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Epidemiological Aspects of Nosocomial Infections in the Intensive Care Unit of the Akanda Army Training Hospital in Gabon from 2019 to 2022

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Abstract

Introduction: The development of preventive and therapeutic strategies to combat nosocomial infections (NI) in intensive care involves monitoring their microbial ecology, studying their antibiotic resistance and their transmission modalities. The aim of our study was to analyze the epidemiological aspects of NI in patients hospitalized in intensive care from 2019 to 2022. **Patients and Method:** A retrospective study, with descriptive and analytical aims, was carried out on 493 records of patients hospitalized in intensive care from January 2019 to December 2022. Included were all patients hospitalized for more than 48 hours in intensive care with confirmed presence of an IN. Clinical, biological, paraclinical and therapeutic information was collected on a standardized Epi-Info 7.3 form and analyzed by Excel Microsoft Office 2019. **Results:** The rate of IN was 11.7% (58/493 patients) for a mean time of onset of 10.5 days. Of the 78 cases of IN recorded, 42% had a urinary location and 34% pulmonary. The bacteriological profile of the 79 germs was composed of 77% Gram-negative bacilli (GNB), 22.7% Gram-positive cocci (GPC). The main urinary germs were Escherichia coli, Klebsiella pneumoniae in 31.4%, at the pulmonary level *Acinetobacter baumanii* in 29.6%, Klebsiella pneumoniae and Pseudomonas aeruginosa in 14.8%. BMR represented 39.2% of the isolated strains, ESBL Enterobacteriaceae 45.1%, *Acinetobacter baumanii* 29%, Pseudomonas Aeruginosa 25.8%. Methicillin-resistant Staphylococci aureus (MRSA) were not found. **Conclusion:** The majority of NIs are due to invasive medical devices. Handling remains the main culprit. Enterobacteriaceae dominate, with Klebsiella pneumoniae, Escherichia coli, and *Acinetobacter baumanii* (BMR) at the top of the list. Resistance to commonly used antibiotics (ATBs) and the low availability of suitable ATBs constitute a significant mortality factor. Therefore, measures to curb the emergence of resistant pathogens must be adopted.

Keywords

Nosocomial Infection (NI), Multi-Resistant Bacteria (MRB), Methicillin-Resistant Staphylococci Aureus (MRSA), Gram-Negative Bacilli (GNB), Resuscitation

1. Introduction

The existence of a significant reservoir of multi-resistant bacteria (MRB) in intensive care associated with invasive procedures performed on patients who are often in critical condition contributes to increasing the risk of nosocomial infection (NI) [1]-[3]. Considered to be avoidable, studies on NI contribute to the development of preventive strategies [4] [5]. Several European or African studies, including Gabon, have carried out epidemiological monitoring of these NI [6]-[16]. This study aims to update our data and aims to analyze the bacteriological profile of NI.

Exclusion criteria

Incomplete files and severe burns. Among the operational definitions.

Data collection

Data were recorded on a standardised individual form designed in Epi-info7, which included information from medical records and the bacteriology department register. These data included age, sex, origin, clinical data such as: reason for hospitalisation, comorbidities, IGSII score, temperature, oxygen saturation, heart and respiratory rates. Paraclinical data included complete blood count (CBC), C-reactive protein (CRP), procalcitonin (PCT), bacteriological examination associated with antibiogram, therapeutic data such as initial antibiotic therapy, invasive procedures, secondary antibiotic therapy, and evolutionary data such as length of hospitalisation and outcome.

Statistical analysis

The tables and data analysis were performed using EPI INFO 7.3 software and Microsoft Office Excel 2019. The association between qualitative variables was made according to percentages with confidence intervals (CI) and the Chi-square test. In univariate and bivariate analysis with the Mac Nemar Chi-square test, significance was set at $p < 0.05$.

Ethical considerations

The study was conducted with the prior consent of the Chief Medical Officer, Commander of the HIAA, and Head of the HIAA Resuscitation Department, and it was conducted in accordance with patient anonymity.

2. Results

Among the 619 patients admitted to the HIAA intensive care unit during the study period, the length of stay was 48 hours or more in 493 patients, of whom 58 patients developed a nosocomial infection (NI), representing a hospital prevalence of 11.7% (Figure 1). Among these patients, some had multiple episodes of nosocomial infections during the study period.

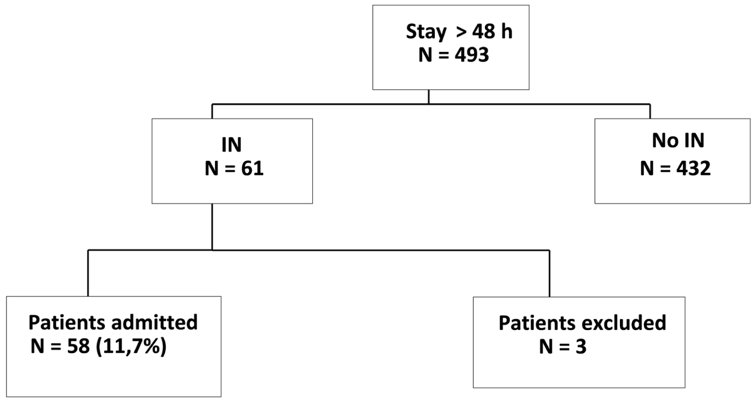


Figure 1. Flow chart.

The median age of patients was 51 ± 17 years, with extremes ranging from 7 to 83 years, and the most represented age group was [52 - 67], accounting for one third of cases. The sex ratio was 0.7, with 56.9% of patients being female (Figure 2).

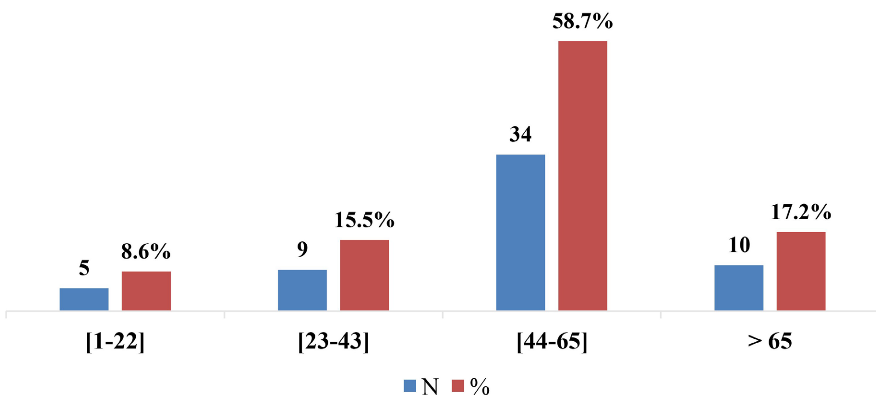


Figure 2. Distribution of patients by age group.

Of the patients included, 70.6% had comorbidities, with high blood pressure (HBP) being the most common at 41.4%, followed by diabetes at 17.2% (Table 1).

Medical conditions accounted for nearly all cases, or 67.2% of the reasons for hospitalisation (Table 2). The average IGSII score was 28, with extremes of 6 and 51.

Table 1. Distribution of comorbidities.

Comorbidities	Number (N)	Percentage
HTA	24	41.4
Diabetes	10	17
Obesity	1	1
HIV	2	3
Pregnant	1	1.7
Sickle cell anaemia	1	1
Asthma	2	3
Neoplasia	1	1.7
None	17	29.3

Table 2. Distribution of patients according to reason for hospitalisation.

Conditions		Number (N)	Percentage
Medical conditions	COVID-19	39	6
	Altered mental status (AMS) due to fever	8	1
	Stroke	4	6
	Acute pulmonary oedema (APO) following drowning	1	1
	Tetanus	1	1
Surgical pathology	Post-traumatic multiple injuries Road traffic accident (RTA)	3	5
	Post-operative surgery Scheduled	2	3.4

All patients had a urinary catheter and a nasogastric tube (NGT), and more than half had orotracheal intubation (OTI), *i.e.* 55.1% (n = 32). The average duration of mechanical ventilation was 17.5 days, ranging from 4 to 32 days (Table 3).

Table 3. Distribution of patients according to medical devices.

Medical devices	Number (N)	Percentage
Urinary catheter	5	1
SNG	58	100
Orotracheal intubation	32	55
Central venous access (CVA)	42	72
Oxygen glasses and mask	2	44.8

Antibiotic therapy was initiated in 47 patients (81%) at the start of hospitalisation, with ceftriaxone/ciprofloxacin in 67.2% of cases, amoxicillin-clavulanic acid in 8.6% and metronidazole in 5.1%. The average time to onset of NI was 10.5 days, with extremes of 3 and 46 days. One-third of patients, or 21.7% (n = 18), developed NI within 3 to 4 days (Table 4).

Table 4. Time to onset of nosocomial infection in days.

Time in days	Number (N)	Percentage
[3 - 5	18	21
[5 - 7	17	20
[7 - 10	14	16.8
[10 - 15	17	20.5
[15 - 46	17	20

Among the 78 cases of NI found, 42.2% (n = 35) were urinary and 33.7% (n = 28) were pulmonary (Figure 3).

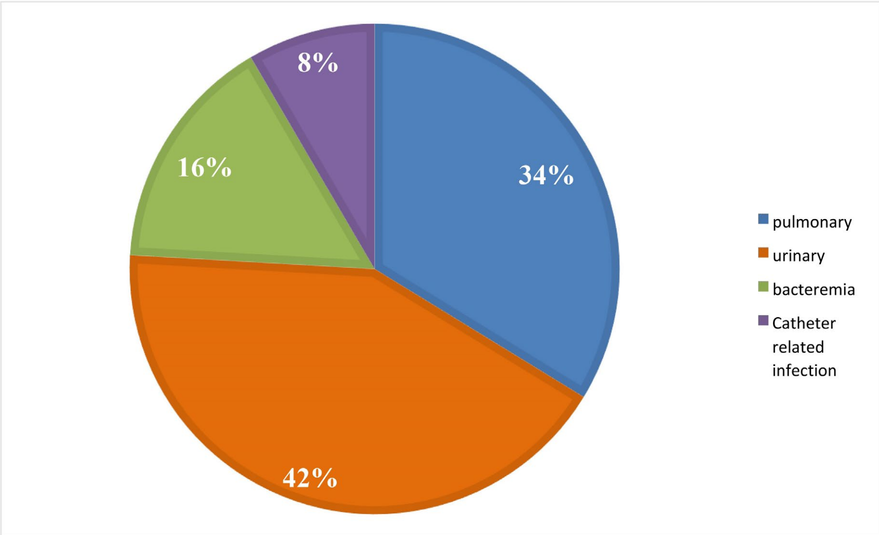


Figure 3. Site of NI.

Of the 83 episodes of NI, 79 bacteria were isolated, of which 77.2% (n = 61) belonged to Gram-negative bacilli (GNB) and 22.7% (n = 18) to Gram-positive cocci (GPC). *Klebsiella pneumoniae* was responsible for 17 isolates, followed by *Escherichia coli* and *Acinetobacter baumannii*, present in 14 and 12 isolates, respectively.

For PCG, *Staphylococcus aureus* was found in 5 isolates (Table 5).

In the lungs, the most common bacteria were Escherichia coli and *Klebsiella pneumoniae*. In the lungs, we found, in order of frequency, *Acinetobacter baumanii*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* (Table 6).

Table 5. Distribution of the different isolated germs.

Germs		Number (N)	Percentage
BGN	*Klebsiella pneumoniae*	17	2
(n = 61; 77%)	*Escherichia coli*	1	17
	Acinetobacter baumannii	12	15
	Pseudomonas aeruginosa	10	12.6
	Enterobacter claocae	3	3

Continued

	Pseudomonas luteale	2	2
	Pseudomonas spp	2	2
	Morganella morganii	1	1
	Proteus mirabilis	1	1
CGP	*Staphylococcus aureus*	5	6
(n = 17; 23%)	*Staphylococcus xylosus*	4	5
	Staphylococcus haemolyticus	3	3
	Staphylococcus saprophyticus	3	3
	Staphylococcus epidermidis	1	1.2
	Staphylococcus spp	2	2.5

Table 6. Distribution of the number of germs according to location.

Location	Germs	N	%
Urinary	*Escherichia coli*	11	3
(n = 35; 44.3%)	*Klebsiella pneumoniae*	1	31.4
	Pseudomonas aeruginosa	5	14.3
	Acinetobacter baumannii	3	8.6
	Pseudomonas luteale	1	2.8
	Staphylococcus homoliticus	1	2.8
	Staphylococcus aureus	1	2.8
	Escherichia claocae	1	2
	Staphylococcus xylosus	1	2.8
Pulmonary	*Acinetobacter baumannii*	8	29
(n = 27; 34.2%)	*Pseudomonas aeruginosa*	4	14.8
	Klebsiella pneumoniae	4	14.8
	Staphylococcus aureus	3	11.1
	Staphylococcus xylosus	2	7.4
	Escherichia coli	1	3.7
	Pseudomonas luteale	1	3
	Morganella morganu	1	3.7
	Escherichia coli	1	3
	Pseudomonas mirabilis	1	3.7
	Pseudomonas spp.	1	3
Bacteremia	*Klebsiella pneumoniae*	3	30
(n = 10; 12.6%)	*Staphylococcus spp.*	2	2
	Staphylococcus aureus	1	1
	Staphylococcus epidermis	2	2
	Staphylococcus xylosus	1	1
CRI	*Staphylococcus haemolyticus*	2	2
(n = 7; 8.8%)	*Staphylococcus saprophyticus*	1	1

Continued

Acinetobacter baumannii	1	14.2
Escherichia coli	2	28.7
Escherichia claocae	1	1

Of the 79 isolated germs, one-third were sensitive to piperacillin/tazobactam, imipenem, fosfomycin and amikacin in 28.4%, 27%, 25.7% and 24.3% of cases, respectively. Regarding the sensitivity profile:

- *Klebsiella pneumoniae* was resistant to piperacillin/tazobactam in 14.3% of cases, to gentamicin in 50% of cases, and to tetracycline in 28.6% of cases. However, it remained susceptible to imipenem in 94% of cases and to amikacin in 79% of cases (**Figure 4**).
- *Escherichia coli* was resistant to ofloxacin, ciprofloxacin, amikacin and ampicillin at 77%, 76.9%, 62.9% and 15.4%, respectively. However, sensitivity to carbapenems was noted, particularly 78% to imipenem and 62% to meropenem, and fosfomycin remained highly active at 85% (**Figure 5**).
- *Acinetobacter baumanii* was resistant to 50% of imipenem, 70% of ticarcillin and more than 50% of the beta-lactams tested and to quinolones for *Acinetobacter baumanii*. Aminoglycosides remain sensitive to amikacin at 50% and tobramycin at 40% (**Figure 6**).
- *Staphylococcus aureus* had an 80% resistance to gentamicin and 40% to levofloxacin and ofloxacin. However, sensitivity to tetracycline was 60% and to vancomycin 40% (**Figure 7**).

In our series, multidrug-resistant bacteria (MDR) accounted for 39.2% (n = 31) of the isolated strains (**Table 7**). Extended-spectrum beta-lactamase-producing Enterobacteriaceae (ESBL) accounted for 45.1% (n = 14). Multiresistant *Acinetobacter baumanii* accounted for 29% (n = 9) and ceftazidime-resistant *Pseudomonas aeruginosa* accounted for 25.8% (n = 1). No methicillin-resistant *Staphylococcus aureus* (MRSA) was found.

Table 7. Distribution of isolated BMRs.

MRB	N	%
Enterobacteriaceae ESBL	1	4
Klebsiella pneumoniae	5	16
Escherichia coli	5	16.1
Enterobacter claocae	3	9.6
Morganella morganii	1	3.2
***Acinetobacter baumanii* multi-resistant**	9	2
***Pseudomonas aeruginosa* resistant to ceftazidime**	8	25.8

Of the 83 cases of NI, antibiotic therapy was appropriate in 39.2% (n = 29) of cases, and the combination of imipenem/amikacin was effective in 48.2% (**Figure 8**).

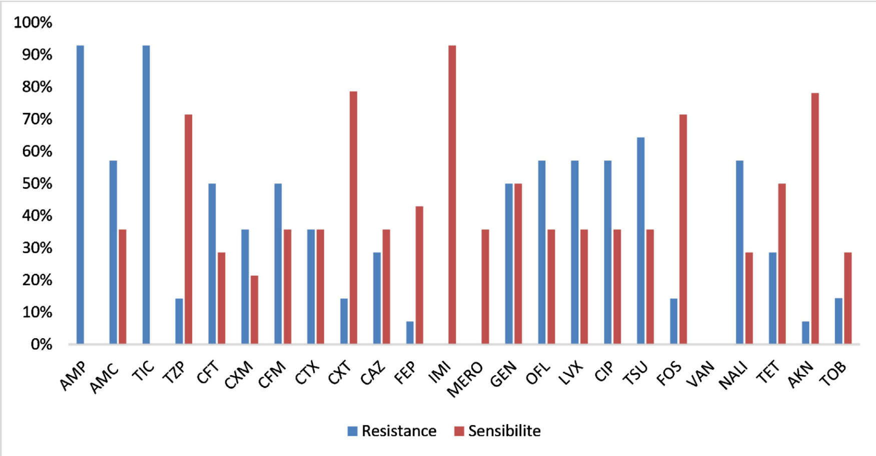


Figure 4. Sensitivity and resistance profile of *Klebsiella pneumoniae.*

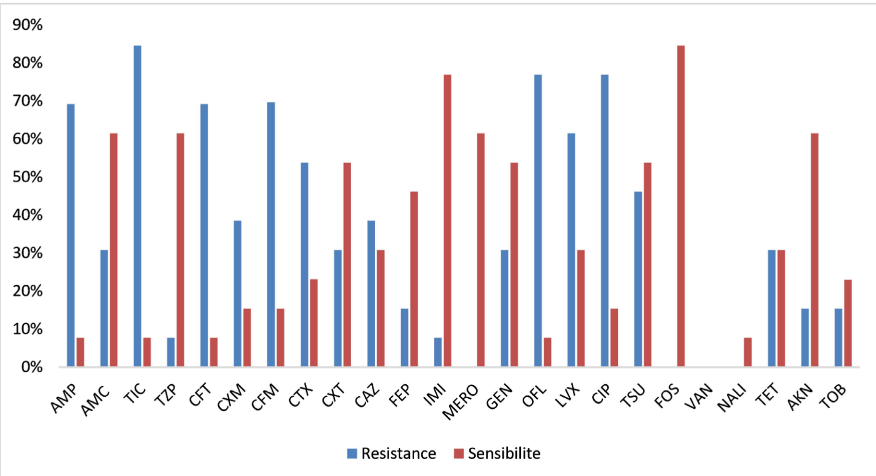


Figure 5. Sensitivity and resistance profile of *Escherichia coli.*

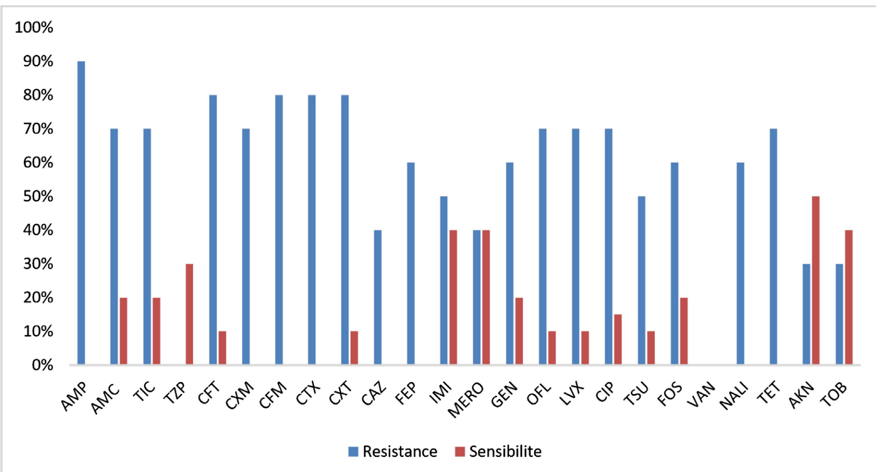


Figure 6. Sensitivity and resistance profile of *Acinetobacter baumannii.*

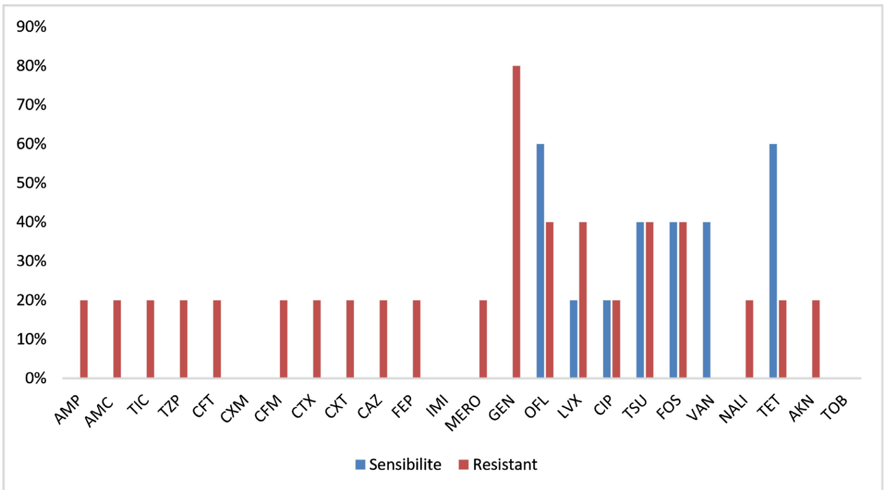
During the study, 27 deaths were recorded, representing 47% of cases.

A bivariate analysis revealed that risk factors for NI included female gender, that its occurrence was not correlated with comorbidities or the reason for hospitalisation, and that its occurrence was significantly associated with the length of hospitalisation (Table 8).

In multivariate analysis, the poor prognostic factor found was length of hospital stay ranging from 42 to 47 days.

Table 8. Risk factors for the occurrence of hospital-acquired infections.

			IN	
	Total	**N**	**OR [95% CI]**	**P**
Sex				
Male	243	34		
Female	250	49	1.71 [1.02 - 2.86]	**0.0394**
Age				0.5317
[0 - 22[	28	7	1	
[22 - 43[	85	15	0.64 [0.24 - 1.87]	0.40
[44 - 65[	155	48	1.35 [0.56 - 3.61]	0.53
>65	66	13	0.74 [0.26 - 2.19]	0.57
		IN		
	Total	**N**	**OR [95% CI]**	**p**
Intubation				<0.001
Yes	52	52		
No	199	26	0.13 [0.07 - 0.22]	
Comorbidities				
HYPERTENSION	145	24	3.34 [1.6 - 6.93]	0.8
Diabetes	74	10	37 [12.37 - 110.63]	
HIV	190	2		
Cancer	84	1	135.66 [28.43 - 647.23]	0.36
Reason for hospitalisation	173	39	1.56 [0.56 - 4.37]	0.36
COVID 19	20	8	0.66 [0.78 - 46.14]	
Febrile ACS	59	6	0.66 [0.18 - 2.46]	
STROKE				
Post-stroke polytrauma	12	4	2 [0.42 - 9.41]	
Length of hospital stay in days				
[1 - 15]	263	33	1	<0.001
[16 - 30]	46	27	9.90 [5.01 - 20.06]	<0.001
>30	25	23	80.15 [22.35 - 514.22]	<0.001



AMP: amoxicillin; AMC: amoxicillin + Clavulanic acid; TIC: ticarcillin; TZP: piperacillin + tazobactam; CFT: cefalotin; CXM: cefuroxime; CFM: cefexime; CTX: cefotaxime; CXT: cefoxitin; CAZ: ceftazidime; FEP: cefepime; IMI: imipenem; MERO: meropenem; GEN: gentamicin; OFL: ofloxacin; LVX: levofloxacin; CIP: ciprofloxacin; TSU: cotrimoxazole; FOS: fosfomycin; VAN: vancomycin; NALI: naliquidic acid; TET: tetracycline; AKN: amikacin; TOB: tobramycin.

Figure 7. Sensitivity and resistance profile of *Staphylococcus aureus.*

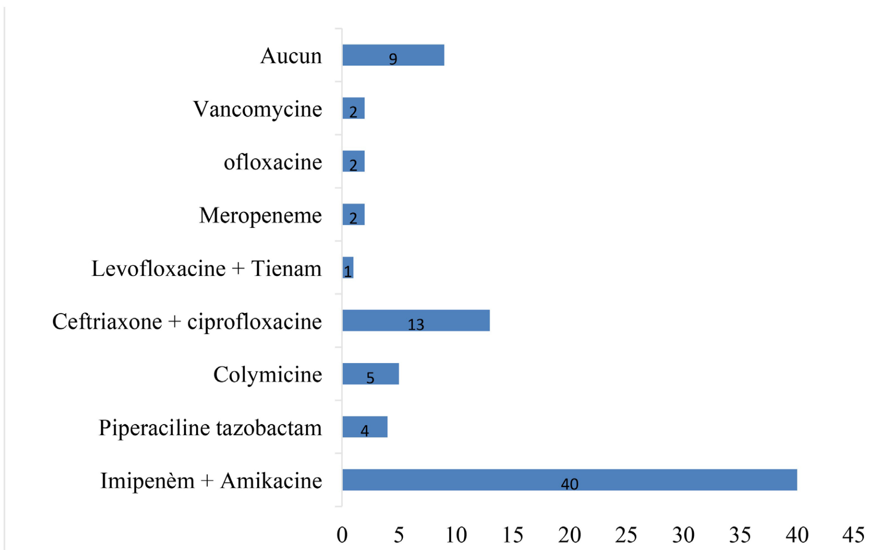


Figure 8. Secondary antibiotic therapy.

3. Discussion

In this study, several limitations were identified and must be taken into account in order to fully appreciate the scope of the results.

Firstly, the quality of medical records was a major challenge, particularly due to the lack of identification of germs in some cases. This situation may have introduced a selection bias, limiting the representativeness and reliability of the data analysed. Furthermore, the limited availability of antibiotic discs, particularly those specific to the identification of MRSA, restricted the accuracy of the antibiogram tests. This constraint may have influenced the ability to detect certain resistance profiles, which could impact the interpretation of the results in terms of bacterial resistance.

The prevalence of NI in this study was 11.7%. This value was significantly associated with the results reported in several studies in the literature, notably in Cameroon in 2013 by Njall *et al.* (12%) [8], in Mali in 2019 by Abeghe (12.3%) [17], and in Morocco in 2014 by Maoulainine *et al.* (13%) [18]. This similarity could be related to the characteristics of the study population. Indeed, the mean age was 51 years and the mean length of hospital stay was 28 days in the present study, which is comparable to the studies by Abeghe and Njall *et al*, which had a mean age of 45.4 ± 20.8 years and 49.6 ± 1.8 years, respectively, a length of hospital stay of 21.7 ± 12.7 days and 11.7 ± 12.1 days. However, the prevalence observed in our study was lower than that identified in some studies, such as in Tunisia in 2018 by Merzougui *et al.* (30.6%) [5], in Algeria in 2022 by Benzaid *et al.* (59%) [19] and in Brazil in 2014 by Santos *et al.* (27.3%) [20]. This finding could be associated with differences in the methodological approach, as these studies were prospective and thus helped to limit case loss. Lower rates were found in China in 2019, France in 2012 and Nigeria in 2018, which reported pre valence rates of 7.6%, 9.7% and 2.4% respectively [21]-[23]. These rates could be explained by the fact that the technical facilities of these intensive care units are much more advanced. This is particularly true of the existence of partitioned cubicles, the presence of water points in front of each cubicle and the fact that infectious risk control is very rigorous. Indeed, according to Gastmeier *et al.,* the prevalence of NI varies according to the level of technical expertise and the size of healthcare facilities [24].

Medical conditions were the most common, with COVID-19 at the top of the list, accounting for 67.2%. This predominance of medical conditions was also found in Gabon, by Baderhwa in 2019 and by Ossaga in 2016 in Senegal, with rates of 92.4% and 52% respectively [16] [24]. Contrary to the results observed by Merzougui *et al.* in Tunisia, Nzoghé Nguéma *et al.* in Gabon and Leye *et al.* in Senegal, for whom traumatic conditions were the main reason for admission, with rates of 53%, 27% and 28.8% respectively [5] [15] [25]. This difference can be explained by the fact that from 2020 to 2021, the HIAA's intensive care unit was specifically dedicated to the care of patients with severe COVID-19. The absence of a trauma unit within the HIAA also explains the low rate of traumatic pathology obtained.

The average time to onset of NI was 10.5 days. This time to onset is similar to that found in the study by Nouetchognou *et al.* in 2018 [26], which found an average of 11 days, and by Merzougui *et al.* in 2018, which was 10 ± 2 days [5]. A study by Njall *et al.* found an onset time for NI of 4.4 ± 3.2 days [8]. This could be explained by the nurse-to-bed ratio, which was >0.5. However, in the HIAA intensive care unit, this ratio was 0.4. A nurse-to-bed ratio > 0.5 significantly increases the risk of cross-infection [27]. Although our ratio could be improved to match that found in Australia, which was 0.2 [28]. In addition, the time taken to change certain invasive devices such as urinary catheters, CVV and endotracheal tubes had an impact on the time taken for NI to develop and occur.

Length of stay is an important risk factor for patients with HAI [28]. The most common length of stay was 10 - 20 days, with 24 positive samples. Our results are similar to those of Baderhwa in Gabon in 2019, Benzaid *et al.* in Algeria and Arnoni *et al.* in India, who found an average length of hospitalisation of 20.8 days ± 12.3 days, 12 - 21 days and 13 days, respectively [16] [19] [29]. This observation can be explained by the fact that the favourable outcome of patients with severe COVID-19 was only achieved ly after a fortnight in the absence of other organ failure. The onset of NI after 10 days was also a factor in prolonging the length of hospitalisation.

Urinary tract infection was the most common IN, at 42%. This predominance of urinary tract infections has also been described in the literature by Richard MJ *et al.* in the United States and by Branger *et al.* in France, who found rates of 31% and 40%, respectively [30] [31]. In Africa, particularly in Senegal and Mali in 2019, urinary tract infection also ranked first with rates of 47.85% and 46.1%, respectively [32] [33]. These authors indicated that urinary catheterisation was associated with the main risk of urinary tract infections. This can be explained by the fact that all patients were subject to bladder catheterisation. Several factors contributing to non-compliance with aseptic techniques during urinary catheterisation were identified in this survey. These included failure to follow written procedures for catheterisation, failure to systematically wash or rub hands before the procedure, and insufficient staffing.

Nosocomial pneumonia ranked second with a frequency of 34%. According to Touzani O., this observation can be explained in part by the fact that intubation increases the risk of nosocomial pneumonia (NP) by 7 to 21 times [34]. This reinforces our findings, where 54% of patients had IOT. Indeed, the majority of patients had severe pulmonary COVID-19 requiring mechanical ventilation (MV). Mechanical ventilation was not in itself a risk factor, but rather the management of intubated patients: failure to comply with suction schedules, which were not carried out in a closed suction system, requiring patients to be disconnected from the ventilator for repeated suctioning; failure to comply with aseptic measures during suctioning due to staff shortages. It is important to note that the suction catheter was reused on the same patient, even though it had previously been immersed in a Betadine-enriched water solution. We also regret the lack of asepsis of certain non-invasive oxygenation devices, such as bubblers, goggles and masks, which could be a source of contamination.

Bacteremia was the third most common type of infection, with a rate of 16%. This result is consistent with that of Abeghe TA, who found a rate of 14.8% [17]. This was explained by complications related to localised NI that spread due to delayed initiation of specific secondary treatment due to long waiting times for microbiological test results and reduced availability of antibiotics in hospital pharmacies. However, higher rates were found in the study by Dicko *et al.* and Savey A. *et al.*, with 44.8% and 21.9% respectively [32] [35]. This difference was explained by the low demand for blood cultures, as blood culture bottles are not provided by the hospital and are paid for by patients.

From a microbiological perspective, data from the literature show that 50 to 90% of nosocomial infections are bacteriologically confirmed [36]. In this survey, microbiological confirmation was performed on 79 of the 83 infectious episodes, with a predominance of BGN at 77.2%. This observation has also been made in several countries around the world, notably in China in 2018, France in 2001, Cameroon in 2013, and Mali in 2022, with respective LGB rates of 60.5%, 84.6%, 76.5% and 40.1% [1] [8] [31] [32]. Among the isolated bacteria, *Klebsiella pneumoniae* was the most common germ (21.5%), followed by Escherichia *coli* (17.7%), *Acinetobacter baumannii* (15.1%) and *Pseudomonas aeruginosa* (12.6%). Similar results were also found in several studies, but with different frequencies. A multicentre study conducted in 27 hospitals found, in descending order*, Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa* and *Klebsiella pneumoniae* [37], while a study by Iliyasu *et al.* in Nigeria found *Staphylococcus aureus* (41.7%), *Klebsiella pneumoniae* (21.4%) *and Escherichia coli* (15.5%) [38] [39]. Garba *et al.* in Niger found *Escherichia coli* (40%) followed by *Pseudomonas aerugenosa* (15.4%) [33]. In Gabon, this trend for *Klebsiella pneumoniae* was also described by Mandji *et al.* in 2008 at the OMAR BONGO Army Training Hospital (HIAOBO), by Nzoghé Nguéma *et al.* in 2015 at the AKANDA University Hospital Centre (CHUA), and in two studies conducted at the CHUL in 2013 and 2019, which found it at 59.2%, 38.8%; 57.1% and 23.3% [13]-[16]. These authors explain the predominance of BGN by: the use of unchlorinated tap water for cleaning patients and bedding; the lack of chlorhexidine during bathing. Indeed, it has been documented that daily chlorhexidine baths for patients can help control *Klebsiella* in hospitals [35]; hand contamination with faecal bacteria such as *Escherichia coli and Enterobacter due to a lack of* strict hand hygiene due to staff exhaustion*, as described in two studies conducted at the CHUL and in Niger in* 2019. These explanations were also found in our study. These explanations were also found in our study.

With regard to urinary tract infections, in descending order, we found *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Acinetobacter baumannii.* The most common pathogen found in the literature for nosocomial urinary tract infections (NUTIs) is *Escherichia coli* [39] [40]. According to some authors, this is justified by the fact that these infections are more common in female patients. This is the case in this study, where female patients predominated with a sex ratio of 0.7. This observation supports the theory of exogenous contamination linked either to the anatomical proximity of the perineum or to hand contamination during care. In the lungs, the main germs were *Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Staphylococcus aureus.* These results are consistent with the work of Qassimi and Amor *et al.*, who found *Acinetobacter baumannii* to be the predominant germ and *Pseudomonas aeruginosa* to be the second most common germ in PN according to these authors [41]-[42]. However, Shimi *et al.* found *Pseudomonas aeruginosa* to be the most common germ. GNB are responsible for more than 60% of PN [43]. More recent studies found *Acinetobacter baumannii* to be the most common germ [43]-[45]. These bacteria produce "slime" (a polysaccharide substance that promotes adhesion to the surface of inert materials), which increases their ability to colonise intubation tubes and, once implanted, to resist antibiotics and phagocytosis. The main germs responsible for nosocomial bacteraemia in our study were *Klebsiella pneumoniae, Staphylococcus spp* and *Staphylococcus aureus.* This is similar to the studies by Samake*,* who found a predominance of *Klebsiella pneumoniae,* followed by *Escherichia coli* and *Staphylococcus aureus,* and by Qassimi, who found a predominance of *Staphylococcus aureus* followed *by Klebsiella pneumoniae* [41]-[46]. However, Savey A *et al.* found a predominance of coagulase-negative Staphylococcus (22%) in bacteraemia [40]. Humans are the main reservoir of Staphylococcus aureus, whether they are sick or healthy carriers. Usually found on the skin, staphylococci can be transmitted by hand-to-hand contact. This difference in isolated germs between studies can be explained by the variability of bacterial ecology between structures.

BGNs are naturally resistant to a wide range of antibiotics. *Klebsiella pneumoniae* showed high resistance to penicillins, particularly 92.9% for ampicillin and 57.1% for amoxicillin clavulanic acid. It also showed resistance to quinolones, namely ofloxacin (50%) and ciprofloxacin (57.1%). However, imipenem, amikacin and piperacillin/tazobactam remained highly active at 92.9%, 78.1% and 71.4% respectively. These results are consistent with those of Ossaga in Senegal, who found *Klebsiella pneumoniae* sensitive to imipenem and amikacin at unspecified rates. Resistance of all strains to ampicillin and amoxicillin clavulanic acid was observed, while resistance to quinolones was 29.1% [24]. For *Escherichia coli*, sensitivity to beta-lactams was 76.9% for imipenem, 62% for amoxicillin + clavulanic acid and 61.5% for meropenem. Resistance to quinolones was 77% for ofloxacin and 76.9% for ciprofloxacin. Resistance to third-generation cephalosporins such as cefixime was 69.7%; cefotaxime was 53.8% and cefalotin was 69.2%. For *Acinetobacter baumanii*, quinolone resistance was 70% for ciprofloxacin, ofloxacin and levofloxacin; beta-lactams, particularly ampicillin at 90% and amoxicillin clavulanic acid at 70%; for cefotaxime, cefixime and cefuroxime at 80%. Sensitivity was observed for amikacin at 50%, imipenem and meropenem at 40%. As for *Staphylococcus aureus*, sensitivity was 60% for fosfomycin and 33.3% for amikacin. Resistance to aminoglycosides such as gentamicin and tobramycin was 80% and 40% respectively, and to quinolones including ofloxacin and levofloxacin was 40%. This resistance to certain aminoglycosides, such as gentamicin at 50% and sensitivity to amikacin at 100%, was also found by Njall *et al.* in Cameroon [8].

In our series, the sensitivity profile of the bacteria showed a 37.8% proportion of MBR. This is similar to the results obtained by Trubiano and Padiglione in

Australia *and* Zilberberg *et al.* in the United States [47] [48]. This multi-resistance could be explained by: the accumulation of natural and/or acquired resistance, and the frequent use of non-targeted antibiotic therapy.

The case fatality rate was 47%, which is similar to the results obtained in Tunisia with 44.7% [5] and in Senegal in 2016, which was 48% [24] [25]. Other researchers have reported lower mortality rates, for example the REA-Raisin network in France, which was 16.7% [3], and Vincent *et al.* in the United States, who found 25% [49]. The higher mortality observed in this study compared to that reported in developed countries can be explained by the low availability of appropriate antibiotics, leading to delays in their administration, the lack of devices such as extracorporeal membrane oxygenation and haemodialysis in cases of multiple organ failure such as severe acute respiratory distress syndrome (ARDS) and acute renal failure (ARF). The direct responsibility of NI in the occurrence of death is difficult to establish, particularly in patients with multiple pathologies, immunocompromised patients or patients with multiple organ failure [50]. In fact, a French study showed no significant excess mortality from these infections after adjusting for the severity of the patients' condition before the onset of infection [51]. However, it is accepted that NI are responsible for an increase in mortality and morbidity [8].

In a bivariate analysis with logistic regression, the factors significantly associated with the occurrence of nosocomial infections (NI) were: female gender, intubation and length of hospital stay. This result is consistent with that of Amazian *et al.* in a multicentre study involving 27 hospitals, which found that risk factors included a stay of more than eight days, urinary catheterisation, the presence of a central catheter, ventilation, age and female gender [37]. Length of hospital stay was associated with the prevalence of NI. This relationship is logical, especially since the risk of acquiring an NI increases with longer stays in intensive care. Urinary catheterisation was not studied because the entire study population had urinary catheters.

The factors identified as poor prognostic indicators included age between 52 and 67 years and a high IGS II score. The isolated germ and the site of infection were not correlated with death. This result may be explained by the small number of different germs found. The IGSII score was associated with mortality. This correlation can be explained by the fact that severely ill patients had a reduced probability of survival.

4. Recommendations

We recommend that the HIAA set up an epidemiological surveillance committee dedicated to the control of nosocomial infections. This committee will be responsible for organising regular continuing education courses for healthcare personnel, focusing in particular on the prevention of nosocomial infections and strict rules for the prescription of antibiotics. In addition, it is strongly recommended that the facility be equipped with devices to facilitate rapid microbiological testing in order to reduce the time to diagnosis and adapt antibiotic treatment as early as possible. Similarly, a wider range of antibiotic discs should be made available to enable better assessment of bacterial resistance.

Strengthening human resources dedicated to infection prevention and control is also a priority, ensuring rigorous monitoring of patients and procedures.

It is essential that healthcare staff actively participate in training on the prevention of nosocomial infections. The use of invasive devices must be limited to what is necessary, with particular attention paid to asepsis and associated good practices.

Antibiotic therapy should be adjusted as soon as possible based on the results of a precise antibiogram to avoid inappropriate treatment. To standardise practices, we recommend developing and monitoring procedural guidelines and providing a validated treatment guide.

The use of chlorhexidine as a patient cleaning agent should be standardised in accordance with current protocols. In addition, systematic screening of patients admitted to intensive care by nasal and anal swabbing is recommended for the early detection of infectious carriers. Finally, the integration of molecular biology analysis methods into microbiological diagnostics will enable rapid and accurate detection of infectious agents, thereby contributing to the overall improvement of nosocomial infection management.

To reinforce these measures, it is also recommended to establish a continuous automated infection surveillance system, rigorously promote hand hygiene with constant availability of hydroalcoholic solutions, and standardise protocols for cleaning and disinfecting surfaces and equipment.

An optimised antibiotic therapy policy, supervised by infectious disease specialists, is essential to limit the emergence of bacterial resistance. It is also essential to promote a multidisciplinary approach involving different healthcare professionals.

Regular audits of care practices must be put in place to identify any weaknesses in the implementation of preventive measures, while patients and their families must be made aware of preventive measures, particularly with regard to hygiene.

Finally, clinical research should be encouraged to test and validate new technologies and strategies in the fight against nosocomial infections, thereby ensuring the continuous development of best practices.

5. Conclusion

The prevalence of NI in intensive care remains high, with urinary tract infections followed by pneumonia. The majority of pathogens found were Gram-negative bacilli resistant to first-line antibiotics. These NI were mainly linked to manuportage, the presence of invasive medical devices and mortality due to the limited availability of appropriate antibiotics.

Conflicts of Interest

There is no conflict of interest.

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