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# Surgical site infection rates in four Mexican cities: Findings of the International Nosocomial Infection Control Consortium (INICC)

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**Summary** From January 2005 to December 2010, we conducted a prospective cohort surveillance study on surgical site infections (SSIs) in five hospitals, all of which were members of the International Nosocomial Infection Control Consortium (INICC) in four cities in Mexico. Data were recorded from hospitalized patients using the methods and definitions of the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC-NHSN) for SSIs. Surgical procedures (SPs) were classified into 11 types according to the ICD-9 criteria. We documented 312 SSIs, associated with 5063 SPs (5.5%; CI, 5.5—6.9). SSI rates per type of SP in these Mexican hospitals compared with the INICC and CDC-NHSN reports, respectively, include: 18.4% for ventricular shunt (vs. 12.9% vs. 5.6%); 10% for spleen surgery (vs. 5.6% vs. 2.3%); 7.3% for cardiac surgery

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(vs. 5.6% vs. 1.3%); 6.4% for open reduction of fracture (vs. 4.2% vs. 1.7%); 5.2% for exploratory abdominal surgery (vs. 4.1% vs. 2.0%), and 5.1% for hip prosthesis (vs. 2.6% vs. 1.3%). Compared with the CDC-NHSN, our SSIs rates were higher in 73% and similar in 27% of the analyzed types of SPs, whereas compared with INICC, rates were similar in 55% and higher in 45% of SPs. There are no data on SSI rates by surgical procedure in Mexico. Therefore, this paper represents an important advance in the knowledge of epidemiology of SSIs in Mexico that will allow us to introduce targeted interventions. This study also demonstrates that the INICC is a valuable international benchmarking tool, in addition to the CDC-NSHN, the participating hospitals of which enjoy factual advantages.


## Introduction

It is difficult to ignore the burden posed by surgical site infections (SSIs) on patients' safety in terms of pain, suffering, delayed wound healing, increased use of antibiotics, revision surgery, increased length of hospital stay, mortality, and morbidity, which are also reflected in excess health care costs [1].

According to the World Bank's categorization, 68% of countries are low-income and lower middle-income economies, which are also referred to as lower income countries, or developing countries. Today, lower income countries comprise more than 75% of the world population [2]. However, the incidence of SSIs in Mexico has not been systematically studied [3]. Therefore, there are neither global SSI rates nor SSI rates stratified by surgical procedure (SP) according to the to the ninth edition of the International Classification of Diseases (ICD-9) criteria [4—7], which would enable a basis for international benchmarking and advancement toward a better understanding of the epidemiology of SSI in Mexico that will allow us to introduce targeted interventions [8].

Surveillance programs focused on healthcare-associated infections (HAIs)—including surgical site infections (SSIs)—are essential tools to prevent their incidence and to reduce their adverse effects. As widely shown in the literature from high income countries, including the U.S., the incidence of HAIs can be reduced by as much as 30%, and by 55% in the case of SSIs, through the implementation of an effective surveillance approach [8,9].

Within the scope of developing countries, several reports of the International Nosocomial Infection Control Consortium (INICC) have also shown that if surveillance and infection control strategies are applied in limited-resource countries, HAIs can also be reduced significantly [10—12]. Before the INICC started to publish SSI data, there were not available data on this subject in developing countries [3].

The first joint effort to provide data on the epidemiology of SSIs was made by the INICC between 2005 and the present for the purpose of providing a better picture of SSI rates in limited-resource countries [3]. Our objective is to provide a comprehensive analysis of a specific country.

As stated in the report published by the World Health Organization in 2011, limited-resource countries such as Mexico have only published data on SSI rates stratified by the level of wound contamination [13]. This multicenter study, which was performed between January 2005 and December 2010 at five hospitals in four cities in Mexico, is the first to report an analysis on the SSI rates stratified by the types of surgical procedures (SPs) according to the ICD-9 and Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC-NHSN.)

## Materials and methods

### Background of the INICC

The INICC is an open, non-profit, HAI surveillance network that applies methods based on the U.S. CDC-NHSN [14]. The INICC was established to measure and control HAIs worldwide in hospitals through the analysis of standardized data collected on a voluntary basis by its member hospitals, fostering the use of evidence-based preventive measures. Since its international inception in 2002, the INICC has increasingly gained new members and is now comprised of nearly 1000 hospitals in 200 cities of 50 countries in Latin America, Asia, Africa, Middle East, and Europe, becoming the only source of aggregate standardized international data on the epidemiology of HAIs internationally [15].

### Study setting and design

From January 2005 to December 2010, we conducted a prospective multicenter cohort surveillance study of SSIs on patients undergoing SPs in 5 medium-sized (88—218 beds), medical non-teaching hospitals in 4 cities in Mexico. Two (40%) of the hospitals are public and the other three (60%) are private community hospitals.

Each hospital's Institutional Review Board agreed to the study protocol.

## The INICC surveillance program

The INICC surveillance program included outcome surveillance of SSI rates [16] according to the standard CDC-NHSN definitions for superficial incisional, deep incisional, and organ/space, including laboratory and clinical criteria [14].

Infection control professionals (ICPs) included nurses and medical doctors that were trained for data collection and reporting, as part of the first stage of the INICC program on SSI prevention. On a daily basis, the ICP collected the list of patients who underwent SPs, who were followed up for 30 post-surgical days to detect early SSIs, or for 12 months for prosthesis SSIs. These data were sent to the INICC headquarters, where SSI rates were calculated using the number of SPs as the denominator and the number of SSIs as the numerator.

For analytical purposes, the collected data were stratified into 11 types of SPs according to the ICD-9 criteria [4—7]. ICPs reviewed each report of the SPs to find all performed procedures and to identify ICD-9 Codes and subsequently reviewed them with the surgeon in charge of the SP. The collected data were validated at the INICC Central Office in Buenos Aires before their inclusion as reported infections into the INICC's database.

Data on the duration of the SPs, the level of contamination, and the infection risk index classification of the American Society of Anesthesiology (ASA) [17] according to the patient's physical condition were not collected. For this reason, it was not possible to calculate the infection risk index of each SP. Therefore, because our data are not stratified by risk categories, we pooled the different risk categories included in the CDC-NHSN report 2006—2008 [18] to obtain the mean rate of SSIs and we compared this rate with our results.

## Surgical procedures

The 11 SPs included in this study are those described in the ICD-9 and listed in the CDC-NSHN report as follows: appendix surgery (APPY); cardiac surgery (CARD); craniotomy (CRAN); open reduction of fracture (FX); hip prosthesis (HPRO); knee prosthesis (KPRO); laminectomy (LAM); spleen surgery (SPLE); vaginal hysterectomy (VHYS); ventricular shunt (VHYS), and exploratory abdominal surgery (XLAP) [14].

## Statistical analysis

EpiInfo® version 6.04b (CDC, Atlanta, GA, USA) and SPSS 16.0 (SPSS Inc. an IBM company, Chicago, IL, USA) were used to conduct data analysis.

Relative risk (RR) ratios, 95% confidence intervals (CIs), and *P*-values were determined for all primary and secondary outcomes.

# Results and discussion

The results of the present study determine the incidence of SSIs in 5 hospitals in 4 cities of Mexico, a limited-resource county.

Table 1 shows the SSI rates, stratified by SP, including the number of SPs, the number of SSIs, and the SSI rate. The SPs with the highest SSI rates

**Table 1** The surgical site infections of the participating Mexican hospitals by type of procedure.

| Code | Procedure name | Procedures, *n* | Mexico SSI, *n* | Mexico SSI rate, % | No. of hospitals |
|---|---|---|---|---|---|
| APPY | Appendix surgery | 549 | 11 | 2.0% (1.0—3.6) | 2 |
| CARD | Cardiac surgery | 821 | 60 | 7.3% (5.6—9.3) | 2 |
| CRAN | Craniotomy | 459 | 19 | 4.1% (2.5—6.4) | 3 |
| FX | Open reduction of fracture | 296 | 19 | 6.4% (3.9—9.8) | 2 |
| HPRO | Hip prosthesis | 255 | 13 | 5.1% (2.7—8.6) | 3 |
| KPRO | Knee prosthesis | 907 | 11 | 1.2% (0.6—2.2) | 2 |
| LAM | Laminectomy | 190 | 12 | 6.3% (3.3—10.8) | 3 |
| SPLE | Spleen surgery | 10 | 1 | 10.0% (0.3—44.5) | 1 |
| VHYS | Vaginal hysterectomy | 74 | 3 | 4.1% (0.8—11.4) | 1 |
| VSHN | Ventricular shunt | 642 | 118 | 18.4% (15.5—21.6) | 1 |
| XLAP | Exploratory abdominal surgery | 860 | 45 | 5.2% (3.8—6.9) | 3 |
| All | | 5063 | 312 | 5.5% (5.5—6.9) | 5 |

INICC, International Nosocomial Infection Control Consortium; SSI, surgical site infection.

**Table 2** Surgical site infection rates in the participating Mexican hospitals compared with the hospitals of the International Nosocomial Infection Control Consortium and the Centers for Disease Control and Prevention National Healthcare Safety Network.

| Code | Procedure name | Mexico 2005–2010, SSI rate, % | INICC 2005–2010, SSI rate, % | Mexico vs. INICC (RR, 95% CI, P value) | CDC-NHSN 2007–2009 SSI rate (pooled risk categories), % | Mexico vs. CDC-NHSN (RR, 95% CI, P value) |
|---|---|---|---|---|---|---|
| APPY | Appendix surgery | 2.0 | 2.9 | 0.7 (0.34–1.25) 0.11 | 1.4 | 1.42 (0.76–2.66) 0.27 |
| CARD | Cardiac surgery | 7.3 | 5.6 | 1.32 (1.0–1.7) 0.02 | 1.3 | 5.68 (4.32–7.46) 0.0001 |
| CRAN | Craniotomy | 4.1 | 4.4 | 0.94 (0.56–1.5) 0.41 | 2.6 | 1.59 (1.00–2.53) 0.05 |
| FX | Open reduction of fracture | 6.4 | 4.2 | 1.51 (0.9–2.4) 0.046 | 1.7 | 3.7 (2.3–5.9) 0.0001 |
| HPRO | Hip prosthesis | 5.1 | 2.6 | 2.0 (1.02–3.4) 0.015 | 1.3 | 4.03 (2.33–6.95) 0.0001 |
| KPRO | Knee prosthesis | 1.2 | 1.6 | 0.74 (0.37–1.32) 0.16 | 0.9 | 1.36 (0.75–2.46) 0.31 |
| LAM | Laminectomy | 6.3 | 1.7 | 3.71 (1.9–6.64) 0.0001 | 1.0 | 6.2 (3.5–11) 0.0001 |
| SPLE | Spleen surgery | 10 | 5.6 | 1.8 (0.04–12.6) 0.3 | 2.3 | 4.3 (0.52–35.6) 0.14 |
| VHYS | Vaginal hysterectomy | 4.1 | 2.0 | 2.1 (0.6–6.8) 0.218 | 0.9 | 4.6 (1.5–14.5) 0.004 |
| VSHN | Ventricular shunt | 18.4 | 12.9 | 1.4 (1.2–1.8) 0.001 | 5.6 | 3.3 (2.6–4.1) 0.001 |
| XLAP | Exploratory abdominal surgery | 5.2 | 4.1 | 1.3 (0.9–1.7) 0.135 | 2.0 | 2.6 (1.8–3.7) 0.001 |

CI, confidence interval; INICC, International Nosocomial Infection Control Consortium; SSI, surgical site infection; CDC, Centers for Diseases Control and Prevention; NHSN, National Healthcare Safety Network; RR, relative risk.

were ventricular shunts (18.4%) and spleen surgeries (10.0%).

Table 2 compares the SSI rates in this study with SSI rates in the INICC Report 2005–2010 and the CDC-NHSN 2007–2009. Compared with the CDC-NHSN report, the SSI rates were significantly higher in 73% (8 out of 11) of the analyzed SPs (CARD, CRAN, FX, HPRO, LAM, VHYS, VSHN, and XLAP), whereas in 27% (3 out of 11) of the analyzed SPs (APPY, KPRO and SPLE), the SSI rates were similar to the findings in the CDC-NHSN report. Compared with the INICC Report, the SSI rates were significantly higher in this study's hospitals in 45% (5 out of 11) of the analyzed SPs (CARD, LAM, FX, HPRO, and VSHN), and similar in 55% (6 out of 11) of the SPs (APPY, CRAN, KPRO, XLAP, SPLE, and VHYS).

Our findings show that the SSI rates for appendix surgery, knee prosthesis and spleen surgery are similar to those in the INICC 2005–2010 [3] and the CDC-NHSN 2006–2008 reported SSI rates [18]. The SSI rates for craniotomy, vaginal hysterectomy and exploratory abdominal surgery are similar to those published by the INICC [3] and are higher than the CDC-NHSN's reported rates [18]. Finally, in the cases of cardiac surgery, laminectomy, open reduction of fracture, hip prosthesis, and ventricular shunt, the SSI rates were higher than both the INICC and CDC-NHSN's rates [3,18].

For decades, the CDC has been the only source available to provide a basis for comparison of infection rates in hospitals worldwide. Comparing the US CDC's hospital rates with those of hospitals from Western Europe and Oceania is considered valid, due to their similar socioeconomic conditions. In contrast, the comparison of CDC rates and those of hospitals with limited resources—or with sufficient available resources, but without enough experience in the field of infection control—is rather unfair. On the one hand, US hospitals enjoy more than 50 years of unrivaled experience in infection control and surveillance, sufficient human and medical supply resource availability, and a comprehensive legal framework backing infection control programs and including mandatory surveillance and hospital accreditation policies. This background can easily result in significantly lower HAI rates in CDC's hospitals, and hospitals from high-income countries, in contrast to hospitals from developing economies or with insufficient resources and experience in infection control. Within this context, the INICC emerges as an alternative valid and fair benchmarking tool for HAI rates in hospitals worldwide due to their shared socioeconomic hospital backgrounds.

The relation between the HAI rates and their associations to the type of hospital (public, academic, and private), and the relation between

HAI rates and the country's socioeconomic level (defined as low income, mid low income and high income) have been recently analyzed and published by the INICC [19,20]. Such findings show that higher socio-economic levels were correlated with lower infection risk [19,20].

Higher SSI rates, in comparison with the US CDC-NHSN report, may reflect the typical hospital situation in limited-resource countries as a whole [21], and several reasons have been proposed to explain this fact [22,23]. Among the primary plausible causes, in almost all the limited-resource countries, there are still no legally enforceable regulations for the implementation of infection control programs, such as national infection control guidelines; yet, if there is a legal framework, adherence to and compliance with the guidelines can be irregular and hospital accreditation is not mandatory. However, there has recently been much progress in health care in some developing countries, such as Mexico, where new technologies have been introduced and official regulations support infection control programs. This new trend in health care is expected to have a positive impact in cases with extremely low nurse-to-patient staffing ratios, hospital over-crowding, a lack of medical supplies, and an insufficient number of experienced nurses or trained healthcare workers [22,23].

Participation in the INICC has played a fundamental role, not only in increasing the awareness of HAI risks in the INICC hospitals but also in providing an exemplary basis for the institution of infection control practices. In many INICC hospitals, for example, the high incidence of HAIs has been reduced by 30—70% due to the implementation of multidimensional programs that include a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback regarding HAI rates, and performance feedback of infection control practices for central line associated bloodstream infections, mechanical ventilator associated pneumonia, and urinary catheters associated with urinary tract infections [10—12].

For a valid comparison of a hospital's SSI rates with the rates from INICC hospitals, it is required that the hospitals concerned start collecting their data by applying definitions of SPs as provided by the ninth edition of the ICD-9 and the definitions described by the CDC NHSN to identify SSIs, and then use the methodology described by the CDC-NHSN to calculate SSI rates.

### Study limitations

Due to the lack of a budget, this study has three main limitations. First, we were unable to calculate the risk category of the SPs because we did not collect the duration of each SP, the level of contamination, and the ASA score. Second, we were not able to collect data of microorganism profile and bacterial resistance. However, since 2012, these data are currently collected by INICC member hospitals, thereby enabling the future assessment of the SSI risk index associated with SPs. Third, with a small sample size of cases in some SPs, these results should be interpreted with caution. In reviewing the literature, no systematic data were found on the global rates of SSI and the SSI rates stratified by SP. For this reason, it is worth mentioning that despite the mentioned limitations, substantial and useful data are provided in this study, which is a first step to advance our understanding of the SSI rate in Mexico.

## Conclusions

The data presented in this report indicate that SSIs in Mexican hospitals pose an infection risk to patient safety that is many times concealed compared with most countries of the developed world. Compared with the CDC-NHSN, the SSI rates in this study's hospitals were higher in 73% of the analyzed types of SPs and similar in 27% of them, whereas compared with the INICC, the rates were similar in 55% and higher in 45% of the analyzed SPs. This paper represents an important advancement toward the knowledge of the epidemiology in Mexico that will allow us to introduce targeted interventions. Furthermore, this study shows that the INICC is a valuable international benchmarking tool, in addition to the CDC-NSHN, the participating hospitals of which enjoy the previously described advantages.

## Authors' contributions

Victor D. Rosenthal contributed greatly towards the core Idea, study conception, study design, data collection, data analysis, interpretation of the data, statistical and epidemiological analyses, providing support on administrative, technical, and logistic fronts, and developing the software, besides drafting the article. Later on all the authors extended their support for data collection and provision of study patients. Regarding the text works, all authors equally contributed towards critical revision of the article for important intellectual content and in approving the final version.

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## Conflict of interest

All authors report no conflicts of interest related to this article. 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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