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Major article

Multicenter study of device-associated infection rates in hospitals of Mongolia: Findings of the International Nosocomial Infection Control Consortium (INICC)

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Key Words:
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Bed days

Background: To report the results of the International Nosocomial Infection Control Consortium (INICC) multicenter study conducted in Mongolia from September 2013-March 2015.
Methods: A device-associated health care–associated infection prospective surveillance study in 3 adult intensive care units (ICUs) from 3 hospitals using the U.S. Centers for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN) definitions and INICC methods.
Results: We documented 467 ICU patients for 2,133 bed days. The central line–associated bloodstream infection (CLABSI) rate was 19.7 per 1,000 central line days, the ventilator-associated pneumonia (VAP) rate was 43.7 per 1,000 mechanical ventilator days, and the catheter-associated urinary tract infection (CAUTI) rate was 15.7 per 1,000 urinary catheter days; all of the rates are higher than the INICC rates (CLABSI: 4.9; VAP: 16.5; and CAUTI: 5.3) and CDC-NHSN rates (CLABSI: 0.8; VAP: 1.1; and CAUTI: 1.3). Device use ratios were also higher than the CDC-NHSN and INICC ratios, except for the mechanical ventilator device use ratio, which was lower than the INICC ratio. Resistance of *Staphylococcus aureus* to oxacillin was 100%. Extra length of stay was 15.1 days for patients with CLABSI, 7.8 days for patients with VAP, and 8.2 days for patients with CAUTI. Extra crude mortality in the ICUs was 18.6% for CLABSI, 17.1% for VAP, and 5.1% for CAUTI.
Conclusion: Device-associated health care–associated infection rates and most device use ratios in our Mongolian hospitals' ICUs are higher than the CDC-NSHN and INICC rates.

INTRODUCTION

Increasingly in scientific literature, device-associated health care–associated 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]

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Additional information: Every hospital's institutional review board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

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The effectiveness of implementing an integrated infection prevention program focused on DA-HAI surveillance was demonstrated in many studies conducted in the United States, whose results reported not only that the incidence of DA-HAI can be reduced by as much as 30%, but that a related reduction in health care costs was also feasible.[2]

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; therefore, informed decisions can be made to effectively prevent transmission of resistant strains and their determinants, such as strains with phenotypes, with a few available treatments with chances of success.[3]

For >40 years, the U.S. Centers for Disease Control and Prevention (CDC)'s National Healthcare Safety Network (NHSN)[4] has provided benchmarking U.S. ICU data on DA-HAIs, which have proven invaluable for researchers and served as an inspiration to the International Nosocomial Infection Control Consortium (INICC).[5]

The INICC is an international nonprofit, open, multicenter, collaborative health care–associated infection (HAI) prevention network with a surveillance system based on that of the CDC's NHSN.[6] Founded in Argentina in 1998, the INICC is the first multinational surveillance and research network established to measure, prevent, 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.[7]

The INICC has the following goals: to create a dynamic global network of hospitals worldwide and conduct surveillance of DA-HAIs and SSIs using standardized CDC-NHSN definitions and established methodologies, to promote the implementation of evidence-based infection prevention practices, and to carry out applied infection prevention research; to provide training and surveillance tools to individual hospitals, which can allow them to conduct outcome and process surveillance of DA-HAIs and SSIs, to measure their consequences, and to assess the impact of infection prevention practices; and to improve the safety and quality of health care worldwide through the implementation of systematized programs to reduce rates of DA-HAIs and SSIs, their associated mortality, excess lengths of stay (LOS), excess costs, antibiotic usage, and bacterial resistance.[8]

Surveillance is conducted by means of an online platform called the INICC Surveillance Online System (ISOS), which comprises 15 modules whose effective impact in DA-HAI rates reduction was shown in several studies.[9-16] The ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply the CDC-NHSN definitions published in January 2015.[6]

This is the first DA-HAI study conducted in Mongolia, which reports a summary of data collected between September 2013 and March 2015 in 3 ICUs participating in the INICC program from 3 hospitals.[5,7]

METHODS

Background on the INICC

INICC is comprised of >2,000 hospitals in 500 cities of 66 countries in Latin America, Asia, Africa, the Middle East, and Europe and has become the only source of aggregate standardized international data on the epidemiology of HAIs internationally.[5] The INICC is focused on the surveillance and prevention of DA-HAIs in adult, pediatric ICUs and neonatal intensive care units (NICUs), step-down units, and inpatient wards and of SSIs in surgical procedures hospital-wide.

Setting and study design

This prospective multicenter cohort surveillance study was conducted in 3 medical-surgical ICUs from 3 hospitals in the capital city of Mongolia, through the implementation of the INICC's multidimensional approach (IMA), as subsequently described.

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

INICC's multidimensional approach

The IMA includes the implementation of CDC-NSHN definitions of HAIs and methodology, but adds the collection of other data essential to increase infection prevention professionals' (ICPSs') sensitivity to detect HAIs and avoid underreporting.[6] According to standard CDC-NSHN methods, numerators are the number of HAIs of each type, and denominators are device days collected from all patients, as pooled data (ie, without determining the number of device days related to a particular patient and without collecting features or characteristics per specific patient).[6] This aspect 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 collecting 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 IMA comprises the simultaneous implementation of the following 6 components for HAI control and prevention: a bundle of interventions, education, outcome surveillance, process surveillance, feedback on HAI rates and consequences, and performance feedback.

Outcome and process surveillance are conducted by means of an online platform called the 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 outcome surveillance modules. The results of 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 through the ISOS allows the classification of prospective, active, cohort surveillance data into specific module protocols that apply the NHSN definitions published in January 2015.[6] The site-specific criteria include reporting instructions and providing full explanations integral to their adequate application.[6]

The ISOS surveillance includes the following 10 modules: cohort surveillance of HAIs in adult and pediatric ICUs; cohort surveillance of HAIs in NICUs; cohort surveillance of HAIs in inpatient wards and step-down units; cohort surveillance of surgical procedures and SSIs; aggregated surveillance of HAIs in adult and pediatric ICUs; aggregated surveillance of HAIs in NICUs; microorganism profile and bacterial resistance; laboratory-based surveillance of multidrug-resistant organisms and *Clostridium difficile* infections; antimicrobial consumption; and surveillance of needlestick injuries.

Table 1
Pooled means of the distribution of crude mortality, crude excess mortality, LOS, and crude excess LOS of adult intensive care unit patients with and without device-associated health care–associated infection

Patients	Patients, n	Deaths, n	Pooled crude mortality, %	Pooled crude extra mortality, %, RR (95% CI), *P* value	LOS, total days	Pooled average, LOS days	Pooled average, extra LOS days (95% CI)
Without DA-HAI	407	81	19.90	-	1,639	4.03	
With CLABSI	26	10	38.46	18.56, 1.93 (1.14-3.26), .043	394	15.15	11.12 (9.66-12.70)
With CAUTI	24	6	25.00	5.10, 1.26 (0.61-2.58), .600	196	8.17	4.14 (3.03-5.36)
With VAP	27	10	37.00	17.14, 1.86 (1.10-3.16), .048	211	7.81	3.78 (2.77-4.91)

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

Data collection and analysis

The ISOS follows the INICC's protocol and ICPs, 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 1,000 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 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 use ratio (DUR) equals the total number of device days divided by the total number of bed days.

Training

The INICC team trained physicians, ICPs, and hospital epidemiologists at hospitals. Physicians and ICPs 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, ICPs assisted webinars and had continuous e-mail and telephone access to a support team at the INICC headquarters in Buenos Aires, Argentina.

Definitions

The ISOS uses the CDC-NHSN surveillance definitions and criteria for all specific types of HAIs, as published in 2015.[6]

Statistical analysis

ISOS version 2.0 (INICC, Buenos Aires, Argentina) was used to calculate HAI rates, device use, LOS, and mortality. EpiInfo version 6.04b (CDC, Atlanta, GA), SPSS 16.0 (SPSS, Chicago, IL), and ISOS version 2.0 were used to conduct data analysis. Relative risk ratios, 95% confidence intervals (CIs), and *P* values were determined for primary and secondary outcomes.

RESULTS

During the study period from September 1, 2013-March 30, 2015, a total of 467 patients were hospitalized in the 3 participating medical-surgical ICUs, amounting to 2,133 bed days. The mean length of data collection ± SD of the ICUs was 12.3 ± 6.0 months (range, 8-9 months).

The pooled means of the DA-HAI rates were 19.7 (n = 26) CLABIs per 1,000 CL days during 1,318 CL days, with a DUR of 0.62 (95% CI, 0.58-0.65); 43.7 (n = 27) VAPs per 1,000 MV days during 618 MV days, with a DUR of 0.29 (95% CI, 0.27-0.31); and 15.7 (n = 24) CAUTIs per 1,000 UC days during 1,528 UC days, with a DUR of 0.72 (95% CI, 0.68-0.75).

Table 2
Benchmarking of device-associated health care–associated infection rates in this report compared with the reports of the INICC (2007-2012) and NHSN data (2013)

Medical-surgical ICUs	This report	INICC report (2007-2012)[5]	U.S. NHSN report (2013)[4]
CL, DUR	0.62 (0.58-0.65)	0.54 (0.54-0.54)	0.37
CLABSI rate	19.72 (12.88-28.90)	4.9 (4.8-5.1)	0.8
MV, DUR	0.29 (0.27-0.31)	0.36 (0.36-0.36)	0.24
VAP rate	43.69 (28.79-63.56)	16.5 (16.1-16.8)	1.1
UC, DUR	0.72 (0.68-0.75)	0.62 (0.62-0.62)	0.54
CAUTI rate	15.71 (10.06-23.37)	5.3 (5.2-5.8)	1.3

NOTE. Data are expressed as mean (95% CI) or mean.
Abbreviations: *CAUTI*, catheter-associated urinary tract infection; *CI*, confidence interval; *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; *NSHN*, National Healthcare Safety Network; *UC*, urinary catheter; *VAP*, ventilator-associated pneumonia.

Crude excess mortality and crude excess LOS, by specific type of DA-HAI, microorganism profile, and bacterial resistance during the study period, are summarized in Tables 1-3.

Table 1 provides data on crude ICU mortality and LOS during the study period for ICU patients with and without DA-HAI (CLABSI, CAUTI, and VAP) CLABSI and VAP were associated with a higher pooled extra mortality. The extra LOS of patients with CLABSI was the greatest among the studied DA-HAIs.

Regarding bacterial resistance of pathogens isolated from patients with DA-HAI in ICUs, we found a high resistance of *Staphylococcus aureus* for CLABSI (100%; n = 2), VAP (80%; n = 5), and CAUTI (100%; n = 2) and coagulase-negative *Staphylococcus* for CLABSI and VAP (100%; n = 1) and CAUTI (50%; n = 2) to oxacilin. We also found a high resistance of *Escherichia coli* to ceftriaxone for CLABSI (100%; n = 7), VAP (100%; n = 6), and CAUTI (75%; n = 16) and ciprofloxacin for CLABSI (100%; n = 5), VAP (100%; n = 3), and CAUTI (83%; n = 12).

Table 2 compares the rate results of this report from Mongolia with the INICC international report for the period 2007-2012 and with the U.S. NHSN report of 2013.[4,5] Overall, we found higher CLABSI, CAUTI, and VAP rates in this study than both in the INICC and U.S. NHSN reports. DURs were also higher compared with U.S. NHSN and INICC rates, except for the MV DUR, which was higher than the U.S. NHSN rate, but lower than the INICC rate.[4,5]

Table 3 compares the antimicrobial resistance rates of this report from Mongolia with the INICC international report for the period 2007-2012[5] and the U.S. NHSN report of 2009-2010.[3] In most cases we found higher resistance rates than those found in the U.S. NHSN report.

DISCUSSION

To our knowledge, there are no publications of scientific studies conducted on DA-HAIs in Mongolian ICUs available. The 3

Table 3
Benchmarking of antimicrobial resistance rates in this report compared with the reports of the INICC (2007-2012) and NHSN data (2009-2010)

Pathogen, antimicrobial	CLABSI, this report resistance	CLABSI, INICC 2007-2012 resistance[5]	CLABSI, NHSN 2009-2010 resistance[3]
Staphylococcus aureus			
Oxacillin	100 (2)	61.2 (196)	54.6 (3,611)
Enterococcus faecalis			
Vancomycin	0 (1)	12.2 (123)	9.5 (2,578)
Pseudomonas aeruginosa			
Ciprofloxacine	0 (3)	37.5 (264)	30.5 (1,114)
Amikacin	0 (2)	42.8 (290)	10.0 (819)
Imipenem or meropenem	0 (1)	42.4 (472)	26.1 (982)
Escherichia coli			
Imipenem or meropenem	0 (2)	8.5 (342)	1.9 (931)

NOTE. Data are % (n).
Abbreviations: *CLABSI*, central line–associated bloodstream infection; *INICC*, International Nosocomial Infection Control Consortium; *NSHN*, National Healthcare Safety Network.

hospitals participating in this study are referral hospitals in Mongolia and receive the most complicated cases from other hospitals in the country. If compared with other similar studies conducted in China, the DA-HAI rates found in our study are much higher.[17,18] In a recent study conducted in 398 ICUs in Shanghai, China, VAP posed the greatest risk (20.8 per 1,000 MV days; 95% CI, 20.4-21.1), followed by CAUTI (6.4 per 1,000 UC days; 95% CI, 6.3-6.6) and CLABSI (3.1 per 1,000 CL days; 95% CI, 3.0-3.2).[17] In another Chinese study, the rate of VAP was 10.46 per 1,000 MV days, the CLABSI rate was 7.66 per 1,000 CL days, and the CAUTI rate was 1.29 per 1,000 UC days; however, DURs were similar.[18] By contrast, the pooled average extra LOS found in our study was lower than the findings of a recent study conducted in ICUs from 4 Chinese hospitals, whose pooled average extra LOS was 15 days for patients with CLABSI, 20.5 days for patients with VAP, and 27 days for patients with CAUTI. Crude extra mortality in our study was higher than the 14% for patients with CLABSI found by Hu et al,[18] but lower than the 22% found for patients with VAP and 43% for patients with CAUTI.[18]

From an international perspective, the results of this study show that the DA-HAI rates and DURs found in the ICU setting of Mongolia were significantly higher than the rates reported by the U.S. NHSN, which would well represent the situation in high-income countries.[4] Likewise, but representing middle- and low-income countries, the DA-HAI rates and DURs found in the INICC report (2007-2012) for 43 countries[5] were also lower than our rates; however, the MV DUR was lower.[4,5] Similarly, the antimicrobial resistance rates found in our ICUs were higher than the U.S. NHSN[3] and INICC[5] report rates for *S aureus* resistant to oxacillin.

There are many reasons that can explain these higher DA-HAI rates compared both with the U.S. NHSN and INICC reports. As described by Ider et al[19] during the 1990s, as a result of significant structural and policy reforms, the Mongolian health care system was dismantled without replacing the previous infection prevention system, which included a sanitary epidemiologic network. It was not until 2002 that a national program was approved and a surveillance system for HAIs with improved laboratory-based monitoring was established in all major hospitals. However, because of insufficient support from stakeholders and a lack of resources and trained infection control professionals, the implementation of these programs was delayed, and nongovernmental infection prevention initiatives are still applied within a very limited scope because of insufficient time and coverage.[19] Gaming has been pointed out as a decisive factor in deliberate, extreme underreporting of HAIs in Mongolian hospitals.[20] Professionals who reported HAIs were penalized until very recently, and as a result, the true rates of HAIs in Mongolia remained unknown until now.[20] Hence this study presents the first active surveillance data. Through the INICC, hospitals in Mongolia are allowed to monitor HAIs rates independently from the government's surveillance system. This inaccuracy estimate precipitated by underreporting had been previously analyzed by Ider et al,[21] who presented a point prevalence of 7.5% of overall HAIs from 2 tertiary hospitals in Mongolia.

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 DA-HAIs. This must be followed by the implementation of practices aimed at DA-HAI prevention and control. Additionally, participation in the INICC has played a fundamental role, not only in increasing the awareness of DA-HAI risks in the ICU, but also by providing an exemplary basis for the institution of infection prevention practices through the use of an online process surveillance tool.

The INICC program is focused on surveillance of DA-HAIs in the ICUs, step-down units, and general wards and surveillance of SSIs hospital-wide. In this particular study, we focused just on the ICUs (ie, health care settings with the highest HAI rates, in which patients' safety is most seriously threatened because of their critical condition and exposure to invasive devices).[22] Over the last 16 years, the INICC has undertaken a global effort in Latin America, Asia, Africa, the Middle East, and Europe to respond to the burden of DA-HAIs and has achieved extremely successful results by increasing HH compliance, improving compliance with other infection prevention bundles and interventions as described in several INICC publications, and consequently reducing the rates of DA-HAI and mortality.[14-16,23-25]

To compare a hospital's DA-HAI rates with the rates identified in this report, it is required that the hospital team concerned collect their data by applying the methods and methodology described by the U.S. 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 in Mongolia 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 the INICC and U.S. NHSN.

Conclusions

The data presented in this report fortify the fact that DA-HAIs in Mongolia are a challenge for patient safety. It is the INICC's main goal to enhance infection prevention practices by facilitating elemental, feasible, and inexpensive tools and resources to tackle this problem effectively and systematically. This will lead to greater and stricter adherence to infection prevention programs and guidelines and the correlated reduction in DA-HAI and its adverse effects in the hospitals participating in the INICC and at any other health care facility worldwide.

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