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Review

# Managing and preventing vascular catheter infections: A position paper of the international society for infectious diseases

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A B S T R A C T

A panel of experts was convened by the International Society for Infectious Diseases (ISID) to overview recommendations on managing and preventing vascular catheter infections, specifically for the prevention and management of central line-associated bloodstream infections. These recommendations are intended to provide insight for healthcare professionals regarding the prevention of infection in the placement and maintenance of the catheter and diagnosis as well as treatment of catheter infection. Aspects of this area in pediatrics and in limited-resource situations and a discussion regarding the selection of empiric or targeted antimicrobial therapy are particular strengths of this position paper.


## Contents



## Introduction

Central lines are essential vascular access devices used in critically-ill patients in many medical settings. Central line-associated bloodstream infections (CLABSIs) are common

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complications encountered with their use, with up to 60% of all hospital-acquired bacteremias/fungemias occurring with a vascular access device (Crnich and Maki, 2001). CLABSIs substantially increase morbidity, mortality, length of hospital stay, and increased hospital costs, both in developed and resource-limited countries (Al-Abdely et al., 2017; Devrim et al., 2016; Ziegler et al., 2014; Tarricone et al., 2010; Higuera et al., 2007; Rosenthal et al., 2003). The CLABSI rates in resource-limited countries are 3–5 times higher than that encountered in high-income settings (Al-Abdely et al., 2017) and 75% of the world's population live in low-to-middle income countries (LMICs) (Alp and Rello, 2019). Established in 1998, the International Nosocomial Infection Control Consortium (INICC) is one group which has used surveillance and applied research to promote appropriate practices to decrease this rate (Rosenthal, 2016). This paper summarizes the key recommendations for CLABSI control and prevention by the International Society for Infectious Diseases.

*Known facts - prevention*

Many guidelines for decreasing CLABSI rates recommend use of "care bundles" (Marwick and Davey, 2009; Agency for Healthcare Research and Quality, 2018), to simplify and enable the reliable application of 4–6 evidence-based best practices simultaneously, to achieve better outcomes than when implemented individually. Care bundles for device-associated infections e.g. CLABSI bundles, are widely-adopted and effective infection prevention strategies in high-income countries and some low-resource settings.

Compliance with bundle elements should be easily and objectively measureable (e.g. 'yes/no' or 'completed/not completed'), allowing for tracking of bundle compliance rates. Infection rate trends can be followed using run-charts. CLABSI bundles have been created for both the insertion and maintenance of central lines. Many CLABSI events are attributed to breaches in catheter maintenance, rather than insertion which, because it remains longer in situ than a peripheral line, accounts for most of the cases of intravascular catheter bacteremia. These bundles are summarized here (Ling et al. 2016; Bell and O'Grady, 2017; Han et al., 2010):

*Insertion bundle*

1. Site/Catheter Selection

Optimal site selection will depend on catheter types and expected duration of use with avoidance of placement in the femoral vein, except for hemodialysis and in some pediatric patients. The type of device and placement site selection are influenced by the training and experience levels of the clinician inserting the device. Ultrasound guidance should be used when available. The hub number on the catheter should be kept to the minimum essential for management, as every additional hub increases the risk for CLABSI development. All components of the system should be compatible to minimize leakages. For needleless systems, a split septum valve may be preferable to a mechanical valve.

Peripherally inserted central catheters (PICC lines) seem more vulnerable to thrombosis and dislodgement than central venous catheters placed in the internal jugular or subclavian veins. Importantly, in patients with renal injury who may require hemodialysis, preservation of upper extremity veins for future dialysis access is advisable so use of PICC lines needs to be prudent in these patients.

The use of a midline catheter (placed in proximal veins such as the brachial or cephalic with the tip in the axillary vein) is associated with a lower complication risk of pneumothorax and thrombosis and lower CLABSI rates in some reports.

1. Hand Hygiene

Hand hygiene is vital before and after palpating the insertion site and before and after all interactions in the placement and maintenance sequences. Hand hygiene can be performed with an alcohol-based hand rub or antiseptic soap with water. Optimal asepsis dictates the use of sterile gloves with placement. The wearing of gloves does not obviate the need for hand hygiene.

1. Skin Preparation

Skin prep is generally done with the use of a 0.5–2% chlorhexidine/70% isopropyl alcohol solution, with alternatives such as iodophors (povidone-iodine) or alcohol alone in patients with known hypersensitivity to chlorhexidine gluconate. The antiseptic should be allowed to dry before catheter insertion.

1. Barrier Precautions

Barrier precautions include the use of sterile gowns and gloves, a surgical mask and cap/hair net as well as a full body sterile drape over the patient (akin to drapes utilized in an operating theater).

All aspects of the insertion bundle are likely essential in preventing CLABSIs. Insertion in the femoral area, not using a full body drape, not using all components of the maximal sterile barrier precautions and not performing all components of the bundle, have been identified as factors associated with an increased risk of CLABSI (Lee et al., 2018).

*Catheter maintenance bundle*

1. Review of Need and Replacement

The need for the line should be reviewed daily since risk of CLABSI development increases over time. If the catheter was placed as an emergency intervention, it should be replaced as soon as possible. Fever alone is not an indication for catheter removal and replacement. However, if CLABSI is clinically suspected in a non-tunneled device, the device should not simply be replaced over a guidewire, but removed, with a new catheter inserted at a different site.

1. Hand Hygiene

This should be performed before and after accessing, repairing or dressing the catheter to maintain aseptic technique at all times. This includes wearing sterile or at least clean gloves when changing dressings.

1. Hub/Access Device Disinfection

Catheter hubs, connectors, and injection ports should be disinfected with alcoholic chlorhexidine, 70% alcohol solution or an iodophor while applying mechanical friction before access. All needleless parts of the system should be changed when the administration set is changed or based on manufacturers' recommendations. There is no benefit in changing more often than 72 h. Access ports should be treated with an antiseptic prior to any access (Marschall et al., 2014). Disinfectant cap protectors may also have a role but require further study (Jimenez et al., 2015).

1. Dressing Changes

A sterile transparent and semipermeable dressing is preferred over sterile gauze. Sterile gauze can be used if the patient is diaphoretic or the site is actively bleeding or oozing. The dressing should be replaced if it becomes damp, loosened or visibly soiled or every 7 days for non-tunneled catheters (Marschall et al., 2014). The use of a chlorhexidine-impregnated dressing, if available, may decrease the risk of infection as compared to non-impregnated dressings, through reduction of bacterial colonization of the skin at the point of catheter insertion. In settings with high CLABSI rates, chlorhexidine-impregnated sponge dressings may be used as an additional intervention.

Topical antimicrobial ointments or creams are generally not used except for hemo-dialysis catheters where they may have a role in minimization of fungal infections and antimicrobial resistant infections.

Patients should be encouraged to report any changes to the catheter insertion site or any discomfort as soon as possible.

Additional Measures (mainly in case of sustained high CLABSI rates or during an outbreak):

1. Daily chlorhexidine bathing has been demonstrated to reduce CLABSI rates among adult and children in intensive care units (Frost et al., 2016; Dicks et al., 2016). Huang et al. (2019), despite a lack of overall protective effect in non-ICU patients, found reductions in MRSA and VRE infections in patients with medical devices.
2. Antibacterial impregnated catheters (minocycline/rifampin or chlorhexidine/silver sulfadiazine) can be used as an additional intervention in units with high CLABSI rates or in patients where a prolonged catheter dwell time is anticipated.
3. A prophylactic antimicrobial (e.g. vancomycin) or antiseptic lock solution (e.g. ethanol or taurolidine-citrate) can be considered in patients with long-term catheters (such as hemodialysis) or in patients with a history of recurrent CLABSI.

Variability in application of CLABSI prevention bundles, compliance assessment and degree of stakeholder involvement, all likely result in suboptimal clinical outcomes. Such variability may explain issues related to suboptimal clinical impact of the guidelines and their implementation (Blanco-Mavillard et al., 2018).

### *Open vs closed intravenous infusion systems*

The impact of the infusion system on CLABSI rates has been studied by comparing open and closed intravenous systems. It has been widely accepted that open systems may increase the risk of contamination and administration-related CLABSI, because of microbial entry into the system through air entry (Maki et al., 2011). As reported in a recent systematic review (Perin et al., 2016), by way of illustration, the rate of CLABSI was 35.3% greater among patients who received compounded parenteral nutrition (PN) through an open system in comparison to those who received PN through a closed system.

In a randomized clinical trial comparing rates of CLABSI between patients using an open system (three-way stopcocks) and standard flushing, and patients using a closed system (pre-pierced septa) and single-use prefilled flushing devices, it was shown that closed systems had significantly lower rates of CLABSI (2.21 per 1000 CL-days vs. 6.40 per 1000 CL-days, 95% CI 0.16-0.76, $p = 0.006$) and was cost-effective (Rosenthal et al., 2015). However, open infusion containers and systems, such as three-way stopcocks, continue to be widely used in limited-resource settings.

### *Management of the CLABSI (suggested practice)*

In a patient with a suspected CLABSI, the healthcare professional is usually presented with a febrile individual without focal signs or symptoms suggesting systemic or device-associated infection. In the case of *Staphylococcus aureus* (*S. aureus*) infection (either methicillin sensitive or resistant), secondary metastatic infection can be found in any organ. Fever without a focus is a clue that should prompt investigation for CLABSI. Blood cultures should be obtained in parallel from the central line and from a peripheral site. A shorter time to positivity (or a higher bacterial load on quantitative blood cultures) from the central source can be a hint that the line is the primary source but it is not particularly sensitive (Bouzidi et al., 2018).

The most common organisms causing CLABSI are biofilm-producing Gram positive cocci including *S. aureus* and coagulase negative staphylococci (CNS). Most CNS-associated CLABSI events present with a milder or more indolent course, however *S. lugdunensis* infections manifest with more prominent symptomatology, behaving clinically similar to *S. aureus*-associated CLABSI.

While cultures are pending, vancomycin is an appropriate antimicrobial to use empirically until identification and antimicrobial sensitivities are available. In countries without high rates of MRSA, an anti-staphylococcal beta-lactam antimicrobial could be the first option. However, in severe illness, neutropenic or otherwise immunocompromised patients and those with a femoral catheter, additional empiric coverage for Gram-negative bacilli is reasonable. Agents such as an extended spectrum penicillin (such as piperacillin/tazobactam), a cephalosporin (such as cefepime) or a carbapenem (such as meropenem) may be appropriate, based on prevailing institutional antimicrobial resistance patterns. Other organisms associated with CLABSIs include fungi (yeasts), especially *Candida* species including the more resistant *C. auris*, and some of the more indolent Gram-positive organisms such as “diphtheroids”, primarily *Corynebacterium* species and *Cutibacterium* (formerly *Propionibacterium) acnes*.

The decision to begin antimicrobials before cultures are positive should be based on clinical judgement and illness severity. Fever in a patient with a central vascular catheter does not necessarily mean that the etiology of the pyrexia is a CLABSI. Numerous other diagnoses, infectious or non-infectious, may be the source of the fever. Absence of fever does not rule out CLABSI, or any other infection for that matter, as especially in debilitated, elderly or with renal injury, a febrile response may not occur. When blood cultures are positive without another identified source for a likely organism, CLABSI is likely the diagnosis. Catheters are often not removed prior to laboratory-confirmation of CLABSI, unless the catheter is no longer required.

Once the blood cultures are positive, especially in the absence of an identified focus, all peripheral venous or arterial catheters, midline catheters and short term nontunneled central venous catheter should ideally be removed (Han et al., 2010). In the case of long-term catheters such as PICC lines, tunneled central lines and implantable devices, explantation is done in most instances. The approach to removal of a central catheter in a patient with bacteremia and a clear alternative focus should be individualized based on the organism and clinical circumstances. Antimicrobial locks as a catheter salvage strategy are unlikely to be effective but may be considered under certain conditions for salvage (Mermel et al., 2009). Certainly, any persistent bacteremia despite appropriate antimicrobials should be managed with antimicrobials and prompt catheter removal.

The length of antimicrobial therapy after catheter removal is often 7–14 days but varies with the pathogen (longer for Gram-negative and fungal infections) and the degree of illness. Some microbes are more likely to cause secondary metastatic infections, especially *S. aureus*, and the clinician should be aware of this possibility. Certainly, if a cardiac valve infection (endocarditis) or a bone infection (osteomyelitis) develops as a secondary manifestation of the CLABSI, more prolonged antimicrobial therapy (4–6 weeks) is required. Classically, endocarditis and osteomyelitis have been treated with parenterally administered antimicrobials but recent data suggests that oral treatment can substitute for some of the course (Iversen et al., 2019; Li et al., 2019) in defined patient groups. This approach, as it becomes more validated (Boucher, 2019) will, like effective antimicrobial stewardship programs that facilitate intravenous to oral therapy switches, decrease the time that the central line is present and therefore will decrease the risk of CLABSI.

*CLABSIs in pediatrics*

CLABSI rates in children and neonates are a challenge and have been reported to be higher than in the adults (The Joint Commission, 2016; Leighton et al., 2012). In a review, neonatal intensive care unit (NICU) CLABSI rates ranged from 2.6 to 60 cases per 1000 central line days in limited-resource countries in comparison with 2.9 cases per 1000 central line days in the USA (Rosenthal, 2009). As a host, the newborn infant, and especially premature newborn, is more susceptible to bloodstream infections (BSIs) because of poor skin integrity and an immature immune system. Their care usually involves A long hospital stay with repeated invasive procedures, exposure to many caregivers, and being in an environment prone to microbial colonization. Neonatal outcomes have been affected by health care-associated infections including CLABSIs. Indeed, the risk of neurodevelopmental impairment especially in very low birthweight infants significantly increases with one or more episodes of infection (Stoll et al., 2004). The mortality related to bloodstream infections has been reported to be 21%. In neonates, they lead to increase in length of stay by 23 days and substantial excess costs (Helder et al., 2013; Verstraete et al., 2014; Payne et al., 2018).

Unlike in the adult ICU, implementations of care bundles in pediatric and neonatal intensive care units have had inconsistent outcomes in reducing CLABSIs (Wirtschafter et al., 2010). Additionally, studies in neonates have failed to demonstrate a significant difference in CLABSI risk between catheter types used mostly in the NICU (peripherally inserted, umbilical and femoral) (Dubbink-Verheij et al., 2017). Studies have also shown that it is possible to reduce neonatal CLABSI rates with hospital-based interventions (Bizzarro et al., 2010; Pronovost, 2008). A recent meta-analysis which included observational and case control studies from different settings but no randomized control trails has revealed a statistically significant reduction in CLABSIs rate (by 60%) following the introduction of care bundles (rate ratio = 0.40 (CI 0.31 to 0.51), $p < 0.00001$) although it is not clear which bundle elements are effective in specific settings (Wirtschafter et al., 2010). Some of the evidence-based interventions to reduce CLABSIs in pediatric and neonatal units are summarized in Table 1.

*Limited-Resource settings*

A 2016 report of responses from 95 both high and middle incomes countries showed a poor adherence to CLABSI prevention guidelines is a universal observation (Valencia et al., 2016). In resource-rich countries, risk reduction bundles are more readily accepted and implemented, with proven efficacy in CLABSI rate reduction. In resource limited settings, however, the CLABSI bundle uptake, implementation, and program sustainability are major

**Table 1**
Neonatal CLABSI Recommended Preventive Measures.

| Category | Suggested intervention |
|---|---|
| Administrative | • Providing hand hygiene facilities in the unit and monitor complains<br>• Provide CVL insertion and maintenance kits<br>• Increase staff/patient ratio<br>• Dedicated central line team<br>• Training and monitoring staff competency in infection control practices and line insertion and maintenance skills.<br>• Continuous monitoring of CLABSIs as quality indicator with periodic feedback<br>• Case root analysis for CLABSI events |
| Policies and Guidelines | • CVL necessity, insertion, removal and daily line care checklists<br>• Guidelines for the enteral and parental feeding of VLBW infants (support breast feeding, duration of TPN and intravenous fluid and medication)<br>• Antimicrobial stewardship |
| Risk Assessment based intervention | • Assess for prematurity, intraabdominal pathology, mucosal barrier injury, invasive procedures<br>• Colonization and/or infection with multidrug resistant pathogen |
| Implement Standard Infection Prevention Techniques | • Perform hand hygiene with an approved alcohol-based product or antiseptic-containing soap before and after accessing a catheter or changing the dressing<br>• Maintain aseptic technique during catheter insertion, changing intravenous tubing and when entering the catheter including 'scrub the hub'<br>• Non-sterile gloves for routine handling of babies <1000 g |
| Skin prep for neonates | • Age less than 2 months : use povidone –iodine with 2 minutes dry time<br>• Age more than 2 months: use 2% chlorhexidine gluconate/70% isopropyl alcohol scrub |
| Site selection | • For catheter insertion in children the upper or lower extremities (or the scalp in neonates or young infants) can be used |
| Dwell time | • No cut-off duration beyond which PICC should be removed electively.<br>• Early UVC removal and replacement by PICC before day 4 might be considered |
| Other risk reduction measures | • Antimicrobial PICCs may reduce CLABSI, especially in high-risk subgroups<br>• Heparin in TPN (0.5 Units/mL)<br>• Fluconazole prophylaxis for babies <1000 g<br>• Minimize the use of H2 receptor blocker and proton pump inhibitor<br>• Minimize the use of broad-spectrum antimicrobials |

(UVC)Umbilical venous catheter, (PICC) Peripherally inserted central catheter, (VLBW) very low birth weight, (CVL) Central Venous line.
(Bizzarro et al., 2010; Pronovost, 2008; Mimoz et al., 2007; Garland et al., 2008; Birch et al., 2010; Cleminson et al., 2015; Puopolo and Escobar, 2014; Sanderson et al., 2017; Kramer et al., 2017; Rosenthal et al., 2010.

**Table 2**
Barriers, Challenges and Considerations for CLABSI Risk Reduction in Low and Middle Income Countries.

| Measures to reduce CLABSI risk | Barriers/Challenges | Considerations/ Solutions |
|---|---|---|
| Establishing Surveillance system to reduction targets and identify areas of priority | • Complex case definitions<br>• Limited laboratory capacities | • Training of lab staff<br>• Introduction of lab quality systems |
| | Staff shortages/<br>Inadequate number of skilled personnel for data management | • Use of cheap technology (Smart phone-based tools/prepro-gramed data analysis systems)<br>• Online resources for data management (e.g. ISOS) |
| Implementing interventions to enhance preventive measures | Staff shortages/<br>Inadequate number of skilled personnel | • Support from management<br>• Unit-based quality nurse to follow up<br>• Assigning multispecialty intervention team<br>• Ongoing in-service training for all staff involved |
| | High patient turnover/ Overcrowding | • Tailored interventions |
| | Limited resources<br>(infrastructure, technology, medical supplies | • Checklists<br>• Audit and feedback |
| | Poor adherence to guidelines/Lack of written guidelines | • Relentless focus on education, process and outcomes feedback<br>• Local training resources (e.g. peer tutoring)<br>• Online training resources |

(Geldenhuys et al, 2017; Assis et al., 2018; Ider et al., 2012; The Joint Commission, 2012).

barriers to wider adoption of this best practice intervention (Table 2). Indeed, in a 2019 report, 5 of 16 sites (27%) in middle-income countries reported no CLABSI prevention bundle use (Alp et al., 2019).

The challenges to reduce CLABSI in LMICs start with the surveillance, which is required to measure the baseline rates, identify priority hospital areas to direct the limited resources, and evaluate the effect of the intervention over time. Challenges include complex case definitions that depend on laboratory criteria for case confirmation, where many of these settings lack laboratory microbiological capacities for standard pathogen identification, in addition to the common clinical practices to obtain single drawing of blood for culture (i.e. solitary blood culture) to save resources, which minimize the amount of drawn blood leading to lower chances to yield the BSI pathogen (Lamy et al., 2016) and also do not allow for estimation of differential time to positivity of blood cultures. As a result, inaccurate rates of BSIs are usually reported. Training of laboratory staff and enforcing lab quality systems in addition to inclusion of clinically based definitions (e.g. the clinical sepsis) have been shown to improve the surveillance sensitivity, and support establishing surveillance programs (See et al., 2013; Talaat et al., 2016).

Another challenge is the availability of skilled staff and resources for data collection and analysis for baseline numbers in assessing infection prevention. For that, cheap technology such as smart phones-based data collection tools, and preprogrammed analysis and reporting tools can be developed to generate automated standard infection reports (Talaat et al., 2016). Other settings may use online platforms for facilitated standardized data collection, entry, and analysis, as the INICC Surveillance Online System (ISOS) (Rosenthal, 2016). Additionally, surveillance approaches can be selected to match the limited human resources, as settings may choose to implement short-time, hospital-wide surveillance approach (e.g. repeated point prevalence surveys) to stratify the burden of BSI among hospital departments (Ben Ayed et al., 2019), whereas other settings utilize their limited resources for surveillance in high risk areas as the ICUs (Rosenthal et al., 2016) (Table 3).

During implementation of the preventive measures, limitations of human resources affect also the compliance with the prevention guidelines, as shown by a study in Jordan where the nurse to patient ratio of 1:1 was the only predictor of higher compliance with the guidelines (Aloush and Alsaraieh, 2018). Effective strategies may be used to overcome this challenge during interventions, including assigning a nurse as a unit-based quality nurse (Thom et al., 2014), or assembly of an intervention team of physician, infection control nurse, and ICU nurse to assess and follow up CLABSI cases (Hussain et al., 2017).

Prevention efforts should be focused on maximal aseptic insertion of catheters, hand hygiene and adequate dressing changes.

As highlighted by Rosenthal (2009), high CLABSI rates suggest that LMICs face significant barriers for CLABSI reduction including resources, appropriate medical supplies and adequate numbers of skilled personnel. Additional examples include inadequate and

**Table 3**
Intervention Results Using INICC Multidimensional Approach.

| Country | Pre-Intervention Rate/1000 central line days | Post-Intervention Rate/1000 central line days | % Decrease | Reference |
|---|---|---|---|---|
| Argentina | 46.63 | 11.10 | 76% | Rosenthal et al., 2003 |
| Colombia | 12.9 | 3.9 | 73% | Alvarez-Moreno et al., 2016 |
| Mexico | 46.3 | 19.5 | 58% | Higuera et al., 2005 |
| Turkey | 22.7 | 12.0 | 47% | Leblebicioglu et al., 2013 |
| India | 6.4 | 3.9 | 39% | Jaggi et al., 2013 |
| Saudi Arabia | 6.9 | 3.1 | 55% | Al-Abdely et al., 2017 |
| 15 countries | 14.7 | 9.7 | 34% | Rosenthal et al., 2010 |
| 5 countries (Pediatric ICU) | 10.7 | 5.2 | 51% | Rosenthal et al., 2012 |
| 4 countries (Pediatric ICU) | 21.4 | 9.7 | 55% | Rosenthal et al., 2013 |
| Argentina (ICU) | 9.6 | 4.1 | 57% | Rosenthal et al., 2018 |

outdated technologies, lines used without sterile dressings, single dose vials used multiple times covered with contaminated tape, cotton balls impregnated with contaminated antiseptic solutions and semi-rigid plastic containers used for intravenous infusate preparation. Furthermore, general infection prevention gaps and breaches may contribute to high CLABSI rates e.g. lack of supplies such as barrier protections and antiseptics, lack of sinks for hand washing or access to alcohol based handrub, overcrowded surroundings and untrained personnel.

Implementation of central-line bundles has the potential to reduce the incidence of CLABSIs, as shown in a recent systematic review and meta-analysis (Ista et al., 2016). It is noteworthy that sustainable compliance with bundles involves the entire infection control team, and a change in their habits may be necessary, as well as continuous institutional support, updated educational interventions, and CLABSI surveillance data to improve patient care practices. In other words, to achieve steady, high levels of compliance with bundle elements, it is not sufficient to implement it as one measure, but rather within a multidimensional infection control approach.

INICC developed the INICC Multidimensional Approach, which is implemented through a Surveillance Online System (ISOS) software application, which includes: (1) a CLABSI prevention bundle, (2) education, (3) outcome surveillance (4) process surveillance, (5) feedback on CLABSI rates and consequences, and (6) performance feedback of process surveillance. As shown in the literature for developing countries and limited-resource hospital settings, the rate of CLABSI has been successfully reduced through the implementation of such multidimensional programs, which include insertion and maintenance bundles for the prevention of CLABSIs in critically ill patients of all ages, but also other interventions simultaneously (Rosenthal et al., 2010).

Effective interventions with the INICC multidimensional approach and ISOS were reported in ICUs from Argentina (46.63 vs. 11.10 CLABSIs per 1000 CL-days), showing a 76% reduction, and 57% reduction (incidence density rate: 0.43; 95% confidence interval, 0.34-0.6; $P < .001$) (Rosenthal et al., 2003); Colombia, showing a 73% CLABSI rate reduction (relative risk, 0.27; 95% confidence interval, 0.14-0.52; $P = .002$) (Alvarez-Moreno et al., 2016); Mexico (46.3 vs. 19.5 BSIs per 1000 IVD days) showing a 58% reduction (Higuera et al., 2005); Turkey (22.7 to 12.0 CLABSIs per 1000 CL-days), showing a 47% reduction (Leblebicioglu et al., 2013); India (6.4 CLABSIs to 3.9 CLABSIs per 1000 CL-days), showing a 39% reduction (Jaggi et al., 2013); and Saudi Arabia (6.9 to 3.1 per 1000 CL-days) (Al-Abdely et al., 2017). In multicentric studies conducted in adult ICUs (14.5 vs. 9.7 CLABSIs per 1000 CL-days) from 15 countries (Argentina, Turkey, Colombia, India, Mexico, Philippines, Brazil, Peru, El Salvador, Costa Rica, Cuba, Lebanon, Macedonia, Morocco, and Panama), showed a 33% reduction (Rosenthal et al., 2010); in pediatric ICUs from 5 countries (Colombia, India, Mexico, Philippines, and Turkey)(10.7 vs. 5.2 CLABSIs per 1000 CL-days), showed a 51% reduction (Rosenthal et al., 2012), and in NICUs from 4 countries (El Salvador, Mexico, Philippines, and Tunisia) showed a CLABSI rate decrease by 55%, from 21.4 per 1000 CL-days during phase 1 to 9.7 per 1000 CL-days during phase 2 (rate ratio, 0.45 [95% confidence interval, 0.33-0.63]) (Rosenthal et al., 2013).

In addition to the successful model of the INICC, other strategies showed significant impact in increasing staff compliance, and reduction of infection rates. Successful strategies included training and education of the staff through formal sessions of presentations and poster materials (Sahni et al., 2017), peer tutoring where nurses and staff share in preparing and provision of the educative materials (Park et al., 2017), or online provision of educative materials (Hassan, 2018).

Finally, as underscored by Alp and Rello (2019), implementation of these prevention techniques can be quite challenging. As presented by Alves et al. (2018), a “4E” approach can be useful:

Engagement of staff with a multi-disciplinary group with involvement of local champions and using peer networks;

Education with materials and sessions;

Execution with standard care processes with redundancy;

Evaluation with measurement of performance with feedback to staff.

## Conflicts of interest

None.


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## Ethical approval

Done.

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