ORIGINAL ARTICLE

Device-associated infection rates in Intensive Care Units of five cities of the Kingdom of Saudi Arabia: International Nosocomial Infection Control Consortium (INCC) findings

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ABSTRACT

Background: This report summarizes the results of the International Nosocomial Infection Control Consortium (INICC) study conducted in five cities of the Kingdom of Saudi Arabia from September 2013 through March 2015.

Methods: We utilized an online surveillance system in a prospective, cohort study of device-associated healthcare-associated infections (DA-HAI) in seven adult and pediatric intensive care units (ICUs) of five hospitals. The study applied CDC/NHSN criteria and definitions, using INICC Surveillance Online System.

Results: Data was collected from 4,551 ICU patients for 30,041 bed-days. In the Medical/Surgical ICUs, the central-line associated bloodstream infection (CLABSI) rate was 4.5 per 1,000 central line (CL)-days; the ventilator-associated pneumonia (VAP) rate was 7.5 per 1,000 mechanical ventilator (MV)-days; and the catheter-associated urinary tract infection (CAUTI) rate was 4.7 per 1,000 urinary catheter (UC)-days. The rates were statistically significantly higher compared to CDC/NHSN rates (0.8 [CLABSI]; 1.1 [VAP]; and 1.3 [CAUTI]), whereas in comparison with INICC rates (4.9 [CLABSI]; 5.3 [CAUTI]; 16.5 [VAP]), CLABSI and CAUTI rates did not attain statistically significant difference and VAP rate was statistically significantly lower. With the exception of CL DUR in the pediatric ICUs, device utilization ratios were higher than INICC and CDC/NHSN's. Excess length of stay was 14.8 days for patients with CLABSI, 17.5 for patients with VAP and 22.1 for patients with CAUTI. Excess mortality was 38.4% for CLABSI, 31.8% for VAP and 19.0% for CAUTI in adult and pediatric ICUs.

Conclusions: DA-HAI rates found in the study are higher than CDC/NSHN reported rates and similar to or lower than INICC's.

KEY WORDS:

Saudi Arabia; hospital infection; antibiotic resistance; ventilator-associated pneumonia; catheter-associated urinary tract infection; central line-associated bloodstream infections.

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INTRODUCTION

Device-associated healthcare-acquired infections (DA-HAIs) are considered one of the principal threats to patient safety in the intensive care settings and are among the main causes of patient morbidity and mortality, particularly in limited-resource parts of the world (1, 2).

Available evidence indicates that DA-HAI surveillance programs may have a positive impact on reducing healthcare-acquired infection rates and healthcare costs (3). Linking the DA-HAI causative microorganisms to their antimicrobial susceptibility is essential to minimize development of resistant strains (4). In the same way, it is fundamental to address the burden of antimicrobial-resistant infections and report pathogens and susceptibility to antimicrobials of DA-HAI-associated pathogens, so that informed decisions can be made to effectively prevent transmission of strain phenotypes with very few available treatments options (4).

For more than 30 years, the U.S. the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC/NHSN) has provided benchmarking U.S. intensive care unit (ICU) data on DA-HAIs, which have proven invaluable for researchers (5).

The International Nosocomial Infection Control Consortium (INICC) is an international non-profit, open, multi-centre, collaborative healthcare-associated infection control program with a surveillance system based on that of the CDC/NHSN, (5) using the INICC Surveillance Online System (ISOS) (6-8). INICC is comprised of more than 2,000 hospitals in 500 cities of 66 countries from Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific (World Health Organization regions) and is currently the only source of aggregate standardized data on the epidemiology of healthcare-associated infections (HAIs) worldwide (9). INICC goals are to create a dynamic global network of hospitals worldwide and conduct surveillance of DA-HAIs and SSIs using standardized definitions and established methodologies, and reduce DA-HAI rates worldwide (10).

This report is a summary of data on DA-HAIs collected using ISOS, between September 2013 and March 2015 in 7 ICUs in 5 hospitals in the Kingdom of Saudi Arabia (6, 7).

METHODS

Setting and study design

This prospective cohort surveillance study was conducted in 7 ICUs of 5 hospitals in five different cities of the Kingdom of Saudi Arabia, through the implementation of the INICC Multidimensional Approach (IMA), as described below.

The types of ICUs participating in this study were as follows: one coronary, five medical/surgical and one pediatric.

TABLE 1: Pooled means of rates of central line-associated bloodstream infection, ventilator-associated pneumonia, and catheter-associated urinary tract infections and utilization ratios, by type of location, adult and pediatric patients

Type of ICU	ICU, n	Patients, n	Bed days	CL days, n	DUR, CL (95% CI)	CLABSI, n	CLABSI rate	MV days, n	DUR, MV (95% CI)	VAP, n	VAP rate	UC days, n	DUR, UC (95% CI)	CAUTI, n	CAUTI rate
Coronary	1	975	4,160	339	0.08 (0.07 - 0.09)	2	5.9	198	0.05 (0.04 - 0.05)	1	5.1	927	0.22 (0.21 - 0.24)	3	3.2
Medical/ Surgical	5	3,337	24,629	17,925	0.73 (0.72 - 0.73)	81	4.5	20,776	0.84 (0.84 - 0.85)	156	7.5	20,675	0.84 (0.83 - 0.84)	98	4.7
Pediatric	1	239	1,252	506	0.40 (0.38 - 0.43)	6	11.9	731	0.58 (0.56 - 0.61)	8	10.9	494	0.39 (0.37 - 0.42)	0	0.0
Pooled	7	4,551	30,041	18,770	0.62 (0.62 - 0.63)	89	4.7	21,705	0.72 (0.72 - 0.73)	165	7.6	22,096	0.74 (0.73 - 0.74)	101	4.6

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; * DA-HAI rates are expressed as healthcare-associated infections per 1000 device-days; DUR, device utilization ratio; CI, confidence interval.

TABLE 2: Pooled means of crude mortality, crude excess mortality, length of stay, and crude excess Length of stay, of adult and pediatric intensive care unit patients with and without device-associated healthcare-acquired infection

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	4,289	759	17.7		23,288	5.4	1.0
With CLABSI	41	23	56.1	38.4 (23.2 - 52.7)	830	20.2	14.8 (13.5 - 16.2)
With CAUTI	49	18	36.7	19.0 (6.9 - 32.8)	1,350	27.6	22.1 (20.7 - 23.6)
With VAP	95	47	49.5	31.8 (22.5 - 41.1)	1,665	17.5	12.1 (11.3 - 12.9)

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.

Return to TABLE OF CONTENTS

We collected denominator data, patient-days and specific device-days to calculate DA-HAI rates per 1000 device-days. Prospective data using INICC patient detailed forms were used to calculate excess mortality and length of stay (LOS).

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

In accordance with the INICC's Charter, the identity of all hospitals and cities is kept confidential. Due to the fact that this was an epidemiological surveillance study, which did not include tests of experimental drugs, biomedical devices or products, and that patient data were anonymized, an informed consent was not

TABLE 3: Benchmarking of device-associated healthcare-acquired infection and antimicrobial resistance rates in this report against the report of the International Nosocomial Infection Control Consortium (2007-2012) and the reports of the US Centers for Disease Control and Prevention's National Healthcare Safety Network Data (2013 and 2009-2010)

	This Report	INICC Report (2007-2012)(9)	CDC/NHSN Report (2013)(5)
Medical Surgical ICU			
CL, DUR	0.73 (0.72 – 0.73)	0.54 (0.54 – 0.54)	0.37
CLABSI rate	4.5 (3.6 – 5.6)	4.9 (4.8 – 5.1)	0.8
MV, DUR	0.84 (0.84 – 0.85)	0.36 (0.36 – 0.36)	0.24
VAP rate	7.5 (6.4 – 8.8)	16.5 (16.1 – 16.8)	1.1
UC, DUR	0.84 (0.83 – 0.84)	0.62 (0.62 – 0.62)	0.54
CAUTI rate	4.7 (3.8 – 5.8)	5.3 (5.2 – 5.8)	1.3
Pediatric ICU			
CL, DUR	0.40 (0.38 – 0.43)	0.50 (0.50 – 0.50)	0.45
CLABSI rate	11.9 (4.4 – 25.8)	6.1 (5.7 – 6.5)	1.2
MV, DUR	0.58 (0.56 – 0.61)	0.53 (0.53 – 0.53)	0.37
VAP rate	10.9 (4.7 – 21.6)	7.9 (7.4 – 8.4)	0.8
UC, DUR	0.39 (0.37 – 0.42)	0.31 (0.31 – 0.32)	0.21
CAUTI rate	0.0 (0.0 – 7.5)	5.6 (5.1 – 6.1)	2.5

Pathogen, antimicrobial	This Report Resistance %	INICC 2007-2012 Resistance % (9)	CDC/NHSN 2009-2010 Resistance % (4)
Staphylococcus aureus			
Oxacillin	60%	61.2%	54.6%
Enterococcus faecalis			
Vancomycin	0%	12.2%	9.5%
Pseudomonas aeruginosa			
Ciprofloxacine	23%	37.5%	30.5%
Piperacillin or piperacillin-tazobactam	25%	33.5%	17.4%
Amikacin	21.4%	42.8%	10.0%
Imipenem or meropenem	37.5%	42.4%	26.1%
Klebsiella pneumoniae			
Ceftriaxone or ceftazidime	60%	71.2%	28.8%
Imipenem or meropenem	30.4%	19.6%	12.8%
Acinetobacter baumanii			
Imipenem or meropenem	95.1%	66.3%	62.6%
Escherichia Coli			
Imipenem or meropenem	0%	8.5%	1.9%

ICU, intensive care unit; CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; DUR, device utilization ratio; INICC, International Nosocomial Infection Control Consortium; CDC/NSHN, Centers for Disease Control and Prevention National Healthcare Safety Network of the United States of America.

necessary according to the ethics committees that evaluated and approved the study.

INICC Surveillance Online System

INICC Surveillance Online System (ISOS) applies standard CDC/NSHN methods and definitions,(11) and also includes INICC methodology, 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, fever, low blood pressure, results of cultures, antibiotic therapy, LOS and mortality. Collecting data on all patients in the ICU makes it possible to match patients with and without HAI by several characteristics.

Data collection and analysis

The ISOS follows the INICC protocol and ICPs and hospital epidemiologist, who collected daily data on central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs) and ventilator-associated pneumonias (VAPs), and 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 1000 device-days, mortality and LOS, 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 equaled crude mortality of ICU patients with DA-HAI minus crude mortality of patients without DA-HAI. Crude excess LOS of DA-HAI equaled crude LOS of ICU patients with DA-HAI minus crude LOS of patients without DA-HAI. Device utilization ratio (DUR) equaled the total number of device-days divided by the total number of bed days.

Training

ICPs and hospital epidemiologists were trained by the INICC team during a two-day session in September 2013. 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 assisted webinars, and had continuous access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Statistical analysis

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

RESULTS

The length of hospitals' participation in the INICC Program was as follows: mean length of participation + SD, 17.4 + 4.6 months, range 6 to 19 months. For the Outcome Surveillance Component, DA-HAI rates, DURs ratios, crude excess mortality, crude excess LOS, by specific type of DA-HAI, microorganism profile and bacterial resistance from September 2013 through March 2015 are summarized in Tables 1 to 4.

Table 1 shows DA-HAI rates in all the participating ICUs and provides data on DURs for CL, UC and MV, and their respective confidence intervals. Central line DUR, mechanical ventilator DUR and urinary catheter DUR were statistically significantly higher in the Medical/Surgical ICUs.

Table 2 provides data on crude ICU mortality and crude LOS in patients hospitalized in each type of unit during the surveillance period, with and without DA-HAI, and crude excess mortality and crude excess LOS of adult and pediatric patients with CLABSI, CAUTI, and VAP. It was possible to calculate this data, because unlike standard CDC/NHSN methodology, which only collects data of devices and DA-HAI, by using ISOS INICC also collects LOS, mortality and several other outcomes.

Table 3 compares the results of DA-HAI rates and DURs in this report from the Kingdom of Saudi Arabia with the INICC international report for the period 2007-2012 and with the US CDC/NHSN report of 2013 (9, 12), and provides data on bacterial resistance of pathogens isolated from patients with DA-HAI in adult and pediatric ICUs, and compares the antimicrobial resistance rates of this report with the INICC international report for the period 2007-2012 and with the CDC/NHSN report of 2009-2010. Overall, CLABSI and CAUTI rates did not attain statistically significant difference in this study to the INICC data, although there was a statistically significantly lower VAP rate in this study compared to INICC. Compared to US CDC/NHSN data, all DA-HAI rates in this study were statistically significantly higher. DUR was higher in most cases as well, but the CL DUR in the pediatric ICUs was lower than the INICC and US CDC/NHSN reported data.

DISCUSSION

Scientific literature has indicated that the rates of reported DA-HAIs in Kingdom of Saudi Arabia's ICUs are higher than the rates reported by the U.S. CDC/NHSN (13). In a study published in 1995, the DA-HAI rates in Saudi Arabia were as follows: 6.4 VAP rate per 1,000 MV-days in the pediatric ICUs, 20.7 CLABSI rate per 1,000 CL-days, and 11.4 CAUTI rate per 1,000 UC-days in the medical ICU (13). Balkhy et al. showed that the most common health-care infections in Saudi Arabia were CLABSI, followed by VAP and CAUTI, while in this study the VAP was the most frequent infection. The excess LOS for health-care infection was 8 days or more in this study, which was less than the 12-22 days in this study (14). In a recent study conducted in a Pediatric ICU, the CLABSI rate was 20.1 per 1,000 CL-days, which was higher than the found 11.9 CLABSI rate in this type of ICUs (15). In another study conducted in an adult ICU from Saudi Arabia the CLABSI rate was 4.6 per 1,000 CL days, which was very similar to the 4.5 rate in this study's medical/surgical ICUs (16). The VAP rate in a different study in a pediatric ICU was 8.9 per 1,000 MV days, which was lower than this study's rate (10.9)(17).

In this study's ICUs, DA-HAI rates and pooled DU ratios did not attain statistical significance to or were statistically significantly lower than the Global INICC Report and higher than CDC/NHSN's data (5, 9). LOS and mortality were statistically significantly higher in patients with DA-HAI; it was possible to calculate this data, because unlike standard CDC/NHSN methodology, which only collects data of devices and DA-HAI, through the use of ISOS, LOS and mortality were also collected.

The percentages for *Enterococcus faecalis* as resistant to vancomycin, and *Escherichia Coli* as resistant to imipenem or meropenem, were lower in this study than in INICC and CDC/NHSN reports (4). On the other hand, the antimicrobial resistance percentages found in this study's ICUs were similar to the CDC/NHSN(4) and INICC reports (9) for *Staphyloccocus aureus* as resistant to oxacillin. By contrast, the resistance percentages for *Pseudomonas aeruginosa* were higher in this study than in U.S. CDC/NHSN's report (4), but similar to the INICC reported resistance (9).

These higher DA-HAI rates compared to CDC/NHSN may be due to the fact that even having evidence-based updated national infection control bundles, adherence of health care workers to infection control bundles might be irregular (18).

In order to reduce the hospitalized patients' risk of infection, DA-HAI surveillance and measurement of consequences, such as length of stay and mortality, are primary and essential, because it effectively describes and addresses the importance and characteristics of the threatening situation created by DA-HAIs.

The INICC program, in this particular study, focuses just on the ICUs; that is, healthcare settings with the highest HAI rates, in which patients' safety is most seriously threatened, due to their critical condition and exposure to invasive devices (18).

Through the last 12 years, INICC has undertaken a global effort in America, Asia, Africa, Middle East, and Europe to respond to the burden of DA-HAIs, and has achieved successful results, by increasing hand hygiene compliance, improving compliance with other infection control bundles and interventions as described in several INICC publications, and consequently reducing the rates of DA-HAI and mortality (11, 19-38).

To compare a hospital's DA-HAI rates with the rates identified in this report, it is required that the participating hospitals collect their data by applying the methodology described for CDC/NHSN and INICC, and then calculate infection rates and DURs for the DA-HAI Module.

The particular and primary application of these data is to serve as a guide for the implementation of prevention strategies and other quality improvement efforts locally for the reduction of DA-HAI rates to the minimum possible level.

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 CDC/NHSN. Second, the member hospitals' laboratories had to be relied on to identify infecting pathogens and delineate bacterial resistance patterns, although different laboratories have varying levels of expertise and resource availability; however, similar concerns can be raised about any multi-institutional surveillance study. Third, the frequency of culturing and the use of other diagnostic tests were 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.

CONCLUSIONS

DA-HAI continues to pose a public health threat that may affect the quality of healthcare service in the Kingdom of Saudi Arabia. There is a growing need to establish surveillance systems including monitoring compliance with intervention bundles, in order to continue reducing the burden of HAIs.

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Return to TABLE OF CONTENTS