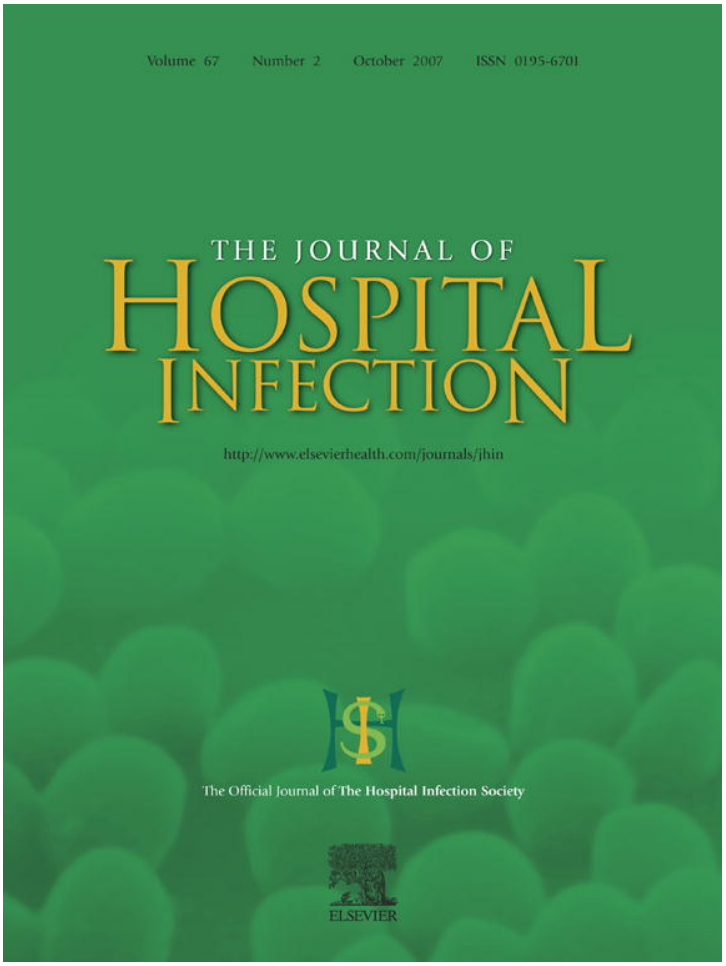

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# Device-associated nosocomial infection rates in intensive care units of seven Indian cities. Findings of the International Nosocomial Infection Control Consortium (INICC)

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**Summary** We sought to determine the rate of healthcare-associated infection (HCAI), microbiological profile, bacterial resistance, length of stay (LOS) and excess mortality in 12 ICUs of the seven hospital members of the International Infection Control Consortium (INICC) of seven Indian cities. Prospective surveillance was introduced from July 2004 to March 2007; 10 835 patients hospitalized for 52 518 days acquired 476 HCAIs, an overall rate of 4.4%, and 9.06 HCAIs per 1000 ICU-days. The central venous catheter-related bloodstream infection (CVC-BSI) rate was 7.92 per 1000 catheter-days;the ventilator-associated pneumonia (VAP) rate was 10.46 per 1000 ventilator-days; and the catheter-associated urinary tract

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infection (CAUTI) rate was 1.41 per 1000 catheter-days. Overall 87.5% of all *Staphylococcus aureus* HCAIs were caused by meticillin-resistant strains, 71.4% of Enterobacteriaceae were resistant to ceftriaxone and 26.1% to piperacillin–tazobactam; 28.6% of the *Pseudomonas aeruginosa* strains were resistant to ciprofloxacin, 64.9% to ceftazidime and 42.0% to imipenem. LOS of patients was 4.4 days for those without HCAI, 9.4 days for those with CVC-BSI, 15.3 days for those with VAP and 12.4 days for those with CAUTI. Excess mortality was 19.0% [relative risk (RR) 3.87; $P \leq 0.001$] for VAP, 4.0% (RR 1.60; $P = 0.0174$) for CVC-BSI, and 11.6% (RR 2.74; $P = 0.0102$) for CAUTI. Data may not accurately reflect the clinical setting of the country and variations regarding surveillance may have affected HCAI rates. HCAI rates, LOS, mortality and bacterial resistance were high. Infection control programmes including surveillance and antibiotic policies are a priority in India.


## Introduction

Industrialized countries have established standardized criteria for the surveillance and control of healthcare-associated infection (HCAI).[1] Most studies related to HCAI were conducted in developed countries and demonstrate the efficacy of surveillance and its significant contribution to minimising patient morbidity and mortality.[2–6] Conversely, in developing countries, few studies providing HCAI using such standardized definitions are available.[7–11]

This study presents HCAI data collected by the International Infection Control Consortium (INICC) in Indian intensive care units (ICUs), benchmarking against regional and international standards.

## Methods

### Setting

The study was carried out in 12 ICUs in seven hospitals of seven Indian cities from July 2004 to March 2007. Each hospital has an infection control team (ICT) with a physician and an infection control practitioner (ICP) with at least one year's experience in infection control (Table I) and a microbiology laboratory to provide in-vitro susceptibility testing of clinical isolates using standardized methods.

Every hospital's Institutional Review Board agreed to the study protocol. Patient confidentiality was protected by codifying the recorded information, making it only identifiable to the ICT.

### Surveillance

Using Centers for Disease Control and Prevention–National Nosocomial Infections Surveillance (CDC-NNIS) definitions, rates of central venous catheter-associated bloodstream infection (CVC-BSI), catheter-associated urinary tract infection (CAUTI) and ventilator-associated pneumonia (VAP) were determined monthly.[12,13]

### Crude excess mortality and length of stay

Crude excess mortality in the ICU was defined as the difference between the crude overall case-fatality of patients with and without HCAI during the same period.

Length of stay (LOS) was collected prospectively when filling out INICC forms daily. Adult patients with HCAI were considered cases, and those without HCAI were used as controls. We calculated excess LOS by subtracting average LOS from patients with and without HCAI.

### Training, forms, validation and data feedback

The INICC Chairman (V.D.R.) provided the participating hospitals with training procedures related to surveillance, which included forms being filled out daily with data related to patients. This included demographics, age, gender, severity of illness score and hospital location. Data collection commenced on admission to the ICU. Subsequently, data on mechanical ventilation (MV), placement of central venous catheter (CVC) and

**Table I** Features of the participant hospitals and patients

| | Hospital | | | | | | | Overall |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | |
| No. of ICUs | 1 | 3 | 4 | 1 | 1 | 1 | 1 | 12 |
| Surveillance period | Jul 2004 to Jul 2005 | Sep 2004 to May 2006 | Apr 2006 to Mar 2007 | Jul 2005 to Mar 2007 | Jan 2005 to Mar 2006 | Jan 2007 to Mar 07 | Feb 2006 to Mar 2006 | Jul 2004 to Mar 2007 |
| Experience of the infection control practitioner (years) | 17 | 17 | 2 | 2 | 20 | 2 | 1 | 1—20 |
| No. of patients studied | 3052 | 2655 | 2151 | 2032 | 751 | 151 | 43 | 10 835 |
| Total ICU days | 15 302 | 14 681 | 8121 | 10 532 | 2873 | 791 | 218 | 52 518 |
| Men (%) | 84.0 | 81.3 | 62.8 | 66.1 | 69.2 | 79.5 | 74.4 | 74.6 |
| Mean age (years) | 58.2 | 57.6 | 55.76 | 56.37 | 43.46 | 49.32 | 42.7 | 56.0 |
| Mean ASIS | 2.34 | 2.10 | 3.15 | 2.51 | 3.69 | 3.99 | 2.70 | 2.60 |
| Device use | | | | | | | | |
| Ventilator-days | 3632 | 680 | 2846 | 4060 | 1903 | 228 | 132 | 13 481 |
| Ventilator use, proportion | 0.24 | 0.05 | 0.35 | 0.39 | 0.66 | 0.29 | 0.61 | 0.26 |
| CVC-days | 17 960 | 5030 | 3054 | 7081 | 3196 | 30 | 196 | 36 857 |
| CVC use, proportion | 1.17 | 0.34 | 0.38 | 0.67 | 1.11 | 0.43 | 0.90 | 0.70 |
| Urinary catheter-days | 9213 | 3748 | 5289 | 8519 | 2824 | 662 | 209 | 30 464 |
| Urinary catheter use, proportion | 0.60 | 0.26 | 0.65 | 0.81 | 0.98 | 0.84 | 0.96 | 0.58 |

ASIS, average severity of illness score; CVC, central venous catheter; ICU, intensive care unit.

urinary catheters (UC), fever, blood pressure, antibiotic use and the results of cultures were collected.

The average severity of illness score (ASIS) was recorded by using the CDC-NNIS criteria.[13]

Patients in the ICU had a check-off when the ICP in charge of reviewing the filled forms was satisfied that the clinical and microbiological criteria for the specific type of HCAI had been met. The ICT in India had access to a team at the Central Office (CO) in Buenos Aires, which provided responses checked by the INICC Chairman to enquiries within 24 h.

Completed forms were sent monthly from each ICT to the CO, where an HCAI adjudication process of each case was performed by analysing the recorded signs (fever, blood pressure) and cultures, in order to assure that the CDC-NNIS criteria for HCAI were met.[12,13] The forms were then uploaded into the database. The CO team prepared monthly reports, which were sent to each ICT. These showed global rates per 100 patients and per 1000 bed-days, HCAI per 1000 device-days, microbiological profile, excess mortality by type of HCAI, excess LOS, hand hygiene compliance (HHC) and CVC and UC care compliance.

### Sampling and culture techniques

*VAP*: In most cases, a deep tracheal aspirate from the endotracheal tube was Gram-stained and cultured aerobically.

*CVC-BSI*: CVC were removed aseptically and the distal 5 cm amputated and cultured using a standardized semiquantitative method.[14] Concomitant blood cultures were drawn percutaneously in nearly all cases.

*CAUTI*: A urine sample was aseptically aspirated from the sampling port of the UC and cultured quantitatively.

In all cases, standard laboratory methods were used to identify microorganisms and a standardized susceptibility test was performed.[15]

## Definitions

### Ventilator-associated pneumonia

Ventilator-associated pneumonia was confirmed when a mechanically ventilated patient had a chest radiograph which showed new or progressive

infiltrates, consolidation, cavitation or pleural effusion. The patient also needed to have at least one of the following criteria: new onset of purulent sputum or change in character of sputum; organism cultured from blood; or isolation of an aetiological agent from a specimen obtained by tracheal aspirate, bronchial brushing or bronchoalveolar lavage, or biopsy.

### Laboratory-confirmed CVC-associated bloodstream infection

Central venous catheter-associated bloodstream infection was confirmed when a patient with a CVC had a recognized pathogen isolated from one or more percutaneous blood cultures after 48 h of vascular catheterization, not related to an infection at another site. The patient also had at least one of the following signs or symptoms: fever (temperature $\geq 38^{\circ}$C), chills or hypotension. With skin commensals (for example, diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci or micrococci), the organism needed to be cultured from two or more blood cultures.

### Catheter-associated urinary tract infection

A diagnosis of CAUTI was confirmed when a patient met one of two criteria. The first was when a patient with a urinary catheter had one or more of the following symptoms with no other recognized cause: fever (temperature $\geq 38^{\circ}$C), urgency or suprapubic tenderness with a culture positive urine showing $\geq 10^5$ colony-forming units per ml, with no more than two micro-organisms isolated. The second criterion was when a patient with a urinary catheter had at least two of the following criteria with no other recognized cause: positive dipstick analysis for leucocyte esterase or nitrate, pyuria ($>$10 leucocytes per ml of urine), organisms seen on Gram stain or physician diagnosis of urinary tract infection.

### Statistical analysis

EpiInfo® version 6.04b (CDC, Atlanta, GA, USA) was used for data analysis. Device-utilization rates were calculated by dividing the total number of device-days by the total number of patient-days. Rates of VAP, CVC-BSI and CAUTI per 1000 device-days were calculated by dividing the total number of HCAIs by the total number of specific device-days and multiplying the result by 1000.[13]

## Results

### Features of population studied

During the four years of study, surveillance data were prospectively collected on 10 835 patients hospitalized in the ICUs for 52 518 ICU-days (Table I). Regarding the type of participating hospital, four were academic (57%), two were private (29%) and one was public (14%). They acquired 476 HCAIs, an overall rate of 4.4% or 9.06 HCAIs per 1000 ICU-days. CVC-BSI represented 61.3% of all HCAIs. VAP represented 29.6%. CAUTI represented 9.0% (Table II). Individual characteristics of each ICU, the number of patients enrolled in the study, the number of ICU-days and ASIS are shown in Table I. Mean patient ASIS, being 2.60 overall, ranged from 2.10 to 3.99.

### Device-utilization ratio

Device utilization ranged widely: for MV, from 0.05 to 0.66 (overall, 0.26); for CVC, from 0.34 to 1.17 (overall, 0.70); and for UC, from 0.26 to 0.98 (overall, 0.58). Distributions by type of HCAI and device utilization are shown in Table II.

### VAP

VAP rates ranged widely, from 3.69 to 18.17 per 1000 MV-days, with an overall rate in the 12 ICUs of

**Table II** HCAIs per 1000 device-days: VAP, CVC-BSI and CAUTI

| Infection site | Device type | Device-days | Device utilization | HCAI (*N*) | Distribution of HCAI (%) | Rate per 100 patients (%) | Rate per 1000 device-days |
|---|---|---|---|---|---|---|---|
| VAP | MV | 13 481 | 0.26 | 141 | 29.6 | 1.3 | 10.46 |
| CVC-BSI | CVC | 36 857 | 0.70 | 292 | 61.3 | 2.7 | 7.92 |
| CAUTI | UC | 30 464 | 0.58 | 43 | 9.0 | 0.4 | 1.41 |

HCAI, healthcare-associated infection; VAP, ventilator-associated pneumonia; CVC-BSI, central venous catheter-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; MV, mechanical ventilator; UC, urinary catheter.

10.46 (Table II). Crude mortality of patients with VAP was 25.6%, with excess mortality of 19.0% [relative risk (RR) 3.87, 95% confidence interval (CI) 2.70−5.54, $P < 0.001$]. Patients without HCAI presented a crude mortality rate of 6.6%, yielding an excess mortality of 19.0%. LOS of patients without HCAI was 4.4 days and of patients with VAP 15.3 days (RR 3.50; 95% CI 3.34−3.67; $P < 0.0001$), representing 11.0 extra days.

### CVC-BSI

CVC-BSI rates ranged widely, from 0.0 to 11.86 per 1000 CVC-days, with an overall rate of 7.92 (Table II). The crude mortality of patients with CVC-BSI was 10.6%, with extra mortality of 4.0% (RR 1.60, 95% CI 1.08−2.37; $P = 0.0174$). LOS of patients with CVC-BSI was 9.4 days (RR 2.15, 95% CI 2.06−2.24; $P < 0.0001$), representing 5.0 extra days.

### CAUTI

CAUTI rates oscillated from 0.0 to 3.59 per 1000 UC-days, with an overall rate of 1.41 (Table II). Crude mortality of patients with CAUTI was 18.2%, with extra mortality for CAUTI of 11.6% (RR 2.74, 95% CI 1.23−6.13, $P = 0.0102$). LOS of patients with CAUTI was 12.4 days (RR 2.83, 95% CI 2.57−3.12; $P < 0.0001$), representing 8.0 extra days.

### Overall bacterial profile and resistance

Overall, 27.3% of all HCAI was caused by *Pseudomonas* spp., 28.6% being resistant to ciprofloxacin, 64.9% to ceftazidime, 42.0% to imipenem and 42.6% to piperacillin-tazobactam; 6.2% was caused by *Acinetobacter* spp. 3.1% was caused by *S. aureus* infection, 87.5% being resistant to meticillin; 46.4% were caused by Enterobacteriaceae, 71.4% being resistant to ceftriaxone, 74.1% to ceftazidime and 42.6% to piperacillin−tazobactam; 8.2% were caused by *Candida* spp; 2.6% were caused by *Enterococcus* spp., 33.3% being resistant to vancomycin; 3.1% were caused by *Stenotrophomonas* spp. 2.6% were caused by coagulase negative-staphylococci; and 0.5% were caused by *Streptococcus* spp.

## Discussion

This study is the first to benchmark HCAI rates in Indian ICUs against international standards. HCAI increases healthcare costs and mortality; using surveillance forms devised by the INICC (founded in 1998 with Latin American Hospitals) for data collection of patients with and without HCAI, ICPs were able to match features and determine excess LOS, costs, mortality and identify major HCAI risk factors.[8−10,16−19]

The study showed a lower use of MV (0.26 vs 0.37) and UC (0.58 vs 0.77) compared with the device utilization reported by the US in the NNIS network, although CVC utilization was higher (0.70 vs 0.50).[4] HCAI distribution was: CVC-BSI 61.3%, VAP 29.6% and CAUTI 9.0%; however, compared with the INICC overall data, VAP represented 41.0% of all HCAIs, followed by CVC-BSI (30.0%) and CAUTI (29.0%).[7]

Although our overall HCAI rate per 100 patients, at 4.4%, was lower than that of Thailand (23.1%) and INICC (14.7%), it was higher than that of another Indian study at 1.5%.[7,20,21] The rate per 1000 bed-days was 9.06, lower than the overall INICC (22.5 per 1000).[7]

Our CVC-BSI overall rate was 7.92 per 1000 CVC-days, higher than that for Thailand (2.6) and NNIS (3.2), but lower than for the overall INICC data (12.5).[4,7,22] Our overall VAP rate of 1000 MV-days was 10.46, lower than for Turkish data (26.5), and the INICC global rate (24.1), but higher than the NNIS rate (5.1).[4,7,11]

Our CAUTI rate (1.41) was lower than the NNIS rate of 3.3 per UC-days and the overall INICC rate of 9.0.[4,7] Our ICU's UC utilization rate (0.58 vs 0.77) was lower than the rate reported for the USA in the NNIS network, which would explain the relatively low CAUTI rate together with the possible influence in CAUTI detection due to scarce laboratory resources.

Extra mortality of patients with VAP was 19.0%; excess mortality of patients with CVC-BSI was 4.0%; and that of patients with CAUTI was 11.6%; all of them being significantly higher than the mortality of patients without HCAI.

Piperacillin−tazobactam was active against Enterobacteriaceae in 73.9% of isolates. In a SENTRY study, piperacillin−tazobactam was even more active against *Escherichia coli*, *Proteus mirabilis*, *Klebsiella oxytoca* and *Klebsiella pneumoniae* (94.9, 98.3, 87.4 and 82.9%, respectively, of isolates susceptible).[23] Our resistance to imipenem, being 51.3%, is alarming, probably due to the over-use of imipenem manufactured locally without strict controls.

Of the *S. aureus* strains, 87.5% were MRSA; however, at NNIS the corresponding value was 29%.[4] The inclusion of barrier precautions and isolation of patients with MRSA is often not followed in India, where most ICUs are wards, without isolation rooms.[24] Resistance of enterococcal isolates to vancomycin was 33.3%. This varies worldwide; in

a US study, more than 60% of patients in long-term acute care hospitals have MRSA or vancomycin-resistant enterococci (VRE) at admission.[25]

Indian INICC ICUs show high HCAI rates and possible reasons for this have been discussed including not having a legal framework for infection control programmes or their implementation, restricted funds, low nurse-to-patient staffing ratios, overcrowded wards and insufficient supplies.[26–28] In addition, hand hygiene compliance rate is highly variable, such as that found in Thailand, 24%,[29] and INICC, at 51%.[30]

Previous studies in developed countries have shown that HCAI rates can be reduced by using HCAI surveillance and simple, effective infection control practices.[3,5] Our study has also demonstrated a reduction in the incidence of CVC-BSI, CAUTI and VAP in INICC members.[31–37]

Limitations of our study included the data not reflecting an entire country, but a representative sample collected prospectively over a period of four years of comprehensive surveillance. Data from the hospitals involved had different study initiation and end dates and variation in surveillance effectiveness possibly affected HCAI rates. Additionally, ASIS was used, rather than Acute Physiological Assessment and Chronic Health Evaluation (APACHE), due to lack of resources.

HCAI is a threat to patient safety and requires improvement in clinical practice. By implementing HCAI surveillance and effective infection control interventions, it is our hope to provide tools and strategies to achieve this goal.

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None declared.

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