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

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ABSTRACT

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. Although the central venous catheter facilitates patients' treatment, it is associated with a variety of complications such as thrombosis, embolism formation and infection. 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. It is a common complication that is associated with increased cost of care, extended hospital stay and increased mortality. It is estimated that 250,000 cases of CLABSI occur in the United States annually, with a 10% mortality rate. The estimated cost of care for each case of CLABSI is USD 33,000, and hospital stay is increased by up to 3 weeks. 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. 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 occurrence 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. 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. 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. Based on an estimated medium effect size ($f^2=0.15, \alpha=0.05, \text{power}=0.95$), 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.

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
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. 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 ($\chi^2=3.2, p=0.00$). 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 ($\chi^2=3.2, p=0.00$); 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 |
|----------------------------|------------------|
| Gender                     | n (%)            |
| 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 n (%) | Done but not complete or not accurate n (%) | Done completely and accurately 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
The nurse-patient ratio is lowered. To further improve nurses' compliance, especially if the experience and reducing ICUs' bed capacity would help a lower risk of complications. Moreover, education, assigned to a nurse may result in the failure of the result in a reduction in the workload; however, 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.

**References**

1. Wilson C. Preventing central venous catheter-related bloodstream infection. *Nurs Stand* 2015; 29: 37-43.
2. Galy A, Lepeule R, Goulenok T, Buzele R, de Lastours V, Fantin B. Presentation and impact of catheter-associated thrombosis in patients with infected long-term central venous catheters: a prospective bicentric observational study. *Annals of medicine* 2016; 48: 182-189.
3. CDC. Bloodstream infection event (central line-associated bloodstream infection and non-central line associated bloodstream infection) Device-associated module BSI [Internet]. 2018 3/2/2018:[1-38 pp.]. Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf.
4. Glied S, Cohen B, Liu J, Neidell M, Larson E. Trends in mortality, length of stay, and hospital charges associated with health care–associated infections, 2006-2012. *Am J Infect Control* 2016; 44: 983-989.
5. Adrie C, Garrouste-Orgeas M, Essaied WI, Schwebel C, Darmon M, Mourvillier B, et al. Attributable mortality of ICU-acquired bloodstream infections: Impact of the source, causative micro-organism, resistance profile and antimicrobial therapy. *J Infect* 2017; 74: 131-141.
6. Brunelli SM, Turenne W, Sibbel S, Hunt A, Pfaffle A. Clinical and economic burden of bloodstream infections in critical care

### 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    | 1.01       | 1.02                  |
| Experience           | -0.08| 0.01 | 0.21    | 0.84       | 0.81                  |
| Number of beds       | -0.12| 0.01 | 0.09    | 0.84       | 0.76                  |
| Nurse-patient ratio  | -1.73| 0.07 | 0.01*   | 6.27       | 0.44                  |

*p<0.05, B - beta, SE - standard error, CI - confidence interval
7. Fisher BT, Vendetti N, Bryan M, Prasad PA, Localio AR, Damianos A, et al. Central venous catheter retention and mortality in children with candidemia: a retrospective cohort analysis. *J Pediatric Infect Dis Soc* 2016; 5: 403-408.

8. Harron K, Mok Q, Dwan K, Ridyard CH, Moitt T, Millar M, et al. Catheter Infections in Children (CATCH): a randomised controlled trial and economic evaluation comparing impregnated and standard central venous catheters in children. *Health Technol Assess* 2016; 20: 1-219.

9. Al-Rawajfah OM, Cheema J, Hewitt JB, Hweidi IM, Musallam E. Laboratory-confirmed, health care-associated bloodstream infections in Jordan: A matched cost and length of stay study. *Am J Infect Control* 2013; 41: 607-611.

10. Septimus EJ, Moody J. Prevention of device-related healthcare-associated infections. *F1000Research* 2016; 5.

11. Ling ML, Apisarnthanarak A, Jaggi N, Harrington G, Morikane K, Ching P, et al. APSIC guide for prevention of Central Line Associated Bloodstream Infections (CLABSI). *Antimicrob Resist Infect Control* 2016; 5: 1-9.

12. Ista E, van der Hoven B, Kornelisse RF, van der Starre C, Vos MC, Boersma E, et al. Effectiveness of insertion and maintenance bundles to prevent central-line-associated bloodstream infections in critically ill patients of all ages: a systematic review and meta-analysis. *Lancet Infect Dis* 2016; 16: 724-734.

13. Furuya EY, Dick AW, Herzig CT, Pogorzelska-Maziarz M, Larson EL, Stone PW. Central line–associated bloodstream infection reduction and bundle compliance in intensive care units: a national study. *Infect Control Hosp Epidemiol* 2016; 37: 805-810.

14. El Nemr WA, Fahmy HH, El Razek GMA, El Salam NMA. An interventional study to decrease central venous catheter related bloodstream infection in intensive care units at Zagazig University Hospital. *Zagazig University Medical Journal* 2015; 19: 492-507.

15. Zingg W, Pittet D. Central-line bundles need a multimodal implementation strategy. *Lancet Infect Dis* 2016; 16: 724-734.

16. Chen W, Yang Y, Li H, Huang X, Zhang W. Adherence to central-line insertion practices (CLIP) with peripherally inserted central catheters (PICC) and central venous catheters (CVC): A prospective study of 50 hospitals in China. *Infect Control Hosp Epidemiol* 2018; 39: 122-123.

17. Caspari L, Epstein E, Blackman A, Jin L, Kaufman DA. Human factors related to time-dependent infection control measures: “Scrub the hub” for venous catheters and feeding tubes. *Am J Infect Control* 2017; 45: 648-651.

18. Erdfelder E, Faul F, Buchner A. GPOWER: A general power analysis program. *Behavior research methods, instruments, & computers* 1996; 28: 1-11.

19. Al-Rawajfah OM, Hweidi IM, Alkhalaileh M, Khader YS, Alshboul SA. Compliance of Jordanian registered nurses with infection control guidelines: a national population-based study. *Am J Infect Control* 2013; 41: 1065-1068.

20. IBM. Statistical Package for the Social Sciences (SPSS). IBM SPSS Statistics for Windows, Version 210. Armonk, NY: IBM; 2012.

21. Lee A, Cheung YSL, Joynt GM, Leung CCH, Wong W-T, Gomersall CD. Are high nurse workload/staffing ratios associated with decreased survival in critically ill patients? A cohort study. *Ann Intensive Care* 2017; 7: 46.

22. Yepez ES, Bovera MM, Rosenthal VD, Flores HAG, Pazmiño L, Valencia F, et al. Device-associated infection rates, mortality, length of stay and bacterial resistance in intensive care units in Ecuador: international nosocomial infection control consortium's findings. *World J Biol Chem* 2017; 8: 95-101.

23. Kwiecień K, Wujtewicz M, Mędrycka-Dąbrowska W. Selected methods of measuring workload among intensive care nursing staff. *Int J Occup Med Environ Health* 2012; 25: 209-217.

24. Shekelle PG. Nurse–Patient Ratios as a Patient Safety StrategyA Systematic Review. *Ann Intern Med* 2013; 158: 404-409.

25. McHugh MD, Ma C. Hospital nursing and 30-day readmissions among Medicare patients with heart failure, acute myocardial infarction, and pneumonia. *Med Care* 2013; 51: 52.

26. Aloush SM. Does educating nurses with ventilator-associated pneumonia prevention guidelines improve their compliance? *Am J Infect Control* 2017; 45: 960-973.
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 the dressing | Dressing appear updated as prescribed |
| 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 | $\chi^2=5.2, p<0.00$ | $\chi^2=0.86, p=0.60$ | $\chi^2=0.046, p=0.00$ | $\chi^2=4.1, p=0.00$ |
| Assessment of the date the dressing | $\chi^2=4.5, p<0.00$ | $\chi^2=1.3, p=0.50$ | $\chi^2=3.4, p=0.03$ | $\chi^2=3.2, p=0.00$ |
| Hand washing | $\chi^2=3.1, p<0.00$ | $\chi^2=3.1, p=0.07$ | $\chi^2=3.7, p=0.04$ | $\chi^2=3.4, p=0.00$ |
| Sterile Gloves | $\chi^2=4.8, p<0.00$ | $\chi^2=0.9, p=0.56$ | $\chi^2=3.2, p=0.00$ | $\chi^2=3.3, p=0.00$ |
| Swap port with antiseptic | $\chi^2=7.8, p<0.00$ | $\chi^2=0.2, p=0.94$ | $\chi^2=3.9, p=0.00$ | $\chi^2=3.1, p=0.00$ |
| Flush with Normal Saline 0.9% | $\chi^2=5.8, p<0.00$ | $\chi^2=0.9, p=0.60$ | $\chi^2=2.3, p=0.00$ | $\chi^2=3.4, p=0.00$ |
| Change intravenous sets | $\chi^2=5.8, p<0.00$ | $\chi^2=0.16, p=0.40$ | $\chi^2=6.2, p=0.00$ | $\chi^2=0.2, p=0.88$ |
| Cover all lumens | $\chi^2=3.2, p<0.00$ | $\chi^2=6.8, p=0.03$ | $\chi^2=7.2, p=0.02$ | $\chi^2=0.03, p=0.33$ |
| Use minimum number of lumen unless in need | $\chi^2=2.4, p<0.00$ | $\chi^2=1.1, p=0.60$ | $\chi^2=2.8, p=0.22$ | $\chi^2=5.1, p=0.00$ |

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

| Participants' characteristics | Sufficient (n=120) | Insufficient (n=51) | $\chi^2$ | P-value |
|------------------------------|--------------------|---------------------|----------|---------|
| Previous education | 108 | 90 | 10 | 20 | 18.3 | 0.00* |
| No previous education | 12 | 10 | 41 | 80 | 1.4 | 0.26 |
| Experience >5 | 67 | 56 | 33 | 65 | 1.1 | 0.28 |
| Experience <5 | 53 | 44 | 18 | 35 | 6.8 | 0.01* |
| 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