ORIGINAL ARTICLE

# 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

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OBJECTIVE.    To analyze the impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional infection control approach to reduce central line–associated bloodstream infection (CLABSI) rates.

SETTING.    Four neonatal intensive care units (NICUs) of INICC member hospitals from El Salvador, Mexico, Philippines, and Tunisia.

PATIENTS.    A total of 2,241 patients hospitalized in 4 NICUs for 40,045 bed-days.

METHODS.    We conducted a before-after prospective surveillance study. During Phase 1 we performed active surveillance, and during phase 2 the INICC multidimensional infection control approach was implemented, including the following practices: (1) central line care bundle, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of CLABSI rates, and (6) performance feedback of infection control practices. We compared CLABSI rates obtained during the 2 phases. We calculated crude stratified rates, and, using random-effects Poisson regression to allow for clustering by ICU, we calculated the incidence rate ratio (IRR) for each follow-up time period compared with the 3-month baseline.

RESULTS.    During phase 1 we recorded 2,105 CL-days, and during phase 2 we recorded 17,117 CL-days. After implementation of the multidimensional approach, the CLABSI rate decreased by 55%, from 21.4 per 1,000 CL-days during phase 1 to 9.7 per 1,000 CL-days during phase 2 (rate ratio, 0.45 [95% confidence interval, 0.33–0.63]). The IRR was 0.53 during the 4–12-month period and 0.07 during the final period of the study (more than 45 months).

CONCLUSIONS.    Implementation of a multidimensional infection control approach was associated with a significant reduction in CLABSI rates in NICUs.

Central line–associated bloodstream infections (CLABSIs) have long been associated with excess lengths of stay, increased hospital costs, and increased attributable mortality in studies from developed countries[1-5] and, more recently, from the developing world.[6-19] Several studies have highlighted the extreme vulnerability of neonates hospitalized in neonatal intensive care units (NICUs) to attributable mortality due to device-associated healthcare-associated infections (DA-HAI) in developed countries, with rates ranging from 24% in the presurfactant era to 11% in the postsurfactant era.[5,20-22] The burden of CLABSIs in the NICU is not limited to mortality, and studies have found associations between newborn sepsis and adverse consequences in the central nervous system, longer duration of mechanical ventilation, and higher incidence of hepatic fibrosis and chronic lung disease.[22-26] This serious threat to the safety of newborns hospitalized in NICUs has been addressed in a wide number of studies, most from high-income settings, in which it was shown that implementation of infection control programs and practice bundles—including hand hygiene, maximal barriers, skin antisepsis, and timely central line (CL) removal, among

TABLE 1.   Characteristics of Participating Hospitals

|  | NICUs | NICU patients | Period |
|---|---|---|---|
| Country |  |  |  |
| Mexico | 1 | 563 | Oct 2003–June 2005 |
| Philippines | 1 | 217 | Jan 2006–Dec 2009 |
| Salvador | 1 | 1,270 | Jan 2007–Aug 2009 |
| Tunisia | 1 | 191 | Oct 2008–May 2009 |
| Type of hospital |  |  |  |
| Academic teaching | 3 (75) | 1,678 | ... |
| Public hospital | 1 (25) | 563 | ... |

NOTE.   Data are no. or no. (%). NICU, neonatal intensive care unit.

others—were associated with a reduction in the incidence density of CLABSIs.[2,27-28]

The rates determined with implementation of the INICC Surveillance Program showed that the CLABSI incidence density is high in NICUs of developing countries. To progress beyond these findings, we implemented a multidimensional infection control approach that included practice bundles for CLABSI prevention, education, outcome surveillance, process surveillance, and feedback of CLABSI rates as well as performance feedback of infection control practices. In this third part of our study, we report an analysis of the specific impact of this preventive strategy on CLABSI rates in NICUs of developing countries.

METHODS

Setting and Study Design

The study was conducted in 4 NICUs in 4 INICC member hospitals in 4 countries (El Salvador, Mexico, Philippines, and Tunisia) on 3 continents (South America, Africa, and Asia). The INICC surveillance methodology, including the statistical methods used, has been fully described in Rosenthal et al.[29] The study period was from October 2003 to December 2009 and was divided into 2 phases: phase 1 (baseline period; first 3 months of participation of each NICU) and phase 2 (which included all the following months of participation of each NICU). At each hospital there is a microbiology laboratory to provide in vitro susceptibility testing of clinical isolates by standardized methods, as described in US Centers for Disease Control and Prevention (CDC)/National Healthcare Safety Network (NHSN) definitions. However, laboratory testing is uncommon and is frequently avoided in practice in these NICUs in developing countries.[30]

Intervention Period (Phase 2)

The intervention period was initiated after 3 months of participation in the INICC Surveillance Program. The average length of the intervention period was 23.5 months (standard deviation, 16.7; range, 5–48). The INICC multidimensional infection control approach included the following items: (1) bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of CLABSI rates, and (6) performance feedback of infection control practices.

Components of CL Care Bundle for CLABSI

The bundle consisted of the following elements: (1) performance of hand hygiene before CL insertion or manipulation;[31] (2) use of an all-inclusive CL cart or kit;[32] (3) use of maximal sterile barrier precautions during CL insertion;[33] (4) presence of sterile dressing at insertion site;[34,35] (5) good condition of sterile dressing at insertion site;[34,35] (6) disinfection of catheter hubs, needleless connectors, and infection ports before accessing the line;[36,37] and (7) removal of nonessential CLs.[38,39]

Education

Regarding education of healthcare personnel involved in the insertion, care, and maintenance of CLs about CLABSI prevention,[27] infection control practitioners received education on the following practices: (a) performance of direct observation of hand hygiene compliance; (b) placement and condition of sterile gauze or sterile polyurethane dressing on the insertion site;[31,40] (c) gauze dressing replacement every 48 hours and replacement of transparent semipermeable membrane dressings at least every 7 days, with the recording of the date and time of the dressing replacement; and (d) use of structured observation tools at regularly scheduled intervals.[31,41]

INICC Methodology

The INICC Surveillance Program included 2 components: outcome surveillance (DA-HAI rates and their adverse effects, including mortality rates) and process surveillance (adherence to hand hygiene and other basic preventive infection control practices).[42] Investigators were required to complete outcome and process surveillance forms at their hospitals, which were then sent for monthly analysis to the office of the INICC headquarters in Buenos Aires.

Outcome Surveillance

Outcome surveillance was performed applying the definitions for HAIs developed by the CDC for the NHSN program.[30] Additionally, INICC methods were adapted to the limited-

TABLE 2.   Characteristics of Patients Hospitalized in Neonatal Intensive Care Units during Phase 1 (Baseline Period) and Phase 2 (Intervention Period)

|  | Baseline | Intervention | P |
|---|---|---|---|
| No. of months | 3 | 23.5[a] |  |
| No. of patients | 374 | 1,867 |  |
| No. of bed-days | 5,654 | 34,391 |  |
| No. of CL-days | 2,105 | 17,117 |  |
| CL use ratio, mean (95% CI) | 0.37 (0.19–0.21) | 0.50 (0.49–0.50) | .0001 |
| CL duration, mean ± SD, days | 5.63 ± 12.0 | 9.18 ± 20.2 | .0001 |
| Sex, no. (%) |  |  |  |
| Male | 241 (64) | 1,117 (60) | .2587 |
| Female | 133 (36) | 748 (40) | .3983 |
| Weight, mean ± SD, kg | 2.37 ± 0.87 | 2.31 ± 0.84 | .0001 |

NOTE.   CI, confidence interval; CL, central line; SD, standard deviation.
[a] Range, 5–45; SD, 16.7.

resource setting of developing countries because of their different socioeconomic status.[42] Outcome surveillance included rates of CLABSIs (cases per 1,000 CL-days), microorganism profile, bacterial resistance, length of stay, and mortality in NICUs.[42]

## CLABSI Rate Calculation

Outcomes measured during the surveillance period included the incidence density rate of CLABSIs (cases per 1,000 CL-days), which was calculated by dividing the total number of CLABSIs by the total number of CL-days and multiplying the result by 1,000.[42] INICC and CDC methodologies differ in how CL-days are calculated. According to INICC methodology, CL-days are calculated for each CL in situ, which are counted separately when calculating the time at risk. By contrast, according to CDC methodology CL-days are calculated for each day a patient has 1 or more CLs in place. That is, if CDC methodology is applied, a patient with 2 CLs in situ for 1 day will contribute 1 day at risk, whereas if INICC methodology is applied, the patient will contribute 2 CL-days. Occasionally, this can lead to a CL DU ratio of more than 1 in ICUs where patients routinely have more than 1 CL in place.

## Process Surveillance

Process surveillance was designed to assess compliance with easily measurable key infection control practices, such as surveillance of compliance rates for hand hygiene practices and specific measures for the prevention of CLABSIs.[42] The hand hygiene compliance rate was based on the frequency with which hand hygiene was performed as indicated in healthcare worker (HCW) infection control training. Observing infection control practitioners were trained to record hand hygiene opportunities and compliance on a form during randomly selected observation periods of 30 minutes to 1 hour 3 times a week. In particular, the INICC direct observation comprised the My 5 Moments for Hand Hygiene, as recommended by the World Health Organization, which included monitoring of the following moments: (1) before patient contact, (2) before an aseptic task, (3) after body fluid exposure risk, (4) after patient contact, and (5) after contact with patient surroundings.[43] Although HCWs knew that hand hygiene practices were regularly monitored, they were not informed of the schedule for hand hygiene observations.

CL care compliance was also monitored, and data on compliance with CL care measures were recorded 5 days a week on a form that evaluated whether infection control procedures were correctly carried out by the HCW. The infection control practitioner observing the activity in the NICU completed a standardized form that contained the following data: total number of inserted CLs for each patient for the whole ICU; total number of dressings placed to protect the puncture site; total number of dressings, specifying the type of dressing (sterile gauze or transparent dressing) used to protect the puncture site; total number of dressings in correct condition, evaluating whether the dressing was clean, dry, and adhered correctly to the puncture site; and total number of cases in which the dates of insertion were written in the administration set of the patient or the dressing.[42]

## Feedback of DA-HAI Rates

Every month, the INICC research team at the INICC headquarters in Buenos Aires prepared and sent to each infection control team (ICT) a final report on the results of outcome surveillance data sent by investigators at each hospital—that is, monthly DA-HAI rates, length of stay, bacterial profile and resistance, and mortality.[42] Feedback of DA-HAI rates is provided to HCWs working in the NICU by communicating the outcomes of patients. The resulting rates were reviewed by the ICT at monthly meetings, where charts were analyzed. Statistical graphs and visuals were displayed in prominent locations inside the ICU to provide an overview of rates of DA-HAIs. This infection control tool is important to increase awareness about outcomes of patients at their ICU, to enable the ICT and ICU staff to focus on the necessary issues, and

TABLE 3.   Hand Hygiene (HH) and Central Line (CL) Care Improvement during Phase 1 (Baseline Period) and Phase 2 (Intervention Period)

|  | Phase 1 | Phase 2 | RR (95% CI) | P |
|---|---|---|---|---|
| No. of HH opportunities |  |  |  |  |
| All | 669 | 2,262 | ... |  |
| NICU A | 121 | 318 | ... |  |
| NICU B | 505 | 1,090 | ... |  |
| NICU C | 43 | 854 | ... |  |
| HH compliance, % (no.) |  |  |  |  |
| All | 51.4 (344) | 71.5 (1,618) | 1.39 (1.24–1.56) | .0001 |
| NICU A | 60.3 (73) | 60.7 (193) | 1.01 (0.77–1.32) | .9653 |
| NICU B | 45.9 (232) | 57.8 (630) | 1.26 (1.08–1.46) | .0027 |
| NICU C | 90.7 (39) | 93.1 (795) | 1.03 (0.74–1.42) | .8738 |
| No. of observed CL |  |  |  |  |
| All | 2,009 | 20,031 | ... |  |
| NICU A | 1,632 | 18,652 | ... |  |
| NICU B | 325 | 787 | ... |  |
| NICU C | 52 | 592 | ... |  |
| CL with sterile gauze, % (no.) |  |  |  |  |
| All | 70.1 (1,409) | 83.7 (16,771) | 1.19 (1.13–1.26) | .0001 |
| NICU A | 68.6 (1,120) | 83.3 (15,545) | 1.39 (1.31–1.48) | .0001 |
| NICU B | 72.9 (237) | 98.1 (772) | 1.35 (1.16–1.56) | .0001 |
| NICU C | 100.0 (52) | 76.7 (454) | 0.77 (0.58–1.02) | .0690 |
| CL with sterile gauze in good condition, % (no.) |  |  |  |  |
| All | 91.8 (1,845) | 95.7 (19,176) | 1.04 (0.99–1.09) | .0883 |
| NICU A | 95.6 (1,561) | 96.0 (17,902) | 1.15 (1.09–1.21) | .0001 |
| NICU B | 71.4 (232) | 86.9 (684) | 1.22 (1.05–1.41) | .0094 |
| NICU C | 100.0 (52) | 99.7 (590) | 1.00 (0.75–1.32) | .9813 |

NOTE.   CI, confidence interval; NICU, neonatal intensive care unit; RR, relative risk.

to apply specific strategies for improvement of high DA-HAI rates.

### Performance Feedback

Upon processing the hospitals' process surveillance data on a monthly basis, the INICC research team at the INICC headquarters in Buenos Aires prepares and sends to each ICT a final report on the results of process surveillance rates, including compliance with hand hygiene and care of CLs.[42] Performance feedback is provided to HCWs working in the NICU by communicating the assessment of practices routinely performed by them. The resulting rates are reviewed by the ICT at monthly meetings where charts are analyzed, and statistical graphs and visuals are posted inside the ICU to provide an overview of rates measuring compliance with infection control practices. This infection control tool is key to enable the ICT and ICU staff to focus on the necessary strategies for improvement of low compliance rates.

### Definitions

CLABSI is included in the following definitions.
*Laboratory-confirmed CLABSI.* When CLABSI is suspected, the CL is removed aseptically and the distal 5 cm of the catheter is amputated and cultured, using the standardized

semiquantitative method.[44] Concomitant blood cultures are drawn percutaneously in most cases. In each hospital, standard laboratory methods are used to identify microorganisms, and standardized susceptibility testing is performed.

A patient with a CL in place is considered to have a CLABSI when a recognized pathogen is isolated from 1 or more percutaneous blood cultures after 48 hours of catheterization, the pathogen cultured from the blood is not related to an infection at another site, and the patient has 1 or more of the following signs or symptoms: fever (temperature of 38°C or higher), chills, or hypotension. With skin commensals (diphtheroids, *Bacillus* species, *Propionibacterium* species, coagulase-negative staphylococci, or micrococci), the organism must be recovered from 2 or more separate blood cultures.[30]

*Clinically suspected CLABSI.* When either blood cultures are not obtained or no organisms are recovered from blood cultures, there is no apparent infection at another site, and the physician institutes antimicrobial therapy, a patient with a CL in place who has at least 1 of the following clinical signs with no other recognized cause was considered to have clinically suspected CL-associated bloodstream infection: fever (temperature of 38°C or higher), hypotension (systolic blood pressure of 90 mm Hg or lower), or oliguria (20 mL/hour or lower).[45]

TABLE 4. Central Line (CL)–Associated Bloodstream Infection (CLABSI) Rates among Patients Hospitalized in Neonatal Intensive Care Units (NICUs) during Phase 1 (Baseline Period) and Phase 2 (Intervention Period)

|  | Phase 1 | Phase 2 | RR (95% CI) | P |
|---|---|---|---|---|
| No. of CLABSIs |  |  |  |  |
| All | 45 | 166 | ... |  |
| NICU A | 21 | 136 | ... |  |
| NICU B | 19 | 23 | ... |  |
| NICU C | 1 | 4 | ... |  |
| NICU D | 4 | 3 | ... |  |
| No. of CL-days |  |  |  |  |
| All | 2,105 | 17,117 | ... |  |
| NICU A | 1,473 | 14,346 | ... |  |
| NICU B | 399 | 1,663 | ... |  |
| NICU C | 37 | 585 | ... |  |
| NICU D | 196 | 523 | ... |  |
| CLABSI rate, cases per 1,000 CL-days |  |  |  |  |
| All | 21.4 | 9.7 | 0.45 (0.33–0.63) | .0001 |
| NICU A | 14.3 | 9.5 | 0.66 (0.42–1.05) | .0797 |
| NICU B | 47.6 | 13.8 | 0.29 (0.16–0.53) | .0001 |
| NICU C | 27.0 | 6.8 | 0.25 (0.03–2.26) | .1840 |
| NICU D | 20.4 | 5.7 | 0.28 (0.06–1.26) | .0758 |

NOTE. CI, confidence interval; RR, rate ratio.

## Statistical Methods

Patient characteristics during the baseline and intervention periods in each NICU were compared using the Fisher exact test for dichotomous variables and the unmatched Student $t$ test for continuous variables. VCStat (Castiglia) was used to calculate 95% confidence intervals (CIs). Relative risk (RR) ratios with 95% CIs were calculated for comparisons of rates of CLABSIs using Epi Info, version 6 (CDC). Differences with $P$ values less than .05 by 2-sided tests were considered significant. Furthermore, we explored the change in CLABSI rates following an ICU joining the INICC by looking at the follow-up period stratified by 3-month periods over the first year, 6-month periods over the second and third years, and then yearly afterward (to somewhat allow for fewer subjects in ICUs with longer periods of follow-up). We calculated crude stratified rates, and, using random-effects Poisson regression to allow for clustering by ICU, we calculated the incidence rate ratio (IRR) for each follow-up time period compared with the baseline 3 months. Device-days were included in the model as an offset with the coefficient constrained to be 0 (patients with no device use during admission were excluded from these analyses). We performed an additional regression considering "time since ICU joined INICC" as a continuous variable in months and calculated the IRR for reduction in HAIs for each month of follow-up.

## Ethics

Every hospital's institutional review board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it identifiable only to the ICT.

## RESULTS

Over the whole study period, 2,241 patients hospitalized for 40,045 bed-days in 4 NICUs were enrolled, for a total of 19,222 CL-days. The first NICUs to participate in the study began collecting data in October 2003, and the latest data included in this analysis are from December 2009.

The participating hospitals were summarized and classified according to number of NICUs, number of NICU patients per hospital, type of hospital, and country. Most of the patients enrolled were from academic teaching hospitals (75%). All participating hospitals were from developing countries (Table 1).

Sex of patients was similar during the baseline and intervention phases. However, we observed a decrease in the patients' weight mean during phase 2 (from 2.37 to 2.31 kg; $P = .001$). We documented 2,105 CL-days, for a CL use mean of 0.37, during the baseline period and 17,117 CL-days, for a CL use mean of 0.50, during the intervention period (Table 2).

Regarding compliance rates, during this study we were not able to measure hand hygiene compliance and CL compliance of 1 of the participating NICUs. At the remaining 3 NICUs, hand hygiene compliance improved significantly, from 51.4% to 71.5%. Likewise, the presence of catheters with sterile gauze or sterile transparent dressing rose from 70.1% to 83.7% (RR, 1.19 [95% CI, 1.13–1.26]; $P = .0001$; Table 3).

Regarding CLABSI rates, during phase 1 (baseline period) there were 45 CLABSIs, for an overall baseline rate of 21.4 per 1,000 CL-days. During phase 2, after implementation of the multidimensional infection control approach, there were 166 CLABSIs, for an incidence density of 9.7 per 1,000 CL-

TABLE 5.   Central Line (CL)–Associated Bloodstream Infection (CLABSI) Stratified by the Length of Time That Each Unit Has Participated in the International Nosocomial Infection Control Consortium (INICC)

| | ICUs | CL-days | CLABSIs | Crude CLABSI rate, cases per 1,000 CL-days | IRR (95% CI) accounting for clustering by ICU |
|---|---|---|---|---|---|
| Months since joining INICC | | | | | |
|   0–3 (baseline) | 4 | 2,105 | 46 | 21.8 | ... |
|   4–12 | 4 | 6,514 | 72 | 11.1 | 0.53 (0.36–0.78) |
|   13–23 | 2 | 7,445 | 73 | 9.8 | 0.46 (0.31–0.68) |
|   24–35 | 2 | 2,692 | 19 | 7.1 | 0.43 (0.23–0.81) |
|   36–48 | 1 | 466 | 1 | 2.1 | 0.07 (0.01–1.26)[a] |
| Time since joining INICC in months, per month | | | | | 0.96 (0.95–0.98)[b] |

NOTE.   Shown are crude stratified rates determined using random-effects Poisson regression. IRR, incidence rate ratio.
[a] $P = .07$.
[b] $P = .001$.

days. These results showed a CLABSI rate reduction from baseline of 54% (from 21.4 to 9.7 CLABSIs per 1,000 CL-days; RR, 0.45 [95% CI, 0.33–0.63]; Table 4).

The stratified rates and rate ratios demonstrate a steadily reducing trend in CLABSI rates as the time the ICU has participated in the INICC increases (although data in the final time period is quite sparse; Table 5 and Figure 1).

Regarding the microorganism profile, during phase 1 coagulase-negative staphylococci was the most frequently isolated microorganism (28.6%). During phase 2 we observed wide variation in the leading pathogens, which were coagulase-negative staphylococci (25%) and *Enterobacter* species (25%). The percentage of coagulase-negative staphylococci did not change significantly during phase 2 ($P = .8936$; Table 6).

## DISCUSSION

The analysis of our surveillance data during baseline showed a high incidence density of CLABSIs in our NICUs, which



FIGURE 1.   Evolution of central line–associated bloodstream infection rates in each neonatal intensive care unit (NICU).

was reduced by 55% after implementation of the multi-dimensional interventions. All the NICUs enrolled in this study are from countries with lower-middle-income and upper-middle-income economies,[46] whose DA-HAI rates have been reported to be negatively influenced by their limited financial and personnel resources compared with those of hospitals in developed economies.[19]

Patient characteristics, such as sex, remained similar during the whole study period; however, during phase 2 we observed that the mean weight of patients had decreased. This difference in patients' mean weight reinforces the fact that the interventions were effective, because lower weight in neonatal patients has been identified as a risk factor for CLABSI.[5,47]

We found statistically significant improvements in hand hygiene compliance and CL care, particularly in relation to the presence and condition of catheters with sterile gauze or sterile transparent dressing. Similarly, it was shown in a study conducted in NICUs in Senegal that a multidimensional hospital infection control program—which included clustering of nursing care, minimal invasive care, and promotion of early discharge of neonates, among other interventions—was an effective tool in reducing CLABSIs in NICUs of developing countries.[48]

Additionally, we observed an increase in mean CL use, which also strengthens our association between improved infection control practices and reduction in CLABSI rate, because increased use of lines increases the risk that there will be more infections.[49] In a prospective cohort study by Mahieu et al,[49] it was demonstrated that catheter manipulations—particularly disconnection of the central venous catheter, which requires disinfection of the catheter hub—increased the risk of CLABSIs in neonates.

Our multidimensional infection control approach was focused on CLABSI outcome and process surveillance, performance feedback, education, adherence to infection control guidelines, and implementation of a bundle of CL care techniques, which were adopted as a comprehensive but simple and feasible bundle for limited-resource settings. Over recent
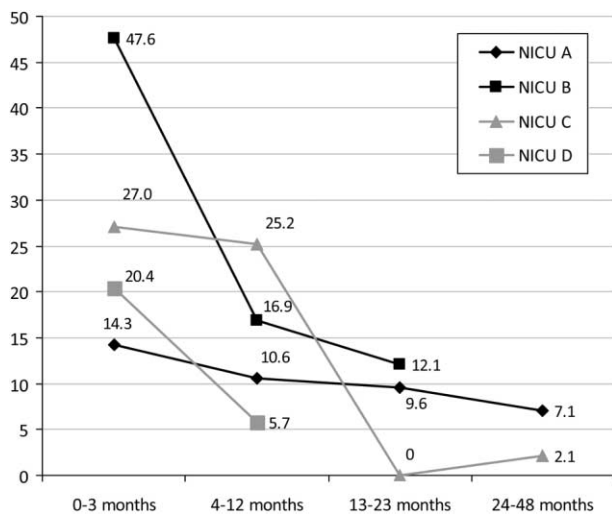
TABLE 6. Microorganisms Related to Central Line–Associated Bloodstream Infections in Neonatal Intensive Care Units during Phase 1 (Baseline Period) and Phase 2 (Intervention Period)

| Isolated microorganism | Phase 1 | Phase 2 | RR (95% CI) | P |
|---|---|---|---|---|
| *Acinetobacter* species | 14.3 (1) | 12.5 (1) | 0.88 (0.05–13.9) | .9247 |
| *Candida* species | 0.0 (0) | 12.5 (1) | ... | .3495 |
| *Escherichia coli* | 14.3 (1) | 12.5 (1) | 0.88 (0.05–13.9) | .9247 |
| *Enterobacter* species | 14.3 (1) | 25.0 (2) | 1.75 (0.16–19.30) | .6434 |
| *Klebsiella* species | 14.3 (1) | 0.0 (0) | ... | .2850 |
| *Staphylococcus aureus* | 14.3 (1) | 0.0 (0) | ... | .2850 |
| Coagulase-negative staphylococci | 28.6 (2) | 25.0 (2) | 0.88 (0.12–6.21) | .8936 |
| *Serratia* species | 0.0 (0) | 12.5 (1) | ... | .3495 |

NOTE. Data are % (no.). CI, confidence interval; RR, rate ratio.

decades, different successful strategies to reduce CLABSIs have been described in the literature,[2,41,50] and in studies performed in the United States it has been shown that a 40% reduction in CLABSI incidence is feasible.[51-53] In a study conducted by the INICC in 15 developing countries, it was shown that after the inception of a strategy that included education, performance feedback, and outcome and process surveillance, there was a cumulative reduction of 54% in the CLABSI rate and of 58% in the mortality rate.[54]

### Study Limitations

Although this study's weakness stems from the fact that its results cannot be generalized to all NICU patients in developing countries, the strength of the study is that it proved that a multidimensional approach, including process and outcome surveillance with a bundle of interventions, is a fundamental tool to understand and fight against the adverse effects of CLABSIs in the NICUs of limited-resource settings. During this study, we were not able to measure hand hygiene compliance and CL compliance of 1 of the participating NICUs. Additionally, we did not measure compliance with all bundle components, and as of January 2012 the INICC multidimensional approach includes the measurement of every element of the bundle.

### Conclusions

Implementation of the multidimensional infection control program for CLABSI prevention showed that the CLABSI rate reduction in our NICUs was related to the effectiveness of our multidimensional strategy. Recognition of CLABSI as a preventable DA-HAI is fundamental to motivating HCWs and effecting cultural changes. However, we consider our rates to also reveal opportunities for improvement, as they are still higher than those in the developed world.[55,56]

We expect that the multidimensional infection control and prevention approach fostered by the INICC will increasingly be carried out in the developing world and will successfully achieve reductions in DA-HAI rates. The INICC provides investigators with free training and methodological tools to perform outcome and process surveillance, and the publi-

cation of the data confidentially collected in the INICC program allows for boosting relevant scientific literature for developing countries. For these reasons, every hospital worldwide is invited to join the INICC network, which was established to respond to the burden of DA-HAIs in limited-resource countries.

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