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Major article

International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module



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For a list of all the members of the International Nosocomial Infection Control Consortium and all the coauthors of this study, see the [Appendix](#).

Conflict of interest: None to report.

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Central line–associated bloodstream infections

Bloodstream infection

Urinary tract infection

Developing countries

Limited resources countries

Low income countries

Network

We report the results of an International Nosocomial Infection Control Consortium (INICC) surveillance study from January 2007–December 2012 in 503 intensive care units (ICUs) in Latin America, Asia, Africa, and Europe. During the 6-year study using the Centers for Disease Control and Prevention’s (CDC) U.S. National Healthcare Safety Network (NHSN) definitions for device-associated health care–associated infection (DA-HAI), we collected prospective data from 605,310 patients hospitalized in the INICC’s ICUs for an aggregate of 3,338,396 days. Although device utilization in the INICC’s ICUs was similar to that reported from ICUs in the U.S. in the CDC’s NHSN, rates of device-associated nosocomial infection were higher in the ICUs of the INICC hospitals: the pooled rate of central line–associated bloodstream infection in the INICC’s ICUs, 4.9 per 1,000 central line days, is nearly 5-fold higher than the 0.9 per 1,000 central line days reported from comparable U.S. ICUs. The overall rate of ventilator-associated pneumonia was also higher (16.8 vs 1.1 per 1,000 ventilator days) as was the rate of catheter-associated urinary tract infection (5.5 vs 1.3 per 1,000 catheter days). Frequencies of resistance of *Pseudomonas* isolates to amikacin (42.8% vs 10%) and imipenem (42.4% vs 26.1%) and *Klebsiella pneumoniae* isolates to ceftazidime (71.2% vs 28.8%) and imipenem (19.6% vs 12.8%) were also higher in the INICC’s ICUs compared with the ICUs of the CDC’s NHSN.

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This report is a summary of device-associated (DA) module data collected by hospitals participating in the International Nosocomial Infection Control Consortium (INICC) for events occurring from January 2007–December 2012 and reported to the INICC by December 31, 2013. This report updates previously published DA module data from the INICC and provides contemporary, comparative rates.^{1–5}

The INICC is an international nonprofit, open, multicenter, collaborative health care–associated infection control program with a surveillance system based on that of the U.S. Center for Diseases Control and Prevention’s (CDC) National Healthcare Safety Network (NHSN). Founded in Argentina in 1998, the INICC is the first multinational surveillance and research network established to measure, control, and reduce health care–associated infections (HAIs) through the analysis of data collected on a voluntary basis by a pool of hospitals worldwide. The INICC has the following goals: to create a dynamic global network of hospitals worldwide, which conduct surveillance on HAIs using standardized definitions and established methodologies, promote implementation of evidence-

based infection control practices, and carry out applied infection control research; to provide training and surveillance tools to individual hospitals, which can allow them to conduct outcome and process surveillance of HAIs, measure their consequences, and assess the impact of infection control practices^{6–22}; and to improve the safety and quality of health care worldwide through the implementation of systematized programs to reduce rates of HAI, associated mortality, excess lengths of stay (LOSs), excess costs, antibiotic use, and bacterial resistance.^{23–32} In 2013, the INICC switched to an online database platform, which is currently in use in 300 cities in 62 countries for data collection, data analysis, and report generation.

METHODS

Study setting and design

From January 2007–December 2012, we conducted a cohort prospective multicenter surveillance study of device-associated

health care–acquired infections (DA-HAIs) in 503 intensive care units (ICUs) in 43 countries from Latin America, Asia, Africa, and Europe currently participating in the INICC. The mean length of participation of hospitals in the INICC program \pm SD is 19.5 ± 17.7 months (range, 1–72 months).

The identity of all INICC patients, hospitals, cities, and countries is confidential, in accordance with the INICC charter.

INICC's surveillance program

The INICC has focused on surveillance and prevention of DA-HAIs in adult ICUs, pediatric ICUs, high-risk nurseries, general wards, and surveillance of surgical site infections (SSIs).^{1–5} The data are collected using standardized protocols from the CDC's NHSN and definitions that include laboratory and clinical criteria.^{33,34}

The INICC has both outcome surveillance and process surveillance components. The modules of the components may be used singly or simultaneously. However, once selected, they must be used for a minimum of 1 calendar month.³⁴

Within the outcome surveillance component, data are classified into specific module protocols addressing the following: HAI rates, excess LOS, evaluation of HAI costs, crude excess mortality, microbiological profile, bacterial resistance, and antimicrobial use data. Antimicrobial use, HAI cost, and SSI rates were not included in this report.

There were 263 hospitals with previous experience in surveillance of DA-HAIs who sent detailed data by patient (49%) and aggregated data (51%) to the INICC. Detailed data by patient and aggregated data were used to calculate DA-HAI rates. Only detailed data by patient were used to calculate mortality and LOS.

In addition, the methodology of the INICC includes a process for adjudication and validation of reported HAIs.³⁴

Infection control professionals collect data on central line–associated primary bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator-associated pneumonias (VAPs), and SSIs occurring in patients hospitalized in a specific patient care location in nearly all hospitals. For surveillance of DA-HAIs, ICUs are stratified according to the patient population: different types of adult ICUs, pediatric ICUs, or neonatal intensive care units (NICUs).

All NICUs are level III or level II and III units, and infection control professionals collect data on CLABSIs and umbilical catheter-associated primary bloodstream infections or VAPs for each of 5 birth-weight categories (<750, 750–1,000, 1,001–1,500, 1,501–2,500, >2,500 g). Corresponding denominator data, patient days, and specific device days are also collected.

The process surveillance component includes the following modules: hand hygiene compliance monitoring in ICUs, central vascular catheter care compliance monitoring, urinary catheter care compliance monitoring, monitoring of compliance with measures to prevent VAP, monitoring of compliance with measures to prevent SSI, and performance feedback. Data from the process surveillance compliance are not included in this report.

Data analysis

Data for ICUs were not stratified by type or size of hospital. For NICUs, device days consist of the total number of central line days, umbilical catheter days, and ventilator days. The data for NICUs were stratified by weight. Device days consisted of the total number of central line days, urinary catheter days, or ventilator days. Crude excess mortality of HAI equals the crude mortality of ICU patients with HAI minus the crude mortality of patients without HAI. Crude excess LOS of HAI equals the crude LOS of ICU patients with HAI minus the crude LOS of patients without HAI.

Table 1

International Nosocomial Infection Control Consortium facilities contributing data used in this report

Details	Africa	America	Asia	Europe	Overall
ICUs, type					
Medical	1	5	54	9	69
Medical cardiac	0	8	21	4	33
Medical and surgical	5	64	61	21	151
Neurologic	0	0	4	2	6
Neurosurgical	0	2	21	3	26
Pediatric	2	22	24	9	57
Respiratory	1	3	17	3	24
Surgical	1	5	46	8	60
Surgical cardiothoracic	0	0	28	3	31
Trauma	0	1	7	0	8
Neonatal	3	17	12	6	38
Total ICUs, n (%)	13 (3)	127 (25)	295 (59)	68 (14)	503 (100)
Hospitals, n (%)					
Academic teaching	6 (6)	24 (23)	46 (44)	29 (28)	105 (100)
Public	2 (2)	31 (37)	47 (57)	3 (4)	83 (100)
Private community	1 (1)	32 (43)	40 (53)	2 (3)	75 (100)
Total hospitals, n (%)	9 (3)	87 (33)	133 (51)	34 (13)	263 (100)

ICU, intensive care unit.

Comparisons of the percentile distribution were made if there were at least 20 locations contributing to the strata. SPSS version 16.0 (SPSS Inc, Chicago, IL) and EpiInfo 6.04b (Centers for Disease Control and Prevention, Atlanta, GA) were used to conduct data analysis. Relative risk ratios, 95% confidence intervals (CIs), and *P* values were determined for primary and secondary outcomes.

RESULTS

Characteristics of 503 ICUs that contributed data for this report are shown in [Table 1](#). For the outcome surveillance component, DA-HAI rates, device utilization (DU) ratios, crude excess mortality by specific type of DA-HAI, and bacterial resistance for January 2007–December 2012 are summarized in [Tables 2–15](#). [Tables 2–7](#) show DA-HAI rates and DU ratios by infection type (CLABSI, CAUTI, VAP) in adult and pediatric ICUs. [Tables 8–11](#) show DA-HAI rates and DU ratios from the high-risk nursery component of the INICC system for CLABSIs and VAP. The overall rate of CLABSI per 1,000 central line days in the adult and pediatric ICUs was 4.78 (95% CI, 4.7–4.9) and 5.17 (95% CI, 4.5–5.9) in the NICUs. The overall rate of VAP per 1,000 mechanical ventilator days was 14.7 (95% CI, 14.5–14.9) in the adult and pediatric ICUs and 9.54 (95% CI, 8.5–10.7) in the NICUs. The overall CAUTI rate per 1,000 catheter days was 5.30 (95% CI, 5.2–5.4) in the adult and pediatric ICUs. ([Tables 2, 4, 6, 8, 10](#)). [Table 12](#) provides data on crude ICU mortality and crude LOS in patients hospitalized in each type of unit during the surveillance period, with and without DA-HAI, and crude excess mortality and crude excess LOS of adult and pediatric patients with CLABSI, CAUTI, and VAP and infants in NICUs with CLABSI or VAP. [Table 13](#) provides data on bacterial resistance of pathogens isolated from patients with DA-HAI in adult and pediatric ICUs and NICUs and compares these rates with the ICUs of the CDC's NHSN. [Table 14](#) compares overall rates of CLABSI, CAUTI, and VAP in the INICC's ICUs and the ICUs of the CDC's NHSN. [Table 15](#) compares the results of the 5 different biennial INICC reports published from 2006–2014.

DISCUSSION

The effectiveness of implementing an integrated infection control program focused on HAI surveillance was demonstrated around 30 years ago as shown in the many studies conducted in the U.S., whose results reported not only that the incidence of HAI can

Table 2

Pooled means, 95% CIs, and key percentiles of the distribution of laboratory-confirmed CLABSI rates by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	No. of patients	No. of CLABSI	CL days	Pooled mean CLABSI rate	95% CI	Percentile				
							10%	25%	50%	75%	90%
Medical	69	84,642	1,043	225,427	4.63	4.4-4.9	0.0	0.0	2.55	7.27	18.04
Medical cardiac	33	42,054	312	89,998	3.47	3.1-3.9	0.0	0.0	1.97	3.97	8.26
Medical and surgical	151	285,654	3,990	809,754	4.93	4.8-5.1	0.0	0.86	3.31	7.90	17.01
Neurologic	6	6,060	85	13,329	6.38	5.1-7.9	NA	NA	NA	NA	NA
Neurosurgical	26	12,217	111	31,893	3.48	2.9-4.2	0.0	0.0	0.0	1.86	7.32
Pediatric	57	41,474	776	127,825	6.07	5.7-6.5	0.0	0.7	4.99	10.67	25.4
Respiratory	24	5,779	225	38,843	5.79	5.1-6.6	0.0	0.0	2.51	8.78	19.5
Surgical	60	75,041	1,214	212,885	5.70	5.4-6.0	0.0	0.0	2.41	6.81	18.02
Surgical cardiothoracic	31	31,468	87	85,554	1.02	0.8-1.3	0.0	0.0	0.0	1.10	3.2
Trauma	8	4,648	44	15,393	2.86	2.1-3.8	NA	NA	NA	NA	NA
Pooled	465	589,037	7,887	1,650,901	4.78	4.7-4.9	0.0	0.0	2.46	6.77	15.6

CI, confidence interval; CL, central line; CLABSI, central line-associated bloodstream infection; ICU, intensive care unit; NA, not applicable.

Table 3

Pooled means, 95% CIs, and key percentiles of the distribution of CL utilization ratios by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	CL days	Patient days	Pooled mean DUR	95% CI	Percentile				
						10%	25%	50%	75%	90%
Medical	69	225,427	481,037	0.47	0.47-0.47	0.23	0.33	0.53	0.79	1.00
Medical cardiac	33	89,998	154,625	0.58	0.58-0.58	0.11	0.35	0.55	0.85	1.00
Medical and surgical	151	809,754	1,488,318	0.54	0.54-0.54	0.21	0.42	0.59	0.83	1.00
Neurologic	6	13,329	41,254	0.32	0.32-0.33	NA	NA	NA	NA	NA
Neurosurgical	26	31,893	76,423	0.42	0.41-0.42	0.18	0.39	0.50	0.88	1.00
Pediatric	57	127,825	254,549	0.50	0.50-0.50	0.11	0.25	0.42	0.66	0.89
Respiratory	24	38,843	70,331	0.55	0.55-0.56	0.26	0.49	0.63	0.93	1.00
Surgical	60	212,885	422,365	0.50	0.50-0.51	0.34	0.42	0.61	0.76	0.91
Surgical cardiothoracic	31	85,554	122,525	0.70	0.70-0.70	0.34	0.45	0.73	0.93	1.00
Trauma	8	15,393	25,672	0.60	0.59-0.61	NA	NA	NA	NA	NA
Pooled	465	1,650,901	3,137,099	0.53	0.53-0.53	0.21	0.38	0.56	0.81	1.00

CI, confidence interval; CL, central line; DUR, device use ratio; ICU, intensive care unit; NA, not applicable.

Table 4

Pooled means, 95% CIs, and key percentiles of the distribution of CAUTI rates by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	No. of patients	No. of CAUTIs	UC days	Pooled mean CAUTI rate	95% CI	Percentile				
							10%	25%	50%	75%	90%
Medical	69	84,642	1,530	342,724	4.46	4.2-4.7	0.00	0.00	2.07	7.19	14.00
Medical cardiac	33	42,054	506	86,410	5.86	5.4-6.4	0.00	0.00	0.64	3.35	10.96
Medical and surgical	151	285,654	4,914	921,015	5.34	5.2-5.5	0.00	1.11	3.08	7.74	14.29
Neurologic	6	6,060	583	36,463	15.99	14.7-17.3	NA	NA	NA	NA	NA
Neurosurgical	26	12,217	422	59,480	7.09	6.4-7.8	0.00	0.00	0.00	5.16	14.90
Pediatric	57	41,474	447	79,832	5.60	5.1-6.1	0.00	0.00	2.28	6.83	11.97
Respiratory	24	5,779	369	39,556	9.33	8.4-10.3	0.00	0.00	7.15	18.15	22.99
Surgical	60	75,041	1,333	283,415	4.70	4.5-5.0	0.00	0.00	2.04	5.88	11.54
Surgical cardiothoracic	31	31,468	103	79,865	1.29	1.1-1.6	0.00	0.00	0.00	0.64	4.4
Trauma	8	4,648	115	18,890	6.09	5.0-7.3	NA	NA	NA	NA	NA
Pooled	465	589,037	10,322	1,947,650	5.30	5.2-5.4	0.00	0.00	2.29	6.86	13.9

CAUTI, catheter-associated urinary tract infection; CI, confidence interval; ICU, intensive care unit; NA, not applicable; UC, urinary catheter.

be reduced by as much as 30% but that a related reduction in health care costs was also feasible.³⁵ For >30 years, the CDC's National Nosocomial Infections Surveillance System and NHSN network has provided benchmarking U.S. ICU data on DA-HAIs and antibiotic resistance, which have proven invaluable for researchers³⁶ and served as an inspiration to the INICC program. Initially, the INICC's surveillance concentrated on DA-HAI surveillance in the ICU: a health care setting with the highest DA-HAI rates in which patients' safety is most seriously threatened because of their critical condition and exposure to invasive devices; however, since 2006, it also focuses on SSI surveillance.³⁴

The DU ratio constitutes an extrinsic risk factor for DA-HAI³⁷ and is also a marker for the severity of illness of patients and vis-à-vis

patients' susceptibility to DA-HAI.³⁷ However, our findings show that although the rate of device use in the INICC's ICUs is analogous or even lower to the one reported in the ICUs of the CDC's NHSN system, DA-HAI rates identified in the INICC's ICUs are higher than the published U.S. rates (Table 14).³⁸ Likewise, the antimicrobial resistance rates found in the INICC's ICUs for *Staphylococcus aureus* isolates resistant to methicillin; *Enterococcus faecalis* resistant to vancomycin; *Klebsiella pneumoniae* resistant to ceftriaxone, ceftazidime, imipenem, and meropenem; *Pseudomonas aeruginosa* resistant to piperacillin and tazobactam, amikacin, and cefepime; and *Escherichia coli* resistant to ceftriaxone, ceftazidime, imipenem, meropenem, and ertapenem were higher than the NHSN's rates (Table 13).³⁹ Nonetheless, the rates found in the INICC's ICUs for

Table 5
Pooled means, 95% CIs, and key percentiles of the distribution of UC utilization ratios by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	UC days	Patient days	Pooled mean DUR	95% CI	Percentile				
						10%	25%	50%	75%	90%
Medical	69	342,724	481,037	0.71	0.71-0.72	0.31	0.49	0.74	0.90	0.98
Medical cardiac	33	86,410	154,625	0.56	0.56-0.56	0.23	0.44	0.64	0.74	0.96
Medical and surgical	151	921,015	1,488,318	0.62	0.62-0.62	0.35	0.54	0.73	0.90	0.99
Neurologic	6	36,463	41,254	0.88	0.88-0.89	NA	NA	NA	NA	NA
Neurosurgical	26	59,480	76,423	0.78	0.78-0.78	0.34	0.61	0.85	0.97	1.00
Pediatric	57	79,832	254,549	0.31	0.31-0.32	0.07	0.15	0.32	0.48	0.61
Respiratory	24	39,556	70,331	0.56	0.56-0.57	0.22	0.52	0.66	0.87	0.96
Surgical	60	283,415	422,365	0.67	0.67-0.67	0.37	0.68	0.82	0.93	1.00
Surgical cardiothoracic	31	79,865	122,525	0.65	0.65-0.65	0.38	0.52	0.77	0.93	1.00
Trauma	8	18,890	25,672	0.74	0.73-0.74	NA	NA	NA	NA	NA
Pooled	465	1,947,650	3,137,099	0.62	0.62-0.62	0.24	0.47	0.72	0.90	0.99

CI, confidence interval; DUR, device use ratio; ICU, intensive care unit; NA, not applicable; UC, urinary catheter.

Table 6
Pooled means, 95% CIs, and key percentiles of the distribution of VAP rates by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	No. of patients	No. of VAP	Ventilator days	Pooled mean VAP rate	95% CI	Percentile				
							10%	25%	50%	75%	90%
Medical	69	84,642	2,794	225,750	12.4	11.9-12.8	0.00	3.24	10.16	27.9	38.52
Medical cardiac	33	42,054	519	45,276	11.5	10.5-12.5	0.00	0.00	7.39	13.68	26.72
Medical and surgical	151	285,654	8,832	536,024	16.5	16.1-16.8	0.00	5.93	12.23	24.94	39.27
Neurologic	6	6,060	193	9,674	20.0	17.2-23.0	NA	NA	NA	NA	NA
Neurosurgical	26	12,217	472	22,683	20.8	19.0-22.8	0.00	0.00	4.66	25.63	119.8
Pediatric	57	41,474	1,060	134,560	7.9	7.4-8.4	0.00	1.23	6.06	13.43	20.74
Respiratory	24	5,779	773	33,895	22.8	21.2-24.5	0.00	0.00	16.33	35.23	62.99
Surgical	60	75,041	2,156	138,034	15.6	15.0-16.3	0.00	3.47	15.19	30.43	44.16
Surgical cardiothoracic	31	31,468	410	38,414	10.7	9.7-11.8	0.00	0.00	2.03	32.84	52.41
Trauma	8	4,648	396	13,371	29.6	26.8-32.7	NA	NA	NA	NA	NA
Pooled	465	589,037	17,605	1,197,681	14.7	14.5-14.9	0.00	2.48	10.67	23.74	40.01

CI, confidence interval; ICU, intensive care unit; NA, not applicable; VAP, ventilator-associated pneumonia.

Table 7
Pooled means, 95% CIs, and key percentiles of the distribution of ventilator utilization ratios by type of location in adult and pediatric ICUs for the device-associated module, 2007-2012

Type of ICU	No. of ICUs	Ventilator days	Patient days	Pooled mean DUR	95% CI	Percentile				
						10%	25%	50%	75%	90%
Medical	69	225,750	481,037	0.47	0.47-0.47	0.08	0.21	0.42	0.69	0.94
Medical cardiac	33	45,276	154,625	0.29	0.29-0.30	0.05	0.14	0.32	0.43	0.51
Medical and surgical	151	536,024	1,488,318	0.36	0.36-0.36	0.14	0.27	0.45	0.62	0.80
Neurologic	6	9,674	41,254	0.23	0.23-0.24	NA	NA	NA	NA	NA
Neurosurgical	26	22,683	76,423	0.30	0.29-0.30	0.02	0.15	0.30	0.49	0.76
Pediatric	57	134,560	254,549	0.53	0.53-0.53	0.10	0.30	0.47	0.61	0.74
Respiratory	24	33,895	70,331	0.48	0.48-0.49	0.14	0.35	0.45	0.73	0.84
Surgical	60	138,034	422,365	0.33	0.33-0.33	0.05	0.13	0.34	0.52	0.71
Surgical cardiothoracic	31	38,414	122,525	0.31	0.31-0.32	0.00	0.05	0.22	0.46	0.64
Trauma	8	13,371	25,672	0.52	0.51-0.53	NA	NA	NA	NA	NA
Pooled	465	1,197,681	3,137,099	0.38	0.38-0.38	0.21	0.38	0.57	0.82	1.00

CI, confidence interval; DUR, device use ratio; ICU, intensive care unit; NA, not applicable.

Table 8
Pooled means, 95% CIs, and key percentiles of the distribution of CLABSI rates for level III neonatal ICUs for the device-associated module, 2007-2012

Birth weight category, kg	No. of ICUs	No. of patients	No. of CLABSI	Central line days	Pooled mean CLABSI rate	95% CI	Percentile				
							10%	25%	50%	75%	90%
<0.750	17	268	7	1,744	4.01	1.6-8.3	0.0	0.0	0.0	8.3	33.3
0.750-1.000	31	1,295	60	8,493	7.06	5.4-9.1	0.0	0.0	0.0	8.9	23.0
1.001-1.500	36	2,408	65	12,435	5.23	4.0-6.7	0.0	0.0	0.0	11.3	28.5
1.501-2.500	37	5,849	67	13,923	4.81	3.7-6.1	0.0	0.0	3.8	11.6	35.9
>2.500	37	6,453	45	10,563	4.26	3.1-5.7	0.0	0.0	0.0	8.0	17.7
Pooled	38	16,273	244	47,158	5.17	4.5-5.9	0.0	0.0	0.0	9.5	25.0

CI, confidence interval; CLASBI, central line-associated bloodstream infection; ICU, intensive care unit.

Acinetobacter baumannii resistance to imipenem and meropenem are similar to the rates of the ICUs of the NHSN.³⁹

Such higher DA-HAI rates, in comparison with the U.S. CDC-NHSN report, may reflect the typical hospital situation in other countries

worldwide as a whole.⁴⁰ Several reasons have been exposed to explain this fact.^{41,42} Among the primary plausible causes, in some countries, there are still no legally enforceable regulations for the implementation of infection control programs (eg, national infection

Table 9

Pooled means, 95% CIs, and key percentiles of the distribution of CL utilization ratios for level III neonatal ICUs for the device-associated module, 2007-2012

Birth weight category, kg	No. of ICUs	CL days	Patient days	Pooled mean DUR	95% CI	Percentile				
						10%	25%	50%	75%	90%
<0.750	17	1,744	4,496	0.39	0.37-0.40	0.00	0.00	0.33	0.81	1.02
0.750-1.000	31	8,493	23,847	0.36	0.35-0.36	0.00	0.09	0.38	0.66	1.00
1.001-1.500	36	12,435	46,880	0.27	0.26-0.27	0.00	0.05	0.21	0.43	0.94
1.501-2.500	37	13,923	67,030	0.21	0.20-0.21	0.00	0.05	0.13	0.46	0.84
>2.500	37	10,563	59,044	0.18	0.18-0.18	0.01	0.07	0.13	0.43	0.74
Pooled	38	47,158	201,297	0.23	0.23-0.24	0.00	0.05	0.17	0.55	0.93

CI, confidence interval; CL, central line; DUR, device use ratio; ICU, intensive care unit.

Table 10

Pooled means, 95% CIs, and key percentiles of the distribution of VAP rates for level III neonatal ICUs for the device-associated module, 2007-2012

Birth weight category, kg	No. of ICUs	No. of patients	No. of VAP	Ventilator days	Pooled mean VAP rate	95% CI	Percentile				
							10%	25%	50%	75%	90%
<0.750	17	268	10	2,057	4.86	2.3-8.9	0.0	0.0	0.0	2.1	11.1
0.750-1.000	31	1,295	56	6,398	8.75	6.6-11.4	0.0	0.0	1.2	14.6	30.0
1.001-1.500	36	2,408	47	5,523	8.51	6.3-11.3	0.0	0.0	0.0	9.5	20.9
1.501-2.500	37	5,849	74	6,915	10.70	8.4-13.4	0.0	0.0	0.0	7.2	23.1
>2.500	37	6,453	95	8,681	10.94	8.9-13.4	0.0	0.0	0.0	8.8	20.0
Pooled	38	16,273	282	29,574	9.54	8.5-10.7	0.0	0.0	0.0	9.3	19.0

CI, confidence interval; ICU, intensive care unit; VAP, ventilator-associated pneumonia.

Table 11

Pooled means, 95% CIs, and key percentiles of the distribution of ventilator utilization ratios for level III neonatal ICUs for the device-associated module, 2007-2012

Birth weight category, kg	No. of ICUs	Ventilator days	Patient days	Pooled mean DUR	95% CI	Percentile				
						10%	25%	50%	75%	90%
<0.750	17	2,057	4,496	0.46	0.44-0.47	0.00	0.09	0.47	0.77	1.00
0.750-1.000	31	6,398	23,847	0.27	0.26-0.27	0.00	0.08	0.22	0.49	0.90
1.001-1.500	36	5,523	46,880	0.12	0.11-0.12	0.00	0.07	0.12	0.21	0.38
1.501-2.500	37	6,915	67,030	0.10	0.10-0.11	0.00	0.03	0.10	0.23	0.48
>2.500	37	8,681	59,044	0.15	0.14-0.15	0.01	0.06	0.11	0.32	0.37
Pooled	38	29,574	201,297	0.15	0.15-0.15	0.00	0.06	0.13	0.36	0.63

CI, confidence interval; DUR, device use ratio; ICU, intensive care unit.

Table 12

Pooled means of the distribution of crude mortality, crude excess mortality, LOS, and crude excess LOS of ICU patients with and without DA-HAI in adult and pediatric ICUs combined and infants in level III neonatal ICUs for the device-associated module, 2007-2012

ICU Patients	No. of deaths	No. of patients	Pooled crude mortality, %	Pooled crude extra mortality, %, RR (95% CI), P value	LOS, total days	Pooled average LOS, days, (95% CI)	Pooled average extra LOS, days
Adult and pediatric patients without DA-HAI	10,237	129,518	7.9	NA	790,579	6.10, (6.07-6.13)	NA
Infants at level III neonatal ICUs without DA-HAI	464	7,447	6.2	NA	80,080	10.75, (10.53-10.99)	NA
Adult and pediatric patients with CLABSI	301	1,209	24.9	17.0, 3.15 (2.8-3.5), .001	23,543	19.47, (18.44-20.59)	13.37
Infants at level III neonatal ICUs with CLABSI	9	51	17.6	11.4, 2.83 (1.46-5.48), .012	1,184	23.22, (17.78-31.03)	12.46
Adult and pediatric patients with VAP	821	3,513	23.4	15.5, 2.96 (2.7-3.2), .001	69,066	19.66, (19.04-20.31)	13.56
Infants at level III neonatal ICUs with VAP	35	178	19.7	13.4, 3.16 (2.24-4.45), .001	6,378	35.83, (31.01-41.67)	25.08
Adult and pediatric patients with CAUTI	160	1,202	13.3	5.4, 1.68 (1.4-1.9), .001	24,384	20.29, (19.23-21.46)	14.18

CAUTI, catheter-associated urinary tract infection; CI, confidence interval; CLABSI, central line-associated bloodstream infection; DA-HAI, device-associated health care-associated infection; LOS, length of stay; NA, not applicable; RR, relative risk; VAP, ventilator-associated pneumonia.

control guidelines); however, if there is a legal framework, adherence to and compliance with the guidelines can be irregular, and hospital accreditation is not mandatory in some countries. It is especially risky in cases with extremely low nurse-to-patient staffing ratios, which have proved to be highly connected to high HAI rates, hospital overcrowding, lack of medical supplies, and in an insufficient number of experienced nurses or trained health care workers.^{41,42} Of the

hospitals that participated in this study, 29% are private institutions that enjoy accreditation and sufficient administrative and financial support to fund infection control programs (eg, INICC's multidimensional approach).⁴³⁻⁵³

There has recently been much progress in health care in most countries, where new technologies have been introduced and official regulations support infection control programs.⁴³⁻⁵³ This

Table 13
Antimicrobial resistance rates in the ICUs of the INICC Consortium and comparison of antimicrobial resistance rates (%) in the ICUs of the INICC with the U.S. NHSN

Pathogen, antimicrobial	No. of pathogenic isolates tested at INICC's ICUs, pooled (VAP)	Resistance percentage at INICC's ICUs, % (VAP)	No. of pathogenic isolates tested at INICC's ICUs, pooled (CAUTI)	Resistance percentage at INICC's ICUs, % (CAUTI)	No. of pathogenic isolates tested at INICC's ICUs, pooled (CLABSI)	Resistance percentage at INICC's ICUs, % (CLABSI)	Resistance percentage at CDC's NHSN ICUs, % (CLABSI)
<i>Staphylococcus aureus</i>							
OXA	266	62.0	11	36.4	196	61.2	54.6
<i>Enterococcus faecalis</i>							
VAN	49	6.1	91	9.9	123	12.2	9.5
<i>Pseudomonas aeruginosa</i>							
FQs	1,132	41.9	148	49.3	264	37.5	30.5
PIP or TZP	1,903	35.8	246	37.0	525	33.5	17.4
AMK	1,233	36.2	153	43.8	290	42.8	10.0
IPM or MEM	1,925	42.8	278	33.5	472	42.4	26.1
FEP	252	59.1	31	58.1	45	51.1	26.1
<i>Klebsiella pneumoniae</i>							
CRO or CAZ	1,023	62.6	269	68.4	514	71.2	28.8
IPM, MEM, or ETP	1,190	17.2	346	13.9	638	19.6	12.8
<i>Acinetobacter baumannii</i>							
IPM or MEM	1,963	77.1	127	67.7	526	66.3	62.6
<i>Escherichia coli</i>							
CRO or CAZ	504	61.5	505	63.0	305	65.9	19.0
IPM, MEM, or ETP	615	7.5	647	5.1	342	8.5	1.9
FQs	391	64.5	373	70.0	215	69.3	41.8

AMK, amikacin; CAUTI, catheter-associated urinary tract infection; CAZ, ceftazidime; CDC, Centers for Disease Control and Prevention; CLABSI, central line-associated bloodstream infection; CRO, ceftriaxone; ETP, ertapenem; FEP, cefepime; FQ, fluoroquinolone (ciprofloxacin, levofloxacin, moxifloxacin, ofloxacin); ICU, intensive care unit; INICC, International Nosocomial Infection Control Consortium; IPM, imipenem; MEM, meropenem; NHSN, National Healthcare Safety Network; OXA, oxacillin; PIP, piperacillin; TZP, piperacillin and tazobactam; VAN, vancomycin; VAP, ventilator-associated pneumonia.

new trend in health care already had a positive impact on DA-HAI and SSI rates in several countries. There is a significant trend toward the reduction of CLABSI, CAUTI, and VAP rates and bacterial resistance in comparing the INICC's reports from 2006, 2008, 2010, and 2012 with this report as shown in Tables 13 and 14. However, this trend has not yet been seen in the cases of pediatric ICUs.

According to the World Bank, countries are categorized into 4 economic strata based on 2012 gross national income per capita: low income ($\leq \$1,035$), lower middle income ($\$1,036-\$4,085$), upper middle income ($\$4,086-\$12,615$), and high income ($\geq \$12,616$).⁵⁴ Within this categorization, 144 out of 209 (68%) countries are low income and lower middle income economies (which can also be referred to as lower income countries, low resource countries, developing economies, or developing or emerging countries), which represent >75% of the world population. The relation between the HAI rates and their association to the type of hospital (public, academic, private) and the relation between HAI rates and the country's socioeconomic level (defined as low income, mid-low income, high income) have been analyzed and published by the INICC.^{55,56} Such studies' findings showed that a country's higher socioeconomic level was correlated with a lower infection risk.^{55,56} The results of one such study showed that in pediatric ICUs, lower middle income countries had statistically significantly higher CLABSI, CAUTI, and VAP rates than upper middle income countries (12.2 vs 5.5 CLABSIs, 5.9 vs 0.6 CAUTIs, 9.0 vs 0.5 VAPs per 1,000 device days.), and hand hygiene compliance rates were higher in public than academic or private hospitals (65.2% vs 54.8% [$P < .001$] vs 13.3% [$P < .01$]).⁵⁶ Similarly, in NICU patients, CLABSI rates were significantly higher in low income countries than in lower middle income countries or upper middle income countries (37.0 vs 11.9 [$P < .02$] vs 17.6 [$P < .05$]) CLABSIs per 1,000 catheter days, respectively.⁵⁵ VAP rates in NICU patients were significantly higher in lower middle income countries than upper middle income countries (3.8 vs 6.7 per 1,000 device days). When examined by hospital type, overall crude mortality for NICU patients without DA-HAIs was significantly higher in academic and public hospitals than in private hospitals (5.8% vs 12.5%; $P < .001$). In contrast, NICU patient mortality among those

Table 14

Comparison of device-associated health care-associated infection rates per 1,000 device days in the ICUs of the INICC (2007-2012) and the U.S. NHSN (2012)

DA-HAI per Type of ICU	INICC 2007-2012 pooled mean (95% CI)	U.S. NHSN 2012 pooled mean (95% CI)
Medical cardiac ICU		
CLABSI	3.5 (3.1-3.9)	1.1 (1.0-1.1)
CAUTI	5.9 (5.4-6.4)	2.2 (2.0-2.3)
VAP	11.5 (10.5-12.5)	1.0 (0.8-1.1)
Medical and surgical ICU		
CLABSI	4.9 (4.8-5.1)	0.9 (0.9-1.0)
CAUTI	5.3 (5.2-5.8)	1.2 (1.2-1.3)
VAP	16.5 (16.1-16.8)	1.1 (1.0-1.2)
Pediatric ICU		
CLABSI	6.1 (5.7-6.5)	1.4 (1.3-1.6)
CAUTI	5.6 (5.1-6.1)	2.7 (2.5-3.0)
VAP	7.9 (7.4-8.4)	0.8 (0.6-0.9)
Newborn ICU (1,501-2,500 g)		
CLABSI	4.8 (3.7-6.1)	0.6 (0.5-0.8)
VAP	10.7 (8.4-13.4)	0.2 (0.1-0.5)

CAUTI, catheter-associated urinary tract infection; CI, confidence interval; CLABSI, central line-associated bloodstream infection; DA-HAI, device-associated health-care-associated infection; ICU, intensive care unit; INICC, International Nosocomial Infection Control Consortium; NHSN, National Healthcare Safety Network; VAP, ventilator-associated pneumonia.

with DA-HAIs was not different regardless of hospital type or the country's socioeconomic level.⁵⁵

In order to reduce the hospitalized patients' risk of infection, HAI surveillance is primary and essential because it effectively describes and addresses the importance and characteristics of the threatening situation created by HAIs. This must be followed by the implementation of practices aimed at HAI prevention and control. Additionally, participation in the INICC has played a fundamental role, not only in increasing the awareness of risks of HAI in the INICC's ICUs and SSI, but also in providing an exemplary basis for the institution of infection control practices. In many INICC's ICUs, the high incidence of DA-HAI has been reduced by carrying out a multidimensional approach, including

Table 15

Comparison of device-associated health care-associated infection rates per 1,000 device days in the ICUs of the INICC as published in the 2006, 2008, 2010, 2012, and 2014 reports

Details	INICC 2002-2005 (published in 2006) pooled mean (95% CI)	INICC 2002-2007 (published in 2008) pooled mean (95% CI)	INICC 2003-2008 (published in 2010) pooled mean (95% CI)	INICC 2004-2009 (published in 2012) pooled mean (95% CI)	INICC 2007-2012 (this report) pooled mean (95% CI)
No. of countries	8	18	25	36	43
Participating countries	Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru, Turkey	Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, El Salvador, Turkey, Uruguay	Argentina, Brazil, China, Colombia, Costa Rica, Cuba, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, El Salvador, Thailand, Tunisia, Turkey, Venezuela, Uruguay	Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, El Salvador, Saudi Arabia, Singapore, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Vietnam, Venezuela, Uruguay	Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, India, Iran, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Romania, El Salvador, Saudi Arabia, Serbia, Singapore, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam
No. of ICUs	55	98	173	422	503
Medical cardiac ICU					
CLABSI	NA	9.9 (8.7-11.3)	8.5 (7.5-9.7)	6.2 (5.6-6.9)	3.5 (3.1-3.9)
CAUTI	NA	6.4 (5.3-7.7)	4.4 (3.5-5.3)	3.7 (3.2-4.3)	5.9 (5.4-6.4)
VAP	NA	20.2 (17.0-23.9)	14.9 (12.4-17.9)	10.8 (9.5-12.3)	11.5 (10.5-12.5)
Medical and surgical ICU					
CLABSI	NA	8.9 (8.4-9.4)	7.4 (7.2-7.7)	6.8 (6.6-7.1)	4.9 (4.8-5.1)
CAUTI	NA	6.6 (6.2-7.0)	6.1 (5.9-6.4)	7.1 (6.9-7.4)	5.3 (5.2-5.8)
VAP	NA	19.8 (14.2-27.1)	14.7 (14.2-15.2)	18.4 (17.9-18.8)	16.5 (16.1-16.8)
Pediatric ICU					
CLABSI	NA	6.9 (5.6-8.3)	7.8 (7.1-8.5)	4.6 (3.7-5.6)	6.1 (5.7-6.5)
CAUTI	NA	4.0 (2.4-6.2)	4.4 (3.6-5.4)	4.7 (4.1-5.5)	5.6 (5.1-6.1)
VAP	NA	7.9 (6.0-10.1)	5.5 (4.9-6.0)	6.5 (5.9-7.1)	7.9 (7.4-8.4)
Newborn ICU (1,501-2,500 g)					
CLABSI	NA	15.2 (10.3-21.5)	13.9 (12.4-15.6)	11.9 (10.2-13.9)	4.8 (3.7-6.1)
VAP	NA	6.68 (3.0-12.7)	9.50 (7.9-11.3)	10.1 (7.9-12.8)	10.7 (8.4-13.4)
Overall					
CLABSI	12.5 (11.7-13.3)	9.2 (8.8-9.7)	7.6 (7.4-7.9)	6.8 (6.7-7.0)	4.8 (4.7-4.9)
CAUTI	8.9 (8.3-9.5)	6.5 (6.1-6.9)	6.3 (6.0-6.5)	6.3 (6.2-6.5)	5.3 (5.2-5.4)
VAP	24.1 (22.8-25.5)	19.5 (18.7-20.3)	13.6 (13.3-14.0)	15.8 (15.5-16.1)	14.7 (14.5-14.9)

CAUTI, catheter-associated urinary tract infections; CI, confidence interval; CLABSI, central line-associated bloodstream infection; ICU, intensive care unit; INICC, International Nosocomial Infection Control Consortium; NA, not applicable; VAP, ventilator-associated pneumonia.

a bundle of infection control interventions; education; outcome surveillance of CLABSI, VAP, CAUTI, and SSI; process surveillance for hand hygiene, central line, ventilator, and urinary catheter care; feedback of HAI rates; and performance feedback.^{23-31,43-53} Finally, control of antibiotic resistance mandates more restrictive use of anti-infectives in addition to effective nosocomial infection control.

During the last 4 decades, the CDC's NHSN has been the only source available to provide a basis for comparison of infection rates with hospitals worldwide. Comparing the hospital rates of the CDC in the U.S. with those of hospitals from Western Europe and Oceania is considered valid because of their similar socioeconomic conditions. In contrast, the comparison between the hospital rates of the CDC and those of hospitals with limited resources (or with sufficient available resources but without enough experience in the field of infection control) may not be adequate. On the one hand, U.S. hospitals enjoy >50 years of

unrivaled experience in infection control and surveillance, sufficient human and medical supply resources availability, and a comprehensive legal framework backing infection control programs, including mandatory surveillance and hospital accreditation policies. Such background can easily result in significantly lower HAI rates for the CDC's hospitals and hospitals from high income countries in contrast with hospitals from developing economies or with insufficient resources and experience in infection control. Within this context, the INICC emerged 15 years ago as an alternative valid and fair benchmarking tool for HAI rates in hospitals worldwide because of their shared socioeconomic hospital backgrounds.

To compare a hospital's DA-HAI rates and DU ratios with the rates identified in this report, it is required that the hospital concerned start collecting their data by applying the methods and methodology described for the CDC's NHSN and INICC and then calculate infection rates and DU ratios for the DA 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 locally to help reduce DA-HAI rates at the minimum possible level.

Finally, it is to be highlighted that although DA-HAIs in our ICU patients continue to be higher than the rates reported in NSHN reports, representing the developed world, we have verified a significant trend toward the reduction of DA-HAI rates in the adult ICUs of the INICC. Therefore, it is the INICC's main goal to continue enhancing infection control practices worldwide by facilitating basic 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 a correlated reduction in DA-HAI and its adverse effects in every health care facility.

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