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Original Article

An eight-year multicenter study on short-term peripheral intravenous catheter–related bloodstream infection rates in 100 intensive care units of 9 countries in Latin America: Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, and Venezuela. Findings of the International Nosocomial Infection Control Consortium (INICC)

Victor Daniel Rosenthal MD[1], Gustavo Jorge Chaparro MD[2], Eduardo Alexandrino Servolo-Medeiros MD[3], Dayana Souza-Fram RN[3], Daniela Vieira da Silva Escudero RN[3], Sandra Milena Gualtero-Trujillo MD[4], Rayo Morfin-Otero MD[5], Esteban Gonzalez-Diaz MD[5], Eduardo Rodriguez-Noriega MD[5], Miguel Angel Altuzar-Figueroa MD[6], Guadalupe Aguirre-Avalos MD[7], Julio César Mijangos-Méndez MD[7], Federico Corona-Jiménez MD[7], Blanca Estela Hernandez-Chena MD[8], Mohamed Rajab Abu-Jarad MD[8], Evelia Maria Diaz-Hernandez MD[8], María Guadalupe Miranda-Novales MD[9], José Guillermo Vázquez-Rosales MD[9], Daisy Aguilar-De-Morós RN[10], Elizabeth Castaño-Guerra RN[10], Gabriel Munoz-Gutierrez MD[11], Nepomuceno Mejia MD[12], Jenia Johana Acebo-Arcentales MD[13] and Gabriela Di-Silvestre MD[14]

[1]International Nosocomial Infection Control Consortium (INICC), City of Buenos Aires, Argentina, [2]Adult Intensive Care Unit, Instituto Medico Platense SA, Province of Buenos Aires, La Plata, Argentina, [3]Hospital Sao Paulo Escola Paulista De Medicina Unifesp, Sao Paulo, Brazil, [4]Pontificia Universidad Javeriana Hospital Universitario San Ignacio, Bogota, Colombia, [5]Adult Infectious Diseases, Antiguo hospital Civil de Guadalajara, Guadalajara, México, [6]Hospital General De Zona UMAA No 1 Oaxaca, Demetrio Mayoral Pardo, Oaxaca de Juarez, Mexico, [7]Intensive Care Unit, Hospital Civil de Guadalajara "Fray Antonio Alcalde," Guadalajara, Jalisco, México, [8]Hospital General Regional Nro 6 IMSS, Madero City, Mexico, [9]Hospital De Pediatria Centro Medico Nacional Siglo XXI IMSS, Mexico DF, Mexico, [10]Hospital del Niño Dr José Renán Esquivel, Panamá, [11]Hospital Clinica Biblica, San Jose de Costa Rica, Costa Rica, [12]Hospital General De La Plaza De La Salud, Santo Domingo, Dominican Republic, [13]Hospital Oncologico Solon Espinoza Ayala, Quito, Ecuador and [14]Hospital De Clinicas Caracas, Caracas, Venezuela

Abstract

Background: Data on short-term peripheral intravenous catheter–related bloodstream infections per 1,000 peripheral venous catheter days (PIVCR BSIs per 1,000 PVC days) rates from Latin America are not available, so they have not been thoroughly studied.

Methods: International Nosocomial Infection Control Consortium (INICC) members conducted a prospective, surveillance study on PIVCR BSIs from January 2010 to March 2018 in 100 intensive care units (ICUs) among 41 hospitals, in 26 cities of 9 countries in Latin America (Argentina, Brazil, Colombia, Costa Rica, Dominican-Republic, Ecuador, Mexico, Panama, and Venezuela). The Centers for Disease Control and Prevention (CDC) National Health Safety Network (NHSN) definitions were applied, and INICC methodology and INICC Surveillance Online System software were used.

Results: In total, 10,120 ICU patients were followed for 40,078 bed days and 38,262 PVC days. In addition, 79 PIVCR BSIs were identified, with a rate of 2.06 per 1,000 PVC days (95% confidence interval [CI], 1.635–2.257). The average length of stay (ALOS) of patients without a PIVCR BSI was 3.95 days, and the ALOS was 5.29 days for patients with a PIVCR BSI. The crude extra ALOS was 1.34 days (RR, 1.33; 95% CI, 1.0975–1.6351; $P = .040$).

The mortality rate in patients without PIVCR BSI was 3.67%, and this rate was 6.33% in patients with a PIVCR BSI. The crude extra mortality was 1.70 times higher. The microorganism profile showed 48.5% gram-positive bacteria (coagulase-negative *Staphylococci* 25.7%) and 48.5% gram-negative bacteria: *Acinetobacter* spp, *Escherichia coli*, and *Klebsiella* spp (8.5% each one), *Pseudomonas aeruginosa* (5.7%), and *Candida* spp (2.8%). The resistances of *Pseudomonas aeruginosa* were 0% to amikacin and 50% to meropenem. The resistance of *Acinetobacter baumanii* to amikacin was 0%, and the resistance of coagulase-negative *Staphylococcus* to oxacillin was 75%.

Author for correspondence: Victor Daniel Rosenthal, E-mail: victor_rosenthal@inicc.org
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Conclusions: Our PIVCR BSI rates were higher than rates from more economically developed countries and were similar to those of countries with limited resources.

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Short-term peripheral intravenous catheters (PIVCs) are the most commonly utilized medical devices in healthcare settings. In the United States, ~330 million PIVCs are purchased each year,[1] and an estimated 30%–80% of hospitalized patients receive at least 1 PIVC during their hospital stay.[2] A survey in Spanish hospitals found that 95% of intravascular catheters were PIVCs.[1] A study in Scotland reported that 30% of patients in acute-care hospitals had a PIVC, accounting for 90% of all intravascular catheters.[1]

PIVCs have traditionally been considered a low risk for catheter-related bloodstream infection (CRBSI).[2] However, according to a study conducted in Spain, of the total CRBSI cases, 77% were related to a central catheter and 23% were related to a PIVC.[3] A previously published literature review revealed that the incidence of peripheral intravenous catheter–related bloodstream infection (PIVCR BSI) was 0.5 per 1,000 PVC days or 0.1%.[4] A study conducted in the United States showed that the PIVCR BSI rate was 0.3%,[5] and a study in Turkey reported that the rate of PIVCR BSI was 0.7%.[6] Recently, the INICC reported that the rate of PIVCR BSI in a pool of 42 limited-resource countries was 2.41 PIVCR BSI per 1,000 PIVC days[7] and was 2.32 in Middle East.[8]

Over the last 2 decades, attention has been focused on risk of infection related to central venous access, leading to national campaigns aimed at reducing such events. However, little attention has been given to the risk of PIVCR BSIs and their prevention despite the fact that 1 in 3 healthcare-associated *S. aureus* CRBSIs are due to PIVCs, with known attributable morbidity and mortality.[1]

PIVCs are associated with a high risk of CRBSI, the most serious complication of catheterization.[2] Given that they are the most frequently used medical devices in hospitals, a high number of patients are at risk of PIVCR BSI and the associated mortality, estimated to be as high as 18%. Hence, a comprehensive assessment of the characteristics of PIVCR BSI is of utmost importance to guide the management of this issue.[9]

The incidence of PIVCR BSI in Latin America remains absent in the literature because data are not available. This prospective surveillance was conducted over 8 years between January 1, 2010, and March 31, 2018, in 100 intensive care units (ICUs) among 41 hospitals in 26 cities of 9 countries that participate in INICC. It is the first comprehensive study conducted in Latin America (Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, and Venezuela) to analyze the incidence rate, microorganism profile, bacterial resistance, length of hospital stay (LOS), and mortality attributable to PIVCR BSI.

Methods

Background of the INICC

The INICC is comprised of hundreds of hospitals in 210 cities of 54 countries in the 6 World Health Organization (WHO) regions: Africa, the Americas, Eastern Mediterranean, Europe, Southeast Asia, and the Western Pacific. It is the oldest and largest source of aggregate standardized international data on the epidemiology of healthcare-associated infections (HAIs) worldwide.[10,11] The INICC aims to prevent all HAIs on ICUs, step-down units, inpatient wards, and to prevent all surgical site infections, through systematic outcome and process surveillance, and the implementation of multidimensional infection prevention programs.[10,11]

INICC methods

The INICC Surveillance Online System (ISOS) software was used to conduct this prospective, cohort surveillance study. The ISOS includes the implementation of The Centers for Disease Control and Prevention (CDC) National Health Safety Network (NHSN) definitions,[12] adding the collection of other data essential to increasing the sensitivity of infection control professionals (ICPs) to the detection of HAI underreporting.[10]

According to standard CDC/NSHN methods, numerators are the number of HAIs related to a specific device and denominators are device days collected from all patients, as pooled data, that is, without determining the number of device days related to a particular patient and without collecting features or characteristics of individual patients.[10,12] This aspect differs from the ISOS; the design of the cohort study through the ISOS also includes the collection of specific data per patient from all patients, both with and without HAIs, such as invasive device utilization, age, gender, date of admission, date of discharge, LOS, microorganism profile, bacterial resistance, and mortality, among many others.[10]

Data collection

In this study, we included only patients with PIVCs. All patients with a central line were excluded. ICPs collected the following daily patient data: PIVC use, date of admission, date of discharge, bed days, outcome, mortality, PIVCR BSIs, microorganism profile, and bacterial resistance.[10]

Training

The INICC team trained ICPs to operate the ISOS.[10] ICPs attended webinars and had continuous access to an INICC support team.[10] The ISOS automatically evaluates routinely that ICPs perform surveillance correctly and reminds ICPs to check and review surveillance data and specific criteria.[10]

Definitions

Laboratory-confirmed bloodstream infection (LCBI)

The CDC/NHSN definitions were used for BSI from its 2008 publication and its amendments. "Patient of any age has a recognized bacterial or fungal pathogen, not included on the NHSN common commensal list, identified from 1 or more blood specimens obtained by a culture or identified to the genus or species level by non–culture-based microbiologic testing methods and organism(s) identified in blood is not related to an infection at another site."[12,13]

PIVCR BSI

A patient with an LCBI who had used a neither central line nor a peripherally inserted central catheters and who only used short-term PIVCs for at least 24 hours before the acquisition of an LCBI was considered to have had a PIVCR BSI.

PIVCR BSIs per 1,000 PVC days

The PIVCR BSI rate per 1,000 PIVC days was calculated by dividing the number of PIVCR BSIs by the number of PIVC days and multiplying the result by 1,000.

Peripheral line utilization ratio

The PIVC utilization ratio was calculated by dividing the number of PIVC days by the number of patient days.

Crude excess mortality and crude excess ALOS of PIVCR BSIS

Crude excess mortality is crude mortality of patients with PIVCR BSI minus crude mortality of patients without PIVCR BSIs. Crude excess ALOS is the crude ALOS of patients with PIVCR BSI minus crude LOS of patients without PIVCR BSI. Patients were followed during 48 hours after discharge from the ICU.

Statistical analysis

ISOS version 5.0 software (Buenos Aires, Argentina) was used to calculate PIVCR BSI rates, device utilization ratios (DURs), LOS, and mortality.[10] We used SPSS version 16.0 software (IBM, Chicago, IL) for the statistical analysis, and 95% confidence intervals (CIs) and *P* values were determined for all outcomes.

Setting

The study was conducted in 100 ICUs among 41 hospitals in 26 cities of 9 countries in Latin America: Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, and Venezuela. All patients admitted to the ICUs during the study period were enrolled in the study, with the approval of the hospitals' research ethics committees.[10]

In accordance with the INICC Charter, the identities of all INICC hospitals and cities remains confidential.[10]

Results

The study was conducted over 8 years from January 1, 2010, to March 31, 2018. Overall, 21 participating hospitals (51.2%) were privately owned, whereas 17 (41.5%) were public hospitals and 3 (7.3%) were academic teaching hospitals.

In total, 100 ICUs were included: cardiothoracic (n = 4), coronary (n = 11) medical (n = 9), medical-surgical (n = 41), neurosurgical (n = 4), oncology (n = 2), pediatric (n = 15), respiratory (n = 3), surgical (n = 4), trauma (n = 2), and other (n = 5).

In total, 51,118 patients were admitted to the 100 ICUs during this period. Of these, 40,998 had a central line at some point during their hospitalization, and all of these were excluded from this analysis. Only 10,120 (19.8%) patients remained who had only a peripheral line during their stay.

Table 1 shows the PIVCR BSI rates and the DURs by ICU type. Overall, 10,120 ICU patients that used only a PIVC during hospitalization were followed for 40,078 bed days and 38,262 PVC days. In total, 79 PIVCR BSIs were identified, for a rate of 2.06 per 1,000 PVC days (95% CI, 1.635–2.257).

Table 2 presents data on crude ICU mortality and crude ALOS in patients with and without PIVCR BSI. The average length of stay (ALOS) was 3.95 days in patients without a PIVCR BSI and 5.29 days in patients with a PIVCR BSI. The crude added ALOS was 1.34 days (RR, 1.33; 95% CI, 1.0975–1.6351; $P = .040$). The mortality rate in patients without a PIVCR BSI was 3.67%, and it was 6.33% in patients with a PIVCR BSI. The crude excess mortality was 1.70 times higher. Mortality was not powered to show significance.

These PVCR BSIs presented a microorganism profile of 49.2% of gram-positive bacteria, with coagulase-negative *Staphylococci* (23.6%), *Streptococcus* spp (13%) and *Staphylococcus aureus* (7.8%) being the predominant species. Gram-negative bacteria accounted for 44.2% of cases and included *Acinetobacter* spp (7.8%), *Escherichia coli* (7.8%), *Klebsiella* spp (7.8%), *Pseudomonas aeruginosa* (5.2%), *Serratia marcescens* (5.2%), *Enterobacter cloacae* (2.6%), and others. *Candida* spp represented 5.2% of cases.

Multidrug-resistant gram-negatives organisms were not found.

In this study, resistance of *Staphylococcus aureus* to oxacillin was detected in 0% of cases, significantly lower than the 49% resistance reported in a study conducted in India.[14] *Enterococcus faecalis* was 100% sensitive to vancomycin. Methicillin-resistant *Staphylococcus aureus* were not found. Figure 1 shows the microorganism profile of PIVCR BSIs. 49.2% were gram-positive bacteria, 44.2% were gram-negative, and *Candida* spp represented 5.2% of cases.

Discussion

Currently, no published data are available for or have been analyzed regarding PIVCR BSI rates in Latin America. This 8-year study is the first to determine PIVCR BSI rates per 1,000 device days in this region, including data from 10,120 ICU patients for 40,078 bed days and 38,262 short-term PIVC days, from 100 ICUs among 83 hospitals in 26 cities of 9 countries.[15]

The pooled mean PIVCR BSI rate was 2.06 per 1,000 PIVC days (95% CI, 1.635–2.257). Similar PIVCR BSI rates have been reported by the INICC recently. In a pool of 42 countries worldwide, the PIVCR rate was 2.41 per 1,000 PIVC days.[7] In Asia, the rate was 2.65 per 1,000 PIVC days,[16] and in the Middle East, the rate was 2.32 per 1,000 PIVC days.[8] The incidence of PIVCR BSI has been determined using the number of PIVC days in 2 studies from more economically developed countries: a 2006 systematic review with data from the United States, Australia, and Italy, observed a rate of 0.5 PIVCR BSIs per 1,000 PIVC days,[4] and a 2018 study conducted in pediatric and neonatal ICUs from Australia, noted a rate of 0.67 PIVCR BSIs per 1,000 PVC days.[17]

In a 2019 systematic review by Alliance for Vascular Access Teaching and Research (AVATAR) group, the selected studies did not report PIVC days as denominators of PIVCR BSI rates. In consequence, such data are not comparable to our present study.[18] The cited AVATAR review did include studies that reported the following PIVCR BSI rates[18]: 0.39 PIVCR BSIs per 10,000 occupied bed days in Australia[19]; 3.04 PIVCR BSIs per 1,000 patient days in Germany[20]; 1.17 PIVCR BSIs per 10,000 patient days in Spain[21]; and 0.05 PIVCR BSIs per 1,000 patient days,[22] and 0.0150 PIVCR BSIs per 100 patient days,[23] and 0.57 PIVCR BSIs per 1,000 patient days in the United States.[24]

Many studies have reported on the adverse consequences of BSIs in ICUs and on the comparative infection risks of central lines (CLs) versus PIVCs, with CLs being much more prone to higher BSIs rates than PIVCs.[25]

A 2019 INICC study published data of CLABSIs in 45 countries, prospectively collected over 6 years (2012–2017), from 532,483 ICU patients hospitalized in 523 ICUs of 242 hospitals for an aggregate of 2,197,304 patient days. In the medical-surgical ICUs, the pooled CLABSI rate was 5.05 per 1,000 central-line days.[11] A comparison of these 2019 CLABSI data with the present study on PIVCR BSI indicates that the CLABSI rate is 45% higher than the PIVCR BSI rate. However, since ~80%–90% of the vascular catheters used worldwide are PIVCs, the raw number of BSIs

Table 1. Pooled Means of the Distribution of Short-Term Peripheral Venous Catheter-Related Bloodstream Infections Rates by Type of Location, in Adult and Pediatric Intensive Care Units

Type of ICU	ICUs, No.	Patients, No.	Bed days, No.	PIVC days, No.	PIVCR-BSIs, No.	Pooled PIVCR-BSI rate (95% CI)	Device Utilization Ratio
Cardiothoracic	4	429	874	812	0	0 (0.0–0.0)	0.92
Coronary	11	2,344	9,696	9,147	7	0.76 (0.3077–1.576)	0.94
Medical	9	173	851	680	0	0 (0.0–0.0)	0.79
Medical/Surgical	41	5,494	21,736	21,242	62	2.91 (2.2238–3.7420)	0.97
Neurosurgical	4	230	795	762	0	0 (0.0–0.0)	0.95
Oncology	2	59	178	233	1	4.29 (1.090–23.913)	1.30
Pediatric	15	524	2,708	2490	9	3.61 (1.6530–6.6861)	0.91
Respiratory	3	87	546	563	0	0 (0.0–0.0)	1.03
Surgical	4	558	1,473	1,203	0	0 (0.0–0.0)	0.81
Trauma	2	27	160	164	0	0 (0.0–0.0)	1.02
Other	5	195	1061	966	0	0 (0.0–0.0)	0.91
Pooled (adult and pediatric ICUs)	100	10,120	40,078	38,262	79	2.06 (1.6350–2.2570)	0.95

Note. ICU, intensive care unit; PIVCR-BSI, short-term peripheral venous catheter–related bloodstream infection; PIVC, short-term peripheral venous catheter; CI, confidence interval.

Table 2. Pooled Means of the Distribution of Crude Length of stay and Mortality of Intensive Care Unit Patients With Short-Term Peripheral Venous Catheter-Related Bloodstream Infections in Adult and Pediatric Intensive Care Units Combined

Variable	No. of Patients	LOS, Total Days	Pooled Mean LOS, days	No. of Deaths	Pooled crude Mortality, %
Adult and Pediatric patients, without PIVCR-BSI	10,041	39,660	3.94	369	3.67
Adult and pediatric patients, with PIVCR-BSI	79	418	5.29	5	6.32
Crude extra LOS/mortality	...	...	Extra LOS: 1.35 days	...	Extra mortality, 2.65
Patients with PIVCR-BSI vs patients without PIVCR BSI	...	...	RR, 1.33; 95% CI, 1.09–1.63; $P = .040$		RR, 1.72; 95% CI, 0.73–4.04; $P > .05$

Note. PIVCR-BSI, short-term peripheral venous catheter-related bloodstream infection; LOS, length of stay; CI, confidence interval.

resulting from PVCs is ~6 times higher than the number of BSIs resulting from central lines.[1,15]

The pooled mean of the distribution of crude mortality was 6.33% of PIVCR BSI cases in our ICUs, compared to 3.67% mortality of PIVC patients who were not infected. Nevertheless, the power of the sample was not enough to show significant difference. Mortality rates attributable to PIVCR BSI in recent studies in Spain and Japan were 13.2% and 12.9% respectively, both of which were higher than in our study.[21,26]

The added ALOS of patients with PIVCR BSI (5.29 days) was 33% higher than in patients without PIVCR BSI (3.95 days). Comparable data showing the extra ALOS attributable to PIVCR BSI are unavailable. Notwithstanding, in the aforementioned INICC study, patients who acquired CLAB had on average 9.4 extra days of hospital stay.[11]

Ripa et al[27] found the following incidences of microorganism in patients with PIVCR BSI: gram-positive *cocci*, 75% (*Staphylococcus aureus 46%,* Coagulase-negative *staphylococci* 25%, *Enterococcus* spp 3.7%); gram-negative bacilli, 22.8% (*Klebsiella* spp 5.6%, *Pseudomonas aeruginosa 4.5%, Escherichia coli* 4.1%, *Enterobacter* spp 3.9%, *Serratia* spp 0.7%, *Acinetobacter* spp, 0.7%) and *Candida* spp, 1.3%.[27] A 2019 study reported a significant increase in the proportion of gram-negative infections with an interval of 20 years: 22.6% in 1992–1996 versus 33.2% in 2012–2016.[27] *Enterococcus faecalis* was 100% sensitive to vancomycin, contrary to the findings of the aforementioned India study in which vancomycin was 100% sensitive to PVCR-BSI *Enterococcus* spp.[14]

PIVCR BSI surveillance by number of device days is essential to reducing the hospitalized patients' risk of infection because it accurately describes the threat of PIVCR BSIs. Additionally, multifaceted and surveillance programs aimed toward PIVCR BSI prevention and control must be implemented. To this end, INICC bundles for insertion and maintenance of PIVCs have been published and applied in limited-resource settings over the past 3 years.[28] Likewise, antimicrobial resistance should be addressed and susceptibility to antimicrobials of PIVCR-BSI–associated pathogens should be reported to effectively prevent the transmission of resistant strains.[18,21]

In the present study, we focused exclusively on the ICU setting. This is the healthcare environment with the highest HAI rates because ICU patients have critical medical conditions and are most often exposed to invasive devices.[29] The INICC was worked tirelessly over the last 20 years and across the 6 WHO regions in an effort to combat the burden of HAIs. Increasing hand hygiene compliance and improving compliance with infection control bundles have proven

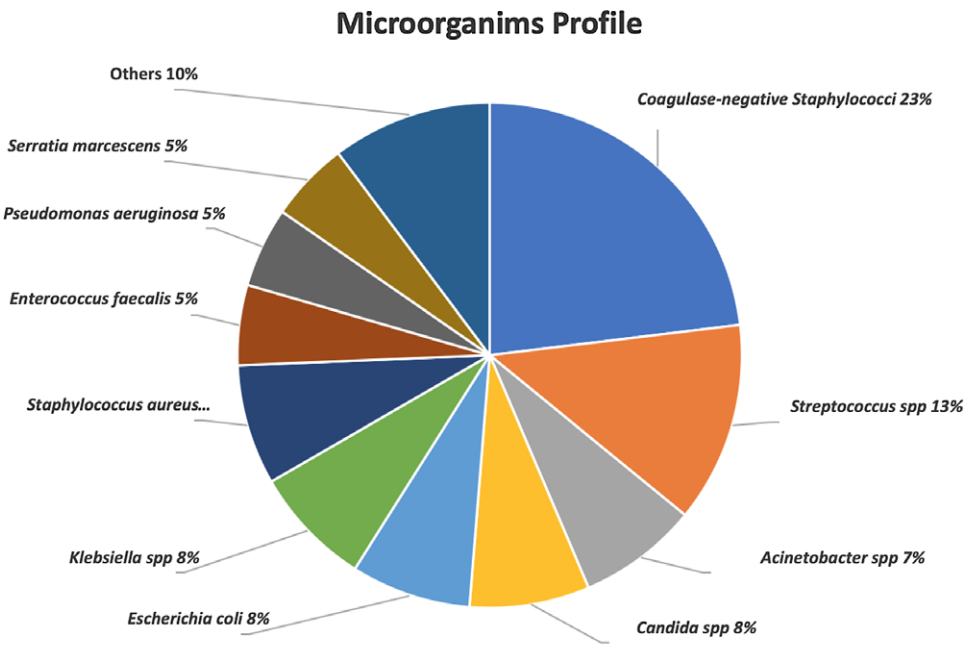

Fig. 1. Microorganism profile of short-term peripheral venous catheter–related bloodstream infections.

to be successful strategies to prevent CLABSIs as described in several INICC publications.[28,30–39] The present data can guide the implementation of prevention strategies and other quality improvement efforts for the reduction of PIVCR BSI rates and their adverse consequences.

This study has several limitations. First, we have not provided insights into the influence of INICC interventions,[28,34–38] such as the implementation of INICC multidimensional approach and ISOS.[10,28,34–38] Second, trends in data over time are not presented for this 8-year study. Moreover, changes in compliance of healthcare workers with preventive measures were not considered. Furthermore, most PIVCs were inserted in the ICU, which may have affected the PIVCR BSI rate. In addition, this study was limited to a benchmark comparison with a few studies that also report PIVCR BSIs by PIVC days. Furthermore, due to limited resources, cultures taken were probably less than ideal, which likely influenced PIVCR BSI rates. Also, resistance rates cannot be generalized due to the small simple size. Additionally, we did not obtain data on the illness severity score at patient admission to the ICU, which is likely associated with crude mortality. Finally, to define ALOS in patients with and without BSI, the time of origin was counted from the first day of admission, and it was not possible to determine whether the longer ALOS was the cause or the consequence of BSI.

In conclusion, we have presented the only comprehensive data on PIVCR BSIs per 1,000 PIVC days from Latin America currently available. Consequently, the benchmark comparison of our findings was limited to the results of 2 studies from more economically developed countries (a 2006 systematic review of data from the United States, Australia, and Italy and an Australian study published in 2018[17]) and to 4 studies INICC conducted in countries of limited resources in Asia[6] and the Middle East[8] and in a pool of 42 countries.[7] The PIVCR BSI rates in this study were higher than those of economically developed countries. Thus, it is clear that PIVCR BSIs in ICUs from limited-resource countries are a detriment to patient safety. The systematic surveillance of PIVCR BSI and prevention programs, such as antibiotic resistance reports, should be implemented widely to reduce the incidence of PIVCR BSI and its adverse consequences worldwide.

One key finding of this research is that, in Latin America, healthcare workers should conduct surveillance of PIVC BSI rates, extra length of stay, and extra mortality. They should develop and implement bundles for insertion and maintenance of PIVC, including proper hand hygiene before insertion and care, select the insertion site with less risk, apply aseptic technique, use chlorhexidine skin antisepsis, use a sterile dressing, use needle-free connectors instead of 3-way stopcock, scrub the access to the catheter before use, use of prefilled syringes, change administration sets every 4 days unless use for blood transfusion or lipids administration, do not change PIVC at fixed intervals, remove PIVC when they are not needed. Finally, they should monitor compliance with bundles.

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