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ORIGINAL ARTICLE

Case Control Study

Device-associated infection rates, mortality, length of stay and bacterial resistance in intensive care units in Ecuador: International Nosocomial Infection Control Consortium's findings

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Institutional review board statement: Every hospital's Institutional Review Board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

Informed consent statement: All involved persons (subjects or legally authorized representative) gave their informed consent prior to study inclusion.

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Abstract

AIM

To report the results of the International Nosocomial Infection Control Consortium (INICC) study conducted in Quito, Ecuador.

METHODS

A device-associated healthcare-acquired infection (DA-

HAI) prospective surveillance study conducted from October 2013 to January 2015 in 2 adult intensive care units (ICUs) from 2 hospitals using the United States Centers for Disease Control/National Healthcare Safety Network (CDC/NHSN) definitions and INICC methods.

RESULTS

We followed 776 ICU patients for 4818 bed-days. The central line-associated bloodstream infection (CLABSI) rate was 6.5 per 1000 central line (CL)-days, the ventilator-associated pneumonia (VAP) rate was 44.3 per 1000 mechanical ventilator (MV)-days, and the catheter-associated urinary tract infection (CAUTI) rate was 5.7 per 1000 urinary catheter (UC)-days. CLABSI and CAUTI rates in our ICUs were similar to INICC rates [4.9 (CLABSI) and 5.3 (CAUTI)] and higher than NHSN rates [0.8 (CLABSI) and 1.3 (CAUTI)] - although device use ratios for CL and UC were higher than INICC and CDC/NSHN's ratios. By contrast, despite the VAP rate was higher than INICC (16.5) and NHSN's rates (1.1), MV DUR was lower in our ICUs. Resistance of *A. baumannii* to imipenem and meropenem was 75.0%, and of *Pseudomonas aeruginosa* to ciprofloxacin and piperacillin-tazobactam was higher than 72.7%, all them higher than CDC/NHSN rates. Excess length of stay was 7.4 d for patients with CLABSI, 4.8 for patients with VAP and 9.2 for patients CAUTI. Excess crude mortality in ICUs was 30.9% for CLABSI, 14.5% for VAP and 17.6% for CAUTI.

CONCLUSION

DA-HAI rates in our ICUs from Ecuador are higher than United States CDC/NSHN rates and similar to INICC international rates.

Key words: Ventilator-associated pneumonia; Catheter-associated urinary tract infection; Healthcare-associated infection; Antibiotic resistance; Developing countries; Intensive care unit; Surveillance; Central line-associated bloodstream infections; Hospital infection

Core tip: This is a prospective, cohort, surveillance study on device-associated infection rates, mortality, length of stay and bacterial resistance conducted in intensive care units (ICUs) in Ecuador from October 2013 to January 2015. Device-associated healthcare-acquired infection rates in our ICUs from Ecuador are significantly higher than United States Centers for Disease Control and Prevention's National Healthcare Safety Network's rates and similar to International Nosocomial Infection Control Consortium's international rates.

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INTRODUCTION

Device-associated healthcare-acquired infections (DA-HAIs) are one of the main threats to the safety of patients, causing patient morbidity, mortality, excess costs and prolonged length of hospital stay (LOS), particularly in intensive care settings of limited-resource countries[1-3].

Multifaceted infection prevention programs integrating target DA-HAI surveillance methods were proved effective in several United States studies, which showed the occurrence of DA-HAI could be reduced by more than 30%, along with an analogous reduction in DA-HAI-related hospital costs[4].

Antimicrobial-resistant infections is another primary issue that needs to be addressed in infection control programs in order to prevent the spread of resistant strains through the report of DA-HAI-associated pathogens and their susceptibility to antibiotics[5].

During the last four decades, the United States Centers for Disease Control and Prevention (CDC)'s National Healthcare Safety Network (NHSN)[6] has developed benchmarking data on DA-HAIs in intensive care unit (ICU) patients, which has afforded the International Nosocomial Infection Control Consortium (INICC) an essential insight[5].

The INICC is an open, international, non-profit, collaborative healthcare-associated infection (HAI) control network comprised of 2000 hospitals in 500 different cities in 66 countries in Africa, Asia, Eastern Europe, Latin America and the Middle East transcontinental region[5,7]. Since it was established in 1998 in Argentina, it has been the first multi centre surveillance and research network centered on the reduction of the rates of DA-HAI in the ICU and of hospital-wide surgical site infections through tools and resources provided for free to healthcare centers to assist them in with the prevention and control this public health burden through the implementation of infection prevention programs[6-9]. The INICC network operates by means of an online surveillance system - the INICC Surveillance Online System (ISOS) - and a systematic multidimensional approach - the INICC Multidimensional Approach (IMA) - whose effectiveness for the decrease of DA-HAI rates was shown in the scientific literature[8-23]. The ISOS applies the definitions of HAIs developed by the CDC/NHSN and standardized methodologies, thereby promoting applied research and evidence-based infection prevention practices.

This is the first study to report an analysis of data on DA-HAI rates from Ecuador using ISOS between October 2013 and January 2015 in 2 ICUs from 2 hospitals of the INICC network[5].

MATERIALS AND METHODS

Background on INICC

The INICC is focused on the surveillance and prevention of HAI in adult, pediatric ICUs and neonatal ICUs, step down units, inpatient wards, and of surgical site infections in surgical procedures hospital wide[5]. Through the ISOS, INICC provides free training and surveillance tools to hospitals worldwide, which allows them to measure HAI consequences, and to evaluate the impact of infection control and prevention practices[24].

Study design and setting

This is a prospective surveillance, cohort study made on all the patients admitted, between October 2013 and January 2015, to 2 adult medical/surgical ICUs from 2 medium-sized hospitals (1 private and 1 public hospital) in Quito, Ecuador, through the implementation of the IMA. The IMA uses 6 components for HAI control to be applied simultaneously, as follows: (1) bundles of infection control interventions; (2) educational and training sessions; (3) outcome surveillance on HAI-related rates; (4) process surveillance; (5) feedback on HAI rates and their related adverse effects; and (6) feedback on health care workers' performance[5].

In accordance with the INICC protocol, hospitals' identities are kept under confidentiality and patient data was anonymized. Due to the fact that this was an epidemiological surveillance study, which did not include tests of experimental drugs, biomedical devices or products, and that patient data were anonymized, an informed consent was not necessary according to the ethics committees that evaluated and approved the study.

ISOS

The ISOS applied CDC/NSHN's methods and definitions published in January 2015[25], and also included INICC methodology. The methods developed by the CDC/NSHN to determine HAI rates indicate that the numerators are the total number of each type of HAIs, and the denominators are the device days recorded from all ICU patients, in the form of pooled data; that is, the number of device days and the characteristics of a particular patient are not calculated[25]. By contrast, the INICC methodology, through the implementation of the ISOS, included the collection of data per specific patient, from all ICU patients (with and without HAI), including surrogates of HAI (low blood pressure, high temperature, antibiotic therapy, results of cultures, LOS and mortality), and data on risk factors, including invasive devices. To have data on all ICU patients enabled a match of patients with and without HAI by various patient features necessary to calculate excess mortality, LOS and HAI-related hospital cost[5].

Analysis and collection of data

Infection control professionals (ICPs) uploaded their daily-collected data on DA-HAIs using ISOS. Data on central line-associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI), denominator data, patient-days and specific device-days in the ICUs were used to determine the rates of each DA-HAI per 1000 device days, LOS and mortality, as follows: (1) device days equaled the number of central line (CL)-days, mechanical ventilator (MV)-days and urinary catheter (UC)-days; (2) DA-HAI crude excess mortality equaled crude mortality of patients with DA-HAI hospitalized in the ICU minus crude mortality of ICU patients who had not acquired a DA-HAI; (3) DA-HAI crude excess LOS equaled crude LOS of patients with DA-HAI hospitalized in the ICU minus crude LOS of patients ICU patients who had not acquired a DA-HAI; and (4) Device utilization ratio (DUR) equaled the number of device days divided by the number of bed days[5].

Training

ICPs were trained at hospitals by the INICC team. Instruction manuals, training tools and tutorial movies describing in detail how to conduct surveillance and upload data to ISOS were also provided to ICPs. Finally, ICPs received technical and methodological support from the INICC team *via* email, telephone calls and webinars.

Definitions

The ISOS applied the definitions and criteria published in 2015 by CDC's NHSN for HAI surveillance[25].

Statistical analysis

Data analysis and the calculation of rates of DA-HAI, LOS, mortality, device utilization were done using ISOS version 2.0 (City of Buenos Aires, Argentina). Relative risk ratios, *P*-values and 95% confidence intervals were calculated using SPSS 16.0 (SPSS Inc. an IBM company, Chicago, Illinois, United States) and EpiInfo® version 6.04b (CDC, Atlanta, GA, United States). The statistical review of the study was done by a biomedical statistician.

RESULTS

From October 1st 2013 to January 30th 2015, 776 patients were admitted to the 2 participating medical/surgical ICUs, for a total of 4818 bed days. During the study period, the mean length of participation of each ICU was as follows: + SD 14.5 + 2.1 mo, range from 13 to 16 mo.

Table 1 provides data on crude excess LOS and mortality in all patients (with and without DA-HAI) admitted to the ICUs over the period of study. CLABSI was associated with the highest pooled excess mortality in the ICUs. The excess LOS of patients with CAUTI was the greatest among the analyzed DA-HAIs.

Table 2 shows the DA-HAI rates and related results of this report from Ecuador benchmarked against the INICC report of data from 43 countries for the period 2007-2012, against the United States CDC/NHSN report of 2013 and against the United States NHSN report of 2009-2010[6,26,27].

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 excess mortality, % (95%CI)	LOS, total days	Pooled average, LOS (d)	Pooled average, excess LOS (d) (95%CI)
Without DA-HAI	678	107	15.80	-	3579	5.3	
With CLABSI	15	7	46.70	30.9 (8.1-54.7)	190	12.7	7.4 (5.8-9.2)
With CAUTI	12	4	33.30	17.6 (-3.2-46.4)	174	14.5	9.2 (7.3-11.4)
With VAP	43	13	30.20	14.5 (4.1-27.4)	434	10.1	4.8 (4.1-5.7)

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.

DA-HAI rates pooled means were as follows: 6.5 (*n*, 39) CLASBIs per 1000 CL-days, with a DUR of 1.24 for 5998 CL-days; 44.3 (*n*, 69) VAPs per 1000 MV-days, with a DUR of 0.32 for 1559 MV-days, and 5.7 (*n*, 21) CAUTIs per 1000 UC-days, with a DUR of 0.77 for 3699 UC-days.

Overall, our CLABSI and CAUTI rates were similar to the INICC report data, but our VAP rate was substantially higher than INICC's. On the other hand, the incidence rates of DA-HAI were higher compared with United States NHSN report data. Our DURs for CL and UC were higher compared both to United States NHSN's and INICC's; however, our DUR for MV was lower than INICC's. Most of the resistance rates found in our ICUs were significantly higher than those found in the US ICUs as reported by the CDC's NHSN.

DISCUSSION

DA-HAIs in Ecuador have not been systematically analyzed in the scientific literature to date. The incidence of DA-HAIs in this study is significantly higher than other recent analogous studies carried out in Latin America. In Colombia, it was recently shown that DA-HAI rates per 1000 device days were higher than ours: The CLABSI rate was 47.4, the VAP rate was 32.3, and the CAUTI rate was 20.3[28]. By contrast, pooled crude mortality was higher in our study than in a study conducted in Colombia, whose findings showed the crude unadjusted mortality attributable to DA-HAI was 18.5% for patients with CLABSI (95%CI: 1.42-2.87); 16.9% for patients with VAP (95%CI: 1.24-3.00); and 10.5% for patients with CAUTI (95%CI: 0.78-3.18)[28]. In Peru, Cuellar *et al*[29] found a CAUTI rate of 5.1 per 1000 UC days, a VAP rate of 31.3 per 1000 MV days and a CLABSI rate of 7.7 per 1000 CL-days. In a comparable study conducted in Brazil, Salomao *et al*[30] found a rate of 20.9 VAPs per 1000 MV days, a CAUTI rate of 9.6 per 1000 UC days and a CLABSI rate of 9.1 per 1000 CL days.

The statistically significantly higher rates of DA-HAI rates and DURs found in the analyzed ICUs of Ecuador compared with the rates reported by the US CDC's NHSN represent the current burden of HAIs in high-income countries[6]. On the other hand, CLAB and CAUTI rates found in the international INICC Report (2007-2012) for 43 countries[26], which would represent middle and low-income economies, were similar to our rates, although our pooled DURs were higher for CL and UC[6,26]. By contrast, although our VAP rate was remarkably higher than INICC's, our DUR for MV was lower, which means there are other risk factors different from DURs influencing DA-HAI rates. Regarding antimicrobial resistance, the resistance percentages found in this study were also higher than those found in United States CDC's NHSN[27] and INICC[26] reports' for *Pseudomonas aeruginosa* as resistant to piperacillin-tazobactam, ciprofloxacin, amikacin, and imipenem or meropenem, as well as the resistance percentages determined for *Acinetobacter baumanii* to imipenem or meropenem.

Different factors can elucidate the possible reasons for these higher DA-HAI rates compared with the United States CDC's NHSN and INICC's reports. As also occurs in other developing countries, we consider that adherence to infection control bundles in Ecuador is variable, there is frequently a low nurse-patient staffing ratio (with a nurse-patient ratio higher than 4:1) and the number of experienced nurses or trained healthcare workers is deficient - which has been demonstrated as significantly associated with considerably high DA-HAI incidence rates in the ICU patient[31]. In addition, there is hospital over-crowding. According to World Health Organization standards[32], there should be between 8 and 10 hospital beds available per 1000 persons, but in 2011, in Ecuador, there were only 1.5 per 1000, with many hospitals remaining at full capacity[33].

The risk of infection of patients hospitalized in ICUs can be reduced though the implementation of surveillance targeted on DA-HAI, because it is successful to focus on characteristics of the burden of DA-HAIs. These surveillance data is necessary to increase ICPS's sensitivity and aids them to detecting HAIs and avoiding underreporting[5].

In addition, surveillance should be complemented with the performance of other practices for DA-HAI control and prevention[34,35]. Therefore, INICC has played a crucial by facilitating free infection prevention tools and resources through the use of ISOS, as well as by fostering increasing awareness about the risks posed by DA-HAIs amongst health care professionals[5,36].

Limitations

The difference in time periods for the diverse data sources was not considered for the benchmarking of our findings against the United States CDC's NSHN and

Table 2 Benchmarking of device-associated healthcare-acquired infection rates, device utilization and antimicrobial resistance in this report against the report of the International Nosocomial Infection Control Consortium (2007-2012) and the reports of the United States Centers for Disease Control and Prevention's National Healthcare Safety Network data (2013 and 2009-2010)

	This report 95%CI	INICC report (2007-2012)[26] 95%CI	United States CDC/NHSN report (2013)[6]/2009-2010[27]
Medical/surgical ICU			
Central line, DUR	1.24 (1.21-1.27)	0.54 (0.54-0.54)	0.37
CLABSI rate	6.5 (4.6-8.9)	4.9 (4.8-5.1)	0.8
Mechanical ventilator, DUR	0.32 (0.31-0.34)	0.36 (0.36-0.36)	0.24
VAP rate	44.3 (34.4-56.0)	16.5 (16.1-16.8)	1.1
Urinary catheter, DUR	0.77 (0.74-0.79)	0.62 (0.62-0.62)	0.54
CAUTI rate	5.7 (3.5-8.7)	5.3 (5.2-5.8)	1.3
Antimicrobial resistance % (*n*)			
Pathogen, antimicrobial	CLABSI (*n*)	CLABSI	CLABSI
Staphylococcus aureus			
Oxacillin	60% (5)	61.20%	54.60%
Pseudomonas aeruginosa			
Ciprofloxacin	71.4% (7)	37.50%	30.50%
Piperacillin or piperacillin-tazobactam	100% (5)	33.50%	17.40%
Amikacin	71.4% (7)	42.80%	10.00%
Imipenem or meropenem	71.4% (7)	42.40%	26.10%
Klebsiella pneumoniae			
Ceftriaxone or ceftazidime	60% (5)	71.20%	28.80%
Imipenem or meropenem	20% (5)	19.60%	12.80%
Acinetobacter baumanii			
Imipenem or meropenem	100% (2)	66.30%	62.60%

ICU: Intensive care unit; CLABSI: Central line-associated bloodstream infection; VAP: Ventilator-associated pneumonia; CAUTI: Catheter-associated urinary tract infection; DUR: Device use ratio; CI: Confidence interval; INICC: International Nosocomial Infection Control Consortium; United States CDC/NSHN: Centers for Disease Control and Prevention's National Healthcare Safety Network of the United States.

INICC reports. Due to the low economic resources of our ICUs, very few cultures were taken, which could have influenced the rates of CLABSI and CAUTI, as they could not be document because they did not fulfill all the United States CDC/NHSN criteria. In addition, the number of patients to whom blood and/or urine cultures should have been taken, but were actually not due to lack of economic resources, is unknown as this data was not registered.

Conclusions

The findings of this study highlight that DA-HAIs pose major challenges for public health and the wellbeing of patients in Ecuador. One of INICC's primary goals is to provide health care facilities worldwide with free tools and resources to support the introduction of systematic infection prevention practices in order to address this burden effectively by accomplishing a reduction in DA-HAI rates and their adverse effects.

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COMMENTS

Background

The International Nosocomial Infection Control Consortium (INICC) program is focused on surveillance of device-associated healthcare-acquired infections (DA-HAIs) in the intensive care units (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. Through the last 12 years, INICC has undertaken a global effort in Africa, Eastern Mediterranean, Europe, Latin America, South East Asia and Western Pacific to prevent and control DA-HAIs, and has achieved extremely successful results, by increasing hand hygiene compliance, improving compliance with other infection control bundles and interventions as described in several INICC publications, and consequently reducing the rates of DA-HAI and mortality. 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 United States NHSN and INICC, and then calculate infection rates and DU ratios for the DA-HAI Module.

Applications

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 Ecuador for the reduction of DA-HAI rates to the minimum possible level.

Peer-review

This is a nice prospective multi-center trial showing similar nosocomial infection

rates in Ecuadorian hospitals as compared with international hospitals.

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