Six-year multicenter study on short-term peripheral venous catheters-related bloodstream infection rates in 204 intensive care units of 57 hospitals in 19 cities of India: International Nosocomial Infection Control Consortium (INICC) findings

Victor Daniel Rosenthal a,⁎, Debkishore Gupta b, Prasad Rajhans c, Sheila Nainan Myatra d, S. Muralidharan e, Yatin Mehta f, Mohit Kharbanda g, Camilla Rodrigues h, Arpita Dwivedy i, Sweta Shah j, Aruna Poojary k, Subhash Kumar Todi l, Supriya Chabukswar m, Mahuya Bhattacharaya n, Bala Ramachandran o, Nagarajan Ramakrishnan p, Sujit Kat Purkayastha q, Asmita Sagar Sakle r, Siva Kumar s, Anup R. Warrier t, Maithili Satish Kavathekar u, Samir Sahu v, Aisha Mubahar w, Nikhil Modi x, Namita Jaggi y, Nadimpalli Gita z, Shakti Bedanta Mishra aa, Suneeta Sahu ab, Burhan Jawadwala ac, Dolatsinh Zala ad, Tenzin Zoomp e, Purva Mathur ff, Suhas Nirkhiwale gg, Sonali Vadi hh, Sanjeev Singh ii, Manoj Agarwal jj, Nagamani Sen kk, Anil Karlekar ll, D.P. Punia mm, Suresh Kumar nn, Ramachadran Gopinath oo, Pravin Kumar Nair pp, Murali Chakravarthy qq, Kavita Sandhu rr, Chandrika Kambam ss, Salil Kumar Mohanty tt, Ami Varaiya uu, Nirav Pandya vv, Vaibhavi R. Subhedar ww, M.R. Vanajakshi xx, Deepak Singh yy, Mayur Patel zz

⁎ International Nosocomial Infection Control Consortium (INICC), Buenos Aires, Argentina

a **B**M **S**irla **H**eart **R**esearch **C**entre, and The **C**alcutta **M**edical **R**esearch **I**nstitute, Calcutta, India

b **P**ramath **M**angeshkar **H**ospital, Pune, India

c **T**ata **M**emorial **H**ospital, Mumbai, India

d **G**. **R**upaswamy **N**aidu **M**emorial **H**ospital, Coimbatore, India

e **M**edanta The **M**edcity, **N**ew Delhi, India

f **D**esam **H**ospital, **K**olkata, India

g **P**al **H**induja **N**ational **H**ospital and **M**edical **R**esearch **C**entre, **M**umbai, India

h **A**crom **M**edical **R**esearch **I**nstitute **D**hakuria **U**nit, **K**olkata, India

i **M**obile **H**ospital, **P**une, India

j **A**ncend **M**edical **R**esearch **I**nstitute **M**aharashtra **U**nit, **K**olkata, India

k **K**ocher **K**omal **C**hild Health **H**ospital, **C**hennai, India

l **A**pollo **M**ain **H**ospital, **C**hennai, India

m **P**eerless **H**ospital **R**esearch **C**entre **L**td, **K**olkata, India

n **R**amakrishna **H**ospital and **M**edical **R**esearch **C**entre, **M**umbai, India

o **R**oyal Medical Center and **H**ospital, **C**oimbatore, India

p **A**ster **M**edinity, **K**ochi, India

q **S**athyasai **E**spectra **H**ospital, **P**une, India

r **K**ollam **H**ospital, **R**obanavoor, **I**ndia

s **K**eral **I**nstitute of **M**edical **S**ciences, **T**hiruvananthapuram, **I**ndia

t **I**ndraprastha **A**pollo **H**ospital, **N**ew Delhi, **I**ndia

u **A**pte re **H**ospital, **N**ew **D**elhi, India

v **R**ao **N**ursing **H**ome, **P**une, **I**ndia


E-mail address: victor.rosenthal@inicc.org (V.D. Rosenthal).

For a list of all the members of the International Nosocomial Infection Control Consortium (INICC) and all the co-authors of this study, see the Appendix.

Conflicts of interest: All authors report no conflicts of interest related to this article. Institutional Review Boards agreed to the study protocol, and patient confidentiality was protected by coding the recorded information, making it only identifiable to the infection control team.

Funding: The funding for the activities carried out at INICC head quarters were provided by the corresponding author, Victor D. Rosenthal, and the Foundation to Fight against Nosocomial Infections.

Author contributions: All authors were involved in drafting of the manuscript, provision of study patients, collection of data, critical revision of the manuscript for important intellectual content, and final approval of the manuscript. V.D.R. was responsible for study conception and design; software development; data assembly, analysis, and interpretation; epidemiologic analytic statistical analysis; administrative, technical, and logistical support.

https://doi.org/10.1016/j.ajic.2018.12.026
0186-6552/© 2020 Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
Short-term peripheral venous catheters (PVCs) therapy is among the most habitual invasive procedure performed in health care settings worldwide. As stated in a recent systematic review, short-term PVCs are widely used, amount to 200 million of them being inserted in the United States each year, and according to different point-prevalence studies, they accounted to 80%, 90%, and 95% of all intravascular devices placed in hospitalized patients in France, in Scotland, and in Spain, respectively.

It has been stated in the 2016 Infusion Nurses Society standards of practice and the 2017 International Nosocomial Infection Control Consortium (INICC) Bundle for the prevention of central and peripheral lines-related BSIs that there is no time limit recommended for PVC removal.

Such high prevalence of short-term PVCs inserted regularly has been reported to result in considerable morbidity, excess length of stay (LOS) and hospital costs, prolonged antibiotics treatments, and BSIs. In addition, it has been reported that the overall PVC failure rate ranges from 35% to 50%, with such failures being responsible for causing PVC-related adverse events, such as phlebitis, occlusion, mechanical failure, infiltration, dislodgment, and bloodstream infections (BSIs). Since short-term PVCs have been rarely associated with BSIs, as stated in the 2011 CDC guidelines for the prevention of intravascular catheter-related BSIs, most studies have therefore been focused on central line-associated BSIs (CLABSi), rather than PVC-related bloodstream infections (PVC-BSIs), which to date have not been thoroughly analyzed. PVC-BSIs are confirmed by the presence of positive blood cultures related by clinical data to short-term PVCs. In health care settings from industrialized countries, the incidence of PVC-BSIs in ICU patients have been reported to be 0.5 per 1,000 short-term PVC-days in ICUs from Australia, Italy and the United States; and 0.67 PVC-BSIs per 1,000 short-term PVC-days in pediatric and neonatal ICUs from Australia. As for the incidence of PVC-BSI in resource-limited countries, there is a gap in the literature, as comprehensive data remain not available.

This prospective surveillance, which was conducted during 6 years, between September 1, 2013 and May 31, 2019 in 204 ICUs in 57 hospitals that participate in INICC, is the first comprehensive...
one conducted in India to analyze the incidence rate, bacterial resistance, LOS, and mortality attributable to PVC-BSI.

METHODS

Background on INICC

INICC is comprised of a group of hospitals, in 210 cities, in 54 countries, and in 6 World Health Organization (WHO) regions: Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific.

INICC has become the oldest and largest source of aggregate standardized international data on the epidemiology of health care-associated infections (HAIs) worldwide.

INICC is focused on the surveillance and prevention of HAIs in adult, pediatric and neonatal ICUs, step down units, inpatient wards, and of surgical site infections in surgical procedures hospital-wide.

Study design

This prospective, cohort surveillance study was conducted by means of an online platform called INICC Surveillance Online System (ISOS). Through ISOS, validation of each PVC-BSI was checked by infection preventionists and the recorded signs and symptoms of infection and the results of cultures, laboratory and radiographic studies, as well as other tests, are scrutinized to assure that the last US CDC/NHSN criteria for PVC-BSIs were met, in accordance with the definition presented below.

INICC methods

The ISOS includes the implementation of CDC/NHSN’s methodology, but adds the collection of other data essential to increase infection preventionists’ sensitivity of to detect PVC-BSIs, and avoids underreporting. According to standard CDC/NHSN methods, numerators are the number of health care-acquired infections related to a specific, and denominators are device-days collected from all patients, as pooled data; that is, without determining the number of device-days related to a particular patient, and without collecting features or characteristics per specific patient.

This aspect differs from the ISOS, because the design of the cohort study through the ISOS also includes the infection preventionists’ collection of specific data per patient from all patients, both those with and those without PVC-BSI, such as invasive devices utilization, age, gender, date of admission, date of discharge, LOS, microorganism profile of HAIs, bacterial resistance, and mortality, among several others.

Outcome surveillance data collection and validation

This study presents the results of Outcome Surveillance of PVC-BSIs in the ICU through the use of the ISOS, which follows the INICC protocol and allows the classification of prospective, active, and cohort data into specific module protocols.

The site-specific criteria include reporting instructions and provide full explanations integral to their adequate application. Infection preventionists collected daily data on PVC-BSIs, and denominator data, such as specific device-days in the ICUs, patient-days, microorganism profile, and bacterial resistance.

Validation is an essential feature of the ISOS to maximize the sensitivity and accuracy of surveillance data. Each PVC-BSI reported by an infection preventionist is validated (ie, scrutinized to be certain that all criteria are satisfied to justify its recording as a PVC-BSI). The validation process also includes data reported for putatively uninfected patients to permit detection of unreported but true PVC-BSIs. To do that, the ISOS shows an online message to the infection preventionists asking them to check the criteria for that putative PVC-BSI.

Training

The INICC team trained and provided infection preventionists with manuals, training tools, and tutorial movies, which described in detail how to perform surveillance and upload surveillance data through the ISOS.

In addition, investigators attended webinars, and had continuous access to a support team at the INICC headquarters in Buenos Aires, Argentina. The INICC support team evaluates on a routine basis that infection preventionists perform surveillance correctly through the ISOS online platform, and sends emails and shows online messages to infection preventionists asking them to check and review surveillance data and specific criteria.

Definitions

BSI: We used US CDC/NHSN’s definitions for BSI from its publication in 2013 and their amendments until its latest publication in 2019.

PVC-BSI: US CDC/NHSN’s definitions do not include the surveillance definition of PVC-BSI. We applied the CDC/NHSN’s definition for patients that met all the criteria for BSI, but never used central lines (CL), nor peripherally inserted central catheters, and that only used short-term PVCs, before and or after the acquisition of a BSI.

Calculation

Data uploaded to ISOS were used to calculate PVC-BSI rates per 1,000 device-days, mortality, and LOS, according to the following formulas: device-days consisted of the total number of PVC-days.

Crude excess mortality of PVC-BSI equaled crude mortality of ICU patients with PVC-BSI minus crude mortality of patients without PVC-BSI.

Crude excess LOS of PVC-BSI equaled crude LOS of ICU patients with PVC-BSI minus crude LOS of patients without PVC-BSI.

Device utilization ratio (DUR) equaled the total number of PVC-days divided by the total number of bed days.

To calculate extra LOS and extra mortality, all CLABSIs were excluded, and only patients with short-term PVCs, both with or without BSIs, were included.

Follow-up of patients

To estimate PVC-BSI rate and excess mortality attributable to PVC-BSI, all patients were followed over 15 days, after step-down from the ICU.

Statistical analysis

ISOS version 2.0 (Buenos Aires, Argentina), was used to calculate PVC-BSI rates, DURs, LOS, and mortality. EpiInfo version 6.04b (CDC, Atlanta, GA), SPSS 16.0 (SPSS Inc., an IBM company, Chicago, IL). 95% confidence intervals and P values were determined for all outcomes.

Setting

The study was conducted in 204 ICUs from 57 hospitals in 19 cities of India, through the implementation of the ISOS, as described above. All the cohort of patients admitted to the ICUs during the study period was enrolled in the study with hospitals’ Research Ethics Committees approval.
Table 1
Type of ICU and hospitals’ ownership

<table>
<thead>
<tr>
<th>ICUs, type</th>
<th>No. of ICUs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiothoracic</td>
<td>11 (5.39)</td>
</tr>
<tr>
<td>Coronary</td>
<td>18 (8.82)</td>
</tr>
<tr>
<td>Medical</td>
<td>41 (20.10)</td>
</tr>
<tr>
<td>Medical-surgical</td>
<td>66 (32.35)</td>
</tr>
<tr>
<td>Neurosurgical</td>
<td>16 (7.84)</td>
</tr>
<tr>
<td>Neurologic</td>
<td>6 (2.94)</td>
</tr>
<tr>
<td>Oncology</td>
<td>2 (0.98)</td>
</tr>
<tr>
<td>Pediatric</td>
<td>9 (4.41)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>4 (1.96)</td>
</tr>
<tr>
<td>Surgical</td>
<td>20 (9.8)</td>
</tr>
<tr>
<td>Trauma</td>
<td>5 (2.45)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (2.94)</td>
</tr>
<tr>
<td>Total ICUs, n (%)</td>
<td>204 (100)</td>
</tr>
<tr>
<td>Hospitals</td>
<td></td>
</tr>
<tr>
<td>Academic teaching</td>
<td>8 (14)</td>
</tr>
<tr>
<td>Public, n (%)</td>
<td>6 (11)</td>
</tr>
<tr>
<td>Private community, n (%)</td>
<td>43 (75)</td>
</tr>
<tr>
<td>Total Hospitals, n</td>
<td>57 (110)</td>
</tr>
</tbody>
</table>

ICU, intensive care unit.

In accordance with the INICC’s Charter, the identity of all INICC hospitals and cities is kept confidential.17

RESULTS

During the study period of 6 years, from September 1, 2013 to May 31, 2019, the mean length of participation of the ICUs was 20 months (SD: 27.3), range from 1 to 149 months.

Table 2 shows type of ICUs and type of hospitals’ ownership.

Table 3 provides PVR-BSI rates and DU rates by type of ICU.

Table 4 provides data on crude ICU mortality and crude LOS in patients with and without PVR-BSI.

Table 4 provides data on bacterial resistance of pathogens isolated from patients with PVR-BSI in adult and pediatric ICUs.

Figure 1 shows microorganism profile of PVR-BSIs.

DISCUSSION

To date, there are no previous representative studies of PVR-BSI rates at national level in India, neither in Asia, nor in resource-limited countries worldwide in the 6 WHO regions.

In a recent prospective study conducted in Southern Odisha, India, with insufficient sample size, which included just 87 patients, the PVR-BSI rate was 40.6/1,000 PVC-days.23 This study was conducted

Table 2
Pooled means, 95% confidence intervals of the distribution of short-term peripheral venous catheter-related bloodstream infections rates by type of location, in adult and pediatric intensive care units

<table>
<thead>
<tr>
<th>Type of ICU</th>
<th>ICU, n</th>
<th>Patients, n</th>
<th>PVR-BSI, n</th>
<th>PVC days, n</th>
<th>Pooled PVR-BSI rate</th>
<th>DU ratio, mean</th>
<th>95% CI for DU mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiothoracic</td>
<td>11</td>
<td>385</td>
<td>1</td>
<td>1,747</td>
<td>0.57</td>
<td>1.085</td>
<td>0.966 1.204</td>
</tr>
<tr>
<td>Coronary</td>
<td>18</td>
<td>1,875</td>
<td>19</td>
<td>7,225</td>
<td>2.63</td>
<td>1.082</td>
<td>1.059 1.105</td>
</tr>
<tr>
<td>Medical</td>
<td>41</td>
<td>14,088</td>
<td>81</td>
<td>59,116</td>
<td>1.37</td>
<td>0.907</td>
<td>0.876 0.937</td>
</tr>
<tr>
<td>Medical-surgical</td>
<td>66</td>
<td>41,709</td>
<td>886</td>
<td>164,719</td>
<td>4.16</td>
<td>1.012</td>
<td>1.006 1.017</td>
</tr>
<tr>
<td>Neurosurgical</td>
<td>16</td>
<td>2,818</td>
<td>2</td>
<td>12,123</td>
<td>0.16</td>
<td>0.994</td>
<td>0.972 1.017</td>
</tr>
<tr>
<td>Neurologic</td>
<td>6</td>
<td>446</td>
<td>14</td>
<td>2,009</td>
<td>6.97</td>
<td>1.142</td>
<td>1.109 1.175</td>
</tr>
<tr>
<td>Oncology</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>31</td>
<td>0.00</td>
<td>1.500</td>
<td>0.991 3.081</td>
</tr>
<tr>
<td>Pediatric</td>
<td>6</td>
<td>270</td>
<td>3</td>
<td>1,920</td>
<td>2.94</td>
<td>0.993</td>
<td>0.966 1.021</td>
</tr>
<tr>
<td>Respiratory</td>
<td>9</td>
<td>2,950</td>
<td>49</td>
<td>16,556</td>
<td>2.96</td>
<td>1.282</td>
<td>1.201 1.303</td>
</tr>
<tr>
<td>Surgical</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>34</td>
<td>0.00</td>
<td>0.859</td>
<td>0.608 1.110</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>20</td>
<td>4,781</td>
<td>2</td>
<td>23,346</td>
<td>0.09</td>
<td>0.983</td>
<td>0.965 0.987</td>
</tr>
<tr>
<td>Pooled (adult and pediatric ICUs)</td>
<td>204</td>
<td>71,513</td>
<td>863</td>
<td>295,795</td>
<td>2.92</td>
<td>1.01</td>
<td>1.01 1.02</td>
</tr>
</tbody>
</table>

CI, confidence interval; DU, device utilization; ICU, intensive care unit; PVC, peripheral venous catheter; PVR-BSI, short-term peripheral venous catheter-related bloodstream

Infections.

Table 3
Pooled means of the distribution of crude mortality and length of stay of intensive care unit patients with short-term peripheral venous catheter-related bloodstream infections in adult and pediatric intensive care units combined

<table>
<thead>
<tr>
<th>No. of deaths</th>
<th>No. of patients</th>
<th>Pooled crude mortality, % (mean; SD; 95% CI)</th>
<th>LOS, total days</th>
<th>Pooled mean LOS days, (SD; 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult and pediatric patients, without PVR-BSI</td>
<td>2,046</td>
<td>76,650</td>
<td>14.44% (0.04; 0.20; 0.03-0.05)</td>
<td>291,800</td>
</tr>
<tr>
<td>Adult and pediatric patients, with PVR-BSI</td>
<td>100</td>
<td>863</td>
<td>11.59% (0.12; 0.05-0.18)</td>
<td>5,093</td>
</tr>
</tbody>
</table>

CI, confidence interval; LOS, length of stay; PVR-BSI, short-term peripheral venous catheter-related bloodstream infections.
at 1 hospital during 1 year, which is not enough to draw any kind of conclusions regarding rates.23 Our study, conducted during 6 years in 204 ICUs in 57 hospitals, in 19 cities in India with 7,513 patients, is the first comprehensive one to calculate PVC-BSI rates per 1,000 device-days.8 Our PVC-BSI rate was 2.92 per 1,000 PVC-days. As far as we are concerned, the incidence of PVC-BSI has been determined by number of PVC-days in only 2 studies from industrialized countries: back in 2006, in a systematic review with data from only 3 industrialized countries (the United States, Australia, and Italy), the rate was 0.5 PVC-BSI per 1,000 PVC-days;14, and in a recent study conducted in pediatric and non-pediatric ICUs from Australia, the rate was 0.67 PVC-BSI per 1,000 PVC-days.15

In a systematic review published in 2019 by Alliance for Vascular Access Teaching and Research group the selected studies did not report PVC-days as denominators of PVC-BSI rates, and for that reason such data are not comparable with our present study.22 The cited review published by AVATAR included studies whose PVC-BSI rates were presented as follows:24 Australia (0.39 PVC-BSI per 1,000 occupied bed-days);25 Germany (3.04 PVC-BSI per 1,000 patient days);26 Spain (1.17 PVC-BSI per 1,000 patient days);27 and 0.05 PVC/1,000 patient days; and the United States (0.015 PVC-BSI per 100 patient days)28 and 0.57 PVC-BSI per 1,000 patient days.29

Most studies have reported on the adverse consequences of BSIs in ICUs, and the comparison of infection risk using CL vs short-term PVCs, with CLs being much more prone to higher BSIs rates than with short-term PVCs.11-21

In 2014, INICC published data of CLABS in India, prospectively collected during 10 years, from 2004 to 2013, from 236,700 ICU patients for 970,713 bed-days. Pooled rates for adult and pediatric ICUs were 5.1 CLABSs per 1,000 central line-days.30 The comparison of INICC previous data collected in India and published in 2014 of CLABS with this study's INICC present data also collected and published in India by INICC on PVC-BSI shows the pooled rate of CLABS is 1.75 times higher than the PVC-BSI rate. However, since around 80%-90% of the vascular catheters used worldwide are short-term PVCs, the raw number of BSIs due to PVC is around 6 times higher than due to CL.34

In our ICUs, the pooled mean of the distribution of crude mortality amounted to 11.59% of PVC-BSIs cases, compared with 4.14% mortality with PVC patients that were not infected. Similarly, in recent studies from Spain and Japan, mortality attributable to PVC-BSI was 13.2% and 12.9%, respectively.27,35

The excess IS of patients with PVC-BSI in our study was 39% higher than in patients without PVC-BSI; in the previously cited study from Japan, patients who had acquired PVC-BSI required a longer duration of antibiotic treatment (33.5 vs 15.8 days; P = .004) than patients without PVC-BSI.35

The microorganism profile of PVC-BSI found in our ICUs showed a predominance of gram negative bacteria (68%): Escherichia coli (23%), Klebsiella spp (15%), Pseudomonas aeruginosa (5%), Enterobacter spp. (5%), Acinetobacter spp. (5%), and others including Serratia marcescens and Burkholderia cepacia (15%). Within the 39% of gram positive bacteria found, the predominant one was Staphylococcus aureus (10%).

Fig 1. Microorganism profile of short-term peripheral venous catheter-associated bloodstream infections.

*Other gram negative bacteria: It includes the following microorganisms that individually accounted for <1%: Citrobacter spp, Morganella, Providencia spp, Salmonella spp, Stenotrophomonas spp, Zymomonas, Acinetobacter spp, Elizabethkingia meningoseptica, Haemophilus influenzae, Aeromonas spp, and Sphingomonas.

**Other gram positive bacteria: It includes the following microorganisms that individually accounted for <1%: coagulase-negative Staphylococci spp, Listeria monocytogenes, Methicillin-resistant Staphylococcus aureus, Rothia sp, Micrococcus spp, Staphylococcus epidermidis.

***Other: It includes Candida spp, and other fungi that accounted for <1%: Cryptococcus laurentii, Gardnerella vaginalis.
This highly contrasts with those findings from industrialized countries, in which gram positive pathogens were the predominant cause of PVR-C-BSI.

A recent study conducted in Japan the causative pathogens were gram-positive in 58% of cases and gram-negative in 35%, but data concerning Candida spp. in 6.2% of cases. The predominance of gram positive pathogens causing PVR-BSI in industrialized countries has been found in a wide range of studies, in which S. aureus PVR-BSI has been identified in industrialized countries as a serious condition that could influence prognosis. There are not available data showing microorganisms profile for PVR-BSI from representative studies from other resource-limited countries.

The most prevalent pathogens found (E. coli, Klebsiella spp, and S. aureus), presented considerable resistance rates. Resistance of P. aeruginosa to fluoroquinolones (ciprofloxacin, levofloxacin, norfloxacin, or ofloxacin), piperacillin, piperacillin-tazobactam, and amikacin was 27.3%, to imipenem (IPM) or meropenem (MEM) was 33.3%; of Klebsiella pneumonia to ceftiraxone or cefazidime was 79.31%, IPM or MEM or etapenem was 68.42%; of Acinetobacter baumannii to IPM or MEM was 80.03%; of E. coli to CRD or CAZ was 66.78%, to IPM or MEM or etapenem was 25.03%, to FQs was 61.03%.

Regarding gram-positive bacteria, in our study, resistance of S. aureus to oxacillin in 50% of cases is similar to a 49% resistance reported in another study in India. Entercoccus faecalis was 100% sensitive to vancomycin, which is also similar to the findings of the cited study conducted in India, in which vancomycin was 100% sensitive to the following gram-positive bacteria: S. aureus, coagulase-negative Staphylococci, and Enterococcus spp.

The implementation of PRC insertion and maintenance bundles to decrease PVR-BSI rates is common in industrialized countries. To reduce the hospitalized patients’ risk of infection, PVR-BSI surveillance by number of device-days is essential, because it effectively characterizes the threatening situation created by PVR-BSIs. This must be followed by the implementation of multifaceted and surveillance programs aimed at PVR-BSI prevention and control.

Likewise, it is important to address the burden of antimicrobial resistance and report susceptibility to antimicrobials of PVR-BSI-associated pathogens, to take effective measures to prevent resistant strains from being transmitted.

In this particular study, INICC focused just on the ICU setting: that is, health care settings with the highest health-care-acquired rates, in which patients’ safety is most seriously threatened, due to their critical condition and exposure to invasive devices. Through the last 17 years, INICC has undertaken a global effort in the 6 WHO regions: Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific to respond to the burden of HAIs, and has achieved extremely successful results, by increasing hand hygiene compliance, improving compliance with infection control bundles and interventions as described in several INICC publications.

The primary application of these data is to serve as a guide for the implementation of prevention strategies and other quality improvement efforts for the reduction of PVR-BSI rates and their related adverse events to the minimum possible level.

**Study limitations**

The purpose of this report is to obtain updated data on PVR-BSI, device utilization (DU), bacterial resistance, LOS, and mortality of patients with and without PVR-BSI in adult and pediatric ICUs, but it does not provide insights regarding the impact of INICC interventions, such as the implementation of INICC Multimensional Approach and ISOS. The impact of the adoption of such resources is to be published in prospective, interventional studies at hospitals that have participated in INICC during a considerable amount of years.

Second, our study was limited by the fact that benchmarking with CDC-NSH, or other institutions, was not possible because PVR-BSI rates are not reported to such institutions, or are not determined by PVC-days.

Third, due to the low economic resources of our ICUs, probably cultures taken were less than ideal, which likely influenced the rates of PVR-BSI, and the number of patients to whom blood cultures should have been taken, but were not, is unknown as these data were not registered.

Finally, we do not present data on trends over years for this 6-year study.

**CONCLUSIONS**

This study presents the only available comprehensive data from a developing country showing PVR-BSIs per 1,000 PVC-days, and benchmarking of our findings was limited to the results of 2 studies from industrialized countries: a systematic review with data from the United States, Australia, and Italy published in 2006, and a prospective study from Australia.

Our PVR-BSI rates were far much higher than the data available from industrialized countries, thereby is evident that PVR-BSIs in ICUs from resource-limited countries are a challenge for patient safety. PVR-BSI systematic surveillance and prevention programs, including antibiotic resistance reports, should be widely implemented to allow a reduction in the incidence of PVR-BSI and its adverse-related events worldwide.

**Acknowledgments**

The authors thank the many healthcare professionals at each member hospital who assisted with the conduct of surveillance in their hospital; Mariano Vilar and Debora Lopez Burgardt, who work at INICC headquarters in Buenos Aires; the INICC Country Directors and Secretaries (Haiiaa Hassan Al-Mousa, Hail Alabdale, Areej Alshehri, Altaf Ahmed, Carlos A. Alvarez-Moreno, Anucha Apisarnthanarak, Biju Hu, Hakon Lefebre-Bolig, Yatin Mehta, Toshiko Mitsuda, and Lui Raka); and the INICC Advisory Board (Carlos J. Alvarado, Nicholas Graves, William R. Jarvis, Patricia Lynch, Dennis Maki, Toshiko Mitsuda, Cat Murphy, Russell N. Olmsted, William Ruta, Syed Sattar, and Wing Hong Seto), who have so generously supported this unique international infection control network.

**APPENDIX WITH REMAINING AUTHORS**

Gautam Khanna (Pd Hinduja National Hospital and Medical Research Centre, Mumbai, India); Anuradha Sriram, Jincy Eappen, Sheena Binu, Suvin Shetty, Valsa Thomas (Dr I H Hirandani Hospital, Mumbai, India); Tanu Singh, Vatsal Kothari, Ram Narain (Kokilaben Dhirubhai Ambani Hospital and Research Institute, Mumbai, India); Priyanka Patil, Seema Kukreja, Sheeba John (Breach Candy Hospital Trust, Mumbai, India); Sarswat Mahangare, Sampada Patwardhan, Dhmuc, Nilesh Mahale, Namita A. Upadhay, Gayu Triwad, Naiyappa Shaik, Savita Bhujbal, Sili Dominic, Vasudha Shingate (Deenanath Mangeshkar Hospital, Pune, India); Baby Padmni, S Sanarya (G Kuppuswamy Naidu Memorial Hospital, Coimbatore, India); Anjana Shri, Sathinath Sampath, Vandana Raut, Sanjay K. Biswas, Rohni Kelkar, Jigeeshu Vasishtha Divatia (Tata Memorial Hospital, Mumbai, India); Arpita Bhakti (Advanced Medicare Research Institute Dhakuria Unit); Ravikumar Krupanadan (Kanchi Kamakoti Childs Trust Hospital, Chennai, India); Lakshmi Ranganathan, Ashwini Kumar Mani, Senthilkumar Rajagopal, Babu Kunuvilla Abraham, Ramesh Venkatraman, Dedeeptaya Devaprasad (Apollo Mal Hospital, Chennai, India); Sinchan, Sudip Tabatat (Peerless Hospital Research Center Ltd, Kolkata, India); Harish Pillai (Aster Medcity, Kochi, India); Deepa Ganesh Devkar, Madhupriya Vijay Suryawanshi (Sahyadri Speciality Hospital, Pune, India); Arjun Rajalakshmi (Kerala Institute of Medical
References


