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Major Article

International Nosocomial Infection Control Consortium report, data summary of 50 countries for 2010-2015: Device-associated module

Víctor Daniel Rosenthal MD, MSc, CIC [a,*], Hail M. Al-Abdely MD [b], Amani Ali El-Kholy MD [c], Safa A Aziz AlKhawaja MD [d], Hakan Leblebicioglu MD [e], Yatin Mehta MD [f], Vineya Rai MD [g], Nguyen Viet Hung MD [h], Souha Sami Kanj MD [i], Mona Foda Salama MD [j], Estuardo Salgado-Yepez MD [k], Naheed Elahi MD [l], Rayo Morfin Otero MD [m], Anucha Apisarnthanarak MD [n], Braulio Matias De Carvalho MD [o], Bat Erdene Ider [p], Dale Fisher MD [q], Maria Carmen S.G. Buenaflor MD [r], Michael M. Petrov MD [s], Ana Marcela Quesada-Mora MD [t], Farid Zand MD [u], Vaidotas Gurskis MD [v], Tanja Anguseva MD [w], Aamer Ikram MD [x], Daisy Aguilar de Moros MD [y], Wieslawa Duszynska MD [z], Nepomuceno Mejia MD [aa], Florin George Horhat MD [bb], Vladislav Belskiy MD [cc], Vesna Mioljevic MD [dd], Gabriela Di Silvestre MD [ee], Katarina Furova MD [ff], Gloria Y. Ramos-Ortiz MD [gg], May Osman Gamar Elanbya MD [hh], Hindra Irawan Satari MD [ii], Umesh Gupta MD [jj], Tarek Dendane MD [kk], Lul Raka MD [ll], Humberto Guanche-Garcell MD [mm], Bijie Hu MD [nn], Denis Padgett MD [oo], Kushlani Jayatilleke MD [pp], Najla Ben Jaballah MD [qq], Eleni Apostolopoulou MD [rr], Walter Enrique Prudencio Leon MD [ss], Alejandra Sepulveda-Chavez MD [tt], Hector Miguel Telechea MD [uu], Andrew Trotter MD [vv], Carlos Alvarez-Moreno MD [ww], Luis Kushner-Davalos MD [xx]

[a] *International Nosocomial Infection Control Consortium, Buenos Aires, Argentina*
[b] *General Directorate of Infection Prevention and Control, Ministry of Health, Saudi Arabia*
[c] *Cairo University Hospital, Cairo; Dar Al Fouad Hospital, 6th of October City, Egypt*
[d] *General Directorate of Infection Prevention and Control, Ministry of Health, Bahrain*
[e] *Ondokuz Mayis University Medical School, Samsun, Turkey*
[f] *Medanta The Medicity, New Delhi, India*
[g] *University Malaya Medical Centre, Kuala Lumpur, Malaysia*
[h] *Bach Mai Hospital, Hanoi, Vietnam*
[i] *American University of Beirut Medical Center, Beirut, Lebanon*
[j] *Mubarak Al Kabir Hospital, Kuwait City, Kuwait*
[k] *Clínica La Merced, Quito, Ecuador*
[l] *Dubai Hospital, Dubai, United Arab Emirates*
[m] *Hospital Civil de Guadalajara Fray Antonio Alcalde Infection Control Committee, Guadalajara, Mexico*
[n] *Thammasat University Hospital, Pratumthani, Thailand*
[o] *Hospital de Messejana, Fortaleza, Brazil*
[p] *Intermed Hospital, Ulaanbaatar, Mongolia*
[q] *National University Hospital Singapore, Singapore, Singapore*
[r] *Philippine Heart Center, Manila, Philippines*

* Address correspondence to Victor Daniel Rosenthal, MD, MSc, CIC, International Nosocomial Infection Control Consortium, 11 de Septiembre 4567, Fl 12, Apt 1201, Buenos Aires, 1429, Argentina.
E-mail address: victor_rosenthal@inicc.org (V.D. Rosenthal).

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

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

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[s] St George University Hospital, Plovdiv, Bulgaria
[t] Hospital Clínica Bíblica, San Jose, Costa Rica
[u] Nemazee Hospital Shiraz University of Medical Sciences, Shiraz, Iran
[v] Hospital of Lithuanian University of Health Sciences Kauno Klinikos, Kaunas, Lithuania
[w] Special Hospital for Surgical Diseases Filip Vtori, Skopje, Macedonia
[x] Armed Forces Institute of Pathology, Rawalpindi, Pakistan
[y] Hospital del Niño de Panama, Panama
[z] Wroclaw University Hospital, Wroclaw, Poland
[aa] Hospital General de La Plaza de La Salud, Santo Domingo, Dominican Republic
[bb] University of Medicine and Pharmacy Victor Babes Timisoara Emergency County Clinical Hospital, Timisoara, Romania
[cc] Privolzhskiy District Medical Center, Nizhniy Novgorod, Russia
[dd] Clinical Center of Serbia, Belgrade, Serbia
[ee] Hospital de Clínicas Caracas, Caracas, Venezuela
[ff] Catholic University in Ruzomberok Faculty Of Health Central Military Hospital Ruzomberok, Ruzomberok, Slovakia
[gg] Hospital Episcopal San Lucas, Guayama, Puerto Rico
[hh] Bahry Teaching Hospital, Khartoum, Sudan
[ii] Ciptomangunkusumo, Jakarta, Indonesia
[jj] Port Moresby General Hospital, Port Moresby, Papua New Guinea
[kk] Ibn Sina Hospital of Morocco, Rabat, Morocco
[ll] National Institute for Public Health of Kosovo and Medical School, Prishtina University, Prishtina, Kosovo
[mm] Joaquin Albarran, La Habana, Cuba
[nn] Zhongshan Hospital, Fudan University, Shanghai, China
[oo] Hospital De Especialidades Del Instituto Hondureno De Seguridad Social, Tegucigalpa, Honduras
[pp] Sri Jayewardenepura General Hospital, Nugegoda, Sri Lanka
[qq] Children Hospital Bechir Hamza of Tunis, Tunis, Tunisia
[rr] General and Oncological Hospital of Kiffissia, Athens, Greece
[ss] Hospital Central De La Fuerza Aerea Del Peru, Lima, Peru
[tt] Clínica Sanatorio Alemán, Concepcion, Chile
[uu] Centro Hospitalario Pereira Rossell, Montevideo, Uruguay
[vv] Grande International Hospital, Kathmandu, Nepal
[ww] Pontificia Universidad Javeriana Hospital Universitario San Ignacio, Bogotá, Colombia
[xx] Caja de Salud De La Banca, La Paz, Bolivia

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Background: We report the results of International Nosocomial Infection Control Consortium (INICC) surveillance study from January 2010-December 2015 in 703 intensive care units (ICUs) in Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific.

Methods: During the 6-year study period, using Centers for Disease Control and Prevention National Healthcare Safety Network (CDC-NHSN) definitions for device-associated health care-associated infection (DA-HAI), we collected prospective data from 861,284 patients hospitalized in INICC hospital ICUs for an aggregate of 3,506,562 days.

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 INICC medical-surgical ICUs, the pooled rate of central line-associated bloodstream infection, 4.1 per 1,000 central line-days, was nearly 5-fold higher than the 0.8 per 1,000 central line-days reported from comparable US ICUs, the overall rate of ventilator-associated pneumonia was also higher, 13.1 versus 0.9 per 1,000 ventilator-days, as was the rate of catheter-associated urinary tract infection, 5.07 versus 1.7 per 1,000 catheter-days. From blood cultures samples, frequencies of resistance of *Pseudomonas* isolates to amikacin (29.87% vs 10%) and to imipenem (44.3% vs 26.1%), and of *Klebsiella pneumoniae* isolates to ceftazidime (73.2% vs 28.8%) and to imipenem (43.27% vs 12.8%) were also higher in the INICC ICUs compared with CDC-NHSN ICUs.

Conclusions: Although DA-HAIs in INICC ICU patients continue to be higher than the rates reported in CDC-NSHN ICUs representing the developed world, we have observed a significant trend toward the reduction of DA-HAI rates in INICC ICUs as shown in each international report. It is INICC's main goal to continue facilitating education, training, and basic and cost-effective tools and resources, such as standardized forms and an online platform, to tackle this problem effectively and systematically.

The first report of health care-associated infection (HAI) rates was published by the Centers for Disease Control and Prevention (CDC) 40 years ago, and has been published uninterruptedly until the present,[1,2] using standardized methods and definitions[3,4] that serve as the basis and inspiration for the International Nosocomial Infection Control Consortium (INICC).[5,6]

This INICC report is a summary of device-associated (DA) module data collected by hospitals participating in the INICC for events reported to INICC occurring from January 1, 2010-December 31, 2015. This report updates previously published DA module data from INICC and provides contemporary, comparative rates.[7-11]

Founded in Argentina in 1998, the INICC was the first multinational research network established to measure, prevent, and control HAIs at an international level through the analysis of validated data collected prospectively using standardized forms provided by INICC (on a voluntary basis) by a pool of hospitals worldwide.[5,6] Since 2003, INICC has been publishing HAI rates and consequences per individual country,[12-14] and since 2006 as international reports.[7-11]

The goals of INICC include the development of a dynamic global hospital network that applies standardized systematic prospective, active surveillance of HAIs, using a form provided by INICC, with standardized definitions and methodologies of the CDC National Healthcare Safety Network (NHSN) to promote evidence-based infection control practices and to conduct applied infection control research to reduce the incidence of HAIs and associated mortality, excess length of stay (LOS), costs, and bacterial resistance.[5,6]

To measure HAI rates accurately, INICC has an online platform with standardized forms: The INICC Surveillance Online System. The methods of the INICC include CDC-NSHN surveillance methodology[3,4] and the collection of other data essential to increase infection preventionist's sensitivity to detect HAIs and avoid underreporting.[5,6]

According to standard CDC-NSHN methods,[3,4] numerators are the number of each type of HAI, 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 characteristics per specific patient. This differs from the INICC method in that the design of the INICC surveillance system also includes specific data per patient from all patients (those with and those without HAI) and collects 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 an intensive care unit (ICU), it is possible to match patients with and without HAI by several characteristics to estimate extra LOS, mortality, cost, and cost-effectiveness of interventions.[5,6]

The goal of this report is to provide updated data on HAI rates, device use (DU), bacterial resistance, LOS, and mortality of patients with and without HAI.

METHODS

The INICC Surveillance Online System has 15 modules. One of them is for surveillance of DA-HAI in adult and pediatric ICUs and neonatal ICUs (NICUs).[5,6]

The data are collected using standardized INICC online forms, following CDC-NHSN methods for calculation of HAI rates and DU ratios, and HAI definitions of the CDC-NSHN that include laboratory and clinical criteria.[3,4] Definitions of HAI used during surveillance were those published by CDC in 2008,[3] and their subsequent updates published in 2013[15] and then in 2015.[16] At present, INICC applies the definitions of HAIs published in 2016, but these were not used in this report.[17]

This report includes ventilator-associated pneumonia (VAP) rates for adult, pediatric, and neonatal units because during the period 2010-2015 the adult INICC units did not yet apply the definition of ventilator-associated event.

The module must be used for a minimum of 1 calendar month.[5,6] Collected data address HAI rates, LOS, mortality, microbiologic profile, and bacterial resistance. Corresponding denominator data, patient days, and specific device days are collected and validated. Detailed data by patient and aggregated data were used to calculate DA-HAI rates and DU ratio. Only detailed data by patient were used to calculate mortality and LOS.

In addition, INICC methodology includes a process for adjudication of and validation of reported HAIs, through which daily data collection of invasive devices are checked for denominators and the fulfillment of CDC-NHSN criteria of HAI in each case of HAI is checked for numerators.[5,6]

Infection preventionists (IPs) collect data on central line-associated primary bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), and VAPs occurring in patients hospitalized in ICUs. ICUs are stratified according to patient population: different types of adult ICUs, pediatric ICUs, or NICUs.

All NICUs are level III or level II-III units, and IPs collect data on CLABSIs and umbilical catheter-associated primary bloodstream infections or VAPs for each of 5 birthweight categories (<750 g, 750-1,000 g, 1,001-1,500 g, 1,501-2,500 g, and >2,500 g).

Data of adult and pediatric ICUs were stratified by ICU type. Data for NICUs were stratified by weight categories.

Data analysis

SPSS 16.0 (IBM-SPSS Inc, Chicago, IL), INICC Surveillance Online System version 2 (Buenos Aires, Argentina),[6] and EpiInfo version 6.04b (CDC, Atlanta, GA) were used for data analysis. Relative risk ratios, 95% confidence intervals (CIs), and *P* values were determined for primary and secondary outcomes. Comparisons of the percentile distribution were made if there were at least 20 locations contributing to the strata. Data for ICUs were not stratified by type or size of hospital.

RESULTS

From January 1, 2010-December 31, 2015 we conducted a cohort prospective multicenter surveillance study of DA-HAI in 703 ICUs in 50 countries from Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific World Health Organization regions currently participating in INICC. Out of all hospitals, 62% were public or academic, and the remaining 38% were private. The identity of all INICC patients, hospitals, cities, and countries is confidential, in accordance with the INICC charter.

Table 1
International Nosocomial Infection Control Consortium facilities contributing data used in this report, by World Health Organization region

	Latin America	Europe	Eastern Mediterranean	Southeast Asia	Western Pacific	Pooled
ICU type						
Surgical cardiothoracic	3	9	4	11	1	28
Medical cardiac	17	3	6	18	8	52
Medical	12	12	29	37	11	101
Medical/surgical	98	44	43	65	27	277
Neurosurgical	5	8	3	9	6	31
Neurologic	1	3	0	3	2	9
Pediatric	27	15	10	17	7	76
Respiratory	3	6	1	1	2	13
Surgical	6	14	11	22	8	61
Trauma	1	0	2	4	0	7
Neonatal	18	3	15	11	1	48
Total ICUs	191 (27.1)	117 (16.6)	124 (17.6)	198 (28.1)	73 (10.3)	703 (100)
Hospitals						
Academic teaching	13 (13.5)	34 (81.0)	15 (26.3)	8 (14.3)	10 (35.7)	80 (28.7)
Public	38 (39.6)	6 (14.3)	34 (59.6)	2 (3.6)	13 (46.4)	93 (33.3)
Private community	44 (45.8)	2 (4.8)	7 (12.3)	45 (80.4)	5 (17.9)	103 (36.9)
Total hospitals	96	42	57	56	28	279

NOTE. Values are presented as n or n (%).
ICU, intensive care unit.

The length of participation of hospitals in the INICC Program ranged from 1-72 months (mean, 12 ± 18.2 months).

Of 703 intensive care units, 436 ICUs (62%) contributed detailed data by patient, and the remaining 267 ICUs (38%) contributed aggregated data to INICC.

Characteristics of the 703 ICUs that contributed data for this report are shown in Table 1.

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 DU ratios from adult, pediatric, and NICUs.

The pooled rate of CLABSI per 1,000 central line-days in the medical surgical ICU was 4.11 (95% CI, 4.0-4.2), and 16.37 (95% CI, 15.2-17.6) in the NICUs. The pooled rate of VAP per 1,000

Table 2
Pooled means, 95% confidence intervals (CIs), and key percentiles of the distribution of central line-associated bloodstream infection (BSI) rates and ventilator-associated pneumonia (PNEU) rates by type of location, in adult, pediatric, and neonatal intensive care units (ICUs), and of urinary catheter-associated urinary tract infection (UTI) rates, by type of location, in adult and pediatric ICUs, device-associated module, 2010-2015

Central line-associated BSI rate							Percentile				
Type of ICU	No. of ICUs	No of patients	No. of central line-associated BSIs	Central line-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	28,431	149	103,458	1.44	1.2-1.7	0.00	0.00	0.50	2.80	5.80
Medical cardiac	52	55,960	366	96,035	3.81	3.4-4.2	0.00	0.00	0.50	4.40	9.90
Medical	101	70,965	712	191,106	3.73	3.5-4.0	0.00	0.00	2.70	8.30	16.20
Medical/surgical	274	587,580	5,365	1,306,151	4.11	4.0-4.2	0.00	1.00	3.70	8.20	18.70
Neurosurgical	31	15,270	168	42,710	3.93	3.4-4.6	0.00	0.00	1.90	5.80	9.50
Neurologic	9	2,072	52	5,130	10.14	7.6-13.3	0.00	0.00	0.00	18.10	-
Pediatric	76	29,197	979	115,715	8.46	7.9-9.0	0.00	0.00	4.00	10.30	25.00
Respiratory	13	2,960	39	13,986	2.79	2.0-3.8	0.00	0.40	3.60	5.20	7.70
Surgical	61	46.182	508	114,498	4.44	4.1-4.8	0.00	0.00	2.00	8.20	17.90
Trauma	7	8,496	90	22,617	3.98	3.2-4.9	0.00	3.80	5.00	8.80	-
Pooled (adult and pediatric ICUs)	652	847,113	8,428	2,011,406	4.19	4.1-4.3	0.00	0.00	2.90	7.5	16.3
Neonatal ICU: Birth-weight category (kg)											
< 750 g	26	1,410	90	4,306	20.90	16.8-25.7	0.00	0.00	0.00	16.00	57.90
751-1,000 g	37	3,076	73	8,351	8.74	6.9-11.0	0.00	0.00	10.20	21.90	134.50
1,001-1,500 g	40	1,888	177	8,987	19.70	16.9-22.8	0.00	0.00	1.70	13.90	37.90
1,501-2,500 g	39	3,603	322	15,435	20.86	18.6-23.3	0.00	0.00	5.50	13.60	31.50
> 2,500 g	43	4,194	99	9,400	10.53	8.6-12.8	0.00	0.00	0.00	15.30	36.80
Pooled (neonatal ICUs)	48	14,171	761	46,479	16.37	15.2-17.6	0.00	0.00	4.00	15.8	39.5
Ventilator-associated PNEU rate							Percentile				
Type of ICU	No. of ICUs	No of patients	No. of VAPs	Ventilator-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	28,431	269	43,615	6.2	5.5-7.0	0.00	0.00	2.30	10.12	25.40
Medical cardiac	52	55,960	595	43,277	13.7	12.7-14.9	0.00	0.00	5.90	16.10	31.00
Medical	101	70,965	1.838	163,931	11.2	10.7-11.7	0.00	0.00	7.20	20.50	48.10
Medical/surgical	274	58,580	9.919	756,478	13.1	12.9-13.4	0.00	3.80	11.20	22.20	37.50
Neurosurgical	31	15,270	416	28,749	14.5	13.1-15.9	0.00	1.10	11.70	23.70	38.60
Neurologic	9	2,072	97	5,046	19.2	15.6-23.5	0.00	0.00	16.60	39.00	-
Pediatric	76	29,197	812	98,853	8.2	7.7-8.8	0.00	0.00	5.50	11.70	28.90
Respiratory	13	2,960	196	14,246	13.8	11.9-15.8	0.00	4.60	11.30	19.90	76.70
Surgical	61	46,182	773	63,135	12.2	11.4-13.1	0.00	0.00	9.50	26.30	82.40
Trauma	7	8,496	258	29,125	8.9	7.8-10.0	0.00	0.00	8.50	42.50	-
Pooled (adult and pediatric ICUs)	652	847,113	15.173	1,246,455	12.2	12.0-12.4	0.00	0.97	8.70	20.4	37.9
Neonatal ICU: Birthweight category (kg)											
< 0.750	26	1,410	4.189	20	4.77	2.9-7.4	0.00	0.00	0.00	7.80	17.20
0.750-1.000	37	3,076	7.755	46	5.93	4.3-7.9	0.00	0.00	0.00	4.40	66.40
1.001-1.500	40	1,888	5.727	29	5.06	3.4-7.3	0.00	0.00	0.00	4.30	28.70
1.501-2.500	39	3,603	9.855	142	14.41	12.1-17.0	0.00	0.00	0.00	4.40	21.40
> 2.500	43	4,194	7.631	80	10.48		0.00	0.00	0.00	1.80	10.40
Pooled (neonatal ICUs)	48	14,171	35,157	317	9.02		0.00	0.00	0.00	4.3	19.6
							Percentile				
Type of ICU	No. of ICUs	No. of patients	No. of CAUTIs	Urinary catheter-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	28,431	144	86,933	1.66	1.4-2.0	0.00	0.00	0.35	2.60	4.90
Medical cardiac	52	55,960	425	94,747	4.49	4.1-4.9	0.00	0.00	1.10	4.30	11.40
Medical	101	70,965	1,147	293,066	3.91	3.7-4.1	0.00	0.00	2.10	6.50	16.80
Medical/surgical	274	587,580	7,152	1,411,980	5.07	4.9-5.2	0.00	0.88	3.00	7.30	14.50
Neurosurgical	31	15,270	428	68,657	6.23	5.7-6.9	0.00	0.50	3.40	9.40	15.70
Neurologic	9	2,072	286	16,653	17.17	15.2-19.3	0.00	0.00	0.00	16.60	–
Pediatric	76	29,197	438	79,696	5.50	5.0-6.0	0.00	0.00	0.00	7.20	20.40
Respiratory	13	2,960	144	20,006	7.20	6.1-8.5	0.00	0.00	4.30	16.20	24.10
Surgical	61	46,182	574	147,697	3.89	3.6-4.2	0.00	0.00	2.00	7.10	14.60
Trauma	7	8,496	130	34,894	3.73	3.1-4.4	0.00	0.00	3.70	6.70	–
Pooled (adult and pediatric ICUs)	652	847,113	10,868	2,254,329	4.82	4.7-4.9	0.00	0.00	2.40	6.8	14.7

CL, central line; *VAP*, ventilator-associated pneumonia.

Table 3
Pooled means, 95% confidence intervals (CIs), and key percentiles of the distribution of central line use ratios, and ventilator use ratios by type of location, in adult, pediatric, and neonatal intensive care units (ICUs), and of urinary catheter use ratios, by type of location, in adult and pediatric ICUs, device-associated module, 2010-2015

Central line use ratio						Percentile				
Type of ICU	No. of ICUs	Patient-days	Central line-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	101,237	103,458	1.02	1.01-1.03	0.36	0.72	0.85	1.12	1.47
Medical cardiac	52	218,345	96,035	0.44	0.44-0.44	0.07	0.31	0.48	0.71	1.11
Medical	101	427,927	191,106	0.45	0.45-0.45	0.11	0.23	0.45	0.66	0.78
Medical/surgical	274	2,052,214	1,306,151	0.64	0.64-0.64	0.18	0.36	0.57	0.78	0.98
Neurosurgical	31	88,374	42,710	0.48	0.48-0.49	0.03	0.23	0.48	0.62	0.86
Neurologic	9	18,012	5,130	0.28	0.28-0.29	0.03	0.17	0.50	0.71	–
Pediatric	76	195,104	115,715	0.59	0.59-0.60	0.14	0.26	0.44	0.73	0.88
Respiratory	13	33,292	13,986	0.42	0.41-0.43	0.15	0.27	0.68	0.95	1.60
Surgical	61	194,795	114,498	0.59	0.59-0.59	0.12	0.29	0.52	0.77	1.01
Trauma	7	44,447	22,617	0.51	0.50-0.51	0.01	0.12	0.41	0.56	–
Pooled (adult and pediatric ICUs)	652	3,373,747	2,011,406	0.60	0.60-0.60	0.15	0.32	0.53	0.76	0.97
Neonatal ICU: Birthweight category (kg)						*Percentile*				
< 750 g	26	8,752	4,306	0.49	0.48-0.51	0,10	0.23	0.60	0.80	1.00
751-1,000 g	37	28,973	8,351	0.29	0.28-0.29	0,03	0.17	0.50	0.72	0.94
1,001-1,500 g	40	18,618	8,987	0.48	0.47-0.49	0,02	0.13	0.37	0.60	0.68
1,501-2,500 g	39	37,576	15,435	0.41	0.40-0.42	0,02	0.10	0.28	0.53	0.84
> 2,500 g	43	38,896	9,400	0.24	0.24-0.25	0,03	0.23	0.44	0.80	1.00
Pooled (neonatal ICUs)	48	132,815	46,479	0.35	0.35-0.35	0,04	0.17	0.42	0.64	0.94
Ventilator use ratio						**Percentile**				
Type of ICU	No. of ICUs	Patient-days	Ventilator-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	101,237	43,615	0.43	0.43-0.43	0.05	0.20	0.33	0.42	0.65
Medical cardiac	52	218,345	43,277	0.20	0.20-0.20	0.06	0.07	0.16	0.29	0.46
Medical	101	427,927	163,931	0.38	0.38-0.38	0.07	0.15	0.35	0.49	0.68
Medical/surgical	274	2,052,214	756,478	0.37	0.37-0.37	0.11	0.23	0.39	0.60	0.74
Neurosurgical	31	88,374	28,749	0.33	0.32-0.33	0.11	0.24	0.32	0.51	0.83
Neurologic	9	18,012	5,046	0.28	0.27-0.29	0.09	0.16	0.26	0.40	–
Pediatric	76	195,104	98,853	0.51	0.50-0.51	0.15	0.32	0.45	0.55	0.67
Respiratory	13	33,292	14,246	0.43	0.42-0.43	0.18	0.34	0.68	0.79	0.92
Surgical	61	194,795	63,135	0.32	0.32-0.33	0.03	0.08	0.25	0.52	0.68
Trauma	7	44,447	29,125	0.66	0.65-0.66	0.06	0.08	0.25	0.57	–
Pooled (adult and pediatric ICUs)	652	3,373,747	1,246,455	0.37	0.37-0.37	0.07	0.18	0.36	0.53	0.70
Neonatal ICU: Birthweight category (kg)										
< 0.750	26	8,752	4,189	0.48	0.46-0.49	0.00	0.19	0.50	0.78	1.00
0.750-1.000	37	28,973	7,755	0.27	0.26-0.27	0.01	0.15	0.30	0.49	0.78
1.001-1.500	40	18,618	5,727	0.31	0.30-0.32	0.01	0.08	0.19	0.41	0.64
1.501-2.500	39	37,576	9,855	0.26	0.26-0.27	0.05	0.11	0.21	0.36	0.49
> 2.500	43	38,896	7,631	0.20	0.19-0.20	0.00	0.13	0.28	0.46	0.62
Pooled (neontal ICUs)	48	132,815	35,157	0.26	0.26-0.27	0.01	0.12	0.27	0.47	0.71
Urinary catheter use ratio						**Percentile**				
Type of ICU	No. of ICUs	Patient-days	Urinary catheter-days	Pooled mean	95% CI	10%	25%	50% (median)	75%	90%
Surgical cardiothoracic	28	101,237	86,933	0.86	0.86-0.86	0.39	0.55	0.76	0.96	1.00
Medical cardiac	52	21,345	94,747	0.43	0.43-0.44	0.20	0.35	0.49	0.62	0.82
Medical	101	427,927	293,066	0.68	0.68-0.69	0.27	0.45	0.62	0.82	0.93
Medical/surgical	274	2,052,214	1,411,980	0.69	0.69-0.69	0.32	0.53	0.72	0.89	0.97
Neurosurgical	31	88,374	68,657	0.78	0.77-0.78	0.51	0.63	0.83	0.96	0.99
Neurologic	9	18,012	16,653	0.92	0.92-0.93	0.50	0.60	0.87	0.96	–
Pediatric	76	195,104	79,696	0.41	0.41-0.41	0.11	0.19	0.34	0.47	0.59
Respiratory	13	33,292	20,006	0.60	0.60-0.61	0.21	0.53	0.92	0.96	0.97
Surgical	61	194,795	147,697	0.76	0.76-0.76	0.15	0.59	0.75	0.91	0.95
Trauma	7	44,447	34,894	0.79	0.78-0.79	0.07	0.26	0.52	0.80	–
Pooled (adult and pediatric ICUs)	652	3,373,747	2,254,329	0.67	0.67-0.67	0.22	0.44	0.66	0.86	0.96

mechanical ventilator-days was 13.1 (95% CI, 12.9-13.4) in the medical surgical ICUs and 9.02 (95% CI, 8.1-10.1) in the NICUs. The overall CAUTI rate per 1,000 catheter-days was 5.07 (95% CI, 4.9-5.2) in medical surgical ICUs.

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 CDC-NHSN hospitals.

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

For CLABSI rates and CAUTI rates in adult and pediatric ICUs, we compared INICC rates with those from the CDC-NHSN report with data from 2013.[18] For VAP rates in pediatric ICUs and NICUs, we also

Table 4
Pooled means of the distribution of crude mortality and length of stay (LOS) of intensive care unit patients with device-associated health care-associated infections (DA-HAIs), adult, pediatric intensive care units combined, and infants in neonatal intensive care units, device associated module, 2010-2015

	No. of deaths	No. of patients	Pooled crude mortality % (95% CI)	LOS (total d)	Pooled average LOS d (95% CI)
Adult and pediatric patients without DA-HAI	13,792	93,675	14.7 (14.5-15.0)	663,008	7.08 (7.06-7.10)
Infants at level III neonatal intensive care units without DA-HAI	586	3,090	19.0 (18.6-20.4)	53,950	17.46 (17.30-17.60)
Adult and pediatric patients with CLABSI	668	1,738	38.4 (36.1-40.8)	30,169	17.36 (17.16-17.55)
Infants at level III neonatal intensive care units with CLABS	78	263	29.7 (24.2-35.6)	9,946	37.82 (37.10-38.60)
Adult and pediatric patients with VAP	1,121	3,119	35.9 (34.2-37.6)	52,949	16.98 (16.83-17.12)
Infants at level III neonatal intensive care units with VAP	21	74	28.4 (18.5-40.0)	2,676	36.16 (34.80-37.60)
Adult and pediatric patients with CAUTI	340	1,337	25.4 (23.1-27.9)	23,228	10.30 (10.09-10.53)

CAUTI, catheter-associated urinary tract infection; *CI*, confidence interval; *CLABSI*, central line-associated bloodstream infection; *RR*, relative risk; *VAP*, ventilator-associated pneumonia.

Table 5
Antimicrobial resistance rates in the intensive care units of International Nosocomial Infection Control Consortium (INICC) hospitals, and comparison of antimicrobial resistance rates in the intensive care units (ICUs) of INICC hospitals and Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN) hospitals

	No. of pathogenic isolated tested at INICC ICUs, pooled	Resistance percentage at INICC ICUs	No. of pathogenic isolated tested at INICC ICUs, pooled	Resistance percentage at INICC	No. of pathogenic isolated tested at INICC ICUs, pooled	Resistance percentage at INICC ICUs	Resistance percentage at NSHN ICUs
Pathogen, antimicrobial	VAP	VAP	CAUTI	CAUTI	CLABSI	CLABSI	CLABSI
Staphylococcus aureus							
OXA	357	44.8	14	57.1	191	65.4	54.6
Enterococcus faecalis							
VAN	25	12.00	73	1.37	93	8.6	9.5
Pseudomonas aeruginosa							
FQs	1.444	32.1	190	43.7	247	32.0	30.5
PIP or TZP	1.240	35.2	156	40.4	205	36.1	17.4
AMK	1.353	21.7	184	25.5	228	29.8	10.0
IPM or MEM	1.341	43.5	189	41.8	234	44.4	26.1
FEP	1.024	38.8	144	41.7	160	46.3	26.1
Klebsiella pneumonia							
CRO or CAZ	1.041	66.6	305	77.4	422	73.2	28.8
IPM, MEM, or ETP	1.067	35.7	359	33.7	454	43.2	12.8
Acinetobacter baumannii							
IPM or MEM	1.395	90.1	111	85.6	287	90.2	62.6
Escherichia coli							
CRO or CAZ	347	70.3	545	63.5	282	66.0	19.0
IPM, MEM, or ETP	334	11.7	579	6.6	288	12.8	1.9
FQs	363	62.8	555	61.3	266	62.0	41.8

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

Table 6
Comparison of device-associated healthcare-associated infection rates, per 1,000 device-days in the intensive care units (ICU) of the International Nosocomial Infection Control Consortium (INICC) (2010-2015) and the US National Healthcare Safety Network (NHSN) (2012)

	CLABSI rate		VAP rate		CAUTI rate	
ICU type	INICC 2010-2015	NHSN 2013	INICC 2010-2015	NHSN 2012*/2013†	INICC 2010-2015	NHSN 2013
Surgical cardiothoracic	1.44 (1.2-1.7)	0.8 (0.8-0.9)	6.2 (5.5-7.0)	1.7 (1.5-1.9)	1.66 (1.4-2.0)	1.8 (1.7-1.9)
Medical cardiac	3.81 (3.4-4.2)	1.0 (0.9-1.1)	13.7 (12.7-14.9)	1.0 (0.8-1.1)	4.49 (4.1-4.9)	2.3 (2.2-2.4)
Medical	3.73 (3.5-4.0)	1.1 (1.0-1.2)	11.2 (10.7-11.7)	0.9 (0.8-1.1)	3.91 (3.7-4.1)	2.0 (1.9-2.1)
Medical/surgical	4.11 (4.0-4.2)	0.8 (0.8-0.9)	13.1 (12.9-13.4)	0.9 (0.8-1.0)	5.07 (4.9-5.2)	1.7 (1.6-1.8)
Neurosurgical	3.93 (3.4-4.6)	0.9 (0.8-1.1)	14.5 (13.1-15.9)	2.1 (1.9-2.5)	6.23 (5.7-6.9)	5.3 (5.1-5.5)
Neurologic	10.14 (7.6-13.3)	1.1 (0.9-1.4)	19.2 (15.6-23.5)	3.0 (2.3-3.8)	17.17 (15.2-19.3)	4.5 (4.1-4.9)
Pediatric	8.46 (7.9-9.0)	1.2 (1.1-1.3)	8.2 (7.7-8.8)	0.7 (0.6-0.8)	5.50 (5.0-6.0)	2.5 (2.2-2.7)
Respiratory	2.79 (2.0-3.8)	1.0 (0.5-1.9)	13.8 (11.9-15.8)	0.7 (0.2-1.7)	7.20 (6.1-8.5)	2.1 (1.5-3.0)
Surgical	4.44 (4.1-4.8)	0.9 (0.8-1.0)	12.2 (11.4-13.1)	2.0 (1.7-2.3)	3.89 (3.6-4.2)	2.0 (1.9-2.2)
Trauma	3.98 (3.2-4.9)	1.4 (1.3-1.6)	8.9 (7.8-10.0)	3.6 (3.3-3.9)	3.73 (3.1-4.4)	4.3 (4.1-4.5)
Neonatal ICU: Birthweight category (kg)						
< 750 g	20.90 (16.8-25.7)	2.1 (1.9-2.3)	4.77 (2.9-7.4)	1.0 (0.8-1.3)	–	–
751-1,000 g	8.74 (6.9-11.0)	1.3 (1.2-1.5)	5.93 (4.3-7.9)	1.1 (0.8-1.6)	–	–
1,001-1,500 g	19.70 (16.9-22.8)	0.8 (0.7-0.9)	5.06 (3.4-7.3)	0.7 (0.3-1.2)	–	–
1,501-2,500 g	20.86 (18.6-23.3)	0.6 (0.5-0.7)	14.41 (12.1-17.0)	0.5 (0.2-1.1)	–	–
> 2,500 g	10.53 (8.6-12.8)	0.7 (0.6-0.9)	10.48 (8.3-13.0)	0.1 (0.0-0.4)	–	–

NOTE. Values are presented as pooled mean (95% confidence interval).
CAUTI, catheter-associated urinary tract infection; *CLABSI*, central line-associated bloodstream infection; *ICU*, intensive care unit; *VAP*, ventilator-associated pneumonia.
*To compare VAP rates for adult ICUs we used an NSHN report with data from 2012.
†To compare VAP rates for pediatric ICU and NICU we used an NSHN report with data from 2013.

Table 7
Comparison of pooled device-associated health care-associated infection rates, per 1,000 device-days in the intensive care units (ICUs) of International Nosocomial Infection Control Consortium (INICC) hospitals, based on reports published in 2006, 2008, 2010, 2012, 2014, and 2016

	INICC Report 2002-2005	INICC Report 2002-2007	INICC Report 2003-2008	INICC Report 2004-2009	INICC Report 2007-2012	INICC Report 2010-2015
Countries	8	18	25	36	43	50
ICUs	55	98	173	422	503	703
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)	4.19 (4.1-4.3)
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)	4.82 (4.7-4.9)
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)	12.2 (12.0-12.4)

NOTE. Values are presented as n or pooled mean (95% confidence interval).
CAUTI, catheter-associated urinary tract infection; *CLABSI*, central line-associated bloodstream infection; *VAP*, ventilator-associated pneumonia.

compared INICC rates with those from the CDC-NHSN report with data from 2013.[18]

But, only for VAP rates in adult ICUs, we compared rates with CDC-NHSN report data from 2012,[2] because during the period 2010-2015 we did not use ventilator-associated event definition criteria.

Table 7 compares the results of the different 6 biennial INICC reports published from 2006-2016.[7-11]

DISCUSSION

From 1975-2004 the CDC's former National Nosocomial Infections Surveillance system,[1] and thereafter, the NHSN,[2] have provided benchmarking US ICU data on DA-HAIs, which are invaluable for researchers and served as an inspiration and foundation to the INICC program, which started its prospective standardized surveillance in 1998.[5,6]

Our findings show that although the DU ratio in INICC ICUs is analogous or even lower to the DU ratio reported of US ICUs by the CDC-NHSN system, DA-HAI rates identified in INICC ICUs are higher than the published US rates (Table 6).

Likewise, the antimicrobial resistance rates found in INICC ICUs in blood samples for isolates of *Klebsiella pneumoniae*, *Pseudomonas*, *Escherichia coli,* and *Acinetobacter baumannii* were higher than CDC-NHSN rates. Nonetheless, the rates found in the INICC ICUs for *Staphylococcus aureus* and *Enterococcus faecalis* resistance were similar to CDC-NHSN ICU rates.[19,20]

Such higher DA-HAI rates, in comparison with the CDC-NHSN report, may reflect the situation in other countries,[21] and several reasons have been exposed to explain this fact.[22,23] Among the primary plausible causes, in some countries, is that adherence to and compliance with the guidelines can be irregular. It is especially risky in cases with extremely low nurse-to-patient staffing ratios (which are highly connected to high HAI rates), hospital overcrowding, lack of medical supplies, and an insufficient number of experienced nurses or trained health care workers.[21-23]

The relation between the rates of HAI and their association to the type of hospital (ie, public, academic, or private), and the relation between HAI rates and the country's socioeconomic level has been analyzed and published by INICC.[24,25] Such studies' findings show that a higher country socioeconomic level is correlated with a lower infection risk.[24,25]

Comparing CDC-NHSN hospital rates with those of hospitals from North America, Western Europe, Oceania, and some countries in Asia is considered valid, due to their similar socioeconomic conditions. In contrast, the comparison between CDC-NHSN hospital rates 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. Within this context, INICC emerged 20 years ago as a complementary benchmarking tool for HAI rates in hospitals worldwide due to their shared socioeconomic hospital backgrounds.[9-11]

Although DA-HAIs in our ICU patients continue to be higher than the rates reported in CDC- NSHN reports representing the developed world, we have observed a significant trend toward the reduction of DA-HAI rates in INICC ICUs, based on comparing INICC reports from 2006, 2008, 2010, 2012, and 2014 with this report, as shown in Table 7.[7-11]

On one hand, these data should be analyzed considering that in each of our 6 reports we had a different number of ICUs, and some of those units did not participate during the entire period. Thus, we should consider the HAI rates shown in Table 7 as 6 point-prevalence studies of HAI rates from a setting with limited resources, rather than the result of a particular targeted intervention.

On the other hand, as shown in unbiased prospective studies conducted by INICC, in many ICUs that participated in the INICC network during several years, their high incidence of DA-HAI has been reduced by adopting the INICC Multidimensional Approach and the INICC Surveillance Online System,[26-31] which include a bundle of infection control interventions; education; outcome surveillance of CLABSI, VAP, CAUTI, and surgical site infections; process surveillance for hand hygiene, central line, ventilator, urinary catheter, and surgical site care; feedback on HAI rates; and performance feedback.[5,6]

It is INICC's main goal to continue facilitating education, training, and basic and cost-effective tools and resources, such as standardized forms and an online platform, to tackle this problem effectively and systematically.

Study limitations

The reduction in HAI rates shown in Table 7, when compared with the 5 previous biannual reports, may not reflect a true HAI rate reduction at all the participating hospitals because, on one hand, the mean participation was 1 year and reported HAI rates may have been influenced by the fact that some hospitals may have interrupted their reporting or may have participated only sporadically, and on the other hand, seasonal diseases, such as complications of flu admissions, may have affected HAI rates. Thus, we consider the HAI rates shown in Table 7 as 6 point-prevalence studies of HAI rates from a setting with limited resources rather than as the result of a particular targeted intervention.[7-11] However, to see the unbiased influence of INICC resources, such as the INICC Multidimensional Approach and INICC Surveillance Online System,[5,6] we also published prospective interventional studies conducted at hospitals that remained in INICC during several years.[26-31] Second, our study was limited by the fact that we did not apply the definition of ventilator-associated event because it became available in 2013 and this report includes prospectively collected data from 2010.

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APPENDIX. REMAINING AUTHORS

Argentina: Desse, J. E.; Maurizi, D. M.; Montanini, A. M.; Chaparro, G. J.; Stagnaro, J. P.; Romani, A.; Bianchi, A. C.; Álvarez, G.; Palaoro, A.; Bernan, M.; Cabrera-Montesino, R.; Domínguez, C.; Rodríguez, C. G.; Silva, C. G.; Bogdanowicz, E.; Riera, F. O. ; Benchetrit, G. ; Perez, I.; Vimercati, J.; Marcos, L.S.; Ramasco, L.; Caridi, M.; Oyola, M. C. ; Rodríguez, M. C.; Spadaro, M. L.; Olivieri, M. S.; Saul, P.; Juarez, P. D.; Pérez, R. H.; Botta, P.; Quintana, D., Q.; Ríos, A. M.; Stagnaro, J. P.; Chediack, V.; Chilon, W.

Bahrain: Alsayegh, A. I.; Yaseen, F. H.; Hani, L. F.; Sowar, S.F.; Magray, T. A.

Brazil: Medeiros, E. A.; Alves De Oliveira, A.; Romario-Mendes, A.; Fernandes-Valente, C.; Santos, C.; Escudeiro, D.; Azevedo-Ferreira Lima, D.; Azevedo-Pereira, D.; Onzi-Siliprandi, E. M.; Serpa-Maia, F.; Aguiar-Leitao, F.; Assuncao-Ponte, G.; Dos Anjos-Lima, J.; Olszewski, J.; Harten Pinto Coelho, K.; Alves De Lima, L. F.; Mendonca, M.; Maciel-Canuto Amaral, M. L.; Tenorio, M. T.; Gerah, S.; Andrade-Oliveira-Reis, M.; Moreira, M.; Ximenes-Rocha Batista, M.; Campos-Uchoa, R. S.; Rocha-Vasconcelos Carneiro, R.; Amaral De Moraes, R.; Do Nascimento, S. C.; Moreira-Matos, T.; Lima-De Barros Araujo, T. M.; De Jesus Pinheiro-Bandeira, T.; Machado-Silva, V. L.; Santos Monteiro, W. M.

Bulgaria: Hristozova, E.; Kostadinov, E. D.; Angelova, K.; Velinova, V. A.; Dicheva, V. J.

China: Guo, X.; Ye, G.; Li, R.; Song, L.; Liu, K.; Liu, T.; Song, G.; Wang, C.; Yang, X.; Yu, H.; Yang, Y.

Colombia: Martínez, A.; Vargas-García, A. R.; Lagares-Guzmán, A.; González, A. P.; Linares, C.; Ávila-Acosta, C.; Santofimio, D.; Yepes-Gomez, D.; Mazo-Elorza, D. P.; Chapeta-Parada, E. G.; Camacho-Moreno, G.; Roncancio-Villamil, G. E.; Valderrama-Marquez, I. A.; Ruiz-Gallardo, J. E.; Ospina-Martínez, J. O.; Osorio, J.; Marín-Uribe, J. I.; López, J. C.; Gualtero, S.; Rojas, J. R.; Gomez-Nieto, K.; Rincon, L. Y. M.; Meneses-Ovallos, L.; Cañas-Giraldo, L. M.; Marin-Tobar, D. A.; Burgos-Florez, L. D.; Amaral-Almeida Costa, M.; Rodriguez, M.; Barahona-Guzmán, N.; Mancera-Paez, O.; Rios-Arana, P. A.; Ortega, R.; Romero-Torres, S. L.; Pulido-Leon, S. M.; Valderrama, S.; Moreno-Mejia, V. M.; Raigoza-Martinez, W.; Villamil-Gomez, W.; Pardo-Lopez, Y. A.

Costa Rica: Argüello-Ruiz, A.; Solano-Chinchilla, A.; Muñoz-Gutierrez, G. A.; Calvo-Hernández, I.; Maroto-Vargas, L.; Zuniga, M. A.; Valverde-Hernandez, M.; Chavarria-Ugalde, O.

Dominican Republic: Herrera, B.; Díaz, C.

Ecuador: Bovera, M. M.; Cevallos, C.; Pelaez, C.; Jara, E.; Delgado, V.; Coello-Gordon, E. E.; Picoita, F.; Guerrero-Toapanta, F.M.; Valencia, F.; Santacruz, G.; Gonzalez, H.; Pazmino, L. N.; Garcia, M. F.; Arboleda, M.; Lascano, M.; Alquinga, N.; Ramírez, V.

Egypt: Yousef, R. H. A.; Abd El Moniem, M.; Ahmed, A.; Elansary, A. M.; Ali, A. M.; Hasanin, A.; Agha, H.; Abd El Messih, A.; ElManakhly, A.; El Awady, B. A.; Hassan, D. M.; Abdel-Aziz, D. M.; Hamza, H; Ghazi, I. A.; ElKholy, J.; Fattah, M. A; Elanany, M.; Mansour, M.; Haleim, M. M. A.; Fouda, R.; El-Sherif, R. H.; Beikheit, S.; Bayani, V.; Elkholy, Y. S.; Abdelhamid, Y. M.; Zeinab Salah.

Greece: Fildisis, G.; Zidianakis, V.; Baltopoulos, G.

Honduras: Rivera, D. M.

India: Chawla, A.; Manked, A. N.; Azim, A.; Mubarak, A.; Thakur, A.; Dharan, A. V.; Patil, A.; Sasidharan, A.; Bilolikar A. K.; Mathew, A. M.; Kulkarni, A.; Agarwal, A.; Sriram A.; Dwivedy, A.; Dasgupta, A.; Bhakta, A.; Suganya, A. R.; Poojary, A.; Mani, A. K.; Sakle, A.; Abraham B. K.; Padmini B.; Ramachandran, B.; Ray, B.; Mishra, S.; Pati, B. K.; Chaudhury, B. N.; Mishra, B. M.; Biswas, S.; Bri Saibala, M.; Jawadwala, B. Q.; Rodrigues, C.; Modi C.; Patel, C.; Khanna, D. K.; Devaprasad D.; Divekar, D.; Aggarwal, D. G.; Divatia, J. V.; Zala, D.; Pathrose, E.; Abubakar F.; Chacko F.; Gehlot, G. S.; Khanna G.; Sale, H. K.; Roy, I.; Shelgaonkar J.; Sorabjee J.; Eappen J.; Mathew J.; Varma K.; Joshi K. L.; Sandhu, K.; Kelkar, R.; Ranganathan, L.; Pushparaj, L.; Lavate, M.; Latha, M.; Suryawanshi, M.; Bhattacharyya, M.; Kavathekar, M.; Agarwal, M. K.; Patel, M; Shah, M; Sivakumar, M. N.; Kharbanda, M.; Bej, M.; Potdar, M.; Chakravarthy, M.; Karpagam, M.; Myatra, S. N.; Gita, N.; Rao, N. P.; Sen, N.; Ramakrishnan, N.; Jaggi, N.; Saini, N.; Pawar, N. K.; Modi, N.; Pandya, N.; Mohanty, N.; Thakkar, P.; Joshi, P.; Sahoo, P. K.; Nair, P. K.; Kumar, P. S.; Patil, P.; Mukherjee, P.; Mathur, P.; Shah, P.; Sukanya, R.; Arjun, R.; Chawla, R.; Gopalakrishnan, R.; Venkataraman R.; Raut, S.; Krupanandan, R.; Tejam, R.; Misra, S. R.; Debroy, R.; Saranya, S.; Narayanan, S.; Mishra, S.; Saseedharan, S.; Patnaik, S. K.; Sinha, S.; Blessymole, S.; Rohra, S.; Rajagopal, S.; Mukherjee, S.; Sengupta; John, S. S.; Bhattacharya, S.; Sijo; Bhattacharyya, S.; Singh, S.; Sohanlal, T.; Vadi, S.; Dalal, S. S.; Todi, S. K.; Kumar, S.; Kansal, S.; Bhattacharyya, S.; Nirkhiwale, S.; Purkayastha, S. K.; Mukherjee, S.; Singh, S.; Sahu, S.; Sharma, S.; Kumar, S.; Basu, S.; Shetty, S.; Shah, S.; Singhal, T.; Francis, T.; Anand, T.; Venkateshwar, V.; Thomas, V.; Kothari, V.; Pandi, V.; Kantroo, V.

Indonesia: Sitohang, G.; Kadarsih R.

Iran: Sanaei A.; Maghsudi B.; Sabetian G.; Masjedi, M.; Alebouyeh, M.; Sherafat, S.J.

Kingdom of Saudi Arabia: Mohamed, Y. K.; Al Khamis A.; Alsaadi, A S.; Al-Jarie, A. A.; Mutwalli, A.H.; Cardinal-Ariola, N.; Tashkandi, N.; Alabdaly H.; Rillorta, A. S. K.; Thomas, A.; Kelany, A.; Manao, A.; Alamri, D. M.; Santiago, E. B.; Cruzpero, E. P.; Sawan, F. A.; Al Qasmah, F. A.; Alabdaly, H.; Al-Dossary, A .H.; Ahmed, H.; Roshdi, H.; Al-Alkami, H. Y.; Hanafi, H.; Ammari, H. E.; Al Hani, H. M.; Alzaydani Asiri, H. I. M.; Mendoza, J. A.; Algwizani, A.; Philipose, J.; Selga, J. O.; Tabassum, K.; Ghalilah, K. M.; Redito, L. S.; Josph, L.; Al-Alawi, M.; Al-Gethamy, M. M.; Madco, M.; Manuel, M. G.; Girvan, M.; Aldalaton, M.; De Guzman, M.; Alkhamaly, M.; Masfar, M.; Ali Karrar, M. A.; Al Azmi, M. M.; Quisai, M. L.; Torres, M. M.; Al-Abdullah, N.; Tawfic, N. A.; Elsayed, N.; Abdulkhalik, N. S.; Bugis; Neilia, N. A.; Ariola, C.; Gad, N.; Alghosn, N.; Tashkandi, N.; Al Zharani, N.; De Vera, P. A.; Krishnan, R.; Al Shehri, R. H.; Jaha, R. N. A.; Thomas R.; Cresencia, R. L.; Penuliar, R.; Lozada, R. V.; Al Qahtani, S.; Twfik, S.; Al Faraj, S H.; El-Sherbiny, S.; Alih, S. J. B.; Briones, S.; Bukhari, S. Z.; Abdulhadi Alotaibi, T. S.; Gopal, U.; Nair, U.; Abdulatif, W. A.; Hussain, W. M.; Demotica, W. M.; Shakeel, S.; Tabassum, K.; Malik, M. R.

Kosovo: Spahija, G.; Baftiu, N.; Gashi, A.

Kuwait: Omar, A. A.; Mohamed, A. M.; Rebello, F. M.; Almousa, H. H.; Abdo, N. M.; George, S. M.; Khamis, S.; Thomas, S.

Lebanon: Ahmad Zaatari, A.; Anwar Al Souheil, A.; Ayash, H.; Zeid, I.; Tannous, J.; Zahreddine, N. K.; Ahmadieh, R.; Mahfouz, T.; Kardas, T.; Tanzi, V.; Kanafani, Z.; Hammoud, Z.

Lithuania: Dagys, A.; Grinkeviciute, D.; Kevalas, R.; Kondratas, T.

Macedonia: Petrovska, M.; Popovska, K.; Mitrev, Z.; Miteva, Z. B.; Jankovska, K.; Guroska, S. T.

Malaysia: Gan, C. S.; Othman, A. A.; Yusof, A. M.; Abidin, A. S. Z.; Aziz, F. A.; Weng, F. K.; Zainol H.; Bakar, K. B. A.; Lum, L. C. S.; Mansor M.; Zaman, M. K.; Jamaluddin, M. F. H.; Hasan, M. S.; Rahman, R. A.; Zaini, R. H. M.; Zhazali, R.; Ponnampala, S. S. L. S.; Chuah, S. L.; Shukeri, W. F. W. M.; Hassan, W. N. W.; Yusoff, W. N. W.; Mat, W. R. W.

Mexico: Villegas-Mota, M. I.; Cureño-Diaz, M. A.; Aguirre-Avalos, G.; Flores-Alvarado, A.; Cerero-Gudino, A.; Zamores-Pedroza, A.; Cano-Munoz, B.; Hernandez-Chena, B. E.; Carreon-Martinez, C. C.; Coronado-Magana, H.; Corona-Jimenez, F.; Rodriguez-Noriega, E.; Alcala-Martinez, E.; Gonzalez-Diaz, E.; Guerra-Infante, F. M.; Arteaga-Troncoso, G.; Martinez-Falcon, G.; Leon-Garnica, G.; Delgado-Aguirre, H. A.; Perez-Gomez, H. R.; Sosa-Gonzalez, I. E.; Galindo-Olmeda, J. A.; Ayala-Gaytan, J. J.; Rodriguez-Pacheco, J.; Zamorano-Flores, L.; Lopez-Pulgarin, J. A.; Miranda-Novales, M. G.; Ramírez, M.; Lopez-Hurtado, M.; Lozano, M.; Gomez, M. E.; Sanchez-Castuera, M. E.; Kasten-Monges, M.; Gonzalez-Martinez, M.; Sanchez-Vargas, M.; Culebro-Burguet, M. C.; Altuzar-Figueroa, M. A.; Mijangos-Mendez, J. C.; Guido-Ramires, O.; Espinosa, O. S.; De Leon-Escobedo, R.; Salas-Flores, R.; Ruiz-Rendon, R.; Petersen-Morfin, S.; Aguirre-Diaz, S. A.; Esparza-Ahumada, S.; Vega-Gonzalez, S.; Gaona-Flores, V.; Monroy-Colin, V. A.; Cruz-Rivera, Z.

Mongolia: Bat-Erdene, A.; Narankhuu, B.; Choijamts, B.; Tuvdennyam, B.; Batkhuu, B.; Chuluunchimeg, K. H.; Enkhtsetseg, D.; Batjargal, G.; Bayasgalan, G.; Dorj, M.; Mendsaikhan, N.; Baatar, O.; Suvderdene, P.; Baigalmaa, S.; Khajidmaa, T.; Begzjav, T.; Uyanga, T.; Ariyasuren, Z.

Morocco: Zeggwagh, A. A.; Berechid, K.; Abidi, K.; Madani, N.; Abouqal, R.

Nepal: Koirala, A.; Giri R.; Sainju, S.; Acharya, S. P.

Pakistan: Ahmed, A.; Raza, A.; Parveen, A.; Sultan, F; Khan, M.; Paul, N.; Daud, N.; Yusuf, S.; Nizamuddin, S.

Panama: Garcia-Mayorca, E.; Castaño, E. G.; Moreno-Castillo, J. L.; Ballinas-Aquino, J. M.; Lara, L.; Vargas, M.; Rojas-Bonilla, M. I.; Ramos, S. J.; Mapp, T.; De Iturrado, V.

Peru: La Hoz Vergara, C. E.; Linares-Calderon, C. F.; Moreno, D.; Ramirez, E.; Ramírez Wong, F. M.; Montenegro-Orrego, G. M.; Sandoval-Castillo, H. R.; Pichilingue-Chagray, J.; Mueras-Quevedo, J.; Aibar-Yaranga, K. F.; Castillo-Bravo, L. I.; Quintana-Peña, M.; Santivanez-Monge, L. M.; Mayorga-Espichan, M. J.; Rosario-Tueros, M. L. G.; Changano-Rodriguez, M. V.; Salazar-Ramirez, N. E.; Marquez-Mondalgo, V. A.

Philippines: Tajanlangit, A. L. N.; Tamayo, A. S.; Llames, C. M. J. P.; Labro, E.; Dy, A. P.; Fortin, J. D.; Bergosa, L. D.; Salvio, L. G.;

Bermudez, V.; Sg-Buenaflor, M. C.; Trajano, M. F.; Mendoza, M. T.; Javellana, O. P.; Maglente, R. R.; Arreza-Galapia, Y; Navoa-Ng, J. A.

Poland: Kubler, A.; Barteczko-Grajek, B.; Dragan, B.; Zurawska, M.; Mikaszewska-Sokolewicz, M.; Zielinska, M.

Puerto Rico: Ramos-Ortiz, G. Y.

Romania: Rogobete, F. A.; Daliborca Vlad, C.; Muntean, D.; Sandesc, D.; Papurica, M.; Licker, M.; Ovidiu Horea Bedreag; Popescu, R.; Grecu, S. D.; Dumitrascu, V.

Russia: Molkov, A.; Galishevskiy, D.; Furman, M.

Serbia: Simic, A.; Lekic, D.; Vasiljevic, S.; Ristic, G.; Eremija, J.; Kojovic, J.; Nikolic, L.; Bjelovic, M.;

Slovakia: Lesnakova, A.; Hlinkova, S.

Sudan: Gamar-Elanbya, M. O.

Thailand: Supa, N.; Prasan, P.; Pimathai, R.; Wanitanukool, S.; Somabutr S.

Tunisia: Ben-Jaballah, N.; Borgi, A.; Bouziri, A.

Turkey: Dilek, A.; Oncul, A.; Kaya, A.; Demiroz, A. P.; Gunduz, A.; Ozgultekin, A.; Asuman Inan; Yalcin, A. N.; Ramazanoglu, A.; Engin, A. Willke, A.; Basak Ceyda Meco; Aygun, C.; Bulut, C.; Uzun, C.; Becerik, C.; Hatipoglu, C. A.; Guclu, C. Y.; Ozdemir, D.; Yildizdas, D.; Ugurcan, D.; Azak, E.; Guclu, E.; Yilmaz, E. M.; Sebnem-Erdinc, F.; Sirmatel, F.; Ulger, F.; Sari, F.; Kizilates, F.; Usluer, G.; Ceylan, G.; Ersoz, G.; Kaya, G.; Ertem, G. T.; Senol, G.; Agin, H.; Cabadak, H.; Yilmaz, H.; Sungurtekin, H.; Zengin, H.; Turgut, H.; Ozgunes, I.; Devrim, I.; Erdem, I.; Işcanlı, I. G. E.; Mehmet Bakir, M.; Geyik, M. F.; Oral, M.; Meric, M.; Cengiz, M.; Ozcelik, M.; Altindis, M.; Sunbul, M.; Elaldi, N.; Engin, A.; Bakir, M.; Kuyucu, N.; Unal, N.; Oztoprak, N.; Yasar, N.; Erben, N.; Bayram, N.; Dursun O.; Karabay, O.; Coskun, O.; Horoz, O. O.; Turhan, O.; Sandal, O. S.; Tekin, R.; Esen S.; Erdogan, S. Y.; Unal, S.; Karacorlu, S; Sen, S.; Sen, S.; Sacar, S.; Yarar, V.; Oruc, Y.; Sahip, Y.; Kaya, Z.

United Arab Emirates: Philip, A.; Elhoufi, A.; Alrahma, H.

Venezuela: Sachez, E.; Perez, F.; Empaire, G. D.; Vidal, H.; Montes-Bravo, L.; Guzman Siritt, M. E.; Orozco, N.; Navarrete, N.; Ruiz, Y.; Duran-Gil De Anez, Z.

Vietnam: Trang, D. T. V.; Minh, D. Q.; Co, D. X.; Anh, D. P. P.; Thu, L. T. A.; Tuyet, L. T. D.; Nguyet, L. T. T.; Ngo Quy, C.; Binh, N. G.; Tien, N. P.; Anh, N. Q.; Hang, P. T.; Hanh, T. T. M.; Hang; T. T. T., Thu, T. A.; Thoa, V. T. H.