Nurses' compliance with central line associated blood stream infection prevention guidelines

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ABSTRACT

الأهداف: تقييم امتثال الممرضين للمبادئ التوجيهية للوقاية من تلوث مجرى الدم المصاحب للأنبوب المركزي مرتبطة بالمحافظة على المبادئ التوجيهية والتنبؤات بالامتثال

الطريقة: كانت هذه الدراسة رصدية استخدمت كتصميم وصفي استعراضي وشملت على 171 وحدة عناية مركزة وتمت ملاحظة الممرضيين وقد سجل امتثالهم في ورقة ملاحظة منظمة حيث أجريت هذه الدراسة في وحدة العناية المركزة في 15 من المستشفيات تقع في 5 مدن في الأردن. تم جمع البيانات على مدى 5 شهور من مارس إلى نهاية يوليو 2017. وأدرجت المبادئ التوجيهية من الأطباء داخل وحدات العناية المركزة.

النتائج: أظهر 120 مشارك (70%) امتثال بشكل كافي. وكان متوسط درجة الامتثال 14.2±4.7 (min=8, max=20). ولكن معدل مبادئ التوجيهية للوقاية من تلوث مجرى الدم المصاحب للأنبوب المركزي كان متغير عبر المشاركة في وحدات العناية المركزة. أجريت 4 وحدات مستقلة للانحدار اللوجستي وهي (خبرات السنوات السابقة، التعليم السابق في مبادئ التوجيهية للوقاية من تلوث مجرى الدم المصاحب للأنبوب المركزي، ونسبة الممرضين والمرضى وقدرة وحدات العناية المركزة السريرية) لتحقق في تنبؤات الامتثال الكافي. كان النموذج كافي ($\chi^2(4)=133.773$, $p=0.00$). كان نسبة الممرضة والمريض المؤشر الوحيد الهام فقط الممرضين مع 1:1 ممرض: ثبت نسبة المرضى امتثال عالي على نظرائهم بنسبة 1:2.

الخاتمة: يمكن تحقيق مزيد من التحسن في الامتثال ونتائج المرضى عن طريق خفض نسبة الممرضين والمرضى

Objectives: To assess nurses' compliance with central line associated bloodstream infection (CLABSI) prevention guidelines related to maintenance of the central line and the predictors of compliance.

Method: This was an observational study that used a descriptive cross-sectional design. A sample of 171 intensive care unit (ICU) nurses were observed and their compliance was recorded on a structured observational sheet. The study was conducted in the ICUs of 15 hospitals located in 5 cities in Jordan. Data were collected over a 5-month period from March to July 2017. Central lines were all inserted by physicians inside the ICUs.

Results: One hundred and twenty participants (70%) showed sufficient compliance. The mean compliance scores were 14.2±4.7 (min=8, max=20); however, the rate of CLABSI was variable across the participating ICUs. Logistic regression with 4 independent variables (years of experience, previous education with CLABSI, nurse-patient ratio and the ICU's bed capacity) was conducted to investigate predictors of sufficient compliance. The model was significant ($\chi^2(4)=133.773$, $p=0.00$). The nurse-patient ratio was the only significant predictor. Nurses with a 1:1 nurse:patient ratio demonstrated superior compliance over their counterparts with a 1:2 ratio.

Conclusion: Further improvement in compliance and patients' outcomes could be achieved by lowering the nurse-patient ratio.

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The central venous catheter is an intravenous infusion device frequently used in intensive care units (ICUs). It is placed in a venous great vessel and indicated for administration of intravenous fluids, medication, blood products and total parenteral nutrition, and to monitor central venous pressure.[1] Although the central venous catheter facilitates patients' treatment, it is associated with a variety of complications such as thrombosis, embolism formation and infection.[2] Central line associated bloodstream infection (CLABSI) is a laboratory-confirmed bloodstream infection that develops at least 2 full days following insertion of the central venous catheter.[3] It is a common complication that is associated with increased cost of care, extended hospital stay and increased mortality.[4,5] It is estimated that 250,000 cases of CLABSI occur in the United States annually, with a 10% mortality rate.[6,7] The estimated cost of care for each case of CLABSI is USD 33,000, and hospital stay is increased by up to 3 weeks.[8] Prevention of CLABSI is essential to reduce the mortality rate and the cost of care. In Jordan, very few studies have explored CLABSI, although one reported that the rate of bloodstream infection related to the use of central line and other invasive procedures is higher than the 90th percentile of the United States.[9] Professional organizations such as the American Society of Anesthesiologists and the Center for Disease Control and Prevention have published evidence-based guidelines to prevent the occurence of CLABSI. Major topics in these guidelines include staff education, catheter site selection, hand hygiene, dressing, use of antiseptic solution, administration of total parenteral nutrition, changing the intravenous fluid and blood set, type of catheter and use of antibiotics.[10,11] Implementation of CLABSI prevention guidelines contributes to a significant reduction in the rate of infection; however, the level of implementation by nurses internationally is uncertain.[12-17] Given the lack of research into nurses' compliance with CLABSI prevention guidelines related to maintenance of the central line, this study aims to evaluate their compliance and the predictors of compliance.

Methods. *Study design and setting.* This study used a descriptive cross-sectional design with an observational non-active approach. The data collectors observed the guidelines under examination using a pre-structured observational sheet. The study was conducted in the ICUs of 15 hospitals located in 5 cities in Jordan: Amman, Irbid, Zarqa, Mafraq and Karak. The participating hospitals were 10 government, 4 private and one educational. All the ICUs were specialized adult medical-surgical units. Common indications for admission were neurological diseases, road traffic accidents and gastrointestinal emergencies. Seven ICUs had fewer than 7 beds, while 8 had 7 beds or more. These hospitals receive an average of 16,000 admissions and perform 5,000 central venous catheter insertion procedures annually. Data were collected over a 5-month period from March to July 2017.

The search for literature relevant to CLABSI prevention guidelines consulted the database of CINAHL, EBSCO, Medline and Cochrane Library using the key terms CLABSI, evidence-based practice, and nurses' compliance, in medical and nursing journals from 2013 to the present.

Inclusion and exclusion criteria. Inclusion criteria in this study were: 1) registered nurse; 2) working as a full-time nurse in the ICU; 3) at least one year of experience. Nurses with less than one year of experience were excluded.

Sample size determination. G*Power software was used to calculate the sample size.[18] Based on an estimated medium effect size (f^2)=0.15, α=0.05, power=0.95, to run logistic regression with 4 independent variables, the required sample size was estimated to be 129. Two hundred nurses were approached, of whom only 171 agreed to participate, giving a response rate of 88%. The nurses who refused to participate were of different genders, ages and academic qualifications.

An observational sheet was developed based on existing CLABSI prevention guidelines from the Center for Disease Control and Prevention. The focus of the selected guidelines was the maintenance of the central line. The observational sheet consisted of 2 parts: general items (nurse-patient ratio, age, gender, academic qualification, position in department, years of experience, previous education on central venous catheter care, and availability of supplies, for instance, antibiotic impregnated central venous catheter); and 10 CLABSI prevention guidelines with 3 choices per item: "done completely and accurately" was given 2 marks, "done but not completely or accurately" was given one mark, and "not done" was given no marks. Nurses' compliance scores lower than 10 were considered as "insufficient compliance"; while scores equal to or higher than 10 were classified as "sufficient compliance." This scoring was based on a previous study conducted on a similar population of ICU nurses.[19]

During the observation, for each item if the nurse applied an action consistent with a CLABSI updated prevention guidelines at every opportunity the data collector documented "done completely and accurately"; if the nurse demonstrated an action inconsistent

with CLABSI prevention guidelines or missed it on any opportunity it was "done but not accurately or completely"; and if the nurse failed to apply a guideline at every opportunity it was "not done". One observational sheet was completed for each nurse even if the nurse took care of more than one patient. The observer changed the documentation in the checklist throughout the shift according to observed nursing activities. For example, if a nurse failed to apply a guideline once, the observer would change the item that was previously documented as "done completely and accurately" to "done but not completely or accurately." The observers received an educational session on how to complete the observational sheet. No translation into Arabic was made as all observers demonstrated English language fluency.

A panel of experts comprising members of 3 nursing faculties, 2 infection control specialists and 5 ICU nurses participated in the validation of the initial draft of the instrument, which contained 13 items. The panel recommended rewording of some items to improve readability and understandability, and removal of 2 other items that were considered not nursing interventions: "using ultrasound guidance during insertion of the central venous catheter" and "removing the central venous catheter if the patient showed signs and symptoms of CLABSI".

A pilot study was conducted to identify any difficulties. One more item was removed as it was difficult to observe "the use of a dedicated port for administration of total parenteral nutrition or blood". The results showed that the observational checklist had very good internal consistency and reliability with Cronbach's alpha of 0.82. Medical records in the participating hospitals were obtained and reviewed during the 5-month period of the study and were used to calculate the rate of CLABSI, length of hospitalization, duration of catheter and the rate of CLABSI-related mortality. The panel of experts approved the content validity of the final draft of the observational sheet.

The study was approved by the institutional review boards of the participating hospitals and the researcher's university. Direct observations of nurses at the bedside were used to measure compliance. The observers were ICU nurses with infection control expertise who were not staff of the participating hospitals. They observed and documented use of the guidelines under investigation without participating in their implementation. They used a structured observational sheet as reference for the phenomena to be observed. An advertisement and short presentation about the study was made in each of the participating hospitals. The nurses were informed that observation would be made but the purposes of the study and the phenomena to be observed were not disclosed. The observers attended the ICUs of the participating hospitals, selecting available nurses who were assigned to care for patients with central venous catheter, and observing them for a whole shift. Once the observation was completed, the nurses were informed of the fact. If a nurse agreed to participate, the informed consent was obtained and the general items were completed from the participant and the response was documented on the sheet by the observer. If the nurse preferred not to participate, the observation was disregarded. All observations were conducted during day shifts. The observers were rotated between hospitals each month to prevent confirmation bias (**Appendix 1**).

Statistical analysis. The Statistical Package for the Social Science version 21 (IBM Corp., Armonk, NY, USA) was used to analyze the data.[20] The means and frequencies for compliance scores were calculated. Nurses' compliance scores were first calculated as a continuous variable then converted into a dichotomous variable; a score below 10 was considered as "insufficient compliance" and scores of 10 or above classified as "sufficient compliance." This newly dichotomous nurses' scores variable was the dependent variable in the logistic regression model.

Logistic regression with 4 independent variables was conducted to find out predictors of nurses' compliance. The independent variables in the model were years of experience, previous education with CLABSI, nurse-patient ratio, and the ICU's beds capacity. Adjusted odd ratios and 95% confidence intervals were calculated. Nagelkerke's R^2 value was used to explain the variation in the dependent variable based on the model. Assumptions of regression were tested and none were violated. A collinearity diagnostic test was conducted to test if there was multicollinearity between the independent variables. No variance inflation factor (VIF) >5 was noted. The Hosmer-Lameshow Test was used to test if the data fit the model.

The Chi-Square test of association was used to discover if there was a relationship between the participants' characteristics and the results of the observations for the items in the observational sheet. It was also used to compare the participants with sufficient compliance against their counterparts with insufficient compliance.

Results. The mean age of the participants was 32.5 years; 32.7 for males, and 31.5 for females. Seventy-two participants (43%) had no previous education about CLABSI prevention guidelines and 154 (90%) reported

lack of supplies in their hospital, such as antibiotic impregnated central venous catheters (**Table 1**).

Based on the medical records in the participating hospitals, during the 5-month period of the study, the participating ICUs admitted 800 patients. Out of those, 500 (63%) had inserted central venous access. The subclavian insertion route was the most common with 400 catheters (80%), followed by the jugular with 70 catheters (14%) and the femoral with 30 catheters (6%). The mean duration of central venous access was 14.6 days, and the total number of central venous catheter days was 7,250. The overall rate of CLABSI was 27 cases/1,000 catheter days (39 cases/month), the mean length of hospitalization was 19.5 days, and the rate of mortality that was related to CLABSI was 40%. The mean compliance score of the participants was 14.2±4.7 (min=8, max=20). One hundred and twenty participants (70%) showed sufficient compliance (**Table 2**).

Analysis of results of performance assessment. A significant association was found for the item "assess date of dressing" with the variable nurse-patient ratio (X^2=3.2, p=0.00). Participants who work with a 1:1 ratio were more likely to assess their patients' central venous catheter date of dressing. On the other hand, participants' experience had no effect on most of the items (**Appendix 2**).

Comparison between participants with sufficient compliance and insufficient compliance. There was a statistically significant association between categories of compliance scores and the nurse-patient ratio (X^2=3.2, p=0.00); participants working with a 1:1 ratio were more likely to comply with CLABSI prevention guidelines. On the other hand, no effect was found for experience on compliance. (**Appendix 3.**)

The effect of participants' characteristics on nurses' compliance. The logistic regression model with 4 independent variables (years of experience, previous education with CLABSI, nurse-patient ratio, and ICU's bed capacity) was significant ($\chi^2(4)$=133.773, p=0.00). The model explained 80% of the variance in nurses' compliance and correctly classified 93% of the cases. Nurses who worked with a 1:1 nurse-patient ratio were 6.3 times more likely to comply with CLABSI prevention guidelines than their counterparts with a 1:2 ratio (**Table 3**).

Discussion. This study found that the majority of nurses were sufficiently compliant; however, the rate of CLABSI varied across the participating ICUs. Nurses working with a lower nurse-patient ratio had higher compliance scores.

This finding was consistent with those of Lee at

Table 1 - Participants' characteristics (N=171).

Variables	Number of nurses	
	n	(%)
Gender		
Female	139	(81)
Male	32	(19)
Nurse-patient ratio		
1:1	86	(50)
1:2	85	(50)
Academic degree		
BSN	145	(90)
MSN	16	(10)
Position in department		
Staff nurse	119	(70)
In-charge nurse	52	(30)
Experience		
>5 years	71	(42)
<5 years	100	(59)
Number of beds in unit		
<7 beds	96	(56)
>7 beds	75	(44)

BSN - bachelor of science in nursing, MSN - master of science in nursing

Table 2 - Results of performance assessment (N=171).

CLABSI prevention guidelines	Not done		Done but not complete or not accurate		Done completely and accurately	
	n	%	n	%	n	%
Daily assessment of the catheter insertion site	39	(23)	33	(19)	99	(58)
Assessment of the date is made for dressing	44	(26)	46	(27)	81	(47)
Dressing is maintained clean and dry	17	(10)	47	(28)	107	(62)
Hand washing	38	(22)	75	(44)	58	(34)
Sterile Gloves	38	(22)	56	(33)	77	(45)
Swap port with antiseptic	40	(23)	31	(18)	100	(59)
Flush with Normal Saline 0.9%	37	(22)	30	(17)	104	(61)
Change intravenous sets	21	(12)	26	(15)	124	(73)
Cover all lumens when not in use	9	(5)	28	(16)	134	(79)
Use minimum number of lumen unless in need	8	(5)	31	(18)	132	(77)

CLABSI - central line associated bloodstream infection

Table 3 - Logistic regression model estimating the effect of the participants' characteristics on compliance scores (N=171).

Variable	B	S.E.	*P*-value	Odds Ratio	95% CI for odds ratio	
Previous education	0.21	0.04	0.99	0.1	0.71	1.02
Experience	-0.08	0.01	0.21	0.92	0.81	1.04
Number of beds	-0.12	0.01	0.09	0.8	0.76	1.02
Nurse-patient ratio	-1.73	0.07	0.01*	6.27	0.44	0.71

*$p<0.05$, B - beta, SE - standard error, CI - confidence interval

al[21] and Yepez et al[22], who reported that lowering the nurse-patient ratio would result in improvement in nurses' compliance and might improve patients' outcomes. Intensive care unit nurses are confronted with severe workloads and emotional stress and are required to make serious and fast decisions regarding patients' lives. The heavy load of tasks required for ICU patients is an important source of stress that may affect their decisions and affect the quality of care. Paying attention to the nurses' workload is of the utmost importance in order to maintain patients' safety and improve outcomes. Lowering the nurse-patient ratio may not necessarily result in a reduction in the workload; however, studies have reported that an increase in the number of patients assigned to a nurse may result in the failure of the nurse to give sufficient time to patients, and increase the risk of complications.[23] Reducing the nurse-patient ratio is associated with increasing the survival rate and a lower risk of complications.[24,25] Moreover, education, experience and reducing ICUs' bed capacity would help to further improve nurses' compliance, especially if the nurse-patient ratio is lowered.[26]

This study expanded the body of knowledge about the status of nurses' compliance with CLABSI prevention guidelines and its effect on the rate of CLABSI in ICUs. Nurses' compliance was sufficient; however more improvement could be achieved by lowering the nurse-patient ratio. Moreover, this study explained that the rate of CLABSI in the ICUs could not be fully explained by nurses' compliance with the guidelines.

Limitations. This study has some limitations. First, the observations were made during day shifts only, which might affect the reliability of the results. Future studies are recommended to conduct observations during both day and night shifts. Also, no observations were made at the time of insertion of central venous catheters. This might hide important data about the compliance with CLABSI prevention guidelines during insertion, and again affect the reliability of the findings. Future studies are recommended to conduct observations during insertion. Although the purpose of the study was hidden from the participants and data were collected over a long period of time, there was a possibility of the Hawthorn effect. Future research is recommended to secretly video-record nurses and other healthcare providers to minimize bias.

Implications for Future Research. This study provides opportunities for future research. First, conducting multidisciplinary observational research would provide a more comprehensive view of the effect of different healthcare providers' compliance on the rate of CLABSI. Second, replication of this study using a larger sample size and inclusion of nurses from several countries would improve the generalizability of findings. Third, future research would add more to the topic of CLABSI prevention guidelines by investigating additional factors that might have an effect on the rate of CLABSI, such as the side effects of medications and severity of illness.

In conclusion, this observational study assesses nurses' compliance with CLABSI prevention guidelines and the factors that affect compliance. Nurses showed sufficient compliance with the guidelines; however the variability in compliance and the rate of CLABSI across the participating hospitals suggested that there is still room for improvement in nurses' compliance. Lowering the nurse-patient ratio would help to improve nurses' compliance and prevent CLABSI.

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Appendix 1 - Performance assessment of compliance with central line associated bloodstream infection (CLABSI) prevention guidelines. (N=171).

CLABSI prevention guideline	Definition of compliance (done accurately and completely)
Daily Assessment of the catheter insertion site	Perform at least one assessment episode during a shift
Assessment of the date is made for dressing	Dressing appear updated as prescribed
Dressing is maintained clean and dry	Dressing of the central line appear clean and dry
Hand washing	Wash hand in every opportunity
Sterile Gloves	The nurse wear gloves or use non touch technique for the port in all the opportunities
Swap port with antiseptic	Swap the port in use in all the opportunities
Flush with Normal Saline 0.9%	Flush the system with Normal Saline 0.9% in all opportunities as prescribed
Change intravenous sets	Intravenous fluid set dated within 72 hours, total parenteral nutrition and blood administration sets dated within 24 hours
Cover all lumens	All lumens not used are covered throughout the whole observation time
Use minimum number of lumen unless in need	Use single lumen for intravenous fluid administration and blood extraction unless needed

Appendix 2 - Analysis of performance assessment (N=171).

Performance	Previous education	Experience	Number of beds	Nurse–patient ratio 1:1
Daily assessment of the catheter insertion site	χ^2=5.2, p=0.00	χ^2=0.86, p=0.60	χ^2=046, p=0.00	χ^2=4.1, p=0.00
Assessment of the date the dressing	χ^2=4.5, p=0.00	χ^2=1.3, p=0.50	χ^2=3.4, p=0.03	χ^2=3.2, p=0.00
Dressing is maintained clean and dry	χ^2=3.1, p=0.00	χ^2=3.1, p=0.07	χ^2=3.7, p=0.04	χ^2=3.4, p=0.00
Hand washing	χ^2=4.8, p=0.00	χ^2=0.9, p=0.56	χ^2=3.2, p=0.00	χ^2=3.3, p=0.00
Sterile Gloves	χ^2=7.9, p=0.00	χ^2=0.9, p=0.55	χ^2=3.4, p=0.00	χ^2=4.6, p=0.00
Swap port with antiseptic	χ^2=7.8, p=0.00	χ^2=0.2, p=0.94	χ^2=3.9, p=0.00	χ^2=3.1, p=0.00
Flush with Normal Saline 0.9%	χ^2=5.8, p=0.00	χ^2=0.9, p=0.60	χ^2=2.3, p=0.00	χ^2=3.4, p=0.00
Change intravenous sets	χ^2=5.8, p=0.00	χ^2=016, p=0.40	χ^2=6.2, p=0.00	χ^2=0.2, p=0.88
Cover all lumens	χ^2=3.2, p=0.00	χ^2=6.8, p=0.03	χ^2=7.2, p=0.02	χ^2=0.03, p=0.33
Use minimum number of lumen unless in need	χ^2=2.4, p=0.00	χ^2=1.1, p=0.60	χ^2=2.8, p=0.22	χ^2=5.1, p=0.00

Appendix 3 - Comparison between participants with sufficient compliance and insufficient compliance (N=171).

Participants' characteristics	Group				χ^2	*P*-value
	Sufficient (n=120)		Insufficient (n=51)			
	n	%	n	%		
Previous education	108	90	10	20	18.3	0.00*
No previous education	12	10	41	80		
Experience >5	67	56	33	65	1.1	0.28
Experience <5	53	44	18	35		
Number of beds >7	43	36	32	63	10.5	0.01*
Number of beds <7	77	64	19	37		
Nurse-patient ratio 1:1	78	65	43	84	14.8	0.00*
Nurse-patient ratio 1:2	42	35	8	16		

*p<0.05