

Device-associated infection rates in pediatric and neonatal intensive care units in El Salvador: Findings of the INICC

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Abstract

Introduction: This study aimed to determine the rate of device-associated, health care-associated infection (DA-HAI), the excess in length of stay, the mortality, and the hand hygiene compliance in a pediatric intensive care unit (PICU) and a neonatal ICU (NICU) in a hospital member of the International Infection Control Consortium (INICC) in El Salvador.

Methodology: A prospective cohort, active DA-HAI surveillance study was conducted on patients admitted in the pediatric and neonatal ICUs from January 2007 to November 2009. The protocol and methodology implemented were developed by INICC. Data were collected in the participating ICUs, and analyzed at INICC headquarters by proprietary software. DA-HAI rates were recorded by applying the definitions of the Centers for Disease Control and Prevention National Healthcare Safety Network.

Results: Of 1,145 patients hospitalized in the PICU for 9,517 days, 177 acquired DA-HAIs (overall rate 15.5%), and 18.6 DA-HAIs per 1,000 ICU-days. Furthermore, 1,270 patients hospitalized in the NICU for 30,663 days acquired 302 DA-HAIs (overall rate 23.8%), and 9.8 DA-HAIs per 1,000 ICU-days. The central line-associated bloodstream infection (CLA-BSI) rates in the NICU and PICU were 9.9 and 10.0 per 1,000 catheter-days respectively. The ventilator-associated pneumonia (VAP) rate was 16.1 per 1,000 ventilator-days in the NICU and 12.1 in the PICU. The catheter-associated urinary tract infection (CAUTI) rate was 5.8 per 1,000 catheter-days in the PICU.

Conclusions: DA-HAI rates in the PICU and NICU of our hospital were higher than international standards; infection control programs including surveillance and antibiotic policies must be a priority in El Salvador.

Key words: health care-associated infection; nosocomial; intensive care unit; developing country; International Nosocomial Infection Control Consortium; INICC; mortality

J Infect Dev Ctries 2011; 5(6):445-451.

(Received 25 June 2010 – Accepted 13 March 2011)

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Introduction

In several high-income countries, device-associated health care-associated infection (DA-HAI) surveillance in the intensive care unit (ICU) plays a substantial role in infection control [1]. Surveillance was reported as an efficacious tool to reduce DA-HAIs by the Centers for Disease Control and Prevention (CDC) “Study of the Efficacy of Nosocomial Infection Control (SENIC Project)” [2].

DA-HAIs are considered a principal threat to patients and are among the main causes of patient mortality [3]. The CDC’s National Nosocomial Infection Surveillance System (NNIS) and National Healthcare Safety Network (NHSN) reported standardized criteria for DA-HAI surveillance [4]. This method allows for the determination of DA-HAI rates per 1,000 device-days. Most of the studies on ICU-acquired infections have been conducted in industrialized countries [5]. Few published studies

report data on DA-HAI rates using the standardized definitions for developing countries [6].

The INICC was founded in 1998 when selected hospitals from Latin America were invited to participate in a project measuring DA-HAIs using standardized definitions and methodology [7]. Today, the INICC comprises a network of approximately 400 ICUs from 40 countries of Latin America, Asia, Africa and Europe [6].

Health care facilities sent prospective routinely gathered data to the INICC on a monthly basis, which were then entered into an international database. There are no previously published data from El Salvador on DA-HAI rates. The data of the present study on El Salvador are part of the INICC database.

Methodology

Setting

Table 1. Features of the pediatric and neonatal Intensive Care Units Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador, 01/2007-11/2009

Variable	pediatric ICU	neonatal ICU	Overall
ICUs, <i>n</i>	1	1	
Patients studied, <i>n</i>	1,145	1,270	2,415
Total ICU days, <i>d</i>	9,517	30,663	40,180
Device use*			
Ventilator days, <i>d</i>	7,709	8,634	16,343
Ventilator use	0.81	0.28	0.41
Central line days, <i>d</i>	6,344	15,819	22,163
Central line use	0.67	0.52	0.55
Urinary catheter days, <i>d</i>	3,437	-	3,437
Urinary catheter use**	0.36	-	0.36

ICU: intensive care unit; *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, 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.

**Urinary catheter use was only calculated in the pediatric ICU.

The study was conducted in the neonatal ICU and the pediatric ICU of the academic hospital Nacional de Niños Benjamin Bloom of San Salvador, El Salvador, from January 2007 to November 2009. The hospital has a total of 386 beds: the NICU has 12 beds and the PICU has 20 beds. The hospital has an infection control team (ICT) with a physician and an infection control practitioner (ICP) with fifteen years of experience in infection control as well as a microbiology laboratory to provide *in-vitro* susceptibility testing of clinical isolates using standardized methods. The hospital Institutional Review Board agreed to the study protocol. Patient confidentiality was protected by codifying the recorded information, making it only identifiable to the ICT.

Surveillance

On a daily basis, data were collected prospectively from all the patients admitted in the ICUs. Data were gathered according to the CDC-NNIS and CDC-NHSN definitions for DA-HAI [4] and the methodology followed was as proposed by INICC [7].

Culture techniques

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 [8]. Concomitant blood cultures were drawn by venipuncture.

Ventilator-associated pneumonia (VAP): A deep tracheal aspirate from the endotracheal tube was cultured aerobically and gram-stained.

Catheter-associated urinary tract infection (CAUTI): A urine sample was aseptically aspirated from the sampling port of the urinary catheter and cultured quantitatively.

Standard laboratory methods were used to identify microorganisms, and a standardized susceptibility test was performed [9].

Definitions

Ventilator-associated pneumonia (VAP) was defined as infection in a mechanically ventilated patient with a chest radiograph with no new or progressive infiltrates, consolidation, cavitation, or pleural effusion. The patient had also to meet at least one of the following criteria: new onset of purulent sputum or change in character of sputum; organism cultured from blood; or isolation of an etiologic agent from a specimen obtained by tracheal aspirate, bronchial brushing or bronchoalveolar lavage, or biopsy.

Laboratory-confirmed central line-associated bloodstream infection (CLA-BSI): was defined as occurring when a patient with a central line had a recognized pathogen isolated from one or more blood cultures after 48 hours of vascular catheterization that was not related to an infection at another site. The patient also had at least one of the following signs or symptoms: fever (temperature ≥ 38 °C), chills, or hypotension. For skin commensals (i.e. diphtheroids,

Table 2. Device-associated infections per 1000 devices days: VAP, CLA-BSI, and CAUTI in pediatric and neonatal ICU, Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador, 01/2007-11/2009

ICU	Infection site	Device type	Device-days	DA-HAI	Distribution of device associated HAI (%)	Rate per 100 patients (%)	Rate per 1000 device-days*
PICU	VAP	MV	7,709	93	53	8.1	12.1 (95% CI 9.7 – 14.8)
	CLA-BSI	CL	6,344	64	36	5.6	10.1 (95% CI 7.8 – 12.8)
	CAUTI	UC	3,437	20	11	1.7	5.8 (95% CI 3.6 – 9.0)
NICU	VAP	MV	8,634	139	47	10.9	16.1 (95% CI 13.5 – 19.0)
	CLA-BSI	CL	15,819	157	53	12.4	9.9 (95% CI 8.4 – 11.6)

DA-HAI: device-associated health care-associated infection; ICU: intensive care unit; PICU: pediatric intensive care unit; NICU: neonatal intensive care unit; VAP: ventilator-associated pneumonia, CLA-BSI: central line associated blood stream infection; CAUTI: catheter-associated urinary tract infection; MV: mechanical ventilator; UC: urinary catheter.

* Rate per 1000 device –days: Rates were calculated by dividing the total number of DAIs by the total number of specific device-days by all of the patients in the selected population during the selected time period and multiplying the result by 1000.

Propionibacterium spp., coagulase-negative staphylococci), the organism had to be recovered from two or more blood cultures.

Clinically suspected sepsis (CSEP) was defined as occurring when a patient with a central line and a negative blood culture had at least one of the following clinical signs with no other recognized cause: fever (temperature ≥ 38 °C), hypotension (systolic blood pressure ≤ 90 mmHg), or oliguria (≤ 20 mL/h).

Catheter-associated urinary tract infection (CAUTI) was defined as occurring when one of the following two criteria were met. The first was satisfied when a patient with a urinary catheter had one or more of the following symptoms with no other recognized cause of infection: fever (temperature ≥ 38 °C), urgency, or suprapubic tenderness and a positive urine culture (equal or greater than 10^5 colony-forming units (CFU) per mL), with no more than two microorganisms isolated. The second was satisfied when a patient with a urinary catheter had the following criteria with no other recognized cause of infection: positive dipstick analysis for leukocyte esterase or nitrate and pyuria (≥ 10 leukocytes/mL).

Device associated infections rates calculation

DA-HAI rates of VAP, CLA-BSI, and CAUTI per 1,000 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 1,000 [10]. Device utilization (DU) ratios were calculated by dividing the total number of device-days by the total number of patient-days.

Length of stay (LOS) and mortality calculation

The extra LOS was the difference between the length of stay of patients with a DA-HAI and the length of stay of patients hospitalized in the ICU during that period who did not acquire a DA-HAI [7].

The crude excess 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 [7].

Hand hygiene compliance surveillance

Hand hygiene compliance by health care workers (HCW) at the ICU was monitored by the infection control practitioner (ICP) through a randomly selected one-hour observational period, done 3 times a week, during all working shifts and including all health care workers, according to a specific sequence set forth by the INICC protocol. The ICP recorded the opportunities for hand hygiene and compliance before contact with each patient on a specific surveillance form designed by INICC [7].

Statistical analysis

EpiInfo version 6.04b (CDC, Atlanta, GA, USA) and SPSS 16.0 (SPSS Inc. IBM, Chicago, IL, USA) were used to conduct data analysis. Chi square analysis for dichotomous variables and 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. P-values < 0.05 for two-sided tests were considered significant.

Table 3. Extra mortality of patients with device-associated nosocomial infections in the pediatric and neonatal ICUs, Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador, 01/2007-11/2009

ICU	Patient infection site	number of patients*	Crude Mortality	Extra Mortality (%)	RR	95% CI	P-value
PICU	no HAI, %	994	13.6%	-	1.0	11.5 – 15.9	
	CLA-BSI	40	25.0%	11.4	1.84	0.97 - 3.50	0.0586
	VAP	63	19.0%	5.5	1.4	0.78 - 2.53	0.2592
	CAUTI	11	18.2%	4.6	1.34	0.33 - 5.41	0.681
NICU	no HAI	962	12.3%	-	1.0		
	CLA-BSI	108	38.0%	25.7	3.09	2.17 - 4.42	0.0001
	VAP	100	23.0%	10.7	1.88	1.20 - 2.93	0.0050

ICU: intensive care unit; PICU: pediatric intensive care unit; NICU: neonatal intensive care unit; HAI: health care-associated infection; VAP: ventilator-associated pneumonia; CLA-BSI: central line-associated bloodstream infection; CAUTI: catheter-associated urinary tract infection.
* Patients with a single infection were only considered

Table 4. Extra length of stay of patients with device-associated nosocomial infections in the pediatric and neonatal ICUs, Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador, 01/2007-11/2009

ICU	Patient infection site*	Average Length of Stay	Extra Length of Stay	RR	95% CI
PICU	no HAI	6.2	-	6.2	5.8 - 6.5
	CLA-BSI	19.1	12.9	19.1	14.1 - 26.5
	VAP	18.6	12.4	18.6	11.8 - 24.0
	CAUTI	13.5	7.4	13.5	7.8 - 26.8
NICU	no HAI	16.7		16.7	15.7 - 17.8
	CLA-BSI	37.7	21.0	37.7	31.3 - 45.9
	VAP	42.3	25.5	42.3	34.8 - 51.9

ICU: intensive care unit; PICU: pediatric intensive care unit; NICU: neonatal intensive care unit; HAI: health care-associated infection; VAP: ventilator-associated pneumonia; CLA-BSI: central line-associated bloodstream infection; CAUTI: catheter-associated urinary tract infection.

Results

Features of population studied

Intensive care unit characteristics, number of patients enrolled in the study, total ICU-days, device use days, device utilization ratio per type of device, and number of patients enrolled in the study are shown in Table 1.

DH-HAI rates in the PIDU and NICU are presented in Table 2. CLA-BSI represented 36% of all DA-HAIs in the PICU and 53% in the NICU. VAP represented 53% in the PICU and 47% in the NICU. CAUTI represented 11% in the PICU (Table 2).

Hand hygiene compliance

The total number of hand hygiene opportunities observed was 438 in the NICU and 1,547 in the PICU.

Hand hygiene compliance rate was 60.3% (95% CI 55.5 – 64.9) in the NICU and 50.4% (95% CI 47.7 – 52.9) in the PICU.

DA-HAI rates, length of stay, and mortality

CLA-BSI, CAUTI and VAP rates as well as extra mortality are presented in table 3. Extra length of stay for PICU and NICU patients is shown in table 4.

Microorganism profiles

The microorganism profiles are shown in Table 5.

Table 5. Microorganism distribution in the participant ICUs, Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador, 01/2007-11/2009

Microorganism related to DA-HAI	CLA-BSI related (%)	VAP related (%)	CAUTI related (%)	Overall (%)
<i>Candida</i> sp.	37.5	0.0	36.3	28.0
<i>Pseudomonas</i> sp.	12.5	66.6	18.2	28.0
<i>Escherichia coli</i>	12.5	16.7	9.1	12.0
<i>Klebsiella</i> sp.	12.5	0.0	18.2	12.0
<i>Coagulase Negative Staphylococci</i>	25.0	0.0	9.1	12.0
<i>Acinetobacter</i> sp.	0.0	16.7	-	4.0
<i>Citrobacter</i> sp.	0.0	0.0	9.1	4.0

ICU: intensive care unit; CLA-BSI: central line-associated blood stream infection; VAP: ventilator-associated pneumonia; CAUTI: catheter-associated urinary tract infection.

Discussion

DA-HAIs have been a serious cause of patient attributable mortality in developing countries [6] and have also been a factor of the increase in health care costs [11]. This is the first study presenting DA-HAI rates in ICUs in El Salvador. The PICU CLA-BSI rate was 10.1 (95% CI 7.8 – 12.8) per 1,000 central line days in this study, which is higher than the INICC reported rate (7.8 per 1,000 central line days [95% CI 7.1 – 8.5]), [6] and higher than the NHSN reported rate of 3.1 (95% CI 2.5 – 3.8) [1]. The NICU CLA-BSI rate was 9.9 (95% CI 8.4 – 11.6) per 1,000 central line days in this study, which is lower than the INICC reported rate (13.9 per 1,000 central line days [95% CI 12.4 – 15.6]) [6] but higher than the NHSN reported rate of 2.9 (95% CI 2.8 – 3.0) [1]. The PICU VAP rate was 12.1 (95% CI 9.7 – 14.8) per 1,000 mechanical ventilator days in this study, which is lower than the INICC reported rate of 5.5 (per 1,000 mechanical ventilator days [95% CI 4.9 – 6.0]) [6] but higher than the NHSN reported rate of 1.8 (95% CI 1.6 – 2.1) [1]. The NICU VAP rate was 16.1 (95% CI 13.5 – 19.0) per 1,000 mechanical ventilator days in this study, which is significantly higher than the INICC reported rate (9.5 per 1,000 CL days [95% CI 7.9 – 11.3]) [6] and higher than the NHSN reported rate of 1.6 (95% CI 1.5 – 1.8) [1].

The overall hand hygiene compliance in the present study was similar to that in the overall INICC ICUs: 52.6% (95% CI 50.4 – 54.8) versus 54.1% (95% CI 53.6 – 54.4) [6].

The mortality of patients without DA-HAI in the PICU in this study was similar to that in the overall INICC ICUs: 13.6% (95% CI 11.5 – 15.9) versus 14.4% (95% CI 14.1 – 14.7) [6]. The mortality of

patients without DA-HAI in the NICU in this study was higher than that observed in the overall INICC NICUs: 12.3% (95% CI 10.3 – 14.5) versus 8.8% (95% CI 8.0 – 9.6) [6]. CLA-BSI mortality in the NICU in this study was similar to the overall INICC NICUs at 38.0% (95% CI 28.8 – 47.8) versus 27.1% (95% CI 18.9 – 36.6) [6].

The average length of stay for patients without DA-HAI, with CLA-BSI, and with VAP in the PICU of our hospital was similar to that in the overall INICC PICUs [6]. However, in this study the NICU LOS of patients without DA-HAI 16.7 (95% CI 15.7 – 17.8) was higher than that seen in the INICC NICUs: 11.1 (95% CI 10.8 – 11.4). The CLA-BSI and VAP LOS in the NICUs of this study (37.7 and 42.3 days respectively) was also higher than that observed in the INICC overall NICUs (33.3 and 27.3 days) [6].

There are several facts that can explain the DA-HAI rates shown in this study. First, in El Salvador, guidelines on specific infection control practices are not adhered to adequately, national infection control surveillance is not conducted, and hospital accreditation is not mandatory. Similarly, in accordance with explanations proposed in previous studies conducted in hospitals from developing countries, in most of these countries there is an absence of legal regulations regarding the implementation of infection control programs [12].

National infection control guidelines are not properly applied, and hand hygiene compliance is low in most health care facilities of El Salvador, reflecting the general situation in most developing countries [12]. As in most developing countries, administrative and financial support is lacking, which results in limited funds and resource availability to deal with infection control [13]. Finally, another

factor contributing to high infection rates is the use of antiquated technology.

The first step that would help reduce the DA-HAI risk in hospitalized patients is the institution of surveillance of DA-HAI [2]. Infection control practices need to be adopted to improve the prevention of DA-HAIs [14-16]. Evidence suggests that positive modifications in hospital practices have resulted in a significantly reduced incidence of CLA-BSI, CAUTI and VAP in several hospitals member of the INICC [17-23].

The present study presents limitations, the first of which is that these data may not be adequate to reflect a whole single country. Secondly, variations in DA-HAI rates among the INICC member hospitals result in significantly different levels of severity of illness. Thirdly, member hospitals' laboratories need to be relied upon in their identification of infecting pathogens and when delineating bacterial resistance patterns.

The improvement showed in INICC member hospitals elsewhere, provides health care personnel with simple, effective and inexpensive preventive strategies [17-23]. We expect that these results will lead to significant DA-HAI reductions occurring in the ICU. Any hospital may participate in the INICC network, which was created in an understanding of the paramount need from all countries worldwide to significantly prevent, control and reduce DA-HAI 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.

Acknowledgments

The authors would like to thank the health care professionals at member hospitals who assisted with the surveillance in their hospitals, including the surveillance nurses, the clinical microbiology laboratory personnel, and the physicians and nurses providing care for the patients during the study; the INICC country coordinators (Altaf Ahmed, Carlos A. Álvarez Moreno, Apisarntharak Anucha, Luis E. Cuéllar, Bijie Hu, Hakan Leblebicioglu, Eduardo A. Medeiros, Yatin Mehta, Lul Raka, Toshihiro Mitsuda, and Virgilio Bonilla Sanchez); and the INICC Advisory Board (Carla J. Alvarado, Gary L. French, Nicholas Graves, William R. Jarvis, Patricia Lynch, Dennis Maki, Russell N. Olmsted, Didier Pittet, Wing Hong Seto and William Rutala).

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Conflict of interests: No conflict of interests has been declared.