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Research Article

Healthcare-Associated Bloodstream Infections in the Neonatal Unit of Dalal Jamm National Hospital, Senegal: Epidemiological and Microbiological Characteristics

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Abstract

Introduction: Healthcare-associated bloodstream infections (HA-BSIs) represent a major cause of morbidity and mortality in neonatal intensive care units, particularly in low- and middle-income countries (LMICs). In Senegal, few data exist regarding the incidence, bacterial spectrum, and antimicrobial resistance patterns of HA-BSIs in neonates. This study aimed to describe the epidemiological and microbiological profile of healthcare-associated bloodstream infections in the neonatal unit of Dalal Jamm National Hospital in Senegal.

Methods: We conducted a retrospective longitudinal study from October 2022 to July 2023 in the neonatal unit of Dalal Jamm National Hospital. All neonates with at least one positive blood culture obtained ≥48 hours after admission were included. Data were extracted from medical records and bacteriology registers and analyzed using R software v4.1.3. Categorical variables were expressed as frequencies, and the time to infection onset was described by the median and interquartile range.

Results: Among 288 admitted neonates, 36 cases of HA-BSIs were recorded, yielding a cumulative incidence of 12.5% and an incidence density of 15.5 cases per 1 000 patient-days. The median time to infection was 6 days [IQR 2–13]. Prematurity and low birth weight (< 2 500 g) were observed in 53% of cases. A total of 38 pathogens were isolated, predominantly Gram-negative bacilli (65.8%), mainly Enterobacter cloacae (18.4%), Klebsiella pneumoniae (15.8%), and Escherichia coli (13.1%). Gram-positive cocci accounted for 31.6% of isolates, primarily coagulase-negative staphylococci (21%). Among 28 strains tested for resistance, 57% were multidrug-resistant, including 61% ESBL- or carbapenemase-producing Enterobacterales. The case-fatality rate was 36%.

Conclusion: The incidence of healthcare-associated bloodstream infections in the neonatal unit of Dalal Jamm Hospital is high, with a predominance of multidrug-resistant Gram-negative bacteria. Strengthening infection prevention and control programs, rational antibiotic use, and continuous surveillance are urgently needed to reduce neonatal morbidity and mortality in resource-limited settings.

Keywords: Neonatal Sepsis; Healthcare-Associated Infections; Bloodstream Infection; Antimicrobial Resistance; Low-Resource Countries; Senegal

Abbreviations

LMICs: Low- and Middle-Income Countries; HAIs: Healthcare-Associated Infections; HA-BSIs: Healthcare-Associated Bloodstream Infections; MDR: Multidrug-Resistant; ESBL: Extended-Spectrum B-Lactamase (ESBL), CPE: Carbapenemase-Producing Enterobacterales; VRSA: Vancomycin-Resistant *Staphylococcus aureus*; MRSA: Methicillin-Resistant *Staphylococcus aureus*; NHSN: National Healthcare Safety Network; IPC: Infection Prevention and Control; MICs: Minimum Inhibitory Concentrations; CVC: Central Venous Catheter; UVC: Umbilical Venous Catheter; CRBSIs: Catheter-Related Bloodstream Infections; WHO: World Health Organization; CoNS: Coagulase-Negative Staphylococci.

Introduction

Bacteremia remains one of the leading causes of severe infection in neonates and constitutes a major public health concern

worldwide. The incidence of neonatal bacteremia varies considerably across settings, ranging from 2 to 20 per 1,000 live births in high-income countries, but reaching 40 to 50 per 1,000 in low- and middle-income countries (LMICs) [1,2]. Mortality associated with neonatal bacteremia remains high, estimated between 20% and 50% in LMICs, with the highest rates observed among preterm and very low birth weight infants [3,4]. The main identified risk factors include prematurity, low birth weight, mechanical ventilation, parenteral nutrition, prolonged use of intravenous catheters, and hospitalization in neonatal intensive care units [5,6]. Healthcare-associated infections (HAIs) represent a major public health challenge, particularly in developing countries where resources for infection prevention and control remain limited or absent [7,8].

In neonates—a population particularly vulnerable due to immune immaturity—HAIs are responsible for substantial morbidity and mortality. They are defined as any infection occurring during or following medical management (diagnostic, therapeutic, palliative, preventive, or educational) of a newborn (0–28 days), which was neither present nor incubating at the time of admission. A delay of at least 48 hours after hospitalization is generally used as the diagnostic threshold.

The incidence of HAIs in neonatal units varies according to the level of care (routine care, special care nursery, neonatal intensive care unit) and the types of interventions provided. In Senegal, limited data are available regarding HAIs in neonatal settings. Therefore, this study was undertaken to determine the incidence and to describe the epidemiological and microbiological profiles of healthcare-associated bloodstream infections (HA-BSIs) within the neonatal unit of Dalal Jamm National Hospital in Dakar, Senegal.

Materials and Methods

Study setting

This study was conducted in the neonatology unit of the pediatric department at the Dalal Jamm National Hospital Center in Guédiawaye, Senegal. This facility is a tertiary-level public healthcare institution located in the suburbs of Dakar.

The neonatal unit functions as an intensive care unit, although endotracheal intubation is not performed. Most admitted newborns are inborn, originating from the hospital's own maternity ward, which is adjacent to the neonatal unit. However, a proportion of patients are outborn, referred from other healthcare facilities in the region.

Study design and period

This was a retrospective longitudinal study conducted over a 10-month period, from October 2022 to July 2023.

Study population

All newborns with at least one positive blood culture obtained more than 48 hours after admission to the neonatal unit were included in the study.

Newborns with bacteremia due to Staphylococcus epidermidis and those with documented maternal–fetal infectionswere excluded from the analysis.

Bacteriological methods

The diagnostic procedures used in the bacteriology laboratory of Dalal Jamm Hospital included two main approaches. Direct diagnostic methods comprised fresh microscopy, stained microscopy (using Gram staining, Ziehl–Neelsen, and Methylene Blue techniques), and culture of pathological specimens on various artificial media, including chromogenic media to facilitate bacterial identification. Antimicrobial susceptibility testing was performed on agar plates using the Kirby–Bauer disk diffusion method, or by determination of minimum inhibitory concentrations (MICs) using the Vitek 2 automated system.

Data collection and analysis

Data were collected from medical records, hospital admission registers, and the bacteriology laboratory logbook. The following information was retrieved: source of admission, age at admission, gestational age, birth weight, sex, bacteriological findings, invasive procedures, and clinical outcome. Data were analyzed using R software, version 4.1.3.

Categorical variables were summarized as frequencies and percentages. The time to onset of healthcare-associated infection was described using the median and interquartile range (IQR: 25th–75th percentiles), as the distribution did not follow a normal pattern according to normality tests.

Results and Discussion

Results

A total of 36 cases of HA-BSI were recorded among 288 neonates admitted, corresponding to a cumulative incidence of 12.5%. For a total of 2,315 hospitalization days, the incidence density was 15.5 cases per 1,000 patient-days.

The incidence density varied by month (Figure 1). It tripled in February, with a peak of eight recorded cases, corresponding to an incidence density of 43.5 cases per 1,000 patient-days. The absence of data for March 2023 was due to the temporary closure of the neonatal unit during that month.

Nearly two-thirds (61%) of neonates were admitted on day 0 of life, and the majority were inborn (69%). More than half (53%) had a low birth weight (<2,500 g) and were preterm (Table I). The median time to onset of HA-BSI was 6 days (IQR: 2–13 days).

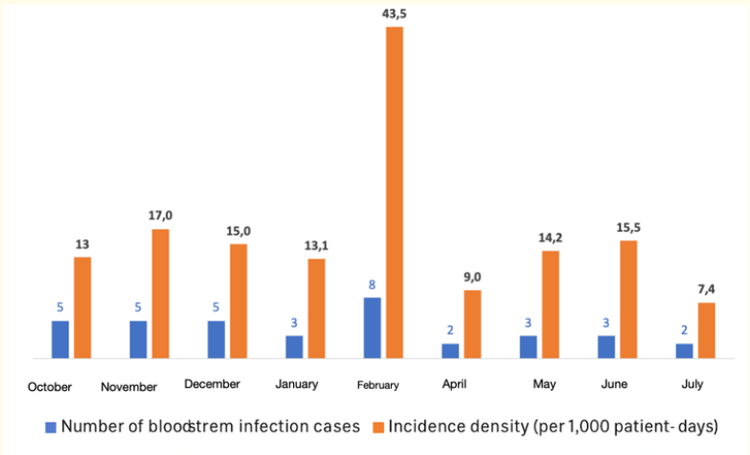

Figure 1: Trend in the incidence density of healthcare-associated bloodstream infections from October 2022 to February 2023, Neonatology Unit, Dalal Jamm National Hospital (Senegal).

Table I: Epidemiological, clinical, and outcome characteristics of healthcare-associated bloodstream infection cases; Neonatology Unit, Dalal Jamm National Hospital (Senegal) (n = 36).

Variable	Number	Percentage (%)
Age at admission		
Day 0 (birth day)	22	61
Day 1–7	11	31
> 7 days	3	8
Origin of admission		
Hospital maternity (inborn)	25	69
Referred from other facilities (outborn)	11	31
Sex		
Female	20	56
Male	16	44
Birth weight (grams)		
< 2500	19	53
≥ 2500	17	47
Prematurity (< 37 weeks of gestation)		
Yes	19	53
No	17	47
Outcome		
Death	13	36
Favorable outcome	23	64

Congenital malformations were observed in 39% (n=14) of cases (including omphalocele, volvulus, congenital heart disease, and intestinal atresia), among which five neonates underwent surgical intervention. Seven (19%) had a central venous catheter (CVC) in place.

A total of 38 bacterial isolates were recovered. Gram-negative bacilli accounted for 65.8% of isolates, predominantly Enterobacterales (47.3%), mainly *Enterobacter, Klebsiella*, and *Escherichia* species (Table II).

Table II: Distribution of cases according to bacteriological findings; Neonatology Unit, Dalal Jamm National Hospital (Senegal) (n = 38).

Gram/Genus	Species	Number	Percentage (%)
Gram-positive (n = 13)			34.2
Staphylococcus (n = 12)			
	Coagulase-negative staphylococci	5	13.1
	Staphylococcus aureus	4	10.5
	Staphylococcus haemolyticus	3	7.9
Enterococcus (n = 1)	*Enterococcus faecalis*	1	2.6
Gram-negative (n = 25)			65,8
Enterobacterales			
Enterobacter	*Enterobacter cloacae*	7	18.4
Klebsiella	*Klebsiella pneumoniae*	6	15.8
Escherichia	*Escherichia coli*	5	13.1
Non-fermenting Gram-negative bacilli			
Acinetobacter	*Acinetobacter baumannii*	3	7.9
	Acinetobacter spp.	2	5.3
Pseudomonas	*Pseudomonas aeruginosa*	1	2.6
	Pseudomonas fluorescens	1	2.6

Among Gram-positive cocci (31.6%), Staphylococcus species were predominant. Staphylococcus haemolyticus and other coagulase-negative staphylococci were identified in 21% of cases.

Antimicrobial resistance profiles were available for 28 isolates. The prevalence of multidrug-resistant (MDR) bacteria was 57% (Figure 2). Among the 18 Enterobacterales

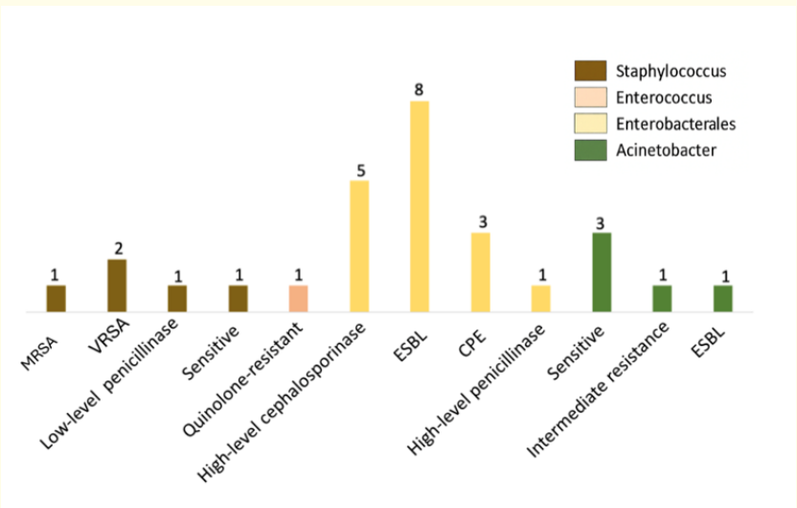

Figure 2: Antimicrobial resistance phenotypes of bacterial isolates. Study on healthcare-associated bloodstream infections in the Neonatology Unit, Dalal Jamm National Hospital (Senegal).

isolates, 61% were extended-spectrum β-lactamase (ESBL) or carbapenemase-producing Enterobacterales (CPE), comprising 8 ESBL-producing and 3 CPE strains.

Additionally, three MDR Staphylococcus strains were identified: two vancomycin-resistant Staphylococcus aureus (VRSA) and one methicillin-resistant Staphylococcus aureus (MRSA) isolate. The in-hospital case fatality rate was 36% (13/36).

Discussion

This study provided a situational analysis of HA-BSIs within the neonatal unit of Dalal Jamm Hospital in Senegal. In our series, the cumulative incidence was 12.5%, with an incidence density of 15.5 cases per 1,000 patient-days. These findings are consistent with those reported in other resource-limited settings, where HA-BSIs remain a major concern in neonatal care.

Indeed, in Cameroon, a longitudinal study conducted at the Yaoundé University Hospital Center reported an incidence density of healthcare-associated infections of 17.44 cases per 1,000 hospitalization-days in the neonatal unit [9]. In Brazil, a study published by the National Healthcare Safety Network (NHSN) reported a sepsis incidence rate of 17.9 cases per 1,000 patient-days, of which 60% were bloodstream infections, accounting for 65.8% of all healthcare-associated infections recorded [10].

At the Diamniadio Children's Hospital in Senegal, the overall incidence of healthcare-associated infections in the neonatal unit was 18.9%, slightly higher than that observed in our study. However, infection was microbiologically confirmed in 68% of cases. Bacteremia and fungemia were the most common types of infection, accounting for 44% of all cases [11].

Among preterm infants, the incidence of healthcare-associated infections was higher, reaching 41.8% [12]. In high-income countries, however, a lower incidence is generally reported. In the United States, Prochaska., *et al*. found an incidence density of 1.1 cases per 1,000 patient-days [13].

In Germany, the series reported by Geffers., *et al*. found an incidence density of 6.5 cases per 1,000 patient-days, with 8.5 per 1,000 among very low birth weight infants and 4.0 per 1,000 among those weighing more than 1,500 g [14].

These disparities may be explained by the limited infrastructure and resources in LMICs. Neonatal units often face bed overcrowding, a low nurse-to-infant ratio, and a lack of essential protective measures such as access to running water, alcohol-based hand rubs, and personal protective equipment. In addition, infection prevention and control (IPC) programs are frequently absent or only partially implemented.

In high-income countries, the incidence rates of bloodstream infections are most often expressed in relation to the number of central venous catheter (CVC) days, since catheterization increases the risk of sepsis three- to fourfold, and this risk rises with the duration of catheter use [15,16].

In our study, 19% of neonates had a CVC inserted. In France, in 2019, the incidence of umbilical venous catheter (UVC)-related bloodstream infections was 2.3 cases per 100 UVCs, with an incidence density of 5 cases per 1,000 UVC-days [17].

In the Netherlands, a surveillance study conducted in a neonatal unit from 2012 to 2020 recorded 310 episodes of HA-BSIs among preterm infants. One-third of these infections were associated with CVCs. The incidence of catheter-related bloodstream infections (CRBSIs) ranged from 8.83 to 25.3 cases per 1,000 CVC-days, with no significant variation over the study period [18]. In Turkey, Kulali., *et al*. reported an incidence of 12.4 UVC-related bloodstream infections per 1,000 UVC-days, which was markedly reduced to 3.9 per 1,000 UVC-days following the implementation of bundles [19]. In our setting, as in most LMICs, the use of CVCs and other invasive devices often occurs without single-use materials and in the absence of standardized insertion and maintenance protocols. Moreover, the removal of such devices is frequently delayed. All these factors contribute to an increased risk of infection.

Apart from CVCs, bacterial translocation from the gastrointestinal tract and systemic dissemination from an initial localized infectious focus are other key mechanisms explaining the occurrence of HA-BSIs in neonatal units [15,20].

It has been demonstrated that gestational age and low birth weight are significant risk factors for the occurrence of HAIs [20,21].

In our series, preterm infants and low birth weight newborns represented the majority of cases (53%). The clinical condition of these infants often necessitates the use of invasive procedures (such as intubation or central venous catheterization), prolonged hospitalization, and broad-spectrum antibiotic therapy, all of which predispose to the development of HAIs.

According to the World Health Organization (WHO), there were an estimated 2.8 million neonatal deaths worldwide in 2015, of which 47.6% were attributable to neonatal infections [7]. HAIs in neonatal units are responsible for a high case fatality rate, ranging from 12% to 52% [22]. In our series, one-third (36%) of neonates died. A similar rate (37%) was reported at the Diamniadio Children's Hospital in Senegal [11].

From a microbiological perspective, five cases of infection due to *Enterobacter cloacae* were identified, strongly suggesting the occurrence of a localized outbreak during that period. In our study, Gram-negative bacilli were the most frequently isolated pathogens in blood cultures (65.8%), predominantly *Enterobacter cloacae* (18.4%), *Klebsiella pneumoniae* (15.8%), and *Escherichia coli* (13.1%). *Gram-positive cocci* accounted for approximately one-third of cases (31.6%).

Gram-positive cocci accounted for one-third of the cases (31.6%). Coagulase-negative staphylococci (CoNS) were isolated in 21% of cases, followed by *Staphylococcus aureus* in 10.5%. These findings are consistent with those reported in Senegal and in other LMICs, showing a predominance of *Gram-negative bacilli*. In the neonatal unit of the Diamniadio Hospital Center in Senegal, the three most frequently isolated pathogens in blood cultures among neonates hospitalized for more than two days were *Klebsiella pneumoniae* (33%), *Enterobacter* spp. (24%), and *Escherichia coli* (8.6%) [23].

In the multicenter prospective "BIRDY" study, *Klebsiella* spp. (24.4%), *Escherichia coli* (22.2%), and Staphylococcusspp. (24.4%) were the main bacterial pathogens isolated in cases of severe neonatal infections [11].

In the meta-analysis published by Zelellw DA., *et al*. *Klebsiella pneumoniae* (26.36%) was identified as the most frequently isolated pathogen in cases of neonatal infections in developing countries [24]. The bacterial ecology in high-income countries, however, is markedly different—particularly in catheter-related bloodstream infections, where CoNS are predominant (28–70%), followed by Staphylococcus aureus (7.5–19%) [20,25].

The management of HAIs is particularly challenging because the isolated bacteria are most often MDR. In our series, analysis of resistance phenotypes showed that 57% of isolates were MDR. Among the 18 Enterobacterales strains, 61% were either ESBL or CPE. In a hospital-based study from South Africa, 80% of *Klebsiella pneumoniae* isolates were ESBL producers, and 66.7% of staphylococcal strains were methicillin-resistant [26].

In LMICs, the emergence of MDR bacteria is linked to several factors, including inappropriate antibiotic prescribing, self-medication, illegal over-the-counter sales of antibiotics, and insufficient regulation of drug quality control, among others [27,28]. The therapeutic arsenal available for the management of MDR HAIs remains limited in Senegal. Indeed, several key antibiotics—such as ertapenem, ceftazidime, linezolid, piperacillin–tazobactam, and dalbavancin—are not readily available. This limitation results in high patient mortality and increases the risk of cross-transmission to other patients if appropriate IPC measures are not strictly observed.

Conclusion

The incidence of HA-BSIs in neonatal units remains relatively high, confirming the major public health challenge posed by this condition. In resource-limited countries, the prevention of infectious risk in neonatology represents the most effective strategy to reduce the morbidity and mortality associated with HA-BSIs. Prevention efforts should focus on the implementation of targeted interventions, including the adequate design and organization of neonatal care units, strengthening of healthcare staffing, regular assessment of clinical practices, training of healthcare workers in infection prevention and hygiene measures, continuous reinforcement of adherence to these practices, and the prospective surveillance of healthcare-associated infections in neonatal settings.

Conflict of Interest

No conflict of interest.

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