

Effect of Care Bundle Education Program on Nurses' Performance Regarding Central Line-Associated Blood Stream Infection in High Risk Neonates

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ABSTRACT

Context: Catheter-related bloodstream infections are the most common type of nosocomial infections among those populations. Central line-associated bloodstream infection (CLABSI) is a preventable complication of the use of CVC.

Aim: This study aimed to evaluate the effect of the care bundle education program on nurses' performance regarding central line-associated bloodstream infections in high-risk neonates. Through the following: assessing nurses' knowledge and performance regarding central line-associated bloodstream infection in high-risk neonates, designing, implementing and evaluating the effect of the care bundle education program on nurses' performance regarding central line-associated bloodstream infection in high-risk neonates.

Methods: A quasi-experimental (pre/post-test) design was utilized to conduct this study at neonatal intensive care units affiliated to Ain Shams University Hospitals and Teaching Hospitals in Cairo. A convenient sample of forty-five 45 nurses was included in the study as a single study group. A structured interview questionnaire, nurses' observation checklists were used to evaluate the effect of care bundle education on nurses' performance regarding central line-associated bloodstream infection in high-risk neonates. The care bundle education program was premeditated as reference guidelines for nurses.

Results: There were statistically significant differences between mean scores of the pre and post-test as regards nurses' knowledge and practices regarding central line-associated bloodstream infection in high-risk neonates.

Conclusion: The study revealed an unsatisfactory knowledge as well as an incompetent practice among nurses regarding central line-associated bloodstream infections in high-risk neonates before the care bundle education program. The research hypotheses are supported, and the care bundle education program achieved a significant improvement in nurses' knowledge and performance regarding CLABSI in high-risk neonates. The current study recommended establishing educational centers in all hospitals for educating and updating the knowledge and performance of new nursing staff working in NICUs and supporting them by instructional brochure and illustrative booklets.

Keywords: Bundle of care, central line-associated bloodstream infection, nurses' performance

1. Introduction

High-risk neonates at neonatal intensive care units (NICUs) are the most venerable group of the population as they are susceptible to various nosocomial infections *American Academy of Pediatrics (2019)*. Central line-associated bloodstream infections (CLABSIs) are the most common type of nosocomial infections among those populations. The use of central venous catheters (CVC) and peripheral venous catheters (PVC) has been recognized as an independent factor for late-onset sepsis in high-risk neonates.

However, umbilical venous catheters (UVC) and peripherally inserted central venous catheters (PICC) are lines increasingly used for administering intravenous fluids, blood products, medications, and total parenteral nutrition. Besides, monitoring central venous pressure and considers one of the steppingstones in the improvement of care for high-risk neonates at NICUs (*Cho & Cho 2018*).

Healthcare-associated infections (HAIs) result in

significant morbidity and late mortality among high-risk neonates, particularly premature ones. Almost 25% of very low birth weight (VLBW, <1,500-g) neonates are experiencing more than one episode of nosocomial infection, which is a significant threat. Risk factors for HAIs in the NICU including prematurity, low birth weight, invasive procedures, indwelling vascular catheters, endotracheal tubes, ventricular shunts, parenteral nutrition with lipid emulsions, alterations in the skin and mucous membrane barriers, broad-spectrum antibiotics, and prolonged hospitalization (*Stevens & Schulman, 2012*).

Central line-associated bloodstream infections (CLABSIs) are one of the most common types of HAIs occurring amongst high-risk neonates in the NICU. It considers a primary bloodstream infection that develops within the first 48 hours following the insertion of the central venous catheter (CVC) and before the development of infection in neonates. It is the most important complication that is associated with CVC consumption in critical care (*Sol et al., 2018*).

Risk factors for CLABSIs include: first, the catheter insertion site can work as a port of entry for organisms.

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In this case, endogenous skin flora of neonates and extrinsic organisms from healthcare workers' hands or even from contaminated disinfectants are potential sources. Second, during catheter hub operation, it can be contaminated with organisms from the neonates' skin flora or healthcare workers' hands. Third, fluids or drugs can be contaminated during the preparation process or the manufacturing process of the company. Finally, there may be a secondary infection that causes catheter infection due to hematogenous dissemination of infection in other parts of the body (Schmid & Gudrun, 2018).

CLABSIs are estimated to cause up to 70% of all hospital-acquired bloodstream infections in high risk and preterm infants. However, late-onset sepsis is caused by central venous catheters (CVCs) occurring after birth in 20%–36% of VLBW neonates (Rosado *et al.*, 2018). Also, premature infants who experience catheter-related infections have sharply increased the risk of a high mortality rate, poor growth, and neurodevelopmental outcomes, as well as prolonged hospital stay, leading to increased medical costs. Therefore, more efforts are needed to reduce the incidence of CVC-related infections among high-risk neonates at the NICU and to enhance their survival and prognosis as CLABSI is mostly preventable (El-Sol & Badawy, 2017).

The etiological organism of CLABSI is similar to that among adults, but the proportion of gram-negative organisms such as *Klebsiella pneumoniae*, *E. coli*, and *Enterobacter cloacae* is relatively increased in high-risk neonates in the NICUs. This increased risk is due to increased bacterial translocation from the gastrointestinal tract, especially in high-risk neonates receiving long-term parenteral nutrition, which is associated with impaired bowel wall function and primary mucosal pathology, gastrointestinal surgery or lack of enteral nutrition. While gram-positive bacteria, including *CONS* and *Staphylococcus aureus*, are more important in developed countries, gram-negative bacteria are found more often in developing countries (Cho & Cho 2018; Rosado *et al.*, 2018).

The Center for Disease Control and Prevention (CDC) has published evidence-based guidelines to prevent the occurrence of CLABSI. A central line insertion bundle guidelines including main topics as staff education and training, hand hygiene, skin antiseptic, selection of catheter site, type of catheters, dressing change, use of the antiseptic solution, administration of total parenteral nutrition, changing the intravenous fluid and blood set, administration of IV fat emulsions and use of antibiotics (Centers for Disease Control and Prevention (CDC), 2017). Implementation of CLABSI prevention guidelines contributes to a significant reduction in the rate of infection. Therefore, the level of implementation by nurses internationally is uncertain. Overall, Garland *et al.* (2018) estimate that up to 67% of CLABSIs in NICU neonates are attributable to luminal care of the catheter rather than care of the catheter site or extraluminal colonization.

Bundle approaches and evidence-based clinical practices are primarily accomplished by effective measures during the insertion and maintenance of central catheters to reduce the incidence of CLABSIs in high-risk neonates at NICUs (Shin *et al.*, 2016). Continuous training and education of medical staffs are one of the most important preventive strategies for central line-associated bloodstream infections (CLABSIs) required at each stage from before insertion to the removal of the catheter. Commonly, chlorhexidine is used as a skin antiseptic in adults before catheter insertion and dressing change; conversely, it is not approved for infants <2 months of age as no recommendation can be made for the safety or efficacy of chlorhexidine in those infants.

However, it is ordinarily used in various neonatal intensive care units owing to the deficiency of alternatives. On the other hand, Chlorhexidine-impregnated dressing and bathing are optional for adults but cannot be recommended to neonates. Appropriate replacement intervals for dressing and administration sets are similar to those recommended for adults. However, the umbilical arterial catheter should not be used for more than five days and the umbilical venous catheter for 14 days of hospital stay. Generally, continuous efforts are suggested to develop effective and safe strategies of infection control for high-risk neonates and young infants (Garland *et al.*, 2018; Aloush & Al saraireh, 2018).

Best practices to prevent CLABSI in high-risk neonates can be hosted singly or as a group or bundle of care practices. However, prevention of CLABSI is a complex process that may drop at any one of many steps from lack of sterility during catheter insertion or utilization of the catheter exit site. Moreover, from incompetent dressing change to contamination of the catheter hub or intravenous tubing during the change of IV fluid. Hence, the application of the bundle of care intended to focus on improved care at multiple steps of the complex process. Although, there is now sufficient literature supporting the use of a bundle of care while there are few data comparing interventions of single versus a bundle of care practices. Nevertheless, supporting the use of evidence, bundled care practices have become a common strategy to reduce CLABSI at NICU (Stevens & Schulman, 2012).

Neonatal nurses in NICUs have the most direct and continuous role in performing care maintenance of the CVC insertion site procedures, and they should be experienced and compliant with supportive care measures in the insertion and maintenance of central lines. Therefore, they are well-positioned to implement the recommendations and have a unique chance to contribute to the primary prevention of these infections via evidence-based best practices (Shah & Muhammad, 2017). Statistics have been conveyed in several surveys in many countries concerning the level of knowledge, performance, and the degree of evidence-based practice guidelines among the nurses works in NICUs. Moreover, nurses are essential to improve the proper use of the central venous catheter, profound knowledge, and attaining this evidence will contribute to

advance anticipatory programs in order to decrease the incidence of CLABSIs in the NICUs (*El bilgahy et al., 2016*).

2. Significance of the study

The prevalence of central-line associated bloodstream infections amongst adult ICUs patients ranged from 1.6 to 44.6 cases per 1,000 central line days, while in high-risk neonates at NICU are varied from 2.6 to 60.0 cases per 1,000 central line days. Besides, the mortality rate fluctuating from 2.8 to 9.5. Central line-associated bloodstream infections mainly considerably contribute to nosocomial sepsis in a tertiary NICU. Several aspects of care for the central line have been implemented to decrease the incidence of central line-related infections. However, care bundle approaches have been shown to have the peak vintage (*Abbadly et al., 2019*).

Nurses' adherence to evidence-based clinical practices is very imperative for minimizing the incidence of CLABSI and improving high-risk neonates' outcome. However, numerous studies have conveyed the impact of the care bundle approach in infection control among various age groups is one of the main hindrances for implementing the evidence-based nursing practice. Furthermore, previous researches have reinforced the nurses' performance about the prevention of CLABSI among adults. However, few studies dedicated to the nurses' knowledge and performance related to CLABSI in high-risk neonates at NICUs. Therefore, the main goal of this study was to evaluate the effect of the care bundle education program on nurses' performance regarding central line-associated bloodstream infections in high-risk neonates.

3. Aim of the study

This study aimed to evaluate the effect of the care bundle education program on nurses' performance regarding central line-associated bloodstream infections in high-risk neonates. This aim was achieved through:

- Assessing nurses' knowledge and performance regarding central line-associated bloodstream.
- Designing, implementing and evaluating the effectiveness of the care bundle education program on nurses' performance regarding central line-associated bloodstream infection in high-risk neonates.

3.1. Research hypotheses

- Nurses who are exposed to the designed care bundle education regarding central line-associated bloodstream infections will exhibit improved knowledge compared to their preintervention level.
- Nurses who are exposed to the designed care bundle education regarding central line-associated bloodstream infection will exhibit improved practice compared to their pre-intervention level.

3.1. Operational definition

Nurses' performance

The Nurses' performance in this study is intended to assess nurses' knowledge and care practices.

4. Subjects & Methods

4.1. Research design

A quasi-experimental design (pre/post-test design) used to achieve the aim of the study. Quasi-experimental research is parallel to experimental research in that there is a guidance of an independent variable. It varies from experimental research because either there is no control group, no random selection, no random assignment, or no active manipulation (*Atia, 2020*).

4.2. Research setting

This study was conducted at Neonatal Intensive Care Units (NICUs) affiliated to Ain Shams University Hospitals and Teaching Hospitals, Cairo, Egypt.

4.3. Subjects

A convenient sample of forty-five nurses was with various educational categories represented. They were distributed over the three shifts. All nurses employed in order to establish the care bundles education program throughout the 24-hour working time to affect the high-risk neonates' outcomes positively.

4.4. Tools of the study

Three tools were used for data collection:

4.4.1. A Structured Interview Questionnaire

It was designed by the researchers based on *El bilgahy et al. (2016)*; *Abbadly et al. (2019)*; *CDC, 2017*). It was designed in a simple Arabic language to assess nurses' knowledge regarding CLABSIs in high-risk neonates. It included three main parts, which include the following parts:

Part I concerned with socio-demographic characteristics for studied nurses such as age in years, qualifications, experience years, and attendance of previous training courses about CLABSIs in high-risk neonates.

Part II encompassed nurses' knowledge assessment questionnaire. It included three main parts.

The first part was related to assessing the knowledge regarding central venous access device (CVAD) insertion site, types of CVC catheters, indications of CVC, and mechanical complications associated with CVC (5 MCQs). The second part concerned with assessing the nurses' knowledge regarding nursing care related to CVC Insertion (pre, during, and post). It included (3 open-ended questions). The third part involved the assessment of nurses' knowledge regarding CLABSIs in high-risk neonates. It included (6 open-ended questions).

This tool used pre-and post-implementation of the care bundle education program. Time expended to fill in the questionnaire by nurses was 30-40 minutes. Reliability was tested using Cronbach's test; it was 0.78.

Scoring system

The tool scored as one score for the correct answer and 0 for an incorrect answer for MCQs. A subtotal score summed for each part separately. The subtotal scores categorized into satisfactory knowledge if the subtotal score was $\geq 75\%$ of the total items' score of the section and unsatisfactory level of knowledge if the subtotal score of each part was less than 75%. Open-end questions included one or more correct answers. Each one got a score of 1. The complete, correct answer was given one score, incomplete or incorrect answer scored as 0. It summed as a total divided by its question to get the mean score of this part.

4.4.2. Nurses' Observation Checklists

It was developed by the researcher based on (Cho & Cho, 2018; El bilgahy et al., (2016); Abbady et al., (2019); CDC, (2017) to assess the actual nurses' practices regarding assisting in CVC insertion and maintenance care procedures. This tool included seven practice checklists designed as done competently or incompetently done. The items were the steps or techniques to be carried out while performing the care of high-risk neonates with a central line catheter.

The checklists covered the actual nurses' practices of hand hygiene (5 steps), maintain sterile aseptic technique on assisting in CVC insertion and care (15 steps), and wearing protective barriers (5 steps). Besides, dressing change (15 steps), aspiration of blood sampling from CVC (15 steps), and nursing role (before, during, and after) assisting in CVC insertion (45 steps) as well as nurses' practices regarding CLABSIs care bundle components describe the component were (20 steps). This tool used twice pre and post-implementation of care bundle education program. The reliability of the observation checklists was determined using the inter rater-observer method among ten nurses in the NICU. Cronbach alpha was $r=0.81$.

Scoring system

Each performance step was estimated either one score for competently done and zero for incompetently done or not done. A subtotal score for each subset of checklists summed and divided by its number to obtain a mean score for each subset. $\geq 85\%$ represents a competent level, and less than 85% considered a competent level of practice.

4.5. Procedures

The researchers developed the data collection tools after an extensive review of related recent literature. Five experts in the field of neonatal nursing reviewed the instruments for content validity. Tool modifications were done according to the panel judgment on the appropriateness of the content, clarity of sentences, and sequence of items.

The studied nurses had the choice to participate in the study. Also, nurses had the right to withdraw at any time

from the study. The study had no adverse effect on the studied high-risk neonates. The researchers were certifying complete privacy and confidentiality.

A pilot study for testing the feasibility of the research process, clarity, and the applicability of the study tools is applied to 10% of the sample size. They were five nurses caring for high-risk neonates with a central line. The subjects of the pilot study were excluded from the study sample finally.

Preparatory phase: An official agreement was achieved from official personnel in the study settings where a clear description was given about the nature, significance, phases, and anticipated outcomes of the study.

Fieldwork achieved in 4 weeks for each group entailed from 5-6 nurses in each set, including one week for pretest followed by two weeks for implementation of care bundle education program (one week for the theoretical part and another week for the practical part) followed by one week for posttest.

The fieldwork was carried out from the first week of August 2019 to the end of January 2020 for data collection and care bundle education program. The researchers were available at the previously mentioned study settings by rotation, two days/week for each research settings during the morning and afternoon shifts as it is the time of work capacity and routine nursing care procedures implementation for high-risk neonates at NICUs.

The researchers have introduced themselves and gave clarification regarding the aim of the study, and the anticipated outcomes were clarified for the studied sample, each nurse was interviewed individually after taken their consent to participate in the study. The interview questionnaire sheet was filled in by the studied nurses in the presence of the researchers to simplify any questions from the nurses related to the questionnaire form while their practices were evaluated during their actual care provided for high-risk neonates with a central line using observational checklists.

Planning and implementation phase: The researchers were distributed two sessions to cover the theoretical part and four sessions for practical procedures as regards CLABSI in high-risk neonates. For the education, each session took 45-60 minutes for theoretical session or demonstration and re-demonstration according to the nurses' readiness. The care bundle education program was applied by the researcher using a clarified Arabic booklet that involved clear guidelines in improving nurses' knowledge and practices regarding CLABSIs in high-risk neonates.

Follow up observation sheet to follow nurses' practices of 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 competent level 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' practices in each visit to the study settings using a follow-up observation sheet. This sheet gave immediate feedback to the actual practice of staff nurses with the care bundle that when the overall practices are reduced, an action took to improve practice level. A poster educational session was scheduled when indicators revealed a lower competency level to enhance the care bundle protocol.

The researchers were conducting an educational session regarding the care bundle on four to six nurses in each study setting per month. The researchers used different teaching methods during the care bundle education program. It was included teaching sessions, group discussion, demonstration, and re-demonstration, as well as guiding booklets with colored pictures. The researchers used various teaching media such as watching videos, posters, PowerPoint presentations, and hand-out for prevention CLABSIs among high-risk neonates. Educational sessions are completed inside the nurses' classrooms affiliated to the NICUs at previously mentioned settings after the morning care and during the sleeping time of high-risk neonates.

The general objective of the care bundle education program was to improve nurses' performance regarding CLABSIs in high-risk neonates by providing the nurses' knowledge and practice. The specific objectives of the care bundle education program included the following:

- Identify the CVC catheter insertion site.
- Mention Types of CVC catheters.
- Describe indications of CVC.
- Mention mechanical complications associated with CVC.
- List the source of infection related to healthcare-associated infection (HAIs).
- Enumerate causes and predisposing factors.
- Describe complications of CVC.
- Discuss nursing intervention before, during, and after insertion of CVC.

Content of the care bundle education program was designed by the researchers according to the previously mentioned objectives. The theoretical content of the program included CVC catheter insertion site, types of CVC catheters, indications of CVC, and mechanical complications associated with CVC. It also included nursing care of neonates with CVC before, during, and after insertion of CVC as well as CLABSIs in high-risk neonates that included definition, source of infection, causes and predisposing factors, clinical pictures, complications, and nursing care.

The practical content of the care bundle education program was included: hand hygiene, maintain sterile aseptic technique of CVC insertion and care, wearing a protective barrier, dressing change, aspiration of blood sampling from CVC, and nursing role (before, during, and after) insertion of CVC as well as nurses' practices

regarding CLABSIs bundle of care components were also included.

Evaluation phase: The researchers assigned one week to evaluate the outcome of the care bundle education program on nurses' knowledge and practices regarding CLABSIs in high-risk neonates. Nurses are assessed for all practical part during their actual care of high-risk neonates. The researchers using the same study tools of the assessment phase immediately after the care bundle education program (post-test).

4.6. Data analysis

The data were collected, organized, revised, coded, tabulated, and analyzed by using the Statistical Package for Social Science (SPSS) version 20. Quantitative data were presented as a number, percentage, mean, and standard deviations. The comparison between quantitative data pre and post of care bundle education program was made by using paired t-test. The correlation coefficient test was used to set the correlation between the study variables. The p-value was considered significant as the following: $P > 0.05$ (Non-significant), $P \leq 0.05$ (Significant) and $P \leq 0.01$ (Highly-significant).

5. Results

Table 1 shows that less than half 40.0% of studied nurses their age was ranging from 20 to less than 25 years while the minority 6.7% of them were in the age group less than 20 years with mean age 25.69 ± 4.24 year. Furthermore, approximately two-thirds of them (60.0%) had a diploma in nursing (secondary schools). Concerning the years of experience, the present study represented that the majority (91.1%) of studied nurses had 1 to less than five years of experience with mean years of experience 2.73 ± 1.88 years.

Figure 1 illustrates that more than two thirds (73.3%) of studied nurses did not receive any training courses about CLABSIs in high-risk neonates.

Table 2 recognizes a highly statistically significant improvement in total nurses' knowledge regarding central venous catheter (CVC) post-test compared to their pre-care bundle education program at $p=0.000$. Regarding all components of CVC, including CVC catheter insertion site, types, duration of use, indications, and mechanical complications paralleled to pre-care bundle education program.

Table 3 clarifies a definite improvement in total nurses' knowledge concerning the care of high-risk neonates with CVC post-test 12.67 ± 2.16 compared to the pre-care bundle education program 5.80 ± 1.24 , which reflected a high statistical significance difference $p=0.000$.

Table 4 concerns with the comparison between mean scores of nurses' knowledge concerning CLABSIs in high-risk neonates' pre and post-care bundle education program, table, 4 shows highly statistically significant differences between mean scores of the pre and post knowledge scores as regards definition, source of infection, causes and predisposing factors of CLABSIs, clinical pictures,

complications, and nursing intervention and also between the total mean scores of nurses' knowledge pre and post-care bundle education program.

Table 5 demonstrates a definite enhancement in the total nurses' knowledge post-care bundle education program concerning the central venous catheter and CLABSIs in high-risk neonates. The total mean score of nurses' knowledge was 24.71±5.95 pre-tests compared to a 54.96±8.96 post-care bundle education program that specifies significant statistical difference with $p < 0.001$.

Table 6 demonstrates a marked improvement in total mean scores of nurses' practices regarding assisting in CVC insertion, care, and maintenance post-test 67.84±7.14 compared to the pre-care bundle education program 29.24±11.19 that demonstrated profoundly highly statistical significance difference $t = 20.438$, $p = 0.000$.

Table 7 indicates the mean scored of nurses' practices regarding CLABSIs care bundle components pre and post-

test education programs. This table was clarified that the total mean score of nurse's practices pre-test was 17.49±6.06. On the other hand, the immediately post-care bundle education program was improved to 41.80±2.63 correspondingly with a statistically significant difference regarding all nurses' practices and the total.

Table 8 reveals a noticeable improvement in the total nurses' practices post-care bundle education program regarding assisting in CVC insertion, care, maintenance, and CLABSIs in high-risk neonates. The total mean score of nurses' practices was 46.73±15.03 pre-test compared to the 109.64±9.49 post-care bundle education program that directs a highly statistically significant difference t-test =25.213 with $p = < 0.001$.

Table 9 shows a positive, statistically significant relationship between total knowledge and total practice of nurses pre/post the care bundle education program.

Table (1): Frequency and percentage distribution of socio-demographic characteristics of the studied nurses in the NICU.

Nurses' Characteristics	Total Number = 45 (100%)	
	No.	%
Age in years		
<20 years	3	6.7
20-<25 years	18	40.0
25- <30 years	15	33.3
≥30 years	9	20.0
Mean±SD		25.69±4.24
Education		
Diploma in nursing (secondary school)	27	60.0
Technical Institute of nursing	12	26.7
Bachelor degree in nursing	6	13.3
Year of Experience		
1-<5	41	91.1
5 – <10 years	3	6.7
10 – <15 years	1	2.2
≥15 years	0	0.0
Mean±SD		2.73±1.88

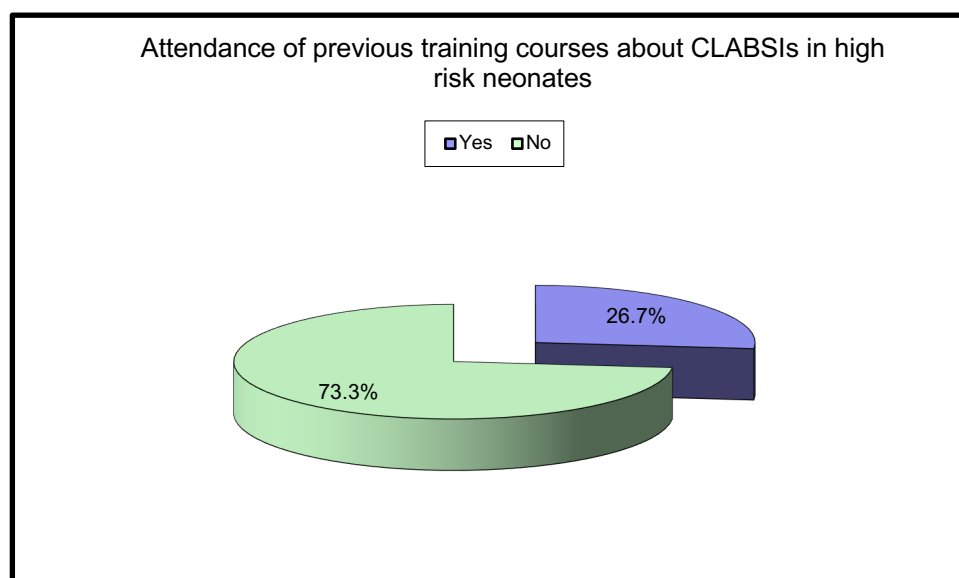


Figure (1): Percentage distribution of the studied nurses' attendance of previous training courses about CLABSIs in high-risk neonates.

Table (2): Comparison of nurses' knowledge regarding central venous access device (CVAD) pre/post the care bundle education program.

Nurses' knowledge	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
CVC catheter insertion site			
Pre	1.93±0.65		
Post	4.07±0.94	-11.941	0.000
Types of CVC catheters according to the purpose and duration of use			
Pre	1.91±0.60		
Post	4.13±1.08	-12.382	0.000
Use of PICC catheter when the duration of use exceeds six days			
Pre	1.84±0.77		
Post	4.09±1.08	-11.745	0.000
Indications of CVC			
Pre	1.91±0.63		
Post	4.2±1.01	-14.514	0.000
Mechanical complications associated with CVC			
Pre	2.04±0.77		
Post	4.18±0.96	-13.817	0.000
Total Mean Scores of Nurses' Knowledge			
Pre	9.64±2.53		
Post	20.67±4.28	-16.813	0.000

Table (3): Comparison of nurses' knowledge regarding nursing care of central venous catheter pre/post the care bundle education program.

Nurses' knowledge	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
Nursing role before insertion of CVC			
Pre	1.96±0.60		
Post	4.29±0.97	-13.633	0.000
Nursing role during insertion of CVC			
Pre	1.98±0.50		
Post	3.96±0.80	-12.840	0.000
Nursing role after insertion of CVC			
Pre	1.87±0.59		
Post	4.42±0.84	-17.319	0.000
Total mean score of nurses' knowledge			
Pre	5.80±1.24		
Post	12.67±2.16	-18.554	0.000

Table (4): Comparison of nurses' knowledge regarding CLABSIs in high-risk neonates pre/post the care bundle education program.

Nurses' knowledge	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
Definition of CLABSIs			
Pre	1.36±0.679		
Post	3.64±0.609	-16.258	0.000
Source of infection related to healthcare-associated infection (HAIs)			
Pre	1.6±0.654		
Post	3.64±0.802	-14.400	0.000
Causes and predisposing factors increase the risk of CLABSIs			
Pre	1.38±0.747		
Post	3.58±0.753	-11.942	0.000
Clinical pictures			
Pre	1.67±0.707		
Post	3.62±0.614	-12.317	0.000
Complications			
Pre	1.4±0.78		
Post	3.64±0.802	-11.585	0.000
Nursing Intervention regarding decrease risk of CLABSIs			
Pre	1.87±0.588		
Post	3.49±0.815	-9.597	0.000
Total mean scores of nurses' knowledge			
Pre	9.27±3.187		
Post	21.62±3.614	-15.154	0.000

Table (5): Comparison of total nurses' knowledge regarding central venous catheter and CLABSIs in high-risk neonates pre/post the care bundle education program.

Nurses' knowledge	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
Total mean score of nurses' knowledge			
Pre	24.71±5.95		
Post	54.96±8.96	18.419	<0.001

Table (6): Comparison of nurses' practices regarding assisting in CVC insertion care and maintenance pre/post the care bundle education program.

Nurses practices	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
Hand hygiene			
Pre	2.00±1.04		
Post	4.82 ± 0.54	16.999	0.000
Maintain sterile aseptic technique of CVC insertion and Care			
Pre	2.00±0.88		
Post	4.80±0.55	18.532	0.000
Wearing protective barriers as a face mask, sterile gloves, and sterile gowns			
Pre	1.98±0.94		
Post	4.80±0.63	16.696	0.000
Dressing change			
Pre	2.04±0.99		
Post	4.73±0.78	16.696	0.000
Aspiration of blood sampling from CVC			
Pre	4.02±1.94		
Post	8.87±0.87	15.096	0.000
Nursing role before insertion of CVC			
Pre	5.67±2.41		
Post	13.22±1.99	16.787	0.000
Nursing role during the insertion of CVC			
Pre	5.76±2.51		
Post	13.22±1.91	16.189	0.000
Nursing role after insertion of CVC			
Pre	5.78±2.69		
Post	13.38±1.96	16.331	0.000
Total mean scores of nurses' practices			
Pre	29.24±11.19		
Post	67.84±7.14	20.438	0.000

Table (7): Comparison of nurses' practices regarding CLABSIs care bundle components pre/post-education program.

Nurses' practices	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
Training and education of medical staff about CVC Insertion and maintenance Care			
Pre	1.98±0.87	19.900	<0.001
Post	4.78±0.64		
Wearing maximum barrier precautions as a face mask, sterile gloves, sterile gowns, and sterile full-body drape			
Pre	2.00±0.85	19.123	<0.001
Post	4.78±0.56		
Skin disinfection with chlorhexidine, povidone-iodine, or 70% alcohol before CVC insertion and during dressing change			
Pre	1.84±0.98	18.558	<0.001
Post	4.82±0.54		
Use of sterile gauze or a sterile transparent semi-permeable dressing to cover the catheter site			
Pre	1.96±0.71	19.411	<0.001
Post	4.76±0.77		
Maintain sterile aseptic technique during dressing change every 48 hrs. or when clinically indicated			
Pre	3.76±1.64	18.923	<0.001
Post	8.87±0.87		
Standardize administration sets change for fluids every seven days and within 24 hrs for blood, blood products, or TPN			
Pre	3.93±1.76	17.505	<0.001
Post	8.96±0.64		
Disinfection of catheter hubs and changing the access lumens or devices			
Pre	2.02±0.97	15.875	<0.001
Post	4.84±0.52		
Total mean scores of nurses' practices			
Pre	17.49±6.06	26.797	<0.001
Post	41.80±2.63		

Table (8): Comparison of total nurses' practices regarding assisting in CVC insertion, care, maintenance, and CLABSIs pre/post the care bundle education program.

Nurses' practices	Studied nurses (no.=45)	Paired t-test	P value
	Mean±SD		
The total mean score of nurses' practices			
Pre	46.73±15.03	25.213	<0.001
Post	109.64±9.49		

Table (9): Correlation between total nurses' knowledge scores regarding CLABSIs and total practice scores.

Program phases	Total knowledge	Total practice	r-test	P value
	Mean±SD	Mean±SD		
Pre-program	24.71 ± 5.95	46.73±15.03	0.794	0.000
Post-program	54.96 ± 8.96	109.64±9.49	0.466	0.001

6. Discussion

CLABSI is a preventable complication of the use of CVC. Catheter practices, equipment, and staff training methods that are effective in decreasing CLABSI are available. An effective implementation to prevent CLABSI needs not only identification and training in the use of best practices for CVC insertion and care but also a considerate of the framework or unit culture into which those practices introduced (Stevens & Schulman, 2012).

Neonatal Nurses are considered to be the backbone in the prevention of CLABSI or CVC complications by applying standardized guidelines through sustaining the aseptic field during the insertion of CVC. Best practices are needed for the prevention of CLABSI in high-risk neonates. Therefore, the study aimed to evaluate the effect of the care bundle education program on nurses' performance regarding central line-associated bloodstream infections in high-risk neonates.

Concerning the socio-demographic characteristics of studied nurses, the current study revealed that nurses' age was varying from 20 to less than 25 years with mean age 25.69 ± 4.24 year denoted the highest percentage of the study sample. The finding parallel to *Bayoumi and Mahmoud (2017)*, whose study about "Effect of an education program on nurses' knowledge and practice regarding care of central venous line in pediatric hemodialysis." The study found that three-quarters of the nurses in their study were less than 25 years old with a mean age of 21.69 ± 4.24 years old.

Inappropriately, the findings of the current study clarified that the majority of studied nurses had one to less than five years of experience with mean years of experience 2.73 ± 1.88 years, and approximately two-thirds of them had a diploma in nursing (secondary schools). Also, the majority of them did not attend any previous training courses regarding CLABSI in high-risk neonates. This finding may be due to the fact that the secondary schools of nursing in Egypt delivered health care organizations with vast numbers of graduated diploma nurses and technical institutes than faculties of nursing.

The result is in contrast with *El bilgahy et al. (2016)*, who stated that approximately two-thirds of studied nurses having 10 years of experience, and three-quarters of them had a Bachelor in nursing while three quarters (73.3%) of nurses had not previously trained about CLABS in the pediatric field.

Additionally, *El-Sol and Badawy, (2017)* in a similar study about "The effect of a designed teaching module regarding prevention of central-line associated bloodstream infection on ICU nurses' knowledge and practice," who founded that most of the studied nurses who attended in-service training courses about infection control, their knowledge and practice increased. Nurse attendance of instructing courses and training programs, keeping them up-to-date, and enhancing their practices principally in applying the procedures that need strict aseptic techniques.

The current study results presented a significant improvement in nurses' knowledge regarding the central venous access device (CVAD) after implementing the care bundle education program with a highly statistically significant difference ($P=0.000$). Also, a noticed improvement in nurses' knowledge regarding all components of CAVD, including CVC catheter insertion site, types, duration of use, indications, and mechanical complications post compared to the pre-care bundle education program that reflected a significant effect of the bundle of care education.

In the same context, *El-Sol and Badawy (2017)* proved that there was a significant improvement in the nurses' knowledge post the implementation of the designed teaching module. The present study findings were in agreement with *Abbadly et al. (2019)*, who studies "the role of the bundle of care for improving nurses' performance related to the central line-associated bloodstream infection." The study informed that the majority of nurses had a sufficient level of knowledge and performance regarding CVC care components post the bundle of care

implementation, which achieved a marked improvement of nurses' knowledge.

The comparison of nurses' knowledge regarding nursing care of CVC before, during, and after insertion of CVC pre- and post-care bundle education program reveals a definite improvement in nurses' knowledge concerning the care of high-risk neonates with CVC post-care bundle education program (12.67 ± 2.16) compared to pre-implementation (5.80 ± 1.24) which reflected a highly statistical significance enhancement ($P=0.000$). This finding reflected the effectiveness of the CLABSI care bundle education program on nurses' knowledge. It was assisted them in learning more about how to prevent CLABSI in high-risk neonates.

This result was supported by *Aloush and Al sarairah, (2018)*, who study nurses' compliance with central line-associated bloodstream infection prevention guidelines. The study indicated that lack of nurses' knowledge and compliance with CLABSI prevention guidelines is one reason for the lack of nursing staff's poor performance. This finding was responded to the study from *El bilgahy et al. (2016)*, who evidenced significant improvement in nurses' knowledge and decline in the rate of CLABSI after implementation of nursing guidelines. Even though in the presence of a low nurse: patient ratio, which was redirected to the implementation of nursing guidelines efficacy on nurses' knowledge and performance as regards the prevention of CLABSI in PICU.

About the variances between mean scores of nurses' knowledge concerning CLABSIs in high-risk neonates pre- and post-care bundle education programs, the study results show highly statistically significant differences between mean scores of the pre and post knowledge scores. Improvement was regarding definition, source of infection, causes, and predisposing factors of CLABSIs, clinical pictures, complications, and nursing intervention and between the total mean scores of nurses' knowledge pre and post-care bundle education program.

This finding may be due to the lack of evidence-based clinical guidelines regarding the prevention of CLABSIs in high-risk neonates. The knowledge deficiency is reflected in obstacles for the implementation of care bundle education as references obtainable at any time for nurses to be oriented of the significance of prevention of CLABSIs and its management. This finding was agreeing with *Rosado et al. (2018)*, who conveyed in a parallel study that the majority of studied subjects had an inadequate level of knowledge, and almost two-thirds of them had unsatisfactory knowledge about CLABSIs pre-program while the almost all (97.2%) of them had adequate knowledge post-care bundle education program.

With relatively to the comparison of total nurses' knowledge regarding CAVD and CLABSIs in high-risk neonates pre/post-implementation of care bundle education program. The result of the current study shows that the total nurses' knowledge was 24.71 ± 5.95 pre-test compared to a 54.96 ± 8.96 post-care bundle education program. It specifies a significant statistical difference with ($p < 0.001$),

which indicates an apparent enhancement in the total nurses' knowledge post-care bundle education program.

The knowledge improvement might be due to the implementation of bundle training that includes information regarding CVC catheter insertion site, types, duration of use, indications, and mechanical complications as well as a bundle of care education guidelines to prevent the occurrence of CLABSI in high-risk neonates and nursing care. The finding of the present study was on the same line with *Esposito et al. (2017)*, who study knowledge, attitudes, and practice on the prevention of central line-associated bloodstream infections among nurses in oncological care: A cross-sectional study in an area of southern Italy. This study concluded that the implementation of the educational program is most vital and should be employed to address the gaps regarding knowledge and performance and to certify that nurses use evidence-based prevention interventions.

In respect to the current study's finding, it was in agreement with *Bayoumi and Mahmoud (2017)*, who concluded that the majority of the nurses in the pediatric hemodialysis unit have a lack of knowledge about evidence-based practice guidelines. There was a highly statistically significant improvement in total nurses' knowledge level immediately post and after six months of teaching guidelines implementation.

In the researchers' opinion, in the current study, there was a significant deficit in nurses' knowledge before the care bundle education program. It may be due to the majority of studied nurses had a secondary school diploma of nursing, and a lot of new trend topics are not included in their syllabus before graduation. Moreover, work overload, lacking in-services educational program along with inaccessibility or lack of textbooks, brochures, booklets, and handbooks guide suitable to their intellectual level.

Besides, the lack of time for reading led to a lack of nurses' knowledge. Meanwhile, there is a noticeable improvement of nurses' knowledge after the implementation of the bundle of care education, which results from explicit content of education, the applicability of the discussed items with repetition and discussion. Also, the distribution of care bundle education booklet designed by the researchers was a factor. So, it is necessary to use appropriate continuous updated training programs. This finding is supporting the first research hypothesis.

Concerning the comparison of nurses' practices regarding assisting in CVC insertion, care, and maintenance pre/post-implementation of care bundle education program, the findings of the current study revealed a marked improvement in total mean scores of nurses' practices regarding the care bundle education program (67.84 ± 7.14) compared to pre-implementation (29.24 ± 11.19) that demonstrated profoundly highly statistical significance difference at ($t = 20.438, p = 0.001$). This finding reflects the positive effect of the CLABSI care bundle education program on nurses' practices, which were eager to know about how to prevent CLABSI in high-risk neonates.

The study findings were harmonious with *Venkatesan and Manikandan, (2018)*, who study "effectiveness of central line bundle care upon the knowledge and compliance staff nurses in the ICU." The study stated that there is poor total nurses' practice pre-implementation of the bundle of care prevention guidelines regarding the insertion and maintenance of CVC catheter was poor compared to the post-test that showed a significant improvement.

Besides, the results of the present study revealed the comparison of nurses' practice regarding CLABSIs care bundle components pre and post-education program. The study findings indicate that the total mean score of nurse's practices pre-test was (17.49 ± 6.06). On the other hand, the immediately post-care bundle education program was improved to (41.80 ± 2.63) correspondingly. It was reflected an enhancement in nurse's performance as regards CLABSIs in high-risk neonates as a result of an effective bundle of care education of these best practices and clinical interventions at NICUs, which needs an understanding of the unit unique culture, knowledge and performance background.

Although the clinical practices, equipment, and nursing staff training necessary to perform the intervention. In the same line, the study conducted by *Stevens & Schulman, (2012)* proved that an effective implementation to prevent CLABSI necessitates both selections of clinical practices and equipment that have the probability of implementing those practices by the clinical health care team in a reliable way over time.

The comparison of total nurses' practices regarding assisting in CVC insertion care maintenance and CLABSIs pre/post-implementation of care bundle education program proved that there is a noticeable improvement in the total nurses' practices. In contrast, the total mean score of nurses' practices was 46.73 ± 15.03 pre-test compared to the 109.64 ± 9.49 post-care bundle education program that directs a highly statistically significant difference (t -test = 25.213 with $p = < 0.001$), this result may be reflected the positive consequence of the care bundle education program for the prevention of CLABSI. The vital role of nurses was passionate to acquire more knowledge and practices about how to prevent CLABSIs in high-risk neonates.

These results were in harmony with *Abbady et al. (2019)*, whose finding revealed that bundle of care implementation improved nurses' performance related to the central line-associated bloodstream infection. Also, these findings were agreed with *Shah and Muhammad. (2017)*, who studied "nursing practice for prevention of central line-associated bloodstream infection CLABSI in a pediatric intensive care unit." The study reported that there was a highly statistically significant improvement in the total nurses' practice post-program implementation. This finding is supporting the second research hypothesis

Regarding the correlation between total nurses' knowledge and their actual total practices regarding assisting in CVC insertion, care, maintenance, and

CLABSIs pre/post care implementation of bundle education program. The current study cleared a positive significant statistical relationship between knowledge and practice of bundle of care education.

In conclusion, the application of bundle approaches and continuous training programs are considered to improve nurses' performance and decrease the gap between scientific knowledge and actual nurses' performance. As definite by El-Sol and Badawy, (2017) that there was the enhancement of total nurses' practice and authenticity to the prevention of CLABSI in critical care units were anticipated.

7. Conclusion

Based on the present study findings, it concluded that there was unsatisfactory knowledge as well as an incompetent practice among nurses regarding central line-associated bloodstream infection in high-risk neonates before the care bundle education program. The research hypothesis is supported, and the care bundle education program achieved significant improvements in nurses' knowledge and performance regarding CLABSI in high-risk neonates.

8. Recommendations

Based on the finding and conclusion of the current study, the following recommendations were recommended:

- Establishing educational centers in all hospitals conducted for new nursing staff working in NICUs being responsible for updating and refreshing the nurses' knowledge and practice.
- Conducting workshops that emphasize the evidence-based practices about a bundle of care regarding the prevention of CLABSI and infection control measures in critical care settings within the hospitals. These services must be delivered to the recently graduated nurses.
- Instructional brochure and demonstrated booklets about the prevention of CLABSI can be designed and provided for all nurses in all NICUs.
- Future studies should be directed to improve nurses' knowledge, and performance regarding factors affecting bundle of care implementation in high-risk neonates was recommended.

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