Effect of Central Venous Catheter Care Bundle Implementation on Outcomes of Critically Ill Patients

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ABSTRACT

Context: Central venous access device (CVAD) bundles for insertion and maintenance demonstrate a reduction in the frequency of complications and bloodstream infection when implemented with compliance monitoring, with the reported success of CVAD bundles.
Aim: This study aimed to examine the effect of central venous catheter care bundle implementation on outcomes of critically ill patients.
Methods: Quasi-experimental research (pre/post-test design) used to achieve the aim of this study. The study conducted at general and surgical intensive care units affiliated to Menoufia University and teaching hospital. Two study samples recruited in this study. All nurses working at the ICUs, as mentioned above, were recruited in this study. They were 6o critical care nurses. A convenient sample of all available critically ill patients at the time of the study was subjected to treatment via a central venous catheter. Four study tools used to collect the data of this study. These are a structured interview questionnaire, CVC nurses' knowledge assessment questionnaire, nurses' compliance assessment checklists, and patient complications assessment records.
Results: The study result showed a highly statistically significant difference between pre and post-test knowledge scores of studied nurses regarding assisting line insertion, removal, maintenance, care, and infection control practices. Besides, a highly statistically significant difference between pre and post-test scores of nurses' compliance to central venous catheter care practices of assisting in CVC insertion, blood sample withdrawal, medication and fluid administration, CVP measurements, CVC removal, and the management of central venous line complications. The study also revealed a highly statistically significant difference between the study and control group patients regarding the central venous catheter complications. However, signs of infection were the most frequent complications in both groups.
Conclusion. The study concluded that a statistically significant difference between pre and post nurses' knowledge and compliance with the CVC care bundle. The patients' outcomes were also improved significantly after the implementation of the CVC care bundle compared to the controls. The study recommended the adoption of the current care bundle that should be disseminated and updated following the international organizations' recommendation for implementing evidence-based practices for successful central line-associated bloodstream infection (CLABSI) prevention.

Keywords: Central venous catheter, care bundle, outcomes, critically ill patients

1. Introduction

Peripheral intravenous catheters (PIVC) are crucial for the delivery of medical treatments in over one billion patients annually *(Alexandrou et al., 2018)*. However, peripheral intravenous catheters complications (phlebitis, extravasation and infiltration, dislodgement, and blockage) result in premature access failure in up to sixty-nine percent of hospital patients *(Marsh et al., 2018)*, requiring the new device to be inserted, with delays in treatment and increased costs. Besides, catheter-associated bloodstream infection (BSI) is a worldwide threat to health outcomes *(Umscheid et al., 2011)*. Recent studies have reported severe complications that increased mortality, morbidity and hospital length of stay due to PIVC among critically ill patients in intensive care units *(Centers for Disease Control and Prevention (CDC), 2017; Fagan, Edwards, Park, Fridkin, & Magill, 2013; Boyce, 2012)*.

The situation becomes more complicated with the use of central venous access devices (CVAD). A central venous catheter is one in which the tip or end of the catheter lies in a large vein of the central circulation such as the lower third of the superior vena cava, aortocaval junction, and upper right atrium. The tip of a femoral catheter lies in the inferior vena cava *(Hamilton & Bodenham 2009)*. Central venous catheters (CVCs) could be in place for hours to weeks or longer and are managed by a variety of care providers. CVCs are accessed numerous times while in place, in order to administer medication and fluids or to collect blood samples. Because each entry into the delivery system's access points provides an opportunity for the introduction of microorganisms, the post-CVC insertion period offers multiple possibilities for infection risk *(Pennsylvania Safety Authority, 2011)*.

Nearly seventy-two percent of all central line-associated bloodstream infections (CLABSIs) (identified by acute care hospitals in Pennsylvania and reported to the National Healthcare Safety Network (NHSN) in 2010) occurred more than five days after insertion. This finding is indicating that lapses in infection prevention were likely to occur in post-insertion care and maintenance of CVCs *(Pennsylvania Safety Authority, 2011)*. *Shapey, Foster, Whitehouse, Jumaa, & Blon (2009)* envisioned to assess the staff members' knowledge and practices regarding CVC post-insertion care in a tertiary care hospital. The study

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figured that lapses in appropriate infection prevention strategies occurred in forty-five percent of post-insertion care episodes; most common deficiencies related to keeping caps and site dressings in place.

Many of the evidence-based procedures used to insert CVCs are also essential for the care and maintenance of these catheters (e.g., hand hygiene, proper skin antisepsis at the insertion site, site dressing, thorough disinfection of CVC hubs and injection ports, changing of administration sets and fluids, regular evaluation of the continuing need for CVC) *(O'Grady et al., 2017).* Using insertion bundles led to a more consistent application of evidence-based practices at CVC insertion, but almost nothing is known about the potential impact post insertion bundles may have on CLABSI prevention.

Care bundles are a package of three to five evidence-based measures that are reliably and effectively implemented together to improve care quality. Care bundles are widely used in healthcare settings in order to prevent and manage various health conditions *(Lavallee, Gray, Dumville, Russell, & Cullum, 2017)*. Insertion and maintenance of central venous access device bundles demonstrate reductions in the frequency of complication and bloodstream infection when implemented with compliance monitoring *(Blot, Bergs, Vogelaers, Blot, & Vandijck, 2014; Ista et al., 2016; Zingg & Pittet, 2016),* with the reported success of CVAD bundles. Central intravenous catheters insertion and maintenance bundles are being implemented successfully in many hospitals *(Bertoglio et al., 2017; Boyd, Aggarwal, Davey, Logan, & Nathwani, 2011).*

CVAD bundles include optimal insertion site selection, hand hygiene, chlorhexidine skin disinfection, maximal sterile barriers for line insertion, and daily review of device necessity with prompt removal of unneeded lines *(Blot et al., 2014).* Implementation of an evidence-based bundle could lead to improved adherence to guidelines for CVC care and improved patient outcomes, but wide variation currently exists among CVC bundles reported in the literature. Current CVC insertion and maintenance bundles include diverse components (not all evidence-based), and study quality is low to fair. The effect of CVC care bundles on CVC-related bloodstream infection rates appears promising but remains uncertain. Standardization of evidence-based bundle components and more rigorous studies with compliance, sustainability, and cost reporting are needed *(Ray-Barruel, Xu, March, Cooke, & Rickard, 2019).*

Nurses play a crucial role in preventing central venous catheter complications. Central line insertion poses a significant risk, but proper nursing and maintenance are vital to preventing complications *(Marschall et al., 2014).* Nurses can have the most significant impact, as they are responsible for being central line care experts *(Dumont & Nesselrodt, 2012; Infection Control Today, 2013; Office of Disease Prevention and Health Promotion, 2013; Cooper, 2019).* The nurse must stick to the evidence-based protocols that protect the patient from infection every time a central venous line is manipulated, or a central venous line dressing is changed. Ensuring that nurses are well-informed and compliant is a key to the success of the complication prevention program *(Barsuk, Cohen, Feinglass, McGaghie, & Wayne, 2009; Perin, Erdmann, Higashi, & Sasso, 2016).*

Nursing compliance with established guidelines is a challenge to efforts to prevent the complication of the CVC. Either due to lack of knowledge or other causes, adherence to evidence-based practices is a known issue that increased CLABSI's incidence *(Flodgren et al., 2013; Jones, Stewart, & Rozell, 2015).* For many organizations, CLABSI prevention efforts are a significant concern, and an effort is widely directed towards this issue. The approaches, however, are not always sufficient to ensure adequate nursing awareness that might affect compliance *(Esposito, Guillari, & Angelillo, 2017).*

2. Significance of the Study

Despite evidence-based guidelines, it can be challenging to incorporate recommendations into clinical practice. The implementation of care bundles in point-of-care reminders that simplify lengthy directions has strengthened workers' compliance with best practices. It is also documented that compliance with CVAD bundles has resulted in complication reduction in adult intensive care units (ICU), the impact of central intravenous catheters insertion and maintenance bundles is unclear. Precise Egyptian statistics regarding the complications associated with CVAD in the ICUs are lacking.

However, scattered Egyptian studies shed light on the CVAD complication in different ICUs, with different rates of incidences. *Khalil, & Azqul (2018)* reported noncompliance of health care providers to care bundle elements of CVC of Center for Disease Control and Prevention, that represent a risk factor for central related bloodstream infection among a prospective cohort of one hundred cardiac patients in cardiac care unit in National Heart Institute medical care unit. *Omran, Gomma, Hayder, & Ali (2013)* conducted a study on 160 post-catheterization patients, examining 160 catheter tips and 160 swabs. The study reported the emergence of multi-resistant pathogens in ICUs. Proper insertion and care of catheters are essential to avoid infection. Education and training of health professionals on the practice of dealing with the CVC is an essential tool in preventing and reducing CVC complications. Based on these studies' findings and recommendations, the present study was eager to examine the effect of the application of care bundle on the outcomes of critically ill patients with the central venous catheter in intensive care units (ICUs) at Menoufia University and Teaching Hospitals.

3. Aim of the study

This study aimed to examine the effect of central venous catheter care bundle implementation on outcomes of critically ill patients.

3.1. Research hypotheses

- Nurses who are exposed to the central venous catheter

care bundle training will have better knowledge compared to their pre-intervention level.
- Nurses who are exposed to the central venous catheter care bundle training will have better compliance compared to their pre-intervention level.
- Critically ill patients who are cared for by trained nurses on the central venous catheter care bundle will exhibit fewer complications compared to the control group patients.

3.2. Operational definition

Patients' outcome

The patients' outcomes in this study are intended to assess the frequency of complications such as infection, bleeding, line occlusion, hematoma, thrombosis, air embolism, ischemia, extravasation, catheter migration, and catheter fracture.

4. Subjects & Methods

4.1. Research design

Quasi-experimental research (pre/post-test design) used to achieve the aim of this study. Quasi-experimental research is similar to experimental research in that there is a manipulation of an independent variable. It differs from experimental research because either there is no control group, no random selection, no random assignment, and/or no active manipulation *(IOWA State University, 2019).*

4.2. Research Setting

The study conducted at general intensive care and surgical intensive care units affiliated to Menoufia University and teaching hospitals.

4.3. Subjects

All nurses who are working at the ICUs mentioned above recruited in this study. They were 6o nurses distributed over the three shifts. All nurses recruited in order to ascertain the implementation of care bundles throughout the 24-hour working time to positively affect the patient outcomes.

A convenient sample of all available critically ill patients at the time of the study was subjected to treatment via a central venous catheter (250 patients). The patients were recruited in this study over one year. The patient recruited through two phases; the first six months admitted patients were selected as a control group to avoid sample contamination. Then, in the next six months, admitted patient was enrolled as a study group patient. One hundred twenty-five patients enrolled in each group. All recruited patients had CVC insertion at the time of the study.

4.4. Tools of the study

4.4.1 A structured Interview Questionnaire

It was developed by the researcher to assess the nurses' sociodemographic characteristics such as age, sex, education, and years of experience in the critical care units.

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4.4.2. CVC Knowledge Assessment Questionnaire

It is developed by the researcher to assess the nurses' knowledge about the care provided to a patient with a central venous access device (CVAD) based on *(Comer et al., 2011).* It included three main parts. The first part concerned assessing the knowledge related to assisting in insertion and removal of the central venous access device (10 MCQs). The second part concerned with assessing the knowledge related to CVAD maintenance (it includes CVP measurement, drug and fluid administration, and blood sampling). It included (10 MCQs). The third part included the assessment of knowledge related to CVAD care and infection control. It included (10 open-end questions). This tool used pre-and post-implementation of the CVAD care bundle. This tool used twice pre and post-intervention.

Scoring system

The tool scored as (1 score for the correct answer and 0 for incorrect answer) for MCQs. A subtotal score summed for each part separately. The subtotal scores classified as adequate if the subtotal score was ≥ 75% of the total items' score of the section and inadequate level of knowledge if the subtotal score for each part was less than 75%. Open-end questions involved one or more correct answers. Each one got a score of 1. It summed as a total divided by its question to get the mean score of this part.

4.4.3. Nursing Practice Observation Checklists

It used to assess the compliance of nurses on the CVC care bundle developed by the researcher guided by *CDC guidelines (2017).* It consisted of 5 subsets of observation checklists with done or not options, which have to be observed. The items were the steps or techniques to be carried out while performing the care of a patient with a central line catheter. Assisting in insertion and withdrawal of blood sample (30 performance statements), maintenance care, and infection control procedures (30 performance statements). Medication and fluid administration (20 statements). Measuring CVP and catheter removal procedures (15 statement). This tool used twice pre and post intervention.

Finally, practices related to spotting and managing the complications were added. It included the management of 10 frequent complications (infection, bleeding, line occlusion, hematoma, thrombosis, air embolism, ischemia, extravasation, catheter migration, and catheter fracture). The reliability of the observation checklists was determined using the inter-rater-observer method among ten nurses in the Critical Care Unit. Cronbach alpha was (r=0.81).

Scoring system

Each performance step was rated either (1 score for done) and (zero for not done). A subtotal score for each subset of checklists summed and divided by its number to obtain a mean score for each subset. The fifth part concerned with spotting and managing complication was

calculated as compliance for nurses who could identify and manage the complications (≥ 75%) and less than 75% considered non-compliant.

4.4.4. Patient Complications Assessment Record

It developed by the researcher to record the patient's age, sex, and possible complications of the central venous catheter within two weeks of catheter insertion. This tool used twice in both studied patient groups. The number and frequency of complications are counted for each group separately. The complications recorded were the most ten frequent possible complications such as infection, bleeding, line occlusion, hematoma, thrombosis, air embolism, ischemia, extravasation, catheter migration, and catheter fracture. It developed based on *(Ray-Barruel et al., 2019)*.

4.5. Procedures

A panel of 5 professors of Microbiology, Medical-surgical, and Critical Care Nursing invited to assess the tool content and face validity, and also, they are invited to validate the CVC bundle of care. Their comments were considered. Official permission secured from the dean of the faculty of nursing. Menoufia University. A letter contained the aim and data collection procedures.

Ethical consideration assured throughout the study implementation phase, as no harmful intervention would affect the patient. The data was confidential and anonymous. Nurses and patient data were coded and secured. Oral informed consent was obtained from nurses who agree to participate in the study.

A pilot study on six critical care nurses (representing 10% of the sample) who are working at the above-mentioned clinical settings to examine the feasibility of the study process and the applicability of the study tools.

The study went through three phases (preparatory, implementation, evaluation). The preparatory phase included the development of data collection tools and the central venous catheter care bundle (CVCCB). The CVC care bundle was developed by the researcher based on *The Joint Commission (2013), Awad, Entwistle, & Townsend (2017); O'Grady et al., (2017).*

The bundle includes two main constituents' insertion and ongoing care bundle. The first constituent is concerned with the insertion bundle that involves (hand hygiene, full barrier precautions, chlorhexidine skin asepsis, optimal catheter type selection, optimal catheter site selection, dressing, safe disposal of sharps and documentation). The second constituent is the ongoing care bundle that includes (hand hygiene, site inspection, dressing, catheter injection ports, catheter access, administration set replacement, and catheter replacement). The CVC care bundle printed as a booklet and posters to be stuck at the unit wall for easy visualization and reminding of the staff nurses.

The preparatory phase also included an organization of five teaching sessions for all the participant nurses. The staff nurses classified according to their work schedule in collaboration with the head nurses of the ICUs. Each session included an explanation of one or two bundle components (it included the theoretical and practical part of each component) such as hand hygiene, dressing, and set replacement.

The implementation phase performed through two stages. The first stage included primary patients' assessment for the frequency of complications over six months (control group). Then, the achievement of the teaching schedule, pasting posters on the unit wall, and distribute the booklet on the staff nurses. Each teaching session involved a group of 5-6 staff nurses. Each session consumed 45 minutes, started with a revision of what had taught before, and ended with group discussion and answering of the nurses' queries. The schedule continued until all the nurses finish all educational content.

The second stage incorporates the application of the care bundle under the supervision of the researcher who visits each research setting three days a week (Sat. Mon. Wed. for Menoufia University Hospital) and (Sun. Tues. Thurs. for the Teaching Hospital). The researcher used the follow-up observation sheet for following up on nurses' compliance during the period of data collection.

Follow up observation sheet to follow nurses' compliance with care bundle carried out and the results recorded at the point of care by the researcher. The goal of the follow-up observation sheet is to perform appropriate action of care every time it is needed and achieve the highest compliance with the care bundle. The follow-up sheet included columns that contain all actions of the care bundle and rows that include the number of observations. The last two rows were used to calculate the total number of times an individual action was performed regardless of the nurse who did the care.

The researcher assessed the nurses' compliance in each visit to the study setting using a follow-up observation sheet. This sheet gave immediate feedback to the compliance of staff nurses with the care bundle that when the overall compliance is reduced, an action took to improve compliance level. A poster educational session was scheduled when indicators revealed a lower compliance level to enhance the adherence to the bundle protocol.

The third phase is an evaluation phase includes the use of the same pre-test assessment tools for knowledge and practice. This phase consumed one month — the study group patients surveyed for complications for six months.

4.6 Data analysis

The collected data is coded, cleaned, and analyzed using SPSS (Statistical Package for Social Science) version 20. Descriptive statistics presented as frequencies and percentages. Non-parametric significance tests for two dependent samples used for studying correlated, or matched, samples. It included the before-after effect and matched paired studies. McNemar'stest, Test of Marginal Homogeneity, assesses if a statistically significant change in proportions has occurred on a dichotomous trait at two-time points on the same population. A paired t-test sample used to determine if the mean difference between the two

observation sets is zero. Each subject is measured twice in a paired sample t-test, resulting in pairs of observations.

5. Results

Table 1 represents the frequency and percentage of the studied staff nurses according to their characteristics. The table shows that 88.3% of the studied nurses were less than 40 years of age. 68.3% of them were females. 53.3% had a bachelor's degree in nursing. 45% of the nurses had 2-5 years of experience.

Table 2 shows a highly statistically significant difference between pre and post-test knowledge scores of studied nurses regarding assisting line insertion, removal, and maintenance.

Table 3 shows a highly statistically significant difference between pre and post-test knowledge scores of studied nurses regarding central venous line care and infection control.

Table 4 reveals a highly statistically significant difference between the nurses' compliance with central venous catheter care practices of assisting in CVC insertion, blood sample withdrawal, medication and fluid administration, CVP measurements, and CVC removal.

Table 5 shows a highly statistically significant difference between pre and post-intervention nurses' compliance regarding the management of central venous line complications.

Table 6 shows the patient's mean age and gender. The patients' mean age 56.20±6.93. 78.8% of the studied patients were males.

Table 7 reveals a highly statistically significant difference between the study and control group patients regarding the central venous catheter frequency of complications. However, signs of infection were the most frequent complication in both groups.

Table (1): Frequency and percentage distribution of studied nurses according to their sociodemographic characteristics.

sociodemographic characteristics	Frequency No. 60	Percentage %
Nurses' age		
Less 40	53	88.3
Between 40-60	7	11.7
Gender		
Male	19	31.7
Female	41	68.3
Education		
Bachelor	32	53.3
Technical Institute	28	46.7
Years of intensive care experience		
Less 2	9	15.0
From 2 -5	27	45.0
From 5-8	15	25.0
From 8-11	9	15.0

Table (2): Comparison of studied nurses' knowledge pre and post bundle implementation regarding central venous catheter insertion, removal, and maintenance (no. 60).

Knowledge domain	Pre-intervention				Post-intervention				p-value
	Adequate		Inadequate		Adequate		Inadequate		
	No.	%	No.	%	No.	%	No.	%	
Knowledge related to central venous line insertion and removal	45	75	15	25	5	8.3	55	91.7	<0.001
Knowledge related to central venous line maintenance	49	81.7	11	18.3	36	60	24	40	<0.001

Table (3): Comparison of studied nurses' knowledge pre and post bundle implementation regarding central venous catheter care and infection control (no. 60).

Knowledge domain	Min.	Max.	Mean±SD	Paired t-test	P-value
knowledge related to central venous line care and infection control (pre-intervention)	1	7	1.82±1.51	28.20	<0.001
knowledge related to central venous line care and infection control (post-intervention)	4	12	10.38±2.03		

Table (4): Comparison of studied nurses' compliance pre- and post-intervention regarding central venous catheter care practices (no.60).

Procedure bundle compliance domain	Preintervention			Post intervention			Paired t-test	P-value
	Min.	Max.	Mean±SD	Min.	Max.	Mean±SD		
Practices related to assisting in insertion and withdrawing a blood sample	1	19	11.00±4.02	15	30	23.88±3.96	20.07	<0.001
Practices related to maintenance care and infection control	1	15	6.28±2.92	23	29	26.43±1.84	43.16	<0.001
Practice related to giving medications and fluid	4	14	7.60±2.39	5	18	13.67±3.13	10.87	<0.001
Practices related to measuring CVP measurement and removal	5	14	11.90±1.77	9	14	12.40±1.29	3.19	<0.001

Table (5): Comparison of studied nurses' compliance pre and post-intervention regarding central venous catheter complications management (no. 60).

Procedure bundle compliance domain	Pre intervention				Post intervention				McNemar test	p-value
	Non- compliant		Compliant		Non- compliant		Compliant			
	No.	%	No.	%	No.	%	No.	%		
Practices related to central venous complication management	50	83.3	10	16.7	11	18.3	49	81.7	35.22	<0.001

Table (6): Frequency and percentage distribution of patients' gender and their age mean score (no. 250).

Patients' age	Min.	Max.	Mean	SD
	41	75	56.20	6.93
	N		%	
Gender				
Male	197		78.8	
Female	53		21.2%	

Table (7): Frequency and percentage distribution of studied patients according to their central venous catheter complications.

Complications	Control group (no. 125)		Study group (no. 125)		P-value
	No.	%	No.	%	
No complication	86	34.4	196	78.4	
Signs of infection	124	49.6	50	20	
Bleeding	14	5.6	4	1.6	
Line occlusion	7	2.8	0	0.0	
Hematoma	7	2.8	0	0.0	
Thrombosis	4	1.6	0	0.0	<0.001
Air embolism	3	1.2	0	0.0	
Ischemia	3	1.2	0	0.0	
Extravasation	2	0.8	0	0.0	
Catheter migration	0	0.0	0	0.0	
Catheter fracture	0	0.0	0	0.0	

6. Discussion

One of the main aims of health research is to optimize health and healthcare by identifying effective healthcare interventions. Care bundles are built around specific patient care elements and consist of three to five primary interventions; the so-called elements (*Resar, Griffin, & Haraden, 2012).* These bundle elements are either evidence-based or are already accepted in ICUs or the national guidelines. The resilience of a bundle of care is that, unless medically contraindicated, all elements must be performed in each eligible patient using the all-or-none (AON) approach *(Resar et al., 2012; Guide, 2012a; Guide, 2012b).* This study aimed to examine the effect of central venous catheter care bundle implementation on outcomes of critically ill patients.

The current study's findings identified a sample characteristic that the majority of ICU staff nurses were under 40 years of age, more than two-thirds of them were females, more than half of them had a bachelor's degree in nursing with around fifty percent of them has a unit experience of 2-3 years. The study also documented a highly statistically significant difference between pre and post-test scores of their knowledge regarding assisting with line insertion, removal, maintenance, care, and infection control. This finding might be due to that the bundle of care is rather a new concept in critical care nursing based on

evidence-based practice, that motivate the current highly qualified studied nurses to inspire such a new concept.

Comer et al. (2011), reported similar findings in a study entitled "web-based training improves knowledge about central venous line bloodstream infections on 177 respondents from 5 hospitals." The mean pre-test score was 59.6% (standard error, 0.9%) and the mean post-test score (test administered immediately after the course) was 77.9% (SE, 0.9%); this represents a significant increase of 18.3% (SE, 1.1%; P < .001).

Bayoumi and Mahmoud (2017) also reported a similar finding. They studied the "effect of an education program on nurses' knowledge and practice regarding care of central venous line in pediatric hemodialysis through the application of evidence-based guidelines." The study reported that nurses who received evidence-based education program guidelines for the maintenance and care of central vascular catheters showed a high level of knowledge and practice after the program was implemented compared to their preintervention level.

Cooper (2019) supported the current finding in a study entitled "Improving nurses' knowledge of central line-associated bloodstream infection." Cooper's study reported a mean pretest score of 72.1. The mean score for the posttest was 94.1. Comparison of pre- and post-test scores shows an increase in test scores of 22 percent that conclude a pronounced improvement of nurses' knowledge.

The findings of the current study also supported by *Borgret, Goossens, and Dongelmans (2015),* who reported a systematic review regarding "what are the effective strategies for the implementation of care bundles on ICUs." Borgret and colleagues reported that the three most effective strategies were education, reminders, audit, and feedback. These findings are supporting the first research hypothesis.

The current study also reported a highly statistically significant difference of pre/post compliance regarding practices related to insertion and maintenance care that included assisting in CVC insertion, blood sample withdrawal, medication and fluid administration, CVP measurements, CVC removal, and management of complication. This finding might reflect the improvement in nurses' knowledge and the motivation to adopt the care bundle; it is specific, relevant, systematized, and easily performed. This finding may also value the follow up done using the follow-up sheet that facilitates the tacking of nurses' compliance and also to the poster educational sessions.

Evidence supported the current study finding that the education of health care personnel is a crucial factor for compliance to infection prevention effort, which is supported by level I evidence *(Dumont & Nesselrodt, 2012; Marschall et al., 2014; APIC, 2015). Margolin, Robinson, D'Andrea and Doyle (2011)* reported a study finding of four hospitals with a target of very low or zero CLABSI incidence. The study revealed a commonality that all four organizations required CLABSI education beyond a standard orientation. The use of a pre and post-test approach in the training of staff has been well supported by evidence and seems to be necessary to improve efforts at the care site to prevent CLABSI *(Cooper, 2019).* Maintenance of knowledge and skills should be an ongoing process, and it is recommended that it should be updated every three years *(Awad et al., 2017).*

Ista et al. (2016) conducted a meta-analysis of 96 studies of CLABSI prevention programs and found that adherence to the established guidelines was only assessed in approximately one-third of the studies, but that compliance was suboptimal in each study dealt with that subject. It was the case in the current study before CVC care bundle implementation. As the mean score of compliance was lower than the post-test with a highly statistically significant difference between the two phases. *Sengupta, Iawim, and Mukhim (2018)* reported similar findings of central line-associated bloodstream infection care bundle adequate practice were 22%, and inadequate practice was 78%.

Also, *Cooper (2019)* reported that the CVC care bundle had not been followed consistently. Thus, training regarding the CLABSI bundle was a significant component of the nursing education provided in Cooper's research. Compliance has been recognized as a problem requiring additional training *(The Joint Commission, 2013).* Implications from this study's findings include the potential for improving patient outcomes and saving lives as CLABSI is the most expensive nosocomial infection, and it is significantly associated with increased death risk. Meanwhile, it is most often preventable if health workers have appropriate care and maintenance *(Haddadin & Regunath, 2019).* The younger age and the higher qualification of ICU staff nurses in the current study besides the fewer years of their experience in the researcher point of view give a rationale to the improvement in their knowledge, compliance level, and the improvement in patients outcomes. They were young, highly qualified, had a little experience that reinforces them to apply this new concept. The current study finding is supporting the second research hypothesis.

The patients' outcomes in the current study were assessed on a group of 250 critically ill patients with a mean age of 56.20±6.93, more than three-quarters of them were males admitted at the study setting over 12 months. The study surveyed the ten most possible complications that might be associated with the insertion and management of CVC. Those are signs of infection, bleeding, hematomas, thrombosis, air embolism, ischemia, extravasation, catheter migration, and catheter fracture. The most common complication was the frequency of the signs of infection, with a highly statistically significant difference between the study and control group regarding the frequency of complications after the implementation of the CVC care bundle. This finding evidenced the effectiveness of the care bundle applied in the current study.

Consistent with the current study, *Jennifer and Venkatesan (2018)* emphasized that the care bundle is a new concept in critical care, which is currently being promoted by the National Health Service Modernization Agency for Critical Care. The theory behind care bundles is

that when several evidence-based interventions are grouped in a single protocol, it will improve patient outcomes. Congruent with the current study findings *Dumont & Nesselrodt, (2012); Marschall et al. (2014); APIC, (2015)* indicated that ensuring the nursing compliance with established care bundle that consists of several interventions have shown to improve outcomes when implemented together. These practices are supported by level I evidence to reduce the incidence of CLABSI *(Barsuk et al., 2009; Institute for Healthcare Improvement, 2017).*

CLABSI bundle elements are introduced at 103 ICUs in Michigan, resulting in a sixty-six percent reduction in infection rates that are expected to save 30,000 lives per year *(Johns Hopkins Medicine, 2009).* Another study reported that the CLABSI bundle education resulted in one hospital achieving a CLABSI rate of zero in 2014 and maintaining it throughout 2015 *(Yaseen et al., 2016).*

Another hospital registered a reduction in CLABSI levels from 7.9 to 1.7 after bundle teaching, and compliance was initiated *(Cooper, 2019).* The bundle adopted in the Surgical Intensive Care Unit by another hospital, and the rate of CLABSI decreased by 68 percent *(Sacks et al., 2014).* The use of the CLABSI bundle is, therefore, endorsed as an evidence-based strategy to reduce infections of the central line *(The Joint Commission, 2013; Perin et al., 2016).* This finding is concluding that adherence to the bundle can improve patient outcomes by reducing or even eliminating the incidence of CLABSI.

The bundled strategy has already shown its efficacy in enhancing clinical outcomes (*Berenholtz et al., 2004*). *Resar et al.* (2005) showed that ICUs with the highest bundle compliance adherence had the highest infection reduction rate. *Pronovost et al. (2006)* showed that the introduction of the central line care bundle has resulted in a significant reduction in infection rates (up to 66%) over the 18-month study period. Positive results can be achieved by enhancing the efficiency of care procedures to ensure that patients provide all evidence-based treatments needed. Care bundles constitute a part of multiple patient safety programs at hospitals and ICUs around the world and are widely accepted at ICUs today.

Similar findings revealed by *Lavallee, et al. (2017),* who reported "effects of care bundles on patient outcomes: a systematic review and meta-analysis." They reported that the relative risk of adverse patient outcomes from controlled before-after studies favored the care bundle treated groups [RR=0.66 (95% CI 0.59 to 0.75; 119,178 participants)]. Lavallee and colleagues added that studies evaluating the effects of care bundles on the incidence of central line-associated bloodstream infections, pressure ulcers, and ventilator-associated pneumonia might have the most substantial reductions in the risk of adverse patient outcomes.

In the same context, *Lee et al. (2018)*, in a study about the "effect of central line bundle compliance on central line-associated bloodstream infections," reported direct evidence that completing all central line bundle components is essential for preventing CLABSIs. Lee et al., emphasized that customized education should be provided, according to specific weaknesses of bundle performance. *Tang et al. (2014)* reported, "the impact of central line insertion bundle on the central line-associated bloodstream infection." The findings revealed a CLABSI rate reduction from 1.65 per 1000 catheter-day during the preintervention period to 0.65 per 1000 catheter-day on the post-intervention period at ($p=0.039$). *Fortunatti (2017)* reported, "the impact of two bundles on central catheter-related bloodstream infection in critically ill patients." The study revealed an improvement in compliance rate with care bundle from 62.9% to 94.7% with a statistically significant difference regarding the rate of central catheter infection (3.48 vs. 1.52 x 1000 days/catheter, $p<0.05$) between the control and study periods.

Contradicting to the current study results, *Salama, Jamal, Al Mousa, and Rotimi, (2015),* who reported findings of "implementation of central venous catheter bundle in an intensive care unit in Kuwait: Effect on central line-associated bloodstream infections." The study revealed 80 CLABSIs in surveying 5367 recorded catheter-days during the pre-intervention period for an incidence rate of 14.9 CLABSIs per 1000 catheter-days. After the implementation of the interventions, there were 5052 catheter-days and 56 CLABSIs, for an incidence rate of 11.08 per 1000 catheter-days. The reduction in the CLABSI/1000 catheter days was not statistically significant ($P = 0.0859$).

Also, *Ray-Barruel et al. (2019)* reported the findings of a systematic review regarding the "effectiveness of insertion and maintenance bundles in preventing peripheral intravenous catheter complications and bloodstream infection in hospital patients." The review displayed the results of 13 studies; 12 of them reported a reduction in phlebitis and bloodstream infection, and only one study recorded no change in bloodstream infection and an increase in the phlebitis rate. The methodological quality of all studies ranged between "low" and "fair" thus concluded that the effect of care bundles on PIVC complications and bloodstream infection rates remains uncertain.

Yoshida, Silva, Simoes, and Guimaraes (2018) reported, "The incidence of central venous catheter-related bloodstream infections: Evaluation of bundle prevention in two intensive care units in central Brazil." The study reported a non-significant reduction in the incidence density of CVC-BSIs after bundle implementation in ICUs, suggesting the need to review the process, as well as continuing education for staff in compliance and correct application of the bundle. The discrepancy between the current study findings and the previous studies might be due to different sample sizes, study settings, and different bundle protocols.

Perin et al. (2016) conducted a systematic review of evidence-based measures to prevent central line-associated bloodstream infections. They concluded that care bundles combined with education and commitment from both staff and institutions are a strategy that can contribute to lower rates of central-line bloodstream infections among adult patients admitted to intensive care units. Improving

awareness of CLABSI among nurses and knowledge of their impact on this issue may reduce the incidence. Nurses who recognize a problem are more likely to support new interventions and understand the benefits of changed behavior *(Peyrot & Rubin, 2007)*. In this way, they improve the outcomes within the community *(Cooper, 2017),* which is supporting the third research hypothesis.

7. Conclusion

This study concluded that there was a statistically significant difference between pre and post-test nurses' knowledge and compliance regarding the CVC care bundle. The patients' outcomes were also improved significantly after the application of the CVC care bundle compared to the controls that supported the current research hypotheses.

8. Recommendations

Based on the current study findings, the following can be recommended:

- Adopting the current recommendations that should be disseminated and updated following the international organizations for evidence-based practices for successful central line-associated bloodstream infection (CLABSI) prevention and to train all personnel and to assign care and maintenance for central lines only to those who exhibit competence.
- Continuous efforts should be made to potentially address the identified gaps in practice and periodically reported and investigated it.
- Policies and protocols should be regularly examined and being accessible to the health care team. Consider additional training regarding CVC for newly hired nurses, especially those working with critically ill patients. Also, support the CVC care bundles with adequate resources for the facilitation of adherence to evidence-based practices.
- Incorporating the current research methodology on a broader scale is also recommended.
- Further research is needed to determine the best approach for implementing the care bundle to achieve high compliance rates, to examine the impact of implementation approaches on compliance levels, to incorporate rigorous study methods, or to enhance quality research. Studies utilized randomized designs should be considered to increase the internal and external validity, especially when the intervention is considered for widespread implementation.

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