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Source: *Infection Control and Hospital Epidemiology*, Vol. 27, No. 4 (April 2006), pp. 349-356

Published by: [The University of Chicago Press](#) on behalf of [The Society for Healthcare Epidemiology of America](#)

Stable URL: <http://www.jstor.org/stable/10.1086/503341>

Accessed: 14/05/2014 00:32

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Device-Associated Infection Rate and Mortality in Intensive Care Units of 9 Colombian Hospitals: Findings of the International Nosocomial Infection Control Consortium

Carlos Álvarez Moreno, MD; Victor D. Rosenthal, MD; Narda Olarte, MD; Wilmer Villamil Gomez, MD; Otto Sussmann, MD; Julio Garzon Agudelo, MD; Catherine Rojas, MD; Laline Osorio, RN; Claudia Linares, RN; Alberto Valderrama, RN; Patricia Garrido Mercado, MD; Patrick Hernán Arrieta Bernate, MD; Guillermo Ruiz Vergara, MD; Alberto Marrugo Pertuz, MD; Beatriz Eugenia Mojica, RN; María del Pilar Torres Navarrete, RN; Ana Sofia Alonso Romero, MD; Daibeth Henríquez, MD

OBJECTIVE. To perform active targeted prospective surveillance to measure device-associated infection (DAI) rates, attributable mortality due to DAI, and the microbiological and antibiotic resistance profiles of infecting pathogens at 10 intensive care units (ICUs) in 9 hospitals in Colombia, all of which are members of the International Infection Control Consortium.

METHODS. We conducted prospective surveillance of healthcare-associated infection in 9 hospitals by using the definitions of the US Centers for Disease Control and Prevention National Nosocomial Surveillance System (NNIS). DAI rates were calculated as the number of infections per 100 ICU patients and per 1,000 device-days.

RESULTS. During the 3-year study, 2,172 patients hospitalized in an ICU for an aggregate duration of 14,603 days acquired 266 DAIs, for an overall DAI rate of 12.2%, or 18.2 DAIs per 1,000 patient-days. Central venous catheter (CVC)-related bloodstream infection (BSI) (47.4% of DAIs; 11.3 cases per 1,000 catheter-days) was the most common DAI, followed by ventilator-associated pneumonia (VAP) (32.3% of DAIs; 10.0 cases per 1,000 ventilator-days) and catheter-associated urinary tract infection (CAUTI) (20.3% of DAIs; 4.3 cases per 1,000 catheter-days). Overall, 65.4% of all *Staphylococcus aureus* infections were caused by methicillin-resistant strains; 40.0% of Enterobacteriaceae isolates were resistant to ceftriaxone and 28.3% were resistant to ceftazidime; and 40.0% of *Pseudomonas aeruginosa* isolates were resistant to fluoroquinolones, 50.0% were resistant to ceftazidime, 33.3% were resistant to piperacillin-tazobactam, and 19.0% were resistant to imipenem. The crude unadjusted attributable mortality was 16.9% among patients with VAP (relative risk [RR], 1.93; 95% confidence interval [CI], 1.24-3.00; $P = .002$); 18.5 among those with CVC-associated BSI (RR, 2.02; 95% CI, 1.42-2.87; $P < .001$); and 10.5% among those with CAUTI (RR, 1.58; 95% CI, 0.78-3.18; $P = .19$).

CONCLUSION. The rates of DAI in the Colombian ICUs were lower than those published in some reports from other Latin American countries and were higher than those reported in US ICUs by the NNIS. These data show the need for more-effective infection control interventions in Colombia.

Infect Control Hosp Epidemiol 2006; 27:349-356

In US hospitals, surveillance of healthcare-associated infection (HAI) has become an integral feature of infection control and of quality assurance, especially in hospital settings where the risk of infection is high, such as the intensive care unit (ICU).^{1,2} The Centers for Disease Control and Prevention (CDC) Study of the Efficacy of Nosocomial Infection Control (SENIC) showed the efficacy of surveillance in the prevention of HAI.³ Many countries, such as the United States,¹ Australia,⁴ Canada,⁵ and Germany,⁶ have standardized measures in

place to make institutional surveillance a necessary practice.

An increasing body of literature shows that HAI is a major cause of patient morbidity and mortality in developed countries.⁷ The greatest threat against safety in the ICU is from device-associated infection (DAI),¹¹ particularly ventilator-associated pneumonia (VAP),⁸ central venous catheter (CVC)-related bloodstream infection (BSI),⁹ and catheter-associated urinary tract infection (CAUTI).¹⁰ The protocol for surveillance of HAI has been well standardized by the

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Received August 31, 2005; accepted December 16, 2005; electronically published March 29, 2006.

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CDC National Nosocomial Infection Surveillance (NNIS) system by means of simple, unambiguous definitions for DAI.^{12,13} Targeted surveillance and calculation of rates of DAI per 1,000 device-days allows benchmarking across similar institutions and detection of unique institutional problems in need of additional attention.

Centers in developed countries have performed most of the published studies of ICU-acquired infection that involve standardized definitions.¹⁴⁻¹⁶ A different situation is found in developing countries, where studies provide relatively few data—especially on rates of DAI—that are based on standardized definitions.¹⁷⁻¹⁹

We report initial findings of the International Infection Control Consortium (INICC) surveillance study in Colombian ICUs for the period of 2002-2005. The INICC was founded by one of use (V.D.R.) in 1998, at which time selected hospitals from Latin America began routinely collecting HAI surveillance data with the intention of including the information in an international database. Hospitals participating in the consortium provide general medical and surgical inpatient services to adults and children who require short-term care. The INICC has initially concentrated on assessing the effect of HAI in level 3 hospitals. Standardized protocols have been followed to collect all data from hospitals that have participated to date,^{12,13} and in this report, we focus on DAI in adult ICUs. Our objective was to perform active, targeted, prospective surveillance to measure the rate of DAI, the microbiological and antibiotic resistance profiles of infecting organisms, and the difference in mortality between patients with and patients without DAI in ICUs of Colombian hospitals participating in the INICC.

METHODS

Settings

This study was conducted in 10 Colombian ICUs at 9 hospitals. Each hospital has an infection control team made up of a physician, an infection control practitioner–surveillance nurse, and support personnel; the person responsible for surveillance in each institution had at least 3 years of infection-control experience (Table 1). Each hospital has complete electronic patient records that are available for use by the infection control team. Moreover, each hospital has a clinical microbiology laboratory that tests the *in vitro* susceptibility of clinical isolates by means of standardized methods.²⁰

The study protocol was approved by the institutional review board at each center. Patient confidentiality was protected by coding the recorded information, which could only be identified by the hospital's infection control team.

Infection Control Activities at the Study Sites

Handwashing resources and compliance varied according to hospital and ICU. The frequency of sterile dressing use at CVC insertion sites ranged widely, as well.²¹

Surveillance

An established infection control program was already in place at each center, with the emphasis on surveillance for HAI, handwashing compliance, and the quality-control process for the care of invasive devices. Rates of CVC-associated BSI, CAUTI, and VAP were assessed monthly during the study period, using current CDC NNIS definitions.^{12,13} We defined “extra mortality” as the difference in mortality between patients with and patients without DAI.

Definitions

We used the CDC definitions for nosocomial infection that appeared in a report by Garner et al.¹³ They were as follows.

Symptomatic UTI. Patients received a diagnosis of symptomatic UTI if 1 of 2 criteria were met. According to criterion 1, (a) at least one of the following signs or symptoms must be present with no other recognized cause: fever (temperature, $>38^{\circ}\text{C}$), urinary urgency, high frequency of urination, dysuria, and/or suprapubic tenderness; and (b) results of urine culture must be positive (defined as ≥ 105 microorganisms/mL of urine, with no more than 2 species of microorganisms per patient). According to criterion 2, (a) at least 2 of the following signs or symptoms must be present with no other recognized cause: fever (temperature, $>38^{\circ}\text{C}$), urinary urgency, high frequency of urination, dysuria, and/or suprapubic tenderness; and (b) at least one of the following characteristics must be present: dipstick test positive for leukocyte esterase and/or nitrate, pyuria (defined as a urine specimen with ≥ 10 white blood cells [WBCs]/ mm^3 or ≥ 3 WBCs per high-power field of uncentrifuged urine), detection of organisms in uncentrifuged urine by Gram stain, at least 2 urine cultures positive for the same type of uropathogen (either gram-negative bacteria or *Staphylococcus saprophyticus*, with 102 or more colonies/mL in nonvoided urine specimens), detection of no more than 105 colonies/mL of a single type of uropathogen (either gram-negative bacteria or *S. saprophyticus*) in cultures of urine specimens obtained from patients receiving treatment for a UTI with an effective antimicrobial agent, physician diagnosis of urinary tract infection, and/or physician initiation of appropriate therapy for urinary tract infection.

Laboratory-confirmed BSI. Patients with a CVC in place received a diagnosis of laboratory-confirmed BSI if 1 of 2 criteria were met. According to criterion 1, one or more blood cultures must yield a recognized pathogen that is not related to an infection at another anatomical site. According to criterion 2, (a) at least one of the following signs or symptoms must be present: fever (temperature, $>38^{\circ}\text{C}$), chills, or hypotension; and (b) at least one of the following conditions must be met: growth of a common skin contaminant (eg, diphtheroids, bacilli, propionibacteria, coagulase-negative staphylococci, or micrococci) in 2 or more cultures of blood drawn on separate occasions; growth of a common skin contaminant (eg, diphtheroids, bacilli, propionibacteria, coagulase-nega-

TABLE 1. Characteristics of Hospitals and Patients in a Study of Device-Associated Infection Rates in Colombian Intensive Care Units (ICUs)

Characteristic	Hospital									Overall
	A	B	C	D	E	F	G	H	I	
Hospital										
Type										
Academic teaching (<i>n</i> = 2)	Yes	No	Yes	No	No	No	No	No	No	...
Public (<i>n</i> = 3)	No	No	No	No	No	Yes	No	Yes	Yes	...
Private community (<i>n</i> = 4)	No	Yes	No	Yes	Yes	No	Yes	No	No	...
No. of ICUs	1	1	2	1	1	1	1	1	1	10
Patient										
No. treated	478	154	578	291	239	58	52	26	296	2,172
No. of patient-days of ICU stay	3,878	1,127	3,210	1,497	1,108	542	372	233	2,636	14,603
Male sex, %	58.6	59.1	55.9	44.0	59.0	51.7	40.4	53.8	56.4	55.0

^a Range, 4-30 years.

tive staphylococci, or micrococci) in at least one culture of blood obtained from a patient with an intravascular line and physician initiation of appropriate antimicrobial therapy; and/or a positive result of a blood antigen test (eg, detection of *Haemophilus influenzae*, *Streptococcus pneumoniae*, *Neisseria meningitidis*, or group B streptococci) and the presence of signs and symptoms and positive results of laboratory tests unrelated to an infection at another site.

Clinical sepsis. Patients with a CVC in place received a diagnosis of clinical sepsis if the following 3 criteria were met: (1) at least one of the following clinical signs or symptoms were present with no other recognized cause: fever (temperature, $>38^{\circ}\text{C}$), hypotension (systolic blood pressure, ≤ 90 mm Hg), and/or oliguria (urine production, <20 mL/hour); (2) blood culture was not performed, no organisms or antigens were detected in blood cultures, or no apparent infection was detected at another site; and (3) a physician initiated treatment for sepsis.

Pneumonia. Patients received a diagnosis of pneumonia if the following 3 criteria were met: (1) two or more serial chest radiographs showed persistent infiltrates (new or progressive), consolidation, and/or cavitation; (2) at least one of the following signs and symptoms were present: fever (temperature, $>38^{\circ}\text{C}$) with no other recognized cause, leukopenia (leukocyte count, $<4,000$ WBCs/mm³) or leukocytosis (leukocyte count, $>12,000$ WBCs/mm³), and for adults aged 70 or more years, altered mental status with no other recognized cause; and (3) at least 2 of the following signs and symptoms were present: (a) new onset of purulent sputum, change in character of sputum, increased quantity of respiratory secretions, or increased suctioning requirements; (b) new onset or worsening cough, dyspnea, or tachypnea⁵; (c) rales⁶ or bronchial breath sounds; and (d) worsening gas exchange, such as O₂ desaturation (eg, a ratio of the partial pressure of O₂ to the fraction of inspired O₂ that is 240 or less), increased oxygen requirement, or increased ventilation demand.

Validation, Training, and Reporting

The forms used to collect surveillance data allow for internal validation that is based on new onset of fever, initiation of antibiotic therapy, culture results, or new onset of hypotension during the 48-hour period after admission. Previous studies have shown that these indicators are statistically significant predictors of HAI.²²

At the time of admission, the patients' personal data, demographic characteristics, illness severity score, and type of ICU were recorded. Infection control practitioners involved in surveillance collected data daily on mechanical ventilation, placement of CVCs and urinary catheters, body temperature and presence of fever, blood pressure, antibiotic use, imaging findings, and culture results for each patient admitted to the ICU. If the patient acquired a HAI, the date of onset, site of infection, and infecting microorganisms and their antimicrobial susceptibilities were also recorded.

All principal investigators at each member hospital were trained by the INICC director (V.D.R.). In all cases, telephone and/or e-mail access was available to the institutional investigators. The support team at the consortium headquarters in Buenos Aires, Argentina, answered all inquiries within 24 hours. Every query and response was further checked by the director.

Each participating hospital sent completed surveillance forms to the INICC headquarters on a monthly basis, and the validity of each case was checked against the recorded signs and symptoms of infection, the findings of laboratory and radiographic analyses, and the results of cultures to ensure that the CDC NNIS criteria for DAI were met. Monthly reports were prepared at the consortium headquarters, and they contained charts and tables with data from each health-care institution that showed the global rates of DAI (defined as the number of DAIs per 100 patients, per 1,000 bed-days, and per 1,000 device-days), the microbiological profile of DAI, the attributable mortality of DAI according to infection

TABLE 2. Overall Microbiological and Antibacterial Resistance Profiles of Isolates Recovered From Patients With Device-Associated Infection in 10 Colombian Intensive Care Units

Variable	Percentage (Proportion) of All Isolates Recovered
Isolates ^a	
<i>Acinetobacter</i> organisms	4.5
<i>Alcaligenes</i> organisms	0.6
<i>Candida</i> organisms	5.1
<i>Escherichia coli</i>	14.2
<i>Enterobacter</i> organisms	7.4
Enterococci	2.3
<i>Haemophilus</i> organisms	2.3
<i>Klebsiella</i> organisms	14.8
<i>Proteus</i> organisms	1.1
<i>Pseudomonas aeruginosa</i>	11.4
<i>Staphylococcus aureus</i>	25.6
Coagulase-negative staphylococci	9.7
<i>Serratia</i> organisms	0.6
Streptococci	0.6
Drug resistance, by organism and antibiotic(s)	
<i>S. aureus</i> , methicillin	65.4 (17/26)
Enterobacteriaceae	
Ceftriaxone	40.0 (10/25)
Ceftazidime	28.3 (13/46)
Piperacillin-tazobactam	37.5 (6/16)
<i>P. aeruginosa</i>	
Ciprofloxacin	40.0 (6/15)
Ceftazidime	50.0 (5/10)
Imipenem	19.0 (4/21)
Piperacillin-tazobactam	33.3 (2/6)
Enterococci, vancomycin	0.0

^a The percentage exceeds 100% because of rounding.

type, duration of extra hospital stay due to DAI, handwashing compliance, and CVC and urinary catheter compliance. Monthly reports were sent to each participating hospital.

Culture Techniques

In all cases, standard laboratory methods were used to identify microorganisms, and standardized susceptibility testing was performed.²⁰ For VAP, in most cases, a deep tracheal aspirate from the endotracheal tube was gram-stained and cultured aerobically. For CVC-associated BSI, CVCs were removed aseptically, and the distal 5-cm portion of the catheter was amputated and cultured using a standardized semiquantitative method.²³ Blood cultures, if performed, always involved samples obtained percutaneously. For CAUTI, a urine sample was aseptically aspirated from the sampling port of a urinary catheter and cultured quantitatively.

Statistical Analysis

EpiInfo, version 6.04b (CDC), was used for data analysis. The rate of device use were calculated by dividing the total number

of device-days by the total number of patient-days. Rates of VAP, catheter-associated BSI, and CAUTI per 1,000 device-days were calculated by dividing the total number of infections by the total number of specific device-days and multiplying the result by 1,000.¹²

RESULTS

Facility Characteristics

During the 3-year study in Colombia, 9 hospitals with 10 ICUs provided prospectively collected surveillance data on 2172 ICU patients hospitalized for 14,603 ICU-days. A total of 266 cases of DAI were reported, with an overall rate of 12.2% and 18.2 infections per 1,000 ICU-days. Three (33.3%) of the participating hospitals were municipally supported public hospitals, 4 (44.4%) were private health care services, and 2 (22.2%) were university-affiliated teaching hospitals. All ICUs in the study were medical-surgical units. Characteristics of individual ICUs, numbers of patients enrolled, and total ICU-days are shown in Table 1.

Device Use and Global Data on Healthcare-Associated Infections

Device use. The rate of device use ranged widely among the ICUs. For mechanical ventilation, the ratio of the number of device-days to the number of patient-days was 0.40-0.76 (mean, 0.59); for CVCs, 0.40-0.95 (mean, 0.76); and for urinary catheters, 0.71-0.95 (mean, 0.85). CVC-associated BSIs represented 47.4% of all device-associated infections, VAP represented 32.3%, and CAUTI represented 20.3%. Mean data on the type of and antibiotic resistance in microorganisms recovered during the study period are shown in Table 2.

VAP. Rates of VAP also ranged widely among ICUs, from 4.7 to 27.5 cases per 1,000 ventilator-days (overall, 10.0 cases per 1,000 ventilator-days) (Table 3). A total of 21.6% of VAPs were caused by *Pseudomonas* organisms, of which 66.7% of isolates were resistant to ciprofloxacin, 50.0% to ceftazidime, and 12.5% to imipenem; 2.7% were caused by *Acinetobacter* organisms; 29.7% were caused by *Staphylococcus aureus*, of which 55.8% of isolates were resistant to methicillin; and 46% were caused by Enterobacteriaceae, of which 22.2% of isolates were resistant to ceftriaxone, 16.7% to ceftazidime, and 33.3% to piperacillin-tazobactam. The crude mortality among patients with VAP was 35.0%, and the extra mortality was 16.9% (relative risk [RR], 1.93; 95% confidence interval [CI], 1.24-3.00; $P = .002$) (Table 4).

CVC-associated BSI. Rates of CVC-associated BSI ranged from 0.0 to 20.3 per 1,000 CVC-days (overall, 11.3 per 1,000 CVC-days) (Table 3). A total of 37.2% of BSIs were caused by *S. aureus*, of which 70.6% of isolates were resistant to methicillin; 7.0% were caused by *Acinetobacter* species; 5.8% were caused by *Pseudomonas* organisms, of which 20.0% of isolates were resistant to imipenem; 15.1% were caused by coagulase-negative staphylococci; and 2.3% were caused by *Candida* organisms. The remaining BSIs were caused by En-

TABLE 3. Primary Types of Device-Associated Infection (DAI) Detected in 10 Colombian Intensive Care Units

DAI Type	Value
Ventilator-associated pneumonia	
Total no. of cases	86
No. of cases per 100 patients (total no. of patients)	4.0 (2,172)
No. of cases per 1,000 ventilator-days (total no. of ventilator-days)	10.0 (8,593)
CVC-associated BSI	
Total no. of cases	126
No. of cases per 100 patients (total no. of patients)	5.8 (2,172)
No. of cases per 1,000 CVC-days (total no. of CVC-days)	11.3 (11,110)
Catheter-associated UTI	
Total no. of cases	54
No. of cases per 100 patients (total no. of patients)	2.5 (2,172)
No. of cases per 1,000 catheter-days (total no. of catheter days)	4.3 (12,433)

NOTE. BSI = blood stream infection; CVC = central venous catheter; UTI = urinary tract infection.

terobacteriaceae, of which 20.0% of isolates were resistant to ceftriaxone, and 21.4% were resistant to ceftazidime. The crude mortality among patients with CVC-associated BSI was 36.6%, with an extra mortality of 18.5% (RR, 2.02; 95% CI, 1.42-2.87; $P < .001$) (Table 4).

CAUTI. Rates of CAUTI also ranged widely in the ICUs, from 0.0 to 23.8 cases per 1,000 catheter-days (overall, 4.3 per 1,000 catheter-days) (Table 3). A total of 14.0% of CAUTIs were caused by *Pseudomonas* organisms, of which 66.7% of isolates were resistant to ciprofloxacin, 60.0% were resistant to ceftazidime, and 14.3% were resistant to imipenem; 2.3% were caused by *Acinetobacter* species; 4.7% were caused by coagulase-negative staphylococci; and 16.3% were caused by *Candida* organisms. The other CAUTIs were caused by Enterobacteriaceae, of which 42.9% of isolates were resistant to ceftriaxone, and 31.3% were resistant to ceftazidime. Crude mortality among patients with CAUTI was 28.6%, with an extra mortality of 10.5% (RR, 1.58; 95% CI, 0.78-3.18; $P = .19$) (Table 4).

DISCUSSION

This is the first multicenter study of DAI in Colombian ICUs. HAIs have been associated with significant patient morbidity and attributable mortality.^{7,24-27} HAIs have also contributed

to increased healthcare costs.^{7,9,10,26,28-31} However, the incidence of HAIs can be reduced by as much as 30%, which may therefore lead to a reduction in healthcare costs, as has been shown in studies performed in US hospitals with an integrated infection control program that includes targeted surveillance for DAI.³

We decided to concentrate the INICC's first efforts on surveillance in the ICU, a hospital setting associated with substantial use of invasive devices and the highest institutional HAI rates. Although device use in the 10 INICC-affiliated Colombian ICUs investigated in this study was remarkably similar to that reported for US ICUs by the NNIS,¹ we found that DAI rates were much higher (Table 5): the overall rate of CVC-associated BSI in the 10 Colombian ICUs was 11.3 cases per 1,000 CVC-days, which is almost 3 times that reported for comparable US ICUs by the NNIS (3.4 cases per 1,000 CVC-days). The overall rate of VAP among the 10 Colombian ICUs was also higher than that among US ICUs (10.0 vs 5.1 cases per 1,000 ventilator-days), and the overall rate of CAUTI was similar between Colombian and US ICUs (4.3 vs 3.3 cases per 1,000 catheter-days).

Notwithstanding the foregoing comparison, the rates we observed are lower than those reported in much smaller earlier studies from other Latin American countries: in one Bra-

TABLE 4. Mortality Associated With Device-Associated Infection (DAI) in 10 Colombian Intensive Care Units (ICUs)

DAI Type	Crude Mortality	Extra Mortality ^a	Relative Risk (95% CI)	P
None	18.1	...	1.0	
Ventilator-associated pneumonia	35.0	16.9	1.93 (1.24-3.00)	.003
CVC-associated BSI	36.6	18.5	2.02 (1.42-2.87)	<.001
Catheter-associated UTI	28.6	10.5	1.58 (0.78-3.18)	.199

NOTE. BSI = bloodstream infection; CI = confidence interval; CVC = central venous catheter; UTI = urinary tract infection.

^a Defined as the difference in mortality between patients with and patients without DAI.

TABLE 5. Comparison of Rates of Device Use and of Device-Associated Infection Between Intensive Care Units (ICUs) in the United States and Colombia

Variable	US ICUs, 1992-2004 ^a	Colombian ICUs, 2002-2005	Relative Risk
Device use rate, no. of device-days divided by no. of patient-days			
Mechanical ventilator	0.35; 0.43	0.59	1.37
Central venous catheter	0.49; 0.56	0.76	1.35
Urinary catheter	0.78; 0.82	0.85	1.03
Infection rate, no. of cases per 1,000 device-days			
Ventilator-associated pneumonia	4.6; 5.1	10.0	1.96
CVC-associated bloodstream infection	3.1; 3.4	11.3	3.32
Catheter-associated urinary tract infection	3.1; 3.3	4.3	1.30
Prevalence of antibiotic resistance among isolates			
<i>Staphylococcus aureus</i> , % resistant to methicillin	48.1	65.4	0.75
Enterobacteriaceae, % resistant to ceftriaxone	17.8	40.0	2.08
Enterococci, % resistant to vancomycin	13.6	0.0	...

NOTE. Data for US ICUs are from the National Nosocomial Infection Surveillance System.¹ CVC = central venous catheter.

^a Unless otherwise indicated, data are fiftieth percentile for US community hospitals (*left*) and fiftieth percentile for teaching hospitals (*right*).

zilian hospital, the BSI rate was 32 cases per 1,000 CVC-days, and the VAP rate was 42 cases per 1,000 ventilator-days.³² In a Mexican hospital, the rates of nosocomial VAP and bacteremia and/or sepsis were 28 and 26 cases per 1,000 device-days, respectively.³³ It is particularly noteworthy that the rates we report occurred in some of the most preeminent medical centers in Colombia, each of which had already shown a commitment to HAI control by establishing an active infection control program. There are a number of possible explanations for the higher rates of DAI that appear to be representative of ICUs in developing countries, some of which have been suggested elsewhere.³³⁻³⁵ First, in 1979, the recommendation to establish infection control committees was published by the Colombian government. National infection control guidelines were not published until July 2004, when the secretary of health in Bogota (the capital of Colombia) published them. Second, hospital accreditation is not yet mandatory. Third, hand hygiene compliance among staff at most centers is highly variable.²¹ Fourth, some of the participating hospitals have limited funds and resources for infection control, and nurse-to-patient staffing ratios are lower, on average, than those in most North American ICUs. A powerful association between the risk of infection and both lower ratios of nurses to patients and higher ratios of inexperienced nurses to experienced nurses has been shown in studies of device-associated infection in US ICUs.³⁶⁻³⁹ Finally, we firmly believe that the use of antiquated technology may also be a factor underlying the high rates of DAI in the consortium ICUs.

The first step toward reducing the risk of HAI among hospitalized patients involves surveillance for these infections.³ The

next step is to adopt basic infection control practices that have proved to be effective for preventing HAIs.⁴⁰⁻⁴²

We believe that knowledge of the significance of the problem of device-associated HAIs in the INICC-affiliated Colombian ICUs will provide the stimulus for instituting change. Moreover, we have already shown that positive change is taking place: implementation of performance feedback programs for hand washing and for CVC and urinary catheter care have substantially reduced the incidence of CVC-associated BSIs, CAUTIs, and nosocomial pneumonia in several of the INICC-affiliated hospitals in different countries.^{24,43-48}

Application of different infection control methods through the INICC initiative resulted in significant improvements in the rates of different types of infection. A reduction in the rate of HAI was associated with a 32% reduction in mortality in an adult ICU in Mexico.²⁴ Elsewhere, the following reductions were observed: a 41% overall reduction of DAI in an adult ICU in Argentina⁴³; a 62% overall reduction of DAI in a neonatal ICU in Mexico⁴⁹; a 58% reduction of CVC-associated BSI in an adult ICU in Mexico²⁴; a 75% reduction of CVC-associated BSI in a neonatal ICU in Mexico⁴⁹; a 50% reduction of IVD-BSI in an adult ICUs in Brazil⁵⁰; an 89% reduction of IVD-BSI in a neonatal ICU in Colombia²¹; a 75% reduction of CVC-associated BSI in an adult ICU in Argentina⁴⁴; a 64% reduction of CVC-associated BSI in an adult ICU in Argentina⁴⁶; a 31% reduction of VAP in an adult ICU in Argentina⁴⁸; and a 42% reduction of CAUTI in an adult ICU in Argentina.⁴⁷ Comparable data have been reported from other hospitals in developing countries.^{51,52} In an Argentine hospital, after all new personnel were taught about the high risk of infection associated with certain procedures and about the consensus guide-

lines developed by physicians and nurses concerning proper handwashing, handling of infants, care of intravenous lines, and endotracheal suctioning, the rate of nosocomial bacteremia decreased from 20.0 to 12.4 cases per 1,000 patient-days within one year ($P < .003$).⁵¹

In a study of antibiotic resistance in gram-positive bacteria recovered Colombian hospitals, Arias et al.⁵³ found that 49.6% of the isolates were *S. aureus*, 29.6% were coagulase-negative staphylococci, and 20.8% were enterococci. All staphylococci were susceptible to vancomycin, teicoplanin, and linezolid, and oxacillin resistance was observed in 52% of *S. aureus* isolates and 73% of coagulase-negative staphylococci. Among enterococci, Arias et al.⁵³ reported that resistance to glycopeptides was detected in 9.7% of isolates, and 58.3% and 41.7% of isolates carried the *vanA* and *vanB* genes, respectively. In addition, they reported rates of resistance among enterococci of 9.7% for ampicillin, 27.4% for ciprofloxacin, 8.9% for chloramphenicol, 43% for rifampicin, 17% for high concentrations of gentamicin, and 28.2% for high concentrations of streptomycin, and all enterococci were determined to be susceptible to linezolid.⁵³

The overall frequency of resistance to methicillin among *S. aureus* isolates in our study was comparable to that in the NNIS report (65.4% vs 48.1%). We observed a greater frequency of ceftriaxone resistance among Enterobacteriaceae (40.0% vs 17.8%) and fluoroquinolone resistance among *P. aeruginosa* (40.0% vs 29.1%), compared with the NNIS (Table 5).

With regard to mortality, to our knowledge, no previous data on HAI-associated mortality have been reported from Colombia.

One limitation in the design of our study that deserves mention is our reliance on the mean illness severity score as an enrollment criterion, because we could not use more-sophisticated severity-of-illness scoring systems, such as the Acute Physiology and Chronic Health Evaluation score, the Simplified Acute Physiology score, and the Mortality Probability Models scoring system.⁵⁴ This may have limited our ability to detect subtle differences in group-level severity of illness that could have biased our study results.

We expect that the initial successes of the INICC, together with present and future efforts to initiate simple and inexpensive preventive measures, will result in widespread acceptance of infection control practices among all INICC hospitals and reductions in all types of DAIs. Control of antibiotic resistance will require more restrictive use of anti-infective agents and more effective control of HAI.⁵⁵

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