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Six-year multicenter study on short-term peripheral venous catheters-related bloodstream infection rates in 246 intensive units of 83 hospitals in 52 cities of 14 countries of Middle East: Bahrain, Egypt, Iran, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, Pakistan, Palestine, Sudan, Tunisia, Turkey, and United Arab Emirates—International Nosocomial Infection Control Consortium (INICC) findings☆

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ABSTRACT

Background: Short-term peripheral venous catheters-related bloodstream infections (PVCR-BSIs) rates have not been systematically studied, and data on their incidence by number of device-days is not available.

Methods: Prospective, surveillance study on PVCR-BSI conducted from September 1st, 2013 to 31st Mays, 2019 in 246 intensive care units (ICUs), members of the International Nosocomial Infection Control Consortium (INICC), from 83 hospitals in 52 cities of 14 countries in the Middle East (Bahrain, Egypt, Iran, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, Pakistan, Palestine, Sudan, Tunisia, Turkey, and United Arab Emirates). We applied U.S.

Results: We followed 31,083 ICU patients for 189,834 bed-days and 202,375 short term peripheral venous catheter (PVC)-days. We identified 470 PVCR-BSIs, amounting to a rate of 2.32/1000 PVC-days. Mortality in patients with PVC but without PVCR-BSI was 10.38%, and 29.36% in patients with PVC and PVCR-BSI. The mean length of stay in patients with PVC but without PVCR-BSI was 5.94 days, and 16.84 days in patients with PVC and PVCR-BSI. The microorganism profile showed 55.2 % of gram-positive bacteria, with Coagulase-negative *Staphylococci* (31%) and *Staphylococcus aureus* (14%) being the predominant ones. Gram-negative bacteria accounted for 39% of cases, and included: *Escherichia coli* (7%), *Klebsiella pneumoniae* (8%), *Pseudomonas aeruginosa* (5%), *Enterobacter* spp. (3%), and others (29.9%), such as *Serratia marcescens*.

Conclusions: PVCR-BSI rates found in our ICUs were much higher than rates published from USA, Australia, and Italy. Infection prevention programs must be implemented to reduce the incidence of PVCR-BSIs.

Introduction

Short-term peripheral venous catheter (PVC) therapy is one of the most common invasive procedure performed in health care settings worldwide [1–3]. As stated in different point-prevalence studies, PVCs accounted to 80%, 90% and 95% of all intravascular devices placed in hospitalized patients in France, in Scotland, and Spain, respectively [3]. According to a recent systematic review, PVCs are widely used, amount to 200 millions of PVCs being inserted in the US each year [3].

It has been reported in the mainstream literature that the overall PVC failure rate ranges from 35% to 50% [1,2,4], with such failures being responsible for causing PVC-related adverse events, such as phlebitis, occlusion/mechanical failure, infiltration, dislodgment, and bloodstream infections (BSIs) [1,2,4–9]. Moreover, the men-

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tioned it was reported that the high prevalence of PVCs being inserted regularly has resulted in considerable morbidity, excess length of stay (LOS) and hospital costs, prolonged antibiotics treatments, and BSIs [10].

PVCs have been rarely associated with bloodstream infections (BSIs), as stated in the 2011 CDC guidelines for the prevention of intravascular catheter-related BSIs [3,11,12]; as a consequence, most studies have therefore been focused on central line-associated BSIs, rather than PVC-related bloodstream infections (PVCR-BSIs), which to date have not been thoroughly analyzed [10].

PVCR-BSIs are confirmed by the presence of positive blood cultures related by clinical data to PVCs [1]. The incidence of PVCR-BSIs in ICU patients has been reported to be 0.5 per 1000 PVCs-days in ICUs from Australia, Italy and the US [12], and 0.67 PVCR-BSIs per 1000 PVCs-days in pediatric and neonatal ICUs from Australia [13]. As for the incidence of PVCR-BSI in other countries, there is a gap in the literature, as comprehensive data remains not available. In accordance with the 2016 Infusion Nurses Society standards of practice [14] 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 [15].

This prospective surveillance, which was conducted during 6 years, between September 1st, 2013 and May 31st, 2019, in 246 ICUs in 83 hospitals that participate in INICC [6–8,16], is the first comprehensive one conducted in 52 cities in 14 countries of the Eastern Mediterranean Region (Bahrain, Egypt, Iran, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, Pakistan, Palestine, Sudan, Tunisia, Turkey, and United Arab Emirates) as a first step to analyze the incidence rate, bacterial resistance, LOS and mortality attributable to PVCR-BSI.

Methods

Background on INICC

INICC is comprised of a group of hospitals, in 210 cities, in 54 countries in the six World Health Organization (WHO) regions: Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific, and has become the oldest and largest source of aggregate standardized international data on the epidemiology of healthcare-associated infections (HAIs) worldwide [6,17]. INICC's main goal is the prevention of HAIs in adult, pediatric and neonatal ICUs, step down units, inpatient wards, and of surgical site infections in surgical procedures hospital-wide through systematic outcome and process surveillance, and implementation of multidimensional infection control programs.

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 PVCR-BSI was checked by infection control professionals (ICPs) 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 U.S. CDC-NHSN criteria for PVCR-BSIs were met, in accordance with the definition presented below [17,18].

INICC methods

The ISOS includes the implementation of CDC/NSHN's methodology, but adds the collection of other data essential to increase ICPs' sensitivity of to detect PVCR-BSIs, and avoid underreporting [17]. According to standard CDC/NSHN 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 ICPs' collecting of specific data per patient from *all* patients, both those with and those without PVCR-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 PVCR-BSIs in the ICU through the use of the ISOS, which follows the INICC protocol and allows the classification of prospective, active, cohort data into specific module protocols.

The site-specific criteria include reporting instructions and provide full explanations integral to their adequate application.

All patients with usage of a central line were excluded from this study. Only patients with PVC were included in this study.

ICPs collected daily data on PVCR-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 PVCR-BSI reported by an ICP is validated (i.e., scrutinized to be certain that all criteria are satisfied to justify its recording as a PVCR-BSI). The validation process also includes data reported for putatively uninfected patients to permit detection of unreported but true PVCR-BSIs. To do that, the ISOS shows an online message to the ICPs asking them to check the criteria for that putative PVCR-BSI [17].

Training

The INICC team trained and provided ICPs 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 ICPs perform surveillance correctly through the ISOS online platform, and sends emails and shows online messages to ICPs asking them to check and review surveillance data and specific criteria.

Definitions

BSI

We used U.S. CDC/NHSN's definition for BSI: "A Laboratory Confirmed Bloodstream Infection (LCBSI) that is not secondary to an infection at another body site" [19–22].

LCBSI

We used U.S. CDC/NHSN's definition for LCBSI: "Patient of any age has a recognized bacterial or fungal pathogen, not included on the NHSN common commensal list: 1. Identified from one or more blood specimens obtained by a culture OR 2. Identified to the genus or species level by non-culture based microbiologic testing (NCT) methods (for example, T2 Magnetic Resonance [T2MR] or Karius Test). [Note: If blood is collected for culture within 2 days before, or 1 day after the NCT, disregard the result of the NCT and use only the result of the CULTURE to make an LCBI surveillance determination. If no blood is collected for culture within this time period, use the

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Table 1
Type of ICU and hospitals' ownership.

ICUs, type	No. of ICUs	%
Burn	2	**0.81**
Cardiothoracic	2	**0.81**
Coronary	14	**5.69**
Medical	55	**22.36**
Medical/surgical	90	**36.59**
Neuro surgical	6	**2.44**
Neurologic	4	**1.63**
Oncology	2	**0.81**
Pediatric	22	**8.94**
Pediatric oncology	3	**1.22**
Respiratory	6	**2.44**
Surgical	22	**8.94**
Trauma	8	**3.25**
Other	10	**4.07**
Total	246	100
Hospitals		
Academic teaching, n, %	11	**13.25**
Public, n, %	55	**66.27**
Private community, n, %	17	**20.48**
Total hospitals, n, %	83	100

ICU, intensive care unit.

result of the NCT for LCBI surveillance determination.], AND Organism(s) identified in blood is not related to an infection at another site" [19–22].

PVCR-BSI

U.S. CDC/NHSN's definitions do not include the surveillance definition of PVCR-BSI [19–22]. We applied the CDC/NHSN's definition for patients that met all the criteria for BSI, but never used central lines, 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 PVCR-BSI rates per 1000 device-days, mortality, and LOS, according to the following formulas: device-days consisted of the total number of PVC-days.

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

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

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

To calculate extra LOS and extra mortality, all central line-associated BSIs were excluded, and only patients with PVCs, both with or without BSIs, were included.

Statistical analysis

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

Setting

The study was conducted in 246 ICUs from 83 hospitals in 52 cities of the following 14 countries from the Middle East Middle East: Bahrain, Egypt, Iran, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, Pakistan, Palestine, Sudan, Tunisia, Turkey, and United Arab Emirates.

All the cohort of patients admitted to the ICUs during the study period was enrolled in the study with hospitals' Research Ethics Committees approval.

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 1st, 2013 to 31st May, 2019, the mean length of participation of the ICUs was 22 months (SD: 25.3), range from 2 to 149 months.

Table 1 shows type of ICUs and type of hospitals' ownership.

Table 2 shows PVCR-BSI rates and DURs by type of ICU. Overall PVCR-BSI rate was 2.32 per 1000 PVC days. The PVCR-BSI rate including only Oncology ICUs was 11.35. The PVCR-BSI rate without including Oncology ICUs was 2.01 (393 PVCR-BSIs/195576 PVC days ×1000).

Table 3 provides data on crude ICU mortality and crude LOS in patients with and without PVCR-BSI.

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

Fig. 1 shows microorganism profile of PVCR-BSIs.

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.

Type of ICU	ICU, n	Patients, n	Bed days, n	PVCR-BSIs, n	PVC days, n	Pooled PVCR-BSI rate	Device utilization ratio			
							Mean	95% CI		SD
Burn	2	3	10	0	15	0.00	1.58	0.29	2.88	0.52
Cardiothoracic	2	66	337	0	334	0.00	1.02	0.96	1.08	0.23
Coronary	14	2116	9280	7	9607	0.73	1.08	1.06	1.10	0.43
Medical	55	2209	16,506	71	18,238	3.89	1.10	1.07	1.12	0.54
Medical/surgical	90	20,182	120,467	247	12,9386	1.91	1.11	1.10	1.12	0.67
Neuro surgical	6	55	937	3	1031	2.91	1.15	0.95	1.36	0.75
Neurologic	4	17	245	2	250	8.00	1.08	0.89	1.28	0.38
Oncology	2	975	3433	77	6784	11.35	1.98	1.96	2.01	0.35
Other	10	19	68	2	73	27.40	1.19	0.79	1.59	0.82
Pediatric	22	3956	28,753	34	26,551	1.28	1.04	1.02	1.05	0.40
Pediatric oncology	3	351	1416	1	1274	0.78	0.92	0.90	0.95	0.23
Respiratory	6	13	89	0	112	0.00	1.09	0.91	1.28	0.31
Surgical	22	1026	7408	23	8034	2.86	1.16	1.12	1.20	0.61
Trauma	8	95	885	3	686	4.37	0.93	0.87	0.98	0.27
Pooled (adult and pediatric ICUs)	246	31,083	189,834	470	202375	2.32	1.123	1.116	1.129	.622

ICU, intensive care unit; PVCR-BSI, short-term peripheral venous catheter-related bloodstream infections; PVC, short-term peripheral venous catheter; DU, device utilization; CI, confidence interval; SD, standard deviation.

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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.

	No. of deaths	No. of patients	Pooled crude mortality, % (mean; standard deviation; 95% CI)	LOS, total days	Pooled mean LOS, days, (standard deviation; 95% CI)
Adult and pediatric patients, without PVCR-BSI	3,179	30,613	10.38% (0.1; 0.31; 0.10–0.11)	181,919	5.94 (8.98; 5.90–5.98)
Adult and pediatric patients, with PVCR-BSI	138	470	29.36% (0.29; 0.46; 0.29–0.30)	7,915	16,84 (23.39; 16.73– 16.95)
Total	3,317	31,083	–	189,834	–

PVCR-BSI, short-term peripheral venous catheter-related bloodstream infections; LOS, length of stay; CI, confidence interval.

Table 4
Antimicrobial resistance rates in intensive care units.

	PVCR-BSI	
Pseudomonas aeruginosa		
PIP or TZP		
AMK		
IPM or MEM		
Klebsiella pneumoniae		
CRO or CAZ		
FQs	11	72.73 (8)
Escherichia coli		
Staphylococcus aureus		
OXA	14	50.00 (7)
Enterococcus faecalis		
VAN	2	0.0 (0)

PVC, short-term peripheral venous catheter; PVCR-BSI, PVC-related bloodstream infections; infection; FQs, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin, or ofloxacin); OXA, oxacillin; PIP, piperacillin; TZP, piperacillin-tazobactam; AMK, amikacin; VAN, vancomycin; IPM, imipenem; MEM, meropenem; CRO, ceftriaxone; CAZ, ceftazidime; ETP, ertapenem.

Discussion

To date, there are not published data available from representative studies analyzing PVCR-BSI rates in countries from the Middle East nor in any of the other five regions of the WHO. Our six-year study, including data of 149,609 patients from 246 ICUs, in 83 hospitals, in 52 cities of 14 countries, is the first comprehensive one to determine PVCR-BSI rates per 1000 device-days in this region [5]. The pooled mean PVCR-BSI rate was 2.32 per 1000 PVC-days; however, there was heterogeneity in PVCR-BSI rates across the different types of ICU, as shown by the 11.35 PVCR-BSI rate including only Oncology ICUs. The PVCR-BSI rate without including Oncology ICUs was 2.01. As far as we are concerned, the incidence of PVCR-BSI has been determined by number of PVC-days in only two studies back in 2006, in a systematic review with data from only three countries (the US, Australia, and Italy), the rate was 0.5 PVCR-BSI per 1000 PVC-days [12]; and in a recent study conducted in pediatric and neonatal ICUs from Australia, the rate was 0.67 PVCR-BSI per 1000 PVC-days [13].

In a systematic review published in 2019 by Alliance for Vascular Access Teaching and Research (AVATAR) group the selected studies did not report PVC-days as denominators of PVCR-BSIs rates, and for that reason such data is not comparable with our present study [23]. The cited review published by AVATAR included studies whose PVCR-BSI rates were presented as follows [23]: Australia (0.39 PVCR-BSI per 10,000 occupied bed-days) [24]; Germany (3.04 PVCR-BSI per 1000 patient days) [25]; Spain (1.17 PIVC-BSI per

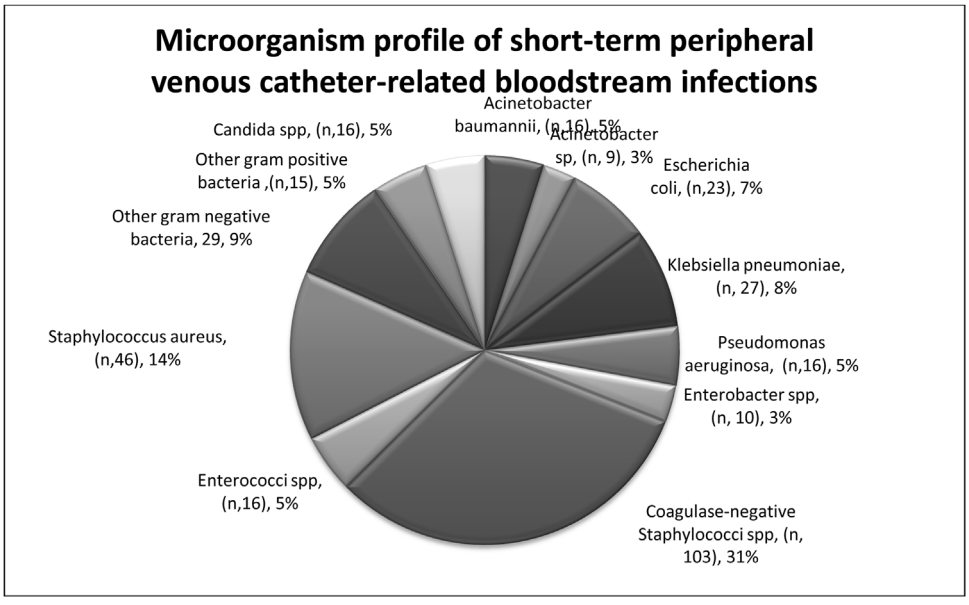

Fig. 1. Microorganism profile of short-term peripheral venous catheter-related bloodstream infections.
*Other gram negative bacteria: It includes the following microorganisms that individually accounted for <1%: *Aeromonas* sp, *Bacteroides fragilis*, *Burkholderia cepacia*, *Citrobacter freundii*, *Citrobacter* spp, *Escherichia* sp, *Klebsiella* sp, *Kluyvera intermedia*, *Legionella pneumophila*, *Morganella morganii*, *Proteus* spp, *Pseudomonas fluorescens*, *Salmonella* spp, *Serratia marcescens*, *Shigella* sp, *Stenotrophomonas maltophilia*, and *Stenotrophomonas* sp.
**Other gram positive bacteria: It includes the following microorganisms that individually accounted for <1%: *Aerococcus* spp, *Corynebacterum jeikeium*, Methicillin-resistant *Staphlococcus aureus*, *S. epidermidis*, *Streptococcus Beta Hemolytic, agalactiae*, *Streptococcus mitis*, *Streptococcus pneumoniae*, *Streptococcus* sp, and *Viridans group Streptococci*.

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10,000 patient days [26], and 0.05 PIVC/1000 patient days [27]; and USA (0.0150 PVCR-BSI per 100 patient days [28], and 0.57 PIVCR-BSI per 1000 patient days) [29].

Most studies have reported on the adverse consequences of BSIs in ICUs, and the comparison of infection risk using central lines (CL) versus PVCs, with CLs being much more prone to higher BSIs rates than with PVCs [30–32].

In 2016, INICC published data of central line-associated BSI (CLABSI) in 50 countries, prospectively collected during 6 years, from 2010 to 2015, from 861,284 ICU patients for 3,506,562 bed-days. Pooled rates for adult and pediatric ICUs were 4.1 CLABSIs per 1000 central line-days [6]. The comparison of INICC these previous data published in 2016 of CLABSI with this study's INICC present data on PVCR-BSI shows the pooled rate of CLABSI is 70% higher than the PVCR-BSI rate. However, since around 80%–90% of the vascular catheters used worldwide are PVCs, the raw number of BSIs due to PVC is around six times higher than due to CL [33].

In our ICUs, the pooled mean of the distribution of crude mortality amounted to 29.36% of PVCR-BSIs cases, compared with 10.38% mortality of with PVC patients that were not infected. In recent studies from Spain and Japan, mortality attributable to PVCR-BSI was 13.2% and 12.9%, respectively [26,34]. The excess LOS of patients with PVCR-BSI (16.84) was almost three-fold higher than in patients without PVCR-BSI (5.94); in the previously cited study from Japan, patients who had acquired PVCR-BSI required a longer duration of antibiotic treatment (33.5 vs. 15.8 days; p = 0.004) than patients without PVCR-BSI [34].

The microorganism profile showed 55.2% of gram-positive bacteria, with Coagulase-negative *Staphylococci* (31%) and *Staphylococcus aureus* (14%) being the predominant ones. Gram-negative bacteria accounted for 39% of cases, and included: *Escherichia coli* (7%), *Klebsiella pneumoniae* (8%), *Pseudomonas aeruginosa* (5%), *Enterobacter* spp. (3%), and others (29.9%), such as *Serratia marcescens*.

The predominance of gram positive pathogens causing PVCR-BSI has been found in a wide range of studies [35], in which *Staphylococcus aureus* PVCR-BSI has been identified as a serious condition that could influence prognosis [26,34,36].

The most prevalent PVCR-BSI pathogens found presented considerable resistance rates. Resistance of *Pseudomonas aeruginosa* to fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin, or ofloxacin) was 33.33%, to piperacillin, piperacillin-tazobactam, 28.57%, to amikacin, 28.57%, and to imipenem (IPM) or meropenem (MEM), it was 14.28%; of *Acinetobacter baumanii* to IPM or MEM was 58.33% and to fluoroquinolones it was 72.73%; of *Klebsiella pneumoniae* to ceftriaxone or ceftazidime was 58.82%, and to IPM or MEM or ertapenem, it was 20.00%; of *Escherichia coli* to ceftriaxone or ceftazidime, it was 50.00%, to IPM or MEM or ertapenem, it was 0.00%, and to fluoroquinolones, it was 77.78%.

Regarding gram-positive bacteria, in our study, resistance of *Staphylococcus aureus* to oxacillin in 50.00% of cases which is similar to a 49% resistance reported in a study conducted in India [37]. *Enterococcus faecalis* was 100% sensitive to vancomycin, which is similar to the findings of the mentioned study conducted in India, in which vancomycin was 100% sensitive to PVCR-BSI *Enterococcus* spp [37].

The implementation of PVC insertion and maintenance bundles to decrease PVCR-BSI rates is common worldwide [23,26]. To reduce the hospitalized patients' risk of infection, PVCR-BSI surveillance by number of device-days is essential, because it effectively characterizes the threatening situation created by PVCR-BSIs. This must be followed by the implementation of multifaceted and surveillance programs aimed at PVCR-BSI prevention and control.

Likewise, it is important to address the burden of antimicrobial resistance and report susceptibility to antimicrobials of PVCR-BSI-associated pathogens, to take effective measures to prevent resistant strains from being transmitted [23,26].

In this particular study, INICC focused just on the ICU setting; that is, healthcare settings with the highest healthcare-acquired rates, in which patients' safety is most seriously threatened, due to their critical condition and exposure to invasive devices [38]. Through the last 17 years, INICC has undertaken a global effort in the six 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 [39–45].

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 PVCR-BSI rates and their related adverse events to the minimum possible level.

Study limitations

The purpose of this study was to obtain updated data on PVCR-BSI, device utilization ratio, bacterial resistance, LOS and mortality of patients with and without PVCR-BSI in adult and pediatric ICUs, but it does not provide insights regarding the impact of INICC interventions, such as the implementation of INICC Multidimensional Approach and ISOS [17,46]. 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 [41,44,45,47–50,52–64]. Second, our study was limited by the fact that benchmarking with CDC-NSHN, or other institutions, was not possible because PVCR-BSI rates are not reported to such institutions, or are not determined by PVC-days [65,66]. Third, probably cultures taken were less than ideal, which likely influenced the rates of PVCR-BSI, and the number of patients to whom blood cultures should have been taken, but were not, is unknown as this data was not registered. In addition, healthcare workers' level of compliance with preventive measures may have changed during the study period, but this was not measured. Fourth, resistance rates cannot be generalized due to the small simple size. Fifth, to define LOS in patients with and without BSI, the time of origin was counted from the first day of admission to the ICU, and it is not possible to know if the longer LOS was the cause or the consequence of BSI. Finally, we do not present data on trends over time for this 6-year study.

Conclusions

This study presents the only available comprehensive data from Middle East showing PVCR-BSIs per 1000 PVC-days, and benchmarking of our findings was limited to the results of two studies the US, Australia, and Italy published in 2006 [12], and a prospective study from Australia [13]. Our PVCR-BSI rates were far much higher than the data available from USA, Australia and Italy, thereby it is evident that PVCR-BSIs in ICUs worldwide are a challenge for patient safety. PVCR-BSI systematic surveillance and prevention programs, including antibiotic resistance reports, should be widely implemented to allow a reduction in the incidence of PVCR-BSI and its adverse-related events worldwide.

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

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and design; software development; data assembly, analysis, and interpretation; epidemiologic analysis; statistical analysis; administrative, technical, and logistical support.

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Competing interests

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 codifying the recorded information, making it only identifiable to the infection control team.

Ethical approval

Not required.

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Appendix A

Appendix with remaining co-authors

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