

ORIGINAL ARTICLE

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

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q1 OBJECTIVE. To perform active targeted prospective surveillance to measure device-associated infection (DAI) rates, attributable mortality
q2 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.

q3 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
q4 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 Columbian 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.

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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
q5 Canada,⁵ and Germany,⁶ have standardized measures in place to make institutional surveillance a common 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 CDC National
Nosocomial Infection Surveillance (NNIS) system by means of simple, unambiguous definitions for DAI.^{12,13} Targeted sur-

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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 |
| Length of experience of infection control practitioner, years | | | | | | | | | | |
| | 8 | 5 | 8 | 15 | 4 | 4 | 30 | 4 | 5 | ... ^a |
| 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.

veillance 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 sur-

veillance 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°C), urinary urgency, high frequency of urination, dysuria, and/or suprapubic tenderness; and (b) results of urine culture must be positive (defined as ≥105 microor-

ganisms/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-negative 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 pro-

gressive), 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/ mm^3) or leukocytosis (leukocyte count, $>12,000$ WBCs/ mm^3), 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 O_2 desaturation (eg, a ratio of the partial pressure of O_2 to the fraction of inspired O_2 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 hospital location were recorded. Infection control practitioners involved in surveillance collected data daily on mechanical ventilation, placement of CVCs and urinary catheters, 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 type, duration of extra hospital stay due to DAI, handwashing compliance, and CVC and urinary catheter compliance.

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

Monthly reports were sent to each participating hospital.

Culture Techniques

q17 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 Columbia, 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 (overall, 0.59); for CVCs, 0.40-0.95 (overall, 0.76); and for urinary catheters, 0.71-0.95 (overall, 0.85). CVC-associated BSIs represented 47.4% of all device-associated infections, VAP represented 32.3%, and CAUTI represented 20.3%. Overall data on the type of and antibiotic resistance in microorganisms recovered during the study period are shown in Table 2.

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TABLE 3. Primary Types of Device-Associated Infection (DAI) Detected in 10 Columbian 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.

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 Enterobacteriaceae, 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, 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 Brazilian 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

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 Columbia

| Variable | US ICUs, 1992-2004 ^a | Columbian 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*).

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 guidelines 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 our study, microbiological analysis revealed that *Pseudomonas* organisms were responsible for 21.6% of VAP cases, 5.8% of CVC-associated BSIs, and 14.0% of CAUTIs; *Acinetobacter* organisms were responsible for 2.7% of VAP cases, 7.0% of CVC-associated BSIs, and 2.3% of CAUTIs; *S. aureus* isolates were responsible for 29.7% of VAP cases and 37.2% of CVC-associated BSIs; and *Candida* organisms were responsible for 2.3% of CVC-associated BSIs and 16.3% of CAUTIs.

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.

q30

One important 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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REFERENCES

1. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004; 32:470-485.
2. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in coronary care units in the United States. National Nosocomial Infections Surveillance System. *Am J Cardiol* 1998; 82:789-793.
3. Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. *Chemotherapy* 1988; 34: 553-561.
4. Reed CS, Gorrie G, Spelman D. Hospital infection control in Australia. *J Hosp Infect* 2003; 54:267-271.
5. Cook DJ, Walter SD, Cook RJ, et al. Incidence of and risk factors for ventilator-associated pneumonia in critically ill patients. *Ann Intern Med* 1998; 129:433-440.
6. Gastmeier P, Hentschel J, de Veer I, Obladen M, Ruden H. Device-associated nosocomial infection surveillance in neonatal intensive care using specified criteria for neonates. *J Hosp Infect* 1998; 38:51-60.
7. Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996; 17:552-557.
8. Fagon JY, Chastre J, Vuagnat A, Trouillet JL, Novara A, Gibert C. Nosocomial pneumonia and mortality among patients in intensive care units. *JAMA* 1996; 275:866-869.
9. Digiovine B, Chenoweth C, Watts C, Higgins M. The attributable mortality and costs of primary nosocomial bloodstream infections in the intensive care unit. *Am J Respir Crit Care Med* 1999; 160:976-981.
10. Tambyah PA, Knasinski V, Maki DG. The direct costs of nosocomial catheter-associated urinary tract infection in the era of managed care. *Infect Control Hosp Epidemiol* 2002; 23:27-31.
11. Fagon JY, Novara A, Stephan F, Girou E, Safar M. Mortality attributable to nosocomial infections in the ICU. *Infect Control Hosp Epidemiol* 1994; 15:428-434.
12. Emori TG, Culver DH, Horan TC, et al. National nosocomial infections surveillance system (NNIS): description of surveillance methods. *Am J Infect Control* 1991; 19:19-35.
13. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. *Am J Infect Control* 1988; 16:128-140.
14. Vincent JL, Bihari DJ, Suter PM, et al. The prevalence of nosocomial infection in intensive care units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. *JAMA* 1995; 274:639-644.
15. Pittet D, Thievent B, Wenzel R, Li N, Auckenthaler R, Suter P. Bedside prediction of mortality from bacteremic sepsis. A dynamic analysis of ICU patients. *Am J Respir Crit Care Med* 1996; 153:684-693.
16. Safdar N, Crnich CJ, Maki DG. Nosocomial Infections in the Intensive Care Unit Associated with Invasive Medical Devices. *Curr Infect Dis Rep* 2001; 3:487-495.
17. Diener JR, Coutinho MS, Zoccoli CM. Central venous catheter-related infections in critically ill patients. *Rev Assoc Med Bras* 1996; 42:205-214.
18. Velasco E, Thuler LC, Martins CA, Dias LM, Goncalves VM. Nosocomial infections in an oncology intensive care unit. *Am J Infect Control* 1997; 25:458-462.
19. Mittal N, Nair D, Gupta N, et al. Outbreak of *Acinetobacter* spp septicemia in a neonatal ICU. *Southeast Asian J Trop Med Public Health* 2003; 34:365-366.
20. Villanova P. *Minimum Inhibitory Concentration Interpretive Standards*. National Committee for Clinical Laboratory Standards; 1997. Document M7-A4.
21. Villamil Gómez W, Ruiz Vergara G, Marrugo Pertuz A, Rosenthal VD. Education and performance feedback effect on rates of central vascular catheter-associated bloodstream infections in new born intensive care units in a private hospital of Sucre, Colombia. In: Program and abstracts of the Association for Professional in Infection Control and Epidemiology 2005 Annual Conference; June 19-23, 2005; Baltimore, MD.
22. Freeman R. Predictors for infection following open-heart surgery. *J Hosp Infect* 1991; 18(Suppl):299-307.
23. Maki DG, Weise CE, Sarafin HW. A semiquantitative culture method for identifying intravenous-catheter-related infection. *N Engl J Med* 1977; 296:1305-1309.
24. Higuera F, Rosenthal VD, Duarte P, Ruiz J, Franco G, Safdar N. The effect of process control on the incidence of central venous catheter-

q31

- associated bloodstream infections and mortality in intensive care units in Mexico. *Crit Care Med* 2005; 33:2022-2027.
25. Pittet D. Nosocomial pneumonia: incidence, morbidity and mortality in the intubated-ventilated patient. *Schweiz Med Wochenschr* 1994; 124:227-235.
 26. Rosenthal VD, Guzman S, Migone O, Crnich CJ. The attributable cost, length of hospital stay, and mortality of central line-associated bloodstream infection in intensive care departments in Argentina: a prospective, matched analysis. *Am J Infect Control* 2003; 31:475-480.
 27. Rosenthal VD, Guzman S, Orellano PW, Safdar N. Nosocomial infections in medical-surgical intensive care units in Argentina: attributable mortality and length of stay. *Am J Infect Control* 2003; 31:291-295.
 28. Orsi GB, Di Stefano L, Noah N. Hospital-acquired, laboratory-confirmed bloodstream infection: increased hospital stay and direct costs. *Infect Control Hosp Epidemiol* 2002; 23:190-197.
 29. Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. *JAMA* 1994; 271:1598-1601.
 30. Rosenthal VD, Guzman S, Migone O, Safdar N. The attributable cost and length of hospital stay because of nosocomial pneumonia in intensive care units in 3 hospitals in Argentina: a prospective, matched analysis. *Am J Infect Control* 2005; 33:157-161.
 - q32 31. Francisco Higuera MR-F, Rosenthal VD, Castanon J, et al. The attributable cost, and length of hospital stay of central line associated blood stream infection in intensive care units in Mexico: a prospective, matched analysis. In: Program and abstracts of the 15th Annual Society for Healthcare Epidemiology of America; April 9-12, 2005; Los Angeles, CA; 2005.
 32. Lopes JM, Tonelli E, Lamounier JA, et al. Prospective surveillance applying the national nosocomial infection surveillance methods in a Brazilian pediatric public hospital. *Am J Infect Control* 2002; 30:1-7.
 33. Martinez-Aguilar G, Anaya-Arriaga MC, Avila-Figueroa C. Incidence of nosocomial bacteremia and pneumonia in pediatric unit. *Salud Publica Mex* 2001; 43:515-523.
 34. Rezende EM, Couto BR, Starling CE, Modena CM. Prevalence of nosocomial infections in general hospitals in Belo Horizonte. *Infect Control Hosp Epidemiol* 1998; 19:872-876.
 35. Tinoco JC, Salvador-Moysen J, Perez-Prado MC, Santillan-Martinez G, Salcido-Gutierrez L. Epidemiology of nosocomial infections in a second level hospital. *Salud Publica Mex* 1997; 39:25-31.
 36. Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. *Infect Control Hosp Epidemiol* 1996; 17:150-158.
 37. Archibald LK, Manning ML, Bell LM, Banerjee S, Jarvis WR. Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric cardiac intensive care unit. *Pediatr Infect Dis J* 1997; 16:1045-1048.
 38. Harbarth S, Sudre P, Dharan S, Cadenas M, Pittet D. Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding, and poor hygiene practices. *Infect Control Hosp Epidemiol* 1999; 20:598-603.
 39. Hugonnet S, Harbarth S, Sax H, Duncan RA, Pittet D. Nursing resources: a major determinant of nosocomial infection? *Curr Opin Infect Dis* 2004; 17:329-333.
 40. Guidelines for prevention of nosocomial pneumonia. Centers for Disease Control and Prevention. *MMWR Recomm Rep* 1997;46(RR-1):1-79.
 41. O'Grady N P, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control* 2002; 30:476-489.
 42. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Am J Infect Control* 2002; 30:1-46.
 43. Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. *Am J Infect Control* 2005; 33:392-397.
 44. Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device-associated bloodstream infections in intensive care units in Argentina. *Am J Infect Control* 2003; 31:405-409.
 45. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003; 31:85-92.
 46. Rosenthal VD, Maki DG. Prospective study of the impact of open and closed infusion systems on rates of central venous catheter-associated bacteremia. *Am J Infect Control* 2004; 32:135-141.
 47. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. *Infect Control Hosp Epidemiol* 2004; 25:47-50.
 48. Rosenthal VD, Guzman S, Crnich C. Impact of an infection control program on rates of ventilator-associated pneumonia in intensive care units in two Argentinean hospitals. *Am J Infect Control* 2005.
 49. Sobreyra Oropeza M, Herrera Bravo M, Rosenthal VD. Nosocomial Infection global rates and central vascular catheter-associated bloodstream infections rates reduction in a new born intensive care unit of one Mexican public hospital. In: Program and abstracts of the 15th Annual Society for Healthcare Epidemiology of America; April 9-12, 2005; Los Angeles, CA; 2005.
 50. Salomao R, Blecher S, Maretti da Silva MA, Vilins M, Hilário da Silva E, Rosenthal VD. Education and performance feedback effect on rates of central vascular catheter-associated bloodstream infections in adult intensive care units of one Brazilian hospital of Sao Paulo. In: Program and abstracts of the Association for Professional in Infection Control and Epidemiology 2005 Annual Conference; June 19-23, 2005; Baltimore, MD.
 51. Kurlat I, Corral G, Oliveira F, Farinella G, Alvarez E. Infection control strategies in a neonatal intensive care unit in Argentina. *J Hosp Infect* 1998; 40:149-154.
 52. Berg DE, Hershov RC, Ramirez CA, Weinstein RA. Control of nosocomial infections in an intensive care unit in Guatemala City. *Clin Infect Dis* 1995; 21:588-593.
 53. Arias CA, Reyes J, Zuniga M, et al. Multicentre surveillance of antimicrobial resistance in enterococci and staphylococci from Colombian hospitals, 2001-2002. *J Antimicrob Chemother* 2003; 51:59-68.
 54. Lemeshow S, Le Gall JR. Modeling the severity of illness of ICU patients: a systems update. *JAMA* 1994; 272:1049-1055.
 55. Safdar N, Maki DG. The commonality of risk factors for nosocomial colonization and infection with antimicrobial-resistant *Staphylococcus aureus*, *Enterococcus*, gram-negative bacilli, *Clostridium difficile*, and *Candida*. *Ann Intern Med* 2002; 136:834-844.