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Major article

Multicenter study in Colombia: Impact of a multidimensional International Nosocomial Infection Control Consortium approach on central line–associated bloodstream infection rates

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Background: The objective of this study was to analyze the impact of a multidimensional infection control approach and the use of the International Nosocomial Infection Control Consortium (INICC) Surveillance Online System on central line–associated bloodstream infection (CLABSI) rates from June 2003-April 2010.
Methods: We conducted a prospective, before-after surveillance study of 2,564 patients hospitalized in 4 adult intensive care units (ICUs) and 424 patients in 2 pediatric ICUs of 4 hospitals in 2 cities of Colombia. During baseline, we performed outcome surveillance of CLABSI applying the Centers for Disease Control and Prevention's National Healthcare Safety Network definitions. During intervention, we implemented the INICC multidimensional approach and the ISOS, which included a bundle of infection prevention practice interventions, education, outcome surveillance, process surveillance, feedback on CLABSI rates and consequences, and performance feedback of process surveillance. Bivariate and multivariate regression analyses were performed using a logistic regression model to estimate the effect of the intervention on the CLABSI rate.
Results: The baseline rate of 12.9 CLABSIs per 1,000 central line (CL) days, with 3,032 CL days and 39 CLABSIs, was reduced to 3.5 CLABSIs per 1,000 CL days, with 3,686 CL days and 13 CLABSIs, accounting for a 73% CLABSI rate reduction (relative risk, 0.27; 95% confidence interval, 0.14-0.52; *P* .002).
Conclusions: Implementing the INICC multidimensional infection control approach for CLABSI prevention was associated with a significant reduction in the CLABSI rate of ICUs of Colombia.

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Central line–associated bloodstream infection (CLABSI) is considered to be among the most serious device-associated infections in the intensive care unit (ICU) setting.[1,2] According to studies from developed[2] and limited-resource countries,[3,4] the most important clinical consequences attributable to CLABSI are increased mortality rates, significant morbidity, and increased length of stay (LOS). From an economic perspective, CLABSIs are also responsible for significant increases in health care costs, as reported in both developed[2,5] and limited-resource countries.[3,4] The burden posed by CLABSI has not been systematically analyzed in limited-resource countries.[6] Although hospitals in limited-resource countries do implement basic infection control programs, compliance with infection control practices is variable.[6] As reported by the International Nosocomial Infection Control Consortium (INICC) in pooled studies[7-11] and in particular studies from Colombia,[12] the rates of CLABSI have been determined to be from 3-5 times higher than in Western countries.

In Western countries, it has been shown that the incidence of CLABSI can be substantially prevented and reduced by >30% through basic but effective measures,[13] such as those described in the bundle for CLABSI prevention developed by the Institute for Healthcare Improvement[14]: (1) hand hygiene, (2) skin antisepsis with chlorhexidine, (3) maximal barriers, (4) insertion in subclavian vein, and (5) timely central line (CL) removal—were associated with a reduction in the incidence density of CLABI in developed countries.[15]

The present study was designed to determine the effect of the INICC multidimensional program for reduction of CLABSI rates in 4 adult ICUs and 2 pediatric ICUs of 4 hospitals of 2 cities in Colombia. Our program was implemented from June 1, 2003-April 30, 2010, and included 6 simultaneous interventions: (1) bundle of infection prevention practices, (2) education, (3) outcome surveillance, (4) feedback of CLABSI rates and adverse consequences, (5) feedback on CLABSI rates and consequences, and (6) performance feedback of process surveillance.

Outcome surveillance is conducted by means of an online platform called the INICC Surveillance Online System (ISOS), which is comprised of 15 modules whose effective impact in CLABSI rates reduction was shown in several studies.[16-23] The ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply the U.S. Centers for Disease Control and Prevention's (CDC's) National Healthcare Safety Network (NHSN) definitions.[24]

The bundles of infection prevention practices of the INICC Multidimensional Approach (IMA) follow the basic recommendations published in the guidelines of the Society for Healthcare Epidemiology of America and Infectious Diseases Society of America in 2008[25] and the CDC in 2002.[26] At present, there is sufficient ethical and theoretical justification for conducting this particular study, and through its publication we can increase and spread awareness on this public health burden in Colombia.

METHODS

Background on the INICC

Founded in Argentina in 1998, the INICC was the first multinational research network established to control and reduce health care–associated infections (HAIs) at the international level through the analysis of data collected on a voluntary basis by a pool of hospitals worldwide.[11] The goals of the INICC include the development of a dynamic global hospital network that applies systematic surveillance of HAIs with standardized definitions and methodologies of the CDC-NHSN,[24] promotes evidence-based infection control practices, and performs applied infection control research to reduce rates of HAI, associated mortality, excess LOSs, costs, and bacterial resistance.[27]

Setting and study design

This multicenter, prospective, before-after study was conducted in 4 adult ICUs (3 medical-surgical and 1 coronary ICUs) and 2 pediatric ICUs of 4 INICC member hospitals in 2 cities from Colombia. This hospital had been actively implementing the IMA, as subsequently described, during a 3-month period for the baseline background in internal medicine, critical care, infectious diseases, an infection control team (ICT) comprised of infection control professionals and medical doctors with formal education and period and the following months for the intervention period, with microbiology, and hospital epidemiology.

Baseline period

The baseline period included only the performance of outcome surveillance and process surveillance. The length of the baseline

of patients and the number of months of data collection during the baseline period are sufficient enough to compare with the sample size of patients and the number of months of data collection during the intervention period. From a statistical perspective, the issue is addressed by considering the changes in rates over time. The relatively short baseline period may impact the SEM of our estimates.

However, we found that this will not cause a bias in the results because there will not be systematic differences between the 2 groups. Second, our priority is to start the intervention as early as possible to achieve the desired results, such as lower CLABSI rates, as soon as possible.

Intervention period

The intervention period started in the fourth month of participation. This is a prospective cohort study, and each ICU joined the INICC program at different moments. Therefore, by the time we analyzed the impact of the INICC intervention, we had ICUs with different lengths of participation in the intervention period. For the coronary ICU, the baseline period was from September 1, 2003-November 30, 2003, and the intervention period was from December 1, 2003-June 30, 2004. For the 2 pediatric ICUs, one had a baseline period from September 1, 2003-November 30, 2003, and an intervention period from December 1, 2003-July 31, 2005, and the other had a baseline period from October 1, 2009-December 31, 2009, and an intervention period from January 1, 2010-April 30, 2010. The 3 medical-surgical ICUs also had different periods of participation: a baseline period from June 1, 2003-August 31, 2003, and an intervention period from September 1, 2003-November 31, 2004; a baseline period from April 1, 2003-June 30, 2003, and an intervention period from July 1, 2003-July 31, 2004; and a baseline period from June 1, 2003-August 31, 2003, and an intervention period from September 1, 2003-December 31, 2004.

IMA

The IMA includes the implementation of the CDC-NSHN methodology, but it adds the collection of other data essential to increase infection control professional's sensitivity to detect HAIs and avoid underreporting.[24] According to standard CDC-NSHN methods, numerators are the number of HAIs of each type, and denominators are device days collected from all patients, as pooled data, without determining the number of device days related to a particular patient and without collecting characteristics per specific patient.[24] This design differs from the IMA because the design of the cohort study through the INICC methods also includes collecting specific data per patient from all patients, both those with and those without HAI,

collecting risk factors of HAIs (eg, invasive devices), and collecting surrogates of HAIs, which include, but are not limited to, high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS, and mortality. By collecting data on all patients in the ICU, it is possible to match patients with and without HAI by several characteristics to estimate extra LOS, mortality, and cost.

The IMA is comprised of the simultaneous implementation of the following 6 components for HAI control and prevention: (1) a bundle of infection prevention practices, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback on HAI rates and consequences, and (6) performance feedback.

The ISOS is comprised of 15 modules, 10 for outcome surveillance and 5 for process surveillance. The modules of the outcome surveillance and process surveillance components may be used singly or simultaneously, but once selected, they must be used for a minimum of 1 calendar month.

Bundle of infection prevention practices

The bundles of infection prevention practices were designed following the recommendations and guidelines published by the CDC in 2002[26] and the Society for Health Care Epidemiology of America and the Infectious Diseases Society of America published in 2008.[25] These guidelines describe different recommendations for HAI prevention that are classified into categories regarding the existing scientific evidence, applicability, and prospective economic effects.

The components of the INICC infection control bundle for CLABSI prevention[25] are as follows: (1) perform hand hygiene before CL insertion or manipulation[28]; (2) use sterile gauze or transparent sterile dressing to cover insertion site[25]; (3) maintain good condition of sterile dressing, and change gauze every 48 hours and transparent dressing every 7 days[25]; (4) remove CL as early as possible, when not necessary, to have lower device utilization ratio (DUR) and shorter length of device use[25]; (5) change administration set every 96 hours, unless used for fat, nutrition, or blood precuts, and in these cases changed every 24 hours[25]; (6) use a chlorhexidine-based antiseptic for skin preparation (implemented in 2006)[25]; (7) preferably use subclavian vein[25] ; (8) use maximal sterile barrier precautions during CL insertion[25]; (9) avoid multiple uses of vials meant to be used only once[25]; (10) disinfect line hubs, needleless connectors, and infection ports before accessing the CL[25]; and (11) use closed collapsible flexible containers instead of open semirigid vented or glass vented intravenous containers.[29]

Education

Education to health care workers included information about infection control measures specific for CLABSI, based on the mentioned guidelines and recommendations, and the correct procedures and technique for hand hygiene.

Outcome surveillance

Prospective active outcome surveillance through the ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply CDC-NHSN definitions published in 1991.[24] The site-specific criteria include reporting instructions and providing full explanations integral to their adequate application.[24]

Process surveillance

The process surveillance is performed through the ISOS modules, which include the monitoring of compliance with some bundle elements for CLABSI prevention, including the (1) proportion of inserted CLs; (2) proportion of dressing placed to protect the puncture site; (3) proportion of dressings in correct condition and evaluating if the dressing was clean, dry, and correctly adhered to the puncture site; (4) proportion of cases in which dates of insertion were written in the administration set of the patient or the dressing; (5) DUR; and (6) length of CL use.

Feedback on device-associated HAI rates and consequences

Health care workers receive feedback on device-associated HAI rates and their consequences at monthly meetings, by means of the review of reports generated through the ISOS,[27] which contains charts and tables with a running record of the monthly data of cohort surveillance. This infection control tool is important to increase awareness about outcomes of patients at their ICU, enable the ICT and ICU staff to focus on the necessary issues, and apply specific strategies for improvement of high device-associated HAI rates.

Performance feedback

This infection control tool is essential to enable the ICT and ICU staff to focus on the necessary strategies for improvement of low compliance rates.

Performance feedback is provided to health care workers working in the ICU by communicating the assessment of practices routinely performed by them. The resulting rates are reviewed by the ICT with ICU staff at monthly meetings, showing bar charts with compliance with infection control measures to prevent CLABSIs.[28,30]

Data collection and analysis

The ISOS meets the criteria set forth in the INICC protocol, which is followed by the infection control professionals who collect daily data on CLABSIs, catheter-associated urinary tract infections, and ventilator-associated pneumonias and denominator data, patient days, and specific device days in the ICUs.

Definitions

We applied CDC-NHSN definitions for CLABSI published by the CDC-NSHN in 1991.[24]

Statistical methods

ISOS version 2.0 (Buenos Aires, Argentina) was used to calculate HAI rates and the DUR.

Patients' characteristics were compared using Fisher exact tests for dichotomous variables and unmatched Student *t* tests for continuous variables. *P* values <.05 by 2-sided tests were considered significant.

We conducted 2 types of analysis to evaluate the impact of our intervention on CLABSI rates. First, we performed an analysis to compare the data of the first 3 months (baseline period) with the remaining pooled months (intervention period) using relative risks, 95% confidence intervals (CIs), and *P* values. Second, to analyze progressive CLABSI rate reduction, we divided the data into the first 3 months (baseline period) followed by the 6-month follow-up periods (intervention period). We compared the CLABSI rates for each follow-up period with the baseline CLABSI rate. We calculated the incidence density rates (IDR), IDR ratios, and IDR reduction to account for the CLABSI rate reduction. Third, we estimated the effect of the intervention on the CLABSI by means of a logistic regression model. A set of covariables was included to account for possible interactions and confusion effects. A backward procedure that compares between nested models using the Akaike information criterion was carried out to get the final set of significant covariables. Collinearity among independent variables was measured using the variance inflation factor. We calculated the odds ratio (OR) and 95% CI for the intervention and other independent variables. The

effectiveness of the intervention was calculated using the formula: (1 - OR) × 100, where OR is the adjusted OR estimated by the model. All statistical analyses were performed using the R software version 3.2.2.

RESULTS

During the study period, we recorded a total of 2,988 patients, hospitalized for 17,370 days, with a total of 13,263 CL days, at 4 hospitals in the following 3 types of ICUs: pediatric (n = 424), coronary (n = 373), and medical-surgical (n = 2,191).

Patients' characteristics, such as sex and age, were similar during both periods.

Regarding the results of the measurement of the bundle components, we registered statistically significant improvements in hand hygiene compliance and less CL DUR (Table 1).

The average length of CL use was lower during the intervention period (Table 1).

The levels of compliance with date on administration set, placed dressing, and correct condition of dressing were high at baseline and remained at the same level during the intervention period (Table 1).

During the baseline period, we recorded 3,032 CL days for a CL use mean of 5.6. There were 39 CLABSIs for an overall baseline rate of 12.9 CLABSIs per 1,000 CL days. (Table 2) Merging all data of the intervention period, during the implementation of the multidimensional infection control program, we recorded 10,231 CL days for a CL use mean of 4.2. The rate of CLABSIs per 1,000 CL days was reduced to 3.5 CLABSIs per 1,000 CL days in the second year, accounting for a 73% cumulative CLABSI rate reduction (IDR ratio, 0.27; 95% CI, 0.14-0.52; *P* .001) (Table 2 and Fig 1).

The results of the logistic regression model are presented in Table 3. These results showed a significant reduction in the CLABSI risk in patients during the intervention period, when controlling for the number of CL days and patients' ages (OR, 0.52; 95% CI, 0.33-0.81). The model also detected a significant excess risk for a unit increase in the CL days (OR, 1.10; 95% CI, 1.08-1.12). The adjusted effectiveness of the intervention was 48% (95% CI, 19%-67%). There was no significant interaction detected between the intervention and the number of CL days. Collinearity indices in the final model were low (1.001-1.003), indicating the absence of multicollinearity among the independent variables.

The microorganisms profile is shown in Table 4. The predominant microorganisms were *Staphylococcus aureus* and coagulase-negative *Staphylococcus* in both periods.

DISCUSSION

This study was conducted with the aim of assessing the effect of a multidimensional infection control approach in the ICU setting in Colombia. The comparison of the baseline rate of CLABSI found in this study (12.9 per 1,000 CL days) shows it is almost 10-fold higher than the United State's 0.8 CLABSI rate per 1,000 CL days determined by the CDC-NHSN for 2013[31] and the 1.4 rate determined by KISS.[32] In comparison with CLABSI rates from other developing countries, our CLABSI baseline rate was higher than the last international INICC report for 2007-2012 (4.9 CLABSIs per 1,000 CL days; 95% CI, 4.8-5.1).[11] Within the limited scope of studies addressing the burden of CLABSIs in Colombia, in a study conducted by Villalobos et al in 10 ICUs, it was shown that the CLABSI rate was 4.8 per 1,000 CL days.[33]

In our study, the high CLABSI rate at baseline was reduced from 12.9 to 3.5 per 1,000 CL days (rate ratio, 0.27; 95% CI, 0.14-0.52; *P* .001), showing a 73% CLABSI rate reduction. This reduction can be associated with the implementation of the IMA, because the results of the measurement of the bundle components showed

Table 1
Patient characteristics, device use, and central line–associated bloodstream infection rates and compliance with care bundle in the baseline and intervention periods

Patient characteristics	Baseline period	Intervention period	RR (95% CI)	*P* value
Study period by hospital in months, mean (range)	3	12.5 (6.0)	-	-
Patients, n	544	2,444	-	-
Bed days, n*	3,575	13,795	-	-
CL days, n†	3,032	10,231	-	-
Age, mean ± SD	44.2 ± 23.2	44.8 ± 24.6		.590
Male, n (%)	304 (55.9)	1,285 (52.6)	-	.772
Bundle to prevent CLABSI				
Hand hygiene compliance, % (n/n)	50 (351/703)	76 (558/732)	0.77 (0.70-0.86)	.001
Compliance with date on administration set, % (n/n)	91 (803/878)	87 (2,691/3,097)	1.02 (1.0-1.1)	.929
Compliance with placed dressing, % (n/n)	85 (744/878)	82 (2,531/3,097)	1.02 (0.9-1.1)	.520
Compliance with correct condition of dressing, % (n/n)	86 (753/878)	78 (2,429/3,097)	1.05 (1.0-1.1)	.110
Average length of CL use ± SD	5.6 ± 10.9	4.2 ± 7.3	-	.001
CL utilization ratio (DUR)‡	0.85	0.74	-	.001

CI, confidence interval; *CL*, central line; *CLABSI*, central line–associated bloodstream infection; *RR*, relative risk.
*Bed days are the total number of days that patients are in the ICU during the selected time period.
†CL days are the total number of days of exposure to CLs by all of the patients in the selected population during the selected time period.
‡DUR: CL days divided by the number of bed days.

Table 2
Central line–associated bloodstream infection rates stratified by length of participation of each intensive care unit

Months since joining INICC	No. of ICUs	CL days	CLABSI	Crude CLABSI rate/1,000 CL days (IDR)	IDR ratio (95% CI)	IDR reduction (%)	*P* value
1-3 mo (baseline)	6	3,032	39	12.9	-	-	-
4-12 mo	6	6,545	69	10.5	0.82 (0.55-1.2)	18	.323
Second year	4	3,686	13	3.5	0.27 (0.14-0.52)	73	.001

CI, confidence interval; *CL*, central line; *CLABSI*, central line–associated bloodstream infection; *ICU*, intensive care unit; *IDR*, incidence density rate; *INICC*, International Nosocomial Infection Control Consortium.

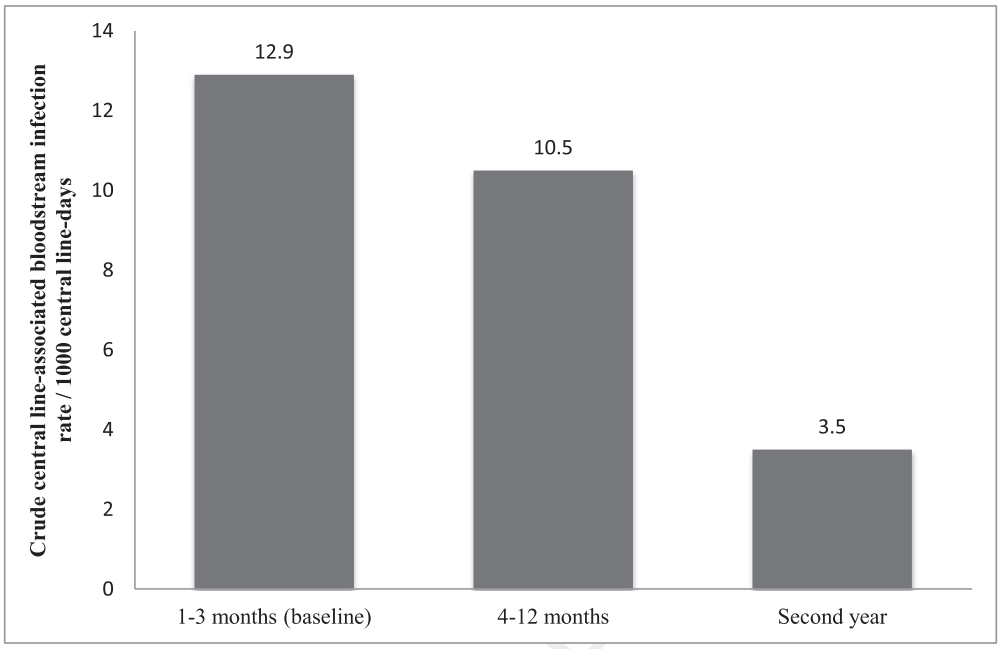

Fig 1. Central line–associated bloodstream infection rate reduction by length of participation of each intensive care unit.

Table 3
Results of the logistic regression model showing the effect of the INICC intervention on the central line–associated bloodstream infection rates

Variables	Coeff (SEM)	Adjusted OR* (95% CI)	*P* value
Period (intervention)	-0.658 (0.231)	0.52 (0.33-0.81)	.00
CL days†‡	0.097 (0.009)	1.10 (1.08-1.12)	.00
Age	-0.014 (0.005)	0.99 (0.98-1.00)	.00

CI, confidence interval; *CL*, central line; *Coeff*, β coefficient of the logistic regression; *INICC*, International Nosocomial Infection Control Consortium; *OR*, odds ratio.
*Adjusted OR for the logistic regression model including the 3 variables in the table.
†CL days is the total number of days of exposure to the central line by all of the patients in the selected population during the selected time period.
‡For a unit increase in the CL days or the age of patients.

Table 4
Microorganisms related to central line–associated bloodstream infection in intensive care units in the baseline and intervention periods

Isolated microorganisms	Baseline	Intervention
Acinetobacter spp	2 (1)	16 (18)
Coagulase-negative *Staphylococcus*	16 (7)	21 (23)
Escherichia coli	2 (1)	11 (12)
Klebsiella pneumoniae	7 (3)	7 (8)
Pseudomonas spp	16 (7)	3 (3)
Staphylococcus aureus	42 (18)	30 (34)
Others*	14 (6)	13 (14)
Total	100 (43)	100 (112)

NOTE. Values are % (n).
*Others refers to the following isolated microorganisms: *Alcaligenes* spp, *Candida* spp, *Citrobacter* spp, *Enterobacter* spp, *Enterococcus* spp, *Haemophilus* spp, *Morganella* spp, *Proteus* spp, *Serratia* spp, and *Stenotrophomonas* spp.

statistically significant improvements most of them, such as more hand hygiene, less DUR, and reduced average length of CL. In addition, compliance with other measures, such as compliance with date on administration set, compliance with placed dressing, and compliance with correct condition of dressing, was high and similar in both phases. Furthermore, patients' characteristics, such as sex and age, were similar during both periods.

The logistic regression analysis showed that the intervention led to a significant reduction in the CLABSI risk, and this relationship was modulated by the number of CL days and the patient's age. Moreover, based on the model's results, the effectiveness of the intervention was nearly 50%, which means there was a significant reduction in the patients' CLABSI risk associated with the INICC method.

One reference from the literature showing a similar reduction was published by Osorio et al, who found that a program based on reduced the incidence of CLABSI from 5.56 CLABSIs per 1,000 CL days to 3.26 per 1,000 CL days.[34] Similarly, it was shown in previous studies performed by the INICC that implementation of a 4- or 6-component multidimensional approach for CLABSI resulted in significant reductions in rates of CLABSI in Argentina (46.63 vs 11.10 CLABSIs per 1,000 CL days, showing a 76% reduction)[19]; in Mexico (46.3 vs 19.5 CLABSIs per 1,000 CL days, showing a 58% reduction)[20]; in Turkey (22.7 vs 12.0 CLABSIs per 1,000 CL days, showing a 47% reduction)[22]; in India (6.4 vs 3.9 CLABSIs per 1,000 CL days, showing a 39% reduction)[21]; in adult ICUs (14.5 vs 9.7 CLABSIs per 1,000 CL days, showing a 33% reduction)[16]; in pediatric ICUs (10.7 vs 5.2 CLABSIs per 1,000 CL days, showing a 51% reduction)[17]; and in neonatal ICUs (21.4 vs 9.7 CLABSIs per 1,000 CL days, showing a 55% reduction).[18]

Regarding the microorganisms profile, we identified a predominance of *S aureus* and coagulase-negative *Staphylococcus*. Olarte et al showed in a previous study in Colombia that *S aureus* is the most frequent microorganism isolated in ICU patients.[35] The increase in the number of isolated *Acinetobacter* spp during the intervention period may be associated with the presence of outbreaks in some of the participating institutions.

Study limitations

The main limitation of this study is that our findings cannot be generalized to all ICU patients from Colombia. However, in this study it was proved that a multidimensional approach is fundamental to fights against the incidence of CLABSIs in the ICU setting.

Second, the setting of a 3-month baseline period may be short and might have overestimated the effect of the intervention. Nevertheless, during the baseline period, the sample size was good enough, and the CIs for the baseline rate were narrow. Third, there may be significant variations in the level of quality control in the ICTs that support each individual hospital, and we could not quantify in detail all the interventions included in our multidimensional approach, such as education and compliance with hand hygiene practice.

CONCLUSIONS

This is the first study to report a substantial reduction in CLABSI rates in the ICU setting of Colombia. The implementation of our multidimensional approach resulted in significant reductions in the CLABSI IDR. These systematically collected data serve as guidance for strategies to improve patient care practices, as demonstrated in several studies conducted in limited-resource countries. These preventive strategies proven effective in the INICC ICUs of Colombia can promote a wider acceptance of infection control programs in hospitals, leading to significant CLABSI rate reduction worldwide.

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