ORIGINAL ARTICLE

Device-Associated Infection Rates in 40 Hospitals From 20 Cities of India, Data Summary for 2004–2013: International Nosocomial Infection Control Consortium's Findings

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OBJECTIVE. To report the International Nosocomial Infection Control Consortium surveillance data from 40 hospitals (20 cities) in India 2004–2013.

METHODS. Surveillance using US National Healthcare Safety Network's criteria and definitions, and International Nosocomial Infection Control Consortium methodology.

RESULTS. We collected data from 236,700 ICU patients for 970,713 bed-days.

Pooled device-associated healthcare-associated infection rates for adult and pediatric ICUs were 5.1 central line–associated bloodstream infections (CLABSIs)/1,000 central line–days, 9.4 cases of ventilator-associated pneumonia (VAPs)/1,000 mechanical ventilator–days, and 2.1 catheter-associated urinary tract infections/1,000 urinary catheter–days.

In neonatal ICUs (NICUs) pooled rates were 36.2 CLABSIs/1,000 central line–days and 1.9 VAPs/1,000 mechanical ventilator–days.

Extra length of stay in adult and pediatric ICUs was 9.5 for CLABSI, 9.1 for VAP, and 10.0 for catheter-associated urinary tract infections. Extra length of stay in NICUs was 14.7 for CLABSI and 38.7 for VAP.

Crude extra mortality was 16.3% for CLABSI, 22.7% for VAP, and 6.6% for catheter-associated urinary tract infections in adult and pediatric ICUs, and 1.2% for CLABSI and 8.3% for VAP in NICUs.

Pooled device use ratios were 0.21 for mechanical ventilator, 0.39 for central line, and 0.53 for urinary catheter in adult and pediatric ICUs; and 0.07 for mechanical ventilator and 0.06 for central line in NICUs.

CONCLUSIONS. Despite a lower device use ratio in our ICUs, our device-associated healthcare-associated infection rates are higher than National Healthcare Safety Network, but lower than International Nosocomial Infection Control Consortium Report.

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Device-associated healthcare-acquired infections (DA-HAIs) are among the principal threats to patient safety in the intensive care unit (ICU) and one of the primary causes of patient morbidity and mortality.[1,2] According to previous studies conducted in India,[1–4] the pooled rates of DA-HAIs are higher than in high-income countries.[5]

The implementation of infection control programs has proven effective for the reduction and control of DA-HAI surveillance, as shown in different studies conducted in the United States, whose results reported not only that the DA-HAI rates can be reduced by 30%, but that a related reduction in healthcare costs was feasible, as well.[5] Likewise, the burden of antimicrobial-resistant infections and susceptibility to antimicrobials of DA-HAI pathogens are an issue to be urgently addressed, so that informed decisions can be made to prevent transmission of resistant strains and their determinants, such as strains with phenotypes with very few available treatments with chances of success.[6]

For more than 40 years, the US Centers for Disease Control and Prevention's (CDC) National Healthcare Safety Network (NHSN) has provided benchmarking of US ICU data on DA-HAIs, which has been invaluable for researchers[5] and has served as an inspiration to the International Nosocomial Infection Control Consortium (INICC).[7] The INICC is an international nonprofit, multicenter, open, collaborative healthcare-associated infection control program with a surveillance system based on that of the CDC/NHSN.[5] Established in Argentina in 1998, INICC is the first multinational surveillance and research network whose main goal is to measure, prevent, and reduce DA-HAIs and surgical site infections hospital-wide through the surveillance and analysis of data collected by a pool of hospitals worldwide on a voluntary basis.[7]

India has a large private sector, and there are more healthcare providers in the private sector than in the public sector, but their services are mostly provided in urban areas. By contrast, the public sector provides health services to India's rural population, which comprises over 800 million people who live in 640,867 villages, through a network of 23,887 primary health centers and 4,809 community health centers staffed by doctors, and 148,124 subcenters staffed by auxiliary nurse midwives.[8]

The aim of the present study is to report a summary of surveillance data on DA-HAI collected in 84 ICUs in 40 hospitals from 20 cities of India participating in the INICC from March 2004 to February 2013.

METHODS

Background on INICC

INICC comprises more than 2,000 hospitals in 500 cities of 66 countries in Latin America, Asia, Africa, the Middle East, and Eastern Europe and is currently the only source of aggregate standardized data on the epidemiology of healthcare-associated infections (HAIs) worldwide.[7] The focus of the INICC surveillance and prevention is the DA-HAI program in adult and pediatric ICUs and neonatal ICUs (NICUs), step-down units, and inpatient wards, and surgical site infections in surgical procedures hospital-wide.

Setting and Study Design

This prospective cohort surveillance study was conducted in 84 adult or pediatric ICUs or NICUs from 40 hospitals in 20 cities of India, through the implementation of the INICC Multidimensional Approach, as described below.

Hospitals were stratified by bed capacity (<200; 201–500; 501–1,000; and >1,000). Corresponding denominator data, patient-days, and specific device-days were also collected.

All NICUs were level III and infection control professionals collected data on central line–associated bloodstream infections (CLABSIs) and umbilical catheter–associated primary bloodstream infections or cases of ventilator-associated pneumonia (VAPs) for each of 5 birthweight categories (<750 g; 750–1,000 g; 1,001–1,500 g; 1,501–2,500 g; >2,500 g).

Detailed and aggregated data were used to calculate DA-HAI rates per 1,000 device-days. Only prospective data using INICC patient detailed forms were used to calculate extra mortality and length of stay (LOS).

The infection control professionals had previous experience conducting surveillance of DA-HAIs.

In accordance with the INICC's Charter, the identity of all INICC hospitals and cities is kept confidential.

INICC Multidimensional Approach

The INICC Multidimensional Approach includes the implementation of CDC/NHSN's methodology but adds the collection of other data essential to helping infection control professionals to detect HAIs and avoid underreporting.[9] According to standard CDC/NHSN methods, numerators are the number of HAIs of each type, and denominators are device-days collected from all patients, as pooled data—that is, without determining the number of device-days related to a particular patient, and without collecting features or characteristics per specific patient.[9] This design differs from the INICC surveillance system because the design of the cohort study through the INICC methods also includes collecting specific data per patient from *all* patients, both those with and those without HAI, collecting risk factors of HAIs, such as invasive devices, and surrogates of HAIs, which include, but are not limited to, high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS, and mortality. By collecting data on all patients in the ICU, it is possible to match patients with and without HAI by several characteristics to estimate extra LOS, mortality, and cost.

The INICC Multidimensional Approach comprises the simultaneous implementation of the following 6 components for HAI control and prevention: (1) a bundle of interventions,

(2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback on HAI rates and consequences, and (6) performance feedback.

Outcome and process surveillance are conducted by means of an online platform called INICC Surveillance Online System (ISOS). The ISOS comprises 15 modules: 10 for outcome surveillance and 5 for process surveillance. The modules of the outcome surveillance and process surveillance components may be used singly or simultaneously, but once selected, they must be used for a minimum of 1 calendar month.

In this study, we present the results of the cohort surveillance of HAIs in adult, pediatric, and neonatal ICUs. The results of the remaining outcome surveillance modules—(1) *Clostridium difficile* infections, (2) antimicrobial consumption, (3) surveillance of needle stick injuries, (4) cohort surveillance of HAIs in inpatient wards and step-down units, and (5) cohort surveillance of surgical procedures and surgical site infections—and of the modules for process surveillance, feedback on HAI rates and consequences, and performance feedback were not included in this report because they will be published in another future study.

Outcome Surveillance

Outcome surveillance included cohort surveillance of HAIs in adult, pediatric, and neonatal ICUs conducted through the ISOS, which allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply US CDC/NHSN's definitions published in 2013.[9] The site-specific criteria include reporting instructions and provide full explanations integral to their adequate application.[9]

Data Collection and Analysis

The ISOS follows the INICC protocol, and infection control professionals collected daily data on CLABSIs, catheter-associated urinary tract infection (CAUTIs), and VAPs as well as denominator data, patient-days, and specific device-days in the ICUs.

These data were uploaded to the ISOS and were used to calculate DA-HAI rates per 1,000 device-days, mortality, and LOS, according to the following formulas: Device-days consisted of the total number of central line–days, urinary catheter–days, or mechanical ventilator–days. Crude excess mortality of DA-HAI equals crude mortality of ICU patients with DA-HAI minus crude mortality of patients without DA-HAI. Crude excess LOS of DA-HAI equals crude LOS of ICU patients with DA-HAI minus crude LOS of patients without DA-HAI. The device use ratio equals the total number of device-days divided by the total number of bed-days.

Training

The INICC chairman trained the principal and secondary investigators at hospitals. Investigators were also provided with tutorial movies, manuals, and training tools that described in detail how to perform surveillance and upload surveillance data through the ISOS. In addition, investigators attended webinars and had continuous access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Statistical Analysis

INICC ISOS, version 2.0, was used to calculate HAI rates, device use, LOS, and mortality. EpiInfo, version 6.04b (CDC), and SPSS, version 16.0 (IBM), were also used. Relative risk ratios, 95% CIs, and *P* values were determined for primary and secondary outcomes.

RESULTS

The data presented in this report are from 84 ICUs in 40 hospitals in 20 cities in India currently participating in the INICC Program. The mean (SD) length of participation of hospitals is 24.9 (22.3) months, with a range of 2 to 85 months.

For the outcome surveillance component, DA-HAI rates, device use ratios, crude excess mortality by specific type of DA-HAI, microorganism profile, and bacterial resistance for March 2004 through February 2013 are summarized in Tables 1–6.

Table 1 shows DA-HAI rates and device-days by infection type (CLABSI, CAUTI, VAP) in adult and pediatric ICUs

TABLE 1. Pooled Means of CLABSI, CAUTI Rates, and VAP Rates by Hospital Size, Adult and Pediatric Patients, Device-Associated Module, 2004-2013

Hospital size, beds, n	ICUs, n	Patients, n	Bed-days, n	CL-days, n	CLABSI, n	CLABSI rate (95% CI)	MV-days, n	VAP, n	VAP rate (95% CI)	UC-days, n	CAUTI, n	CAUTI rate (95% CI)
<200	16	22,373	123,134	43,303	138	3.19 (2.7–3.8)	21,779	188	8.6 (7.4–10.0)	61,579	183	3.0 (2.6–3.4)
201–500	30	85,784	372,152	147,732	956	6.47 (6.1–6.9)	80,008	586	7.3 (6.7–7.9)	192,508	282	1.5 (1.3–1.6)
501–1,000	27	121,072	439,581	185,894	857	4.61 (4.3–4.9)	91,048	983	10.8 (10.1–11.5)	244,472	602	2.5 (2.3–2.7)
>1,000	6	6,401	27,214	23,584	91	3.86 (3.1–4.7)	14,466	193	13.3 (11.5–15.4)	22,021	42	1.9 (1.4–2.6)
Pooled	79	235,630	962,081	400,513	2,042	5.10 (4.9–5.3)	207,301	1,950	9.4 (9.0–9.8)	520,580	1,109	2.1 (2.0–2.3)

NOTE. CAUTI, catheter-associated urinary tract infection; CL, central line; CLABSI, central line–associated bloodstream infection; ICU, intensive care units; MV, mechanical ventilator; UC, urinary catheter; VAP, ventilator-associated pneumonia.

TABLE 2. Pooled Means and Key Percentiles of the Distribution of CLABSI Rates, VAP Rates, CAUTI Rates; CL Use Ratio, MV Use Ratio, UC Use Ratio, by Type of Location, Adult and Pediatric Patients, Device-Associated Module, 2004–2013

Type of ICU	ICU, n	Patients	Bed-days	CL-days	CL DUR (95% CI)	MV days	MV DUR (95% CI)	UC-days	UC DUR (95% CI)	HAI, n[a]	HAI rate[b]	95% CI	Percentiles 10	25	50	75	90
Medical cardiac	8	19,793	63,299	43,763	0.69 (0.69–0.69)	12,875	0.20 (0.20–21)	33,993	0.54 (0.53–0.54)								
CLABSI										262	5.99	5.3–6.8	0.0	0.3	2.3	6.6	–
VAP										146	11.3	9.6–13.3	0.0	2.5	7.5	16.3	–
CAUTI										121	3.56	3.0–4.3	0.0	0.0	0.6	7.7	–
Cardiothoracic	5	7,391	24,086	19,559	0.81 (0.81–0.82)	5,528	0.23 (0.22–0.23)	16,150	0.67 (0.66–0.68)								
CLABSI										14	0.72	0.4–1.2	0.0	0.0	0.0	19.7	–
VAP										1	0.2	0.0–1.0	0.0	0.0	0.0	55.6	–
CAUTI										0	0.00	0.0–0.2	0.0	0.0	0.0	0.0	0.0
Medical	16	33,319	130,652	55,163	0.42 (0.42–0.42)	33,135	0.25 (0.25–0.26)	82,016	0.63 (0.63–0.63)								
CLABSI										372	6.74	6.1–7.5	0.0	0.7	3.5	5.0	48.4
VAP										283	8.5	7.6–9.6	2.2	3.7	7.4	12.1	70.4
CAUTI										162	1.98	1.7–2.3	0.3	0.9	2.0	4.2	14.5
Medical/ surgical	22	144,143	609,570	237,636	0.39 (0.38–0.41)	126,593	0.21 (0.21–0.21)	321,499	0.53 (0.53–0.53)								
CLABSI										1,145	4.82	4.5–5.1	0.0	0.3	3.3	10.8	18.1
VAP										1,311	10.4	9.8–10.9	1.0	4.1	8.9	13.0	27.1
CAUTI										666	2.07	1.9–2.2	0.0	0.5	1.7	3.5	10.2
Neurologic	3	3,000	12,025	2,617	0.22 (0.21–0.23)	3,662	0.30 (0.30–0.31)	8,081	0.67 (0.66–0.68)								
CLABSI										22	8.41	5.3–12.7					
VAP										50	13.7	10.1–18.0					
CAUTI										29	3.59	2.4–5.2					
Neurosurgical	2	1,947	8,536	3,372	0.40 (0.38–0.41)	1,273	0.15 (0.14–0.16)	5,946	0.70 (0.69–0.71)								
CLABSI										6	1.78	0.7–3.9					
VAP										4	3.1	0.9–8.0					
CAUTI										25	4.20	2.7–6.2					
Pediatric	9	6,031	25,177	7,326	0.29 (0.29–0.30)	7,492	0.30 (0.29–0.30)	7,486	0.30 (0.29–0.30)								
CLABSI										62	8.46	6.5–10.8	0.0	0.0	5.7	21.2	–
VAP										11	1.5	0.7–2.6	0.0	0.0	1.0	7.6	–
CAUTI										6	0.80	0.3–1.7	0.0	0.0	0.4	2.6	–
Surgical	11	13,352	59,031	22,276	0.38 (0.37–0.38)	8,533	0.14 (0.14–0.15)	32,819	0.56 (0.55–0.56)								
CLABSI										123	5.52	4.6–6.6	0.2	1.4	2.3	8.8	29.7
VAP										83	9.7	7.7–12.1	0.2	2.1	5.9	19.0	33.9
CAUTI										58	1.77	1.3–2.3	0.1	0.5	1.5	4.6	81.6
Trauma	2	3,285	14,680	8,267	0.56 (0.56–0.57)	8,177	0.56 (0.55–0.57)	11,223	0.76 (0.76–0.77)								
CLABSI										36	4.35	3.1–6.0					
VAP										61	7.5	5.7–9.6					
CAUTI										41	3.65	2.6–5.0					
Ward	1	3,369	15,025	534	0.04 (0.03–0.04)	33	0.00 (0.00–0.00)	1,367	0.09 (0.09–0.10)								
CLABSI										0	0.00	0.0–6.9					
VAP										0	0.0	0.0–111.8					
CAUTI										1	0.73	0.0–4.1					
Pooled	79	235,630	962,081	400,513	0.42 (0.42–0.42)	20,7301	0.22 (0.21–0.22)	520,580	0.54 (0.54–0.54)								
CLABSI										2,042	5.10	4.9–5.3	0.0	0.2	2.5	6.7	18.6
VAP										1,950	9.4	9.0–9.8	0.0	2.3	6.1	12.5	29.6
CAUTI										1,109	2.13	2.0–2.3	0.0	0.3	1.5	3.9	8.6

NOTE. CAUTI, catheter-associated urinary tract infection; CL, central line; CLABSI, central line–associated bloodstream infection; DUR, device use ratio; HAI, healthcare-associated infection; ICU, intensive care unit; MV, mechanical ventilator; UC, urinary catheter; VAP, ventilator-associated pneumonia.

[a]HAI, n: CLABSI, VAP, CAUTI.

TABLE 3. Pooled Means of the Distribution of CLABSI Rates, VAP Rates, CL and MV Use Ratios, for Level III NICUs, Stratified by Birthweight Category, Device-Associated Module, 2004–2013

Birthweight category	ICU, n	Patients, n	Bed-days, n	CL-days, n	DUR, central line (95% CI)	MV-days, n	DUR, MV (95% CI)	CLABSI, n	CLABSI rate (95% CI)	VAP, n	VAP rate (95% CI)
<750 g	4	17	379	19	0.05 (0.03–0.08)	56	0.08 (0.11–0.19)	1	52.63 (1.3–293.2)	0	0.00 (0.0–65.9)
751–1,000 g	5	121	2,142	174	0.08 (0.07–0.09)	219	0.09 (0.09–0.12)	4	22.99 (6.3–58.9)	1	4.57 (0.1–25.4)
1,001–1,500 g	5	404	3,358	212	0.06 (0.06–0.07)	313	0.07 (0.08–0.10)	8	37.74 (16.3–74.4)	0	0.00 (0.0–11.8)
1,501–2,500 g	5	528	2,753	534	0.19 (0.18–0.21)	453	0.21 (0.15–0.18)	21	39.33 (24.3–60.1)	1	2.21 (0.1–12.3)
Pooled	5	1,070	8,632	939	0.11 (0.10–0.12)	1,041	0.12 (0.11–0.13)	34	36.21 (25.1–50.6)	2	1.92 (0.2–6.9)

NOTE. CL, central line; CLABSI, central line–associated bloodstream infection; DUR, device use ratio; ICU, intensive care unit; MV, mechanical ventilator; NICU, neonatal ICU; VAP, ventilator-associated pneumonia.

TABLE 4. Pooled Means of the Distribution of Crude Mortality and Crude Excess Mortality of Adult and Pediatric ICU Patients With and Without HAI

Adult and pediatric ICUs combined, patients, n	Patients, n	Deaths, n	LOS, total days, n	Pooled crude results (95% CI)	RR (95% CI)	*P* value
Without HAI	62,359	4,289	284,616			
Mortality				6.9% (6.7%–7.0%)		
LOS				4.6 days (4.5–4.6)		
With CLABSI	760	176	10,714			
Mortality				23.2% (20.2%–26.3%)	3.37 (2.90–3.91)	.0001
LOS				14.1 days (13.2–15.1)	3.09 (3.03–3.14)	
With CAUTI	193	26	2,814			
Mortality				13.5% (8.9%–19.1%)	1.96 (1.33–2.88)	.0004
LOS				14.6 days (12.7–16.8)	3.19 (3.07–3.3)	
With VAP	683	202	9,306			
Mortality				29.6% (26.2%–33.1%)	4.30 (3.73–4.95)	.0001
LOS				13.6 days (12.7–14.7)	2.98 (2.9–3.04)	
Neonatal ICUs combined, patients, n						
Without HAI	2,153	36	16,582			
Mortality				1.7% (1.1%–2.3%)		
LOS				7.7 days (7.4–8.0)		
With CLABSI	70	2	1,032			
Mortality				2.9% (0.3%–9.9%)	1.71 (0.41–7.10)	.4554
LOS				14.7 days (11.8–18.8)	1.91 (1.8–2.0)	
With VAP	10	1	464			
Mortality				10.0% (0.2%–4.4%)	5.98 (0.82–43.6)	.0445
LOS				46.4 days (25.5–96.3)	6.0 (5.5–6.6)	

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; HAI, healthcare-associated infection; ICU, intensive care unit; LOS, length of stay; RR, relative risk ratio; VAP, ventilator-associated pneumonia.

stratified by hospital size. Device-days consisted of the total number of central line–days, urinary catheter–days, or mechanical ventilator–days. The pooled mean of the CLABSI rates was 5.10 (95% CI, 4.9–5.3). The pooled mean of the VAP rates was 9.4 (95% CI, 9.0–9.8), and the pooled mean of the CAUTI rates was 2.1 (95% CI, 2.0–2.3).

Table 2 shows pooled means and key percentiles of the distribution of DA-HAI rates, and device use ratios stratified by type of ICU. The highest pooled CLABSI rate was found in the pediatric ICU (8.46). The highest pooled VAP rate was found in the neurologic ICU (13.7), and the highest pooled CAUTI rate was found in the neurosurgical ICU (4.20).

Table 3 shows pooled means of the distribution of CLABSI and VAP rates, and device use ratios in all the participating NICUs stratified by weight categories of neonatal patients. The highest pooled CLABSI rate was found in the less-than-750 g birthweight category (52.63) and the highest pooled VAP rate was found in the 751–1,000 g birthweight category (4.57).

Table 4 shows crude ICU mortality and LOS in adult, pediatric, and neonatal patients hospitalized in each type of unit during the surveillance period, with and without DA-HAI. VAP had the highest mortality both in adult and pediatric ICUs (29.6 % [95% CI, 26.2%–33.1%]) and in NICUs (10.0% [95% CI, 0.2%–4.4%]). In NICUs, the highest LOS was found for VAP (46.4 days), whereas it was similar for DA-HAIs in adult and pediatric ICUs.

Table 5 provides data on bacterial resistance of pathogens isolated from patients with DA-HAI in adult and pediatric

TABLE 5. Antimicrobial Resistance Rates in the Participating ICUs

Pathogen, antimicrobial	Pathogenic isolates tested, pooled, n (CLABSI)	Resistance, % (CLABSI)	Pathogenic isolates tested, pooled, n (VAP)	Resistance, % (VAP)	Pathogenic isolates tested, pooled, n (CAUTI)	Resistance, % (CAUTI)	Resistance, % Pooled
Staphylococcus aureus							
Oxacillin	61	47.5%	85	49.4%	2	0.0%	48.0%
Coagulase-negative staphylococci							
Oxacillin	158	51.3%	89	60.7%	2	100.0%	55.0%
Enterococcus faecalis							
Vancomycin	26	15.4%	16	0.0%	55	10.9%	10.3%
Pseudomonas aeruginosa							
Ciprofloxacin	123	48.0%	602	55.6%	70	64.3%	55.2%
Piperacillin or piperacillin-tazobactam	329	36.8%	1,043	38.5%	124	51.6%	39.2%
Amikacin	148	39.9%	719	41.2%	72	55.6%	42.1%
Imipenem or meropenem	270	50.4%	1,115	44.0%	149	38.9%	44.7%
Klebsiella pneumonia							
Ceftriaxone or ceftazidime	319	80.9%	738	73.2%	142	73.9%	75.3%
Imipenem or meropenem	385	21.8%	853	21.9%	218	25.7%	22.5%
Acinetobacter baumanii							
Imipenem or meropenem	242	66.1%	1,118	84.8%	44	77.3%	81.3%
Escherichia coli							
Ceftriaxone or ceftazidime	162	72.2%	329	78.1%	253	72.7%	75.0%
Imipenem or meropenem	210	11.0%	371	10.5%	363	6.3%	9.0%
Fluoroquinolones	144	79.2%	210	80.0%	246	82.9%	81.0%

NOTE. CLABSI, central line–associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; ICU, intensive care unit; VAP, ventilator-associated pneumonia.

ICUs and NICUs. Coagulase-negative staphylococci and *Escherichia coli* counts are high in CLABSI and VAP.

Table 6 compares the results of this report from India, with the INICC international report for the period 2007–2012[7] and with CDC/NHSN report of 2013.[5] In the medical/surgical ICUs, the rate of VAP was higher in this study than in CDC/NHSN report, although it was lower than INICC's rates. The CLABSI and CAUTI rates in this study were higher than CDC/NHSN's rates, but similar to INICC's rates. Device use ratios for central line, mechanical ventilator, and urinary catheter were lower in this study than in the INICC report. Similarly, device use ratios for mechanical ventilator and urinary catheter were lower than the CDC/NHSN report, although central line device use ratio was slightly higher in our study.[5,6]

DISCUSSION

In our study, it was shown that the DA-HAI rates found in the participating Indian ICUs were higher than the rates reported by the CDC/NHSN.[5] Our CLABSI rate was similar to the pooled rate found in a previous study conducted in India showing 7.92 CLABSIs per 1,000 central line–days.[1] Likewise, our CAUTI rate was similar to the findings of another study from ICUs in India showing 10.6 CAUTIs per 1,000 urinary catheter–days.[3] The VAP rate in our study was 10.4 per 1,000 mechanical ventilator–days in adult ICUs. In 2010, Singh et al[4] found a rate of 21.92 VAPs per 1,000 mechanical ventilator–days, and Mehta et al[2] found a global VAP rate of 17.43 VAPs per 1,000 mechanical ventilator–days in a multicenter study performed in 14 hospitals in 2012.

Comparing DA-HAI rates at medical cardiac and medical ICUs, we found that CLABSI and VAP rates were similar, but CAUTI rates were higher at the medical cardiac ICU, and this is most probably due to the usually increased use of antibiotics at medical ICUs.

Although pooled device use ratios in our adult ICUs were similar to, and even lower than in some cases, CDC/NHSN's data, [5] DA-HAI rates were markedly higher in our ICUs. This shows that there are other risk factors that need to be addressed to explain these higher rates. Likewise, the antimicrobial resistance rates found in our ICUs were higher than CDC/NHSN rates for *Staphylococcus aureus* and coagulase-negative staphylococci isolates as resistant to oxacillin; *Enterococcus faecalis* as resistant to vancomycin; *Klebsiella pneumoniae* as resistant to ceftriaxone, ceftazidime, imipenem, and meropenem; *Pseudomonas aeruginosa* as resistant to piperacillin-tazobactam, amikacin, imipenem, or meropenem and ciprofloxacin; and *E. coli* as resistant to ceftriaxone, ceftazidime, imipenem, meropenem, and ertapenem.[6] For most pathogens, percent resistance differed little among DA-HAI types.

These high DA-HAI rates may reflect the typical ICU situation in hospitals in India, and several reasons can explain this fact. In India, adherence to practice bundles is irregular,

TABLE 6. Benchmarking of Device-Associated Healthcare-Acquired Infection Rates in This Report Against the Report of INICC (2007–2012) and Report of the US CDC/NHSN (2013)

Variable	This Report	INICC Report (2007–2012)[7]	CDC/NHSN Report (2013)[5]
Medical cardiac ICU			
CL, DUR	0.69 (0.69–0.69)	0.58 (0.58–0.58)	0.43
CLABSI rate	5.99 (5.3–6.8)	3.5 (3.1–3.9)	1.0
MV, DUR	0.20 (0.20–0.21)	0.29 (0.29–0.30)	0.26
VAP rate	11.3 (9.6–13.3)	11.5 (10.5–12.5)	1.0
UC, DUR	0.54 (0.53–0.54)	0.56 (0.56–0.56)	0.52
CAUTI rate	3.6 (3.0–4.3)	5.9 (5.4–6.4)	2.3
Medical ICU			
CL, DUR	0.42 (0.42–0.42)	0.47 (0.47–0.47)	0.45
CLABSI rate	6.7 (6.1–7.5)	4.6 (4.4–4.9)	1.1
MV, DUR	0.25 (0.25–0.26)	0.47 (0.47–0.47)	0.34
VAP rate	8.5 (7.6–9.6)	12.4 (11.9–12.8)	0.9
UC, DUR	0.63 (0.63–0.63)	0.71 (0.71–0.71)	0.61
CAUTI rate	2.0 (1.7–2.3)	4.5 (4.2–4.7)	2.0
Medical Surgical ICU			
CL, DUR	0.39 (0.38–0.41)	0.54 (0.54–0.54)	0.37
CLABSI rate	4.8 (4.5–5.1)	4.9 (4.8–5.1)	0.8
MV, DUR	0.21 (0.21–0.21)	0.36 (0.36–0.36)	0.24
VAP rate	10.4 (9.8–10.9)	16.5 (16.1–16.8)	1.1
UC, DUR	0.53 (0.53–0.53)	0.62 (0.62–0.62)	0.54
CAUTI rate	2.1 (1.9–2.2)	5.3 (5.2–5.8)	1.3
Neurologic ICU			
CL, DUR	0.22 (0.21–0.23)	0.32 (0.32–0.33)	0.47
CLABSI rate	8.4 (5.3–12.7)	6.4 (5.1–7.9)	1.1
MV, DUR	0.30 (0.30–0.31)	0.23 (0.23–0.24)	0.33
VAP rate	13.7 (10.1–18.0)	20.0 (17.2–23.0)	3.0
UC, DUR	0.67 (0.66–0.68)	0.88 (0.88–0.89)	0.69
CAUTI rate	3.6 (2.4–5.2)	16.0 (14.7–17.3)	4.5
Pediatric ICU			
CL, DUR	0.29 (0.29–0.30)	0.50 (0.50–0.50)	0.45
CLABSI rate	8.5 (6.5–10.8)	6.1 (5.7–6.5)	1.2
MV, DUR	0.30 (0.29–0.30)	0.53 (0.53–0.53)	0.37
VAP rate	1.5 (0.7–2.6)	7.9 (7.4–8.4)	0.8
UC, DUR	0.30 (0.29–0.30)	0.31 (0.31–0.32)	0.21
CAUTI rate	0.8 (0.3–1.7)	5.6 (5.1–6.1)	2.5
Neonatal ICU (weight 751–1,000 g)			
CL, DUR	0.08 (0.07–0.09)	0.36 (0.35–0.36)	0.33
CLABSI rate	23.0 (6.3–58.9)	7.1 (5.4–9.1)	1.3
MV, DUR	0.09 (0.09–0.12)	0.27 (0.26–0.27)	0.23
VAP rate	4.57 (0.1–25.4)	8.8 (6.6–11.4)	1.2
Neonatal ICU (weight 1,501–2,500 g)			
CL, DUR	0.19 (0.18–0.21)	0.21 (0.20–0.21)	0.17
CLABSI rate	39.3 (24.3–60.1)	4.8 (3.7–6.1)	0.6
MV, DUR	0.21 (0.15–0.18)	0.10 (0.10–0.11)	0.07
VAP rate	2.21 (0.1–12.3)	10.7 (8.4–13.4)	0.2

NOTE. CAUTI, catheter-associated urinary tract infection; CDC/NHSN, Centers for Disease Control and Prevention National Healthcare Safety Network; CL, central line; CLABSI, central line–associated bloodstream infection; DUR, device use ratio; ICU, intensive care unit; INICC, International Nosocomial Infection Control Consortium; MV, mechanical ventilator; UC, urinary catheter; VAP, ventilator-associated pneumonia.

hospital accreditation is not mandatory, and some of the technology applied is different from that of high-income countries.[10,11] This situation is further emphasized by the fact that administrative and financial support in public hospitals is insufficient to fund full infection control programs, which invariably results in extremely low nurse-to-patient staffing ratios—which have proved to be highly connected to high DA-HAI rates in ICUs—and hospital overcrowding.[12]

The particular and primary application of this study's data is to serve as a guide for the implementation of prevention strategies and other quality improvement efforts locally for the reduction of DA-HAI rates to the minimum possible level. To reduce the hospitalized patients' risk of infection, DA-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 DA-HAI prevention and control and limitations on the administration of anti-infectives in order to effectively control antibiotic resistance.

The effectiveness of implementing an integrated infection control program focused on DA-HAI surveillance was demonstrated in the many studies conducted in the United States.[5] For almost 20 years, INICC has undertaken a global effort in America, Asia, Africa, Middle East, and Eastern Europe to respond to the burden of HAIs and has achieved very successful results by increasing hand hygiene adherence, improving compliance with other infection control bundles and interventions as described in several INICC publications, and consequently reducing the rates of HAI and mortality.[7,13–17]

The methods applied by the INICC are based on those of the CDC/NHSN, in terms of definitions and criteria[12]; however, through the INICC Multidimensional Approach and ISOS, INICC collects additional extra data as well, including specific data per patient from *all* patients, both those with and those without HAI, collecting risk factors of HAIs, such as invasive devices, and surrogates of HAIs. This approach is useful to increase the ability of infection control professionals to detect HAIs, and allows the matching of patients by several characteristics to estimate extra LOS, mortality, and cost.

According to the World Bank, 68% of countries are classified into low-income and lower middle-income economies, representing more than 75% of the world population. India is defined by the World Bank as a lower middle-income economy. The relation between DA-HAI rates and the country socioeconomic level, and between DA-HAI rates and their association to the type of hospital (public, academic, or private), has been analyzed in only 2 studies in pediatric ICUs and NICUs and should be further studied in adult ICU patients. These studies found a negative correlation in most types of DA-HAI—that is, a higher country socioeconomic level was correlated with a lower infection risk.[18,19] Participation in INICC has played a fundamental role, not only in increasing the awareness of DA-HAI risks in the ICU of limited-resource countries, but also in providing an exemplary basis for the institution of infection control practices.

To compare a hospital's DA-HAI rates with the rates identified in this report, it is required that the hospital concerned start collecting its data by applying the methods and methodology described for CDC/NHSN and INICC, and then calculate infection rates and device use ratios for the DA-HAI module.

This study presents some limitations. First, we must rely upon the member hospitals' laboratories to reliably identify infecting pathogens and delineate bacterial resistance patterns, and different laboratories have varying levels of expertise and resource availability; however, similar concerns can be raised about any multi-institutional surveillance study. Second, the frequency of culturing and the use of other diagnostic tests are beyond the control of infection control programs; in hospitals where culturing and other laboratory testing is infrequent and suspected infections are treated empirically, the capacity of the surveillance program to detect most DA-HAIs is likely to be low. Finally, for ward, trauma, neurological, and neurosurgical ICUs, we present data of fewer than 5 ICUs; therefore, for those 4 ICU types percentiles are not presented. However, because the number of patients in each of them is higher than 1,000, their data represent a sufficient sample size.

In conclusion, the high DA-HAI rates presented in this report confirm that HAIs in India pose a higher risk to patient safety compared with the developed world.[5] It is INICC's main goal to enhance infection control practices, 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 to the correlated reduction in DA-HAI and its adverse effects in the hospitals participating in INICC, as well as at any other healthcare facility worldwide.

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