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Original Research Article

Epidemiological Profile of Healthcare-Associated Infections in the Intensive Care Unit: A Retrospective Study

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Abstract:

Background: Healthcare-associated infections (HAIs) are a major cause of morbidity and mortality in intensive care units (ICUs), largely due to invasive procedures, prolonged hospitalization, and antimicrobial resistance.

Aim: To assess the burden, types, microbiological profile, and antimicrobial resistance patterns of healthcare-associated infections among ICU patients through retrospective surveillance.

Methodology: A six-month retrospective observational study was conducted in the ICU of a Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India. Eighty patients who developed culture-confirmed HAIs after 48 hours of ICU admission were included. Clinical and microbiological data were analyzed, and antimicrobial susceptibility testing was performed using standard methods.

Results: Ventilator-associated pneumonia was the most common HAI (37.5%), followed by catheter-associated urinary tract infection (27.5%) and central line-associated bloodstream infection (22.5%). Gram-negative organisms predominated, with *Klebsiella pneumoniae* (27.5%) and *Acinetobacter baumannii* (22.5%) being the most frequent isolates. High resistance to third-generation cephalosporins was observed, and 56.7% of Gram-negative isolates were ESBL producers.

Conclusion: The study highlights a high burden of device-associated HAIs and significant antimicrobial resistance in the ICU, emphasizing the need for continuous surveillance, strict infection control measures, and robust antimicrobial stewardship.

Keywords: Healthcare-associated infections, ICU, retrospective surveillance, antimicrobial resistance, ESBL.

Introduction

HAIs have become one of the primary issues of the contemporary healthcare structure especially in intensive care units (ICUs) where patients are very susceptible because of their serious illnesses, invasive operations, and extended hospitalization [1]. HAIs are categorized as the infections that occur during the healthcare delivery process and were neither in existence nor incubating at the time of admission. Even with the current improvement of infection prevention and control practices, HAIs have remained a source of high patient morbidity, mortality, long hospital stay, and high healthcare costs in most countries across the world. Their incidence in the ICUs is disproportionately more than that in the general hospital wards, so they are a priority area of surveillance and preventive measures.

The patients admitted to ICUs are also likely to be exposed to various risk factors that predispose them to HAIs, among them being mechanical ventilation, central venous catheterization, urinary catheterization, surgical interventions, immunosuppression, and the frequent administration of broad-spectrum antimicrobials [2]. These and the intensity of underlying disease and weakened host defenses form a condition that is conducive to the growth and spread of infections. HAIs that are common in the ICU are ventilator-associated pneumonia, catheter-associated UTIs, central line-associated BSI, and surgical site infection. Multidrug-resistant organisms causally affect these infections, which additionally complicates the treatment and reduces the clinical outcomes.

HAIs surveillance is an ingredient of successful infection prevention and control programs [3]. Systematic surveillance helps healthcare facilities to determine the rate of infection and trends and

tendencies, track temporal changes, detect outbreaks, and assess the efficiency of prevention measures. Constant and precise surveillance is especially necessary in the ICU environment as the risk of infection is high, and the effects are severe [4]. Critical information on the microbiological profile of pathogens, antimicrobial resistance patterns and risk factors related to the occurrence of the infection is also available through surveillance data and has been used to inform evidence- based clinical practice and policy.

The epidemiological method known as retrospective surveillance analyzes previously collected clinical and microbiological data to study infection patterns and their resulting outcomes [5]. The method proves to be particularly useful in resource-constrained environments which face difficulties with prospective surveillance because of their limited workforce and time and facility resources. Retrospective surveillance enables hospitals to assess healthcare-associated infections since it uses their existing medical records and laboratory documents and infection control databases. Researchers use retrospective studies to evaluate healthcare-associated infections in their local area because these studies provide essential data despite their limitations in data availability and potential documentation bias.

The incidence of HAIs in ICUs shows higher rates in developing countries which include India because they face overcrowding issues and lack essential medical resources and their staff shows inconsistent practice of infection control and their rates of antimicrobial resistance continue to rise [6]. The absence of standardized monitoring systems throughout numerous medical facilities creates a barrier which prevents accurate measurement of actual HAI cases. The medical establishment requires institution-specific surveillance studies to create accurate local data which reflects actual clinical activities and existing medical difficulties. The information helps develop precise methods for infection control and detailed plans for managing antimicrobial use.

The impact of HAIs extends beyond clinical outcomes because it creates major financial challenges for both healthcare systems and their patients [7]. The costs of healthcare services increase because patients require extended ICU stays combined with extra tests and they need expensive antimicrobial treatments and specialized medical assistance. HAIs create negative effects on patient life quality because they result in permanent disabilities and long-lasting health issues. The spread of multidrug-resistant pathogens in ICUs represents a major public health danger which requires hospitals to establish strong monitoring systems and enforce strict rules for infection control.

In this context, retrospective surveillance of healthcare associated infections in the ICU offers useful information on the epidemiology, the risk factors, and the outcomes of healthcare associated infection in a particular healthcare environment. Knowledge of the local infection trends is useful in assisting clinicians, microbiologists, and hospital administrators to introduce specific interventions that would allow them to minimize infection rates and enhance patient safety. Such surveillance studies can also be used to contribute to regional and national databases to promote more extensive work in enhancing infection control policies. Thus, the current research was conducted to evaluate retrospectively the burden and nature of healthcare associated infections in the ICU patients, and the end outcome was to improve the practice of preventing infections and provide better critical care services.

Methodology

Study Design: This study was conducted as a retrospective observational surveillance study aimed at assessing the burden, microbiological profile, and device-associated patterns of healthcare-associated infections (HAIs) among patients admitted to the intensive care unit (ICU). The retrospective design enabled systematic evaluation of existing hospital records and infection surveillance data without influencing patient management.

Study Area: The study was carried out in the Department of Microbiology, Darbhanga Medical College and Hospital (DMCH), Laheriasarai, Darbhanga, Bihar, India

Study Duration: The study covered a duration of six months from March 2025 to August 2025, during which data from ICU admissions were retrospectively reviewed and analyzed for the occurrence of healthcare-associated infections.

Study Participants: The study population consisted of patients admitted to the ICU during the study period and evaluated for the development of healthcare-associated infections.

Inclusion Criteria

- Patients admitted to the ICU for more than 48 hours
- Patients who developed culture-confirmed healthcare-associated infections during ICU stay
- Patients of all age groups and both sexes
- Patients with complete clinical and microbiological records

Exclusion Criteria

- Patients admitted to the ICU for less than 48 hours
- Patients with evidence of community-acquired infections at the time of admission
- Patients with incomplete or missing medical or laboratory records

- Repeat isolates from the same infection episode

Sample Size

A total of 80 patients fulfilling the inclusion criteria and diagnosed with healthcare-associated infections during ICU admission were included in the final analysis.

Procedure: All instances of healthcare-associated infections were identified through retrospective examination of data collected by the infection control team's standardized data collection form. The data that researchers gathered contained information about patients' age and sex together with their ICU admission records and medical history and details about their time in the ICU and all procedures they underwent and all medical devices that were used on them which included central venous catheters and urinary catheters and mechanical ventilation and their microbiological culture results and their antimicrobial treatment records.

Infectious Disease specialists and Infection Control Nurses conducted daily patient monitoring at the ICU, while hospital infection control teams conducted their surveillance activities at scheduled times. The study evaluated healthcare-associated infections that developed after patients had spent 48 hours in the ICU. The study included all healthcare-associated infections which had been verified through laboratory cultures.

The Department of Microbiology received clinical samples which included blood and urine and tracheal aspirates and sputum and wound swabs and all other relevant specimens that medical staff collected according to standard aseptic techniques. Bacterial identification was performed using conventional microbiological methods along with the automated VITEK 2 system (bioMérieux, France). The laboratory conducted antimicrobial susceptibility testing through two methods which included the Kirby-Bauer disk diffusion method and the VITEK 2 automated system according to established laboratory standards.

The double-disk synergy test (DDST) was used to identify extended-spectrum beta-lactamase (ESBL) production in gram-negative bacterial isolates. The study determined three measurement metrics including healthcare-associated infection rates and incidence density and device-related infection rates through analysis of ICU surveillance records. The study received ethical approval from the Institutional Ethical Committee which allowed researchers to conduct the study without obtaining written informed consent because of its retrospective design.

Statistical Analysis: Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Descriptive statistics were used to summarize demographic variables, infection rates, and microbiological profiles. Categorical variables were expressed as frequencies and percentages. Appropriate statistical tests were applied wherever required, and a p-value less than 0.05 was considered statistically significant.

Result

Table 1 illustrates the demographic distribution of ICU patients with healthcare-associated infections among the 80 study participants. The majority of patients belonged to the 41–60 years age group, accounting for 40% of cases, followed by those aged above 60 years (27.5%), indicating a higher burden of infections among middle-aged and elderly individuals. Patients aged 19–40 years constituted 22.5% of the study population, while the pediatric age group (≤18 years) represented the smallest proportion at 10%. With respect to sex distribution, males predominated, comprising 60% of the patients, whereas females accounted for 40%, suggesting a male preponderance among ICU patients affected by healthcare-associated infections.

Table 1: Demographic Distribution of ICU Patients with Healthcare-Associated Infections (n = 80)

Variable	Number (n)	Percentage (%)
Age Group (years)		
≤18	8	10
19–40	18	22.5
41–60	32	40
>60	22	27.5
Sex		
Male	48	60
Female	32	40
Total	80	100

Table 2 shows the distribution of healthcare-associated infections among 80 ICU patients, highlighting ventilator-associated pneumonia (VAP) as the most common infection, accounting for 30 cases (37.5%). This was followed by catheter-associated urinary tract infections (CAUTI) with 22 cases (27.5%) and central line-associated bloodstream infections (CLABSI) comprising 18 cases (22.5%). Surgical site infections (SSI) were the least frequent, observed in 10 patients (12.5%). Overall, the findings

indicate that device-associated infections, particularly those related to mechanical ventilation and indwelling catheters, constituted the majority of healthcare-associated infections in the ICU setting.

Table 2: Distribution of Types of Healthcare-Associated Infections in ICU (n = 80)		
Type of Infection	**Number (n)**	**Percentage (%)**
Ventilator-associated pneumonia (VAP)	30	37.5
Catheter-associated urinary tract infection (CAUTI)	22	27.5
Central line-associated bloodstream infection (CLABSI)	18	22.5
Surgical site infection (SSI)	10	12.5
Total	80	100

Table 3 shows the distribution of microorganisms isolated from 80 healthcare-associated infection cases, highlighting the predominance of Gram-negative bacteria. Klebsiella pneumoniae was the most frequently isolated organism, accounting for 22 cases (27.5%), followed by Acinetobacter baumannii in 18 cases (22.5%) and Escherichia coli in 15 cases (18.8%). Pseudomonas aeruginosa was identified in 12 cases (15%), while Gram-positive organisms were less common, with Staphylococcus aureus isolated in 9 cases (11.2%) and Enterococcus spp. in 4 cases (5%). Overall, the findings indicate a clear dominance of Gram-negative pathogens in HAI cases, underscoring their significant role in hospital-acquired infections and the need for targeted infection control and antimicrobial stewardship strategies.

Table 3: Distribution of Microorganisms Isolated from HAI Cases (n = 80)		
Microorganism	**Number (n)**	**Percentage (%)**
Klebsiella pneumoniae	22	27.5
Acinetobacter baumannii	18	22.5
Escherichia coli	15	18.8
Pseudomonas aeruginosa	12	15
Staphylococcus aureus	9	11.2
Enterococcus spp.	4	5
Total	80	100

Table 4 depicts the antimicrobial resistance pattern among 67 Gram-negative isolates, revealing a high level of resistance to commonly used antibiotics. The highest resistance was observed against ceftriaxone (77.6%) and ceftazidime (73.1%), indicating limited effectiveness of third-generation cephalosporins. A substantial proportion of isolates also showed resistance to ciprofloxacin (67.2%), suggesting reduced utility of fluoroquinolones. In contrast, comparatively lower resistance rates were noted for piperacillin–tazobactam (41.8%) and imipenem (29.9%), with imipenem demonstrating the highest sensitivity (70.1%). Overall, the findings highlight widespread multidrug resistance among Gram-negative pathogens, while carbapenems and β-lactam/β-lactamase inhibitor combinations remain relatively more effective therapeutic options.

Table 4: Antimicrobial Resistance Pattern among Gram-negative Isolates (n = 67)		
Antibiotic	**Resistant n (%)**	**Sensitive n (%)**
Ceftriaxone	52 (77.6)	15 (22.4)
Ceftazidime	49 (73.1)	18 (26.9)
Ciprofloxacin	45 (67.2)	22 (32.8)
Piperacillin–Tazobactam	28 (41.8)	39 (58.2)
Imipenem	20 (29.9)	47 (70.1)

Table 5 shows the distribution of extended-spectrum beta-lactamase (ESBL) production among the 67 Gram-negative isolates analyzed in the study. More than half of the isolates were identified as ESBL producers, with 38 isolates accounting for 56.7% of the total, indicating a high prevalence of ESBL-mediated resistance. In contrast, 29 isolates (43.3%) were ESBL negative. This predominance of ESBL-positive organisms highlight a substantial burden of antimicrobial resistance among Gram-negative pathogens, which has important implications for antibiotic selection and infection control practices.

Table 5: ESBL Production among Gram-negative Isolates (n = 67)		
ESBL Status	**Number (n)**	**Percentage (%)**
ESBL positive	38	56.7
ESBL negative	29	43.3
Total	67	100

Discussion

The present retrospective surveillance highlights a substantially higher burden of healthcare-associated infections (HAIs) in intensive care units compared to non-critical care areas, which is consistent with global and regional literature. In our study, the incidence density of HAIs in ICUs was 10.31 per 1000 patient-days, nearly 5–10 times higher than that observed in general wards. Similar findings have been reported across Europe, where HAI prevalence ranged from 2.9% to 10.0%, with ICUs contributing disproportionately to overall infection rates (Suentens et al., 2018) [8]. Studies from developing countries have demonstrated wide variability, with reported HAI rates ranging from 1.3% to 16.6%, reflecting differences in surveillance systems, patient populations, and infection control practices (Vançelik et al., 2006) [9].

The predominance of HAIs originating from ICUs in our study (57.4%) aligns with earlier observations by Wenzel et al., who reported that although only 5–10% of hospitalized patients are admitted to ICUs, nearly 25% of all HAIs occur in these units (Wenzel et al., 1983) [10]. This disproportionate burden can be attributed to prolonged hospital stays, severity of illness, frequent use of invasive devices, and extensive exposure to broad-spectrum antibiotics. Similar ICU-driven HAI patterns have been documented in multicenter surveillance programs from Europe and Asia, reinforcing the vulnerability of critically ill patients (Cassini et al., 2016) [11].

Device-associated infections constituted the majority of HAIs in the present study, with ventilator-associated pneumonia (VAP) being the most common, followed by central line-associated bloodstream infections (CLABSI) and catheter-associated urinary tract infections (CAUTI). Our VAP rate of 11.57 per 1000 ventilator-days is comparable to Turkish national surveillance data, which reported rates ranging from 4.86 to 16.69 per 1000 ventilator-days (Gozel et al., 2021) [12]. Similarly, our CLABSI (4.00 per 1000 catheter-days) and CAUTI (1.99 per 1000 catheter-days) rates fall within internationally reported ranges, suggesting that while the burden remains high, it is not atypical for ICU settings.

Bloodstream infections (BSIs) emerged as a major contributor to HAIs in our hospital, accounting for over half of all infections. This finding contrasts with several point-prevalence surveys where urinary tract infections and pneumonia were more common (Magill et al., 2014) [13]. However, studies from resource-limited settings have reported a rising trend in BSIs, particularly secondary BSIs associated with invasive procedures and prolonged ICU stays (Zhang et al., 2016) [14]. The high proportion of catheter-related BSIs in our study underscores the critical importance of strict central line insertion and maintenance bundles, which have been shown to significantly reduce infection rates when consistently applied (Khan et al., 2017) [15].

The microbiological profile of HAIs in our ICU was dominated by Gram-negative organisms, particularly Klebsiella pneumoniae and Acinetobacter baumannii. This predominance mirrors findings from European and Southeast Asian studies, where Gram-negative bacteria accounted for nearly half of all HAIs, especially in VAP and UTIs (Ling et al., 2015) [16]. The increasing isolation of non-fermenting Gram-negative bacilli, especially Acinetobacter spp., has also been reported by the SENTRY Antimicrobial Surveillance Program, which documented Acinetobacter as a significant ICU pathogen across the United States and Europe (Sader et al., 2014) [17].

Antimicrobial resistance patterns observed in the present study are particularly concerning. The prevalence of multidrug-resistant (MDR) organisms was 45.66%, comparable to reports indicating that 50–60% of HAIs in developed countries are caused by resistant pathogens (Bereket et al., 2012) [18]. High rates of extended-spectrum beta-lactamase (ESBL) production among E. coli (51.1%) and K. pneumoniae (60.3%) in our study are consistent with data from European hospitals, where ESBL-producing Enterobacteriaceae have been increasingly reported in ICU settings (Eriksen et al., 2005) [19].

Carbapenem resistance was alarmingly high among A. baumannii isolates (95.1%), which is higher than rates reported for P. aeruginosa (29.8%) and K. pneumoniae (18.2%) in our study. Similar trends have been reported in multicenter European analyses, where A. baumannii demonstrated the highest resistance rates and was associated with poor clinical outcomes (Cassini et al., 2016). The relatively preserved carbapenem susceptibility among P. aeruginosa in our ICU contrasts with findings from some Asian studies reporting resistance rates exceeding 40%, highlighting regional variations in resistance patterns (Ling et al., 2015).

Overall, the findings of this study are consistent with global evidence demonstrating that ICUs are epicenters for HAIs and antimicrobial resistance. The convergence of high device utilization, predominance of Gram-negative pathogens, and rising

MDR rates underscores the urgent need for sustained surveillance, strict infection prevention bundles, and robust antimicrobial stewardship programs. Continuous monitoring of local resistance trends and judicious antibiotic use remain essential to curb the growing burden of HAIs in intensive care settings.

Conclusion

The present retrospective surveillance study highlights the substantial burden of healthcare-associated infections among ICU patients, with device-associated infections forming the majority. Ventilator-associated pneumonia emerged as the most frequent HAI, followed by catheter-associated urinary tract infections and central line-associated bloodstream infections, underscoring the pivotal role of invasive devices in infection occurrence. The predominance of Gram-negative pathogens, particularly Klebsiella pneumoniae and Acinetobacter baumannii, along with high rates of multidrug resistance and ESBL production, reflects a significant therapeutic challenge. These findings emphasize the need for continuous ICU-based surveillance, strict adherence to infection prevention bundles, and strengthened antimicrobial stewardship practices. Targeted interventions based on local epidemiological data are essential to reduce HAI rates, limit antimicrobial resistance, and ultimately improve patient outcomes and the quality of critical care services.

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