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Device-associated infection rates in adult intensive care units of Cuban university hospitals: International Nosocomial Infection Control Consortium (INICC) findings

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SUMMARY

Objectives: To determine the rate of device-associated healthcare-associated infection (DA-HAI), microbiological profile, length of stay (LOS), extra mortality, and hand hygiene compliance in two intensive care units (ICUs) of two hospital members of the International Infection Control Consortium (INICC) of Havana, Cuba.
Methods: An open label, prospective cohort, active DA-HAI surveillance study was conducted on adults admitted to two tertiary-care ICUs in Cuba from May 2006 to December 2009, implementing the methodology developed by INICC. Data collection was performed in the participating ICUs, and data were uploaded and analyzed at the INICC headquarters on proprietary software. DA-HAI rates were registered by applying the definitions of the US Centers for Disease Control and Prevention National Healthcare Safety Network (CDC NHSN). We analyzed the mechanical ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLA-BSI), and catheter-associated urinary tract infection (CAUTI) rates, microorganism profile, extra length of stay (ELOS), extra mortality, and hand hygiene compliance.
Results: During 14 512 days of hospitalization, 1982 patients acquired 444 DA-HAIs, an overall rate of 22.4% (95% CI 20.6–24.3) or 30.6 (95% CI 27.8–33.5) DA-HAIs per 1000 ICU-days. The CLA-BSI rate was 2.0 (95% CI 1.2–3.1) per 1000 central line-days, the VAP rate was 52.5 (95% CI 47.2–58.3) per 1000 ventilator-days, and the CAUTI rate was 8.1 (95% CI 6.5–10.0) per 1000 catheter-days. LOS of patients was 4.9 days for those without DA-HAI, 23.3 days for those with CLA-BSI, and 23.8 days for those with VAP. CAUTI LOS was not calculated due to the lack of data. Extra mortality was 47% (relative risk (RR) 2.42; $p = 0.0693$) for VAP and 17% (RR 1.52; $p = 0.5552$) for CLA-BSI. The only patient with CAUTI died, but there was too little mortality data regarding this infection type to consider this significant. *Escherichia coli* was the most commonly isolated microorganism. The overall hand hygiene compliance was 48.6% (95% CI 42.8–54.3).
Conclusions: DA-HAI rates, LOS, and mortality were found to be high, and hand hygiene low. It is of primary importance that infection control programs that include outcome and process surveillance are implemented in Cuba.

1. Introduction

In the USA, as well as in several other high-income countries, device-associated healthcare-associated infection (DA-HAI) surveillance in the intensive care unit (ICU) plays a substantial role in hospital infection control and quality assurance.[1] Likewise, surveillance has been reported by the US Centers for Disease Control and Prevention (CDC) Study of the Efficacy of Nosocomial Infection Control (SENIC) as an efficacious tool to reduce DA-HAIs.[2]

In an increasingly large quantity of the scientific literature, DA-HAIs are considered the principal threat to patient safety in the ICU, and are among the main causes of patient morbidity and mortality.[3–5] The CDC's National Nosocomial Infection Surveillance System (NNIS) and National Healthcare Safety Network (NHSN) have reported standardized criteria for DA-HAI surveillance.[6,7] This standardized surveillance method allows for the determination of DA-HAI rates per 1000 device-days, comparable among healthcare

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centers, and provides infection control practitioners (ICP) with an in-depth look at the institutional problems they are confronted with, so as to provide an effective solution to them.In the context of an expanded framework for DA-HAI control, most of the relevant studies of ICU-acquired infections have been carried out in the industrialized countries.[8] In the developing countries, however, only a few published studies have reported DA-HAI rate data using standardized definitions.[9–17]The International Infection Control Consortium (INICC) was founded in 1998 when selected hospitals from Latin America were invited to participate in the project in order to measure DA-HAI using standardized definitions and methodology.[18] Shortly afterwards, other hospitals located in different parts of the world also requested membership of the INICC. Currently, the INICC comprises a worldwide network of around 250 ICUs from 38 countries of Latin America, Asia, Africa, and Europe.[9–17]

On a monthly basis, healthcare facilities send routinely gathered prospective data to the INICC, which are then entered into an international database. Hospital members of the INICC provide general medical and surgical inpatient services to adults and children hospitalized in the ICUs.

The findings of the present study from Cuba form an integral part of the INICC project, and reflect the systematically collected outcome and process surveillance data.

2. Methods

2.1. Setting

The study was carried out in two ICUs in two hospitals of Havana, Cuba, from May 2006 to December 2009. The hospitals each have an infection control team (ICT) with a physician and an ICP with at least 5 years of experience in infection control and a microbiology laboratory to provide in vitro susceptibility testing of clinical isolates using standardized methods. Each hospital's institutional review board approved the study protocol. Patient confidentiality was protected by codifying the recorded information, making it only identifiable to the ICT.

2.2. Surveillance

Data were collected prospectively on a daily basis from all the patients admitted to the ICUs, by means of specifically designed forms. The data were gathered according to the DA-HAI definitions provided by the CDC-NNIS and CDC-NHSN,[6,7] and methodology of the INICC.[18]

2.3. Hand hygiene compliance surveillance

Hand hygiene compliance by healthcare workers (HCWs) at the ICU is monitored by the ICP through observations of a randomly selected 1-h period, three times a week, during all working shifts and including all HCWs, according to a specific sequence set forth in the INICC protocol. The ICP records the opportunities for hand hygiene and compliance before contact with each patient on a specific surveillance form designed by the INICC.[18]

2.4. Culture techniques

For central line-associated bloodstream infection (CLA-BSI), central lines were removed aseptically and the distal 5 cm of the catheter was amputated and cultured using a standardized semiquantitative method.[19] Concomitant blood cultures were drawn percutaneously in nearly all cases. For ventilator-associated pneumonia (VAP), in most cases, a deep tracheal aspirate from the endotracheal tube was cultured aerobically and Gram-stained. For catheter-associated urinary tract infection (CAUTI), a urine sample was aseptically aspirated from the sampling port of the urinary catheter and cultured quantitatively.

In all cases, standard laboratory methods were used to identify microorganisms, and a standardized susceptibility test was performed.[20]

2.5. Calculation of device-associated infection rates

Outcomes measured during the surveillance period included the incidence density rate of CLA-BSI (number of cases per 1000 central line-days), of CAUTI (number of cases per 1000 urinary catheter-days), and of VAP (number of cases per 1000 mechanical ventilator-days).

DA-HAI rates for VAP, CLA-BSI, and CAUTI per 1000 device-days were calculated by dividing the total number of DA-HAI by the total number of specific device-days and multiplying the result by 1000.[21]

Device utilization (DU) ratios were calculated by dividing the total number of device-days by the total number of patient-days. Device-days are the total number of days of exposure to the device (central line, ventilator, or urinary catheter) for all of the patients in the selected population during the selected time period. Patient-days are the total number of days that patients are in the ICU during the selected time period.[21]

2.6. Length of stay and mortality calculation

Length of stay (LOS) and mortality was collected prospectively when filling out INICC forms daily.

The extra LOS is the difference between the LOS of patients with a DA-HAI and the LOS of patients hospitalized in the ICU during that period who did not acquire a DA-HAI.[18]

The crude extra mortality was calculated as the difference between the crude overall case-fatality of patients with a DA-HAI and the crude case-fatality of patients hospitalized in the ICU during that period who did not acquire a DA-HAI.[18]

2.7. Statistical analysis

EpiInfo version 6.04b (CDC, Atlanta, GA, USA) and SPSS 16.0 (IBM SPSS, Chicago, IL, USA) were used to conduct the data analysis.

Table 1
Features of the International Nosocomial Infection Control Consortium hospitals and intensive care units; hospitals A and B, Havana, Cuba, May 2006–December 2009

Variable	Medical–surgical ICU	Trauma ICU	Overall
ICUs, *n*	1	1	2
Hospitals, *n* (%)	1	1	2
Academic teaching	1	1	2 (100%)
Public	0	0	0
Private community	0	0	0
Patients studied, *n*	836	1146	1982
Total ICU days	4762	9750	14 512
Device use[a]			
Ventilator-days	1902	4515	6417
Ventilator use	0.40	0.46	0.44
Central line-days	3028	6863	9891
Central line use	0.64	0.70	0.68
Urinary catheter-days	3867	6822	10 689
Urinary catheter use	0.81	0.70	0.74

ICU, intensive care unit.
[a] Device utilization (DU): DU ratios were calculated by dividing the total number of device-days by the total number of patient-days. Device-days are the total number of days of exposure to the device (central line, mechanical ventilator, or urinary catheter) by all of the patients in the selected population during the selected time period. Patient-days are the total number of days that patients are in the ICU during the selected time period.

Table 2
Device-associated infections per 1000 device-days: VAP, CLA-BSI, and CAUTI; hospitals A and B, Havana, Cuba, May 2006–December 2009

Infection site	Device type	Device-days	DA-HAI	Distribution of device associated DA-HAI (%)	Rate per 100 patients	Rate per 1000 device-days[a]
VAP (overall rate)	MV	6417	337	76%	17.0%	52.5 (95% CI 47.2–58.3)
Trauma ICU	MV	4515	298	78%	26.0%	66.0 (95% CI 58.9–73.7)
Medical–surgical ICU	MV	1902	39	63%	4.7%	20.5 (95% CI 14.6–27.9)
CLA-BSI (overall rate)	CL	9891	20	4%	1.0%	2.0 (95% CI 1.2–3.1)
Trauma ICU	CL	6863	13	3%	1.1%	1.9 (95% CI 1.0–3.3)
Medical–surgical ICU	CL	3028	7	11%	0.8%	2.3 (95% CI 0.9–4.8)
CAUTI (overall rate)	UC	10 689	87	20%	4.4%	8.1 (95% CI 6.5–10.0)
Trauma ICU	UC	6822	71	19%	6.2%	10.4 (95% CI 8.1–13.1)
Medical–surgical ICU	UC	3867	16	26%	1.9%	4.1 (95% CI 2.4–6.7)

VAP, Ventilator-associated pneumonia; CLA-BSI, central line-associated blood stream infection; CAUTI, catheter-associated urinary tract infection; DA-HAI, device-associated healthcare-associated infection; ICU, intensive care unit; MV, mechanical ventilator; CL, central line; UC, urinary catheter; CI, confidence interval.
[a] Rate per 1000 device-days: rates were calculated by dividing the total number of DA-HAIs by the total number of specific device-days for all of the patients in the selected population during the selected time-period and multiplying the result by 1000.

Table 3
Hand hygiene compliance in the participating ICUs—comparison per stratum; hospital A, Havana, Cuba, May 2006–December 2009

Variable	% (No. HH/No. opportunities)	Comparison	RR	95% CI	*p*-Value
Gender					
Female	45.2%	Female vs. male	1.15	0.83–1.58	0.3921
Male	51.9%				
Healthcare worker					
Nurses	49.3%	Nurses vs. physicians	1.48	0.21–10.57	0.6950
Physicians	43.3%	Nurses vs. ancillary staff	1.14	0.64–2.01	0.6574
Ancillary staff	33.3%	Physicians vs. ancillary staff	1.30	0.17–9.94	0.7998
Procedure					
Non-invasive	46.3%	Non-invasive vs. invasive	1.15	0.82–1.61	0.4218
Invasive	53.1%				
Work shift					
Morning	49.5%	Morning vs. afternoon	1.05	0.76–1.46	0.7746
Afternoon	47.2%				

ICU, intensive care unit; HH, hand hygiene; RR, relative risk; CI, confidence interval.

Table 4
Extra mortality for patients with device-associated nosocomial infections in the medical–surgical ICU; hospital A, Havana, Cuba, May 2006–December 2009

	Patients (n)[a]	Crude mortality	Extra mortality	RR	95% CI	*p*-Value
Patients without infection, %	782	33%	-	1.0		
Patients with CLA-BSI, %	4	50%	17%	1.52	0.4–6.1	0.5552
Patients with VAP, %	5	80%	47%	2.42	0.9–6.5	0.0693

ICU, intensive care unit; RR, relative risk; CI, confidence interval; CLA-BSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia.
[a] We only considered cases of patients with a single infection to calculate mortality.

Chi-square analyses for dichotomous variables and the *t*-test for continuous variables were used to analyze baseline differences among rates. Relative risk (RR) ratios, 95% confidence intervals (CIs), and *p*-values were determined for all primary and secondary outcomes.

3. Results

3.1. Features of the study population

During the 3 years and 7 months of study, surveillance data were prospectively collected for 1982 patients hospitalized in the ICUs over 14 512 ICU-days (Table 1). The two participating hospitals were academic teaching facilities. These patients acquired 444 DA-HAIs, an overall rate of 22.4% (95% CI 20.6–24.3) or 30.6 (95% CI 27.8–33.5) DA-HAIs per 1000 ICU-days. CLA-BSI represented 5% of all DA-HAIs, VAP represented 76%, and CAUTI represented 20% (Table 2). Individual characteristics of each ICU, the number of patients enrolled in the study, the number of ICU-days, and the device-days are shown in Table 1. One of the two ICUs collected and sent original data to the INICC headquarters, and the other collected and sent aggregated data to the INICC. We only calculated mortality, LOS, bacterial profile, and hand hygiene from the original data.

3.2. Device utilization (DU) ratio

The DU ratio for mechanical ventilation use was 0.44, for central line use was 0.68, and for urinary catheter use was 0.74. DA-HAI distribution and device utilization are shown in Table 1.

3.3. Hand hygiene compliance

The total number of hand hygiene opportunities observed was 311. The overall hand hygiene compliance rate was 48.6% (95% CI 42.8–54.3). There were no significant differences between the strata compared (Table 3).

3.4. DA-HAI rates, mortality, and length of stay

3.4.1. CLA-BSI

CLA-BSI rates ranged from 1.9 to 2.3 per 1000 central line-days, with an overall rate in the two ICUs of 2.0 per 1000 central line-days (95% CI 1.2–3.1) (Table 2).

Table 5
Extra length of stay for patients with device-associated nosocomial infections in the medical–surgical ICU; hospital A, Havana, Cuba, May 2006–December 2009

	Average length of stay	Extra length of stay	RR	95% CI
Patients without infection, days	4.9	–	1.0	4.6–5.2
Patients with CLA-BSI, days	23.3	18.3	4.7	9.4–85.8
Patients with VAP, days	23.8	18.9	4.9	10.5–73.3

ICU, intensive care unit; RR, relative risk; CI, confidence interval; CLA-BSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia.

Table 6
Microorganism profile in the participating ICUs; hospital A, Havana, Cuba, May 2006–December 2009

Microorganism related to DA-HAI	CLA-BSI- related	VAP-related	CAUTI-related	Overall %
Acinetobacter spp	33.3%	15.4%	0%	10.3%
Escherichia coli	33.3%	15.4%	53.8%	34.5%
Klebsiella spp	0%	23.1%	15.4%	17.2%
Pseudomonas spp	0%	30.8%	7.7%	17.2%
Streptococcus pneumoniae	0%	7.7%	0%	3.4%
Coagulase-negative staphylococci	33.3%	7.7%	23.1%	17.2%

ICU, intensive care unit; DA-HAI, device-associated healthcare-associated infections; CLA-BSI, central line-associated blood stream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection.

The crude mortality of patients without a healthcare-associated infection was 33%. The crude mortality of patients with a CLA-BSI was 50%, with extra mortality for CLA-BSI of 17% (RR 1.52, 95% CI 0.4–6.1, $p = 0.5552$) (Table 4).

The LOS of patients without DA-HAI was 4.9 days (95% CI 4.6–5.2) and the LOS of patients with a CLA-BSI was 23.3 days (95% CI 9.4–85.8), yielding an extra LOS of 18.3 days (RR 4.7) (Table 5).

3.4.2. VAP

VAP rates ranged widely, from 20.5 to 66.0 per 1000 mechanical ventilator-days, with an overall rate in the two ICUs of 52.5 per 1000 mechanical ventilator-days (95% CI 47.2–58.3) (Table 2).

The crude mortality of patients with VAP was 80%, with an extra mortality of 47% (RR 2.42, 95% CI 0.9–6.5, $p = 0.0693$) (Table 4).

The LOS of patients without a DA-HAI was 4.9 days and the LOS of patients with VAP was 23.8 days (95% CI 10.5–73.3), yielding an extra LOS of 18.9 days (RR 4.9) (Table 5).

3.4.3. CAUTI

The CAUTI rate ranged from 4.1 to 10.4 per 1000 urinary catheter-days, with an overall rate in the two ICUs of 8.1 per 1000 urinary catheter-days (95% CI 6.5–10.0) (Table 2).

3.5. Overall microorganism profile

Overall, 34.5% of all DA-HAI were caused by *Escherichia coli*, 17.2% by *Klebsiella spp*, 17.2% by *Pseudomonas spp*, 17.2% by coagulase-negative staphylococci, 10.3% by *Acinetobacter spp*, and 3.4% by *Streptococcus pneumoniae* (Table 6).

4. Discussion

DA-HAIs pose a serious threat to patient safety, being among of the most serious causes of morbidity and attributable mortality in resource-limited countries. However, insufficient data are available from these settings in the developing world.[9–17,22–30] In addition, it has been reported that DA-HAIs are a primary cause of healthcare cost increases.[9,10,31,32] Nevertheless, according to several scientific studies carried out in the USA, which have included targeted device-associated surveillance in their infection control programs, it is possible to reduce the incidence of DA-HAIs by as much as 30%, resulting in a correlative reduction in healthcare costs.[2]

In a study conducted in 139 Cuban hospitals in 2004, the global HAI prevalence was 7.3% (95% CI 6.3–7.9), but since this represents the rate for the whole hospital, it is not comparable to our ICU rate.[33] In accordance with the results of another study from seven Cuban university hospitals, the ICU HAI rate per 100 patients was 16.4, which is lower than our present rate of 22.4%.[34]

The CLA-BSI rate was 2.0 (95% CI 1.2–3.1) per 1000 central line-days in this study, which is lower than the INICC reported rate (7.4 per 1000 central line-days, 95% CI 7.2–7.7), but similar to that of the NHSN: 1.5 (95% CI 1.4–1.6).

On the other hand, the VAP rate was higher in this study (52.5 per 1000 mechanical ventilator-days, 95% CI 47.2–58.3) than the one in the INICC report (14.7 per 1000 mechanical ventilator-days, 95% CI 14.2–15.2)[12] or in the NHSN (1.9 per 1000 mechanical ventilator-days, 95% CI 1.8–2.1). This may be explained by the considerable level of practice variation concerning mechanical ventilator care.[35,36] We found that the VAP rate in our trauma ICU was three times higher than that in our medical–surgical ICU; similarly in the NSHN report, VAP rates in the trauma ICU are three times higher than in the medical–surgical ICU.

The CAUTI rate was 8.1 per 1000 catheter-days in this study, which is slightly higher than the rate of 6.1 (95% CI 5.9–6.4) found in the INICC ICUs overall,[12] and significantly higher than the NHSN rate of 3.1 (95% CI 3.0–3.3).

Hand hygiene compliance was similar in this study to that found in the overall INICC ICUs: 48.6% (95% CI 42.8–54.3) vs. 54.0% (95% CI 53.6–54.4).[12]

The mortality of patients without a DA-HAI was higher in this study than in the overall INICC ICUs: 33.0% (95% CI 29.7–36.4) vs. 14.4% (95% CI 14.1–14.7),[12] which may be due to the greater severity of illness in these ICU patients. CLA-BSI and VAP mortality were similar in Cuba to those in the overall INICC ICUs.[12]

The average LOS for patients without a DA-HAI, for those with a CLA-BSI, and for those with VAP were similar in this study to those in the overall INICC ICUs.[12]

Different facts can be listed to explain these DA-HAI rates. Infection control guidelines on specific practices are not adhered to adequately, despite the presence of a national nosocomial infection prevention program in Cuba (PNPCIN) since 1983. Similarly, there is a lack of a regulatory legal framework on which to implement infection control programs, which is a relatively common fact in most developing countries, according to suggestions found in the scientific literature from resource-limited settings. However, in some developing countries where such regulations are actually in force, they are not properly applied either.[37,38]

Additionally, in Cuba, hand hygiene compliance is low in healthcare facilities, reflecting the general situation in other developing countries.[37,38] Furthermore, in Cuba, as in most developing countries, administrative and financial support is lacking, there are insufficient supplies, and wards are overcrowded, which almost inevitably results in limited funds and resource availability to deal with infection control.[39] Likewise, it is almost certain that the low nurse-to-patient staffing ratios also result in high healthcare-associated infection rates. In addition, there is an inadequate number of trained staff, which has been highly associated, together with low nurse-to-patient ratios and an inexperienced nurse service, with a greatly increased risk of DA-HAI.[40] Finally, in these settings, the use of antiquated technology may be another underlying factor of the high infection rates.To help reduce DA-HAI risk in hospitalized patients, the first measure is the implementation of DA-HAI surveillance.[2] The second effective and basic measure is to adopt infection control and preventive practices for DA-HAIs in hospitals.[41–44] It is noteworthy that disseminating knowledge and accurate information on the serious public health problem posed by device-associated infections in these hospital ICUs, can be highly motivating for developing successful high-quality infection control strategies. There is evidence suggesting positive modifications in hospital practices: hand hygiene compliance has substantially increased, performance feedback programs for hand hygiene have been instituted, and central line and urinary catheter care have shown a significantly reduced incidence of CLA-BSI, CAUTIs, and VAP in several of the hospital members of the INICC.[14,45–50]

This having been said, this study presents some limitations. First, the data may not be adequate to reflect a whole single country. During 3 years and 7 months, we prospectively collected data as an integral part of the implementation of a comprehensive surveillance system in two Cuban hospital ICUs. There is a likelihood that variations in the efficacy of surveillance and the different availability of institutional resources could have affected the determined rates; this poses the major limitation. Second, variations in DA-HAI rates among the INICC member hospitals, and between countries, result in significantly different severity of illness or, in most cases, in differences in efficacy of surveillance. Third, member hospital laboratories need to be relied upon in their identification of infecting pathogens and when delineating bacterial resistance patterns. This is a limitation in that different laboratories may have widely varying levels of expertise and resource availability; however, this can also be observed in any other multicenter clinical surveillance data. Finally, other severity illness scores, such as the acute physiology and chronic health evaluation (APACHE) score, were not applied because of the lack of resources to calculate more labor-intensive scores. Similar to other cohort studies, the hospitals initiated clinical surveillance at different time periods, and also their surveillance was suspended at different time points. This resulted in a lack of simultaneously collected data from the two hospitals enrolled in this study.

In conclusion, the fact that DA-HAIs pose a serious and largely under-recognized threat to patient safety in the developing countries is of crucial importance. Consequently, the improvement shown in INICC member hospitals elsewhere can provide healthcare professionals with simple, inexpensive, but effective, preventive strategies,[14,45–51] leading to increasing acceptance of infection control programs in all INICC member hospitals, and to substantial DA-HAI reductions, in particular, of those DA-HAIs that are acquired in the ICU. For that reason, as in the case of these Cuban hospitals, any hospital may participate in the INICC network, which was created as a result of the paramount need of developing countries to significantly prevent, control, and reduce DA-HAIs and their adverse consequences. In INICC, not only are investigators freely provided with training and methodological tools to conduct outcome and process surveillance, but through the publication of these confidentially collected data, relevant scientific evidence-based literature is fostered as well.

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