ORIGINAL ARTICLE

Device-associated infection and mortality rates, bacterial resistance, and length of stay in hospitals of Malaysia: International Nosocomial Infection Control Consortium (INICC)'s findings

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ABSTRACT

Background: To report the results of the International Nosocomial Infection Control Consortium (INICC) study conducted in Malaysia from August 2009 through July 2015.

Methods: A device-associated healthcare-acquired infection (DA-HAI) prospective surveillance study was conducted in 3 adult and 1 pediatric intensive care units (ICUs) from two hospitals, applying the U.S. CDC/NHSN criteria and definitions and INICC methods.

Results: There were 2,292 ICU patients documented for 12,932 bed-days. In the medical/surgical ICU the central line-associated bloodstream infection (CLABSI) rate was 9.4 per 1,000 central line-days, the ventilator-associated pneumonia (VAP) rate was 21.2 per 1,000 mechanical ventilator-days, and the catheter-associated urinary tract infection (CAUTI) rate was 5.0 per 1,000 urinary catheter-days. These rates were similar to or higher than the rates of medical/surgical ICUs reported in the INICC international report (4.9 [CLABSI]; 16.5 [VAP]; 5.3 [CAUTI]), and higher than CDC/NHSN reported rates (0.8 [CLABSI]; 1.1 [VAP]; and 1.3 [CAUTI]) for the medical/surgical ICU. Device utilization ratios in the medical/surgical ICU were higher than INICC and CDC/NHSN reported rates for the same type of ICUs. Resistance of *Acinetobacter baumanii* to imipenem or meropenem was 30.8%, *P. aeruginosa* to piperacillin or piperacillin-tazobactam was 10.7%, and *K. pneumoniae* to ceftriaxone 25.0%.
Excess length of stay was 6.4 days for patients with CLABSI, 12.3 for patients with VAP and 0.4 days for patients with CAUTI.
Excess crude mortality was 53.1% for CLABSI, 14.8% for VAP, and 32.2% for CAUTI.

Conclusions: DA-HAI rates in our ICUs are higher than CDC/NSHN rates and INICC international rates.

KEY WORDS

Hospital infection; healthcare-associated infection; antibiotic resistance; ventilator-associated pneumonia; catheter-associated urinary tract infection; central line-associated bloodstream infections

Acknowledgements
The authors thank the many healthcare professionals at each member hospital; Mariano Vilar and Débora López Burgardt, who work at INICC headquarters in Buenos Aires; the INICC Country Directors and Secretaries (Haifaa Hassan Al-Mousa, Hail Alabdaley, Areej Alshehri, Altaf Ahmed, Carlos A. Álvarez-Moreno, Anucha Apisarnthanarak, Bijie Hu, Hakan Leblebicioglu, Yatin Mehta, Toshihiro Mitsuda, and Lul Raka); and the INICC Advisory Board.

Potential conflicts of interest: All authors report no conflicts of interest related to this article. Institutional Review Boards agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

Funding: The funding for the activities carried out at INICC headquarters were provided by the corresponding author, Victor D. Rosenthal, and the Foundation to Fight against Nosocomial Infections.

INTRODUCTION

Increasingly in scientific literature, device-associated healthcare-acquired infections (DA-HAIs) are considered one of the principal threats to patient safety in the intensive care unit (ICU) and are among the main causes of patient morbidity and mortality (1, 2).

The effectiveness of implementing an integrated infection control program focused on DA-HAI surveillance was demonstrated in the many studies conducted in the U.S. (3-5) Their results indicated not only that the incidence of DA-HAI can be reduced by as much as 30%, but that a related reduction in healthcare costs was also feasible (3).

Addressing the burden of antimicrobial-resistant infections and reporting on susceptibility of DA-HAI-associated pathogens to antimicrobials is important for making informed decisions when only few effective treatment options are available (6).

For more than 40 years, the U.S. Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC/NHSN)(7) has provided benchmarking U.S. ICU data on DA-HAIs, which served as an inspiration to the International Nosocomial Infection Control Consortium (INICC) (8).

The INICC is an international non-profit, open, multi-centre, collaborative healthcare-associated infection control network with a surveillance system based on that of the CDC/NHSN.(9) Founded in Argentina in 1998, INICC is the first multinational surveillance and research network established to measure, control and reduce DA-HAI, and surgical site infections (SSIs) hospital wide through the analysis of data collected on a voluntary basis by a pool of hospitals worldwide (10).

Surveillance is conducted by means of an online platform called INICC Surveillance Online System (ISOS) which comprises15 modules that demonstrated effective impact on DA-HAI rates in several studies (11-15). The ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply U.S. CDC/NHSN's definitions published in January 2015 (16).

This is the first INICC DA-HAI prospective surveillance study conducted in Malaysia, which reports a summary of data collected between August 2009 and July 2015 in 4 ICUs in 2 hospitals (8, 17).

METHODS

Setting and study design

This prospective cohort surveillance study was conducted in 1 pediatric ICU, 1 Medical ICU, 1 Medical/Surgical ICU, and 1 Surgical ICU from two hospitals in two cities of Malaysia. Identities of all INICC hospitals and their specific geographic locations are kept confidential. The study was conducted through implementation of the INICC Multidimensional Approach (IMA), which is based on CDC/NSHN's definitions of HAIs and methodology with added patient-specific data, to increase infection control professionals' (ICP)'s sensitivity, and avoid underreporting (9). Unlike CDC/NHSN methodology relying on aggregate device-days, IMA methodology adds precision to the surveillance by collecting additional specific data of patients with and without HAI. These data enables the matching of patients to estimate excess LOS, mortality and cost.

The IMA comprises simultaneous implementation of the following six 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.

This study presents the results of the cohort outcome surveillance of HAIs in the participating ICUs through the ISOS. 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 is managed by ICPs, who collect daily data on central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator-associated pneumonias (VAPs), denominator data, patient-days and patient-specific device-days in the ICUs.

The data was uploaded to ISOS, and used to calculate DA-HAI rates per 1000 device-days. Mortality and LOS were calculated according to the following formulas: Device-days consisted of the total number of central line (CL)-days, urinary catheter (UC)-days, or mechanical ventilator (MV)-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. Device utilization ratio (DUR) equals the total number of device-days divided by the total number of bed days.

Training

The INICC team trained infection control professionals (ICP) and hospital epidemiologists (HE) at the participating hospitals. ICPs were also provided with tutorial movies, manuals and training tools that described in detail how to perform surveillance and upload surveillance data through ISOS. In addition, investigators attended webinars, and had continuous access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Statistical analysis

ISOS version 2.0 (Buenos Aires, Argentina) was used to calculate HAI rates, device utilization, LOS and mortality. EpiInfo® version 6.04b (CDC, Atlanta, GA), SPSS 16.0 (SPSS Inc. an IBM company, Chicago, Illinois), and ISOS version 2.0 (Buenos Aires, Argentina), were used to conduct data analysis. Relative risk (RR) ratios, 95% confidence intervals (CIs) and P-values were determined for primary and secondary outcomes.

RESULTS

During the study period from August 1st 2009 through July 31st 2015, 2,292 patients were hospitalized in the four participating ICUs, for a total of 12,932 bed-days. The mean length of participation of the ICUs in the study was (SD) 22.8 (4.3) months, ranging from 19 to 29 months.

Table 1 shows pooled means of the distribution of the rates of CLABSI, VAP and CAUTI, and DURs for CL, UC, and MV by type

TABLE 1: Pooled means of the distribution of device-associated infections and device utilization ratios by type of location, adult and pediatric patients. Device-Associated Module, 2009-2015

Type of ICU	Patients	Bed days	CL days	CL DUR (95% CI)	MV days	MV DUR (95% CI)	UC days	UC DUR (95% CI)	*DA-HAI, n	**DA-HAI rate per 1000 device days
Medical	363	1,382	716	0.52 (0.49 – 0.54)	446	0.32 (0.30 – 0.35)	792	0.57 (0.55 – 0.60)		
CLAB									0	0.0
VAP									3	6.7
CAUTI									2	2.5
Medical Surgical	833	5,341	5,618	1.05 (1.03 – 1.07)	3,963	0.74 (0.73 – 0.75)	4,396	0.82 (0.81 – 0.83)		
CLAB									53	9.4
VAP									84	21.2
CAUTI									22	5.0
Pediatric	809	5,075	2,850	0.56 (0.55 – 0.58)	3,073	0.61 (0.59 – 0.62)	2,495	0.49 (0.48 – 0.51)		
CLAB									9	3.2
VAP									49	15.9
CAUTI									1	0.4
Surgical	287	1,134	740	0.65 (0.62 – 0.68)	421	0.37 (0.34 – 0.40)	845	0.75 (0.72 – 0.77)		
CLAB									0	0.0
VAP									4	9.5
CAUTI									1	1.2
Pooled ICUs	2,292	12,932	9,924	0.77 (0.76 – 0.77)	7,903	0.61 (0.59 – 0.62)	8,528	0.66 (0.65 – 0.77)		
CLAB									62	6.2
VAP									140	17.7
CAUTI									26	3.0

ICU, intensive care unit; CL, central line; CLABSI, central line-associated bloodstream infection; MV, mechanical ventilator; VAP, ventilator-associated pneumonia; UC, urinary catheter; CAUTI, catheter-associated urinary tract infection; DUR, device utilization ratio; CI, confidence interval; DA-HAI, device-associated healthcare-acquired infections.

*DA-HAI rates are expressed as DA-HAIs per 1000 device days.

TABLE 2: Pooled means of the distribution of crude mortality, crude excess mortality, length of stay, and crude excess length of stay Intensive Care Units patients

Patients	Patients, n	Deaths, n	Pooled crude mortality, %	Pooled crude excess mortality, % (95% CI)	LOS, total days	Pooled average LOS, days	Pooled average excess LOS, days (95% CI)
Without DA-HAI	2,123	165	7.8%	-	10,127	4.8	-
With CLABSI	23	14	60.9%	53.1% (31.9 – 71.3)	257	11.2	6.4 (5.0 – 7.7)
With CAUTI	5	2	40.0%	32.2% (-1.4 – 76.3)	26	5.2	0.4 (-1.5 – 2.7)
With VAP	93	21	22.6%	14.8% (7.9 – 23.4)	1,593	17.1	12.4 (11.4 – 13.1)

ICU, intensive care units; CI, confidence interval; DA-HAI, device-associated healthcare-acquired infection; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; LOS, length of stay; CI, confidence interval.

TABLE 3: Benchmarking of device-associated healthcare-acquired infection rates in this report against International Nosocomial Infection Control Consortium (2007-2012) and US National Healthcare Safety Network (2013) reports

	This Report Rate (95% CI)	INICC Report (2007-2012) Rate (95% CI)	U.S. CDC/NHSN Report (2013) Rate
Medical ICU			
CL, DUR	0.52 (0.49 – 0.54)	0.47 (0.47 – 0.47)	0.45
CLABSI rate (CLABSIs per 1000 CL-days)	0.0	4.6 (4.4 – 4.9)	1.1
MV, DUR	0.32 (0.30 – 0.35)	0.47 (0.47 – 0.47)	0.9
VAP rate (VAPs per 1000 MV-days)	6.7 (1.4 – 19.7)	12.4 (11.9 – 12.8)	0.34
UC, DUR	0.57 (0.55 – 0.60)	0.71 (0.71 – 0.71)	0.61
CAUTI rate (CAUTIs per 1000 UC-days)	2.5 (0.3 – 9.1)	4.5 (4.2 – 4.7)	2.0
Medical Surgical ICU			
CL, DUR	1.05 (1.03 – 1.07)	0.54 (0.54 – 0.54)	0.37
CLABSI rate (CLABSIs per 1000 CL-days)	9.4 (7.1 – 12.3)	4.9 (4.8 – 5.1)	0.8
MV, DUR	0.74 (0.73 – 0.75)	0.36 (0.36 – 0.36)	0.24
VAP rate (VAPs per 1000 MV-days)	21.2 (16.9 – 26.2)	16.5 (16.1 – 16.8)	1.1
UC, DUR	0.82 (0.81 – 0.83)	0.62 (0.62 – 0.62)	0.54
CAUTI rate (CAUTIs per 1000 UC-days)	5.0 (3.1 – 7.6)	5.3 (5.2 – 5.8)	1.3
Pediatric ICU			
CL, DUR	0.56 (0.55 – 0.58)	0.50 (0.50 – 0.50)	0.45
CLABSI rate (CLABSIs per 1000 CL-days)	3.2 (1.4 – 6.0)	6.1 (5.7 – 6.5)	1.2
MV, DUR	0.61 (0.59 – 0.62)	0.53 (0.53 – 0.53)	0.37
VAP rate (VAPs per 1000 MV-days)	15.9 (11.8 – 21.1)	7.9 (7.4 – 8.4)	0.8
UC, DUR	0.49 (0.48 – 0.51)	0.31 (0.31 – 0.32)	0.21
CAUTI rate (CAUTIs per 1000 UC-days)	0.4 (0.0 – 2.2)	5.6 (5.1 – 6.1)	2.5
Surgical ICU			
CL, DUR	0.65 (0.62 – 0.68)	0.50 (0.50 – 0.51)	0.55
CLABSI rate (CLABSIs per 1000 CL-days)	0.0	5.7 (5.4 – 6.0)	0.9
MV, DUR	0.37 (0.34 – 0.40)	0.33 (0.33 – 0.33)	0.34
VAP rate (VAPs per 1000 MV-days)	9.5 (2.6 – 24.3)	15.6 (15.0 – 16.3)	2.0
UC, DUR	0.75 (0.72 – 0.77)	0.67 (0.67 – 0.67)	0.71
CAUTI rate (CAUTIs per 1000 UC-days)	1.2 (0.0 – 6.6)	4.7 (4.5 – 5.0)	4.4

ICU, intensive care unit; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; DUR, device utilization ratio; CI, Confidence Interval; CL, Central line; MV, mechanical ventilator; UC, urinary catheter; INICC, International Nosocomial Infection Control Consortium; U.S. NSHN, National Healthcare Safety Network of the United States of America.

of ICU. The most frequent DA-HAI was VAP with an overall rate of 17.7 per 1,000 MV days. The least frequent DA-HAI was CAUTI with an overall rate of 3.0 per 1,000 UC days. CL DUR was the highest (0.77) compared to duration ratios and their respective confidence intervals for UCs and MVs.

Table 2 provides data on crude ICU mortality and LOS in patients hospitalized in each type of unit during the surveillance period, with and without DA-HAI. The DA-HAI with the highest mortality was CLABSI. The DA-HAI with the longest LOS was VAP. In contrast, VAP showed the lowest mortality, whereas CAUTI had the least LOS.

Table 3 is the comparison of the results of this report from Malaysia with the INICC international report for the period 2007-2012 the US CDC/NHSN report of 2013 (7, 8). In the Medical/Surgical ICUs, the rate of VAP was higher in this study than in INICC and CDC/NHSN's reports (7, 8). The CLABSI rate

in this study was higher than CDC/NHSN's and INICC rates. Finally, the rate of CAUTI was similar in this study to the cited INICC report, but was also higher than the CDC/NHSN rate (7, 8). DURs for all type of DA-HAIs were higher in this study than in the INICC and CDC/NHSN in the Medical/Surgical, Pediatric and Surgical ICUs. In the Medical ICU, by contrast, DURs for all types of DA-HAIs were higher than in the CDC/NHSN, but lower than in the INICC report (7, 8).

Table 4 is the comparison of antimicrobial resistance rates of this report from Malaysia with the INICC international report for the period 2007-2012(8) and with the US CDC/NHSN report of 2009-2010 (6). Resistance of *Klebsiella pneumonia* to ceftriaxone or ceftazidime was higher in study than in the CDC/NHSN report. Overall, antimicrobial resistance rates were lower in this study than in the INICC and CDC/NHSN reports.

DISCUSSION

The few previous studies conducted in Malaysia have shown that DA-HAIs have a serious impact on patient safety. In a study conducted from 2003 to 2006, Katherason, S. et al found a VAP rate of 27.0 % (n = 58) (1). In 2008, Katherason *et. al.* found a rate of 8.9 bloodstream infection per 1,000 bed days, 4.7 nosocomial pneumonia per 1,000 bed days and 20.5 urinary tract infections per 1,000 bed days (18). Hughes *et. al.* found an overall DA-HAI rate of 13.9% per 100 patients, and the most common infection was pneumonia (19).

This study is the first conducted in Malaysia with a large number of patients (2,292) and using the CDC/NHSN methodology to calculate DA-HAI rates per 1000 device-days. In the ICUs of this study, DA-HAI rates were higher than the rates found in the U.S. CDC/NHSN's data (7), and in the international INICC Report (2007-2012) for 43 countries (8), except for CAUTI, which was similar. CL, MV and UC DURs were higher in this study than in CDC/NHSN and INICC's in the medical/surgical, pediatric and surgical ICUs, whereas they were lower than INICC's DURs in the medical ICU (7, 8). The antimicrobial resistance rates found in this study were lower than U.S. CDC/NHSN (6) and INICC reports'(8) rates, although this could be due to the small sample size of isolated microorganism in this study.

The reasons for relatively higher DA-HAI rates in Malaysia are multifactorial (20). Common to the developing world, adherence to infection control bundles in Malaysia is suboptimal, nurse-to-patient staffing ratios are low, hospitals are overcrowded, and there is a shortage of experienced nurses or trained healthcare workers (21, 22).

In order to reduce the hospitalized patients' risk of infection, having an effective DA-HAI surveillance is an essential first step. It must be followed by the implementation of practices aimed at DA-HAI prevention and control and increasing the awareness of DA-HAI risks in the ICU, as well as providing an exemplary basis for the institution of infection control practices through the use of an online process surveillance tool.

For other Malaysian hospitals to compare their own DA-HAI rates with the rates identified in this report, it is recommended they collect the data by applying the methods and methodology described for U.S. CDC/NHSN and INICC, and then calculate infection rates and DU ratios for the DA-HAI Module.

Study limitations:

The findings in this report did not consider the difference in time periods for the different data sources in the comparisons made with INICC and U.S. CDC/NHSN.

TABLE 4: Benchmarking of antimicrobial resistance rates in this report against the report of the International Nosocomial Infection Control Consortium (2009-2012) and the report of the US National Healthcare Safety Network data (2009-2010).

	This Report Resistance % (n/n)	INICC 2007-2012 Resistance %(8)	CDC/NHSN 2009-2010 Resistance, %(23)
Pathogen, antimicrobial	Pooled	VAP	VAP
Pseudomonas aeruginosa			
Ciprofloxacine	0% (0/19)	41.9%	32.7%
Piperacillin or piperacillin-tazobactam	10.7% (3/28)	35.8%	19.1%
Imipenem or meropenem	23.1% (3/13)	42.8%	30.2%
Klebsiella pneumoniae			
Ceftriaxone or ceftazidime	25.0% (2/8)	62.6%	23.8%
Imipenem or meropenem	0% (0/13)	17.2%	11.2%
Acinetobacter baumanii			
Imipenem or meropenem	30.8% (4/13)	77.1%	61.2%
Escherichia Coli			
Imipenem or meropenem	0% (0/5)	7.5%	3.5%

VAP, ventilator-associated pneumonia

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