http://www.jhpr.ir
Hosp Pract Res. 2026 March;11(1):812-819
doi 10.30491/hpr.2025.542225.1505
HPR Hospital Practices and Research
Original Article

Comparative Epidemiology of Device-Associated Infections in an Adult ICU at a Tertiary Care Center

Bineeta Kashyap [1*], Bhavya Ramakrishnan [1], Keerthana Mariappan Rajendran [1], Vinod Kumar [2]

[1] Department of Microbiology, University College of Medical Sciences and Guru Teg Bahadur Hospital, Delhi-110095, India
[2] Guru Teg Bahadur Hospital, Delhi-110095, India

***Corresponding Author:** Bineeta Kashyap, MD., Department of Microbiology, University College of Medical Sciences and Guru Teg Bahadur Hospital, Delhi-110095, India. Tel: 9899583514, Email: bineetakashyap@yahoo.co.in

Received August 23, 2025; **Accepted** December 7, 2025; **Online Published** March 30, 2026

Abstract

Background: Hospital-acquired infections (HAIs), particularly device-associated infections (DAIs) in ICUs, pose a significant global health burden, especially in low- and middle-income countries.

Objectives: This study aims to estimate the HAI burden by analyzing DAI rates and resistance patterns in ICU settings, contributing to evidence-based infection control strategies.

Methods: We conducted a six-month prospective observational study in the adult ICU of GTBH (July–December 2024), focusing on patients with DAIs. Incidence and device utilization rates were calculated using CDC-standardized metrics based on device and patient days.

Results: Out of 286 patients, 40 developed a total of 62 DAIs, comprising 25 cases of ventilator-associated pneumonia (VAP) (40.3%), 19 cases of catheter-related bloodstream infections (CLABSI) (30.65%), and 18 cases of catheter-associated urinary tract infections (CAUTI) (29.03%). VAP had the highest cumulative infection rate (22.6%), followed by CLABSI (21%) and CAUTI (10.8%). *Acinetobacter baumannii* was the dominant isolate in VAP cases, *Klebsiella pneumoniae* and *Enterobacter spp.* were predominant in CLABSI cases, and non-*albicans Candida* was the leading pathogen in CAUTI cases. Significant antimicrobial resistance was observed, especially among *Acinetobacter* and *Pseudomonas* species. Notably, the case fatality rate among DAI patients reached 57.5%.

Conclusion: In conclusion, our surveillance study highlights a substantial burden of DAIs in the ICU, with VAP being the most prevalent. The dominance of multidrug-resistant pathogens and the striking 57.5% fatality rate emphasize the urgent need for robust infection control, tailored stewardship programs, and continuous local epidemiological monitoring.

Keywords: Intensive Care Unit, Device-Associated Infections, Surveillance, Epidemiology, Infection Control

1. Background

Nosocomial infections, also known as hospital-acquired infections, are those infections acquired during a hospital stay, typically after 48 hours of admission. World Health Organization (WHO) data indicates that 7–12% of patients admitted to hospitals globally experience healthcare-associated infections, with low- and middle-income countries bearing a substantially greater burden.[1] Device-associated infections, namely CAUTI, CLABSI, and VAP, pose a major risk to patient safety in ICUs, contributing to substantial morbidity and mortality.[2] The WHO has incorporated HAI surveillance as a key element of its infection prevention and control programs at both national and healthcare facility levels. HAI surveillance data helps quantify the burden of HAIs, track trends over time, point out areas needing improvement in prevention efforts, and evaluate infection control measures to reduce HAIs.[3]

A standardized network-based approach to HAI surveillance can generate high-quality data by maintaining consistent case definitions and methodologies across reporting facilities.[4] The implementation of HAI surveillance systems in low- and middle-income countries is hindered by insufficient funding, limited personnel, and reduced diagnostic capacity, especially in clinical microbiology.[5] ICMR established an AMR surveillance network and launched a website containing information on HAI surveillance, including methodology, standard operating procedures, and training modules.

As a result of these initiatives, the AMRSN report for 2023 was published, featuring data from 39 hospitals across India. It also suggested that 23% of medical ICU patients were reported with HAIs, of which the CLABSI rate in the AMRSN network was 8.3 per 1,000 central line days, while the CAUTI rate stood at 3.0 per 1,000 urinary catheter days. The ventilator-associated pneumonia (VAP) rate was recorded at 7.6 per 1,000 ventilator days. *Klebsiella* species (24.8%) were the most commonly identified pathogen in CLABSI cases, followed by *Acinetobacter* species (20.7%), *Enterococcus* species

(10.3%), *Staphylococcus aureus* (6.1%), *Pseudomonas aeruginosa* (5.7%), and *Escherichia coli* (5.5%). For CAUTI, *Candida* species were the predominant pathogen (20.9%), with *Escherichia coli* (19.6%) and *Enterococcus* species (18.8%) also frequently reported. In VAP cases, *Acinetobacter* species accounted for the highest proportion (43.6%), followed by *Klebsiella* species (17.17%) and *Pseudomonas* species (17.5%). A multi-center-based surveillance study reported that *Klebsiella* species accounted for the highest proportion of bloodstream infections (24.8%), while *Candida* species were the most frequently identified pathogens in UTIs (29.4%). Carbapenem resistance was widespread, affecting 72–77% of bloodstream infections and 72–76% of UTIs caused by *Klebsiella, Acinetobacter, and Pseudomonas* species.[7] Understanding the local epidemiology of device-associated infections is essential for tailoring preventive measures and optimizing antimicrobial use.

2. Objectives

This study aims to estimate the HAI burden by analyzing DAI rates and resistance patterns in ICU settings, contributing to evidence-based infection control strategies.

3. Methods

This prospective observational study was conducted in the adult Intensive Care Unit (ICU) at Guru Teg Bahadur Hospital over six months from July to December 2024. The ICU is a closed, multidisciplinary unit with a capacity of 10 beds, catering to critically ill patients requiring invasive monitoring and organ support.

The infection control team conducted daily screenings of ICU admissions to identify eligible patients. A structured surveillance form was used to record demographic details, comorbidities, device exposure, and clinical parameters. Routine infection control audits and standard preventive practices were followed throughout the study period in accordance with institutional protocols and national guidelines.

Laboratory-confirmed bloodstream infections are primary bloodstream infections confirmed by a positive blood culture, and the isolated organism is not attributed to any other body site.

- LCBI-1: One positive blood culture for a recognized pathogen regardless of symptoms (any age). (or)
- LCBI-2: One sign or symptom (fever or chills, or hypotension) and two or more separate positive blood cultures for a common skin commensal (any age).
- LCBI-3: One sign or symptom (fever or chills, or hypotension) and two or more separate positive blood cultures for a common skin commensal (age ≤ 1year).

AND a central vascular catheter in place ≤ 2 days before the first meeting is a component of the confirmed BSI definition.

The NHSN VAE algorithm is based on objective indicators of worsening oxygenation following a period of stability or improvement on the ventilator. It is a tiered system, with higher tiers suggesting a greater likelihood of infection.

3.1. Ventilator-Associated Condition (VAC)

Trigger: After ≥ 2 days of stable/improving ventilation, the patient shows worsening oxygenation.

- Increase in PEEP by ≥ 3 cmH_2O, or
- Increase in FiO_2 by ≥ 0.20 (20%).

3.2. Infection-Related Ventilator-Associated Complication (IVAC)

Builds on VAC, adding signs of infection/inflammation.

- Fever (> 38 °C or < 36 °C) or abnormal WBC count (≥ 12,000 or ≤ 4,000 cells/mm³),
- A new antimicrobial agent started and continued for ≥ 4 days.

3.3. Possible Ventilator-Associated Pneumonia (PVAP)

Builds on IVAC, with microbiological confirmation.

- Positive cultures from respiratory specimens (e.g., BAL, tracheal aspirate),
- Presence of purulent secretions with identified pathogens, or
- Specific diagnostic tests (e.g., Legionella, viral PCR, pleural fluid culture).

For NHSN surveillance, a healthcare-associated urinary tract infection is classified as a CAUTI if it meets specific clinical and laboratory criteria.

Device criteria: The patient must have had an indwelling urinary catheter in place for more than two calendar days.

Clinical criteria: The patient must have at least one of the following signs or symptoms:

- Fever (> 38.0 °C)
- Suprapubic tenderness
- Costovertebral angle (CVA) pain or tenderness

Urinary urgency, frequency, or dysuria (cannot be used if a catheter is still in place)

Laboratory criteria: The patient must have a positive urine culture that shows no more than two species of organisms, with at least one bacterial species having a colony count of 10^5 colony-forming units (CFU) per milliliter.

- BSI: Blood is drawn from two or more venipuncture sites and inoculated into BacT/Alert blood culture bottles.
- CAUTI: Aseptic technique is used to collect a urine sample from the catheter's sampling port, not the collection bag.
- VAP: A lower respiratory tract specimen is collected, often through an endotracheal aspirate or broncho-alveolar lavage (BAL).

Upon arrival, microbiological processing begins with a Gram stain to provide a rapid presumptive identification of the pathogen, guiding early treatment decisions. The sample is then cultured on various selective and differential media to isolate and identify the causative microorganism. Information on pathogens isolated from patients with healthcare-associated infections, along with their antibiotic susceptibility profiles (antibiotic susceptibility testing was performed using the modified Kirby-Bauer method), was collected from the microbiology laboratory following the Clinical and Laboratory Standards Institute (CLSI M100-2024) guidelines and interpretive breakpoints.[11] A multi-drug resistant organism is a microorganism that has developed resistance to at least one antimicrobial agent in three or more different drug classes.

3.4. HAI Rate Analysis

For CLABSI, the incidence rate was calculated by dividing the number of confirmed CLABSI cases by the total number of central venous catheter (CVC) days, then multiplying by 1,000. Similarly, for CAUTI, the number of confirmed CAUTI cases was divided by the total number of urinary catheter days and multiplied by 1,000. Device utilization was determined by dividing the total number of device days by the total number of patient days. As per the CDC's standardized definitions, device utilization days refer to the cumulative number of days that patients were exposed to a specific device (such as an endotracheal tube, central venous catheter, or urinary catheter) during the defined surveillance period.[8,9]

3.5. Formula for the calculation of DAI rates[10]

VAP Rate (%) = (VAP cases ÷ Ventilator days) × 1,000

CLABSI Rate (%) = (CLABSI cases ÷ Central line days) × 1,000

CAUTI Rate (%) = (CAUTI cases ÷ Urinary catheter days) × 1,000

Routine infection control practices are actively monitored in our ICU, with strict adherence to hand hygiene protocols and aseptic techniques during the insertion and maintenance of devices. These measures are regularly reinforced by the Infection Control Nurse (ICN) through daily rounds and compliance checks, ensuring consistent implementation of bundle care and minimizing the risk of DAIs. In addition, routine training and audits are conducted for hand hygiene practices among nurses and doctors, with structured sessions held during induction and periodically thereafter to reinforce compliance and best practices.

Basic data analysis was conducted using Microsoft Excel, including data cleaning and calculation of descriptive statistics (counts, percentages, means). Charts and pivot tables were used to summarize and visualize key trends.

3.6. Ethical Approval

This study was part of our hospital's routine infection surveillance activities in the ICU. All data were collected as part of standard clinical care, without any additional interventions. Patient identities were kept confidential, and all analyses were performed using anonymized data in accordance with institutional protocols.

4. Results

This descriptive study was conducted over six months, from July to December 2024, in the main ICU of GTBH, which serves the population of East Delhi and its neighbouring states. The patients admitted to the ICU were monitored for DAI, including VAP, CLABSI, and CAUTI. The total number of patients admitted to the ICU during this period was 286. Among them, 56% were males and 44% were females.

The total number of patients who suffered from DAI in our study was 40. The total number of DAIs that occurred during this period was 62. This includes 25 cases of VAP (40.3%), 19 cases of CLABSI (30.65%), and 18 cases of CAUTI (29.03%). The number of each DAI that occurred during the study period, month by month, is provided in Figure 1.

The monthly surveillance data reported that the incidence of DAI from July 2024 to December 2024 is presented in Table 1.

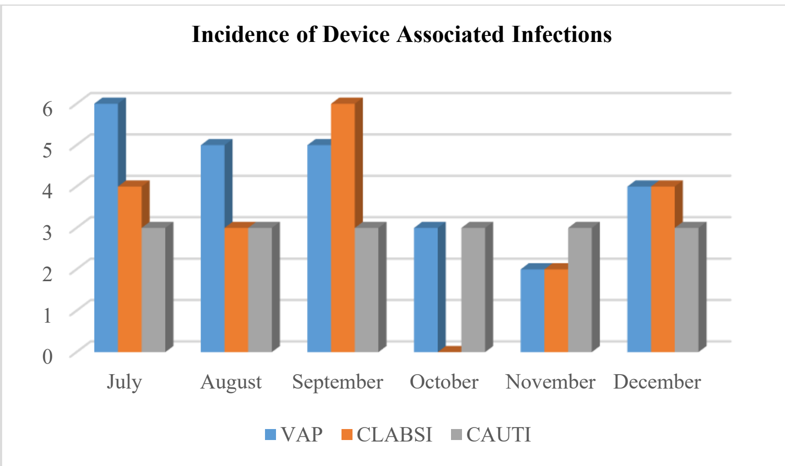

Figure 1. Incidence of DAIs from July to December 2024.

Table 1. Rate of DAI Observed During the Study Period

DAI rates	July	August	September	October	November	December	Cumulative rate
VAP rate	29%	24%	27%	14%	12%	30%	22.6%
CLABSI rate	20%	28%	44%	0%	14%	20%	21%
CAUTI rate	10%	11%	12%	10%	12%	10%	10.8%

The microbiological profile of DAIs has been derived from the culture reports of respective infections as follows: Organisms isolated from tracheal aspirates were *Acinetobacter baumannii* (56%), *Escherichia coli* (20%), *Pseudomonas aeruginosa* (16%), and *Klebsiella pneumoniae* (8%). This distribution highlights the dominance of *Acinetobacter baumannii* as a predominant pathogen causing VAP, as shown in Figure 2.

Among the cases of CLABSI, *Klebsiella pneumoniae* was the most prevalent causative organism, accounting for 27% of infections. *Enterobacter* species followed closely, contributing to 26%. *Acinetobacter baumannii* and *Pseudomonas aeruginosa* were each responsible for 21%, while *Escherichia coli* had the lowest representation at 5%. Figure 3 shows the distribution of organisms causing CLABSI, highlighting the significant presence of *Klebsiella pneumoniae* and *Enterobacter* species in CLABSI cases.

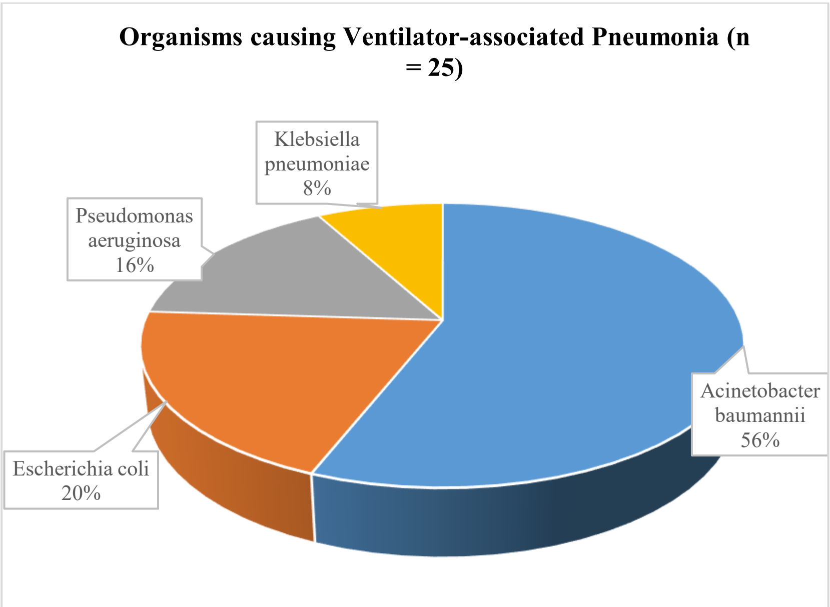

Figure 2. Percentage of Organisms Causing Ventilator-Associated Pneumonia.

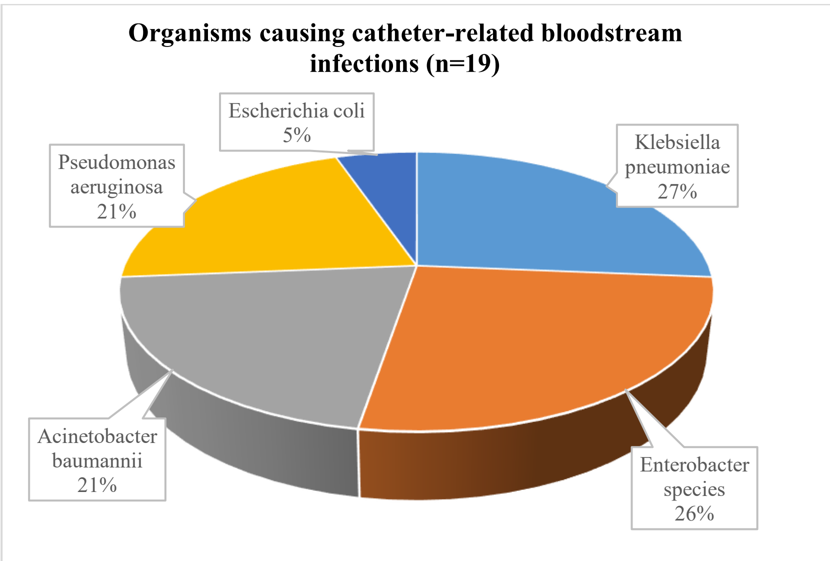

Figure 3. Percentage of Organisms Causing Catheter-Related Bloodstream Infections.

The distribution of organisms causing CAUTI is shown in Figure 4, which indicates that *non-albicans Candida* is the predominant pathogen, reported in 9 cases, followed by *Candida albicans* in 5 cases, and *Escherichia coli* in 4 cases.

The study examined antibiotic resistance patterns in organisms responsible for VAP, highlighting significant resistance across multiple antibiotics. Figure 5 shows the interpretation of the resistance patterns in HAI-associated pathogens, highlighting significant antibiotic resistance trends. *Acinetobacter baumannii* shows extensive resistance, particularly to Ceftriaxone, Ciprofloxacin, and Imipenem. *Pseudomonas aeruginosa* demonstrates resistance mainly to Piperacillin-tazobactam and Ceftazidime. Enterobacterales, including *E. coli* and *Klebsiella pneumoniae*, exhibit notable resistance to Ceftriaxone and Gentamicin. Among the isolated organisms in our study, 15 isolates that caused CLABSI were multidrug-resistant (MDR), with *Klebsiella* species (33%) and *Enterobacter* species (33%) being the most common. Out of 28 isolates from VAP cases, 26 were MDR, with *Acinetobacter baumannii* (53%) as the dominant organism, followed by *Escherichia coli* (19%).

Among the 40 patients diagnosed with DAI, 23 died during the observation period, reflecting a notably high case fatality rate of 57.5%. Seventeen patients were transferred out to the wards.

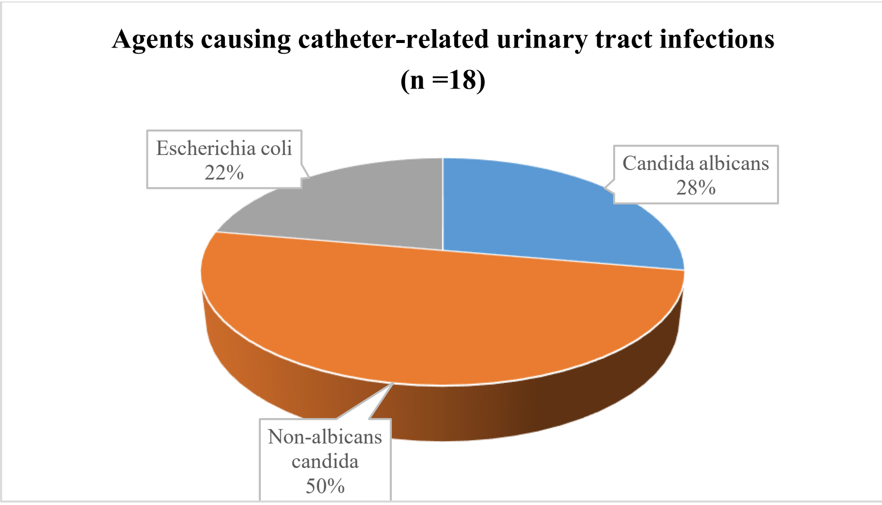

Figure 4. Percentage of Organisms Causing Catheter-Related Urinary Tract Infections.

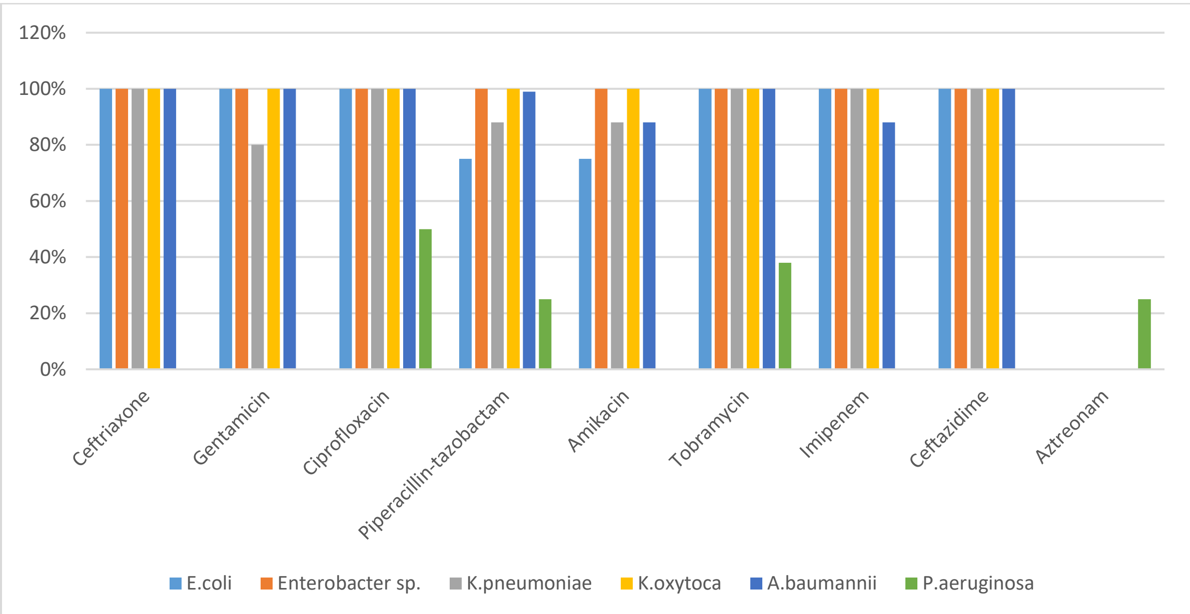

Figure 5. Percentage Resistance of Organisms Associated with HAI.

5. Discussion

Our study took place in the adult ICU over six months and involved 286 patients. Among them, 62 patients (21%) were found to have been affected by DAIs. This is comparable to data from AMRSN and a multicenter surveillance study on HAI incidence in medical ICU patients, which reported 23% and 22%, respectively.[6] The DAIs reported in our study include 25 VAP (40.3%), 19 CLABSI (30.65%), and 18 CAUTI (29.03%) cases. This alignment with national and multicenter data reinforces the representativeness of our cohort and underscores the persistent burden of DAIs in critical care settings.

Our study reported that VAP accounts for the highest cumulative rate among reported device-associated infections at 22.6%, followed by CLABSI at 21%, and CAUTI at 10.8%. According to the AMRSN 2023 report, the overall BSI rate was 6.38%, while the UTI rate was noted at 1.86%.[6] The VAP rate stood at 7.6%.[6] The comparison highlights a consistent trend, with VAP emerging as the most significant device-associated infection across both your findings and national surveillance. This alignment emphasizes the need for targeted preventive strategies, particularly for VAP, while maintaining vigilance toward CLABSI and CAUTI. The 2024 study from AIIMS Patna reported device-associated infection rates of 16.07% for VAP, 1.64% for CAUTI, and 1.91% for CLABSI.[12] When compared to our findings, the VAP rate is considerably higher, whereas CAUTI and CLABSI rates are lower, indicating potentially more effective urinary and central line infection control at their center.

Surveillance from July to December 2024 showed varied infection trends, with VAP peaking in July and December, and CLABSI spiking in September before dropping to zero in October. CAUTI remained stable between 8% and 12%, indicating effective control measures. Compared with national data and a study by AIIMS Patna showing stable DAI trends, our findings were more erratic. This suggests local procedural and seasonal influences. Continuous monitoring and targeted staff training remain essential.[12]

The pathogen profile among the DAIs showed that among VAP cases, *Acinetobacter baumannii* was the leading organism, constituting over half of the tracheal aspirate isolates, followed by *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. CLABSI cases were primarily caused by *Klebsiella pneumoniae* and *Enterobacter species*, with *Acinetobacter baumannii* and *Pseudomonas aeruginosa* also contributing significantly, while *Escherichia coli* was less common. CAUTI showed a different pattern, with *non-albicans Candida* species as the most prevalent pathogens, followed by *Candida albicans* and *Escherichia coli*. This study largely reflects national surveillance trends, with a few key differences. *Acinetobacter baumannii* was the leading pathogen in VAP, aligning with national data. In CLABSI cases, *Klebsiella pneumoniae* and *Enterobacter* species dominated, while *Acinetobacter baumannii* and *Pseudomonas aeruginosa* were also significant, more so than typically reported in national datasets. For CAUTI, *non-albicans Candida* species were most prevalent, suggesting a shift in fungal epidemiology.[6] These variations likely reflect local resistance patterns and patient risk factors within our setting. A 2025 study from Ruby Hall Clinic, Pune, identified *Acinetobacter baumannii* as the dominant pathogen in VAP and CRBSI, while *Escherichia coli* was most common in CAUTI cases. These findings reinforce the microbial trends observed in our analysis across device-associated infections.[13] The dominance of *Acinetobacter baumannii* in both VAP and CLABSI highlights its persistence in ICU settings and association with invasive procedures. The emergence of non-*albicans Candida* in CAUTI suggests a shift in fungal epidemiology, likely driven by prolonged catheter use and broad-spectrum antibiotics. These patterns reinforce the need for unit-specific antibiograms and regional surveillance to guide targeted infection control strategies.

The observed resistance patterns across VAP, CLABSI, and CAUTI in our study reflect critical antimicrobial challenges, consistent with national surveillance trends reported by AMRSN. *Acinetobacter baumannii* displayed widespread resistance to ceftriaxone, ciprofloxacin, and imipenem, confirming its multidrug-resistant nature. *Pseudomonas aeruginosa* showed reduced susceptibility to piperacillin-tazobactam and ceftazidime, while *E. coli* and *Klebsiella pneumoniae* among Enterobacterales exhibited resistance to ceftriaxone and gentamicin. AMRSN data similarly revealed high imipenem resistance in *Klebsiella pneumoniae* and *Acinetobacter baumannii*, alongside notable oxacillin and vancomycin resistance in *Staphylococcus aureus* and *Enterococcus faecium*.[6] A multicentric study from India (2022) reinforces these findings, highlighting widespread carbapenem resistance among Gram-negative pathogens in both CLABSI and CAUTI cases. *Klebsiella* spp. and *Acinetobacter spp.* showed particularly high resistance rates, mirroring the trends observed in our dataset. Additionally, *Candida spp.* emerged as a leading cause of UTIs, underscoring the growing role of fungal pathogens.[7,14,15]

Compared to national data, where 14-day fatality rates were reported as 35% for BSIs and 20.7% for UTIs, the mortality observed in DAI cases from our cohort was significantly higher at 57.5%.[6,16] This deviation may be attributed to a combination of factors such as the severity of the underlying illness, delays in initiating appropriate therapy, and the intricate clinical profiles of patients managed in our setting. Additionally, the presence of multidrug-resistant organisms, limitations in critical care resources, and challenges in early detection may further contribute to this elevated mortality.

5.1. Limitations

This study was limited by its short six-month duration, potentially missing long-term infection trends and seasonal variations. Findings are specific to a single adult ICU setting, which may restrict generalizability across diverse hospital environments. The adult ICU was selected as the surveillance unit because it serves as the epicenter for HAIs, receiving patients from all hospital wards except pediatrics and neonatology. This high patient turnover, combined with a limited number of ICNs overseeing multiple wards, may have influenced the consistency of surveillance and contributed to the observed infection burden. Additionally, the lack of stratification by comorbidities or severity scores may obscure confounding factors affecting infection rates and outcomes.

6. Conclusion

The findings from our six-month surveillance of 286 adult ICU patients underscore a concerning burden of DAIs, with 21% of patients affected—closely mirroring national and multicenter data. VAP emerged as the most prevalent DAI, contributing to the highest infection rate and aligning with national and regional trends, although our rates exceeded those of AIIMS Patna and Ruby Hall Clinic. Seasonal and procedural variability was evident in infection trends, particularly for VAP and CLABSI, reinforcing the need for dynamic infection control strategies. The microbial landscape was dominated by *Acinetobacter baumannii* in VAP and *Candida* species in CAUTI, with a notable presence of multidrug-resistant Gram-negative pathogens across all DAI types. Resistance to key antibiotics, especially carbapenems, poses a significant therapeutic challenge, paralleling national surveillance patterns and further elevating clinical complexity. The substantially higher 14-day fatality rate of 57.5% in our cohort, compared to national figures for BSIs and UTIs, highlights the compounded risk associated with DAIs, likely driven by critical illness severity, delayed care, and antimicrobial resistance. These findings collectively advocate for enhanced surveillance, antimicrobial stewardship, and rigorous adherence to preventive protocols tailored to local epidemiology.

Author Contributions

BK: Scientific conception and design, Final review and approval of the version to be published; BR: Drafting of the article; KMR: Data acquisition and analysis; VK: Critical review of the article.

Conflict of Interest Disclosures

All authors declared that they have no conflict of interest.

Research Highlights

What Is Already Known?

- Infections linked to medical devices, such as ventilators, central lines, and urinary catheters, are a major cause of HAIs, especially in ICUs.
- These infections are more common and harder to manage in low- and middle-income countries due to limited resources and rising antimicrobial resistance.
- Multidrug-resistant organisms, such as *Acinetobacter baumannii* and *Pseudomonas aeruginosa* are frequently involved, often leading to poor outcomes.

What Does This Study Add?

- Nearly 14% of ICU patients developed DAIs, with VAP being the most frequent and severe.
- The pathogens driving these infections varied by device type, with *Acinetobacter baumannii* dominating VAP cases, *Klebsiella pneumoniae* and *Enterobacter spp.* leading CLABSI, and non-*albicans Candida* causing most CAUTIs.
- Alarmingly, more than half of the patients with DAIs did not survive, highlighting the urgent need for stronger infection control practices, targeted antimicrobial stewardship, and ongoing local surveillance.

References

1. WHO. Report on the Burden of Endemic Health Care-Associated. Infection Worldwide Clean Care is Safer Care. 2011:1−40. Available at: https://apps.who.int/iris/bitstream/handle/10665/80135/9789241501507_eng.pdf;sequence=1 [accessed 25 May 2025]
2. Mehta Y, Jaggi N, Rosenthal VD, Kavathekar M, Sakle A, Munshi N, et al. Device-associated infection rates in 20 cities of India, data summary for 2004–2013: findings of the International Nosocomial Infection Control Consortium. Infect Control Hosp Epidemiol. 2016;37(2):172-81. doi:10.1017/ice.2015.276
3. Storr J, Twyman A, Zingg W, Damani N, Kilpatrick C, Reilly J, et al. Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. Antimicrob Resist Infect Control. 2017;6(1):6. doi:10.1186/s13756-016-0149-9
4. Hebden JN. Rationale for accuracy and consistency in applying standardized definitions for surveillance of health care–associated infections. Am J Infect Control. 2012;40(5):S29-31. doi:10.1016/j.ajic.2012.03.009
5. Stempliuk V. Surveillance of Healthcare-Associated Infections in Low-and Middle-Income Countries: From the Need to a Reality. Curr Treat Options Infect Dis. 2018;10(1):1-6. doi:10.1007/s40506-018-0148-x
6. Antimicrobial Resistance Research & Surveillance Network. Annual report. January 2023- December 2023. Available at https://www.icmr.gov.in/icmrobject/uploads/Documents/1725536060_annual_report_2023.pdf [accessed 26 May 2025]
7. Mathur P, Malpiedi P, Walia K, Srikantiah P, Gupta S, Lohiya A, et al. Health-care-associated bloodstream and urinary tract infections in a network of hospitals in India: a multicentre, hospital-based, prospective surveillance study. Lancet Glob Health. 2022;10(9):e1317-25. doi:10.1016/s2214-109x(22)00274-1
8. National Centre for Disease Control, India. Standard operating procedures: surveillance of priority bacterial pathogens under the national AMR surveillance network. Delhi: National Centre for Disease Control, 2019.
9. Centers for Disease Control and Prevention. National Healthcare Safety Network Patient Safety Component Manual. Atlanta, GA: Centers for Disease Control and Prevention, 2022.
10. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. ScienceDirect. https://www.sciencedirect.com/science/article/abs/pii/S0196655308001673. [accessed 20 April 2025]
11. Performance standards for antimicrobial testing. 34th

ed, CLSI supplement M100. Wayne, PA; 2024.
12. Bhushan D, Hegde AV, Kumar V, Thakuria B, Kumar P, Sudheer Varma Y. Prevalence of device associated hospital acquired infection in a medical intensive care unit of a tertiary care centre. J Antimicrob Stewardsh Pract Infect Dis. 2024;2:46-52. doi:10.62541/jaspi056
13. Zirpe KG, Gurav SK, Dhawad PA, Tiwari AM, Deshmukh AM, Suryawanshi PB, et al. Hospital-acquired infections in the adult intensive care unit: Epidemiology, resistance patterns, and risk factors. J Assoc Physicians India. 2025;73(2):51-5.
14. Srivastava R, Mahajan S, Kakru DK. Clinico-microbiological profile of *Acinetobacter baumannii* infections in a tertiary care hospital in Greater Noida. Int J Acad Med Pharm. 2024;6(2):517-20.
15. Singhal E, Singh R, Bhardwaj P, Kumari M. *Candida* species in catheter associated urinary tract infection in ICU patients at a tertiary care hospital in North India: An observational study. J Med Sci Res. 2024;12:11-5. doi:10.17727/JMSR.2024/12-2
16. Murhekar MV, Kumar CG. Health-care-associated infection surveillance in India. The Lancet Glob Health. 2022;10(9):e1222-3. doi:10.1016/s2214-109x(22)00317-5