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ORIGINAL ARTICLE

Surgical site infection rates in 6 cities of India: findings of the International Nosocomial Infection Control Consortium (INICC)

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Background: Surgical site infections are a threat to patient safety. However, in India, data on their rates stratified by surgical procedure are not available.

Methods: From January 2005 to December 2011, the International Nosocomial Infection Control Consortium (INICC) conducted a cohort prospective surveillance study on surgical site infections in 10 hospitals in 6 Indian cities. CDC National Healthcare Safety Network (CDC-NHSN) methods were applied and surgical procedures were classified into 11 types, according to the ninth edition of the International Classification of Diseases.

Results: We documented 1189 surgical site infections, associated with 28 340 surgical procedures (4.2%; 95% CI 4.0–4.4). Surgical site infections rates were compared with INICC and CDC-NHSN reports, respectively: 4.3% for coronary bypass with chest and donor incision (4.5% vs 2.9%); 8.3% for breast surgery (1.7% vs 2.3%); 6.5% for cardiac surgery (5.6% vs 1.3%); 6.0% for exploratory abdominal surgery (4.1% vs 2.0%), among others.

Conclusions: In most types of surgical procedures, surgical site infections rates were higher than those reported by the CDC-NHSN, but similar to INICC. This study is an important advancement towards the knowledge of surgical site infections epidemiology in the participating Indian hospitals that will allow us to introduce targeted interventions.

Keywords: Developing countries, Healthcare-associated infection, Hospital infection, India, Nosocomial infection, Surgical wound infection

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 and antibiotic resistance, revision surgery, increased length of hospital stay, mortality, morbidity and excess healthcare costs. SSIs have also been associated with the emergence multi-drug resistant bacteria.[1] However, the incidence of SSIs in India has not been systematically studied. 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[2–4] that enables a basis for international benchmarking.[5]

According to the World Bank's categorization based on the 2012 gross national income per capita, 68% of the world countries are low-income and lower middle-income economies, which can also be referred to as lower-income countries, or developing countries.[6] However, the incidence of SSIs in limited-resource countries has not been systematically assessed in these settings.[7,8]

Surveillance programs focused on healthcare-associated infections (HAI), including surgical site infections (SSIs), are essential tools to prevent their incidence and reduce their adverse effects, thereby allowing for the reduction of patients' risk of infection. As widely shown in the literature from high-income countries, including the United States, the implementation of an effective surveillance approach can lead to a reduction in the incidence of HAI by as much as 30%, and by 55% in the case of SSIs.[9] Within the scope of developing countries, several reports from 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]

As stated in the report published by WHO in 2011, limited-resource countries, like India, only have published data on SSI rates stratified by level of wound contamination.[13] This current multicenter study, conducted between January 2005 and December 2011 in 10 hospitals in 6 cities of India, is the first to analyze SSIs rates within 11 types of surgical procedures stratified according to the ICD-9 and National Healthcare Safety Network (NHSN).

Materials and methods

Background on INICC

The INICC is an open, non-profit, HAI surveillance network that applies methods based on the 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, 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 2011, we conducted a cohort prospective multi-centre surveillance study of SSIs on patients undergoing SPs in 10 hospitals of 6 cities in India. Seven of the participating hospitals were private community hospitals, two were academic teaching hospitals and one was public. Each of the hospitals' Institutional Review Boards agreed to the study protocol.

INICC surveillance program

As part of the INICC program on SSI prevention, infection control professionals at each participating hospital were trained to conduct 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]

Data collection

Data by type of SP were collected from the book of surgical procedures of operating theatres at each participating hospital. The collected data included the list of patients who underwent SPs; these patients were followed-up during the 30 post-surgical days to detect early SSIs, or for 12 months for prosthesis SSIs. These data were sent to INICC headquarters, where SSI rates were calculated, using the number of SP as the denominator and the number of SSI as the numerator.

For analytical purposes, collected data were stratified into 11 types of SPs according to the ICD-9 criteria.[2–4,17] Infection control professionals reviewed each report of the SPs in order to find all performed surgical procedures, and identify the ICD-9 codes. The collected data were validated at the INICC Central Office in Buenos Aires before their inclusion as reported infections into the INICC's database. Validation processes included revision of age, gender, length of stay, among other data revised for consistency.

Data on the duration of SPs, level of contamination, and the infection risk index classification (of the American Society of Anaesthesiology)[18] according to the patient's physical condition were not collected. For this reason, it was not possible to calculate

Table 1. Surgical site infections of the participating hospitals 2005–2011

CODE	Procedure name	Procedures (n)	SSI (n)	SSI rate, % (95% CI)	No. of hospitals
1. AMP	Limb amputation	135	4	3.0% (0.8–7.4)	1
2. BRST	Breast surgery	96	8	8.3% (3.7–15.8)	1
3. CBGB	Coronary bypass with chest and donor incision	10341	445	4.3% (3.9–4.7)	7
4. CARD	Cardiac Surgery	7121	461	6.5% (5.9–7.1)	1
5. CRAN	Craniotomy	3495	114	3.3% (2.7–3.9)	6
6. HER	Herniorrhaphy	184	7	3.8% (1.5–7.7)	2
7. HPRO	Hip prosthesis	2527	52	2.1% (1.5–2.7)	7
8. KPRO	Knee prosthesis	3280	57	1.7% (1.3–2.2)	5
9. THOR	Thoracic surgery	855	24	2.8% (1.8–4.1)	1
10. VHYS	Vaginal hysterectomy	40	1	2.5% (0.1–13.2)	1
11. XLAP	Exploratory abdominal surgery	266	16	6.0% (3.5–9.6)	2
All		28 340	1189	4.2% (4.0–4.4)	10

SSI: surgical site infection.

the infection risk index of each SP. Therefore, since our data are not stratified by risk categories, we pooled the different risk categories included in the CDC-NHSN report 2006–2008[19] to obtain the mean rate of SSIs and we compared this rate with our results.

Surgical procedures

Included in this study are the following 11 SPs: limb amputation (AMP); breast surgery (BRST); coronary bypass with chest and donor incision (CBGB); cardiac surgery (CARD); craniotomy (CRAN); herniorrhaphy (HER); hip prosthesis (HPRO); knee prosthesis (KPRO); thoracic surgery (THOR); vaginal hysterectomy (VHYS) and exploratory abdominal surgery (XLAP).[14]

Validation of reported surgical site infection rates

Internal validation of data forms was performed by investigators at the participating hospitals to ensure relevant infection criteria had been accurately recorded for each case. External validation was performed at the INICC headquarters, by reviewing and entering data of the reported infection into the INICC's database, following discussion of queries, as the case may be, with the submitting hospital. Finally, consistency analyses of the database were performed to ensure matching of data entered and medical records.

Statistical analysis

EpiInfo version 6.04b (CDC, Atlanta, GA, USA) and SPSS 16.0 (IBM, Chicago, IL, USA) were used to conduct data analysis. Relative risk (RR) ratios, 95% confidence intervals and p-values were determined for all primary and secondary outcomes. P-values <0.05 were reported as statistically significant. The initial assumption was that the SSI rate was higher in this study than in the INICC and CDC-NHSN reports. To compare incidence densities of SSI we considered as 'exposed' the data of this study and 'non-exposed' the events of the INICC and CDC benchmarks.

Results

Table 1 shows SSI rates, stratified by SP, including the number of SPs, number of SSIs and SSI rate. SPs with the highest SSI rates were breast surgery (8.3%) and exploratory abdominal surgery (6.0%).

Table 2 compares SSI rates in this study with SSI rates in the INICC Report 2005–2010 and CDC-NHSN 2006–2008. Compared with the CDC-NHSN report, SSI rates were significantly higher in 73% (8/11) of the analyzed types of SPs (BRST, CBGB, CARD, CRAN, HPRO, KPRO, THOR, XLAP), whereas in 27% (3/ 11) of the analyzed types of SPs (AMP, HER, VHYS) SSI rates were similar in this study and in the CDC-NHSN report.

Compared with the INICC Report, SSIs rates were significantly higher in this study's hospitals in 27% (3/11) of the analyzed types of SPs (BRST, CARD, HER), similar in 55% (5/11) of the analyzed types of SPs (AMP, HPRO, KPRO, VHYS, XLAP) and lower in 18% (3/11) of the analyzed types of SPs (CBGB, CRAN, THOR).

Table 3 compares three types of surgical procedures (CBGB, CRAN and HPRO) by type of hospital, and shows that SSI rates for CBGB and CRAN were statistically significantly higher in academic compared with public and private hospitals, whereas for

Table 2. Comparison of surgical site infection (SSI) rates with the hospitals of the International Nosocomial Infection Control Consortium and the CDC National Healthcare Safety Network

CODE	Procedure name	India rates, % (n)	INICC 2005–2010, SSI rate, % (n)	India vs INICC (RR, 95% CI, p-value)	CDC-NHSN 2006–2008 SSI rate, % (n) (pooled risk categories)	India vs CDC-NHSN (RR, 95% CI, p-value)
1. AMP	Limb amputation	3.0% (4/135)	2.7% (111/4040)	1.08 (0.4–2.9) 0.882	2.3% (33/1414)	1.27 (0.45–3.58) 0.65
2. BRST	Breast surgery	8.3% (8/96)	1.7% (72/4148)	4.8 (2.3–10.0) 0.001	2.3% (71/3136)	3.68 (1.77–7.65) 0.001
3. CBGB	Coronary bypass with chest and donor incision	4.3% (445/10341)	4.5% (1615/36057)	0.96 (0.9–1.1) 0.455	2.9% (3622/123055)	1.46 (1.32–1.61) 0.001
4. CARD	Cardiac Surgery	6.5% (461/7121)	5.6% (781/14070)	1.17 (1.0–1.3) 0.008	1.3% (369/28685)	5.03 (4.4–5.77) 0.001
5. CRAN	Craniotomy	3.3% (114/3495)	4.4% (551/12501)	0.74 (0.6–0.9) 0.003	2.6% (252/9663)	1.25 (1.0–1.56) 0.047
6. HER	Herniorrhaphy	3.8% (7/184)	1.8% (173/9843)	2.16 (1.0–4.6) 0.040	2.3% (169/7477)	1.68 (0.8–3.58) 0.17
7. HPRO	Hip prosthesis	2.1% (52/2527)	2.6% (225/8607)	0.79 (0.6–1.1) 0.118	1.3% (1651/130391)	1.63 (1.23–2.14) 0.001
8. KPRO	Knee prosthesis	1.7% (57/3280)	1.6% (153/9299)	1.06 (0.8–1.4) 0.724	0.9% (1528/171183)	1.95 (1.5–2.54) 0.001
9. THOR	Thoracic surgery	2.8% (24/855)	6.1% (482/7880)	0.46 (0.3–0.7) 0.001	1.1%(22/1979)	2.53 (1.42–4.5) 0.001
10. VHYS	Vaginal hysterectomy	2.5% (1/40)	2.0% (31/1584)	1.28 (0.2–9.4) 0.809	0.9% (165/18869)	2.86 (0.4–20 42) 0.27
11. XLAP	Exploratory abdominal surgery	6.0% (16/266)	4.1% (339/8204)	1.46 (0.9–2.4) 0.139	2.0% (103/5099)	3.0 (1.76–5.04) 0.001

INICC: International Nosocomial Infection Control Consortium; NHSN: National Healthcare Safety Network; RR: relative risk; SSI: surgical site infection.

Table 3. Comparison of three types of surgical procedures by type of hospital 2005–2011

CODE	Procedure name	SSI rate, % [95% CI]		
		Academic hospitals	Private hospitals	Public hospitals
CBGB	Coronary bypass with chest and donor incision	6.4% (398/6189) [5.8–7.1]	1.2% (38/3146) [0.9–1.7]	0.9% (9/1006) [0.4–1.7]
CRAN	Craniotomy	3.9% (102/2596) [3.2–4.7]	1.4% (12/840) [0.7–2.5]	0% (0/59) [0.0–6.1]
HPRO	Hip prosthesis	2.1% (45/2108) [1.6–2.8]	2.1% (7/333) [0.8–4.3]	0% (0/86) [0.0–4.2]

SSI: surgical site infection.

HPRO procedures there were no statistically significant differences in SSI rates between public, private and academic hospitals.

Discussion

The present study was designed to determine the incidence of SSIs in 6 cities in 10 hospitals of India, a limited-resource economy. In our study, SSI rates in breast surgery and cardiac surgery were higher than both the INICC 2005–2010[8] and CDC-NHSN for 2006–2008[19] reported rates. In the cases of coronary bypass with chest and donor incision, hip prosthesis, knee prosthesis and exploratory abdominal SPs, SSI rates were higher than CDC-NHSN's reported rates, but similar to INICC rates.[8,19] SSI rates for craniotomy and thoracic surgery were lower than INICC, but higher than CDC-NHSN's rates.[19] SSI rates for limb amputation and vaginal hysterectomy procedures were similar to both INICC and CDC-NHSN's reported rates.[8,19] Finally, SSI rate for herniorrhaphy was higher than the INCC's rate,[8] but similar to the CDC-NHSN's rate.[19]

During the last few decades, the CDC has been the only available source to provide a basis for comparison of hospital infection rates worldwide. Comparing the CDC's hospitals' rates with those of hospitals from Western Europe and Oceania is considered valid, due to their similar socio-economic conditions. In contrast, the comparison of CDC's hospitals' rates and those of hospitals with limited-resources or with sufficient available resources, but without enough experience in the field of infection control, should involve the consideration of the mentioned disadvantages in terms of socio-economic factors. US hospitals enjoy more than a 50-year unrivalled experience in infection control and surveillance, sufficient human and medical supply resources availability, and a comprehensive legal framework backing infection control programs, including mandatory surveillance and hospital accreditation policies. The higher SSI rates found in our study, in comparison to the rates for CDC's hospitals, have also been influenced by such factual background. The relation between the HAI rates and the type of hospital (public, academic and private), and the relation between HAI rates and the country's socio-economic level (defined as low-income, mid-low-income and high- income) have recently been analyzed and published by the INICC.[20,21] Such studies' findings showed that a higher country socio-economic level was correlated with a lower infection risk.[20,21] Within this context, INICC reports can be an alternative valid benchmarking tool for HAI rates in hospitals worldwide due to their shared factual and socio-economic hospital backgrounds.

Such higher SSI rates, in comparison with the CDC-NHSN report, may reflect the typical hospital situation in limited-resources countries as a whole,[22] and several reasons have been suggested to explain this fact.[23,24] Among the primary plausible causes, it can be mentioned that, in almost all the limited-resources 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 most irregular and hospital accreditation is not mandatory. However, the data from these hospitals may not reflect real Indian data. The Indian hospitals that participated in our study enjoy accreditation status and sufficient administrative and financial support to fund infection control programs, such as the INICC multidimensional approach.[23,24]

Participation in 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 HAI has been reduced by 30 to 70% by implementing multidimensional programs that include a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback of HAI rates and performance feedback of infection control practices, for central line-associated bloodstream infections, mechanical ventilator-associated pneumonia and catheter-associated 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 ICD-9, the definitions described by CDC-NHSN in order to identify SSIs, and then the methodology described by CDC-NHSN to calculate SSI rates.

Study limitations

Due to lack of 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 to differentiate superficial, deep and organ/space SSIs, data of microorganism profile and bacterial resistance, nor implement any other kind of post-discharge surveillance, such as phone calls, visits or letters to patients. However, since 2012, these data have been currently collected by INICC member hospitals, thereby enabling the assessment in the future of SSI risk index associated with SPs. Third, with a small sample size of cases in some SPs, these results should be interpreted with caution. There may be some under reporting of SSIs, as some patients may have presented a SSI after the study period (such as, orthopaedic procedures and implants) and these may not have been included. In reviewing the literature, no systematic data was found on SSI global rates and SSI rates stratified by SP. For this reason, it is worth mentioning that despite the mentioned limitations, substantial and useful data is provided in this study, which is a first step to advance our understanding of the SSI rate in India.

Conclusions

The comparison between this study's findings and the data reported by the INICC 2005–2010[8] showed that SSI rates were similar in 55% of the analyzed SPs, whereas if compared with the CDC-NHSN for 2006–2008,[19] SSI rates in this study were significantly higher in 73% of the analyzed SPs. This paper represents an important advance towards the knowledge of SSI epidemiology in India that will allow us to introduce targeted interventions. Furthermore, this study shows that INICC is a valuable international benchmarking tool, in addition to the CDC-NSHN, whose participating hospitals have unrivalled infection control experience and resources.

Authors' contributions: VDR designed the study; all authors were involved in the study implementation, data analysis and interpretation and in writing and revising the manuscript. All authors read and approved the final manuscript. VDR is the guarantor of the paper.

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