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Article

Prevalence and Types of Hospital-Acquired Infections in ICU Patients at a Tertiary Hospital in the Eastern Cape, South Africa

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Abstract: Hospital-acquired infections (HAIs) are a critical challenge in intensive care units (ICUs), contributing to significant morbidity, mortality, and healthcare costs. This retrospective cross-sectional study evaluated the prevalence, types, and risk factors for HAIs among 113 ICU patients at Nelson Mandela Academic Hospital, Mthatha, South Africa, admitted between January 2020 and December 2022. Patients included were hospitalized for more than 48 hours. Data analyzed encompassed demographics, ICU stay duration, HAI types, microorganisms, invasive device use, comorbidities, and outcomes. The cohort's median age was 33 years, with 61.1% having chronic illnesses. The ICU mortality rate was 26.5%. All patients had urinary catheters, and 53.1% used multiple invasive devices, including mechanical ventilation and central lines. Catheter-associated urinary tract infection (CAUTI) was the most common HAI, followed by surgical site infection, ventilator-associated pneumonia, and central line-associated bloodstream infection. The *Acinetobacter baumannii* complex was the predominant pathogen. Logistic regression revealed intravenous central lines as a significant risk factor for HAIs, with CAUTI strongly linked to ICU mortality ($p < 0.001$). These findings highlight the urgent need for targeted infection prevention strategies, focusing on invasive medical device management to reduce HAI prevalence and associated mortality in ICU settings.

Keywords: hospital-acquired infections; ICU; prevalence catheter-associated urinary tract infection; infection prevention

1. Introduction

Hospital-acquired infections (HAIs), also known as healthcare-associated infections, refer to infections that are neither present nor incubating at the time of hospital admission but manifest 48 hours or more after hospitalization [1]. These infections include those that affect healthcare workers and infections detected post-discharge if they are linked to the healthcare environment [2,3]. Major organizations such as the Centers for Disease Control and Prevention (CDC), through the National Healthcare Safety Network (NHSN), actively monitor and guide the prevention of HAIs to enhance patient safety and improve healthcare outcomes [4].

The most common HAIs are central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), surgical site infections (SSIs), ventilator-associated pneumonia (VAP), hospital-acquired pneumonia (HAP), and skin and soft tissue infections (SSTIs). The causative agents of these infections include multidrug-resistant (MDR) bacteria, viruses, and fungi [1,2]. Globally, approximately 5%-10% of hospitalized patients develop HAIs. In high-income

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countries, prevalence rates range from 4.5% in the United States to 7.5% in Europe, while low- and middle-income countries report significantly higher rates, ranging from 5.7% to 19.2% [2].

Several factors contribute to the occurrence of HAIs, including inappropriate use of antimicrobials, suboptimal hospital hygiene, and inadequate adherence to infection prevention protocols among healthcare workers and patients [5]. The risk factors are particularly pronounced in intensive care units (ICUs) due to the severity of illnesses, frequent use of invasive devices, and prolonged hospital stays. These include immunosuppression, advanced age, comorbidities, mechanical ventilation, recent invasive procedures, and prior use of intravenous antibiotics [6,7].

Despite advancements in healthcare and technology, HAIs remain a global challenge, causing significant morbidity and mortality, extended hospital stays, and increased healthcare costs [8,9]. Moreover, HAIs facilitate the selection and spread of MDR pathogens, further complicating treatment and containment [9]. Recent studies have highlighted the burden of HAIs in resource-limited settings, where surveillance and control measures are often inadequate. For instance, in sub-Saharan Africa, the prevalence of HAIs in ICUs ranges from 15% to 40%, with *Klebsiella pneumoniae, Acinetobacter baumannii*, and *Staphylococcus aureus* being common pathogens [10].

Effective prevention and control strategies for HAIs emphasize adherence to infection prevention guidelines, proper hand hygiene, and the judicious use of antimicrobials. Organizations such as the CDC and WHO have provided comprehensive protocols aimed at reducing HAI prevalence, including surveillance systems and the implementation of evidence-based practices [11,12]. However, in many regions, including South Africa, there is limited data on the prevalence and types of HAIs, particularly in ICUs.

This study aims to determine the prevalence and types of HAIs among patients admitted to the ICU at Nelson Mandela Academic Hospital (NMAH) in Mthatha, Eastern Cape, South Africa. The findings will contribute to the growing body of evidence needed to inform targeted interventions for HAI prevention and control in similar settings.

2. Methods

2.1. Study Design and Setting

This retrospective cross-sectional study analyzed hospital records of patients admitted to the ICU for various medical conditions between January 2020 and December 2022 at Nelson Mandela Academic Hospital (NMAH) in Mthatha, Eastern Cape, South Africa. The NMAH is a central academic hospital located in Mthatha, the main city of the King Sabata Dalindyebo Municipality in the rural northeastern region of the Eastern Cape Province, South Africa. The hospital's adult intensive care unit (ICU) comprises eight ICU beds and six high-dependency care beds.

2.2. Population and Sampling

The study population comprised patients admitted to the adult Intensive Care Unit (ICU) of Nelson Mandela Academic Hospital for more than 48 hours between January 2020 and December 2022. Secondary data for this study were obtained from the clinical records of these patients, following ethical approval (HREC: 062/2023) and the Eastern Cape Department of Health (EC_202308_025). A simple random sampling method was employed to select 113 clinical records. Patients with incomplete medical records were excluded from the study. The dataset included information on the participants' demographic characteristics, length of hospitalization (LOH), types of healthcare-associated infections (HAIs), associated microorganisms, use of invasive medical devices (IMDs), underlying health conditions (UHCs), and patient outcomes. Relevant data were systematically reviewed and recorded in an Excel spreadsheet to establish a structured dataset for statistical analysis. This method ensured efficient data handling, organization, and preparation for subsequent statistical processing, with an emphasis on standardizing the extracted data to ensure its accessibility and readiness for analysis.

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2.3. Data Analysis

Hospital records of ICU patients at Nelson Mandela Academic Hospital, Mthatha, were analyzed using IBM SPSS version 20 (IBM Corporation, Armonk, NY, USA). Descriptive statistics summarized the data, with results presented in graphs and tables. The Shapiro–Wilk test assessed the normality of quantitative data. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and as median with interquartile range (IQR) for non-normally distributed data. Comparisons between two groups were conducted using the student's t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Categorical variables were presented as frequencies and proportions, with comparisons made using Fisher's exact test, Pearson's chi-square test, or the chi-square test, as appropriate. Logistic regression analysis was performed to identify independent determinants of prolonged ICU admission and factors associated with healthcare-associated infections (HAIs). A p-value of < 0.05 was considered statistically significant for all analyses.

2.4. Ethical Considerations

Although the research used secondary data with no risk to patients, all due ethical processes were observed. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Postgraduate Education, Training, and Research Ethics Committee, Faculty of Medicine and Health Sciences, Walter Sisulu University (HREC: 062/2023) and the Eastern Cape Department of Health (EC_202308_025).

3. Results

Socio-Demographic Characteristics of ICU Patients

A total of 113 patients were included in this retrospective study. The patients' ages ranged from 13 to 80 years, with a median age of 33 years. The majority (53.1%) were between the ages of 13 and 34 years. Male patients constituted slightly more than half of the study population (51.1%). Additionally, 61.1% of the patients had at least one underlying chronic illness, such as diabetes, hypertension, chronic renal failure, or other conditions. Of the total patient cohort, 26.5% succumbed during their ICU stay (Table 1).

Table 1. The socio-demographics of patients admitted in the ICU (113).

Variables	**Number of patients**	**Percent**
Age		
13-34	60	53.1
35-60	36	31.9
>60	17	15.0
Gender		
Male	60	51.1
Female	53	46.9
Underlying health conditions		
Yes	69	61.1
No	44	38.9
Outcome		
Discharged	83	73.5
Demised	30	26.5

Invasive Medical Device Usage Among ICU Patients

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All 113 patients in the study had urinary catheters during their ICU admission. More than half of the patients (53.1%, 60/113) utilized a combination of all three invasive medical devices (mechanical ventilation, urinary catheter, and intravenous central line). Additionally, 20 patients had only a urinary catheter, while 14 patients used both urinary and intravenous (IV) catheters (Table 2).

Table 2. Frequency of use of invasive medical devices among patients.

Types of invasive device	**Number of patients**	**Percentage**
Ventilation and urinary catheter	20	17.7
Ventilation, urinary, and IV catheters	60	53.1
Urinary catheter alone	19	16.8
Urinary catheter and IV catheter	14	12.4
Total	113	100

Distribution and Types of Hospital-Acquired Infections

Catheter-associated urinary tract infection was the most common HAI (8/25) followed by surgical site infection and ventilator-associated pneumonia (7/250 and central line bloodstream infection (6/25) (Table 3).

Table 3. Distribution and types of hospital-acquired infections.

Type of HAI	**Number of patients with HAI**	**Percent (%)**
CAUTI	8	16.33
CLABSI	6	9.84
SSI	7	8.54
VAP	7	11.48

***CAUTI**- Catheter-associated urinary tract infection. **CLABSI**- Central line-associated bloodstream infection. **SSI**- Surgical site infection. **VAP**- Ventilator-associated pneumonia.

Distribution of Isolated Microorganisms

The most frequently isolated microorganism among patients with HAIs was *Acinetobacter baumannii* complex, accounting for 8 cases (47%). This was followed by Coagulase-Negative *Staphylococci*, identified in 3 cases (17%). Other isolated pathogens included *Staphylococcus aureus*, *Escherichia coli*, and *Candida* species, each contributing 1 case (6%) (Figure 1).

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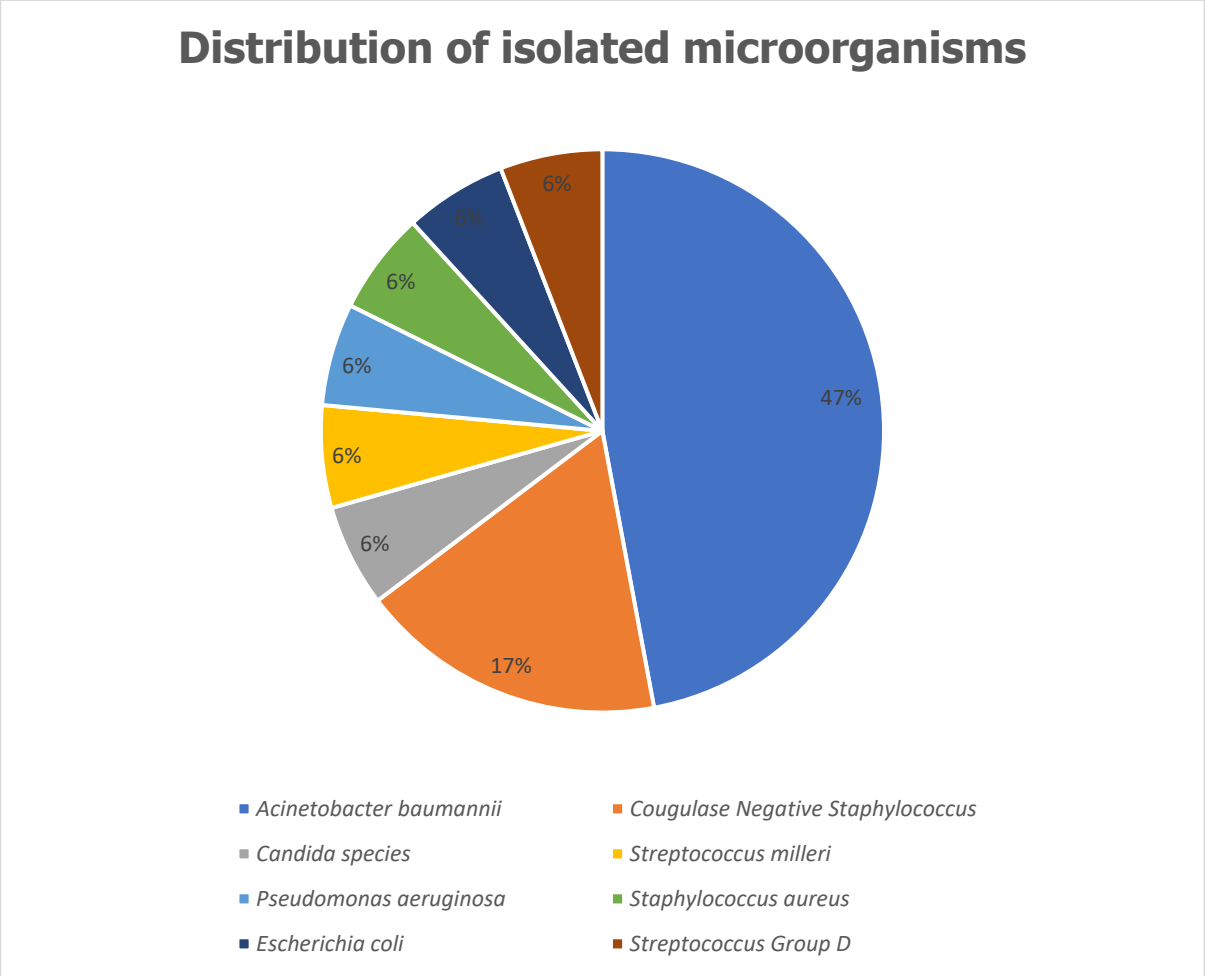

Figure 1. Distribution of isolated microorganisms.

Hospital-Acquired Infections and Types of Invasive Medical Devices

Among patients who developed HAIs, 85% (21 out of 25) had all three invasive medical devices: mechanical ventilation, urinary catheter, and intravenous catheter. This represents a proportion of 35% (21 out of 60) of patients in this category. The prevalence of HAIs in this group was significantly higher compared to other categories (p = 0.02, Table 4).

Table 4. Frequency of hospital-acquired infections according to the types of invasive medical devices.

Types of invasive device	Number of patients with HAI	Proportion	Chi-square	p-value
Ventilation urinary catheter	2/20	0.10	17.387	***0.002***
Ventilation, urinary, and IV catheters	21/60	0.35		
Urinary catheter alone	1/19	0.05		
Urinary catheter and IV catheter	1/14	0.071		

Factors Associated with Hospital-Acquired Infections

A univariate analysis was conducted to identify factors associated with the occurrence of HAIs, including gender, age, underlying health conditions, use of invasive medical devices, and length of stay in the ICU. Among these factors, only the length of ICU stays, and the use of invasive medical devices demonstrated a significant association with the development of HAIs (Table 5).

Table 5. Factors associated with hospital acquired infections.

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Variable	Hospital Acquired Infections		Chi-square	p-value
	Positive	Negative		
Gender				
Male	14	46	0.109	0.702
Female	11	42		
Age				
≤35	13	51	0.281	0.596
>35	12	37		
UCHC				
Present	10	32	0.110	0.74
Absent	15	56		
IMD				
Ventilation	3	36	7.199	*0.007*
IV Catheter	22	52		
Days in ICU				
≤7 days	13	68	6.126	*0.013*
>7 days	12	20		

Patients' Outcome

Catheter-associated urinary tract infection (CAUTI) was the only infection significantly associated with mortality in the ICU. Among participants with CAUTI, 87.5% (7/8) died, compared to 21.9% (23/105) of those without CAUTI ($p < 0.001$). In contrast, central line-associated bloodstream infection (CLABSI) ($p = 0.573$), surgical site infections (SSI) ($p = 0.900$), and ventilator-associated pneumonia (VAP) ($p = 0.058$) showed no significant association with mortality due to hospital-acquired infections (HAIs) (Table 6).

Table 6. Patients outcome according to the type of hospital acquired infections.

Type of HAI	Participant's outcome		Chi-square	p-value
	Demised	Discharged		
CAUTI				
Positive	7	1	16.402	*<0.001*
Negative	23	82		
CLABSI				
Positive	1	5	0.317	0.573
Negative	29	78		
SSI				
Positive	2	5	0.016	0.900
Negative	28	78		
VAP				
Positive	3	7	3.582	0.058
Negative	26	80		

The Association Between Underlying Health Conditions and Outcome

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71 (62.8%) of the 113 participants had an underlying health condition before admission to ICU. There was no association between the underlying health conditions and the patients' outcomes (p=0.165) (Table 7).

Table 7. Participants' outcome stratified by the presence of underlying chronic illness before admission to ICU.

		Underlying health conditions				
		Present	**None**	**Total**	**Chi-square**	**p-value**
Outcome	Discharged	49	34	83	1.929	0.165
	Demised	22	8	20		
Toal		71	42	113		

4. Discussion

This retrospective study included 113 patients, with ages ranging from 13 to 80 years and a median age of 33 years. The majority (53.1%) were between the ages of 13 and 34 years, and slightly more than half of the cohort were male (51.1%). A significant proportion of patients (61.1%) had at least one underlying chronic illness, such as diabetes, hypertension, or chronic renal failure. During their ICU stay, 26.5% of the patients succumbed to their condition (Table 1). All patients had urinary catheters during their ICU admission. Over half (53.1%) of the patients used a combination of three invasive devices: mechanical ventilation, urinary catheter, and intravenous central line. Additionally, 20 patients used only a urinary catheter, while 14 patients used both urinary and intravenous catheters (Table 2).

The most common hospital-acquired infection (HAI) was catheter-associated urinary tract infection (CAUTI), observed in 8 out of 25 patients, followed by surgical site infection (SSI) and ventilator-associated pneumonia (VAP), each occurring in 7 out of 25 patients, and central line-associated bloodstream infection (CLABSI) in 6 out of 25 patients (Table 3). The predominant pathogen isolated was *Acinetobacter baumannii* complex (47%), followed by Coagulase-negative *Staphylococci* (17%), with fewer cases of *Staphylococcus aureus*, *Escherichia coli*, and *Candida* species (6% each) (Figure 1).

Among patients who developed HAIs, 85% (21 out of 25) had all three invasive medical devices, representing 35% of the 60 patients in this category. This group had a significantly higher prevalence of HAIs compared to others ($p = 0.02$, Table 4). A univariate analysis revealed that the length of ICU stays, and use of invasive medical devices were significantly associated with the occurrence of HAIs. Logistic regression identified the invasive intravenous central line as the sole independent risk factor for acquiring HAIs. Regarding mortality, CAUTI was significantly associated with ICU mortality: 87.5% of patients with CAUTI died, compared to 21.9% of those without CAUTI ($p < 0.001$). Other infections (CLABSI, SSI, and VAP) did not show significant associations with mortality. Of the 113 participants, 71 (62.8%) had underlying health conditions, but these conditions were not significantly associated with patient outcomes ($p = 0.165$).

The findings of this study are consistent with those from other studies examining hospital-acquired infections (HAIs) in ICU settings. Like our study, previous research has identified CAUTI as a leading cause of HAIs in ICU patients [13,14], with mechanical ventilation and central venous lines being the most common risk factors [15]. The association between the use of invasive devices and HAIs is well-established [16], and our study's logistic regression analysis corroborates these findings, particularly the role of intravenous central lines as an independent risk factor for HAIs.

However, unlike studies that found a broader range of underlying health conditions linked to poor outcomes [17], our study did not find significant associations between underlying chronic illnesses and mortality or HAI occurrence. This difference could be due to variations in patient populations or healthcare practices, such as infection control measures, which may mitigate the effects of pre-existing conditions in some ICU settings [18].

The higher mortality associated with CAUTI in this study aligns with findings by Al-Hasan and colleagues [19], who reported that CAUTI significantly increased ICU mortality rates. This contrasts

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with some studies, where the impact of CAUTI on mortality was less pronounced [20]. Differences in patient demographics, infection severity, and management strategies may account for these disparities.

5. Conclusion

This study highlights the critical role of invasive medical devices, particularly the intravenous central line, in increasing the risk of hospital-acquired infections in ICU patients. CAUTI emerged as a key factor associated with mortality, emphasizing the need for improved infection prevention strategies in ICU settings. The findings are largely consistent with existing literature, although further research is needed to understand the varying impacts of underlying conditions and the specific pathogens involved in ICU-associated infections.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Postgraduate Education, Training, and Research Ethics Committee, Faculty of Medicine and Health Sciences, Walter Sisulu University (HREC: 062/2023) and the Eastern Cape Department of Health (EC_202308_025).

Informed Consent Statement: Informed consent for this study was not obtained from the subjects involved because the research involved no risk to the subjects. The primary data were collected for purposes of patient management, not for research, and were de-identified to reduce the risk to privacy.

Data Availability Statement: The data that support the findings of this study are not publicly available due to privacy and ethical restrictions. The data contains sensitive information that could compromise the privacy of the research participants. As such, access to these data is restricted and Trop. Med. Infect. Dis., and can only be provided upon reasonable request to the corresponding author, subject to approval by the relevant ethics review board.

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Conflicts of Interest: The author declares no conflicts of interest from any quarters. This study was not funded; it was purely the authors' initiative to research an issue that is under-researched within the province.

Authors' contributions: SJ: data acquisition, and development of manuscript; **CBB**: data analysis, interpretation of data, and manuscript development; **DTA:** conception and design of the work; data acquisition, manuscript development, proofreading of the final manuscript, and corresponding author.

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