patients in Intensive Care Units in Palestine: Quasi Experimental Study"

حيث ستقوم الطالبة بجمع معلومات عن طريق حول معرفة معدل الوفيات ومعدل الاصابة بعدوى مجرى الدم الناتج عن القسطرة الوريدية المركزية ومعدل اقامة المريض بوحدات العناية الحثيثة في مستشفيات شمال الضفة المذكورة في كتاب تسهيل المهمة وايضا تشمل الدراسة تعبئة استبيان وذلك قبل وبعد تنفيذ برنامج تعليمي خاص برعاية القسطرة الوريدية المركزية (بعد اخذ موافقة مدراء التمريض في المستشفيات المعنية)، وذلك في:

مستشفيات: - جنين – التأمين الوطني - رفيديا - طولكرم

مع العلم ان مشرف الدراسة: د. ايمن منصور ود. عماد قشاقشة.
على ان يتم الالتزام بالمحافظة على اخلاقيات البحث العلمي وسرية المعلومات.
على ان يتم تزويد الوزارة بنسخة PDF من نتائج البحث، التعهد بعدم النشر لحين الحصول على موافقة وزارة الصحة.

مع الاحترام،،،

د. عبد الله القواسمي
رئيس وحدة التعليم الصحي والبحث العلمي

نسخة: عميد كلية الدراسات العليا المحترمة/ الجامعة العربية الامريكية

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Appendix H

The observational checklist of nursing practices of CVC care and maintenance

The employee code:

The hospital Name:

Type of CVC inserted:

Nurse' Practice	**Performed completely and accurately**	**Performed but not completely or accurately**	**Not Performed**
1-Hand hygiene is performed			
2.The required equipment is prepared:			
3.The procedure is explained to the patient, provided that they are conscious			
4.The mask is put on			
5.The patient's head is turned in the opposite direction of the catheter, and if it cannot be turned, a mask is put on his/her face.			
6.Disposable gloves are put on.			
7.The old dressing is removed.			
8.Entrance site, sutures, and surrounding tissues are evaluated			
9.The integrity of the catheter and its hub is evaluated			
10.Gloves are removed.			
11.Hand hygiene is performed.			
12.Sterile gloves are put on.			
13. The region is wiped with friction movements starting from the entrance site.			
14.The wiped region is allowed to dry			
15.The region is dressed with sterile transparent or gauze dressing, placing the dressing so that the entrance site remains in the center			
16.The cap of the lumen is removed			

17.The catheter hub is cleaned with chlorhexidine, povidone iodine, or alcoholic wipes for 15 seconds.			
18.The syringe filled with 0.9% saline solution is placed in the hub and the clamp is opened			
19. The syringe is withdrawn to observe positive blood return			
20.The hub is flushed with the saline solution in the syringe.			
21. A new cap is put on the hub.			
22.Gloves are removed.			
23.Hand hygiene is performed.			
24.The time and date of the dressing change and the initials of the nurse are written on the dressing			
25. The procedures and observations are recorded on the nurse's observation form.			

Appendix I

Content Validity Ratio (CVR) for the knowledge assessment questionnaire

The communicated letter via electronic mail to experts inquiring validation of the CLABSI Prevention-Knowledge Assessment Questionnaire

Dear Expert

Greetings,

I'm writing to you since you are an infection control and prevention expert. I am a Ph.D. candidate at The Arab American University of Palestine (AAUP). My dissertation focuses on hospital-acquired infection, specifically, CLABSI prevention. My study is quasi-experimental and conducted to determine the effectiveness of the education-based intervention on intensive care nurse's competence level and patients' outcomes in terms of mortality rate and length of stay in intensive care units in the MOH of the north region of Palestine I will be in charge of the intensive care nurse's education workshop. The participants will receive lecture-based education supported by hand on training based on the WHO and CDC recommendations regarding CLABSI prevention. The knowledge level will be assessed based on the CLABSI Prevention- Knowledge Assessment questionnaire.

I believe that your experience would be incredibly useful in examining the content validity of my questionnaire. As a result, I'm writing to ask for your assistance in evaluating the content validity of my questionnaire items. (**Attach file).** In order to examine the content validity, the following categorized scale can be used with categorical options "(Not necessary", "Useful but not essential" and "Essential" for each item and using a Relevancy scale illustrated in the form below.

I really appreciate you taking the time to review and apply content validity to my questionnaire items Thank you for your time and consideration. I look forward to hearing from you soon.

Sincerely,

Rasha Abu Zaitoun

Ph.D. Candidate, School of Nursing AAUP -Palestine

Please fill in the data by placing (√) in the appropriate answer box: -

Item	Not necessary	Useful but Not	Essential	Not relevant	Need some Revision	Need minor Revision	Very Relevant
Bundle CLABSI definition							
A laboratory-confirmed infection where a CVC is in place for >2 calendar days before a positive culture and is also in place the day of or the day before the culture and combined with chills, fever, hypotension, and tachycardia that is not related to an infection from another site							
CVAD Maintenance and CLABSI Prevention Practices							
The insertion site of CVAD should be assessed at least once a day.							
After flushing the CVAD lumens, it is important to close the clamp and lock the lumen at the last 1 ml of saline because Positive pressure prevents the backflow of blood into the lumen and							

Item	Not necessary	Useful but Not	Essential	Not relevant	Need some Revision	Need minor Revision	Very Relevant
can increase the patency of your IV							
The transparent chlorohexidine dressing over the central line insertion site must be changed every seven days and when needed.							
Chlorohexidine 2% in 70% alcohol is the recommended disinfectant solution for CVAD dressing							
When accessing the lumen of the CVAD, the patient should wear a mask.							
The non-touch technique is the most recommended to access the CVAD.							
Chlorhexidine is recommended over alcohol to care for the CVAD insertion site because it has more than 12 hours of residual activity after application.							
The correct mechanism to do dressing over the CVAD insertion site is by using the backward, forward and friction for 30 seconds.							

Item	Not necessary	Useful but Not	Essential	Not relevant	Need some Revision	Need minor Revision	Very Relevant
When discontinuing an IV line from the CVAD lumen, Hand Hygiene is obligatory with using the non-touch technique.							
The CVAD hub must be scrubbed for 15 seconds using alcohol 70%.							
The luer lock adapter (Cap) of the CVAD hub must be changed with every dressing and when needed.							
The luer lock adapter (Cap) of the CVAD hub is a single-used apparatus.							
The proper syringe size to flush or withdraw blood samples from CVAD is a 10 ml syringe.							
A pulsatile push pause mechanism using a 10 ml syringe size is the proper flushing technique for all CVAD types.							
The administration sets for continuous infusions shall be changed no more frequently than every 4							

Item	Not necessary	Useful but Not	Essential	Not relevant	Need some Revision	Need minor Revision	Very Relevant
days, but at least every seven days.							
The administration sets for fat emulsions should be changed every 24 hours.							
The administration sets for blood should be changed every 24 hours.							
After medication administration through CVAD, the lumen must be flushed with Normal Saline 0.9%.							
Blood Sample and Culture from CVAD							
A dead space must be withdrawn and discarded before collecting blood culture.							
The peripheral blood culture should be withdrawn first then the central culture for patients with CVAD.							
The blood collected for culture from CVAD MUST be collected from each lumen in one bottle.							
When withdrawing a blood sample from CVAD, all lumens with continuous fluid							

Item	Not necessary	Useful but Not	Essential	Not relevant	Need some Revision	Need minor Revision	Very Relevant
infusion must be closed for 2-3 minutes before the procedure.							
The lumen with vasopressor infusion shall not be clamped for blood sampling from CVAD.							
The blood that is withdrawn directly from the central line just after insertion is considered a peripheral blood sample.							
The CVAD bundle contains hand hygiene, using Chlorhexidine 2% in 70% alcohol, daily review of necessity, site selection for insertion, and maximum barrier precaution.							
The maximum barrier precautions for CVAD insertion include wearing a sterile gown, sterile gloves, and cap, and a full body drape							
Comments:							

Expert Name and signature: Date:

Appendix J

Informed consent

الاختبار القبلي لتقييم المعرفة بعدوى مجرى الدم المرتبطة بالقثطار الوريدي المركزي والممارسات الوقائية لمنع العدوى المرتبطة القثطار الوردي المركزي

عنوان الدراسة :

فعالية التدخل الوقائي لمكافحة عدوى مجرى الدم المرتبطة بالقسطرة الوريدية المركزية على كفاءة ممرضي ومرضات وحدات العناية الحثيثة في العناية بالقثطار الوريدي المركزي ومعدل عدوى مجرى الدم المرتبطة بالقسطرة الوريدية المركزية ومعدل الوفيات، ومدة إقامة المرضى في فلسطين

الموافقة على المشاركة في البحث والإجابة على استبيان المعرفة عدوى مجرى الدم المرتبط بالقسطرة الوريدية المركزية Consent Form –

السلام عليكم وحمة الله وبركاته

زملائي وزميلاتي العزيزات

أنتم مدعوون للمشاركة في هذه الدراسة البحثية وهي عبارة عن رسالة دكتوراه في التمريض تهدف الى تنفيذ تدخل تعليمي وتدريبي حول الرعاية الصحيحة في القسطرة الوريدية المركزية ومن ثم دراسة تأثير هذا التدخل على مدى الكفاءة المهنية لدى التمريض بالعناية بالقسطرة الوريدية المركزية ومعدل إقامة المريض ومعدل الوفاة وذلك قبل وبعد تنفيذ التدخل. وتستهدف ممرضي وممرضات العناية الحثيثة في مستشفيات شمال فلسطين.

مشاركتكم الفعالة تتمثل في الإجابة على استبيان قياس المعرفة حول العناية بالقسطرة الوريدية المركزية وعدوى مجرى الدم المرتبطة بها وأيضا تشمل حضور التدريب المزمع عقده لاحقا وبالتنسيق مع ادارة التمريض. المشاركة اختيارية ويمكن لحضرتكم الانسحاب في أي لحظة ودون إبداء الأسباب ودون أن يلحق بكم أ ي ضرر وكما نؤكد أن جميع البيانات التي سوف يتم جمعها لأغراض البحث سوف تبقى سرية ولن يطلع عليها ألا فريق البحث ولن تستخدم الا لأغراض البحث العلمي.

هذا الاستبيان يهدف إلى قياس مستوى معرفتكم بمبادئ العناية بالقسطرة الوريدية المركزية والتعامل معها في العنايات الحثيثة لمنع عدوى مجرى الدم المرتبطة بها ويتكون من جزئيين (معلومات شخصية وامتحان لقياس مستوى المعرفة). قد يستغرق الاستبيان من 15 الى 20 دقيقة لتعبئته.

إن كان لديك أي استفسار عن البحث يمكن التواصل مع الباحث:

رشا أبو زيتون: 0592444699 / r.abuzaitoun@student.aaup.edu

فعالية استخدام مداخلة لتعليم منع العدوى في مجرى الدم المرتبطة بالقثطار الوريدي المركزي وتأثير ذلك على الكفاءة التمريضية للحفاظ على فاعلية القثطار الوريدي ومخرجات رعاية المريض في وحدات العناية الحثيثة في فلسطين: دراسة شبه تجريبية

رشا صبحي عبد الفتاح أبو زيتون

أيمن حمدان منصور

عماد فشافشة

جعفر الشريدة

خلدون حمدان

بسمة سالم سلامة

ملخص

عدوى مجرى الدم المرتبطة بالقثطار الوريدي المركزي (CLABSI) هي عدوى خطيرة ومكتسبة في المستشفيات ولكن يمكن الوقاية منها وعليه هدفت هذه الدراسة إلى تقييم فعالية تطبيق مداخلة التعليم لمنع عدوى مجرى الدم المرتبطة بالقثطار الوريدي المركزي (CLABSI) على كفاءة الممرضين في الحفاظ على القثطار الوريدي المركزي ومعدل وفيات المرضى ومدة الإقامة.

أُجريت الدراسة في وحدات العناية المركزة بمستشفيات وزارة الصحة في المحافظات الشمالية من فلسطين بين أيلول 2023 واذار 2024. واستخدم تصميم شبه تجريبي وكانت العينة ملائمة وتم تعيين الممرضين عشوائيًا لمجموعة المداخلة او المجموعة التجريبية على مستوى المستشفى بناء على سعة العناية المكثفة في المستشفيات المقصودة. وتمت عملية تقييم المعرفة باستخدام استبيان مترجم يُملأ ذاتيًا واما مهارات الممرضين فتم مراقبتها باستخدام نسخة مختصرة من أداة بإيبرو كازان وغولنور كار. فيما يتعلق بمعدل الوفيات والإقامة بين مرضى العناية الحثيثة، تم قياسهما بقراءة مبدئية وبأثر رجعي لمدة ثلاثة أشهر قبل بدء التدخل، ثم شهريًا طوال فترة الدراسة.

شارك في الدراسة ما مجموعه 98 ممرضًا من العاملين في العناية الحثيثة. كانت المعرفة الأساسية حول التعامل الآمن مع القثطار الوريدي المركزي متوسطة إلى عالية دون وجود فرق بين المجموعة التجريبية ومجموعة المداخلة في مستوى المعرفة ما قبل تلقي التدريب ($t = -0.61,$

(p=0.537 والممارسة التمريضية قبل تلقي التدريب (t=−0.376, p =0.708) وأظهرت المجموعة التجريبية تحسنًا مستمرًا في المعرفة خلال تقييم ما بعد التدخل ($F_{(1, 41)}$ = 4485.58, p < 0.001). أما فيما يتعلق بمهارات الممرضين، كان متوسط مستوى المهارات الأساسي 33.05 (الانحراف المعياري = 5.88) ولم يكن هناك فرق كبير بين المجموعتين مع الحفاظ على ديمومة التحسن خلال فترة ما بعد التدخل(t = −12.91, p<0.001) ، وأما فيما يتعلق بنتائج المرضى لم يكن هناك تأثير ملحوظ للتدخل على معدل الوفيات (t = −1.85, p=0.138)، ومدة الإقامة (t = 177, p= 0.151) في كلتا المجموعتين .

نظرًا لتأثير التدخل التعليمي في هذه الدراسة على تحسين كفاءات ممرضي العناية المركزة في رعاية القثطار الوريدي المركزي، يُوصى بتطبيق التعليم المستمر والتدريب أثناء الخدمة في مجال مكافحة العدوى لتعزيز وضمان ديمومة كفاءات الممرضين في التعامل الآمن مع القثطار الوريدي المركزي والوقاية من العدوى المرتبطة به. كما يُوصى بتوحيد السياسات لضمان الصيانة الآمنة والفعالة للقثطار الوريدي المركزي والتعامل الآمن معه.

الكلمات المفتاحية: القثطار الوريد المركزي، المعرفة، التمريض، مهارات التمريض، العدوى