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Major Article

International Nosocomial Infection Control Consortium (INICC) report, data summary of 45 countries for 2012-2017: Device-associated module

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Author contributions: V.D.R. was responsible for study conception and design, drafting of the manuscript, software development, technical support, report generation, data validation, data assembly, data interpretation, epidemiologic, and statistical analysis. All authors were involved in provision of study patients, critical revision of the manuscript for important intellectual content, and final approval of the manuscript.

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Hospital infection
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Background: We report the results of International Nosocomial Infection Control Consortium (INICC) surveillance study from January 2012 to December 2017 in 523 intensive care units (ICUs) in 45 countries from Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific.
Methods: During the 6-year study period, prospective data from 532,483 ICU patients hospitalized in 242 hospitals, for an aggregate of 2,197,304 patient days, were collected through the INICC Surveillance Online System (ISOS). The Centers for Disease Control and Prevention-National Healthcare Safety Network (CDC-NHSN) definitions for device-associated health care–associated infection (DA-HAI) were applied.
Results: Although device use in INICC ICUs was similar to that reported from CDC-NHSN ICUs, DA-HAI rates were higher in the INICC ICUs: in the medical-surgical ICUs, the pooled central line-associated bloodstream infection rate was higher (5.05 vs 0.8 per 1,000 central line-days); the ventilator-associated pneumonia rate was also higher (14.1 vs 0.9 per 1,000 ventilator-days,), as well as the rate of catheter-associated urinary tract infection (5.1 vs 1.7 per 1,000 catheter-days). From blood cultures samples, frequencies of resistance, such as of *Pseudomonas aeruginosa* to piperacillin-tazobactam (33.0% vs 18.3%), were also higher.
Conclusions: Despite a significant trend toward the reduction in INICC ICUs, DA-HAI rates are still much higher compared with CDC-NHSN's ICUs representing the developed world. It is INICC's main goal to provide basic and cost-effective resources, through the INICC Surveillance Online System to tackle the burden of DA-HAIs effectively.

The International Nosocomial Infection Control Consortium (INICC) was the first multinational health care–associated infection (HAI) research network established for the prevention and control of HAIs worldwide.[1] Its main goals include the promotion of evidence-based infection control and prevention practices to reduce the incidence of HAIs and their associated mortality, bacterial resistance, excess length of stay (LOS) and costs.[2]

More than 40 years ago, the Centers for Disease Control and Prevention (CDC) published the first HAI rates report,[3] using standardized methods and definitions.[4, 5] Since 2002, INICC HAI rates reports have adopted the CDC's definitions and criteria,[5, 6] and obtained accurate, validated, and comparative HAI rates from hospitals worldwide. According to standard CDC/National Healthcare and Safety Network (NHSN) methods,[5, 6] HAI denominators are device days collected from all patients, as pooled data, without specification of each patient's characteristics nor of the number of device days related to such a patient. INICC surveillance is conducted through an online platform, named INICC Surveillance Online System (ISOS),[7-12] which includes CDC's methods, but adds the collection of specific data per patient from *all* patients, both those with and those without HAI, as well as their particular HAI risk factors, such as invasive devices, high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS, and mortality. Data of all patients admitted to the intensive care unit (ICU), whether infected or non-infected, allows their matching by several characteristics, serving to the purposes of estimating other adverse events associated to HAIs, such as excess LOS, mortality, cost, and the cost-effectiveness of interventions.[1, 2] In addition, these data increase the awareness and sensitivity of infection preventionists to detect HAIs and, therefore, avoid rate underreporting.[1, 2]

This INICC report provides updated data on device-associated HAI (DA-HAI) rates, device utilization (DU), bacterial resistance, LOS, and mortality of patients, with and without DA-HAI, in adult and pediatric ICUs, and neonatal ICUs (NICUs).[1, 2] This is a summary of the DA module data of events occurring from January 1, 2012 to December 31, 2017, which updates previously published, comparative rates.[13-18]

METHODS

The DA module data were collected using the ISOS platform,[2] which applies CDC/NHSN's latest criteria and reported methods for calculation of HAI rates and DU ratios, and DA-HAI definitions that include laboratory and clinical criteria.[5, 6] For this report, definitions of HAI used during surveillance were those published by CDC in 2008,[5] and their subsequent updates, until 2017.[19]

This report includes ventilator-associated pneumonia (VAP) rates for adults, and for pediatric and neonatal units, because from 2012-2015, the adult INICC units did not yet apply the definition of ventilator- associated event (VAE).

Denominator data, patient days, and specific device days were collected and validated using the ISOS platform.[2] Detailed data by patient and aggregated data were used to calculate central line-associated bloodstream infections (CLABSIs), VAP, and catheter-associated urinary tract infection (CAUTI) rates, DU ratio, microbiological profile, and bacterial resistance. LOS and mortality were calculated using detailed data by patient only.

The INICC methods include adjudication and validation of reported DA-HAIs, through which daily data collection of invasive devices are checked, for denominators, and the fulfillment of CDC/NHSN criteria of DA-HAIs in each case of DA-HAI are checked for numerators.[1, 2]

Infection preventionists (IPs) collected data on DA-HAIs occurring in all patients admitted to the ICU. Data of adult and pediatric ICUs were stratified by ICU type. Data for NICUs (level III or level II/III units) were stratified by the following weight categories: <750 kg, 750-1,000 kg, 1,001-1,500 kg, 1,501-2,500 kg, and >2,500 kg. In NICUs, IPs collected data on CLABSIs and umbilical catheter-associated primary bloodstream infections (BSIs) or VAPs for each of the birth-weight categories.

Follow-up of patients

To estimate DA-HAI rates and excess mortality, all patients were followed for more than 15 days, after step-down from the ICU.

Data analysis

SPSS software version 16.0 (IBM Corporation, Chicago, IL), ISOS (Buenos Aires, Argentina),[2] and EpiInfo version 6.04b (CDC, Atlanta, GA) were used for data analysis. The 95% confidence intervals (CI) were determined for primary and secondary outcomes. Percentile distribution comparisons were made with a minimum of 20 locations contributing to the strata. Data for ICUs were not stratified by type or size of hospital.

RESULTS

From January 1, 2012, to December 31, 2017, we conducted a multicenter prospective cohort surveillance study of DA-HAIs in 523 ICUs in 242 hospitals in 45 countries from Latin America, Europe, Eastern Mediterranean, South East Asia, and Western Pacific World Health Organization regions, currently participating in INICC. Of all the hospitals, 30% were academic, 27% were public, and the remaining 43% were private. As stated in the INICC charter, the identity of patients and hospitals are kept confidential.

The length of participation of hospitals in INICC ranged from 3-72 months (mean, 10; SD, 17.2).

Table 1 shows types of ICU and percentage of type of hospital ownerships that contributed data to this report stratified by regions: Africa (3%), Latin America (27%), Eastern Mediterranean (20%), Europe (15%), South East Asia (30%), and Western Pacific (5%). Regarding type of ownership, 30% were academic teaching hospitals, 27% were private community hospitals, and 43% were public hospitals.

Table 2 shows DA-HAI rates by infection type of adult and pediatric patients with CLABSI, CAUTI, and VAP, and patients in NICUs with CLABSI or VAP.

Table 3 shows DURs from adult, pediatric, and NICUs. The CL DUR in pooled adult and pediatric ICUs was 0.58 (CI, 0.57-0.58), and in pooled NICUs, it was 0.29 (CI, 0.29-0.29.) Mechanical ventilator DUR in pooled adult and pediatric ICUs was 0.37 (CI, 0.37-0.37), and in pooled NICUs, it was 0.23 (CI, 0.23-0.23.) Urinary catheter DUR in pooled adult and pediatric ICUs was 0.60 (CI, 0.60-0.60).

Table 4 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 of adult and pediatric patients with CLABSI, CAUTI, and VAP, and infants in NICUs, with CLABSI or VAP.

Table 5 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, in accordance with the summary of data reported for 2011-2014.[20]

Table 6 compares pooled rates of CLABSI, CAUTI, and VAP in the INICC and the CDC's NHSN ICUs.

Table 1
INICC facilities contributing data used in this report per World Health Organization region

Facility	Africa	Latin America	Eastern Mediterranean	Europe	South East Asia	Western Pacific	Pooled
ICUs, type							
Surgical cardiothoracic	1	4	1	6	9	0	21
Medical cardiac	0	14	10	2	12	2	40
Medical	5	11	17	7	29	3	72
Medical/surgical	2	61	35	30	44	11	183
Neonatal	3	22	20	6	17	2	70
Neuro surgical	0	3	2	4	8	3	20
Neurologic	0	1	0	1	5	0	7
Oncology	0	1	2	0	0	0	3
Pediatric	2	19	11	9	11	5	57
Respiratory	0	2	0	3	1	0	6
Surgical	3	3	4	10	15	2	37
Trauma	0	2	2	0	3	0	7
Total ICUs, n (%)	16 (3%)	143 (27%)	104 (20%)	78 (15%)	154 (30%)	28 (5%)	523 (100%)
Hospitals							
Academic teaching, n (%)	3 (75%)	12 (17%)	11 (20%)	35 (85.4%)	6 (10%)	5 (33%)	72 (30%)
Public, n (%)	0 (0%)	19 (27%)	37 (66%)	2 (4.8%)	4 (7%)	4 (33%)	66 (27%)
Private community, n (%)	1 (25%)	39 (56%)	8 (14%)	4 (9.8%)	48 (83%)	4 (33%)	104 (43%)
Total Hospitals, n	4	70	56	41	58	13	242

ICU, intensive care unit; INICC,

Table 2
Pooled means, 95% confidence intervals and key percentiles of the distribution of central line-associated BSI rates and ventilator-associated PNEU rates by type of location, in adult, pediatric, and neonatal intensive care units, and of urinary catheter-associated UTI rates, by type of location, in adult and pediatric intensive care units, DA module, 2012-2017

Central line-associated BSI rate								Percentile*				
Type of ICU	N° of ICUs	No. of patients	No. of CLABSIs	Central line days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	22,979	169	76,729	2.20	1.8	2.6	0.0	0.0	0.9	2.5	5.2
Medical Cardiac	40	44,526	439	86,395	5.08	4.6	5.6	0.0	0.0	0.6	4.3	18.0
Medical	72	38,313	642	143,716	4.47	4.1	4.8	0.0	0.0	3.8	9.3	30.6
Medical/Surgical	185	304,958	6,140	1,216,897	5.05	4.9	5.2	0.0	0.7	3.6	9.4	24.8
Neuro Surgical	20	15,949	197	44,466	4.43	3.8	5.1	0.0	1.1	3.9	7.9	11.4
Neurologic	7	1,901	15	5,883	2.55	1.4	4.2	0.0	0.0	0.0	6.1	-
Oncology	3	832	44	2,998	14.68	10.7	19.7	1.6	1.6	15.6	-	-
Pediatric	57	27,486	975	135,543	7.19	6.7	7.7	0.0	0.0	3.5	7.5	23.5
Respiratory	6	2,139	54	21,843	2.47	1.9	3.2	0.0	0.9	4.4	13.5	-
Surgical	37	29,654	424	81,013	5.23	4.7	5.6	0.0	0.0	2.5	10.9	35.2
Trauma	7	10,260	151	27,614	5.47	4.6	6.4	0.0	0.0	10.1	12.6	-
Pooled (Adult and Pediatric ICUs)	455	498,997	9,250	1,843,097	5.02	4.9	5.1	0.0	0.0	3.1	8.7	21.1

NICU Birth weight category, Kg						95% CI		Percentile			
< 750 kg	70	1,739	137	7,468	18.3	15.4	21.7	0.0	0.0	3.6	36.5	71.4
751–1,000 kg	70	2,442	255	17,553	14.5	12.8	16.4	0.0	0.0	0.0	24.7	70.2
1,001- 1,500 kg	70	10,223	566	36,978	15.3	14.1	16.6	0.0	0.0	0.0	21.3	47.4
1,501 – 2,500 kg	70	9,492	156	20,310	7.7	6.5	9.0	0.0	0.0	0.0	4.6	46.5
> 2,500 kg	70	9,981	180	19,376	9.3	8.0	10.8	0.0	0.0	0.0	0.0	36.6
Pooled (NICUs)	70	33,877	1,294	101,685	12.7	12.0	13.4	0.0	0.0	0.0	15.9	52.6

Ventilator-associated PNEU rate							Percentile				
ICU type	No. of ICUs	No. of patients	No. of VAPs	Ventilator days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	22,979	288	39,073	7.4	6.5	8.3	0.0	0.0	1.6	10.8	14.7
Medical Cardiac	40	44,526	735	41,409	17.7	16.5	19.1	0.0	0.0	10.1	20.7	37.5
Medical	72	38,313	1,192	93,867	12.7	12.0	13.4	0.0	0.0	6.6	20.9	42.2
Medical/surgical	185	304,958	10,882	771,025	14.1	13.8	14.4	0.0	3.2	11.7	24.2	41.8
Neuro surgical	20	15,949	450	32,987	13.6	12.4	15.0	0.0	2.3	13.4	33.0	51.2
Neurologic	7	1,901	31	2,243	13.8	9.4	19.6	0.0	0.0	0.0	17.6	—
Oncology	3	832	13	1,574	8.3	4.4	14.1	0.0	0.0	0.0	—	—
Pediatric	57	27,486	1,356	114,845	11.8	11.2	12.5	0.0	0.0	4.6	11.9	29.4
Respiratory	6	2,139	207	19,356	10.7	9.3	12.3	8.5	10.8	16.9	40.2	—
Surgical	37	29,654	566	41,767	13.6	12.5	14.7	0.0	0.0	7.1	17.6	72.4
Trauma	7	10,260	379	35,460	10.7	9.6	11.8	0.0	8.5	27.5	32.4	—
Pooled (adult and pediatric ICUs)	455	498,997	16,099	1,193,606	13.5	13.3	13.7	0.0	0.0	8.4	21.7	39.0

NICU. Birth-weight category, Kg						95% CI		Percentile			
<0.750	70	1,739	26	7,807	3.3	2.2	4.9	0.0	0.0	0.0	0.0	14.2
0.750-1.000	70	2,442	62	12,582	4.9	3.8	6.3	0.0	0.0	0.0	0.0	24.3
1.001-1.500	70	10,223	298	22,650	13.2	11.7	14.7	0.0	0.0	0.0	16.3	48.8
1.501-2.500	70	9,492	114	17,728	6.4	5.3	7.7	0.0	0.0	0.0	0.0	30.4
>2.500	70	9,981	112	20,534	5.5	4.5	6.6	0.0	0.0	0.0	0.0	25.6
Pooled (NICUs)	70	33,877	612	81,301	7.5	6.9	8.1	0.0	0.0	0.0	2.1	31.2

Urinary catheter-associated UTI rate							Percentile				
ICU type	No. of ICUs	No of patients	No. of CAUTIs	Urinary catheter days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	22,979	148	65,836	2.2	1.9	2.6	0.0	0.0	0.3	2.4	6.2
Medical Cardiac	40	44,526	344	79,539	4.3	3.8	4.8	0.0	0.0	1.0	4.4	8.5
Medical	72	38,313	729	165,930	4.4	4.1	4.7	0.0	0.0	1.1	7.2	16.1
Medical/Surgical	185	304,958	6,527	1,274,202	5.1	5.0	5.2	0.0	1.0	3.0	7.0	15.1
Neuro Surgical	20	15,949	337	73,508	4.6	4.1	5.1	0.0	1.0	2.8	11.3	16.9
Neurologic	7	1,901	56	9,395	6.0	4.5	7.7	0.0	0.0	1.4	3.3	—
Oncology	3	832	9	3,441	2.6	1.2	5.0	0.7	0.7	9.4	—	—
Pediatric	57	27,486	425	80,782	5.3	4.8	5.8	0.0	0.0	0.0	5.1	20.5
Respiratory	6	2,139	155	23,132	6.7	5.7	7.8	0.0	3.2	6.1	11.2	—
Surgical	37	29,654	329	94,577	3.5	3.1	3.9	0.0	0.0	3.2	9.1	47.3
Trauma	7	10,260	153	43,622	3.5	3.0	4.1	0.0	0.0	3.3	6.9	-
Pooled (adult and pediatric ICUs)	455	498,997	9,212	1,913,964	4.8	4.7	4.9	0.0	0.0	2.4	6.5	14.7

ICU, intensive care unit; *NICU*, Neonatal intensive care unit; *CLABSI*, central-line associated bloodstream infection; *CL*, central line; *BSI*, bloodstream infection; *VAP*, ventilator-associated pneumonia; *PNEU*, pneumonia, *CAUTI*, catheter-associated urinary tract infection; *DA*, device-associated; *CI*, confidence interval.
**Percentile distribution comparisons were made with a minimum of 20 locations contributing to the strata.*

For CLABSI rates and CAUTI rates in adult and pediatric ICUs, we compared INICC rates with those from the CDC's NHSN report with data of 2013.[21] For VAP rates in pediatric ICUs and NICUs, we also compared INICC rates with those from the CDC's NHSN report with data of 2013.[21] But, only for VAP rates in adult ICUs, we compared rates with CDC's NHSN report with data of 2012, because this study period covers 2012-2017, and in 2012 the VAE definition criteria was not being used.[22]

Table 3
Pooled means, 95% confidence intervals, and key percentiles of the distribution of central line utilization ratios, and ventilator utilization ratios by type of location, in adult, pediatric, and neonatal intensive care units, and of urinary catheter utilization ratios, by type of location, in adult and pediatric intensive care units, DA module, 2012-2017

Central line utilization ratio							Percentile				
ICU Type	No. of ICUs	Central line days	Patient days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	76,729	76,336	1.01	0.9	1.01	0.3	0.7	0.9	1.2	1.5
Medical cardiac	40	86,395	355,575	0.24	0.24	0.24	0.1	0.2	0.3	0.6	0.8
Medical	72	143,716	374,411	0.38	0.38	0.39	0.1	0.3	0.5	0.7	0.9
Medical/surgical	185	1,216,897	1,870,390	0.65	0.65	0.65	0.2	0.3	0.6	0.9	1.1
Neuro surgical	20	44,466	89,881	0.49	0.49	0.50	0.1	0.2	0.4	0.7	0.8
Neurologic	7	5,883	12,925	0.46	0.44	0.47	0.0	0.2	0.5	0.7	—
Oncology	3	2,998	4,328	0.69	0.67	0.72	0.6	0.6	0.9	—	—
Pediatric	57	135,543	210,935	0.64	0.64	0.65	0.0	0.2	0.4	0.8	1.1
Respiratory	6	21,843	27,624	0.79	0.78	0.80	0.3	0.6	0.8	1.2	—
Surgical	37	81,013	118,523	0.68	0.68	0.69	0.2	0.4	0.6	0.8	1.0
Trauma	7	27,614	55,548	0.50	0.49	0.50	0.2	0.2	0.5	0.6	—
Pooled (adult and pediatric ICUs)	455	1,843,097	3,196,476	0.58	0.57	0.58	0.1	0.3	0.5	0.8	1.1
NICU, Birth-weight category, Kg							Percentile				
< 750 kg	70	16,435	7,468	0.45	0.44	0.46	0.0	0.1	0.44	0.77	1.0
751-1,000 kg	70	39,578	17,553	0.44	0.43	0.45	0.0	0.14	0.43	0.74	1.0
1,001-1,500 kg	70	111,732	36,978	0.33	0.32	0.33	0.0	0.03	0.24	0.53	0.77
1,501-2,500 kg	70	97,378	20,310	0.21	0.21	0.21	0.0	0.0	0.09	0.28	0.5
> 2,500 kg	70	89,084	19,376	0.22	0.21	0.22	0.0	0.0	0.11	0.29	0.46
Pooled (NICUs)	70	354,207	101,685	0.29	0.29	0.29	0.0	0.02	0.2	0.49	0.77
Mechanical ventilator utilization ratio							Percentile				
ICU type	No. of ICUs	Ventilator days	Patient days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	39,073	76,336	0.51	0.51	0.52	0.05	0.20	0.33	0.42	0.65
Medical cardiac	40	41,409	355,575	0.12	0.12	0.12	0.06	0.07	0.16	0.29	0.46
Medical	72	93,867	374,411	0.25	0.25	0.25	0.07	0.15	0.35	0.49	0.68
Medical/surgical	185	771,025	1,870,390	0.41	0.41	0.41	0.11	0.23	0.39	0.60	0.74
Neuro surgical	20	32,987	89,881	0.37	0.36	0.37	0.11	0.24	0.32	0.51	0.83
Neurologic	7	2,243	12,925	0.17	0.17	0.18	0.09	0.16	0.26	0.40	—
Oncology	3	1,574	4,328	0.36	0.35	0.38	0.0	0.0	0.32	—	—
Pediatric	57	114,845	210,935	0.54	0.54	0.55	0.15	0.32	0.45	0.55	0.67
Respiratory	6	19,356	27,624	0.70	0.69	0.71	0.18	0.34	0.68	0.79	0.92
Surgical	37	41,767	118,523	0.35	0.35	0.36	0.03	0.08	0.25	0.52	0.68
Trauma	7	35,460	55,548	0.64	0.63	0.65	0.06	0.08	0.25	0.57	—
Pooled (Adult and pediatric ICUs)	455	1,193,606	3,196,476	0.37	0.37	0.37	0.07	0.18	0.36	0.53	0.70
NICU Birth-weight category, Kg							Percentile				
<0.750	70	16,435	7,807	0.48	0.46	0.49	0.05	0.33	0.59	0.88	1.0
0.750-1.000	70	39,578	12,582	0.32	0.31	0.32	0.0	0.13	0.32	0.54	0.89
1.001-1.500	70	111,732	22,650	0.20	0.20	0.21	0.0	0.02	0.11	0.31	0.53
1.501-2.500	70	97,378	17,728	0.18	0.18	0.18	0.0	0.03	0.08	0.20	0.38
>2.500	70	89084	20,534	0.23	0.23	0.23	0.0	0.04	0.14	0.8	0.46
Pooled (NICUs)	70	354,207	81,301	0.23	0.23	0.23	0.0	0.01	0.15	0.38	0.64
Urinary catheter utilization ratio							Percentile				
ICU type	No. of ICUs	Urinary catheter days	Patient days	Pooled mean	95% CI		10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	21	65,836	76,336	0.86	0.86	0.86	0.18	0.43	0.69	0.90	0.99
Medical cardiac	40	79,539	355,575	0.22	0.22	0.23	0.28	0.49	0.84	0.95	1.0
Medical	72	165,93	374,411	0.44	0.44	0.44	0.11	0.26	0.43	0.63	0.85
Medical/surgical	185	1,274,202	1,870,390	0.68	0.68	0.68	0.23	0.44	0.71	0.87	0.99
Neuro surgical	20	73,508	89,881	0.82	0.82	0.82	0.28	0.54	0.75	0.92	0.99
Neurologic	7	9,395	12,925	0.73	0.72	0.73	0.04	0.39	0.85	0.93	—
Oncology	3	3,441	4,328	0.80	0.78	0.81	0.07	0.07	0.81	—	—
Pediatric	57	80,782	210,935	0.38	0.38	0.39	0.03	0.17	0.34	0.49	0.76
Respiratory	6	23,132	27,624	0.84	0.83	0.84	0.71	0.88	0.99	1.0	—
Surgical	37	94,577	118,523	0.80	0.80	0.80	0.24	0.55	0.78	0.94	1.0
Trauma	7	43,622	55,548	0.79	0.78	0.79	0.24	0.30	0.80	0.93	—
Pooled (Adult and pediatric ICUs)	455	1,913,964	3,196,476	0.60	0.60	0.60	0.18	0.43	0.69	0.90	0.99

CI, confidence interval; *ICU*, intensive care unit; *NICU*, neonatal intensive care unit.

DISCUSSION

In this report, the DU ratios identified in INICC ICUs are similar or even lower to the DU reported of US ICUs by the CDC's NHSN system; however, all DA-HAI rates found in INICC ICUs are higher than in US ICU rates.[21]

The antimicrobial resistance rates identified in INICC ICUs in blood samples for isolates of *Staphylococcus aureus*, *Pseudomonas,* and

Table 4
Pooled means of the distribution of crude mortality and length of stay of intensive care unit patients with device-associated health care–associated infections, adult, pediatric intensive care units combined, and infants in neonatal intensive care units, DA module, 2012-2017

	No. of deaths	No. of patients	Pooled crude mortality, % (95% CI)	LOS, total days	Pooled average LOS, days, (95% CI)
Adult and pediatric patients, without DA-HAI	23,682	175,538	13.5%	1,432,638	8.16
Infants at level III neonatal intensive care units, without DA-HAI	1,448	15,199	9.5%	199.737	13.1
Adult and pediatric patients, with CLABSI	1,039	2,500	41.6%	43,958	17.6
Infants at level III neonatal intensive care units, with CLABSI	167	522	32.0%	20,885	40.0
Adult and pediatric patients, with VAP	1,907	5,208	36.6%	91,933	17.6
Infants at level III neonatal intensive care units, with VAP	40	155	25.8%	6,757	43.6
Adult and pediatric patients, with CAUTI	563	2,162	26.0%	38,312	17.7

CAUTI, catheter-associated urinary tract infection; *CI*, confidence interval; *CLABSI*, central line-associated bloodstream infection; DA, device-associated; *DA-HAI*, device-associated health care–associated infection; *LOS*, length of stay; RR, relative risk; *VAP*, ventilator-associated pneumonia. .

Table 5
Antimicrobial resistance rates in the intensive care units of the International Nosocomial Infection Control Consortium, and comparison of antimicrobial resistance rates (%) in the intensive care units of the International Nosocomial Infection Control Consortium and the U.S. National Healthcare Safety Network

Pathogen, antimicrobial	*No. of pathogenic isolated tested at INICC ICUs, pooled* (VAP)	*Resistance percentage at INICC ICUs, %* (VAP)	*No. of pathogenic isolated tested at INICC ICUs, pooled* (CAUTI)	*Resistance percentage at INICC ICUs, %* (CAUTI)	*No. of pathogenic isolated tested at INICC ICUs, pooled* (CLABSI)	*Resistance percentage at INICC ICUs, %* (CLABSI)	*Resistance percentage at CDC NSHN ICUs, %* (CLABSI)
Staphylococcus aureus							
OXA	141	41.8	7	57.1	51	64.7	50.7
Enterococcus faecalis							
VAN	12	16.7	54	5.6	27	18.5	9.8
Pseudomonas aeruginosa							
FQs	436	34.6	87	40.2	110	20.0	30.2
PIP or TZP	367	39.2	68	38.2	91	33.0	18.4
AMK	446	24.7%	82	26.8%	112	21.4%	10.0%
IPM or MEM	426	39.4%	89	39.3%	92	43.48%	26.1%
FEP	304	40.5%	54	48.1%	60	41.67%	26.1%
Klebsiella pneumonia							
CRO or CAZ	393	72.8%	130	82.3%	191	67.54%	28.8%
IPM, MEM or ETP	445	37.3%	153	33.3%	205	36.10%	12.8%
Acinetobacter baumanii							
IPM or MEM	677	92.8%	73	80.8%	128	73.44%	62.6%
Escherichia Coli							
CRO or CAZ	102	57.8%	242	68.6%	85	52.94%	19.0%
IPM, MEM or ETP	115	7.0%	243	7.8%	81	8.64%	1.9%
FQs	108	53.7	269	55.0	81	49.38	49.3

CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; AMK, amikacin; FEP, cefepime; CRO, ceftriaxone; ETP, ertapenem; FQs, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin, or ofloxacin); IPM, imipenem; MEM, meropenem; OXA, oxacillin; PIP, piperacillin; TZP, piperacillin-tazobactam; CAZ, ceftazidime; VAN, vancomycin.

Enterococcus faecalis were higher than the CDC's NHSN rates identified in the last published report 2011-2014.[20] Whereas the resistance rates found in the INICC ICUs for *Pseudomonas* to fluoroquinolones were lower, and for *Escherichia coli* were similar to the percentages found by CDC's NHSN.[20]

Such higher DA-HAI rates, in comparison with the last CDC's NHSN report, may be representative of the burden of DA-HAIs in other countries, particularly in resource-limited ones.[23] There are different underlying reasons that can explain this adverse situation,[24, 25] such as lower compliance rates with the guidelines, low nurse-to-patient staffing ratios, over-crowding in ICUs, insufficient medical supplies, outdated technology, and lack of trained and experienced health care workers.[23-25] In addition, HAI rates have also been connected to the type of hospital ownership (public, academic, and private), and the country's socioeconomic level.[26, 27] Moreover, it has been reported in the literature that there is a correlation between a lower infection risk and a higher country socioeconomic level.[26, 27]

Benchmarks have long played a key role in aiding researchers to have standardized, comparable surveillance measures, and so benchmarking to US ICU data on DA-HAIs with international data has served as a fundamental tool for HAI preventionists worldwide.[2] The INICC started conducting prospective, standardized HAI surveillance in 1998,[1, 2] and was inspired in the former National Nosocomial Infections Surveillance (NNIS) 2004 system,[3] and thereafter, in the CDC's NHSN reporting methods to provide unbiased, reliable, and comparable benchmarking data.[22]

INICC's main objective is to tackle the HAI burden effectively and systematically worldwide by facilitating education, training, and basic and cost-effective tools and resources in resource-limited countries.[1, 2] According to the World Bank income classification of economies into 4 groups (high, upper-middle, lower-middle, and low), the countries where the participating hospitals are located in the regions of Africa (3%), Latin America (27%), Eastern Mediterranean (20%), Europe (15%), South East Asia (30%), and Western Pacific (5%) are low, lower-middle, and upper-middle income economies. This allows for an adequate comparison and benchmarking tool for HAI rates in hospitals with analogous socio-economic situations, in contrast with the situation of high income countries.[28] In those hospitals with limited-resources or insufficient availability of experienced IPs, the comparison with the CDC-NHSN's ICUs may not be valid. [15-17] Through the publication of the different INICC reports since 2006,[13-18] we have observed that, despite INICC ICUs have higher DA-HAI rates in comparison with CDC-NHSN's ICUs, there has been a trend towards their reduction through the implementation of the INICC Multidimensional Approach (IMA) and the INICC Surveillance Online System (ISOS). The IMA includes: bundles of DA-HAI prevention practice

Table 6
Comparison of device-associated health care–associated infection rates, per 1,000 device-days in the intensive care units of the International Nosocomial Infection Control Consortium (2012-2017) and the National Healthcare Safety Network (2012)

	CLABSI rate		VAP rate		CAUTI rate	
ICU type	INICC 2012-2017 Pooled mean (95% CI)	US NHSN 2013 Pooled mean (95% CI)	INICC 2012-2017 Pooled mean (95% CI)	US NHSN 2012* / 2013** Pooled Mean (95% CI)	INICC 2012-2017 Pooled mean (95% CI)	US NHSN 2013 Pooled mean (95% CI)
Surgical cardiothoracic	2.20 (1.8-2.6)	0.8 (0.8-0.9)	7.4 (6.5-8.3)	1.7 (1.5-1.9)	2.2 (1.9-2.6)	1.8 (1.7-1.9)
Medical cardiac	5.08 (4.6-5.6)	1.0 (0.9-1.1)	17.7 (16.5-19.1)	1.0 (0.8-1.1)	4.3 (3.8-4.8)	2.3 (2.2-2.4)
Medical	4.47 (4.1-4.8)	1.1 (1.0-1.2)	12.7 (12.0-13.4)	0.9 (0.8-1.1)	4.4 (4.1-4.7)	2.0 (1.9-2.1)
Medical/surgical	5.05(4.9-5.2)	0.8 (0.8-0.9)	14.1 (13.8-14.4)	0.9 (0.8-1.0)	5.1 (5.0-5.2)	1.7 (1.6-1.8)
Neuro surgical	4.43 (3.8-5.1)	0.9 (0.8-1.1)	13.6 (12.4-15.0)	2.1 (1.9-2.5)	4.6 (4.1-5.1)	5.3 (5.1-5.5)
Neurologic	2.55 (1.4-4.2)	1.1 (0.9-1.4)	13.8 (9.4-19.6)	3.0 (2.3-3.8)	6.0 (4.5-7.7)	4.5 (4.1-4.9)
Oncology	14.68 (10.7-19.7)		8.3 (4.4-14.1)		2.6 (1.2-5.0)	
Pediatric	7.19 (6.7-7.7)	1.2 (1.1-1.3)	11.8 (11.2-12.5)	0.7 (0.6-0.8)	5.3 (4.8-5.8)	2.5 (2.2-2.7)
Respiratory	2.47 (1.9-3.2)	1.0 (0.5-1.9)	10.7 (9.3-12.3)	0.7 (0.2-1.7)	6.7 (5.7-7.8)	2.1 (1.5-3.0)
Surgical	5.23(4.7-5.6)	0.9 (0.8-1.0)	13.6 (12.5-14.7)	2.0 (1.7-2.3)	3.5 (3.1-3.9)	2.0 (1.9-2.2)
Trauma	5.47 (4.6-6.4)	1.4 (1.3-1.6)	10.7 (9.3-12.3)	3.6 (3.3-3.9)	3.5 (3.0-4.1)	4.3 (4.1-4.5)
NICU. Birth-weight category, Kg						
< 750 kg	18.3 (15.4-21.7)	2.1 (1.9-2.3)	3.3 (2.2-4.9)	1.0 (0.8-1.3)	–	–
751-1,000 kg	14.5 (12.8-16.4)	1.3 (1.2-1.5)	4.9 (3.8-6.3)	1.1 (0.8-1.6)	–	–
1,001 – 1,500 kg	15.3 (14.1-16.6)	0.8 (0.7-0.9)	13.2 (11.7-14.7)	0.7 (0.3-1.2)	–	–
1,501–2,500 kg	7.7 (6.5-9.0)	0.6 (0.5-0.7)	6.4 (5.3-7.7)	0.5 (0.2-1.1)	–	–
> 2,500 kg	9.3(8.0-10.8)	0.7 (0.6-0.9)	5.5 (4.5-6.6)	0.1 (0.0-0.4)	–	–

CAUTI, catheter-associated urinary tract infection; *CI*, confidence interval; *CLABSI*, central line-associated bloodstream infection; *ICU*, intensive care unit; *INICC*, International Nosocomial Infection Control Consortium; NHSN, National Healthcare Safety Network;
NICU, neonatal intensive care unit; *VAP*, ventilator-associated pneumonia;
*To compare VAP rates for adult ICUs, we used NSHN report with data of 2012.
**To compare VAP rates for pediatric ICU and NICU, we used NSHN report with data of 2013.

interventions; education; outcome surveillance of CLABSI, VAP, CAUTI, and SSI rates: process surveillance for hand hygiene practice, insertion and maintenance of central and peripheral lines, and mechanical ventilator, urinary catheter, and surgical site care; and feedback on DA-HAI rates and performance.[29-49]

Study limitations

The purpose of this report is to obtain updated data on device-associated HAI rates (DA-HAI), device utilization (DU), bacterial resistance, LOS and mortality of patients with and without DA-HAI in adult and pediatric ICUs, and neonatal ICUs (NICUs), which is comparable to previously published data, but it does not provide insights regarding the impact of INICC interventions, such as the implementation of IMA and ISOS, and stratifications of type of hospital ownership, which would require a specific study.[1, 2] The impact of the adoption of such resources is published in prospective, interventional studies at hospitals that have participated in INICC during a considerable amount of years.[29-49] Second, in some cases patients may have had more than 1 CL in place simultaneously (for example, 1 CL in the subclavian vein, 1 CL in an internal jugular vein, and also 1 CL in the femoral vein); and in accordance with INICC Methods, all CL days are aggregated, and if the patient has 2 CLs in place on the same day, that day counts as 2 CL days, the denominator is higher, and this may result in a lower CLABSI rate than the real CLAB rate; that is, the higher denominator, the lower the CLABSI rate. Third, our study was limited by the fact that we did not apply the definition of VAE, because it became available in 2013 and this report includes prospectively collected data from 2012.[22] Fourth, in this report we analyzed all-cause mortality, and not attributable mortality, because patients were not matched by more than 5 similar characteristics. Finally, benchmarking with CDC-NHSN DA-HAI rates and DU ratios against INICC rates was done using the latest report published in 2016, which is the last one to provide these data stratified in ICU types.[50, 51] The currently available CDC-NHSN reports apply standardized infection ratio and standardized utilization ratio for data which has not been stratified into ICU types anymore, but is shown for each US state.[50, 51] To facilitate international benchmarks it would be useful that NHSN could stratify their new standardized infection ration/standardized utilization ratio data by ICU types as well.[50, 51]

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APPENDIX

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