



Original Article



Prevalence of Device Associated Hospital Acquired Infection in a Medical Intensive Care Unit of a Tertiary Care Centre

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ABSTRACT

Background: Infections acquired within a hospital setting, commonly called healthcare-associated infections (HAIs), are nosocomial infections that are typically absent or in an incubation phase upon admission. The study aimed to determine the prevalence of device-associated HAI and the factors affecting HAI in the Medical Intensive Care Unit (MICU).

Methods: A prospective observational study was conducted, including patients admitted to the MICU of a tertiary care medical centre from March 2020 to March 2023. The patient's total ventilator days, catheter days, central line days, and development of HAI, according to the definition of surveillance, were recorded for each patient. Rates for device-associated infections and device utilisation ratios (DURs) were calculated. Statistical analysis involved descriptive statistics, Kaplan-Meier curve analysis with the Log Rank test, and logistic regression analysis to identify factors associated with HAI.

Results: 386 patients were included in the study, of which 52 (13.47%) developed HAI. The DUR for ventilators, catheters, and central lines were found to be 0.502, 0.949, and 0.545, respectively. Ventilator-associated pneumonia (VAP) rate was 16.07 per 1000 ventilator days, the catheter-associated urinary tract infection (CAUTI) rate was calculated to be 1.64 per 1000 catheter days, and the central line-associated bloodstream infection (CLABSI) rate was 1.91 per 1000 central line days. On multivariate analysis, the length of stay [adjusted odds ratio (AOR), 1.292; 95% CI: 1.200-1.391], and history of hospitalisation in the past 90 days (AOR, 6.556; 95% CI: 2.619-16.411) were also found to be independent predictors for HAI.

Conclusion: Our institution has lower rates of CAUTI and CLABSI. However, the VAP rate is higher than in studies conducted in an Indian setting. Hence, adopting the INICC multidimensional approach can address and reduce our VAP rate.

KEYWORDS: Intensive Care Units; Healthcare-associated infections; Pneumonia; Ventilator-associated; Catheter-related; CLABSI; Device-associated

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INTRODUCTION

Infections acquired within a hospital setting, commonly called healthcare-associated infections (HAIs), are nosocomial infections that are typically absent or in an incubation phase upon admission. These infections usually manifest post-hospitalisation, with symptoms emerging at least 48 hours after the patient's admission to the healthcare facility.¹

With the ever-increasing complexity of medical interventions, devices such as ventilators, catheters, and central lines have become integral to patient care. These life-saving devices risk acquired infection for the patient, significantly impacting in-hospital mortality.² This usually results in a more extended hospital stay, leading to an even more significant economic burden on the patient. The incidence of HAI in an Indian study by Dasgupta et al. is around 13.6%. The prevalence varies in different studies as VAP accounts for 10.4 per 1000 ventilator days in Mehta et al., and CAUTI 9.4 per 1000 catheters per day in Pariher et al. It is estimated that HAIs cause a substantial economic burden per year, even in the United States, necessitating proper medical surveillance.³

Various measures have been employed to reduce the incidence of HAIs, including hand hygiene practices, maintaining a hygienic hospital environment, categorising patients based on risk factors, implementing robust public health surveillance systems, advocating for judicious antibiotic use, and ensuring adherence to established patient safety guidelines.⁴ Despite these various measures taken into account to reduce different types of HAIs, the prevalence of HAI in India remains higher. According to the International Nosocomial Infection Control Consortium (INICC), the prevalence of HAI in India is approximately 9.06 infections per 1,000 ICU patient days.⁵ Thus, understanding the dynamics of device-associated HAIs in ICUs is essential for implementing effective preventive measures and ensuring the safety of patients who rely on these critical medical interventions.

According to a literature review by Iyer et al. (2015), the prevalence of HAIs in India is impacted by challenges such as resource constraints, lack of standardised infection control practices, and the rising incidence of antimicrobial resistance.⁶

Therefore, this study is conducted to determine the prevalence of device-associated HAI and the factors affecting HAI in a tertiary care centre's medical intensive care unit (ICU).

METHODOLOGY

Study design and setting: This prospective observational study was conducted in the medical intensive care unit (MICU) of the All India Institute of Medical Sciences, Patna, a tertiary care medical centre in eastern India, after approval from the Institute Ethics Committee (IEC).

Study participants: The study involved patients admitted to the MICU between March 2020 and March 2023.

Case definitions

CAUTI: Patients with any of the following with no alternative source: fever, rigors, new onset hypotension, confusion/ functional decline, and increased leucocytosis. New costovertebral tenderness/ pain, new supra pubic tenderness/ pain, pus around catheter insertion site AND any of the following – (A) If the catheter was removed in the past 2 days -clean catch urine culture with no more than two species of micro-organisms, at least one of which is bacteria of 100,000 or more colonies; in/out catheter urine culture with any number of micro-organisms, at least 1 of which is bacteria of 100 or more colonies ($\geq 10^2$ CFU/ml), (B) If an indwelling catheter is in place – then a positive urine culture with any number of microorganisms, at least 1 of which is bacteria of 100,000 colonies or more (10^5 CFU/ml).⁷

VAP: National Health Safety Network Pneumonia (NHSN PNU1) definition includes at least one of the following- new-onset fever (> 100.4 F), leucopenia/ leukocytosis, for adults > 70 years – altered mental status with no other cause. With at least one of the following in chest X-ray- new progressive infiltrates, consolidation, cavitation. And at least 2 of the following- new-onset purulent sputum, change in colour of sputum, increased suction requirement, increased respiratory secretion/ worsening gas exchange/ new onset or worsening cough/ dyspnea/ tachypnea, rales or bronchial breath sounds.⁷

CLABSI: patients with central venous catheter and Fever (> 100.4 F), chills, hypotension, and organisms identified in the blood are unrelated to an infection at another site. The same NHSN common commensal is determined by culture from two or more blood specimens collected separately.⁷

Inclusion criteria

1. Patients admitted to the MICU for any indication.
2. As per the definition of HAI, the minimum ICU stay is 48 hours.
3. Patients aged 15 years or older.

Exclusion criteria

1. Patients with evidence of any pre-existing HAI (i.e., HAI developed in the wards or at other hospitals).

Sampling technique : Complete enumeration: all patients admitted to the MICU during the study period meeting the inclusion criteria were included.

Study protocol: All patients admitted to the MICU were assessed for possible inclusion in the study. Informed consent was obtained from each participant or their first-degree relative if the patient was not mentally sound to provide consent. Surveillance was done during their stay in the ICU, and the following data was recorded:

1. Demographic parameters such as age and gender
2. Detailed history, including the presence of comorbidities and any history of hospitalisation in the past 90 days
3. Surveillance data includes ICU stay duration (patient days), ventilator days, catheter days, and central line days.
4. Clinical parameters, including intubation, the development of any HAI, and the outcome in terms of either a fatality or discharge from the MICU

Measures: The rates for device-associated infections were calculated. The VAP rate was calculated as the number of VAP cases per 1000 ventilator days.

The CAUTI rate was calculated as the number of CAUTI cases per 1000 catheter days.

The CLABSI rate was calculated as the number of CLABSI cases per 1000 central line days.

The device utilisation rates (DURs) for ventilators, catheters, and central lines were also calculated as the ratio of the number of days a device was used to the total patient days.

Statistical analysis: Data was entered in Microsoft Excel, cleaned, and coded. Analysis was performed using IBM SPSS ver. 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and proportions. Kaplan-Meier curve analysis and Log Rank test were performed to calculate and compare the median survival times of patients who developed an HAI and those who did not.

A univariate binary logistic regression analysis was performed to look for factors associated with the development of HAI, and the variables with a p-value less than 0.2 were considered for the multivariate analysis model. The crude odds ratios with 95% confidence intervals (CI) were reported. The 'Enter Method' in SPSS was used to build the multivariate

model, and the Hosmer-Lemeshow goodness of fit test assessed the model fit. The model variability was given by Nagelkerke's R square (pseudo-R square). Adjusted odds ratios were calculated with their 95% CI. Statistical significance was attributed to $p < 0.05$.

Ethics approval: This study was started after the approval of the Institute Ethics Committee with reference number AIIMS/Pat/IEC/PGTh/Jan21/21

RESULTS

A total of 386 patients were included in the study. Most of the patients, i.e., 166 (43.0%), belonged to the age group of 60–80 years, followed by 109 (28.2%) in the age category of 40–60 years. 218 (56.5%) were males. Most of the participants, i.e., 346 (89.9%), were admitted to the ICU for 2 weeks or less, and 300 (77.7 %) died during their stay. 52 (13.5%) individuals developed HAI (Table 1).

Table 1: Demographic details and clinical outcomes of the patients admitted to the ICU (N=386)

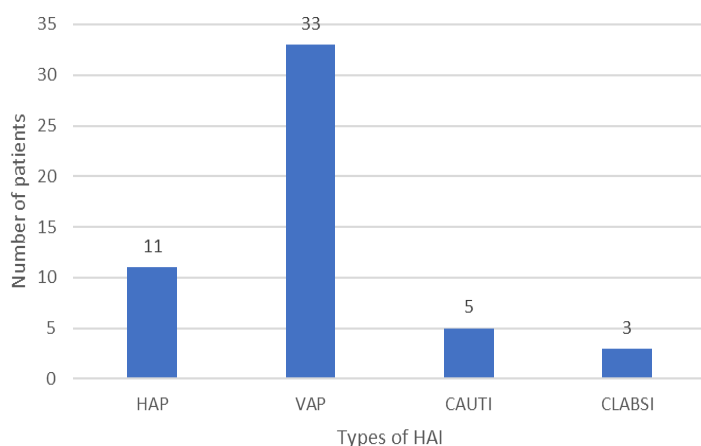
Variable	Categories	n (%)
Age	Less than 20	12 (3.1)
	20 - 40 years	73 (18.9)
	40 - 60 years	109 (28.2)
	60 - 80 years	166 (43.0)
	80 -100 years	26 (6.8)
Gender	Female	168 (43.5)
	Male	218 (56.5)
Length of ICU stay	7 days or less	207 (53.2)
	8 - 14 days	142 (36.6)
	15 - 28 days	27 (7.8)
	29 days or more	9 (2.4)
Hospital-acquired infection	Yes	52 (13.2)
	No	334 (86.8)
Final Outcome	Death	300 (77.7)
	Discharged (from ICU)	86 (22.3)

The total number of patient days (the sum of the total number of patients admitted to the ICU) was 3843 days. The DUR for ventilators, catheters, and central lines were found to be 0.502, 0.949, and 0.545, respectively. The VAP rate was 17.12 per 1000 ventilator days, the CAUTI rate was calculated to be 1.37 per 1000 catheter days, and the CLABSI rate was found to be 1.43 per 1000 central line days (Table 2).

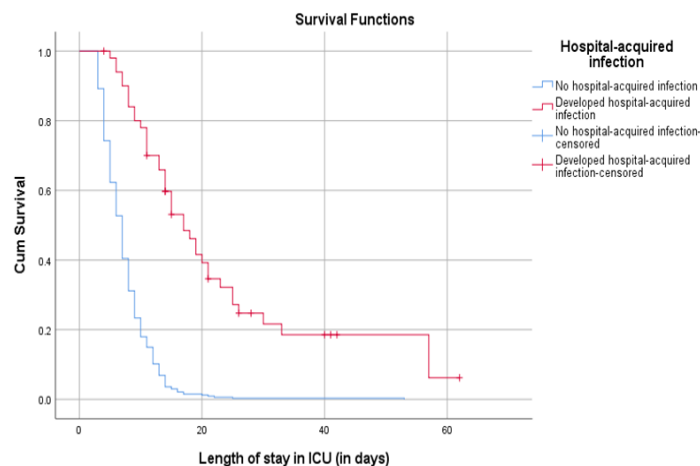
Table 2: Summary of the surveillance data for ventilator-associated, catheter-associated, and central line-associated events

Variable	Number of days (Total number of patient days = 3843)	Device utilization ratio	Number of events	Rate
Ventilator days	1929	0.502	33	17.12 per 1000 ventilator days
Catheter days	3646	0.949	5	1.37 per 1000 catheter days
Central line days	2094	0.545	3	1.43 per 1000 central line days

Among the 52 patients who developed HAI, 33 (63.5%) patients had VAP, 11 (21.2%) patients had HAP, 5(9.6%) patients had CAUTI, and 3 (5.7%) patients had CLABSI (Figure 1).

Figure 1: The distribution of various types of hospital-acquired infections among the patients (n=52)

In our study, 261 out of 344 patients who didn't have HAI succumbed, and 13 out of 52 who had HAI also succumbed. For total patients who expired, on Kaplan-Meier Curve analysis, it was seen that the median survival time in patients who did not develop HAI was 7 (95% CI: 6.518–7.582) days, while the median survival time in patients who did develop HAI was 17 (95% CI: 13.088–20.912) days (Figure 2).

Figure 2: Kaplan-Meier curves of patients in the ICU with and without hospital-acquired infection

The Log Rank test revealed that there was a statistically significant difference between the curves [Chi-square=91.037 (at 1 degree of freedom) and $p < 0.001$]. This paradox might suggest that those who stayed more in the ICU developed HAI, and those who did not develop HAI succumbed early due to their illness. More use of broad-spectrum higher antibiotics and other supportive measures in patients with HAI might have prolonged the stay but not overall survival.

On univariate logistic regression analysis, it was observed that the length of stay [crude odds ratio (COR), 1.254; 95% CI: 1.175-1.339], history of hospitalisation in the past 90 days (COR, 2.775; 95% CI: 1.442-5.337), and intubation (COR, 0.187; 95% CI: 0.101-0.346) were significant predictors of HAI.

On multivariate analysis, the length of stay [adjusted odds ratio (AOR), 1.292; 95% CI: 1.200–1.391], and history of hospitalisation in the past 90 days (AOR, 6.556; 95% CI: 2.619–16.411), were also found to be independent predictors for HAI (Table 3).

Table 3. Associates of hospital-acquired infection in ICU patients

Variable	Crude Odds	95% Confidence Interval		p-value	Adjusted Odds	95% Confidence Interval		p-value
		Lower Bound	Upper Bound			Lower Bound	Upper Bound	
Age (in years)	0.987	0.972	1.003	0.108	0.980	0.958	1.002	0.080

Female sex	1.6 87	0.9 32	3.0 52	0.0 84	1.40 8	0.6 14	3.2 29	0.41 9
Length of stay (in days)	1.2 54	1.1 75	1.3 39	<0.001	1.29 2	1.2 00	1.3 91	<0.001
History of hospitalization in the past 90 days	2.7 75	1.4 42	5.3 37	0.002	6.55 6	2.6 19	16. 411	<0.001

Chi-square – 2.624 (df 8), p-value - 0.956

Nagelkerke R Square = 0.561

DISCUSSION

Our study screened 386 patients, and 52 patients developed HAI. VAP was the most prevalent HAI, followed by CAUTI and CLABSI (17.12 per 1000 ventilator days, 1.43 per 1000 central line days, and 1.37 per 1000 catheter days were the VAP, CLABSI, and CAUTI rates, respectively). Length of stay, history of hospitalisation in the past 90 days, and intubation were independent predictors of HAI.

HAIs pose a significant challenge in the management of ICU patients, thus requiring proper surveillance. The incidence of HAI in our study (13.2%) is comparable to a survey by Dasgupta S. et al. in the ICU setting in eastern India (11.98%).⁸ However, the incidences of CAUTI were lower compared to other Indian studies.⁹⁻¹¹ The VAP rate found in our study (17.12 per 1000 ventilator days) is higher than the VAP rate evaluated in other Indian cities (10.4 per 1000 ventilator days),¹²⁻¹³ and other Southeast Asian countries.¹⁴⁻¹⁵ However, the VAP rate observed in our study is like the pooled mean VAP rate observed (16.3 per 1,000 device days) in 43 countries.¹⁶ This high rate of VAP can be due to a lack of Infection control practices in the ICU, cross-contamination and the non-availability of isolation facilities in the ICU. The INICC-developed multimodal approach for the prevention of VAP should be used. It has six main parts: (1) bundle care, which has 10 elements to prevent pneumonia; (2) educational programmes; (3) outcomes monitoring; (4) online process surveillance to see how healthy bundles are being followed; (5) giving feedback on VAP rates and their effects; and (6) performance feedback.¹⁷

The Device Utilisation Ratio (DUR) is a measure that assesses the usage of a medical device in a healthcare setting.¹⁸ DUR is a decisive factor known for its positive correlation with HAI. In 2014, the National Healthcare Safety Network (NHSN) reported a DUR of 0.44, less than the DUR of the endotracheal tube observed at our study site, which stands at 0.502. This can be attributed

to the transfer of more complex cases from all over the state, as our centre is one of the three tertiary care centres in Bihar, the third most populated state of the nation.

More than five million patients globally in intensive care hospital environments experience the insertion of urinary catheters, elevating their susceptibility to CAUTI.¹⁹ The CAUTI rate in our study is 1.37 per 1000 catheter days, which is very low compared to the study done in an Indian setting by Parihar S. et al. (9.4 per 1000 urinary catheter days).²⁰ A survey by Letica-Kriegel A. S. et al. reported a similar CAUTI rate compared to our institution.²¹ This can be attributed to adequately implementing hand hygiene, infection control, and catheter care bundles. The DUR for catheter utilisation in our study is 0.9, which is very high compared to the INICC report. This can be attributed to the severity of cases treated at tertiary-level referral hospitals requiring output monitoring.

The central line is one of the most common procedures done in the ICU setting, and CLABSIs are associated with significant morbidity and mortality in the patient, ultimately causing increased healthcare costs. The CLABSI rate in our study was 1.43 per 1000 central line days, which is lower than the rate reported by INICC (4.47 per 1000 central line days) and about the same as the rate reported by Rosenthal V. D. in the US (1.6 per 1000 central line days).²² Our study's central line utilisation rate is 0.545, similar to the INICC report (0.53). CLABSI is the most preventable form of HAI infection, and its incidence is higher in developing countries. The low rate of CLABSI can be attributed to the incorporation of quality aseptic precaution methods, skilled healthcare workers, and compliance with the insertion bundle method in the hospital's culture and policies.

Risk factors like length of hospital stay and history of hospitalisation in the past 90 days are the independent risk factors that cause an increase in the incidence of HAIs. HAI was found to be shared in advancing age and females, but they didn't show statistical significance. Among device-associated HAIs, VAP is a major contributor to prolonged patient stays. Stewart S. et al. highlight that preventing a single HAI can result in an average reduction of 7.8 days in hospital stay. Consequently, preventing HAIs diminishes the length of stay. It contributes to the availability of hospital beds to treat additional patients—a particularly valuable outcome in countries with high patient loads, such as India.²³⁻²⁵

There are some limitations to this study as well. Since this study was conducted at a single centre, its findings

may not be generalised to other institutions. Other limitations are the recruitment from the medical ICU, the inability to include pediatric patients, and the failure to assess the quality of infection control practice among healthcare workers. Certain suspected cases of bloodstream infections and CAUTI in whom initial cultures were sterile were missed because of their untimely death or due to leave against medical advice (LAMA). However, it's worth noting that our study included a large sample size, which helps mitigate the potential for selection bias.

CONCLUSION

While our medicine ICU has lower rates of CAUTI and CLABSI, it is noteworthy that the VAP rate is higher compared to studies conducted in the Indian setting. Hence, adopting the INICC multidimensional approach can address and reduce our VAP rate. The device utilisation rate is also high at our centre, which needs to be dealt with through training and education of healthcare workers, audits and protocol-wise care in the Intensive care unit.

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None

CONFLICTS OF INTEREST STATEMENT

The authors declare no conflict of interest.

SOURCE OF FUNDING

None

ETHICS STATEMENT INCLUDING PATIENT CONSENT

Not applicable

AUTHOR'S CONTRIBUTION

DV: Concept, methodology, write-up of article, analysis

AVH: Data collection and analysis, writing of project

VK: Conceptualisation, write-up review, discussion

BT: Methodology write-up, concept to detailed project preparation

PK: Methodology write-up, concept to detailed project preparation, analysis

SV: Data collection and write up

JA: Data collection and write up

AI DECLARATION

No AI tool was used to generate research data, perform

data analysis, interpret findings, formulate scientific conclusions, or make editorial decisions. All AI-assisted content was critically reviewed, verified, and revised by the authors. The authors take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.

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