Preventing central line-associated bloodstream infections: A position paper of the International Society for Infectious Diseases, 2024 update

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Highlights:

- The CLABSI rates continue to be very high, especially in resource-limited regions.
- CLABSIs are associated with extra hospital stays, costs, and mortality.
- This document presents the main risk factors for CLABSI.
- We updated the recommendations for CLABSI prevention, including those for LMICs.

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All authors have contributed equally to this scientific review paper. The tasks of conceptualization, literature review, data analysis, and interpretation, drafting of the initial manuscript, critical review and editing, supervision, and final approval of the manuscript were jointly undertaken by all authors

ABSTRACT

A panel of experts convened by the International Society for Infectious Diseases (ISID) has reviewed and consolidated current recommendations for preventing vascular catheter infections, particularly central line-associated bloodstream infections (CLABSIs). This review provides healthcare professionals with insights into key issues such as the rates of CLABSI in high-income countries and low- and middle-income countries, the attributable extra length of stay, cost and mortality, and risk factors. This position paper highlights evidence-based strategies for preventing infections, applicable to both high-income and low- and middle-income countries.

Contents

INTRODUCTION

This document reviews the evidence and offers an international perspective on epidemiology, clinical outcomes, risk factors, and recommendations to aid central line-associated bloodstream infection (CLABSI) prevention efforts in low—and middle-income (LMICs) and high-income countries. We acknowledge recommendations from previous guidelines, such as those of the Infusion Nurses Society,[1] and from the Society for Healthcare Epidemiology of America, the Infectious Diseases Society of America, and the Association for Professionals in Infection Control and Epidemiology.[2]

The Centers for Disease Control and Prevention (CDC) / National Healthcare Safety Network (NHSN) reports a CLABSI rate of 0.8/1,000 CL-days in medical-surgical intensive care units (ICUs).[3] The International Nosocomial Infection Control Consortium (INICC) report indicated a CLABSI rate of 12.5/1,000 CL-days in LMICs from 2002 to 2005, which gradually reduced to 4.5/1,000 CL-days in the report covering 2015 to 2020.[4]

Pooling data from 630 ICUs across 45 LMICs in Africa, Asia, Eastern Europe, Latin America, and the Middle East, covering 204,770 patients, 1,480,620 patient days, and 4,270 CLABSIs from 2015 to 2020, the length of stay (LOS) was 6.57 days, and mortality was 14.06% for patients without healthcare-associated infections (HAIs), while the LOS was 23.17 days and the mortality rate was 39.81% for those with CLABSI.[4] In a multicenter, multinational, multicontinental study involving 786 ICUs in 147 cities spanning 37 countries between 1998 and 2022, 300,827 patients were followed for 2,167,397 patient days, with 21,371 HAIs. Multiple logistic regression identified the acquisition of a CLABSI as an independent mortality risk factor.[5]

The likelihood of CLABSI is higher among ICU patients due to the insertion of multiple CLs and the use of high-risk types.[6] Urgent circumstances often result in repeated daily access and prolonged usage.[1, 2] Factors identified as CLABSI risks include patient factors, such as neutropenia, BMI >40, and prematurity, and healthcare factors, such as prolonged LOS before catheterization, extended catheter duration, high microbial colonization at the insertion site and catheter hub, multi-lumen catheter use, concurrent use of multiple catheters, reduced nurse-to-patient ratio, care by float nurses, parenteral nutrition, inadequate catheter care, blood product transfusion, femoral insertion site, and internal jugular site with concurrent tracheostomy.[1, 2]

From 1998 to 2022, a multinational prospective cohort study involving 728 ICUs in 147 cities across 41 African, Asian, Eastern European, Latin American, and Middle Eastern countries used an online standardized surveillance system to identify CLABSI risk factors. On the one hand, this study evidenced that the risk of CLABSI is increased by 4% per day of CL use. On the other hand, tracheostomy use, hospitalization at a public facility, and hospitalization in a middle-income country were also associated with higher CLABSI risk.

Finally, the highest CLABSI risk was associated with internal jugular and femoral sites, while the lowest risk was found with peripherally inserted central catheters (PICCs).[7]

Methods

The International Society of Infectious Diseases (ISID) recruited five subject-matter experts in CLABSI prevention to edit the ISID guidelines. Each expert conducted a comprehensive search of PubMed and Embase (January 2014–June 2024). The experts first reviewed the abstracts of the articles identified and then proceeded with full-text reviews. Relevant references were incorporated into the review. Recommendations resulting from this process were classified based on the quality of evidence and the balance between the desirable and potential undesirable effects of various interventions. The experts reached a consensus regarding the literature findings, recommendations, the quality of evidence supporting these recommendations, and their classification into the following categories: (1) Necessary prerequisites, (2) Implementation of CLABSI prevention strategies, (3) Before insertion, (4) At insertion, (5) After insertion, (6) Supplementary interventions, (7) Not advisable interventions to prevent CLABSI, (8) Interventions pending resolution, and (9) Suggested practice in under-resourced settings. After reaching a consensus, the experts reviewed the draft manuscript and approved the document and its recommendations. All panel members adhered to ISID policies on conflict-of-interest disclosure.

SUGGESTED PRACTICE

1) NECESSARY PREREQUISITES

a) Establishments and implementation of CLABSI prevention interventions should possess the following components: (1) Assets for delivering education and training, (2) An infection prevention team tasked with identifying patients who meet the CLABSI definition, (3) An Infection prevention program with information technology support for gathering CL-days, (4) Patient-days for determining CL-device utilization (DU) ratio. (5) Validation of CL-days obtained from information systems by comparing them to a manual method, with an acceptable margin of error not exceeding ±5%. (6) Effective laboratory support for the timely processing of specimens and reporting results.[1, 2]

2) IMPLEMENTATION OF CLABSI PREVENTION STRATEGIES

a) **Implement a Multidimensional approach** with: (a) bundle, (b) education, (c) CLABSI surveillance, (d) monitoring compliance with recommendations, (e) internal CLABSI rate reports, and (f) performance feedback.

i) Previous national, multinational, and multicontinental studies employing a multidimensional approach have been conducted, achieving a significant reduction in CLABSI rates.[8] See Table 1.

b) **Implement a Bundle of care:**

i) Care "bundles" are a set of evidence-based practices that, when implemented collectively, improve the reliability of their delivery and improve patient outcomes.[8]

ii) A cross-sectional study was conducted at a pediatric tertiary teaching hospital in Turkey from 2007 to 2020. The study assessed the impact of implementing a CL bundle. The baseline CLABSI rate was 10.5, and during the intervention, it was 3.6/1,000 CL-days.[9]

iii) The INICC implemented a bundle to reduce CLABSI rates across 30 countries in Africa, Asia, Latin America, Eastern Europe, and the Middle East. This approach

successfully reduced the CLABSI rate from 15.34/1,000 CL-days to 2.23 over a 29-month follow-up period.[8]

iv) The INICC Bundle included the following components: (1) Adherence to hand hygiene before CL insertion or manipulation; (2) Implementation of maximal barrier precautions during CL insertion; (3) Utilization of alcoholic chlorhexidine antiseptic for skin preparation; (4) Avoid the femoral site; (5) Reduction of CL-days by eliminating nonessential CLs; (6) Maintenance of proper insertion site dressing, changing it when it becomes loose, wet, dirty, or bloody; (7) Minimization of the LOS by promptly discharging eligible patients; (8) Daily chlorhexidine bath for ICU patients aged over 2 months; (9) Prefer needleless connectors (NC) connectors over three-way stopcocks; (10) Prefer collapsible closed intravascular (IV) fluid systems over semi-rigid open systems; and (11) Prefer single-use prefilled flush syringes over manual admixture.[8]

c) **Educate** Healthcare professionals (HCPs), patients, and caregivers involved in CL care should receive training and demonstrate competence according to their roles.

i) This includes understanding appropriate indications for insertion, implementing recommendations to prevent CLABSI, and conducting daily assessments to evaluate the ongoing necessity of the CL.[1, 2]

ii) Chamblee, T. B. et al. analyzed family engagement for preventing CLABSIs. In a prospective quasi-experimental study with 121 legal guardians of children having a CL in the PICU, educating parents on CLABSI prevention and encouraging family participation in CL care obtained a CLABSI rate reduction.[10]

d) Conduct Surveillance of CLABSI:

i) Employ CDC/NHSN uniform surveillance methods and definitions.[3]

ii) Calculate the CLABSI rate by dividing the number of CLABSIs by the total number of CL-days, then multiply the result by 1,000 to express the measure as the number of CLABSIs/1,000 CL-days.[3]

iii) Stratify CLABSI rates based on the type of patient-care unit and provide comparisons using historical data, CDC/NHSN data,[3] and INICC international data.[4]

iv) Longitudinally monitored CL-DU ratio to identify variations, facilitating hospital and unit-level comparisons. The CL-DU ratio, a CDC/NHSN,[3] and INICC measure,[4] considers facility- and location-level factors influencing device use and is calculated as the observed CL- days divided by observed patient days.

v) A nationwide study conducted in Israel from 2011 to 2019 and published in 2023 reported on the effectiveness of National CLABSI prevention guidelines, surveillance, and feedback in reducing CLABSI rates. The mean incidence of CLABSI decreased from 7.4 at baseline to 2.1 CLABSIs/1,000 CL-days during intervention.[11]

e) **Conduct Surveillance of other types of catheters, extending surveillance programs to cover all catheter types, such as peripheral arterial catheters, short-term peripheral venous catheters, and midline catheters**.[1, 2]

i) Calculating the peripheral intravascular (PIV) infection rate per 1,000 PIV days is recommended to adjust to the main risk factor of a catheter-associated BSI, which includes PIVs in addition to CLs.[12]

ii) A study demonstrated that PIV-associated BSIs have a significant burden.[13]

f) **Implement Internal reporting of CLABSI rates:**

i) These measures are crafted to enhance internal hospital quality improvement initiatives, and it is important to convey these measures to senior hospital leadership, and clinicians engaged in the care of patients at risk for CLABSI.[1, 2]

ii) When providing internal reporting as a benchmark, compare the CLABSI rates and CL-DU ratio of the given hospital against data from the CDC/NHSN,[3] and the international data from INICC.[4]

g) Monitoring Compliance with Recommendations to Prevent CLABSI:

i) Assessing and documenting compliance with CL insertion and maintenance guidelines by employing a checklist ensures adherence to proper procedural steps and identifies and addresses any gaps.[1, 2]

ii) Calculate compliance by dividing the compliance of each recommendation by the total number of CL insertions, then multiply by 100 for a percentage expression.[1, 2]

h) **Implement performance feedback:**

i) Infection prevention professionals present charts showcasing data related to attending HCPs' monthly degree of compliance with infection prevention practices and increased compliance with the bundle.[8]

ii) This tool plays a crucial role, enabling attending HCPs to identify areas for improvement in cases of low compliance with infection prevention practices. Leveraging the "observer effects" on HCPs' behavior, this method's strength lies in influencing their practices to enhance efficiency.[1, 2]

MAIN APPROACHES

3) BEFORE INSERTION

a) **Mandated education and competency assessments for HCPs engaged in the insertion, care, and maintenance of CL**. (Quality of Evidence [QoE]: MODERATE).

i) Incorporate information on indications for CL use, proper insertion and maintenance practices, the CLABSI risk, and infection prevention strategies into the education and competency assessments for HCPs involved in CL procedures.[1]

ii) Guarantee that all HCPs engaged in CL insertion and maintenance undergo an educational program covering practices to prevent CLABSI before undertaking these responsibilities.[1, 2]

iii) Conduct periodic assessments of HCP's knowledge and adherence to preventive measures.[1, 2]

iv) Mandate that all HCPs involved in CL insertion undergo a credentialing process to verify their competence. This process should ensure their ability to insert a CL and maintain an aseptic technique throughout the procedure and subsequent access and maintenance of the CL.[1, 2]

v) Provide additional education when an institution modifies components of the infusion system.[1, 2]

vi) Incorporate simulation training for accurate catheter insertion and maintenance procedures.[1, 2]

b) **Administer a daily chlorhexidine preparation bath to ICU patients aged over two months**. (QoE: HIGH).

i) The effectiveness of chlorhexidine (CHG) bathing in non-ICU patients is still uncertain.[14] In a cluster-randomized study, this patient population observed a notable decrease in CLABSI with CHG bathing.[14]

ii) Multiple studies have indicated potential benefits for adult hematology-oncology patients; nevertheless, a comparable reduction was not observed in pediatric patients with similar conditions.[15]

iii) The safety and effectiveness of routinely employing CHG bathing in infants under two months of age after birth are not clearly established. Life-threatening skin injuries resulting from CHG have been reported in infants with a birth weight below 1,000 grams who are less than 7 days postnatal age.[16]

iv) The extensive use of CHG may decrease its effectiveness as an antiseptic.[17]

4) AT INSERTION

a) **A checklist is recommended in both ICU and non-ICU settings (**QoE: MODERATE).

i) Guarantee and document the adherence to aseptic technique.[1, 2]

ii) Ensure optimal insertion practices. Observation of CL insertion should be performed by another HCP who has received appropriate education to guarantee the maintenance of the aseptic technique.[1, 2]

iii) The observer should have the authority to suspend the procedure if any lapses in aseptic technique are identified.[1, 2]

b) **Use an all-inclusive catheter cart or kit** (QoE: MODERATE)

i) Ensure that all units where CLs are inserted have readily accessible catheter kits containing all essential components for aseptic CL insertion.[1, 2]

c) **Perform hand hygiene before catheter insertion or manipulation** (QoE: MODERATE)

i) Utilize either an alcohol-based waterless product or soap and water.[1, 2]

ii) Wearing gloves does not eliminate the need for hand hygiene.[1, 2]

d) **Adopt maximum sterile barrier precautions during CL insertion**. (QoE: MODERATE)

i) Employ maximum sterile barrier precautions by ensuring that all HCPs involved in the CL insertion procedure and when exchanging a CL over a guidewire wear a mask, cap, sterile gown, and sterile gloves. Additionally, the patient should be covered with a large sterile drape.[1, 2]

ii) Despite a prospective, randomized study in surgical patients showing no additional benefit for maximum sterile barrier precautions, the majority of available evidence suggests a risk reduction with this intervention.[1, 2]

e) **Utilize an alcoholic chlorhexidine antiseptic for skin preparation**. (QoE: HIGH)

i) Before CL insertion, apply an alcoholic CHG solution containing a minimum of 2% CHG to the insertion site, allowing the antiseptic solution to dry before making the skin puncture.[18]

ii) Applying an alcoholic CHG solution to the insertion site in the neonatal ICU (NICU) lacks a clear definition.[18]

f) **In the ICU setting, avoid using the femoral site to minimize infectious complications when placing the CL**. (QoE: HIGH)

i) Several studies indicate that femoral insertion sites increase the risk of CLABSI.[1, 2]

ii) Recent large-scale, prospective, multicenter, multinational studies employing multiple logistic regression analyses demonstrate that PICCs exhibit the lowest risk of CLABSI compared with other CL types.[7]

iii) Femoral vein catheterization may be considered for infants if upper body sites are contraindicated. Tunneled femoral vein catheters positioned with an exit site outside the diaper area on the mid-thigh could provide enhanced safety and an additional level of risk reduction.[1, 2]

iv) Risk-benefit assessments are recommended for patients undergoing or expected to require hemodialysis, with the subclavian site avoided due to the risk of stenosis.[1, 2]

v) Observational studies indicate a potential decrease in CLABSI risk with midline catheters compared to PICCs,[19] and versus CLs (2018),[20] respectively.

vi) Femoral vein catheterization may be contemplated for children and infants if upper body sites.[21] Tunneled femoral vein catheters could be safer positioned with an exit site outside the diaper area on the mid-thigh.[22]

vii) The evaluation of risk and benefit for different insertion sites must be conducted on an individual basis, and it is particularly relevant for patients currently undergoing or anticipated to require hemodialysis, where the subclavian site is avoided due to the associated risk of stenosis.[23].

g) **Incorporate ultrasound guidance for catheter insertion.** (QoE: HIGH)

i) Using ultrasound guidance for internal jugular and femoral vein catheterization has decreased the risk of noninfectious complications linked with CL placement. However, the effectiveness of ultrasound-guided subclavian vein insertion in reducing infectious complications remains uncertain.[1, 2]

5) AFTER INSERTION

a) **Maintain an appropriate nurse-to-patient ratio and restrict the use of float nurses in ICUs.** (QoE: HIGH)

i) Observational studies underscore the significance of maintaining an adequate nurse-to-patient ratio in ICUs. These studies propose minimizing the presence of float nurses in the ICU setting.[1, 2]

b) **Apply dressings containing chlorhexidine for CLs in patients over two months of age.** (QoE: HIGH)

i) A meta-analysis was conducted to evaluate CHG dressings' effectiveness in preventing CLABSI, including 20 studies involving 15,590 catheters and primarily conducted in ICUs. CHG dressings significantly reduced CLABSIs (pRR, 0.71; 95% CI, 0.58-0.87), regardless of the CHG dressing type. The benefits were mainly observed in adults with short-term CLs, including onco-hematological patients, while for long-term CLs, CHG dressings reduced exit-site/tunnel infections (pRR, 0.37; 95% CI, 0.22-0.64).[24]

ii) However, contact dermatitis was a significant adverse event associated with CHG dressings (pRR, 5.16; 95% CI, 2.09-12.70), particularly in neonates and pediatric populations, where severe reactions occurred.[24]

c) Replacement of dressings. (QoE: MODERATE)

i) For non-tunneled CLs, transparent dressings should be replaced, and site care should be performed using a CHG-based antiseptic at least every seven days.[1, 2]

ii) Gauze dressings should be changed every 2 days.[1, 2]

iii) Immediate replacement is advised if the dressing becomes soiled, loose, or damp.[1, 2]

iv) If there is significant bleeding or drainage from the catheter exit site, opt for gauze dressings rather than transparent dressings until the drainage resolves.[1, 2]

v) Less frequent dressing changes may be considered for NICU patients or those at a high risk of serious complications from catheter dislodgement.[1, 2]

vi) Based on clinical indications, less frequent dressing changes may be considered for NICU patients or those at a high risk of serious complications from catheter dislodgement.[25]

d) **Before accessing the catheter, disinfect the catheter hubs, NCs, and injection ports. Either use an antiseptic-containing cap or port protector to cover the NC, or perform mechanical disinfection of the catheter hub, NC, and injection port.** (QoE: MODERATE)

i) Consider passive disinfection by applying a cap containing a disinfectant agent (e.g., 70% isopropyl alcohol, iodinated alcohol, chlorhexidine gluconate) over the needleless connector. A systematic review has demonstrated a high level of decontamination compliance and reduced CLABSI rates.[26]

ii) Active disinfection with alcohol-based chlorhexidine gluconate swab pads or passive disinfection with caps containing 70% isopropyl alcohol was associated with lower rates of CLABSI. Swab pads containing 70% isopropyl alcohol were the least effective method, according to a meta-analysis.[27]

iii) If active disinfection is used, mechanical friction should be applied using an alcoholic CHG preparation or 70% alcohol, and in the absence of manufacturer-specific recommendations, it should be applied for 5 to 15 seconds.[1, 2]

iv) A study has demonstrated that passive decontamination with 70% isopropyl alcohol–impregnated caps was associated with reduced phlebitis and infection.[28]

v) Other studies show no difference between passive decontamination with caps and active decontamination with swabs.[29]

vi) Apply and monitor compliance with hub-connector-port disinfection protocols regularly, as approximately half of such catheter components may become colonized under standard practice conditions.[30]

e) **Remove catheters that are not essential.** (QoE: MODERATE)

i) Evaluate the necessity of daily intravascular access, as studies showed a 4% increase in the risk of CLABSI per day of CL in place.[7]

f) **Routinely replace administration sets not used for blood, blood products, or lipid formulations at intervals of up to 7 days.** (Quality of Evidence: HIGH)

i) The most effective schedule for replacing intermittently used administration sets remains undetermined.[31]

g) **Conduct surveillance for CLABSI in both ICU and non-ICU settings.** (QoE: HIGH)

i) Quantify the unit-specific incidence of CLABSI per 1,000 CL-days. Communicate this data to the respective units, clinician leadership, and hospital administrators overseeing the units.[1, 2]

ii) Compare the occurrence of CLABSI with historical data, CDC/NHSN (2015) [3], and international INICC rates.[4]

iii) Conduct periodic audits of surveillance to reduce variation in interobserver reliability.[1, 2]

6) SUPPLEMENTARY INTERVENTIONS

a) These additional measures are recommended for implementation among settings experiencing unacceptably high CLABSI rates, even after applying essential CLABSI prevention strategies, or individuals with restricted venous entry and a background of recurring CLABSI.[1, 2]

b) **Utilize CLs that are impregnated with antiseptic or antimicrobial agents.** (QoE: HIGH in adult patients, and MODERATE in pediatric patients).

i) The risk of CLABSI is reduced with certain antiseptic-impregnated (e.g., CHG-silver sulfadiazine) catheters and antimicrobial-impregnated (e.g., minocycline-rifampin) catheters.[32]

ii) A meta-analysis included 10 studies published between January 2010 and September 2021 regarding impregnated CLs. The results showed that antimicrobial catheters with CHG or silver sulfadiazine significantly reduced the occurrence of CLABSI, with ORs of 0.66 and 0.54, respectively. These interventions were also associated with the lowest rates of catheter colonization, with ORs of 0.45 and 0.31.[33]

iii) Consider using these catheters under the following conditions: When hospital units or patient populations maintain a CLABSI rate above institutional goals despite adherence to essential CLABSI prevention practices and in individuals with restricted venous entry and a background of recurring CLABSI.[32]

iv) Clinical evidence supporting the risk reduction associated with the routine use of silver-coated catheter connectors or other antimicrobial catheter connectors is currently limited.[1, 2]

c) **Implement antimicrobial lock therapy for long-term CLs.** (QoE: HIGH)

i) Filling the catheter lumen with a supratherapeutic concentration of an antibacterial or antiseptic solution and maintaining it until catheter hub re-access is known as an anti-infective lock, has shown potential in reducing the risk of CLABSI. Due to concerns about potential resistance emergence in exposed organisms, antimicrobial locks should be considered as a preventive strategy for patients with long-term hemodialysis catheters and who have a history of recurrent CLABSI.[34]

ii) This preventive measure can be considered for patients at a heightened risk of severe consequences from CLABSI, such as those with recently implanted intravascular devices like prosthetic heart valves or aortic grafts.[1, 2]

iii) To minimize systemic toxicity risk, aspirate the antimicrobial lock solution after its designated dwell time rather than flushing it.[1, 2]

iv) A thorough assessment of potential adverse effects is essential before employing ethanol locks (EL).[1, 2]

v) A 2023 meta-analysis examined EL in pediatric patients with CLs to prevent CLABSI, and EL significantly decreased mean CLABSI rates.[35]

d) **Leverage infusion or vascular access teams to decrease rates of CLABSI.** (QoE: LOW)

i) Establishing an infusion/vascular access team responsible for inserting and maintaining PIV effectively reduces the risk of BSIs.[1, 2]

e) **Apply antimicrobial ointments to the insertion sites of hemodialysis catheters.** (QoE: HIGH)

i) For hemodialysis catheter insertion, utilize Polysporin "triple" or povidone-iodine ointment, ensuring compatibility with the catheter material.[1, 2]

ii) Glycol-containing ointments should be avoided on insertion/exit sites of polyurethane catheters.[1, 2]

iii) Refrain from applying Mupirocin ointment due to the risks associated with mupirocin resistance and potential harm to polyurethane catheters.[1, 2]

7) NOT ADVISABLE INTERVENTIONS TO PREVENT CLABSI.

a) Avoid using antimicrobial prophylaxis during short-term or tunneled catheter insertion or while catheters are in place. (QoE: HIGH).[1, 2]

b) Avoid the routine replacement of CL or arterial catheters. (QoE: HIGH).[1, 2]

8) INTERVENTIONS PENDING RESOLUTION

a) **The use of silver-coated catheter connectors may be associated with reduced intraluminal contamination in ex vivo catheters and a potential decrease in CLABSI.**

i) Limited clinical evidence exists regarding the risk reduction associated with silver-coated catheter connectors.[1, 2]

b) The relationship between the use of standard, nonantimicrobial transparent dressings and the risk of CLABSI.

i) An unresolved issue stems from a meta-analysis identifying a connection between CLABSI and the use of transparent dressings.[1, 2]

c) The influence of employing chlorhexidine-based products on the development of bacterial resistance to chlorhexidine.

i) Standardized testing for CHG susceptibility is lacking, and the clinical implications of reduced CHG susceptibility remain uncertain.[1, 2]

d) Suture-less securement

i) The effectiveness of suture-less securement devices in reducing CLABSI is currently uncertain.[36]

e) **The impact of silver zeolite-impregnated umbilical catheters on preterm infants, especially in areas where approval for pediatric use has been authorized.**[1, 2]

i) A randomized study suggests that antimicrobial-impregnated umbilical catheters are safe and effective in NICU patients.[1, 2]

9) SUGGESTED PRACTICE IN UNDER-RESOURCED SETTINGS

a) **Collapsible closed-system intravenous fluid containers are suggested.** (QoE: MODERATE)

i) A meta-analysis and research with a bundle implementation, including a closed IV fluid system, NCs, and single-use prefilled flush syringes, have demonstrated that open-system semi-rigid or rigid IV fluid containers increase the risk of CLABSI compared with closed-system collapsible IV fluid containers. [8]

b) **It is suggested that needleless connectors be used instead of three-way stopcocks and positive displacement NCs be used instead of negative or neutral displacement** (QoE: MODERATE).

i) NCs are associated with a lower risk of CLABSI compared with three-way stopcock, as demonstrated in a meta-analysis.[37]

ii) A meta-analysis demonstrated that NCs with positive displacement are associated with a lower risk of CLABSI than those with negative or neutral displacement. This suggestion applies to LMICs and high-income countries.[38]

c) Compliance with recommendations to prevent CLABSI in LMICs needs to be improved (QoE: LOW).

i) Observations conducted in the ICUs of 58 hospitals across three Middle Eastern countries revealed that lower patient-nurse ratios were associated with higher compliance.[39]

ii) A study sampled nurses from three hospitals in Jordan and found significant differences in compliance with the CL care bundle, and the nurse-to-patient ratio emerged as A significant predictor of nurse compliance with the CL care bundle.[40]

SUMMARY

This review's evidence shows that CLABSI rates in LMICs are over five times higher than in high-income countries. It provides scientific insights into the efficacy of various interventions and recommends additional measures specifically for adoption in LMICs.

Conflicts of interest

None.

Funding sources

None.

Ethical approval

Done.

References

[1] B. Nickel *et al.*, "Infusion Therapy Standards of Practice, 9th Edition," *J Infus Nurs,* vol. 47, no. 1S Suppl 1, pp. S1-S285, Jan-Feb 01 2024, doi: 10.1097/NAN.0000000000000532.

[2] N. Buetti *et al.*, "Strategies to prevent central line-associated bloodstream infections in acute-care hospitals: 2022 Update," *Infect Control Hosp Epidemiol,* pp. 1-17, Apr 19 2022, doi: 10.1017/ice.2022.87.

[3] M. A. Dudeck *et al.*, "National Healthcare Safety Network report, data summary for 2013, Device-associated Module," *Am J Infect Control,* vol. 43, no. 3, pp. 206-21, Mar 1 2015, doi: 10.1016/j.ajic.2014.11.014.

[4] V. D. Rosenthal *et al.*, "International Nosocomial Infection Control Consortium (INICC) report of health care associated infections, data summary of 45 countries for 2015 to 2020, adult and pediatric units, device-associated module," *Am J Infect Control,* Jan 6 2024, doi: 10.1016/j.ajic.2023.12.019.

[5] V. D. Rosenthal *et al.*, "The impact of healthcare-associated infections on mortality in ICU: A prospective study in Asia, Africa, Eastern Europe, Latin America, and the Middle East," *Am J Infect Control,* vol. 51, no. 6, pp. 675-682, Jun 2023, doi: 10.1016/j.ajic.2022.08.024.

[6] L. A. Mermel, "How Should Surveillance Systems Account for Concurrent Intravascular Catheters?," *JAMA Netw Open,* vol. 3, no. 3, p. e200400, Mar 2 2020, doi: 10.1001/jamanetworkopen.2020.0400.

[7] V. D. Rosenthal *et al.*, "Multinational prospective study of incidence and risk factors for central-line-associated bloodstream infections in 728 intensive care units of 41 Asian, African, Eastern European, Latin American, and Middle Eastern countries over 24 years," *Infect Control Hosp Epidemiol,* pp. 1-11, Apr 28 2023, doi: 10.1017/ice.2023.69.

[8] V. D. Rosenthal *et al.*, "Decreasing central line-associated bloodstream infections rates in intensive care units in 30 low- and middle-income countries: An INICC approach," *Am J Infect Control,* vol. 52, no. 5, pp. 580-587, May 2024, doi: 10.1016/j.ajic.2023.12.010.

[9] I. Devrim *et al.*, "The impact of central line bundles on the timing of catheter-associated bloodstream infections and their microbiological distribution in critically ill children," *Eur J Pediatr,* vol. 182, no. 10, pp. 4625-4632, Oct 2023, doi: 10.1007/s00431-023-05141-7.

[10] T. B. Chamblee and D. K. Miles, "A Prospective Study of Family Engagement for Prevention of Central Line-associated Blood Stream Infections," *Pediatr Qual Saf,* vol. 6, no. 5, p. e467, Sep-Oct 2021, doi: 10.1097/pq9.0000000000000467.

[11] D. Ben-David *et al.*, "Impact of intensified prevention measures on rates of hospital-acquired bloodstream infection in medical-surgical intensive care units, Israel, 2011 to 2019," *Euro Surveill,* vol. 28, no. 25, Jun 2023, doi: 10.2807/1560-7917.ES.2023.28.25.2200688.

[12] V. D. Rosenthal *et al.*, "Six-year multicenter study on short-term peripheral venous catheters-related bloodstream infection rates in 727 intensive care units of 268 hospitals in 141 cities of 42 countries of Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific Regions: International Nosocomial Infection Control Consortium (INICC) findings," *Infect Control Hosp Epidemiol,* vol. 41, no. 5, pp. 553-563, May 2020, doi: 10.1017/ice.2020.20.

[13] V. D. Rosenthal *et al.*, "International Nosocomial Infection Control Consortium (INICC) report, data summary of 45 countries for 2012-2017: Device-associated module," *Am J Infect Control*, vol. 48, no. 4, pp. 423-432, Apr 2020, doi: 10.1016/j.ajic.2019.08.023.

[14] S. S. Huang *et al.*, "Chlorhexidine versus routine bathing to prevent multidrug-resistant organisms and all-cause bloodstream infections in general medical and surgical units (ABATE Infection trial): a cluster-randomised trial," *Lancet*, vol. 393, no. 10177, pp. 1205-1215, Mar 23 2019, doi: 10.1016/S0140-6736(18)32593-5.

[15] D. M. Zerr *et al.*, "Chlorhexidine gluconate bathing in children with cancer or those undergoing hematopoietic stem cell transplantation: A double-blinded randomized controlled trial from the Children's Oncology Group," *Cancer*, vol. 127, no. 1, pp. 56-66, Jan 1 2021, doi: 10.1002/cncr.33271.

[16] C. J. Chandonnet *et al.*, "Safety of Biweekly Chlorhexidine Gluconate Bathing in Infants 36 To 48 Weeks' Postmenstrual Age," *Am J Crit Care*, vol. 28, no. 6, pp. 451-459, Nov 2019, doi: 10.4037/ajcc2019967.

[17] G. Kampf, "Acquired resistance to chlorhexidine - is it time to establish an 'antiseptic stewardship' initiative?," *J Hosp Infect*, vol. 94, no. 3, pp. 213-227, Nov 2016, doi: 10.1016/j.jhin.2016.08.018.

[18] T. Masuyama, H. Yasuda, M. Sanui, and A. K. Lefor, "Effect of skin antiseptic solutions on the incidence of catheter-related bloodstream infection: a systematic review and network meta-analysis," *J Hosp Infect*, vol. 110, pp. 156-164, Apr 2021, doi: 10.1016/j.jhin.2021.01.017.

[19] L. Swaminathan, S. Flanders, J. Horowitz, Q. Zhang, M. O'Malley, and V. Chopra, "Safety and Outcomes of Midline Catheters vs Peripherally Inserted Central Catheters for Patients With Short-term Indications: A Multicenter Study," *JAMA Intern Med*, vol. 182, no. 1, pp. 50-58, Jan 1 2022, doi: 10.1001/jamainternmed.2021.6844.

[20] A. Mushtaq *et al.*, "Comparison of complications in midlines versus central venous catheters: Are midlines safer than central venous lines?," *Am J Infect Control*, vol. 46, no. 7, pp. 788-792, Jul 2018, doi: 10.1016/j.ajic.2018.01.006.

[21] A. J. Ullman *et al.*, "The Michigan Appropriateness Guide for Intravenous Catheters in Pediatrics: miniMAGIC," *Pediatrics*, vol. 145, no. Suppl 3, pp. S269-S284, Jun 2020, doi: 10.1542/peds.2019-3474I.

[22] A. Chau, J. A. Hernandez, S. Pimpalwar, D. Ashton, and K. Kukreja, "Equivalent success and complication rates of tunneled common femoral venous catheter placed in the interventional suite vs. at patient bedside," *Pediatr Radiol*, vol. 48, no. 6, pp. 889-894, Jun 2018, doi: 10.1007/s00247-018-4090-3.

[23] J. J. Parienti *et al.*, "Intravascular Complications of Central Venous Catheterization by Insertion Site," *N Engl J Med*, vol. 373, no. 13, pp. 1220-9, Sep 24 2015, doi: 10.1056/NEJMoa1500964.

[24] M. Puig-Asensio, A. R. Marra, C. A. Childs, M. E. Kukla, E. N. Perencevich, and M. L. Schweizer, "Effectiveness of chlorhexidine dressings to prevent catheter-related bloodstream infections. Does one size fit all? A systematic literature review and meta-analysis," *Infect Control Hosp Epidemiol*, vol. 41, no. 12, pp. 1388-1395, Dec 2020, doi: 10.1017/ice.2020.356.

[25] K. L. Short, "Implementation of a Central Line Maintenance Bundle for Dislodgement and Infection Prevention in the NICU," *Adv Neonatal Care*, vol. 19, no. 2, pp. 145-150, Apr 2019, doi: 10.1097/ANC.0000000000000566.

[26] V. Gillis, M. J. van Es, Y. Wouters, and G. J. A. Wanten, "Antiseptic barrier caps to prevent central line-associated bloodstream infections: A systematic review and meta-analysis," *Am J Infect Control,* vol. 51, no. 7, pp. 827-835, Jul 2023, doi: 10.1016/j.ajic.2022.09.005.

[27] J. M. Flynn, E. N. Larsen, S. Keogh, A. J. Ullman, and C. M. Rickard, "Methods for microbial needleless connector decontamination: A systematic review and meta-analysis," *Am J Infect Control,* vol. 47, no. 8, pp. 956-962, Aug 2019, doi: 10.1016/j.ajic.2019.01.002.

[28] C. M. Rickard *et al.*, "Needleless connector decontamination for prevention of central venous access device infection: A pilot randomized controlled trial," *Am J Infect Control,* vol. 49, no. 2, pp. 269-273, Feb 2021, doi: 10.1016/j.ajic.2020.07.026.

[29] A. M. Milstone, C. Rosenberg, G. Yenokyan, D. W. Koontz, M. R. Miller, and C. A. Group, "Alcohol-impregnated caps and ambulatory central-line-associated bloodstream infections (CLABSIs): A randomized clinical trial," *Infect Control Hosp Epidemiol,* vol. 42, no. 4, pp. 431-439, Apr 2021, doi: 10.1017/ice.2020.467.

[30] R. Hankins *et al.*, "Microbial colonization of intravascular catheter connectors in hospitalized patients," *Am J Infect Control,* vol. 47, no. 12, pp. 1489-1492, Dec 2019, doi: 10.1016/j.ajic.2019.05.024.

[31] C. M. Rickard *et al.*, "Effect of infusion set replacement intervals on catheter-related bloodstream infections (RSVP): a randomised, controlled, equivalence (central venous access device)-non-inferiority (peripheral arterial catheter) trial," *Lancet,* vol. 397, no. 10283, pp. 1447-1458, Apr 17 2021, doi: 10.1016/S0140-6736(21)00351-2.

[32] A. J. Ullman *et al.*, "Do antimicrobial and antithrombogenic peripherally inserted central catheter (PICC) materials prevent catheter complications? An analysis of 42,562 hospitalized medical patients," *Infect Control Hosp Epidemiol,* vol. 43, no. 4, pp. 427-434, Apr 2022, doi: 10.1017/ice.2021.141.

[33] Q. Cao and Y. Wang, "Effectiveness of nanoparticle-based antimicrobial agents in the prevention and treatment of Central Venous Catheter-Associated Bloodstream Infections," *Comput Methods Biomech Biomed Engin,* pp. 1-13, Jun 30 2024, doi: 10.1080/10255842.2024.2310076.

[34] M. C. Arechabala *et al.*, "Antimicrobial lock solutions for preventing catheter-related infections in haemodialysis," *Cochrane Database Syst Rev,* vol. 4, no. 4, p. CD010597, Apr 3 2018, doi: 10.1002/14651858.CD010597.pub2.

[35] C. M. Sierra, C. Rodriquez, and K. Bahjri, "Ethanol Lock for Prevention of CVC-Related Bloodstream Infection in Pediatric Patients: A Systematic Review and Meta-Analysis," *J Pediatr Pharmacol Ther,* vol. 28, no. 5, pp. 386-396, 2023, doi: 10.5863/1551-6776-28.5.386.

[36] T. J. Karpanen *et al.*, "A clinical evaluation of two central venous catheter stabilization systems," *Ann Intensive Care,* vol. 9, no. 1, p. 49, Apr 17 2019, doi: 10.1186/s13613-019-0519-6.

[37] V. D. Rosenthal, "Impact of needle-free connectors compared with 3-way stopcocks on catheter-related bloodstream infection rates: A meta-analysis," *Am J Infect Control,* vol. 48, no. 3, pp. 281-284, Mar 2020, doi: 10.1016/j.ajic.2019.08.015.

[38] Y. P. Tabak, W. R. Jarvis, X. Sun, C. T. Crosby, and R. S. Johannes, "Meta-analysis on central line-associated bloodstream infections associated with a needleless intravenous connector with a new engineering design," *Am J Infect*

Control, vol. 42, no. 12, pp. 1278-84, Dec 2014, doi: 10.1016/j.ajic.2014.08.018.

[39] S. M. Aloush *et al.*, "Compliance of Middle Eastern hospitals with the central line associated bloodstream infection prevention guidelines," *Appl Nurs Res*, vol. 43, pp. 56-60, Oct 2018, doi: 10.1016/j.apnr.2018.06.018.

[40] A. A. Matlab, M. O. Al-Hussami, and M. Alkaid Albqoor, "Knowledge and compliance to prevention of central line-associated blood stream infections among registered nurses in Jordan," *J Infect Prev*, vol. 23, no. 4, pp. 133-141, Jul 2022, doi: 10.1177/17571774211066778.

Table 1. Impact of a Multidimensional Approach on CLABSI Rates in Low- and Middle-Income Countries

Setting	Number of ICUs	Study period	ICU type	Baseline CLABSI rate	Intervention CLABSI rate	RR; 95% CI; p value	Ref
30 LMICs	316	2007-2022	AICU	15.34	2.23	RR=0.15; 95% CI=0.13-0.17; p<0.001	Rosenthal VD, Jin Z, Brown EC, et al. Decreasing central line-associated bloodstream infections rates in intensive care units in 30 low- and middle-income countries: An INICC approach. Am J Infect Control. 2024;52(5):580-7.
15 LMICs	86	2002-2009	AICU	14.5	7.4	RR=0.46, 95% CI= 0.33-0.63; p<0.001	Rosenthal VD, Maki DG, Rodrigues C, et al. Impact of International Nosocomial Infection Control Consortium (INICC) strategy on central line-associated bloodstream infection rates in the intensive care units of 15 developing countries. Infect Control Hosp Epidemiol. 2010;31(12):1264-72.
5 LMICs	9	2003-2010	PICU	10.7	5.2	RR=0.48, 95% CI=0.29-0.94, p=0.02	Rosenthal VD, Ramachandran B, Villamil-Gomez W, et al. Impact of a multidimensional infection control strategy on central line-associated bloodstream infection rates in pediatric intensive care units of five developing countries: findings of the International Nosocomial Infection Control Consortium (INICC). Infection. 2012;40(4):415-23.
4 LMICs	4	2003-2009	NICU	21.4	9.7	RR=0.45; 95% CI=0.33-0.63; p<0.001	Rosenthal VD, Duenas L, Sobreyra-Oropeza M, et al. Findings of the International Nosocomial Infection Control Consortium (INICC), part III: effectiveness of a multidimensional infection control approach to reduce central line-associated bloodstream infections in the neonatal intensive care units of 4 developing countries. Infect Control Hosp Epidemiol. 2013;34(3):229-37.
9 Asian countries	122	2008-2022	AICU	16.64	2.18	RR=0.13; 95% CI=0.11-0.15; p<0.001	Rosenthal VD, Yin R, Myatra SN, Divatia JV, et al. Evaluating the outcome of a bundle with 11 components and the INICC multidimensional approach in decreasing rates of central line-associated bloodstream infections across nine Asian countries. J Vasc Access. 2024:11297298241242163.
Mexico	2	2002-2003	AICU	46.3	19.5	RR=0.42; 95% CI=0.27-0.66; p=0.0001	Higuera F, Rosenthal VD, Duarte P, et al. The effect of process control on the incidence of central venous catheter-associated bloodstream infections and mortality in intensive care units in Mexico. Crit Care Med. 2005;33(9):2022-7
India	16	2004-2012	AICU	6.4	3.9	RR=0.47, 95% CI=0.31-0.70; p=0.0001	Jaggi N, Rodrigues C, Rosenthal VD, Todi SK, Shah S, Saini N, et al. Impact of an international nosocomial infection control consortium multidimensional approach on central line-associated bloodstream infection rates in adult intensive care units in eight cities in India. Int J Infect Dis. 2013;17(12):e1218-24.
Turkey	13	2003-2011	AICU	22.7	12.0	RR=0.613; 95% CI=0.43-0.87; p=.007	Leblebicioglu H, Ozturk R, Rosenthal VD, et al. Impact of a multidimensional infection control approach on central line-associated bloodstream infections rates in adult intensive care units of 8 cities of Turkey: findings of the International Nosocomial Infection Control Consortium (INICC). Ann Clin Microbiol Antimicrob. 2013;12:10.

Colombia	6	2003-2010	AICU and PICU	12.9	3.5	RR=0.27; 95% CI=0.14-0.52; p=0.002	Alvarez-Moreno CA, Valderrama-Beltran SL, Rosenthal VD, et al. Multicenter study in Colombia: Impact of a multidimensional International Nosocomial Infection Control Consortium (INICC) approach on central line-associated bloodstream infection rates. Am J Infect Control. 2016;44(11):e235-e41.
Saudi Arabia	5	2013-2015	AICU and PICU	6.9	3.1	RR=0.44; 95% CI=0.28-0.72; p=0.001]	Al-Abdely HM, Alshehri AD, Rosenthal VD, et al. Prospective multicentre study in intensive care units in five cities from the Kingdom of Saudi Arabia: Impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional approach on rates of central line-associated bloodstream infection. J Infect Prev. 2017;18(1):25-34.
Bahrain	1	2013-2016	AICU	10.4	1.2	RR=0.11; 95% CI=0.1-0.3; p= 0.001	Alkhawaja S, Saeed NK, Rosenthal VD, et al. Impact of International Nosocomial Infection Control Consortium's multidimensional approach on central line-associated bloodstream infection rates in Bahrain. J Vasc Access. 2020;21(4):481-9.
Argentina	4	1999-2001	AICU	46.63	11.10	RR= 0.25; 95% CI=0.17-0.36; p<0.0001	Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device-associated bloodstream infections in intensive care units in Argentina. Am J Infect Control. 2003;31(7):405-9.

LMICs= low and middle income country; ICU= intensive care unit; AICU= adult intensive care unit;
PICU= pediatric intensive care unit; NICU= neonatal intensive care unit;
CLABSI= central line associated bloodstream infection; RR= relative risk; CI= confidence interval; Ref= reference

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