ORIGINAL RESEARCH

Surveillance of device-associated infections and antimicrobial resistance profile in a hospital intensive care unit in India

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ABSTRACT

Background: Hospital-acquired infections (HAIs) pose a major concern, particularly in developing countries. The burden is significant in the intensive care units (ICUs) due to prolonged hospital stays, co-morbidities, and the use of invasive devices. This study analysed surveillance data on device-associated HAIs (DA-HAIs) – catheter-associated urinary tract infection (CAUTI), central line-associated bloodstream infection (CLABSI), and ventilator-associated pneumonia (VAP) to assess trends and guide infection prevention measures in our facility. Additionally, the micro-organisms causing DA-HAIs were identified, along with their susceptibility pattern over 10 years.
Methods: Retrospective data on DA-HAIs were collected from two adult ICUs over ten years using National Healthcare Safety Network (NHSN) definitions. Sources included daily ICU visits by infection control nurses, admission files, laboratory records, patient charts, and discharge summaries.
Results: A total of 1,146 DA-HAIs were recorded. VAP was the most common (56.7%), with an overall DAI rate of 15.2 per 1,000 device days. VAP accounted for 26.4/1,000, followed by CAUTI 10.9/1,000 and CLABSI 6.1/1,000 device days. *Acinetobacter* spp. was the most frequently isolated pathogen, followed by *Klebsiella, Pseudomonas, Escherichia,* and *Enterococcus* species. Most isolates were multidrug-resistant organisms (MDROs).
Conclusion: The study revealed a decreased in DA-HAI rates over the period of 10 years with a high rate of multidrug-resistant organisms (MDROs). Implementation of simple interventions reduced DA-HAI rates over time. The findings emphasize the need for sustained commitment from healthcare personnel toward infection prevention and control. Although reducing DA-HAIs in developing countries remains challenging, consistent adherence to simple, evidence-based practices in daily routine is promising.

KEYWORDS:
Catheter-associated urinary tract infection (CAUTI), central-line associated bloodstream infection (CLABSI), ventilator-associated event (VAE), surveillance, multidrug-resistant organisms, infection prevention and control

INTRODUCTION

Healthcare-associated infections (HAIs) are infections that are neither present nor incubating at the time of hospital admission but develop after at least two calendar days of hospitalization (Monegro, 2023). The World health organization (WHO) have reported that around 7%-12% of the hospitalized patients acquire HAIs during hospital admission (WHO, 2002). HAIs are increasingly recognized as a major etiological factor contributing to morbidity, increased financial burden and even mortality among hospitalized patients. The majority of HAIs are reported from intensive care units (ICU) and accounts for more than 50% mortality in patients admitted to these areas (Mukhopadhyay, 2018; WHO, 2022). This situation is further complicated as modern healthcare interventions require the use of various invasive, indwelling, and prosthetic devices to improve patient outcomes. These devices constitute a significant source of infection to patients which are collectively referred to as device-associated infections (DAIs).

For surveillance purposes, the Centers for Disease Control and Prevention-National Healthcare Safety Network (CDC-NHSN) has classified major DAIs into catheter-associated urinary tract infection (CAUTI), central line-associated bloodstream infection (CLABSI), and ventilator-associated events (VAP) (Horan, 2008). Among these device-associated- hospital acquired infections (DA-HAIs), CAUTI is one of the most common, particularly in ICUs, where approximately 75% of hospitalized patients undergo urinary catheterization during their stay, thereby increasing its risk (Burton, 2011). CLABSI is another critical DAI, associated with high mortality rates of around 12–25%, whereas VAP is the major cause of mortality among ICUs (Rosenthal, 2024).

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Recognizing the global burden of HAIs, the Centers for Disease Control and Prevention (CDC) initiated a comprehensive national surveillance and prevention program nearly five decades ago (Dudeck, 2009). Although this program is widely adopted in high-income countries (HICs), gaps still persist in the developing nations. It has been suggested that HAI rates in low- and middle-income countries (LMICs) are approximately 10 times higher than in HICs (Rosenthal, 2016). Owing to the scarcity of surveillance data and the lack of standardized definitions in LMICs, the International Nosocomial Infection Control Consortium (INICC) was created with a key focus on LMICs (INICC, 2023). The methodology and the definitions in INICC surveillance network are consistent with the CDC-NHSN criteria (Rosenthal, 2016). In addition to the HAI rates, another major concern has been the increasing reports of drug resistance in the majority of hospital acquired micro-organisms which adds to the mortality rate and increases healthcare costs to the patients (Zirpe, 2025).

The purpose, therefore, of compiling DA-HAIs surveillance results over the period of 10 years in the current study, was to identify rends, assess data completeness and lacunas over time and provide evidence to support infection prevention and control practices in the ICUs. In addition, micro-organisms causing DA-HAIs in the adult ICUs were identified along with their resistance patterns in order to inform antibiotic stewardship policies.

METHODS

Study setting

In this retrospective study, we collected data from January 2014 to December 2023 from two adult ICUs of a 1,300-bedded tertiary care hospital in North India. The total number of beds in the two ICUs were 14. The routine surveillance of major DAIs – CAUTI, CLABSI, and VAP (PNU2/3) was done by the hospital infection control unit. Surveillance case definitions were based on NHSN criteria (CDC-NHSN; 2025). During this period, dedicated infection control nurse (ICN) evaluated ICU patients and collected the relevant data daily from multiple sources, including admission files, laboratory records, patient charts, physical examination notes, temperature charts, transfer records, discharge summaries and hospital information system.

Device associated infection surveillance and antimicrobial resistance determination

The surveillance case definition for DAIs included ICU admission for more than two calendar days with the presence of an invasive device in situ (with the day of placement considered as day one. The definitions for CAUTI, CLABSI, and VAP (PNU2/3) were consistent with CDC-NHSN guidelines (CDC-NHSN; 2025).

Clinical samples collected were urine, paired blood cultures, endotracheal aspirates and bronchoalveolar lavage according to the in-situ device. Samples were processed using standard conventional methods for both culture and identification. *Candida spp.* was speciated on CHROMagar. Repeated isolation of the same *Candida* species from a patient, despite corrective measures was considered significant to be reported as a DA-HAIs. Bacterial isolates were tested for antimicrobial susceptibility using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, following Clinical and Laboratory Standards Institute (CLSI) guidelines. MDROs were identified as per CDC definitions (CDC, 2006).

Data analysis

Data analysis involved monthly calculation of DAI rates. The numerator was the number of CAUTI, CLABSI, or VAP (PNU2/3) events, while the denominator was the total device-days recorded. Susceptibility testing was conducted for all isolates to guide appropriate antibiotic therapy for the patients.

$$\text{Device associated infection rate} = \frac{\text{Number of CAUTI / CLABSI / VAP (PNU2/3) X 1,000}}{\text{Number of device-days}}$$

Rates were reported as events per 1,000 catheter, central line, or ventilator days.

Institutional ethical clearance

The study was registered and approved by the Chandigarh Government Medical College and Hospital Institutional Ethical Committee with registration number – IEC Regd. No. ECR/658/Inst/PB/RR-20.

RESULTS

This retrospective surveillance for three DA-HAIs, i.e., CAUTI, CLABSI, and VAP (PNU2/3) was done over a period of 10 years. A total of 1,146 DA-HAI events were identified and reported. VAP (PNU2/3) was the most common DAI, accounting for 56.7% (650/ 1,146 cases), followed by CAUTI, 40% (423/1,146 cases) and CLABSI 6.3% (73/1146 cases). Female predominance was observed in all the three DA-HAIs, with 59.5% (683/1146) females and 40.5% (463/1,146) in males (Figure 1).

The total number of device-days for all the DAIs during the study period was 75,154 days, and overall DA-HAI rate reported was 15.2 per 1,000 device-days (average of 10 years). Individually, VAP (650 cases and 24,613 ventilator days) contributed the highest rate of 26.4 per 1,000 ventilator days, followed by CAUTI (423 cases and 38,628 catheter days) 10.9 per 1,000 catheter days, and CLABSI rate (73 cases and 11,913 central line days) was 6.1 per 1,000 central line days. The annual DAI rates per 1,000 device-days are presented in Table 1.

Table 1: Device associated infection rate for VAP (PNU2), CAUTI and CLABSI over 10 years

Year		CAUTI	CLABSI	VAP (PNU2)	Total
2014	Total infections	42	13	63	118
	In situ device days	3,412	1,112	2,312	6,836
	Rate per 1,000 device days	12.3	11.7	27.3	17.2
2015	Total infections	42	10	65	117
	In situ device days	3,800	1,058	2,500	7,358
	Rate per 1,000 device days	11.0	9.4	26	15.9
2016	Total infections	44	9	69	122
	In situ device days	3,702	1,232	2,407	7,341
	Rate per 1,000 device days	11.8	7.3	28.6	16.6
2017	Total infections	47	8	66	121
	In situ device days	3,810	1,199	2,510	7,519
	Rate per 1,000 device days	12.3	6.6	26.3	16.1
2018	Total infections	47	7	85	139
	In situ device days	4,232	1,102	2,732	8,066
	Rate per 1,000 device days	11.1	6.3	31.1	17.2
2019	Total infections	43	6	62	111
	In situ device days	3,950	1,305	2,024	7,279
	Rate per 1,000 device days	10.9	4.2	30.6	15.2
2020	Total infections	45	8	64	117
	In situ device days	4,332	1,364	2,656	8,352
	Rate per 1,000 device days	10.4	5.8	24.1	14.2
2021	Total infections	39	4	60	103
	In situ device days	3,668	1,327	2,424	7,419
	Rate per 1,000 device days	10.6	3.0	24.7	13.8
2022	Total infections	39	4	58	101
	In situ device days	3,922	900	2,328	7,150
	Rate per 1,000 device days	9.9	4.5	24.9	14.1
2023	Total infections	35	4	58	97
	In situ device days	3,800	1,314	2,720	7,834
	Rate per 1,000 device days	9.2	3.1	21.3	12.4
Total	Total infections	423	73	650	1,146
	In situ device days	38,628	11,913	24,613	75,154
	Rate per 1,000 device days	10.95	6.1	26.4	15.2

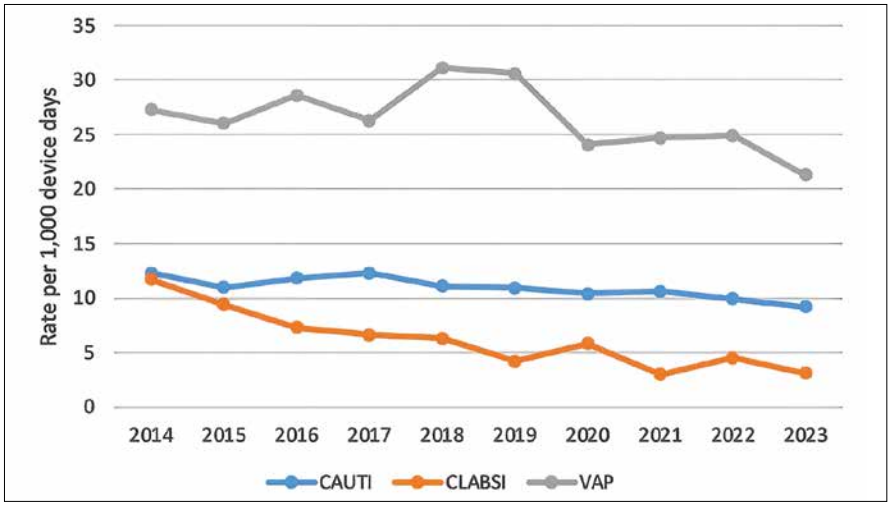

Figure 1: Trends for DA-HAIs, over the 10-year study period.

A total of 2,390 isolates were recovered, including Gram-positive bacteria, Gram-negative bacteria, and *Candida spp.* Gram-negative bacteria were the most frequently isolated organisms (85.5%; 2044/2,390), among them almost 35% were *Acinetobacter spp.* followed by *Klebsiella spp.*, *Pseudomonas spp.*, *Escherichia coli*, and *Enterococcus spp.* Other isolates included 5% (123/2,390) *Candida spp.*, and 5.1% (124/2,390) Gram-positive organisms. The majority of *Candida* isolates (107/124) were obtained from the urine samples. The percentage distribution of various isolates of all DA-HAIs and VAP, CAUTI, and CLABSI is shown in Figure 2 (a–d)**.**

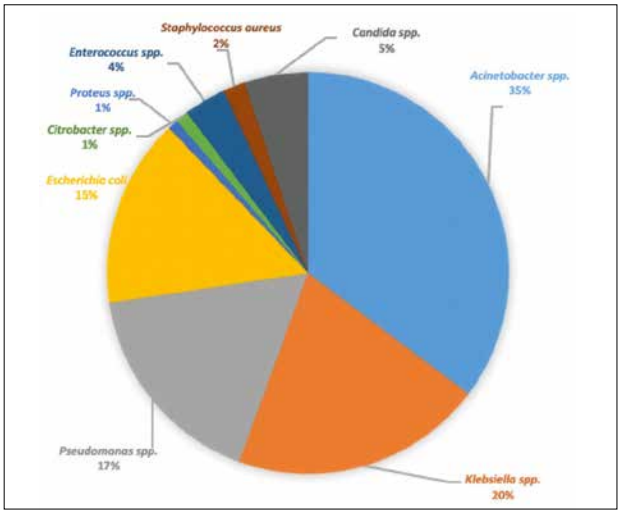

Figure 2 (a): Total DAI Isolates

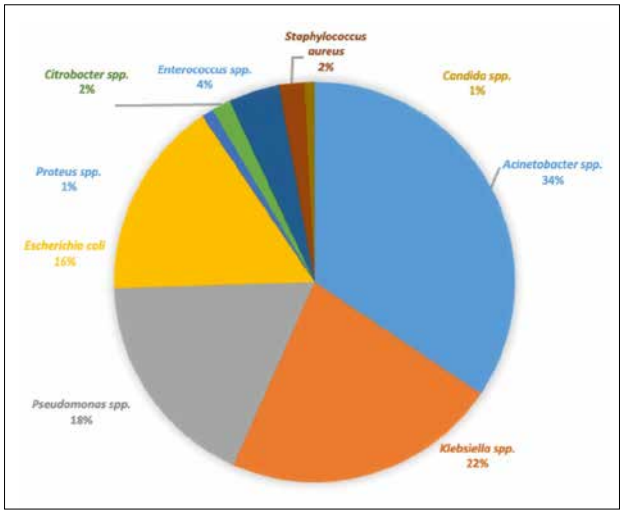

Figure 2 (b): VAP Isolates

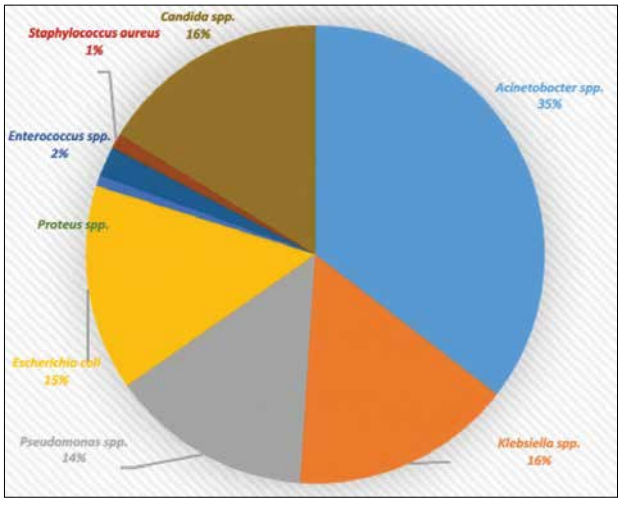

Figure 2 (c): CAUTI Isolates

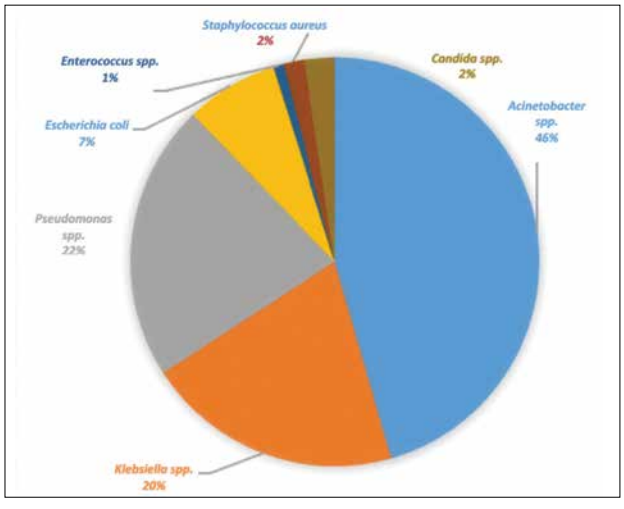

Figure 2 (d): CLABSI Isolates.

Antimicrobial resistance profile over the study period

Antimicrobial susceptibility testing suggested that most isolates were MDROs (Figure 3).

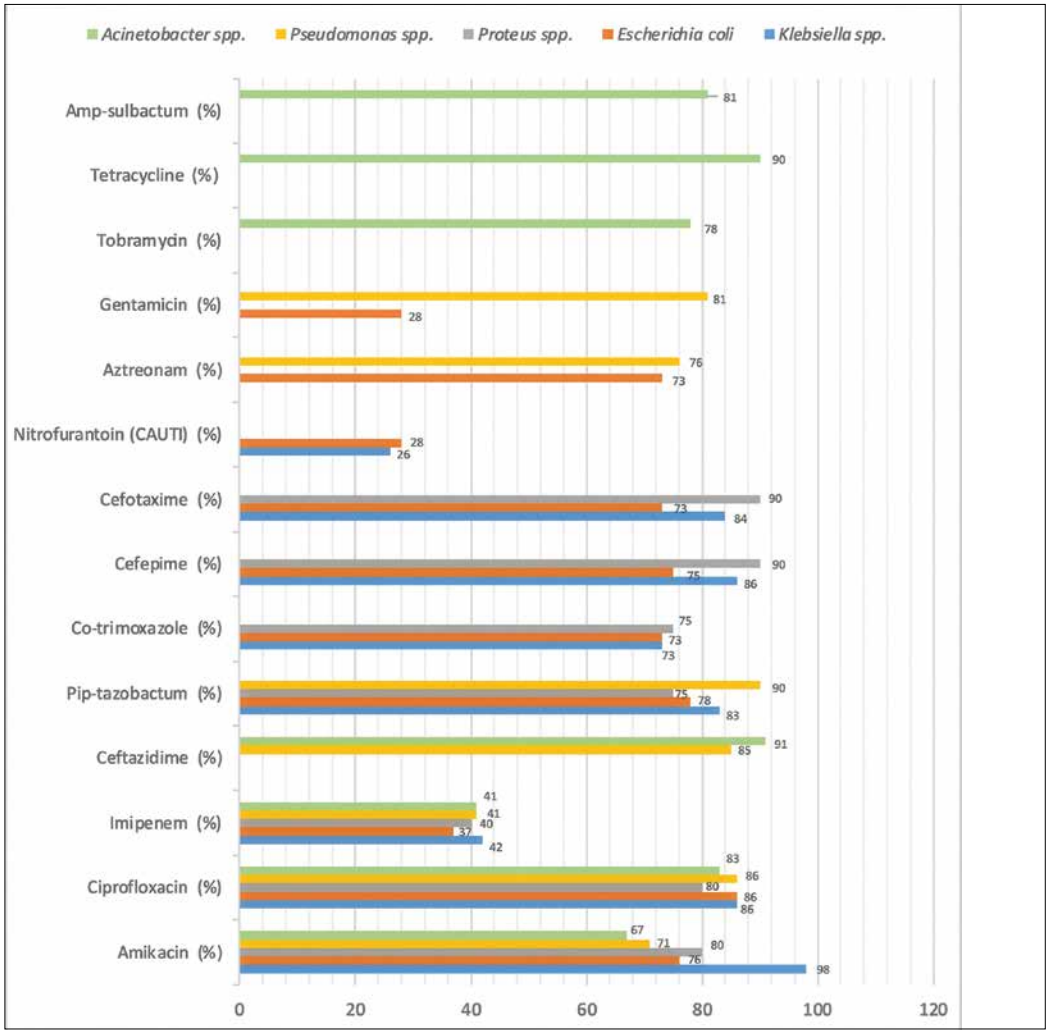

Figure 3: Resistance reported in percentage among various Gram-negative isolates.

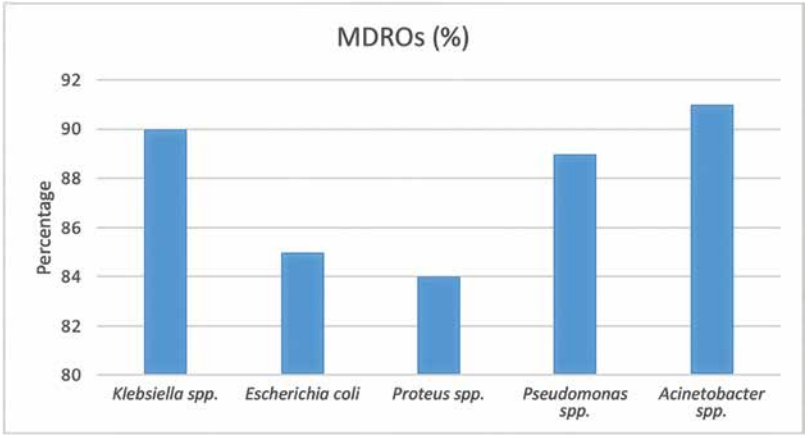

Figure 4: Percentage of various multidrug-resistant organisms (MDROs).

More than 80% of the isolates were reported to be resistant to most antimicrobials and 88% were MDROs. Figure 4 shows percentage of various MDROs in our study.

The highest resistance was reported in *Acinetobacter* spp. Resistant organisms were mostly from the respiratory samples, reflecting the high MDRO burden in VAP cases. Detailed resistance patterns for DAIs are presented in Table 2.

Table 2: Resistant pattern of all the isolates from CLABSI, CAUTI and VAP						
	CLABSI		CAUTI		VAP (PNU2/3)	
	Isolates reported	Resistant Isolates (%)	Isolates reported	Resistant Isolates (%)	Isolates reported	Resistant Isolates (%)
Gram-negative isolates – Total isolates (n)						
Acinetobacter spp. (843)	56		234		553	
Amikacin		37 (66)		175 (74.6)		361 (65.3)
Ciprofloxacin		49 (87.5)		194 (82.9)		456 (82.5)
Tetracycline		46 (82.1)		209 (89.5)		507 (91.7)
Ceftazidime		46 (82.1)		211 (90.3)		505 (91.3)
Amp-Sulbactum		40 (71.4)		188 (80.1)		451 (81.5)
Tobramycin		45 (80.3)		173 (73.9)		441 (79.7)
Imipenem		29 (51.8)		82 (35.1)		229 (41.4)
Klebsiella spp. (485)	25		103		357	
Amikacin		25 (100)		99 (96.1)		353 (98.8)
Co-trimoxazole		21 (84)		67 (65.0)		156 (43.6)
Ciprofloxacin		20 (80)		87 (84.5)		309 (86.5)
Cefepime		21 (84)		79 (76.7)		317 (88.8)
Cefotaxime		19 (76)		79 (76.7)		308 (86.3)
Pip-Tazobactum		25 (100)		75 (72.8)		302 (84.6)
Imipenem		9 (36)		33 (32.1)		162 (45.4)
Nitrofurantoin (CAUTI)	Not tested			27 (26.2)	Not tested	
Escherichia coli (363)	9		96		258	
Amikacin		7 (77.8)		75 (78.1)		194 (75.2)
Co-trimoxazole		4 (44.5)		69 (71.8)		191 (74.0)
Ciprofloxacin		8 (88.9)		87 (90.6)		218 (84.5)
Cefepime		7 (77.8)		59 (61.5)		204 (79.1)
Ceftriaxone		7 (77.8)		67 (69.8)		191 (74.0)
Pip-Tazobactum		6 (66.7)		72 (75)		203 (78.6)
Imipenem		3 (33.3)		31 (32.3)		99 (38.4)
Nitrofurantoin CAUTI	Not tested			27 (28.1)	Not tested	
Fosfomycin CAUTI	Not tested			8 (8.3)	Not tested	
Pseudomonas spp. (408)	27		94		287	
Amikacin		19 (70.4)		60 (63.8)		209 (72.8)
Ciprofloxacin		22 (81.5)		73 (77.6)		254 (88.5)
Ceftazidime		25 (92.6)		72 (76.6)		248 (86.4)
Gentamicin		23 (85.2)		65 (69.1)		242 (84.3)
Pip-Tazobactum		22 (81.5)		81 (86.2)		264 (91.9)
Imipenem		13 (48.4)		36 (38.3)		119 (41.5)
Aztreonam		19 (70.4)		68 (72.3)		223 (77.7)
Gram-positive isolates – Total isolates (n)						
Enterococcus spp. (81)	1		14		66	
Ampicillin		0		9 (64.3)		52 (76.5)
Ciprofloxacin		0		13 (92.8)		54 (81.8)
Gentamicin HLG		1 (100)		14 (100)		56 (84.8)
Tetracycline		1 (100)		3 (21.4)		28 (42.4)
Linezolid		0		7 (50)		16 (24.2)
Vancomycin		0		0		0
Nitrofurantoin (CAUTI)	Not tested			3 (21.4)	Not tested	
Fosfomycin *(E. faecalis)*	Not tested			7 (18.9)	Not tested	

	CLABSI		CAUTI		VAP (PNU2/3)	
	Isolates reported	Resistant Isolates (%)	Isolates reported	Resistant Isolates (%)	Isolates reported	Resistant Isolates (%)
Staphylococcus aureus (42)	2		7		33	
Penicillin		2 (100)		7 (100)		33 (100)
Co-trimoxazole		1 (50)		5 (71.4)		17 (51.5)
Chloramphenicol		2 (100)		7 (100)		33 (100)
Tetracycline		1 (50)		2 (28.6)		30 (90.9)
Linezolid		0		0		0
Vancomycin		0		0		0
Nitrofurantoin (CAUTI)	Not tested			2 (28.6)	Not tested	
Cefoxitin (MRSA)	20	2 (100)		5 (71.4)		13 (39.4)

Among Gram-positive isolates, only *Staphylococcus aureus* and *Enterococcus spp.* were recovered. Both showed high resistance (that is 87% for *Enterococcus spp.* and 88% for *Staphylococcus aureus* isolates). All *Staphylococcus aureus* isolates were resistant to penicillin, and approximately 47% were methicillin-resistant (MRSA).

DISCUSSION

The surveillance of HAIs is often a challenge especially in low- and middle-income countries due to the lack of uniform, implementable and standardize protocols. The 10 years' worth of surveillance data from our institute for device-associated hospital-acquired infections revealed invariably high incidence with VAP being the most common. The results revealed that DA-HAI rates fluctuated annually underscoring the persistent burden of HAIs in this setting. The crude DA-HAI rate reported in the current study was 15.2 per 1,000 device-days (average of 10 years) which is higher compared to the rate of 10.07 reported by INICC from 2015 to 2020 (Rosenthal, 2024). However, the rates reported across India vary widely, ranging from 4.4 to 83.1% (Balusu, 2022; Bhushan, 2024; Khan, 2017).

More specifically, the DA-HAIs rates reported in the current study were 10.6/1,000 catheter days, 6/1,000 central line days and 24.7/1,000 ventilator days for CAUTI, CLABSI and VAP respectively. VAP constituted the highest burden with 57% of all the DA-HAIs reported. Our data is consistent with reports from the WHO that identified VAP as the most frequent DAI in ICU setups. The individual incidence rates of DA-HAIs reported by WHO were 12.2 for CLABSI, 8.8 for CAUTI, and 23.9 per 1,000 device-days for VAP (WHO, 2011). Similar results with high VAP incidence have also been reported from the other areas of India, reflecting its significant burden among ICU patients (Chakraborty, 2025; Gangumalla, 2024).

The majority of isolates in the current study were Gram-negative bacteria (85.5%), with *Acinetobacter spp.*, *Klebsiella spp.*, *Pseudomonas spp.*, and *E. coli* being the most common. Other studies in India have also reported similar microorganisms, although the predominant organism varies (Babbar, 2019; Ganesan, 2021; Gunasekaran, 2020). Also, over 85% of isolates in the current study were MDROs, with the highest resistance observed in *Acinetobacter* and *Klebsiella*. Among the Gram-positive isolates, *Enterococcus spp.* was mainly reported, consistent with an earlier published report (Sahoo 2020). Our findings corroborate global concerns on the rising threat of antimicrobial resistance (AMR).

As a quality improvement study, efforts were made to reduce the infection rates, healthcare workers education was initiated including the appropriate use of personal protective equipment, aseptic procedures during patient care, hand hygiene, needle stick injury prevention, spill and bio-medical waste (BMW) management. These educational sessions were followed by regular monitoring of compliance. Also, care bundle forms for both insertion and maintenance for invasive devices were instituted to ensure strict maintenance of invasive devices were instituted to ensure strict aseptic techniques during device insertion and maintenance. Audits for compliance of hand hygiene practices, BMW management, care bundle adherence were initiated. Following these interventions and initiatives, our DA-HAI rates are expected to decrease over time.

Despite being a multi-year study with a large sample size, there were some notable limitations. Empirical treatment was often initiated before complete microbiological testing which may result in false negative results. There was also the lack of qualitative audit results to correct the audit intervention and outcome. Other lacunae due to limited ICNs were that the patients who were transferred from the ICU to the wards were not followed for HAI, even though the invasive devices remained in place, increasing the possibility of missing HAI cases. Time-dependent bias was another limitation, as longer hospital stays were associated with higher DAI risk, which were not correlated. Therefore, the possibility of higher DA-HAI rates than reported, cannot be ruled out. Furthermore, this was a single-centre study, limiting generalizability.

Despite these limitations, the study contributes significant epidemiological data from a large cohort of patients, including cost-effective infection control interventions in decreasing DA-HAI rates. Moreover, the study fills an important data gap in low- and middle-income countries due to the lack of effective surveillance systems or non-uniform case definitions across institutions. Together, the findings emphasize the need for sustained focus in infection prevention and control practices to reduce the rate of DA-HAIs and antimicrobial resistance.

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