



CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTION PREVENTION: KNOWLEDGE ASSESSMENT AMONG CRITICAL CARE NURSES

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Abstract: Intravascular catheters (CVC) are commonly used in critically ill patients in the intensive care unit (ICU) for multiple purposes. Central line-associated bloodstream infection (CLABSI) could be associated with using CVCs. Nurses can be educated and motivated to implement interventions that facilitate and improve patient outcomes. Certainly, noncompliance with the CLABSI bundle, can negatively impact patient outcomes. Only limited studies in Saudi Arabia have evaluated nurses' knowledge about current prevention guidelines for CLABSI.

Method: A cross-sectional study was conducted between January and June 2019 to determine the level of critical care nurses' knowledge of the CDC's guidelines for CLABSI prevention. Previously validated instrument was used to achieve the study objectives.

Results: A total of 100 nurses participated in the study. The vast majority of them (94%) they heard about the CLABSI guidelines and 78% receive training for applying the CLABSI guidelines. Only 13% of the nurses had fully mastered the guidelines. Shortage of nurses and overwork was the main barrier to compliance to CLABSI guidelines. The overall knowledge score was 13.07 (± 4.0) out of 20. There is a lack of knowledge CLABSI guidelines, since only 39% of nurses had a high score, whereas 43% had an average level of knowledge and 18% had a weak level.

Conclusion: These findings indicate a potential risk for patient safety and highlights the need for providing continuous educational programmes to improve patients' outcomes in the ICUs. Improvement of ICU nurses' knowledge is greatly needed regarding the prevention guidelines for CLABSI.

Keywords: Bloodstream infection; Central line; Knowledge; Nurses; Saudi Arabia.

I. INTRODUCTION

Nosocomial infections are the main reason for morbidity and mortality among hospitalised patients. These infections affect about 5% to 15% of admitted patients and can lead to complications in 25% to 50% of those patients in ICUs [1]. It has been shown that intravascular lines are rated the most significant risk factor for the development of nosocomial infection [2]. The National Healthcare Safety Network (NHSN) is a system developed by the U.S. Centres for Disease Control and Prevention (CDC) to record Health Care Associated Infections (HAIs) in the United States [3]. This system can document these infections, help to find possible sources of infection and provide prevention strategies. NHSN established a specific definition for all infections in terms of epidemiologic surveillance, involving CLABSIs.

Approximately half of ICU patients have CVCs, around 15 million central catheter days annually. In the United States,

CLABSI has a higher mortality rate of approximately 18%, and its cost reaches \$18,432 with an average length of stay of

12 days. A huge body of evidence shows that specific guidelines can help to achieve the goal of preventing CLABSI. On 1 January 2010, the Joint Commission National Patient Safety Goals instructed hospitals to adhere to the evidence-based guidelines in practice to prevent CLABSI (Coral et al., 2016). A central line-associated bloodstream infection (CLABSI) is defined by the CDC's NHSN as a primary bloodstream infection in a patient with a central venous catheter that develops within 48 hours before the confirmation of positive blood cultures and is not related to an infection at another site [4]. Still, diagnosis of CLABSI remains challenging because of the absence of local signs of infection such as purulent secretion, pain, or tenderness and due to unspecific systemic signs like fever, chills, and hypotension [5].

The National Nosocomial Infection Surveillance (NNIS) system, reporting and evaluating the data from the ICU setting, indicates that most nosocomial bloodstream infections are associated with the use of intravascular devices, with a higher rate among patients with CVCs than those with peripheral lines [6]. Additionally, more than 85% of primary bacteraemia are related to catheter placement [1]. Bloodstream infections represented 12% of all infections that were marked in 10,038 patients from 1,417 ICUs in the European Prevalence of Infection in Intensive Care (EPIC) Study [7]. An estimated 80,000 CVC-related bloodstream infections occur in ICUs in the USA each year [6]. Furthermore, it suggested that treating such infections each year could cost up to \$2.3 billion, with an average cost of care per patient of \$45,000 [8]. In general, lower infection rates associated with a central line are reported in developed countries, ranging from 1 to 60 per 1,000 central catheter days [9].

Nurses play a crucial role in maintaining patient safety and reducing the occurrence of HAIs including CLABSI. However, prevention policies are not consistently adhered to in many hospitals [10]. Nursing interventions that comply with evidenced-based practices have a significant impact on patient outcomes [11]. Nurses spend more time with patients compared to other health care providers and have a great responsibility for caring for and maintenance of the central lines. Educational programmes and adherence to guidelines may improve compliance and reduce the incidence of HAIs including CLABSI.

Nurses caring for patients with central line needs to gain knowledge about guidelines for preventing CLABSI. In the Saudi literature, research about the prevention of CLABSI is lacking, as is research about nurses' knowledge and practice of bundling of care to prevent CLABSI. This study aims to assess critical care nurses' knowledge of the CDC's guidelines for CLABSI prevention and to identify the barriers to adherence to evidence-based guidelines for the prevention of CLABSI in ICUs.

II. METHODS

A. Study design

A cross-sectional study was conducted between January and June 2019 to determine the level of critical care nurses' knowledge of the CDC's guidelines for CLABSI prevention.

B. Setting

The study was conducted in the adult ICU at King Faisal Hospital in Makkah. It is a governmental hospital in the western region of the Kingdom of Saudi Arabia providing services to patients with life-threatening illnesses. It is organised and equipped with medical resources to provide close supervision and constant care for critically ill patients. The unit consists of 26 beds and is staffed by highly trained physicians and nurses who specialise in caring for critically ill patients.

C. Sample size

A total of (n=100) registered nurses who work in the adult ICU were recruited in the current study. Nurses on annual leave and maternity leave were excluded from this study. This sample size was calculated based on the confidence level and the margin of error. As we chose an estimated population size of 100, a margin of error of 5% and a confidence level of 95%, the sample size was 80 participants.

D. Data collection tool

The study questionnaire was distributed to the participants and consisted of the following sections: nurses' demographic data including age, sex, nationality, years of ICU experience and level of nursing education. A previously validated instrument regarding evidence-based knowledge about the prevention of CLABSI was used to assess critical care nurses' knowledge of evidence-based guidelines for CLABSI prevention [12]. The questionnaire's content is based on the CDC's CLABSI prevention guidelines.

E. Ethical Approval

The study was approved by the Institutional Review Board (IRB) of Imam Abdulrahman bin Faisal University and by the

Research and Ethics Committee of King Faisal Hospital in Makkah. Permission was obtained from the Ministry of Health, hospital administration and unit head nurse (IRB – 2019 – 04 – 128). Signed informed consent was secured before starting data collection.

F. Questionnaire tool validity and reliability

A panel of experts examined the questionnaire for face and content validation and unanimously declared agreement with its content and clarity, whereas internal consistency reliability was measured through a pilot study by applying Cronbach's Alpha with Cronbach's coefficient ($\alpha = 0.895$). It was revised after expert consultation with ten nurses and five doctors in this field, who agreed with the questionnaire's clarity and content. It was used in a pilot study of 25 nurses to determine the difficulty index, which ranged from 0.35 to 0.8 and had a range of value $0 > 0.4$ for the discrimination index. The final version of the questionnaire had 20 items consisting of multiple-choice and single-choice questions, involving clinical practice such as optimal insertion site of CVCs, the performance of hand hygiene, barrier precautions, disinfection and covering of catheter sites, dressing changes, use of chlorhexidine 2%, replacement of CVCs and administration of antimicrobial prophylaxis [13]. Nurses' awareness of the guidelines scale comprised three questions: Have you heard about the CLABSI guidelines? Did you receive training for applying the guidelines? What is the level of your mastery of the guidelines? Barriers to adhering to the guidelines in clinical practice were assessed using one question: What are the barriers to adhering to the prevention guidelines in your clinical practice? **G. Data analysis**

Statistical analysis of the present study was conducted using Statistical Package for Social Science software version 27. Continuous variables were presented as mean (standard deviation). Categorical variables were presented as frequency (percentage). Each correct answer for the knowledge scale scored 1, based on which the maximum obtainable knowledge score was 20. The difference in the mean knowledge score between participants from different sociodemographic groups was assessed using student t-test analysis and analysis of variance (ANOVA) as appropriate. Participant scores were categorised as follows: weak = ≤ 60 ; average = 60 to < 75 , and high ≥ 75 . A confidence interval of 95% ($p \leq 0.05$) was applied to represent the statistical significance of the results and the level of significance assigned was 5%.

III. RUSELTS

The questionnaire was distributed to a total of 100 nurses working in the ICU of King Faisal Hospital. The response rate was 100%.

A. Sociodemographic characteristics

Table 1 describes the sociodemographic characteristics of the study participants. More than half (55%) of the nurses who participated in this study were aged less than 30 years. The vast majority were female (98%) and the majority (80%) were non-Saudis. Nearly all (92%) held a bachelor's degree. Most nurses (58%) had one to five years of work experience.

TABLE 1: SOCIODEMOGRAPHIC CHARACTERISTICS OF THE STUDY PARTICIPANTS.

Variable	Percentage
Age	
Less than 30 years	55%
30 – 40 years	43%
40 years and above	2%
Gender	
Females	98%
Nationality	
Non-Saudi	80%
Education	
Diploma	4%
Bachelor degree	92%
Master degree	4%
Work experience	
Less than 6 months	2%
1 – 5 years	58%
5 – 10 years	35%
10 years and above	5%

B. Nurses' awareness of the CLABSI prevention guidelines

Nurses' awareness of the CLABSI was assessed by asking three questions. The first question was "Have you heard about the CLABSI guidelines?", to which 94% of the nurses responded positively. The second question was "Did you receive training for applying the CLABSI guidelines?", to which three-quarters (78%) responded positively. The last question was "What is the level of your mastery of the guidelines?" Only 13% of the nurses believed they had fully mastered the guidelines, whereas 42% reported mastery of the guidelines (Table 2).

TABLE 2: NURSES' AWARENESS OF THE CLABSI PREVENTION GUIDELINES.

	Percentage
Have you heard of CLABSI guidelines	
Yes	94.0%
Did you receive training for applying the guidelines	
Yes	78.0%
What is the level of your mastery of the guidelines	
Little or no mastery	45.0%
Meets mastery	42.0%
Exceeds mastery	13.0%

C. Barriers to compliance with the CLABSI prevention guidelines in clinical practice

Barriers to compliance with guidelines in clinical practice were investigated by specifying four main barriers identified in the literature. Table 3 shows the frequency and percentage of nurses' responses when asked about the barriers to adhering to CLABSI prevention guidelines. Shortage of nurses and overwork was considered the main barrier to compliance to CLABSI prevention guidelines by 61% of nurses. Lack of training and unfamiliarity with the guidelines had almost similar percentages as barriers to compliance with CLABSI prevention guidelines, 51% and 50% respectively. Lack of policy about CLABSI prevention guidelines had the lowest percentage, with only 37% of nurses considering it the main barrier.

TABLE 3: BARRIERS TO ADHERENCE TO THE CLABSI PREVENTION GUIDELINES IN CLINICAL PRACTICE

	Percentage
Lack of training	
Yes	51%
Unfamiliar with the guidelines	
Yes	50%
Lack of policy about CLABSI bundles	
Yes	37%
Shortage of nurses and over-workload	
Yes	61%

D. Evidence-based knowledge about the CLABSI prevention guidelines

Knowledge about CLABSI prevention guidelines was assessed using a questionnaire that consisted of 20 questions, including the preventive measures of catheter-related infection which included both central line insertion bundles and central line maintenance bundles. Table 4 presents the frequency and percentage distribution of the correct answers for each of the 20 items of the questionnaire.

TABLE 4: EVIDENCE-BASED KNOWLEDGE ITEMS ABOUT THE CLABSI PREVENTION GUIDELINES

Item number	Items and Correct Answers	Percentage of participants with correct response
1	In order to minimize infection risk for non-tunneled central venous catheter placement, which site is optimized in adults?	
	Correct Response: Subclavian vein	38.0%
2	Which site should be avoided in hemodialysis patients and patients with advanced kidney disease?	
	Correct Response: Subclavian access	32.0%
3	What kind of insertion method can reduce mechanical complications when placing central venous catheters (CVC)?	
	Correct Response: Ultrasound guidance	77.0%
4	When should hand hygiene be performed?	
	Correct Response: Before and after inserting, repairing or dressing the catheter	96.0%

5	What are the correct ways to wash hands?	
	Correct Response: Wash hands using water and soap for 1 minute	86.0%
6	What are the contents of „maximal sterile barrier precautions“ for the insertion of CVCs?	
	Correct Response: Sterile gown, gloves, mask and cap along with full body sterile drape to cover the patient	83.0%
7	It is recommended to disinfect the catheter insertion site with	
	Correct Response: 0.5% alcoholic chlorhexidine	30.0%
8	It is recommended to cover up the catheter insertion site with ...	
	Correct Response: Polyurethane dressing (transparent, semipermeable)	92.0%
9	What kind of dressing should be used if the patient is diaphoretic or if the site is bleeding or oozing until this is resolved?	
	Correct Response: Sterile gauze dressing	69.0%
10	When is it recommended to change the dressing on the catheter insertion site?	
	Correct Response: When indicated (soiled, loosened, etc.) and at least weekly	83.0%
11	It is recommended to change dressings used on short-term CVC sites for gauze dressings every.....days.	
	Correct Response: 2 days	62.0%
12	It is recommended to change dressings used on short-term CVC sites for transparent dressings every.....days.	
	Correct Response: 7 days	76.0%
13	What is the correct intervention when changing the dressing?	
	Correct Response: Using aseptic technique	88.0%
14	Is it right for using a 2% chlorhexidine wash for daily skin cleansing, which can reduce CLABSI?	
	Correct Response: No, there is no effect in reduced CLABSI	5.0%
15	Which situation should a chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated CVC be used in patients?	
	Correct Response: In patients whose catheter is expected to remain in place for more than >5 days	54.0%
16	Is it recommended to replace CVCs routinely?	
	Correct Response: No, only when indicated	81.0%
17	When neither lipid emulsions nor blood products are administered through a CVC, it is recommended to replace the administration set ...	
	Correct Response: Within 24 hours	86.0%
18	It is recommended to replace tubing used to administer Propofol infusions every.... hour.	
	Correct Response: 12 Hours	69.0%

19	Is it recommended to replace pressure transducers and tubing routinely?	
	Correct Response: No, only when indicated	53.0%
20	Is it recommended to administer systemic antimicrobial prophylaxis routinely before insertion or during use of an intravascular catheter to prevent catheter colonization or CLABSI?	
	Correct Response: No, it is not recommended	47.0%

E. Questions related to insertion bundles (Items 1-7 and 20)

None of the nurses answered every question correctly. Correct answers were often given for Item 3: “What kind of insertion method can reduce mechanical complications when placing central venous catheters (CVC)?”, which 77% of nurses answered correctly, and Item 4: “When should hand hygiene be performed?” for which almost all participants (96%) chose the correct answer. Concerning Item 5: “What are the correct ways to wash hands?” the correct answer was chosen by 86% of the participants.

Regarding „maximal sterile barrier precautions“ for the insertion of CVCs, 83% of the nurses selected the correct answer. The majority of the sample (92%) agreed that 0.5% alcoholic chlorhexidine is recommended as a skin disinfectant solution on the catheter insertion site. Only 47% of nurses were able to select the correct answer for Item 20: “Is it recommended to administer systemic antimicrobial prophylaxis routinely before insertion or during use of an intravascular catheter to prevent catheter colonisation or CLABSI?”

F. Questions related to maintenance bundles (Items 8-19)

The vast majority (92%) answered Item 8 correctly. Concerning the kind of dressing that should be used if the patient is diaphoretic or the site is oozing, 69% of nurses correctly marked the suitable kind of dressing that should be implemented.

Concerning the recommended time to change the dressing on the CVC site, the correct answer was selected by a majority of nurses (83%). Regarding Item 11 about the recommendation to change dressings used on short-term CVC sites for gauze dressings, the right answer was chosen by most of the participants (62%). Most nurses (76%) chose seven days as the correct answer for Item 12: “It is recommended to change dressings used on short-term CVC sites for transparent dressings every day.” Among all participants, 88% confirmed the use of the aseptic technique when changing the dressing. Concerning Item 14, only 5% of nurses recognised that 2% chlorhexidine does not reduce CLABSI if used daily as a skin wash and 84% of nurses thought it significantly reduced CLABSI. More than half of the participants (54%) correctly answered Item 15, about situations in which a chlorhexidine/silver sulfadiazine or minocycline/rifampin impregnated CVC should be used in patients.

Regarding the replacement of CVC and the administration set, 81% of participants correctly answered Item 16: “Is it recommended to replace CVCs routinely?” Furthermore, 68% of nurses correctly responded to the question about the replacement of the administration set when neither lipid nor blood is administered. The correct answer for Item 18: “It is recommended to replace tubing used to administer Propofol infusions every ...hours.” was selected by 69% of nurses and 53% responded correctly for Item 19: “Is it recommended to replace pressure transducers and tubing routinely?”

G. Evaluation of the level of nurses' knowledge about the Evidence-based Guidelines for the Prevention of CLABSI

The overall score for the study participants, which ranged between 4 and 19 with a mean score of 13.07 (± 4.0), demonstrates the overall evaluation of the level of nurses' knowledge about the evidence-based guidelines for the prevention of CLABSI. The results showed a lack of knowledge about the prevention guidelines for CLABSI, since only 39% of nurses had a high score, whereas 43% had an average level of knowledge and 18% had a weak level.

H. Nurses' levels of knowledge and awareness of CLABSI prevention guidelines and barriers to compliance with the guidelines

Table 5 shows a statistically significant difference in the knowledge scores based on whether participants had received training for applying the guidelines ($p < 0.01$). The knowledge scores were higher among nurses who had received training. Concerning the barriers to adhering to the guidelines, the difference in the knowledge scores based on the lack of policy about CLABSI bundles ($p < 0.001$) was statistically significant, as was the difference in the knowledge scores based on shortage of nurses and overwork ($p < 0.001$).

TABLE 5: KNOWLEDGE SCORE AND NURSES' AWARENESS OF CLABSI PREVENTION GUIDELINES AND BARRIERS TO COMPLIANCE WITH THE GUIDELINES.

		N	Knowledge		F or T	ANOVA or T-test	
			Mean	± SD		test value	P-value
Have you heard of CLABSI guidelines	Yes	94	12.989	± 3.917	T	-0.793	0.43
	No	6	14.333	± 5.68			
Did you receive training for applying the guidelines	Yes	78	13.705	± 3.644	T	3.103	<0.01*
	No	22	10.818	± 4.542			
What is the level of your mastery of the guidelines	Little or no mastery	35	13.2	± 3.571	T	0.021	0.984
	Meets mastery	33	13.182	± 3.653			
	Exceeds mastery	10	17.2	± 1.549			
Lack of training	No	49	12.286	± 3.764	T	-1.94	0.055
	Yes	51	13.824	± 4.146			
Unfamiliar with the guidelines	No	50	12.46	± 3.604	T	-1.528	0.13
	Yes	50	13.68	± 4.345			
Lack of policy about CLABSI bundles	No	63	11.746	± 3.869	T	-4.743	<0.001*
	Yes	37	15.324	± 3.215			
Shortage of nurses and over-workload	No	39	11.41	± 4.734	T	-3.483	<0.001*
	Yes	61	14.131	± 3.085			

IV. DISCUSSION

CVCs can be considered life-supporting devices and a time-honoured way of quickly accessing the major venous system in patients with compromised hemodynamic requiring aggressive care in ICU. However, inappropriate use of an intravascular catheter can increase the risk of CVC-related infections by breaking the skin barrier and providing a favourable environment for biofilm formation. It is considered a common cause of subsequent excess morbidity, mortality and medical care cost in ICUs. Compliance with CLABSI prevention guidelines is extremely important to minimise the incidence of CLABSI and to enhance patient outcomes.

Nearly two-thirds (61.0%) of our study participants showed a weak-to-average level of knowledge about CLABSI prevention guidelines. A previously published multicounty survey study assessing the knowledge of European ICU nurses about CLABSI prevention guidelines showed that nurses' knowledge still needs to be optimised to

ensure delivery of optimal care to critically ill patients [12]. Nurses have a curial role in handling and maintaining CVCs and controlling their infection rates. However, nurses' lack of knowledge can be an obstacle to adhering to evidence-based guidelines for the prevention of CLABSI [12]. Comer *et al.* (2011) suggested that the CLABSI rate was reduced after educational programmes were conducted on strategies to prevent CVC infection and it confirmed the value of nurses' knowledge [4]. In addition, a literature review of neonatal ICUs documented that educational interventions have a great role in reducing CLABSI in patients with CVC.

In our study, the majority of nurses (94%) reported that they had heard about the guidelines, and 78% of nurses said they had received training for applying the guidelines. Regarding the level of mastery of the guidelines, 45% of nurses admitted they had little or no mastery and 42% of nurses had achieved mastery in applying the guidelines.

Regarding the nurses' knowledge about the evidence-based guidelines for the prevention of CLABSI, the present study found that the highest proportion of nurses (43%) had average knowledge, which could be a risk for developing CLABSI in critically ill patients. This indicates the need for periodic evaluation of their knowledge and practices regarding the guidelines. This finding is consistent with a previous cross-sectional survey study conducted in developed countries on nursing staff and nurse managers working in tertiary level paediatric ICUs in Australia and New Zealand. That study's findings suggested that healthcare providers' knowledge about CLABSI prevention guidelines was generally low [14].

More than half of nurses (83%) in the current study declared that they followed the maximal sterile barrier precautions during insertion of CVCs, which reflects their adequate knowledge about the importance of maximal sterile barrier precautions, contrary to the findings of a previous study conducted by Rosenthal *et al.* (2006) [9], who found that less than half of ICU nurses used maximal sterile barrier precaution during CVC procedure. In agreement with other studies, the dressing should be handled following aseptic techniques by using sterile gloves, sterile gauze and disposable facial masks. Clean gloves only could be used while removing the old dressing without contact with the insertion point of the catheter. In connection with this protocol, the majority of nurses are aware of these guidelines, where the use of the aseptic technique during changing dressings has proven to be effective for the prevention of CLABSI.

Regarding the recommendation of an antiseptic solution to be used on the insertion site of the CVC, this study pointed out a significantly low percentage of nurses (30%) knowing such an important measure, which is associated with increasing the incidence of CLABSI. A previous study by Ferreira *et al.* confirmed the positive relationship between the use of alcoholic chlorhexidine with lowering the rate of CVC colonisation when compared to other antiseptic substances [15]. A transparent, semipermeable dressing is recommended to cover the catheter insertion site. Most participants (92%) answered this item correctly. This result is in line with a study conducted in critically ill surgical patients, which concluded that the majority of nurses (69%) correctly answered the item related to the best type of dressing to cover the CVCs [13].

Regarding the nurses' knowledge about the frequency of CVC changes, our findings showed the highest score of knowledge, which was confirmed in a previous study conducted to determine European ICU nurses' knowledge of guidelines for preventing CLABSI in 22 European countries [12]. Another study conducted at haemodialysis units pointed out that nurses have adequate knowledge about the periodicity of CVC dressing change, which should be done only if indicated [16].

In our study, the majority of nurses (86%) knew that patients not receiving blood products or lipid emulsions must have their administration set replaced after 96 hours. This finding is in line with a previous study by Labeau *et al.* [12], who reported that more than half of nurses knew this fact. Concerning the replacement of the administration set when the line was used to infuse Propofol, more than half of the nurses (69%) knew what is recommended by

this protocol. This is in contrast to the finding of an earlier study that showed limited knowledge about the periodic time to change the line with Propofol [17].

Regarding the effect of sociodemographic characteristics on nurse knowledge scores, no statistically significant difference appeared in nurses' knowledge scores based on their age ($P = 0.430$). However, the scores varied significantly among female and male nurses; one explanation of this could be unequal numbers of participants from different genders as female nurses were the majority (98%). Moreover, the current study revealed a statistically significant difference in the level of knowledge based on the participants' nationality. Non-Saudi nurses showed higher knowledge scores compared to Saudi nurses ($p < 0.001$).

Concerning work experience and level of education, our study found a statistically significant difference in knowledge scores based on these two demographic characteristics. More years of experience can increase knowledge about best practices, and nurses with a bachelor's degree have a higher score than those with a diploma. This was not in line with a previous study that found nurses' knowledge was not a statistically significant difference based on years of ICU experience [14].

Another finding of our study was that the majority of nurses (94%) had heard about the guidelines and most (78%) had received training for applying them; training had a significant relation with increasing the level of knowledge. On the other hand, no statistically significant difference in the knowledge scores was found based on whether participants had heard about the guidelines or the level of mastering the guidelines. A previous study by Yilmaz *et al.* in Turkey involved three separate periods: pre-education, education, and post-education [18].

Furthermore, the present study revealed several barriers to compliance with the CLABSI prevention guidelines, including lack of training, unfamiliarity with the guidelines, lack of policy about CLABSI bundles, and shortage of nurses and overwork. All of these factors affected the knowledge score significantly concerning adherence to the guidelines, except unfamiliarity with the guidelines ($p \geq 0.05$).

Overall, the current study found that the majority of ICU nurses' knowledge of the guidelines is in an average range, with a mean score of (17.9 ± 2.5), which could reflect a potential risk to patient safety. This finding is similar to a previous study conducted in surgical and emergency ICUs at Zagazig University Hospital in Egypt, which revealed that implementation of a simple education programme increased adequacy of knowledge, improved the practice of healthcare providers and reduced CVC bloodstream infection rates in ICUs by almost 50% during the intervention period [19]. Another previous study recommended providing a continuous educational programme to improve nurses' knowledge [12].

V. RECOMMENDATIONS

The knowledge and practice of CLABSI prevention guidelines should be evaluated for nurses involved in CVC insertion and management. Nursing administration and infection control units should plan for periodic educational programmes, accompanied by training based on evidence-based practice guidelines. Adaptation of new strategies for training and dissemination of the protocol should be emphasised to ensure the learning and understanding of recommended practices. Multidisciplinary interventions and continuous educational programmes should cover the improvement of critical care nurses.

Further studies are needed to evaluate the nurses' knowledge before and after the educational programme on evidence-based guidelines for the prevention of CLABSI and to identify the best methods to help healthcare workers overcome the barriers to compliance with the prevention guidelines for CLABSI. Further research is needed in other healthcare centres in Saudi Arabia using a larger sample size to generalise the findings. Future qualitative research is needed to understand the barriers to implementing the CLABSI prevention guidelines.

VI. LIMITATIONS OF THE STUDY

The present study has some limitations. The generalisation of the findings is limited due to the small size and the conduct of the study in one setting. The findings may be influenced by the intrinsic methodological limitations of the survey, which is based on self-report. This study is a requirement for the fulfilment of a master's degree, and the project must be conducted within one semester of the master's programme. As a result, time to conduct further investigation and analysis to understand the actual phenomena and interpret its findings is limited.

VII. CONCLUSION

Most critical care nurses had a minimum amount of knowledge about the prevention guidelines for CLABSI. Adequate knowledge and strict adherence to the published guidelines for the prevention of CLABSI is important for all healthcare workers, particularly nurses, who assist in CVCs insertion and maintenance. Improvement is greatly needed in the knowledge of nurses in critical care settings regarding the prevention guidelines for CLABSI and their practice by gaining the competencies required while caring for patients with CVCs. This should be accompanied by frequent monitoring and evaluation of the implementation of these measures to eliminate the occurrence of CLABSI.

Data Availability

All data are available from the corresponding author upon reasonable request.

Consent

Consent was obtained from the respondents before administering the questionnaire, and participants were assured of the confidentiality of the information, and the data was collected anonymously.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis, and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work.

Funding

No fund was received for this study.

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