

CONCISE REPORT

Device-associated infection rates, bacterial resistance, length of stay, and mortality in intensive care units of Costa Rica: Findings of the International Nosocomial Infection Control Consortium (INICC)

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ABSTRACT

Objective: To report the results of the International Nosocomial Infection Control Consortium (INICC) study conducted in Costa Rica from April 2007 to April 2015.

Methods: A device-associated healthcare-acquired infection (DA-HAI) prospective surveillance study in two adult intensive care units (ICUs) from two hospitals applying CDC/NHSN's criteria and definitions, using INICC Online Surveillance System.

Results: Data was collected from 1,128 adult ICU patients over 4,055 bed-days. The central line-associated bloodstream infection (CLABSI) rate was 2.9 per 1,000 central line (CL)-days, the ventilator-associated pneumonia (VAP) rate was 30.7 per 1,000 mechanical ventilator (MV)-days, and the catheter-associated urinary tract infection (CAUTI) rate was 1.5 per 1,000 urinary catheter (UC)-days. The CLABSI rate was similar to INICC rates (4.9) and higher than CDC/NHSN rates (0.8), with a higher CL device utilization ratio (DUR). The CAUTI rate was lower than INICC's (5.3) and similar to CDC/NHSN's (1.3), with a lower UC DUR. Despite the VAP rate being higher than INICC (16.5) and CDC/NHSN's rates (1.1), MV DUR was lower in this study's ICUs.

Resistance rates of *S. aureus* to oxacillin and of *E. coli* to imipenem and meropenem were higher than INICC and CDC/NHSN's rates.

Excess length of stay was 11.2 days for patients with CLABSI and 13.6 for patients with VAP. Excess crude mortality was 25.6% for patients with VAP.

Conclusions: Most DA-HAI rates found in this study's ICUs are higher than CDC/NHSN's rates and similar to or higher than INICC rates.

KEY WORDS

Hospital infection; device-associated infection; antibiotic resistance; ventilator-associated pneumonia; catheter-associated urinary tract infection; central line-associated bloodstream infections.

INTRODUCTION

Device-associated healthcare-acquired infections (DA-HAIs) are among the primary threats to patient safety in the intensive care unit (ICU), and are responsible for substantial patient morbidity and mortality (1). Comprehensive infection control programs focused on DA-HAI surveillance have had effective results, as demonstrated in different studies conducted in the U.S. that stated the incidence of DA-HAI can be reduced by as much as 30%, and that a parallel reduction in healthcare costs was also possible (2).

In the same way, it is essential to address the burden of antimicrobial-resistant infections and report pathogens and susceptibility to antimicrobials of DA-HAI-associated pathogens, so that informed decisions can be made to effectively prevent transmission of resistant strains and their determinants, such as strains with phenotypes with very few available treatments with chances of success (3).

In the U.S., the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC/NHSN) (4) has provided benchmarking U.S. ICU data on DA-HAIs, which have

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proven invaluable for researchers during more than 40 years, and served as an inspiration to the International Nosocomial Infection Control Consortium (INICC)(5).

Founded in Argentina in 1998, the INICC is an international non-profit, open, multi-centre, collaborative healthcare-associated infection control network with a surveillance system based on that of the CDC/NHSN (6). INICC is the first multinational surveillance and research network established to measure, control and reduce DA-HAI, and surgical site infections (SSIs) hospital wide through the analysis of data collected on a voluntary basis by a pool of hospitals worldwide (7, 8).

The INICC has the following goals: to create a dynamic global network of hospitals worldwide and conduct surveillance of DA-HAIs and SSIs using standardized CDC/NHSN definitions and established methodologies, to carry out applied infection control research and promote the implementation of evidence-based infection control practices; to provide surveillance tools and training to individual hospitals to conduct outcome and process surveillance of DA-HAIs and SSIs, measure their consequences, and assess the impact of infection control practices; to improve the safety and quality of healthcare world-wide through the implementation of systematized programs to reduce rates of DA-HAIs and SSIs, their associated mortality, excess lengths of stay (LOS), excess costs, antibiotic usage, and bacterial resistance (9). Surveillance is conducted by means of an online platform called INICC Surveillance Online System (ISOS) that comprises 15 modules, whose effective impact in DA-HAI rates reduction was shown in several studies (10-25).

The ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply U.S. CDC/NHSN's definitions published in January 2015 (26). This report is a summary of data on DA-HAIs collected between April 2007 and April 2015 in 2 ICUs in two hospitals in Costa Rica that participate in the INICC (8).

METHODS

Background on INICC

INICC is comprised of more than 2,000 hospitals in 500 cities of 66 countries in Latin America, Asia, Africa, Middle East, and Europe, and has become the only source of aggregate standardized international data on the epidemiology of healthcare-associated infections (HAIs) internationally (5). The INICC is focused on the surveillance and prevention of DA-HAI in adult, pediatric ICUs and neonatal ICUs (NICUs), step down units, inpatient wards, and of SSIs in surgical procedures hospital wide.

Setting and study design

This prospective cohort surveillance study was conducted in two medical/surgical ICUs from two hospitals in San José, Costa Rica, through the implementation of the INICC Multidimensional Approach (IMA), as described below. In accordance with the INICC's charter, the identity of all INICC hospitals and cities is kept confidential.

INICC multidimensional approach

The IMA includes the implementation of CDC/NSHN's definitions of HAIs and methodology, but adds the collection of other data essential to increase ICPS's sensitivity of to detect HAIs, and avoid underreporting (6). According to standard CDC/NSHN methods, numerators are the number of HAIs of each type, and denominators are device-days collected from all patients, as pooled data; that is, without determining the number of device-days related to a particular patient, and without collecting features or characteristics per specific patient (6). This aspect differs from the INICC surveillance system, because the design of the cohort study through the INICC methods also includes collecting specific data per patient from *all* patients, both those with and those without HAI, collecting risk factors of HAIs, such as invasive devices, and surrogates of HAIs, which include, but are not limited to, high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS and mortality. By collecting data on all patients in the ICU, it is possible to match patients with and without HAI by several characteristics to estimate extra LOS, mortality and cost.

The IMA comprises the simultaneous implementation of the following six components for HAI control and prevention: 1) a bundle of interventions; 2) education; 3) outcome surveillance; 4) process surveillance; 5) feedback on HAI rates and consequences; and 6) performance feedback.

Outcome and process surveillance are conducted by means of an online platform called INICC Surveillance Online System (ISOS). The ISOS comprises 15 modules: 10 for Outcome Surveillance and five for Process Surveillance. The modules of the outcome surveillance and process surveillance components may be used singly or simultaneously, but once selected; they must be used for a minimum of one calendar month.

This study presents the results of the Cohort Surveillance of HAIs in adult, pediatric and neonatal ICUs. The results of the remaining Outcome Surveillance modules (1) *C. difficile* infections (CDIs); 2) Antimicrobial Consumption; 3) Surveillance of Needle Stick Injuries, 4) Cohort Surveillance of HAIs in inpatient wards and step down units; 5) Cohort Surveillance of surgical procedures and surgical site infections] and of the modules for Process Surveillance, Feedback on HAI rates and consequences, and Performance Feedback were not included in this report, because they will be published in another future study.

Outcome surveillance

Outcome surveillance included Cohort Surveillance of HAIs in adult ICUs conducted through the ISOS, which allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply U.S. CDC/NHSN's definitions updated in 2015 (6). The site-specific criteria include reporting instructions and provide full explanations integral to their adequate application (6).

TABLE 1: Pooled means of the distribution of crude mortality, crude excess mortality, length of stay, and crude excess length of stay, of adult intensive care unit patients with and without device-associated healthcare-acquired infection

Patients	Patients, n	Deaths, n	Pooled crude mortality, %	Pooled crude extra mortality, % (95% CI)	LOS, total days	Pooled average. LOS, days	Pooled average. extra LOS, days (95% CI)
Without DA-HAI	1,086	41	3.8%	-	3,093	2,8	-
With CLABSI	6	0	0.0%	-	67	11.2	8.3 (5.9–11.2)
With VAP	34	10	29.4%	25.6% (12.4 - 42.4)	461	13.6	10.7 (9.6 - 11.9)

ICU, intensive care units; CI, confidence interval; DA-HAI, device-associated healthcare-acquired infection; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; LOS, length of stay; CI, confidence interval.

Table 2: Antimicrobial resistance rates in the participating intensive care units

	Pathogenic isolated tested, pooled, n	Resistance, %	Pathogenic isolated tested, pooled, n	Resistance, %	Pathogenic isolated tested, pooled, n	Resistance, %	Resistance, %
Pathogen, antimicrobial	(CLABSI)	(CLABSI)	(VAP)	(VAP)	(CAUTI)	(CAUTI)	(Pooled)
<i>S. aureus</i> Oxacillin	0	-	1	100%	0	-	100%
Coagulase-negative staphylococci Oxacillin	1	100%	0	-	0	-	100%
<i>P. aeruginosa</i> Ciprofloxacin	0	-	5	20%	0	-	20%
Piperacillin-tazobactam	2	50%	5	40%	1	0%	37.5%
Amikacin	0	-	0	-	5	40%	40%
Imipenem or meropenem	1	100%	0	-	8	50%	55.6%
<i>K. pneumoniae</i> Imipenem or meropenem	0	-	4	0%	0	-	0%
<i>A. baumannii</i> Piperacillin-tazobactam	0	-	1	0%	0	-	0%
Imipenem or meropenem	0	-	1	0%	0	-	0%
<i>E. coli</i> Imipenem or meropenem	0	-	2	50%	0	-	50%

CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection.

Data collection and analysis

The ISOS follows the INICC protocol and infection control professionals (ICPs), who collected daily data on central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs) and ventilator-associated pneumonias (VAPs) and denominator data, patient-days and specific device-days in the ICUs.

These data were uploaded to the ISOS, and were used to calculate DA-HAI rates per 1000 device-days, mortality and LOS, according to the following formulas: Device-days consisted of the total number of central line (CL)-days, urinary catheter (UC)-days, or mechanical ventilator (MV)-days. Crude excess mortality of DA-HAI equals crude mortality of ICU patients with DA-HAI minus crude mortality of patients without DA-HAI. Crude excess LOS of DA-HAI equals crude LOS of ICU patients with DA-HAI minus crude LOS of patients without DA-HAI. Device utilization ratio (DUR) equals the total number of device-days divided by the total number of bed days.

Training

The INICC team trained infection control professionals (ICP) and hospital epidemiologists at hospitals. ICPs were also provided with tutorial movies, manuals and training tools that described in detail how to perform surveillance and upload surveillance data through the ISOS. In addition, ICPs assisted webinars, had continuous e-mail and telephone access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Definitions

The ISOS uses the CDC/NHSN surveillance definitions and criteria for all specific types of HAIs published in 2015 (6).

Statistical analysis

INICC Surveillance Online System (ISOS) version 2.0 (Buenos Aires, Argentina), was used to calculate HAI rates, DUR, LOS and mortality. EpilInfo® version 6.04b (CDC, Atlanta, GA), SPSS 16.0 (SPSS Inc. an IBM company, Chicago, Illinois), and ISOS version 2.0 (Buenos Aires, Argentina), were used to conduct data analysis. Relative risk (RR) ratios, 95% confidence intervals (CIs) and P-values were determined for primary and secondary outcomes.

RESULTS

During the study period from 1 April 2007 through 30 April 2015, 1,128 patients were hospitalized in the two participating medical surgical ICUs, amounting to 4,055 bed-days. The mean length of participation of the ICUs was (SD), 43.7 (35.6) months, range from 22 to 97 months.

The pooled means of the DA-HAI rates were 2.9 (n, 7) CLABs per 1,000 CL-days, during 2,422 CL-days with a DUR of 0.60 (95% CI, 0.58 – 0.61); 30.7 (n, 36) VAPs per 1,000 MV-days, during 1,173 MV-days, with a DUR of 0.29 (95% CI, 0.28 – 0.30); and 1.5 (n, 3) CAUTIs per 1,000 UC-days, during 2,021 UC-days, with a DUR of 0.50 (95% CI, 0.48 – 0.51).

Table 1 provides pooled means on crude ICU mortality and LOS in patients hospitalized during the surveillance period, with and without DA-HAI, and crude excess mortality and LOS of patients with CLABSI and VAP. The DA-HAI associated with the highest mortality and longest LOS was VAP. CAUTI mortality was not calculated due to the small sample size.

Table 2 provides data on bacterial resistance of pathogens isolated from patients with DA-HAI in ICUs. Resistance rates of *S. aureus* and coagulase negative staphylococcus to oxacillin and of *P. aeruginosa* to imipenem/meropenem were high.

Table 3 compares the results of this report from Costa Rica with the INICC international report for the period 2007-2012 and with the US CDC/NHSN report of 2013 (4, 5). The rate of VAP was higher in this study than in INICC and CDC/NHSN reports. The CLABSI rate was higher in this study than in CDC/NHSN, but it was similar to the INICC rates. Finally, the rate of CAUTI in this study was lower than INICC and similar to CDC/NHSN's rate. Although the DUR was higher for CL in this study compared to INICC and CDC/NHSN, UC DUR was lower than INICC and CDC/NHSN's.

Table 4 compares the antimicrobial resistance rates of this report from Costa Rica with the INICC international report for the period 2007-2012(5) and with the US CDC/NHSN report of 2009-2010 (3). Resistance of *S. aureus* to oxacillin and *E. coli* to imipenem or meropenem was higher in this study than in both of the afore-mentioned international reports.

DISCUSSION

This is the first study that has analyzed DA-HAIs in Costa Rica. If compared with other similar studies conducted in Latin America, the DA-HAI rates found in this study are significantly higher. In a study conducted in Colombia, DA-HAI rates were higher than this study's: the rate of VAP was 32.3 per 1,000 MV-days, the CLABSI rate was 47.4 per 1,000 CL-days, and the CAUTI rate was 20.3 per 1,000 UC-days (27). By contrast, pooled crude mortality was higher in this study than in a study conducted in Colombia, whose findings showed that the crude unadjusted mortality attributable to DA-HAI 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 CLABSI (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).(27) In Peru, Cuellar L. et al. found that the VAP rate was 31.3 per 1000 MV-days; the CLABSI rate was 7.7 cases per 1000 CL-days; and the rate for CAUTI was 5.1 cases per 1000 UC-days.(28) In a similar study conducted in ICUs in Brazil, VAP posed the greatest risk (20.9 per 1000 MV-days), followed by CAUTI (9.6 per 1000 UC-days) and CLABSI (9.1 per 1000 CL-days) (29).

From an international perspective, the results of this study show that most DA-HAI rates and DURs found in the ICU setting of Costa Rica were significantly higher than the rates reported by the U.S. CDC/NHSN, which would well represent the situation in high-income countries (4). On the other hand, the CLABSI rate in this study was higher than the international INICC Report (2007-2012) for 43 countries (5),

TABLE 3: Benchmarking of device-associated healthcare-acquired infection rates in this report against the report of the International Nosocomial Infection Control Consortium (2007-2012) and the report of the US Centers for Disease Control and Prevention's National Healthcare Safety Network data (2013)

Medical Surgical ICU	This Report Rate (95% CI)	INICC Report (2007-2012)(5) Rate (95% CI)	U.S. CDC-NHSN Report (2013)
CL, DUR	0.60 (0.58 – 0.61)	0.54 (0.54 – 0.54)	0.37
CLABSI rate (CLABSIs per 1000 CL-days)	2.9 (1.2 – 6.0)	4.9 (4.8 – 5.1)	0.8
MV, DUR	0.29 (0.28 – 0.30)	0.36 (0.36 – 0.36)	0.24
VAP rate (VAPs per 1000 MV-days)	30.7 (21.5 – 42.5)	16.5 (16.1 – 16.8)	1.1
UC, DUR	0.50 (0.48 – 0.51)	0.62 (0.62 – 0.62)	0.54
CAUTI rate (CAUTIs per 1000 UC-days)	1.5 (0.3 – 4.3)	5.3 (5.2 – 5.8)	1.3

ICU, intensive care unit; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; DUR, device utilization ratio; CI, Confidence Interval; CL, Central line; MV, mechanical ventilator; UC, urinary catheter; INICC, International Nosocomial Infection Control Consortium; CDC-NSHN, Centers for Disease Control and Prevention's National Healthcare Safety Network.

Table 4: Benchmarking of Antimicrobial Resistance Rates in this Report Against the Report of the International Nosocomial Infection Control Consortium (2007-2012) and the Report of the US National Healthcare Safety Network Data (2009-2010)

	This Report Resistance % (n/n)	INICC 2007-2012 Resistance %	CDC-NHSN 2009-2010 Resistance, %
Pathogen, antimicrobial	VAP	VAP	VAP
<i>S. aureus</i> Oxacillin	100% (1/1)	62%	48.4%
<i>P. aeruginosa</i> Ciprofloxacin	20% (1/5)	41.9%	32.7%
Piperacillin or piperacillin-tazobactam	40% (2/5)	35.8%	19.1%
<i>K. pneumoniae</i> Imipenem or meropenem	0% (0/4)	17.2%	11.2%
<i>A. baumannii</i> Imipenem or meropenem	0% (0/1)	77.1%	61.2%
<i>E. coli</i> Imipenem or meropenem	50% (1/2)	7.5%	3.5%

VAP, ventilator-associated pneumonia; CDC-NSHN, Centers for Disease Control and Prevention's National Healthcare Safety Network.

representing middle and low-income countries, as was the CL DUR. By contrast, despite the VAP rate in this study being substantially higher than INICC's, the DUR for MV in this study was lower, pointing to potential risk factors other than DURs influencing DA-HAI rates. Finally, the CAUTI rate in this study was lower than INICC's and similar to CDC/NHSN's, with a lower UC DUR than both international reports; however, these results should be considered cautiously due to a small sample size (4, 5).

The antimicrobial resistance rates found in this ICUs were higher than CDC/NHSN (4) and INICC reports'(5) rates for *S. aureus* as resistant to oxacillin, for *P. aeruginosa* as resistant to piperacillin-tazobactam, and for *E. coli* as resistant to imipenem or meropenem. On the other hand, the resistance rates for *P. aeruginosa* to ciprofloxacin, *K. pneumoniae* as resistant to imipenem or meropenem, and *A. baumannii* as resistant to imipenem or meropenem were lower in this study than U.S. CDC/NHSN report,(3) and also lower than the INICC reported resistance rates (5).

There are many reasons that can explain these higher DA-HAI rates compared both to US CDC/NHSN and INICC reports (30, 31). As in other countries, adherence to infection control bundles in Costa Rica is variable, nurse-to-patient staffing ratios are usually low (and closely associated with higher DA-HAI rates in ICUs), as well as hospital over-crowding, and an insufficient number of experienced nurses or trained healthcare workers (32).

In order to reduce the risk of infection of patients hospitalized in ICUs, surveillance targeting DA-HAI is fundamental to effectively addressing the burden of DA-HAIs. Surveillance should be complemented with implementation of other practices aimed at DA-HAI control and prevention. In this sense, participation in INICC has played a critical role, not only in increasing the awareness of the risks posed by DA-HAIs in the ICU, but also providing an exemplary basis for the implementation of infection control practices through the use of an online process surveillance tool.

The INICC program is focused on surveillance of DA-HAIs in the ICUs, step down units and general wards, and surveillance of SSIs hospital wide. This particular study was focused on ICUs, because they are the healthcare settings that represent the highest HAI rates, due to patients' critical condition and exposure to invasive devices (32). Through the last 12 years, INICC has undertaken a global effort in America, Asia, Africa, Middle East, and Europe to prevent and control DA-HAIs, and has demonstrated success by increasing HH compliance, improving compliance with infection control bundles and interventions as described in several INICC publications, and consequently facilitating reduction of the rates of DA-HAI and mortality (15, 16, 33-35).

To compare a hospital's DA-HAI rates with the rates identified in this report, it is required that the hospital team concerned collect their data by applying the methods and methodology described for U.S. CDC/NHSN and INICC, and then calculate infection rates and DU ratios for the DA-HAI Module.

The particular and primary application of these data is to serve as a guide for the implementation of prevention strategies and other quality improvement efforts in Costa Rica for the reduction of DA-HAI rates to the minimum possible level.

Study limitations

The findings in this report did not consider the difference in time periods for the different data sources in the comparisons made with INICC and U.S. CDC/NHSN.

CONCLUSIONS

In conclusion, the data presented in this report fortify the fact that DA-HAIs in Costa Rica are a challenge for patient safety. It is INICC's main goal to enhance infection control practices, by facilitating elemental, feasible and inexpensive tools and resources to tackle this problem effectively and systematically, leading to greater and stricter adherence to infection control programs and guidelines, and subsequently to the reduction in DA-HAI in the hospitals participating in INICC, as well as at any other healthcare facility worldwide.

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