ORIGINAL RESEARCH

Clinical Influence of Nursing Intervention Under FOCUS-Plan-Do-Check-Act Cycle Management Model on Preventing and Controlling Central Line-associated Bloodstream Infections in Patients in ICU

Amin Zhang, BD; Yanxia Gong, BD; Xiaoxiao Li, BD; Kali Zhu, MM

ABSTRACT

Background • Central venous catheterization is an invasive procedure that may lead to central line-associated bloodstream infection, affecting the patient's prognosis and recovery. Thus, it is essential to master the right interventions for the prevention and control of central line-associated bloodstream infections. FOCUS-Plan-Do-Check-Act (PDCA) cycle management model, also known as Deming circle management model, is a programmed and scientific management method.

Objective • We attempted to clarify the impact of nursing intervention on preventing and controlling central line-associated bloodstream infection under the FOCUS- PDCA cycle management model, in order to effectively deplete central line-associated bloodstream infection in each intensive care unit, facilitate early recovery of patients.

Design • Our study retrospectively analyzed the clinical data of intensive care unit patients before and after implementation of nursing intervention under the FOCUS-PDCA cycle management model. This study was a retrospective study.

Setting • This study was performed in the Department of Infection Management, Taihe County People's Hospital.

Participants • A total of 214 intensive care unit patients with indwelling central venous catheters before implementation of nursing intervention under the FOCUS-PDCA cycle management model in our hospital in 2021 were selected as the control group. A total of 220 ICU patients with indwelling CVC after nursing intervention under the FOCUS-PDCA cycle management model in 2022 were included in the experimental group. All patients met the inclusion criteria of patients with CVC puncture catheterization for ≥ 2 days.

Interventions • The control group underwent conventional nursing, including (1) nurses observing aseptic technique; (2) nurses regularly inspected and replaced dressings; (3) nurses timely handled abnormal situations at the puncture site; (4) nurses provided relevant education and psychological counseling to patients and their families. The experimental group adopted nursing intervention under the FOCUS-PDCA cycle management model on the basis of that of the control group.

Primary Outcome Measures • (1) central venous catheterization puncture status (2) central venous catheterization application status (3) central line-associated bloodstream infection status, and (4) hospitalization status.

Results • The one-time success rate of puncture and success rate of puncture in the experimental group exhibited elevation relative to those in the control group ($P < .05$). The central venous catheterization application rate in the experimental group exhibited depletion relative to that in the control group ($P < .05$). The daily infection rate of CLABSI in the experimental group exhibited depletion relative to that in the control group, but without statistical significance ($P > .05$), indicating that nursing intervention under the FOCUS-PDCA cycle management model had no obvious inhibitory effect on the daily infection rate of CLABSI. The time of central line-associated bloodstream infection occurrence in the experimental group was later than that in the control group ($P < .05$). The hospitalization time and hospitalization expenses in the experimental group exhibited depletion relative to those in the control group ($P < .05$).

Conclusion • Nursing intervention under the FOCUS-PDCA cycle management model can effectively deplete central line-associated bloodstream infection in each intensive care unit, facilitate early recovery of patients, and shorten hospital stay, which is worthy of promotion. Our study provide a clinical nursing reference for the preventing and controlling central line-associated bloodstream infections in patients in each intensive care unit. (*Altern Ther Health Med.* [E-pub ahead of print.])

Amin Zhang, BD; **Yanxia Gong**, BD; **Xiaoxiao Li**, BD; **Kali Zhu**, MM, Department of Infection Management; Taihe County People's Hospital; Taihe; Anhui; China.

Corresponding author: Amin Zhang, BD
E-mail: mam1452@163.com

INTRODUCTION

The central venous catheter (CVC) is a percutaneous catheter inserted into the central vein, majorly through the internal jugular, subclavian, and femoral veins into the superior and inferior vena cava.[1-3] CVC has the advantages of measuring central venous pressure, evaluating circulatory physiological indexes, realizing urgent and rapid fluid rehydration in critically ill patients, avoiding repeated puncture, reducing peripheral venous injury, etc.. It has become the first choice for critically ill patients in the intensive care unit (ICU).[4-6] Nevertheless, while treating critically ill patients, bloodstream infections caused by CVC have also become a new challenge for healthcare workers.[7,8] Central line-associated bloodstream infection (CLABSI) refers to the development of bacteremia or fungemia within 48 hours after the insertion or removal of intravascular catheters, accompanied by infectious manifestations such as fever (body temperature >38°C), chill, or hypotension, excluding other clear sources of infection other than vascular catheters.[9,10] The systemic immune function of ICU patients is poor, and most of them are treated with immunosuppressive agents or antibiotics. The CVC is the vascular channel of ICU

patients. During catheter placement, bacteria shift on the skin, biofilm forms inside and outside the catheter lumen, and microorganisms colonize and enter the blood, which is likely to cause CLABSI.[11] In China, the case infection rate of VCAI ranges from 2.75% to 6.3%, and the 1000-day catheter infection rate ranges from 4.0‰ to 9.8‰.[12] In the United States, more than 5 million patients use CVC each year, more than 250 000 patients occur VCAI, nearly 80 000 of these patients from the ICU, the mortality rate of VCAI patients in the ICU is as high as 30%, the cost of a single infected person is as high as $56 000, and the annual related expenses exceed $2 billion.[13] Since CVC catheterization is an invasive operation, and the systemic immune function of critically ill patients admitted to ICU is quite low, the incidence of CLABSI is increased, which affects the prognosis and rehabilitation of patients, increases the medical cost of patients, prolongs the hospital stay, and increases the burden of treatment.[14,15] Thus, it is essential to master the right interventions for the prevention and control of CLABSI and to implement them in clinical practice.

The traditional CVC nursing intervention model lacks scientific theoretical support, and it provides patients with nursing only based on previous experience which has the defects of inconsistency in care, lack of standardized protocols, or gaps in knowledge.[16] Nurses are busy, and their intervention measures for patients are not perfect, which affects the quality of nursing and the normal rehabilitation of patients. The risk of nursing disputes is high. Scholars have applied the FOCUS-PDCA cycle management model in nursing research and achieved good application results.[17]

Plan-Do-Check-Act (PDCA) cycle management, also known as Deming circle management, is a programmed and scientific management method that has been gradually applied in the nursing field with the development of medical models in recent years.[18,19] FOCUS-PDCA is a continuous quality improvement model proposed by the Hospital Corporation of America (HCA) in the 1990s, which is an extension and improvement of the traditional PDCA cycle.[20] FOCUS-PDCA program includes 9 steps: find, organize, clarify, understand, select, plan, do, check, and act. Its advantages are to identify problems, establish a team, identify causes, clarify norms, and improve with goals and plans, which can be correctly implemented by the responsible person, promptly identify problems, and provide solutions. Currently, the FOCUS-PDCA cycle management model has been studied in the field of nursing and has achieved excellent application results.[21] It has been reported that the application of the FOCUS-PDCA procedure improves the self-care ability of rectal cancer patients undergoing colostomy, reduces colostomy complications, and improves their quality of life.[22] Seamless nursing management for patients with acute cerebral infarction and dysphagia under the FOCUS-PDCA model can effectively improve the patient's swallowing function, reduce the degree of neurological deficit, improve their nutritional status and quality of life.[23] Nevertheless, little has been reported about its impact on CLABSI.

Thus, this research attempted to clarify the impact of nursing intervention on the incidence of CLABSI under the FOCUS-PDCA cycle management model and provide practical and effective clinical nursing reference for the prevention of CLABSI patients. Our study provide a clinical nursing reference for the preventing and controlling central line-associated bloodstream infections in patients in each intensive care unit.

MATERIALS AND METHODS

General data

A total of 214 ICU patients with CVC indwelling before the implementation of nursing intervention under the FOCUS-PDCA cycle management model in our hospital in 2021 received selection as the control group (CG). A total of 220 ICU patients with CVC indwelling after nursing intervention under the FOCUS-PDCA cycle management model in 2022 received inclusion in the experimental group (EG). The research achieved approval from our hospital's ethics committee, and all patients' family members have given informed consent.

Inclusion and exclusion criteria

(1) Aged ≥ 14 years old; (2) Those with CVC puncture catheterization for ≥ 2 days; (3) those with complete clinical data. Exclusion criteria: (1) Those suspected of catheter-related bloodstream infection before hospitalization; (2) those having received hormone and immunosuppressive drug therapies; (3) those having received organ transplants.

Nursing methods

The control group underwent conventional nursing, including (1) nurses observing aseptic technique; (2) nurses regularly inspected and replaced dressings; (3) nurses timely handled abnormal situations at the puncture site; (4) nurses provided relevant education and psychological counseling to patients and their families.

The experimental group underwent nursing intervention under the FOCUS-PDCA cycle management model on the basis of that of the control group, including the following 9 stages. 1) Find. The 35 ICU clinical nurses were screened, and questionnaires were conducted. The major investigation content included CLABSI diagnostic standards, CLABSI operating procedures, hand washing and disinfection, CLABSI specimen collection and transportation requirements, and ICU nurses' understanding of the implementation of nursing measures under the FOCUS-PDCA cycle management model for CLABSI. (2) Organize. Under the leadership of the head nurse, an ICU-CLABSI quality control team was built, majorly including nursing department, the infection management department of the hospital, the laboratory department, the ICU ward quality control team leader, and the quality controller. (3) Clarify. Under the organization of the ICU-CLABSI quality control group, the risk factors related to CLABSI were analyzed and listed through a problem list method. The *International Joint Commission Measurement*

Table 1. General data in both groups

Groups	n	Gender [n (%)]		Age	Disease types [n (%)]				
		Male	Female		Multiple organ failure	Multiple trauma	Respiratory distress syndrome	Poisoning	Others
CG	214	132 (61.68)	82 (38.32)	45.70 ± 13.05	70 (32.71)	47 (21.96)	56 (26.17)	13 (6.07)	28 (13.08)
EG	220	116 (52.73)	104 (47.27)	45.19 ± 12.88	66 (30.00)	55 (25.00)	51 (23.18)	21 (9.55)	27 (12.27)
χ^2/t		1.657		0.137	1.558				
P value		.198		.891	.816				

Abbreviations: CG, control group; EG, experimental group.

Index Library was referred to for selecting measurement indicators for possible problems of CLABSI infection and developing quality improvement and patient' safety monitoring plans. (4) Understand. The causes of CLABSI were analyzed according to risk factors and operating procedures, and the ICU-CLABSI quality control group was organized to discuss. (5) Select. Specific measures that could control CLABSI were selected, new forms were designed based on risk factors, and new operating standards were clarified. CLABSI preventive standard operating procedures are developed according to the actual situation of the department. (6) Plan. The data of CVC patients in the ICU were collected, the specific conditions of patients were comprehensively evaluated, the risk factors of infection were summarized, the causes were analyzed, and the prevention plan for CLABSI was developed. (7) Do. The knowledge and theory of catheter-related bloodstream infections among medical staff were improved, various processes and management systems were established and improved, the training of general practitioners' risk awareness was strengthened, and nursing staff were encouraged to master relevant operations. The preoperative puncturator strictly performed aseptic techniques and assessed whether the patient needed an indwelling catheter on a daily basis. (8) Check. The ICU-CLABSI quality control team managed and monitored the corresponding operating procedures, aseptic techniques, patient evaluation, catheter selection, catheter placement time, etc., conducted regular assessments, and timely corrected non-standard operations. (9) Act. The results of the summary inspection were processed and analyzed. Questions and suggestions from medical staff were collected. Suspected or existing cases of CLABSI were analyzed. Risk factors and issues that may lead to catheter-associated infections during medical treatment and care were identified, and further improvements were developed. The process was modified and implemented in time for the next FOCUS-PDCA cycle, while the effective methods of the previous stage were retained and continue to be applicable.

Clinical observation indicators

(1) CVC puncture status after intervention. The number of one-time success of puncture, two-time success of puncture, three- or more-time success of puncture, and failure of puncture in both groups after intervention received recording. (2) CVC application status. The total length of stay and total catheterization time in both groups received recording. CVC application rate (%) = (total catheterization time / total length of stay) × 100%. (3) CLABSI status. The number of cases of CLABSI and the time of infection in both groups received recording. Daily infection rate of CLABSI (‰) = (CLABSI cases / total catheterization time) × 1000‰. (4) Hospitalization status. The average length of stay and average hospitalization expenses in both groups received recording.

Diagnostic criteria and clinical monitoring

Diagnosis was made using the latest diagnostic criteria from the Centers for Disease Control and Prevention (CDC).[24] When the patient developed infection symptoms such as fever (body temperature ≥ 38.5°C), chills, and low blood pressure within 48 hours after CVC retention or 48 hours after CVC removal, the doctor notified the nurse in charge to perform a blood culture. When the body temperature of the patient was elevated or shivering, the catheter blood and peripheral blood of the limb were collected for aerobic culture and anaerobic culture. The sample size of the catheter blood and peripheral blood were the same, and the collection interval was < 5 min.

Statistical analysis

The data received is processed through SPSS 27.0 statistical software (IBM, Armonk, New York, USA). The measurement data received representation by $\bar{x} \pm s$ and subjection to *t* test. The counting data received representation by [n (%)] and subjection to χ^2 test. $P < .05$ indicated a statistically significant difference.

RESULTS

Comparison of general data between both groups

No statistical significance in general clinical data such as gender, age, and disease type was exhibited between both groups ($P = .198$, $P = .891$, and $P = .816$; Table 1), indicating comparability.

Comparison of CVC puncture status between both groups after intervention

The one-time success rate of puncture and success rate of puncture in EG was 97.73% and 100%, exhibited elevation relative to those of 84.11% and 95.79% in CG, indicating statistical significance ($P < .001$ and $P = .043$; Table 2 & Figure 1). These results suggested that nursing intervention under FOCUS-PDCA cycle management model could effectively improve the CVC puncture status of patients in intensive care unit.

Comparison of CVC application status between both groups

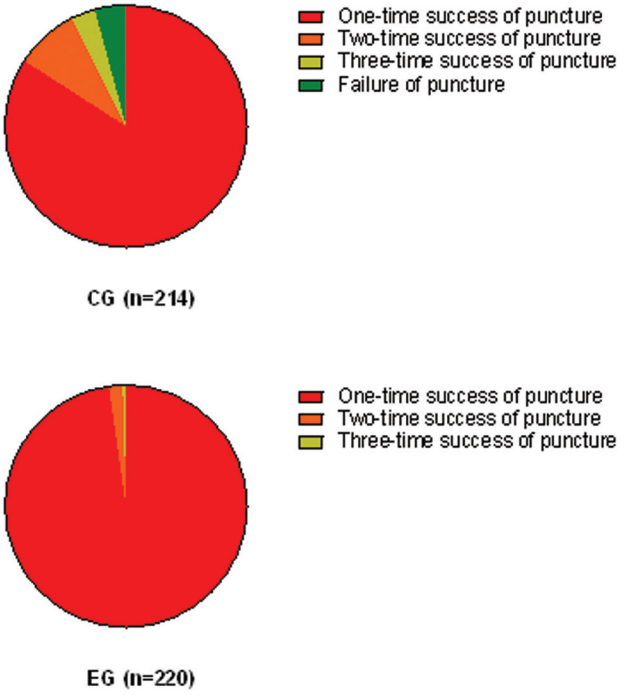
The CVC application rate in EG was 94.18%, exhibited depletion relative to that of 81.29% in CG, indicating statistical significance ($P = .005$; Table 3). These results

Table 2. CVC puncture status in both groups after the intervention

Groups	Expected catheterization cases (n)	One-time success of puncture (n)	Two-time success of puncture (n)	Three-time success of puncture (n)	Failure of puncture (n)	One-time success rate of puncture (%)	Success rate of puncture [n (%)]
CG	214	180	18	7	9	84.11	205 (95.79)
EG	220	215	4	1	0	97.73	220 (100)
χ^2	/	/	/	/	/	11.966	4.082
P value	/	/	/	/	/	<.001	.043

Abbreviations: CG, control group; EG, experimental group.

Figure 1. CVC puncture status in both groups after intervention.



Abbreviations: CG, control group; EG, experimental group.

Table 3. CVC application status in both groups

Groups	Total length of stay (d)	Total catheterization time (d)	CVC application rate (%)
CG	1817	1477	81.29
EG	1530	1441	94.18
χ^2		/	7.726
P value		/	.005

Abbreviations: CG, control group; EG, experimental group; CVC, central venous catheter.

suggested that nursing intervention under FOCUS-PDCA cycle management model could effectively reduce the CVC application status of patients in intensive care unit.

Comparison of CLABSI status between both groups

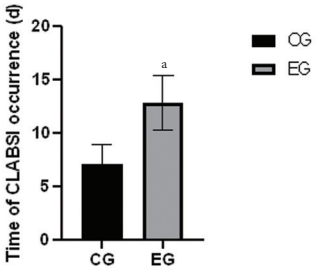
The daily infection rate of CLABSI in EG was 0.00%, exhibiting depletion relative to that of 2.71% in CG, whereas it was without statistical significance ($P = .081$). The time of CLABSI occurrence in EG was 12 days, presented later than that of 7 days in CG, indicating statistical significance ($P < .001$; Table 4 & Figure 2). These results suggested that nursing intervention under FOCUS-PDCA cycle management model could effectively reduce the time of CLABSI occurrence of patients in intensive care unit.

Table 4. CLABSI status in both groups

Groups	Total catheterization time (d)	CLABSI cases (n)	Daily infection rate of CLABSI (‰)
CG	1477	4	2.71
EG	1441	0	0
χ^2	/	/	3.046
P value	/	/	.081

Abbreviations: CG, control group; EG, experimental group; CLABSI, central line associated bloodstream infection.

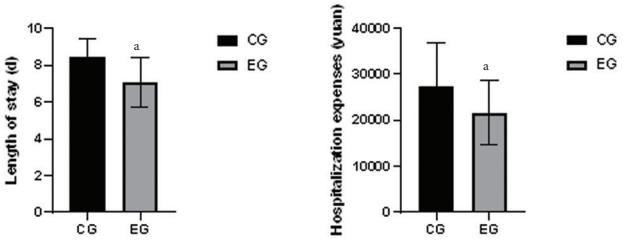
Figure 2. CLABSI status in both groups.



[a]$P < .001$.

Abbreviations: CG, control group; EG, experimental group; CLABSI, central line associated bloodstream infection.

Figure 3. Hospitalization status in both groups.



[a]$P < .001$.

Abbreviations: CG, control group; EG, experimental group.

Comparison of hospitalization status between both groups

The hospitalization time and hospitalization expenses in EG were 7.5 days and 20000 yuan, exhibited depletion relative to those of 8.3 days and 28000 yuan in CG, indicating statistical significance ($P < .001$; Figure 3). These results suggested that nursing intervention under FOCUS-PDCA cycle management model could effectively promote the recovery and reduce healthcare costs of patients in intensive care unit.

DISCUSSION

Our study investigated the impacts of nursing intervention on preventing and controlling central line-associated bloodstream infection under the FOCUS- PDCA cycle management model, and discovered that nursing intervention under FOCUS-PDCA cycle management model could effectively improve the CVC puncture status, reduce the CVC application status, reduce the time of CLABSI occurrence, promote the recovery and reduce healthcare costs of patients in intensive care unit.

CVC has been widely used in clinical practice and is also a commonly used medical device in ICU. While CVC provides blood transfusion and nutritional support to

patients, there is also a risk of CLABSI. Data demonstrates that catheter-related bloodstream infection accounts for approximately 15% of hospital infections, and most of them are caused by CVC.[25] Hospital infection not only increases patients' pain and treatment difficulty but also prolongs the patient's hospital stay and even endangers the patient's life in severe cases. Therefore, it is necessary to strengthen the relevant nursing of CVC to control the risk of catheter-related bloodstream infection.

The ways of catheter-related infections caused by microorganisms include intraluminal infection and extraluminal infection.[26] Intraluminal infections include joint, liquid contamination, and endogenous contamination, while extraluminal infection is mainly caused by the migration of skin colonizing bacteria. Hand hygiene is the most economical and effective measure to control hospital infections and is one of the basic links to ensure patients' safety.[27,28] Strict and correct hand hygiene before puncture, after catheterization and during catheterization maintenance can effectively reduce the incidence of catheter bloodstream infection in ICU.[29] Improving the success rate of catheterization and avoiding repeated punctures and catheterization can reduce damage to the intima of blood vessels, thereby reducing the risk of bloodstream infections.

The nursing intervention under the FOCUS-PDCA cycle management model takes strict nursing measures for CVC patients in the intensive care unit, evaluates and analyzes patients' conditions, collects problems, and makes adjustments and improvements according to deficiencies. Meanwhile, nursing intervention is carried out under a strict supervision system to standardize nursing operations and improve the compliance of patients and their families. Continuously improve the nursing process and enhance the quality of nursing. Nursing interventions under the FOCUS-PDCA cycle management model can attenuate catheter-related bloodstream infections, facilitate patients' recovery, and reduce medical and economic burdens of patients and their families.

Herein, we established the ICU-CLABSI quality control team. After implementing CLABSI-related nursing measures, the implementation rate of hand hygiene, skin disinfection, and joint disinfection of the ICU-CLABSI quality control team members has significantly improved. Consistently, it has been reported that PDCA cycle is well applied in nursing quality management and risk control in the digestive endoscope room.[30] The results demonstrated that the one-time success rate and success rate of CVC puncture in EG after intervention reached 97.73% and 100%, respectively, indicating that nursing intervention measures under the FOCUS-PDCA cycle management model were quite effective. Likewise, PDCA cycle management can help improve the first-attempt success rate of internal jugular vein puncture and catheterization, shorten the duration of puncture and catheterization, and reduce the incidence of complications.[31] Additionally, the application rate of CVC in EG exhibited depletion relative to that in CG. The daily infection rate of CLABSI in EG exhibited depletion relative to that in CG but with no statistical significance. The occurrence time of CLABSI in the EG group was later than in the CG group. The hospitalization time and hospitalization expenses in EG exhibited depletion relative to those in CG, suggesting that nursing intervention under the FOCUS-PDCA cycle management model could effectively reduce the incidence of CLABSI and shorten the length of hospital stay. In line with our findings, it has been documented that nursing management for patients with acute cerebral infarction and dysphagia under the FOCUS-PDCA model can effectively improve the patient's swallowing function, reduce the degree of neurological deficit, improve their nutritional status and quality of life, and has fewer complications.[23]

The main limitation of this study is the small sample size, and future studies with a larger sample size are needed to support the conclusions. In addition, the study was conducted on the Chinese population, and the geographical area involved was not broad enough, which may lead to cultural and ethnic differences. Our study will carry out large-scale and multicenter studies in the future, and our study will be studied in different geographical region.

In conclusion, nursing intervention under the FOCUS-PDCA cycle management model can effectively deplete CLABSI in each ICU, facilitate early recovery of patients, and shorten hospital stays, which is worthy of promotion. Our study provide a clinical nursing reference for the preventing and controlling central line-associated bloodstream infections in patients in each intensive care unit, which might effectively reduce the risk of antibiotic resistance and promote the effective control of CLABSI.

REFERENCES

1. Lockwood J, Desai N. Central venous access. *British journal of hospital medicine (London, England : 2005)*. 2019;80(8):C114-c119.
2. Maddali MM, Al Aliyani KRS, Arora NR, Sathiya PM. Central Venous Catheter Tip Malposition After Internal Jugular Vein Cannulation in Pediatric Patients With Congenital Heart Disease. *J Cardiothorac Vasc Anesth*. 2022;36(8)(8 Pt A):2483-2487. doi:10.1053/j.jvca.2022.01.033
3. Johnson RR, Faustino EVS. Central venous catheter-associated deep vein thrombosis in critically ill pediatric patients: risk factors, prevention, and treatment. *Curr Opin Pediatr*. 2022;34(3):273-278. doi:10.1097/MOP.0000000000001128
4. Burke C, Jakub K, Kellar I. Adherence to the central line bundle in intensive care: an integrative review. *Am J Infect Control*. 2021;49(7):937-956. doi:10.1016/j.ajic.2020.11.014
5. Costa CAB, Araújo FL. Central Venous Catheter bundle: professional knowledge and behavior in adult Intensive Care Units. 2020;54:e03629.
6. Lacostena-Pérez ME, Buesa-Escar AM, Gil-Alós AM. Complications related to the insertion and maintenance of peripheral venous access central venous catheter. *Enferm Intensiva (Engl Ed)*. 2019;30(3):116-126. Complicaciones relacionadas con la inserción y el mantenimiento del catéter venoso central de acceso periférico. doi:10.1016/j.enfie.2018.05.001
7. Estrada-Orozco K, Cantor-Cruz F, Larrotta-Castillo D, Díaz-Ríos S, Ruiz-Cardozo MA. Central venous catheter insertion and maintenance: evidence-based clinical recommendations. *Rev Colomb Obstet Ginecol*. 2020;71(2):115-162.
8. Velasquez Reyes DC, Bloomer M, Morphet J. Prevention of central venous line associated bloodstream infections in adult intensive care units: A systematic review. *Intensive Crit Care Nurs*. 2017;43:12-22. doi:10.1016/j.iccn.2017.05.006
9. Reynolds SS, Woltz P, Keating E, et al. Results of the CHlorhexidine Gluconate Bathing implementation intervention to improve evidence-based nursing practices for prevention of central line associated bloodstream infections Study (CHanGing BathS): a stepped wedge cluster randomized trial. *Implement Sci*. 2021;16(1):45. doi:10.1186/s13012-021-01112-4
10. Ardura MI, Bibart MJ, Mayer LC, et al. Impact of a Best Practice Prevention Bundle on Central Line-associated Bloodstream Infection (CLABSI) Rates and Outcomes in Pediatric Hematology, Oncology, and Hematopoietic Cell Transplantation Patients in Inpatient and Ambulatory Settings. *J Pediatr Hematol Oncol*. 2021;43(1):e64-e72. doi:10.1097/MPH.0000000000001950
11. Al-Shukri RN, Al-Rawajfah OM, Al-Daken L, Al-Busaidi M. ICU-acquired central line-associated bloodstream infection and its associated factors in Oman. *Am J Infect Control*. 2022;50(9):1026-1031. doi:10.1016/j.ajic.2021.12.024
12. Zhu S, Kang Y, Wang W, Cai L, Sun X, Zong Z. The clinical impacts and risk factors for non-central line-associated bloodstream infection in 5046 intensive care unit patients: an observational study based on electronic medical records. *Crit Care*. 2019;23(1):52. doi:10.1186/s13054-019-2353-5
13. Tacconelli E, Smith G, Hieke K, Lafuma A, Bastide P. Epidemiology, medical outcomes and costs of catheter-related bloodstream infections in intensive care units of four European countries: literature- and registry-based estimates. *J Hosp Infect*. 2009;72(2):97-103. doi:10.1016/j.jhin.2008.12.012

14. Devrim İ, Özkul MT, Çağlar İ, et al. Central line bundle including split-septum device and single-use prefilled flushing syringes to prevent port-associated bloodstream infections: a cost and resource-utilization analysis. *BMC Health Serv Res*. 2020;20(1):336. doi:10.1186/s12913-020-05221-6
15. Snyder AN, Burjonrappa S. Central line associated blood stream infections in gastroschisis patients: A nationwide database analysis of risks, outcomes, and disparities. *J Pediatr Surg*. 2020;55(2):286-291. doi:10.1016/j.jpedsurg.2019.10.028
16. Foka M, Nicolaou E, Kyprianou T, et al. Prevention of Central Line-Associated Bloodstream Infections Through Educational Interventions in Adult Intensive Care Units: A Systematic Review. *Cureus*. 2021;13(8):e17293. doi:10.7759/cureus.17293
17. Xie C, Zhang J, Luo J, et al. FOCUS-PDCA can effectively optimize the critical value of test items: FOCUS-PDCA može efikasno da optimizuje kritičnu vrednost ispitivanja. *J Med Biochem*. 2022;41(3):347-354. doi:10.5937/jomb0-34958
18. Liu C, Liu Y, Tian Y, et al. Application of the PDCA cycle for standardized nursing management in sepsis bundles. *BMC Anesthesiol*. 2022;22(1):39. doi:10.1186/s12871-022-01570-3
19. Chen H, Wang P, Ji Q. Analysis of the Application Effect of PDCA Cycle Management Combined With Risk Factor Management Nursing for Reducing Infection Rate in Operating Room. *Front Surg*. 2022;9:837014. doi:10.3389/fsurg.2022.837014
20. Jin Y, Li C. Effect of FOCUS-PDCA procedure on improving self-care ability of patients undergoing colostomy for rectal câncer. 2021;55:e03729. doi:10.1590/s1980-220x2020012503729
21. Heidaranlu E, Amiri M, Salaree MM, Sarhangi F, Saeed Y, Tavan A. Audit of the functional preparedness of the selected military hospital in response to incidents and disasters: participatory action research. *BMC Emerg Med*. 2022;22(1):168. doi:10.1186/s12873-022-00728-z
22. Jin Y, Li C, Zhang X, Jin Y, Yi L, Cui J. Effect of FOCUS-PDCA procedure on improving self-care ability of patients undergoing colostomy for rectal câncer. *Rev Esc Enferm USP*. 2021;55:e03729. doi:10.1590/s1980-220x2020012503729
23. Niu Y, Zhang L, Sun X. Efficacy of Seamless Care Management Under FOCUS-PDCA for Patients with Acute Cerebral Infarction Complicated with Dysphagia and its Influence on Nutritional Status and Neurological Functions. *Altern Ther Health Med*. 2023;AT9668.
24. Chi X, Guo J, Niu X, He R, Wu L, Xu H. Prevention of central line-associated bloodstream infections: a survey of ICU nurses' knowledge and practice in China. *Antimicrob Resist Infect Control*. 2020;9(1):186. doi:10.1186/s13756-020-00833-3
25. Moriyama K, Ando T, Kotani M, et al. Risk factors associated with increased incidences of catheter-related bloodstream infection. *Medicine (Baltimore)*. 2022;101(42):e31160. doi:10.1097/MD.0000000000031160
26. Gilardi E, Piano A, Chellini P, Fiori B, Dolcetti L, Pittiruti M. Reduction of bacterial colonization at the exit site of peripherally inserted central catheters: A comparison between chlorhexidine-releasing sponge dressings and cyano-acrylate. 2021;22(4):597-601. doi:10.1177/1129729820954743
27. Ojanperä H, Kanste OI, Syrjala H. Hand-hygiene compliance by hospital staff and incidence of health-care-associated infections, Finland. *Bull World Health Organ*. 2020;98(7):475-483. doi:10.2471/BLT.19.247494
28. Mouajou V, Adams K, DeLisle G, Quach C. Hand hygiene compliance in the prevention of hospital-acquired infections: a systematic review. *J Hosp Infect*. 2022;119:33-48. doi:10.1016/j.jhin.2021.09.016
29. Buetti N, Timsit JF. Management and Prevention of Central Venous Catheter-Related Infections in the ICU. *Semin Respir Crit Care Med*. 2019;40(4):508-523. doi:10.1055/s-0039-1693705
30. Xu Y, Shi C, Liu Y. Application effect of PDCA circulation on nursing quality management and risk control in digestive endoscopy room. *Medicine (Baltimore)*. 2023;102(48):e35885. doi:10.1097/MD.0000000000035885
31. Lai F, Xie D, Weng Y, et al. Application of plan-do-check-act management to improve first-attempt insertion success rates of internal jugular vein catheterization for standardized training residents in an intensive care unit. *BMC Med Educ*. 2022;22(1):420. doi:10.1186/s12909-022-03418-3