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Prevalence and determinants of neonatal infections in Benin based on a retrospective study in six reference hospitals

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Maternal and neonatal infections pose a significant public health challenge, particularly in developing countries like Benin. This retrospective study investigates the frequency and determinants of maternal and neonatal infections in Benin during 2022, utilizing data from six reference hospitals. The study includes 123 neonates suspected of infection, analyzing factors such as birth weight, breastfeeding practices, clinical delivery parameters, and laboratory-confirmed infection rates. Findings reveal that 32% of suspected cases were confirmed infections, with a higher prevalence among premature newborns and those born in specific hospitals. The study emphasizes the need for improved diagnostic facilities, infection control practices, and awareness among healthcare workers and pregnant women. Recommendations for future research include broader geographic coverage and enhanced training programs.

Keywords Neonatal infections, Retrospective study, Risk factors, Benin

Maternal and neonatal infections represent a significant public health challenge with severe consequences for mothers and children[1]. Women and newborns are particularly vulnerable to infection during pregnancy, childbirth and the postpartum period[2,3]. Neonatal infections are caused by pathogenic microorganisms (bacterial, viral, or fungal) in newborns, and include conditions such as neonatal sepsis, neonatal pneumonia and other neonatal infections[4,5]. Each year, an estimated 2.3 million newborns die within the first 28 days of life[6], with approximately 550,000 of these deaths (about 24%) attributed to neonatal infections[7]. The clinical manifestations range from subclinical infection to severe manifestations of focal or systemic disease[8]. Notably, sepsis accounts for 40% of infection-related neonatal deaths and contributes to 10% of maternal deaths worldwide[9]. A 2022 study by the Global Antibiotic Research and Development Partnership (GARDP) highlights an increasing number of infants are dying from resistant infections as current treatments fail[10].

Regarding maternal health, around 75,000 pregnant women die annually from sepsis[11]. Infections, whether endemic or epidemic, bacterial, viral, fungal, or parasitic, can significantly impact pregnant women, leading to complications such as preterm labor, maternal morbidity, and fetal distress. Additionally, the physiological changes during pregnancy can increase the severity of these infections, leading to more severe health outcomes for the mother (miscarriage, fetal death, premature delivery)[12]. Bacterial pathogens are primarily responsible for these infections, although viruses, fungi, and parasites also contribute[13,14]. The most common bacteria involved include group B streptococcus and *Escherichia coli*[15–17] and for viruses cytomegalovirus and herpes simplex virus[18,19]. Transmission can occur in utero, during delivery or after birth, through exposure to the environment or caregivers[20].

Sub-Saharan Africa is one of the regions with the highest neonatal mortality rates globally, and neonatal sepsis in this region is caused by both Gram-positive and Gram-negative bacteria[14]. Annually, approximately 280,000 maternal deaths and about 4 million stillbirths and early neonatal deaths occur, mainly in low and middle-income settings (LMICs)[21]. Serious bacterial infection is the most important clinical syndrome in low- and middle-income countries, with an estimated 6.9 million episodes occurring each year among infants aged 0–59 days[7]. The high incidence of infections can be attributed to the precarious situation of populations which

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leads to poor hygiene among mothers who transmit the pathogen to their children[22]. In addition to this fact, poor hygiene during childbirth, especially during the passage of the child through the uterus, and the invasive actions of nursing staff also constitute one of the frequent causes of these infections in this region of Africa[23–25].

In Benin, the maternal and neonatal mortality rate is 391 maternal deaths per 100,000 live births and has remained stabilized since 10 years [26]. This rate is to be compared to a global average of 223 deaths, while this rate is only 8 deaths per 100,000 live births in Europe. Newborns in Benin face significant risks as well, with a neonatal mortality rate of 30 deaths per 1000 births, compared to the global average of 18 deaths per 1000. Although the national rate is stable, it should be noted that sporadic studies have taken place in hospitals. For instance, a study by Saizonou carried out from August 2009 to February 2010 at the Oueme-Plateau Departmental University Hospital Center reported an incidence of peripartum infections was 5.9 per 100 deliveries (110/1875)[27]. At the Laguna Mother and Child Hospital Center, neonatal infections accounted for 19% of all births[28], during the period from January 1, 2015 to December 31, 2016. However, these studies offer a fragmented view, as they are limited to specific hospitals and lack comprehensive national data. A more holistic, nationwide analysis is crucial for gaining a clearer understanding of the situation and formulating targeted strategies to reduce the frequency of these infections. This is what motivated the present study. Our initiative is based on the fact that by better understanding the state of these infections, we will be able to better analyze the situation in order to find the gaps that are hindering strategies to reduce the frequency of these infections.

Methods

Study design

The retrospective study focused on newborns in the perinatal period and pregnant women who consulted during the third trimester of pregnancy. The study considered the maternity and neonatology records for the year 2022 of the hospitals mentioned above.

Hospitals involved

This study was conducted across six major hospitals in Benin, strategically selected to represent different regions of the country (North, South, and Center) to ensure a comprehensive analysis of neonatal infections National University Hospital Center Hubert K. MAGA (CNHU-HKM), Lagune Mother and Child University Hospital Center (CHUMEL), Departmental Hospital Center (CHD) Zou-Collines, Departmental University Hospital Center (CHUD) Borgou Alibori, Zone Hospital (HZ) Tanguieta, and CHD Ouémé-Plateau. These hospitals were selected for their high patient volume and their status as reference centers for the 12 departments of Benin (Fig. 1).

Inclusion and exclusion criteria

Neonates were included in the study if they were suspected of having an infection based on clinical symptoms, laboratory test results, or risk factors such as premature birth or maternal infection. Regarding newborns, reference cases were included given the status of reference hospitals of the selected hospitals. Exclusion criteria included neonates with congenital abnormalities unrelated to infections, those transferred from another health facility after receiving prolonged treatment. However, no cases of newborns admitted at home during the neonatal period were included in the study. For pregnant women who consulted during the third trimester of pregnancy at the same hospitals. The inclusion criteria for this population encompassed women presenting for routine antenatal care or with complications requiring hospitalization. Exclusion criteria included those with a history of conditions unrelated to the pregnancy. The sample size of 123 neonates was determined based on the availability of eligible participants within the study period across multiple hospitals.

Factors

Primary factors of the study included the prevalence of neonatal infections (confirmed through microbiological laboratory tests), neonatal mortality, and antibiotic usage patterns. Secondary factors involved the analysis of maternal factors, such as educational level, age, breastfeeding initiation, and history of infections during pregnancy, and their association with neonatal outcomes. Definitions of neonatal infections were based on clinical presentations like fever, hypothermia, respiratory distress, and laboratory-confirmed bacterial or viral infections.

Ethical approval

A formal request for ethical approval of the proposed research activities was submitted to the Research Ethics Committee of the Institute of Applied Biomedical Sciences in Cotonou. The committee conducted a comprehensive review of the request and, subsequently, issued a favorable opinion on December 22, 2022, under number 155. Subsequently, a request for research authorization was obtained from the Ministry of Health (No. 2582/MS/DC/SGM/DGMHED/DEH/SA). The requirement for informed consent was waived by Research Ethics Committee of the Institute of Applied Biomedical Sciences due to the retrospective nature of this study. The protocol was approved by the Research Ethics Committee of the Institute of Applied Biomedical Sciences and all methods were performed in accordance with the Declaration of Helsinki.

Data collection

The data collection phase of this study was conducted from August 7th to September 8th, 2023. During this period, a team of investigators established initial contact with relevant hospital authorities and were subsequently directed to storage facilities housing archived medical records from January to December 2022. The investigators organized these records, identifying and selecting files of mothers and newborns (0–28 days) suspected of

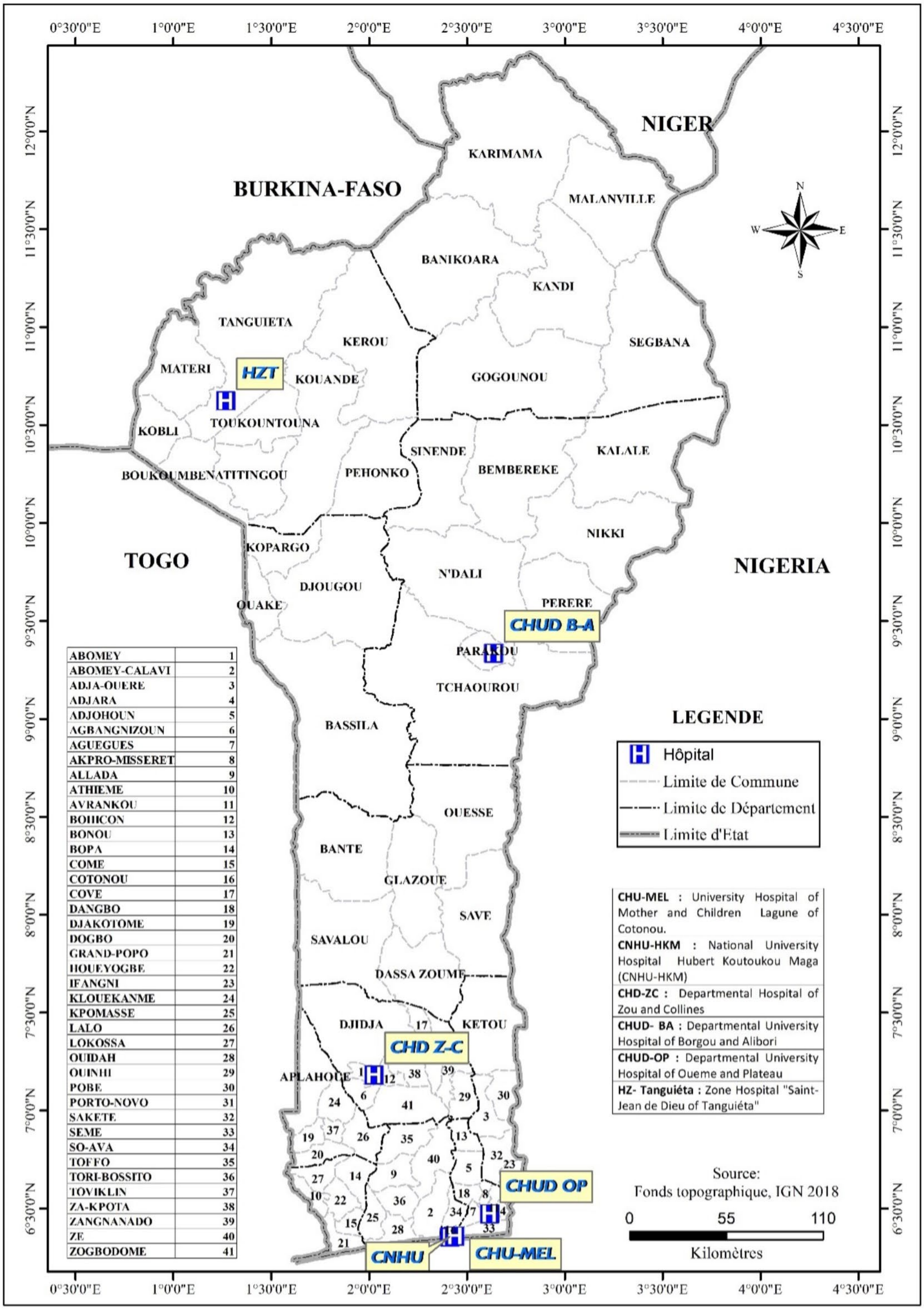

Fig. 1. Presentation of data collection sites. The map was designed with ArcGIS pro software version 10.8. https://enterprise.arcgis.com/fr/portal/10.8/use/what-s-new-in-portal-for-arcgis.htm.

bacterial infections. Upon selection, detailed information from these records was electronically documented using Kobocollect software (KoboToolbox available on https://www.kobotoolbox.org/).

The study collected various variables for both neonates and pregnant women based on their medical records. For neonates, the variables included clinical signs and symptoms (e.g., fever, hypothermia, respiratory distress), laboratory results confirming neonatal infections (bacterial or viral), neonatal outcomes (mortality and morbidity), duration of hospital stay, and mode of delivery (vaginal or cesarean). For pregnant women, the variables included age, educational level, breastfeeding initiation (within the first hour of birth), and any history of infections during pregnancy. These variables were analyzed to explore their association with neonatal infection outcomes and to identify potential factors contributing to the risk of infection in newborns. Supervision of the data collection process was maintained to ensure accuracy and reliability. The research team primarily conducted quality control online, systematically reviewing all submitted forms on the server. They checked for inconsistencies and errors, requesting data re-collection when necessary to ensure that all information was verified and accurate. This structured approach ensured the integrity of the data and the reliability of the study's findings.

Data processing and analysis

Following the data collection phase, the final stage involved comprehensive data cleaning activities, focusing primarily on forms designated as "Validated" by the quality control team. During this phase, any anomalous data, duplicates, or discrepancies identified during quality control were rectified after discussing with investigators. Forms with statuses of "Not validated" and/or "Pending" at the conclusion of the data collection period after rounds of checking with investigators were excluded from the final dataset to ensure accuracy and consistency.

Data tabulation and processing were exclusively conducted on the validated and approved dataset using SPSS software 30.0.0 (https://www.ibm.com/products/spss-statistics).

The subsequent analysis predominantly employed descriptive and qualitative approaches, including the examination of statistical tables relevant to the study's specific objectives and required indicators.

Results

Neonatal characteristics and feeding practices

A total of 123 newborn files were registered in this study, distributed as follows: 17 at CNHU-HKM, 19 at CHUD-OP, 10 at HZ-Tanguieta, 13 at CHD-ZC, 45 at CHUD-BA, and 19 at CHU-MEL. These files pertained to newborns suspected of infections and registered in the six hospitals from January to December 2022. The study's findings indicate that most newborns were full-term (61%), with a significant percentage of premature babies (33%) and a smaller proportion of post-term births (7%). Immediate breastfeeding within 1 h of birth was practiced in 93% of cases, reflecting a high adherence to recommended breastfeeding practices. Most newborns were exclusively breastfed (87%), with a small percentage receiving combined feeding (9%) or formula (4%) (Table 1).

Birth weight, temperature, and health outcomes of newborns

In this study, 59% of newborns had a birth weight between 2500 and 4000 g, representing a significant portion of the sample. Newborns with low birth weight (< 2500 g) accounted for 42%. The mean birth weight of all newborns was 2665 ± 664 g (mean ± SD), which falls within the normal range. The majority of newborns (78%) had temperatures at or below 37 °C, though at CNHU-HKM and HZ-Tanguieta, there was a notable frequency of newborns with temperatures between 37.1 and 38.5 °C (Table 2). Results showed that 90% of newborns suspected of infection did not exhibit severe jaundice, a symptom indicative of neonatal infection, and 92% did not suffer from asphyxia at birth, indicating favorable respiratory and oxygenation outcomes. The majority of newborns (78%) had temperatures at or below 37 °C, though at CNHU-HKM and HZ-Tanguieta, there was a notable frequency of newborns with temperatures between 37.1 and 38.5 °C (Table 2).

From the total number of suspected cases selected in this study, 27% were diagnosed with infections at birth. Notably, a higher prevalence of confirmed infections was observed at CNHU-HKM and CHUD-OP. During neonatal consultations, infections were confirmed in 33% of the newborns (Table 3). In this context, suspicion of infection arises when the clinician identifies clinical signs indicative of an infection and subsequently requests diagnostic tests, such as bacteriological examinations (including blood cultures and cerebrospinal fluid analysis,

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Gestational age of newborn							
Prematurity (≤ 37 weeks)	6	8	2	4	12	8	40 (32%)
Terms (37–41)	10	10	7	6	32	10	75 (61%)
Post term (≥ 41 weeks)	1	1	1	3	1	1	8 (7%)
Total	17	19	10	13	45	19	123
Newborns being breastfed within 1 h of birth							
Yes	16+	18	8	12	44	16	114 (93%)
No	1	1	2	1	1	3	9 (7%)
Total	17	19	10	13	45	19	123
Type of feeding after delivery/birth							
Maternal/breastfeeding	7	13	10	13	45	19	107 (87%)
Formula	5	0	0	0	0	0	5 (4%)
Combination	5	6	0	0	0	0	11 (9%)
Total	17	19	10	13	45	19	123

Table 1. Neonatal characteristics and feeding practices at birth.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Birth weight of newborns (g)							
< 2500	8	8	4	5	18	8	51 (42%)
[2500–4000]	9	11	6	8	27	11	72 (59%)
Total	17	19	10	13	45	19	123
Body temperature (°C) of newborns							
≤ 37	5	16	6	10	41	18	96 (78%)
37.1–38.5 °C	11	2	4	2	3	1	23 (19%)
> 38.5	1	1	0	1	1	0	4 (3%)
Total	17	19	10	13	45	19	123
Severe jaundice among newborns							
Yes	2	4	1	1	2	2	12 (10%)
No	15	15	9	12	43	17	111 (90%)
Total	17	19	10	13	45	19	123
Asphyxia at birth among newborns							
Yes	4	0	1	1	3	1	10 (8%)
No	13	19	9	12	42	18	113(92%)
Total	17	19	10	13	45	19	123
Newborns history of resuscitation at birth							
Yes	1	3	2	6	11	2	25 (20%)
No	16	16	8	7	34	17	98 (80%)
Total	17	19	10	13	45	19	123
Survival of newborns							
Survived	16	18	8	12	44	16	114 (93%)
Died	1	1	2	1	1	3	9 (7%)
Total	17	19	10	13	45	19	123

Table 2. Clinical delivery parameters of newborn. < 37 weeks = Prematurity; 37–42 weeks = Terms and > 42 weeks = Post term.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Infection diagnosis among newborns right at birth							
Positives	10	16	1	0	3	3	33 (27%)
Negatives	7	3	9	13	42	16	90 (73%)
Total	17	19	10	13	45	19	123
Presence of infection among newborns at the neonatal consultation after birth							
Yes	12	17	1	1	7	2	40 (33%)
No	5	2	9	12	38	17	83 (68%)
Total	17	19	10	13	45	19	123

Table 3. Infection cases among newborns at birth and during neonatal consultation.

or other tests like NFS and CRP) to confirm the diagnosis. Meanwhile, probabilistic antibiotic therapy is initiated. If the test results later confirm the infection, it is classified as a diagnosed infection.

Antibiotic treatment and hospitalization duration

Regarding antibiotic treatment, 50% of the newborns in the study received antibiotics. The majority of neonates were hospitalized for 1–7 days (Table 4).

The most frequently prescribed antibiotics for treating these newborns were cefotaxime and gentamicin (Table 5).

Maternal file registration and demographics

A total of 1596 maternal files were registered, distributed as follows: 234 at CNHU-HKM, 233 at CHUD-OP, 124 at HZ-Tanguieta, 155 at CHD-ZC, 616 at CHUD-BA, and 234 at CHU-MEL. These files correspond to mothers whose children were registered in the same six hospitals between January and December 2022 and were suspected of having an infection. This maternal data set is directly linked to the neonate data set, as it provides essential background on maternal characteristics that may influence neonatal health outcomes. The highest number of maternal files was recorded at CHUD-BA, while the lowest was at HZ-Tanguieta. The

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Newborns treatment with antibiotics							
Yes	12	16	6	1	22	4	61 (50%)
No	5	3	4	12	23	15	62 (50%)
Total	17	19	10	13	45	19	123
Hospitalization of newborns after birth							
0 days "Not hospitalized"	1	2	1	3	2	3	12 (10%)
1–7 days	9	14	9	5	33	13	83 (68%)
8–14 days	5	3	0	4	9	3	24 (20%)
15–21 days	1	0	0	1	1	0	3 (2%)
22-days	1	0	0	0	0	0	1 (1%)
Total	17	19	10	13	45	19	123

Table 4. Newborn's antibiotic treatment and hospitalization during and after birth.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD BA	CHU-MEL	Total N (%)
Amikacin	0	1	0	0	2	0	3 (5%)
Amoxicillin	1	2	0	1	0	0	4 (7%)
Ampicillin	0	1	0	0	2	1	4 (7%)
Cefepime	0	0	1	0	0	0	1 (2%)
Cefotaxime	4	3	1	0	7	1	16 (26%)
Ciprofloxacin	1	2	1	0	1	0	5 (8%)
Gentamicin	6	2	1	0	3	2	14 (23%)
Imipenem	0	1	2	0	3	0	6 (10%)
Meropenem	0	2	0	0	2	0	4 (7%)
Metronidazole	0	2	0	0	2	0	4 (7%)
Total	12	16	6	1	22	4	61

Table 5. Distribution of antibiotic usage among newborns.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	TotalN (%)
Mother's age							
[10–20]	16	18	35	18	56	19	162 (10%)
[20–35]	186	173	83	129	491	183	1245 (78%)
[36–45]	30	38	3	5	61	28	189 (10%)
[45–50]	2	4	3	3	8	4	24 (2%)
Total	234	233	124	155	616	234	1596
Mother's level of education							
Unschooled	178	186	112	138	376	225	1215 (76%)
Primary	21	7	2	12	142	0	184 (12%)
High school	16	26	4	3	61	2	112 (7%)
University	19	14	6	2	37	7	85 (5%)
Total	234	233	124	155	616	234	1596

Table 6. Meternal age and educational level's distribution.

majority of mothers (78%) were within the recommended age range for motherhood (20–35 years). However, 10% experienced teenage pregnancy (under 19 years), while 12% were over 35 years old. Most mothers (76%) had no formal education (Table 6).

Maternal pregnancy and delivery history

A total of 1114 mothers (70%) had experienced a previous pregnancy, compared to 30% who were primigravida. In CHD-ZC, nearly all the mothers were primigravida (91% of mothers selected at CHD-ZC). Among the study population, primiparous mothers (those who had given birth once) predominated at 57%, followed by multiparous mothers (those who had given birth more than once) at 38%. Most mothers (83%) had never undergone a Cesarean section. Among those who had, the majority had only experienced one C-section (15%).

Women who had never given birth vaginally made up 67% of the sample. However, most of those who had given birth vaginally did so at least twice (21%), compared to 12% who had done so only once (Table 7).

Referral status, pregnancy duration, and antenatal care

There was an unbalanced distribution between referred and non-referred mothers, with 65% being referred and 35% not referred. This disparity highlights the diverse ways mothers access hospital services, with the high proportion of referred mothers indicating strong collaboration with other health facilities. Healthcare workers used the last menstrual period to calculate pregnancy duration. Over half of the selected mothers (51%) had a pregnancy duration of 37 weeks or more, while 44% experienced moderately or late preterm pregnancies. A significant number of mothers (42%) had not attended any antenatal clinic visits for the current pregnancy. However, 34% attended at least four antenatal visits, and 24% attended one to three visits. The data also revealed a predominance of vaginal deliveries (57%) among the selected mothers (Table 8).

HIV status, BMI, and maternal health during childbirth

The results reveal a significant disparity between HIV-positive and HIV-negative mothers. HIV-positive mothers represented 6% of the sample, while HIV-negative mothers constituted a substantial majority at 94%. The majority of mothers (76%) had temperatures between 37 and 38.5 °C. Postpartum hospitalization was common, with 79% of mothers being hospitalized after delivery. The majority (53%) were hospitalized for a period of 1 week, while some (18%) were hospitalized for more than 2 weeks (Table 9).

Genital and postpartum infections, and antibiotic treatment

A relatively low proportion of mothers, 11%, reported experiencing a genital infection during pregnancy. This finding prompts further investigation into the factors contributing to the low incidence of infections. During delivery, 5% of mothers were identified as having an infection, and 2% experienced a postpartum infection (Table 10). Notably, only 16% of mothers with available data underwent microbiological analysis. Among the total sample, 56% of mothers received antibiotic treatment after delivery (Table 10).

The most commonly prescribed antibiotics were amoxicillin clavulanic acid (29%) and amoxicillin (28%) (Table 11).

Discussion

Maternal and neonatal infections pose significant socio-economic and health challenges globally, particularly in developing countries like Benin.

Newborn data

This retrospective study, conducted in six hospitals in Benin, revealed that 48% of admitted newborns were premature (gestational age < 37 weeks). This high prematurity rate underscores the need for enhanced prenatal care to prevent premature births. Recent research emphasizes the role of interventions such as administering

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Pregnancy history available							
Yes	168	196	122	14	431	183	1114 (70%)
No	66	37	2	141	185	51	482 (30%)
Total	234	233	124	155	616	234	1596
Number of previous pregnancies							
Primiparous	123	91	53	143	344	152	906 (57%)
Multiparous	103	126	57	10	236	74	606 (38%)
Grand multiparous	8	16	14	2	36	8	84 (5%)
Total	234	233	124	155	616	234	1596
Number of cesarean deliveries in the past							
0	213	148	103	154	498	204	1320 (83%)
1	16	71	19	0	105	24	235 (15%)
2	3	14	2	1	11	6	37 (2%)
3	0	0	0	0	0	0	0 (0%)
> 3	2	0	0	0	2	0	4 (1%)
Total	234	233	124	155	616	234	1596
Number of vaginal deliveries in the past							
0	191	111	57	143	405	167	1074 (67%)
1	17	39	32	3	69	26	186 (12%)
[2–5]	25	82	32	8	138	40	325 (20%)
[5–10]	1	1	3	1	4	1	11
Total	234	233	124	155	616	234	1596

Table 7. Medical history of pregnancy woman.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Admission ways for deliveries							
Referred	124	121	72	107	462	133	1019 (65%)
Not referred	110	112	52	48	154	80	552 (35%)
Total	234	233	124	155	616	234	1596
Pregnancy weeks							
< 28	1	0	0	0	0	0	1 (1%)
[28–32[	19	18	2	7	20	19	85 (5%)
[32–37[	92	102	19	97	299	92	701 (44%)
[37–42]	122	113	103	51	297	123	809 (51%)
Total	234	233	124	155	616	234	1596
Prenatal visits							
0	114	47	16	143	204	156	680 (43%)
1	9	10	19	1	29	7	75 (5%)
2	10	22	26	1	48	10	117 (7%)
3	17	44	24	3	84	16	188 (12%)
4	30	22	16	5	82	16	171 (11%)
> 4	54	88	23	2	169	29	365 (23%)
Total	234	233	124	155	616	234	1596
Type of delivery							
Cesarean delivery	140	100	10	40	209	110	609 (38%)
Vaginal birth	91	133	76	96	394	122	912 (57%)
Instrumental vaginal delivery	3	0	38	19	13	2	75 (5%)
Total	234	233	124	155	616	234	1596

Table 8. Patterns of admission, pregnancy's duration, prenatal care and delivery methods.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A.	CHU-MEL	Total N (%)
Mother's HIV status							
Positives	54	30	0	2	6	7	99 (6%)
Negatives	180	203	124	153	610	227	1497 (94%)
Total	234	233	124	155	616	234	1596
Mother's temperature during delivery							
≤ 37	117	28	79	5	25	105	359 (23%)
[5, 37, 38]	112	200	45	144	585	126	1212 (76%)
> 38.5	5	5	0	6	6	2	24 (1%)
Total	234	233	124	155	616	234	1596
Mother's hospitalization duration after birth							
Not hospitalized	198	0	0	131	7	0	336 (21%)
[1–7]	26	47	122	19	474	154	842 (53%)
[7–14]	5	2	2	5	92	33	139 (9%)
[14–35]	5	184	0	0	43	47	279 (18%)
Total	234	233	124	155	616	234	1596

Table 9. Clinical parameter at delivery.

corticosteroids to accelerate fetal lung maturation and closer monitoring of at-risk pregnancies, which can lower prematurity rates and improve neonatal outcomes[29,30]. The WHO recommends eight antenatal visits for pregnant women, but in Benin, limited access to primary healthcare services, particularly in rural areas, makes achieving this target difficult, contributing to regional disparities in hospital outcomes.

In our study, neonatal hypothermia was prevalent in our study, with 54% of newborns having a body temperature < 36.5 °C at birth. Hypothermia is a known risk factor for neonatal morbidity and mortality, potentially leading to multi-organ failure and increased infection risk[31]. International guidelines recommend immediate warming measures, such as skin-to-skin contact and incubator use, to prevent hypothermia in newborns[32–34]. However, in resource-limited settings, relying on hypothermia as an indicator of infection can lead to unnecessary antibiotic use, especially in health centers lacking medical laboratories. Therefore, additional clinical and biological data are essential before initiating antibiotic treatment.

	CNHU-HKM	CHDOP	HZ-Tanguiéta	CHD ZC	CHD BA	CHU-MEL	Total N (%)
Infection during pregnancy							
Yes	47	12	4	9	92	5	169 (11%)
No	187	221	120	146	524	229	1427 (89%)
Total	234	233	124	155	616	234	1596
Mother's infection during delivery							
Yes	5	26	0	6	43	2	82 (5%)
No	229	207	124	149	573	232	1514 (95%)
Total	234	233	124	155	616	234	1596
Postpartum infection among mothers							
Yes	5	19	1	2	6	0	33 (2%)
No	229	214	123	153	610	234	1563 (98%)
Total	234	233	124	155	616	234	1596
Mother's microbiology diagnosis during delivery							
Yes	9	30	7	3	31	173	253 (16%)
No	225	203	117	152	585	61	1343 (84%)
Total	234	233	124	155	616	234	1596
Mother receiving treatment with antibiotic after delivery							
Yes	19	42	115	14	530	176	896 (56%)
No	215	191	9	141	86	58	(44%)
Total	234	233	124	155	616	234	1596

Table 10. Pregnancy and postnatal infections.

	CNHU-HKM	CHUD-OP	HZ-Tanguieta	CHD ZC	CHUD B.A	CHU-MEL	Total N (%)
Amikacin	1	0	0	0	0	0	1 (1%)
Amoxicillin	4	1	21	6	164	55	251 (28%)
Amoxicillin + clavulanic acid	0	3	0	0	196	65	264 (30%)
Ampicillin	4	1	63	1	32	9	110 (12%)
Cefepime	3	0	0	0	0	0	3 (1%)
Cefotaxime	4	9	10	7	0	0	30 (3%)
Ciprofloxacin	0	5	0	0	0	0	5 (1%)
Gentamicin	1	4	21	0	0	0	26 (3%)
Metronidazole	2	18	0	0	11	7	38 (4%)
Not specified	0	1	0	0	127	40	168 (19%)
Total	19	42	115	14	530	176	896

Table 11. Antibiotic's usage for infection's treatment among mothers during pregnancy, delivery and post-partum period.

Breastfeeding initiation was delayed in many cases, with only 26% of mothers breastfeeding within 1 h of birth, with 44% starting between one and 24 h. This is consistent with demographic studies showing an increase in exclusive breastfeeding rates from 42% in 2017–2018 to 45% in 2021–2022[35]. Early breastfeeding is crucial for neonatal health, providing immunological protection and reducing morbidity and mortality risks. Recent studies indicate that breastfeeding within the first hour of life can reduce neonatal deaths by 22%[36]. Initiatives to promote early breastfeeding should be strengthened in the hospitals studied. However, socio-economic and health factors in Benin often prevent immediate breastfeeding within the first 24 h.

Among the newborns studied, 58% were diagnosed with an infection at birth, and 48% received antibiotics for more than 7 days. This highlights that many cases of antibiotic therapy occur without laboratory confirmation, sometimes extending for about 7 days. This practice can lead to antibiotic resistance and adverse effects in newborns, such as microbiota disruption[37], antibiotic-associated diarrhea (AAD)[38], and kidney damage[39]. Managing neonatal infections is a major challenge in resource-limited settings like Benin. The use of broad-spectrum antibiotics is common to prevent infectious complications but must be balanced against the risk of bacterial resistance. Recent literature emphasizes the importance of antibiotic stewardship programs to optimize antibiotic use and reduce resistance[40,41]. However, many hospitals lack bacteriology departments and infectious disease specialists to support clinicians in antibiotic therapy. Defining the infection ecology in these hospitals is crucial for guiding probabilistic antibiotic prescribing.

The average length of hospitalization was 10 days, aligning with international practices for complex neonatal care. Prolonged hospitalization allows for continued monitoring and optimal complication management but can increase family stress and hospital costs. Studies suggest that strategies like family-centered care and parent training can improve outcomes and reduce hospitalization length[42,43]. This is important as the risk of hospital-acquired infections for newborns remains high due to poor adherence to hygiene protocols in Benin's hospitals[44,45].

The results of our study are comparable to international data, though some disparities exist in terms of resources and care protocols. For instance, rates of prematurity and neonatal infections in Benin remain high compared to developed countries, highlighting the need to strengthen local capacities and standardize neonatal care practices. Comprehensive initiatives such as healthcare professional training programs and improved hospital infrastructure are key to closing these gaps[46].

Pregnancy women data

Our study revealed diversity in the sociodemographic characteristics of mothers of the included newborns. For example, 64% of mothers had a primary education level, while only 12% had a secondary education level or above. Recent studies have shown that maternal education level is a determining factor for neonatal care practices and newborn health outcomes. A higher level of education is often associated with a better understanding of prenatal and neonatal care, as well as more effective use of health services[47]. This diversity of socio-demographic characteristics is explained by the fact that the studies covered the entire country with a disparity in urban and rural populations. This factor has a great influence on the health system in Benin because it influences aspects such as access to health care, precariousness, etc.

Mothers' ages ranged from 15 to 45 years, with an average of 28 years. Approximately 30% of mothers were first-time mothers. Maternal age is an important factor influencing pregnancy and birth outcomes. Adolescent mothers and those over the age of 35 are generally at higher risk of obstetric complications, including premature birth and neonatal infections[48]. Parity, or the number of previous pregnancies, can also affect neonatal care and outcomes. Primiparous women may have less experience and knowledge about neonatal care, which may influence the health outcomes of their newborns. This could in particular influence the monitoring of pregnancy because the experience of pregnancy allows self-care of certain aspects which limit the problems and complications during the pregnancy. It also facilitates compliance with the prescriptions of health agents.

Prenatal practices, such as attending antenatal clinics and taking nutritional supplements, are crucial for the health of mothers and newborns. In our study, 78% of mothers attended at least four antenatal visits, which is consistent with WHO recommendations for adequate antenatal care. Even if it now requires planning 8 consultations instead of 4 because this allows the perinatal mortality rate to be reduced to 8 per 1000 births[49]. However, the quality of prenatal consultations and the specific interventions carried out during these consultations generally vary depending on professional practice and living environment. Studies have shown that comprehensive prenatal care, including nutritional counseling, vaccinations, and screening for maternal infections, is essential to prevent birth complications[46].

Our study identified that 22% of mothers had a history of infections during pregnancy, which can have a significant impact on neonatal health. Maternal–fetal infections, such as group B streptococcal infection, can be transmitted to the newborn during delivery and lead to serious neonatal infections. Early detection and treatment of maternal infections is crucial to prevent neonatal complications[41]. This also contributed in our study to a high consumption of antibiotics which once again raises the issue of antibiotic resistance.

Limitations of the study

While this study provides valuable insights into maternal and neonatal infections, several limitations warrant consideration. Firstly, the study was limited to six health centers. Including a broader range of health centers across various regions could have yielded a more diverse and comprehensive dataset, potentially offering a deeper understanding of the prevalence and patterns of maternal and neonatal infections throughout the entire country. However, the selected health centers were strategically located to cover significant regions in the North, South, and Center of the country, enhancing the study's representativeness to some extent. Unfortunately, the available records did not provide data on live births, so we are unable to present the neonatal mortality rate per live births in this study.

Conclusion

Our study highlights the challenges and common practices in the management of newborns with suspected infections in several hospitals in Benin. Targeted interventions, such as improved breastfeeding practices, rigorous antibiotic stewardship, and temperature regulation, are crucial to improve neonatal health outcomes in these settings. Future research should focus on optimizing care protocols and evaluating interventions to reduce rates of prematurity and neonatal infections. Maternal data from our study highlight the importance of sociodemographic characteristics, prenatal practices, and history of infections in determining neonatal outcomes. Strategies to improve maternal education, promote adequate prenatal practices, and support early breastfeeding are important to improve newborn health outcomes. Future research should focus on optimizing prenatal care and evaluating interventions to reduce maternal -fetal and neonatal complications.

Data availability

All data generated and/or analyzed during the current study are included in this published article. The datasets used and/or analyzed during this study are also available from the corresponding author on reasonable request.

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Author contributions

Arielle Kounou: Conceptualization, data collection, data analysis, and manuscript writing. Hornel Koudokpon: Data collection, data analysis, and critical review of the manuscript. Kevin Sintondji: Data collection, data interpretation, and manuscript editing. Boris Lègba: Data analysis, interpretation of results, and manuscript preparation. Kafayath Fabiyi: Conceptualization, supervision of data collection, and critical review of the manuscript. Anges Yadouléton: Supervision, validation of results, and review of the manuscript. Susanne Saarinen: Supervision, validation of results, and review of the manuscript. Victorien Dougnon: Principal investigator, project administration, funding acquisition, conceptualization, and final manuscript review and approval.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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