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Factors Associated with Neonatal Mortality at the Mother and Child University Hospital of N'Djamena (Chad): A Retrospective Cohort Study

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Abstract **Original Research Article**

***Introduction*:** Neonatal mortality is a major public health concern, especially in developing countries such as Chad. It is the result of several factors contributing to the maintenance of a high rate. The objective of this study was to determine the factors associated with hospital-based neonatal mortality at the Mother and Child University Hospital of N'Djamena in Chad. ***Methods*:** This was a retrospective cohort study conducted in the neonatology department of the Mother and Child University Hospital of N'Djamena and involved 1264 newborns hospitalized in the department in 2021. A logistic regression model was used to determine the factors associated with neonatal death, with a significance level of $p<0.05$. The variables of the final model were selected by a top-down approach based on the Akaike information criterion. ***Results*:** The cumulative incidence of deaths was 28.7% [26.4%; 31.3%]. The most lethal pathologies were: hypoxic-ischemic encephalopathy (53.5%), prematurity (47.5%), respiratory distress (45.9%), hypotrophy (43.6%), and hemorrhagic disease of the newborn (43.6%). In multivariate analysis, the factors associated with neonatal death were: preterm birth (OR=3.37 [2.27; 5.04]), hypotrophy (OR=2.32 [1.63; 3.31]), respiratory distress (OR=2.97 [2.06; 4.30]), hypoxic-ischemic encephalopathy (OR=1.85 [1.20; 2.88]), cyanosis (OR=2.67 [1.60; 4.51]), impaired consciousness (OR=2.05 [1.41; 2.98]), primary reflex abnormalities (OR=3.69 [2.46; 5.58]), blood transfusion (OR=2.23 [1.13; 4.42]), delivery outside the university hospital (OR=2.93 [2.09; 4.14]) and insufficient prenatal consultations (OR=1.42 [1.02; 1.98]). ***Conclusion*:** Hospital-based neonatal mortality is high at the Mother and Child University Hospital of N'Djamena. The implementation of maternal and neonatal health actions based on the identified risk factors will contribute to its reduction.

Keywords: Neonatal Mortality, Newborn, Mortality Factors, Chad.

1. INTRODUCTION

Improving child health is one of the global health priorities due to high infant mortality, especially in developing countries [1]. High infant mortality can be a reflection of a failing health system, but also of the local context of each country. It increases in the same direction as neonatal mortality, due to the frailty of the newborn [2]. Neonatal mortality refers to any death that occurs between the first and 28th day of life. It is said to occur early when it occurs during the first 7 days of life, and late when it occurs between the 8th and 28th day of life [3]. According to the World Health Organization (WHO), 2.4 million children worldwide died during the neonatal period in 2019, accounting for 47% of all deaths in children under 5 years of age [2]. Thus, an improvement in newborn survival would reduce infant mortality. Many factors related to the quality and supply of care, as well as to demand and perinatal characteristics, are reported by many authors as being detrimental to the survival of the newborn [4–8]. Prematurity, complications during childbirth, infections, and congenital malformations are the causes of most neonatal deaths [2].

In Chad, a low-income country in Central Africa, neonatal mortality remains high despite the measures implemented to reduce it. From 39‰ in 2004, neonatal mortality is estimated at 34‰ in 2014 according to the Demographic Health and Multiple Indicator Survey [9]. Thus, the evaluation of the Millennium Development Goals in terms of health has shown a reduction of 5‰ in 10 years, far from the expected target. As part of the achievement of the Sustainable Development Goals by 2030, a reduction in neonatal

mortality from 34‰ to 10‰ is a priority objective of Chad's national health policy [10]. With less than 10 years to go before 2030, this target is far from being achieved, since in 2019, neonatal mortality was 33‰ [11].

Given the inadequacy of the technical platform of the leading hospitals and the lack of qualified human resources at all levels of the country's health pyramid, hospital mortality remains high even in university hospitals, which are considered to be the reference centers for the entire country. Improving newborn care in all health facilities in the country would help reduce newborn mortality. This improvement could only be effective if the determinants of mortality are well identified. Thus, knowledge of the factors associated with neonatal mortality in reference centers will allow for better actions, including the implementation of strategic approaches to reduce neonatal mortality based on the factors identified. The present study is part of this logic and proposes to identify the factors associated with neonatal mortality at the Mother and Child University Hospital of N'Djamena.

2. PATIENTS AND METHODS

2.1 Place of Study

The study was conducted in the neonatology department of the Mother and Child University Hospital in N'Djamena. It is a national hospital center classified at level III of the country's health pyramid. It is therefore a national reference centre for maternal and child health. The neonatology department welcomes newborns and infants under 2 months of age. The newborns admitted to the department come from the maternity department of the Mother and Child University Hospital, other health facilities in the capital, N'Djamena, provincial health facilities, and homes. In 2021, the department included a 35-bed inpatient unit and a neonatal intensive care unit for newborns in vital distress and very premature infants. The technical platform of the intensive care unit included eight incubators, six heating tables, seven heart monitors, and a conventional phototherapy lamp. Continuous positive airway pressure, intensive phototherapy, and controlled hypothermia were not performed in the department during this period.

2.2 Study Population

The study population consisted of newborns hospitalized in the neonatal department during the period from January to December 2021.

The study included newborns with a usable medical record (anamnestic, clinical, biological, therapeutic, and evolutionary data, including dates of entry and discharge).

Those with an incomplete medical file with little information on hospital stay, discharged against medical advice, or escaped, who died on arrival, as well as abandoned newborns, were not included. The same is true for infants under 2 months of age hospitalized in the neonatal unit during the study period.

Abandoned newborns were those found in the streets by a third party and brought to the Mother and Child University Hospital, most often by the national police. Given the absence of parents, their files were incomplete and lacked vital data.

The sampling was exhaustive and non-probabilistic. All newborns meeting the inclusion criteria admitted during the period from January to December 2021 were included consecutively. Thus, 1264 hospitalized newborns were included.

2.3 Study Design

This was an observational retrospective cohort study. Newborns admitted to hospitalization were followed until they were discharged to determine their status regarding the event of interest (death).

2.4 Data Collection

The data collected as part of this research were those routinely collected as part of the care of newborns hospitalized in the neonatology department in 2021. They were extracted from the patients' physical medical records and transcribed on a pre-established individual collection sheet. Data collection was carried out during the period from February to May 2022. Data included maternal, obstetric, and neonatal characteristics.

2.5 Study Variables

2.5.1 Dependent Variable

The dependent variable was neonatal death, which was binary (yes/no) and defined as any death of a newborn that occurred during hospitalization in the neonatal department between the first and 28th day of life.

2.5.2 Independent Variables

The independent variables were:

- Maternal age in years
- Pregnancy follow-up assessed in terms of the number of antenatal consultations (ANCs);
- Pregnancy, parity, type of pregnancy, place of delivery, route of delivery, prematurity;
- The age of the newborn at admission in hours, the sex of the newborn; Apgar score at 5th minute, resuscitation in the delivery room, newborn weight in grams, hypotrophy defined by birth weight below the 10th percentile on gestational age reference curves [12] ;
- Respiratory distress, the Silverman score allows respiratory distress to be classified according to severity from signs of struggle [12];
- Moderate or severe hypoxic-ischemic encephalopathy (Sarnat II or III), disturbances

of consciousness, abnormalities of primary reflexes, convulsions;

- Hyperthermia (temperature ≥39°C), the neonatal infection which is defined according to the management algorithm of the neonatology department of the Mother and Child University Hospital [13] ;
- Neonatal anaemia, which is defined as a haemoglobin level of less than 14 g/dl, jaundice of the newborn, haemorrhagic disease of the newborn, and congenital malformations;
- Self-medication before admission, force-feeding, length of stay in days, regularity of treatment, oxygen therapy, and blood transfusion.

2.6 Data Processing

2.6.1 Missing Data Management

The independent variables retained were included in the analysis only if they had less than 10% missing data. Due to the context in which the biological assessment was not carried out, either for economic reasons among the children's parents or for reasons of the technical platform, the biological data used for the definition of pathological states were only those systematically carried out at admission.

A complete data analysis was performed for the dependent variable. Patients whose status with respect to the variable of interest was not reported in the medical record were not included in the analysis.

2.6.2 Quality Control Methods

The data submitted for analysis were those from patients' medical records. These files were written by paediatric residents and validated by senior paediatricians.

The data entered was double-checked to ensure consistency on the individual collection sheets.

2.6.3 Bias Management Methods

To minimize information bias regarding the data reported by the parents, the data were compared with those observed by the practitioner to keep only the objective data. Similarly, for the classification of certain disease states, standard grids available in the newborn examination room were used, thus minimizing the measurement bias related to the multiplicity of practitioners. The determination of the mothers' age was based only on their claims.

2.6.4 Statistical Analysis

The data collected on the individual sheets were entered into the Epi Info 7 software. The analyses were carried out using R software version 3.6.3 and Epi Info 7.

A descriptive analysis was carried out using the Epi Info 7 software. It determined the cumulative incidence of deaths during the year with its 95% confidence interval (CI) and described the characteristics of hospitalized newborns. Results were expressed as absolute numbers and percentages for categorical variables and as means and standard deviations for quantitative variables.

The factors were identified by the binary logistic regression method with death as the dependent variable. The explanatory variables included in the final regression model were selected using univariate and multivariate analyses.

The candidate variables were selected by a univariate analysis carried out on the Epi Info 7 software. Univariate analysis consisted of looking for the association between the explanatory variables and the variable to be explained (death) by calculating the risk ratio (RR) and its 95% confidence interval. The Chi2 test or the exact Fisher test was used for the comparison of proportions. Explanatory variables for which the p-value was ≤ 25% were retained for the multivariate analysis.

The R software then used a top-down approach based on the Akaike Information Criterion (AIC) to select variables for the final model.

A calculation of the adjusted odds ratio (ORa) with its 95% confidence interval, as well as the p-value, was performed for each variable of the final model. The significance threshold chosen was $p < 0.05$.

This step made it possible to determine the factors independently associated with hospital neonatal mortality.

2.7 Ethical Considerations

The study was purely observational and did not involve any risk for the patients included. Its purpose was to use the data collected to manage them during hospitalization.

Prior authorization from the head of the neonatology department was obtained to allow access to the medical records of newborns hospitalized during the study period.

The data collection sheets were pseudonymized. The data collected was only used within the strict research framework.

3. RESULTS

3.1 Characteristics of the Study Population

3.1.1 Obstetrical Characteristics

The 1264 newborns included were from mothers with a mean age of 25.4±6.1 years, with extremes of 15 and 46 years. The most common maternal

age group was 18 to 35 years (89.6%). Mothers were multi-gestational in 71% of cases and multiparous in 71.2% of cases. There were fewer than four antenatal consultations in 56.4% of cases.

The newborns were born from a singleton pregnancy in 89.7% of cases, came from health facilities other than the Mother and Child University Hospital in 61.1% of cases with a vaginal delivery in 81.3% of cases. They had difficulties adapting to extrauterine life for 28.8% and were resuscitated at birth in 26.6% of cases.

The obstetrical characteristics of hospitalized newborns are presented in Table I.

3.1.2 Neonatal Characteristics

Newborns were admitted in the first 24 hours of life in 62% of cases. They were male for 58.7% with a sex ratio of 1.4. At intake, they had an average weight of 2587.9±843.4 g, with extremes of 500 and 4800 g. Among newborns admitted, 38.1% weighed less than 2500 g. Newborns had severe respiratory distress (Silverman score ≥5) for 26.3%, impaired consciousness for 30%, and primary reflex abnormalities for 51.5% (Table II).

Table I: Obstetric characteristics of newborns hospitalized at the Mother and Child University Hospital of N'Djamena (Chad), 2021

Characteristics	n	%
Maternal age		
< 18 years old	47	3.8
18 – 35 years old	1097	89.6
> 35 years old	80	6.6
Gesturity		
Primigesture	366	29
Multi-gesture	898	71
Parity		
Primiparous	364	28.8
Multiparous	900	71.2
Number of ANCs		
< 4	714	56.5
≥ 4	550	43.5
Type of pregnancy		
Monofetal	1134	89.7
Multiple	130	10.3
Place of delivery		
Inborn	492	38.9
Outborn	772	61.1
Mode of delivery		
Vaginal delivery	1027	81.3
Caesarean section	237	18.7
Apgar score at 5 mins		
< 7	359	28.8
≥ 7	886	71.2
Resuscitation at birth	336	26.6

Table II: Clinical characteristics of newborns hospitalized at the Mother and Child University Hospital of N'Djamena (Chad), 2021

Characteristics	n	%
Age of the newborn		
< 24 h	784	62
24 – 72 hrs	233	18.4
> 72 h	247	19.6
Sex		
Male	742	58.7
Female	522	41.3
Weight		
< 2500 g	482	38.1
≥ 2500 g	782	61.9
Hyperthermia	193	15.3

Characteristics	n	%
Cyanosis	101	8
Silverman Score		
< 5	931	73.7
≥ 5	333	26.3
Disorder of consciousness	379	30
Convulsion	146	11.6
Primary reflex abnormalities	651	51.5

3.1.3 Neonatal Morbidities and Therapeutic Data

The main neonatal morbidities in hospitalization were: neonatal respiratory distress (50.8%), neonatal infections (43.5%), hypotrophy (27.6%), prematurity (23.7%), neonatal anaemia (22.6%), and moderate or severe hypoxic-ischemic encephalopathy (20.3%) (Table III).

In terms of therapy, self-medication before admission was noted for 1% of newborns and gavage for 1.7%.

In the hospital, 44.9% of newborns received oxygen therapy, and 6.2% received blood transfusions. Treatment was regular for 98% and discontinuous for 2%.

Table III: Neonatal morbidities in newborns hospitalized at the Mother and Child University Hospital of N'Djamena (Chad), 2021

Morbidities	n	%
Respiratory distress	642	50.8
Neonatal infections	550	43.5
Hypotrophy	349	27.6
Prematurity	299	23.7
Neonatal anemia	286	22.6
Hypoxic-ischemic encephalopathy (Sarnat II or III)	256	20.3
Malformations	97	7.7
Neonatal jaundice	94	7.4
Hemorrhagic disease	39	3.1

3.2 In-Hospital Neonatal Mortality

Of the 1264 newborns included, 363 deaths were recorded, a cumulative incidence of 28.7% [26.4%; 31.3%]. The mean length of stay for all hospitalized newborns was 4.4±3.8 days, with extremes of 1 and 27 days. For deceased newborns, the average was 2.6±3.2 days, with extremes of 1 and 23 days. The median was 1 day, and the interquartile range was [1; 3.5].

The most lethal morbidities were: hypoxic-ischemic encephalopathy (53.5%), prematurity (47.5%), respiratory distress (45.9%), hemorrhagic disease of the newborn (43.6%), and hypotrophy (43.6%) (Table IV).

Table IV: Lethality of neonatal morbidities in newborns hospitalized at the Mother and Child University Hospital of N'Djamena (Chad), 2021

Morbidities	N	Death	
		n	%
Prematurity	299	142	47.5
Hypotrophy	349	152	43.6
Respiratory distress	642	295	45.9
Hypoxic-ischemic encephalopathy (Sarnat II or III)	256	137	53.5
Neonatal infections	550	154	28
Neonatal jaundice	94	29	30.9
Neonatal anemia	286	104	36.4
Malformations	97	31	32
Hemorrhagic disease	39	17	43.6

3.3 Factors Associated with In-Hospital Neonatal Mortality

3.3.1 Obstetric Factors

In bivariate analysis, the risk of death was significantly higher in newborns born to mothers younger than 18 years of age (RR=1.6; p=0.007), with less than 4 ANCs (RR=1.8; p< 10-4), with an Apgar score less than seven at the 5th minute (RR=2.4; p< 10-4) and resuscitated at birth (RR=1.9; p<10-4) (Table V).

Table V: Obstetric factors associated with hospital neonatal mortality at the Mother and Child University Hospital of N'Djamena (Chad), 2021: bivariate analyses

Characteristics	Death	RR	95% CI	p
Maternal age				
< 18 years old	22 (46.8%)	1.6	[1.2 ; 2.3]	0.007
18 – 35 years old	312 (28.4%)		-	
> 35 years old	18 (22.5%)	0.8	[0.5 ; 1.2]	0.253
Gesturity				
Primigesture	97 (26.5%)			
Multi-gesture	266 (29.6%)	1.1	[0.9 ; 1.4]	0.27
Parity				
Primiparous	98 (26.9%)			
Multiparous	265 (29.4%)	1.1	[0.9 ; 1.3]	0.37
Number of ANCs				
< 4	254 (35.6%)	1.8	[1.5 ; 2.2]	< 10-4
≥ 4	109 (19.8%)			
Type of pregnancy				
Monofetal	319 (28.1%)	0.8	[0.6 ; 1.1]	0.17
Multiple	44 (33.9%)			
Place of delivery				
Inborn	127 (25.8%)			
Outborn	236 (30.6%)	1.2	[0.99 ; 1.4]	0.07
Mode of delivery				
Vaginal delivery	297 (28.9%)	1.04	[0.83 ; 1.30]	0.7
Caesarean section	66 (27.9%)			
Apgar score at 5 mins				
< 7	176 (49%)	2,4	[2.1 ; 2.9]	< 10-4
≥ 7	179 (20.2%)			
Resuscitation at birth				
Yes	148 (44%)	1,9	[1.6 ; 2.2]	< 10-4
No	5 (3.2%)			

3.3.2 Neonatal Factors

In bivariate analysis, the risk of death was significantly higher in newborns admitted during the first 24 hours of life (RR=2.6; p< 10-4), female (RR=1.2; p=0.04), with a weight of less than 2500g (RR=2.1; p< 10-4), a Silverman score ≥5 (RR=3.5, p< $^{10-4}$), cyanosis (RR=2.51; p< 10-4), impaired consciousness (RR=3.1; p< 10-4) and abnormalities of primary reflexes (RR=5.4; p< 10-4) (Table VI).

Table VI: Neonatal factors associated with in-hospital neonatal mortality at the CHUME of N'Djamena (Chad), 2021: bivariate analyses

Characteristics	Death	RR	95% CI	p
Age of the newborn				
< 24 h	286 (36.5%)	2.6	[1.9 ; 3.6]	< 10-4
24 – 72 hrs	33 (14.2%)	-		
> 72 h	44 (17.8%)	1.3	[0.8 ; 1.9]	0.28
Sex				
Male	197 (26.6%)			
Female	166 (31.8%)	1.2	[1.01 ; 1.42]	0.04
Weight				
< 2500 g	206 (42.7%)	2.1	[1.8 ; 2.5]	< 10-4
≥ 2500 g	157 (20.1%)			
Hyperthermia				
Yes	22 (11.4%)	0.4	[0.2 ; 0.5]	< 10-4
No	341 (31.8%)			
Cyanosis				
Yes	65 (64.4%)	2.51	[2.10 ; 2.99]	< 10-4
No	298 (25.6%)			

Characteristics	Death	RR	95% CI	p
Silverman score				
< 5	160 (17.2%)			
≥ 5	203 (61%)	3.5	[3.0 ; 4.2]	< 10-4
Disorder of consciousness				
Yes	206 (54.4%)	3.1	[2.6 ; 3.6]	< 10-4
No	157 (17.7%)			
Convulsion				
Yes	39 (26.7%)	0.9	[0.7 ; 1.2]	0.5
No	324 (29%)			
Primary reflex abnormalities				
Yes	309 (47.5%)	5.4	[4.1 ; 7.0]	< 10-4
No	54 (8.8%)			

3.3.3 Neonatal Morbidities

In bivariate analysis, the main morbidities associated with death in hospitalized newborns were: prematurity (RR=2.1; p< 0.001), hypotrophy (RR=1.9; p< 0.001), respiratory distress (RR=4.2; p< 0.001), hypoxic-ischemic encephalopathy (RR=2.4; p<0.001), neonatal anaemia (RR=1.4; p=0.001) and hemorrhagic disease of the newborn (RR=1.5; p=0.040) (Table VII).

Table VII: Neonatal morbidities associated with in-hospital neonatal mortality at the Mother and Child University Hospital of N'Djamena (Chad), 2021: bivariate analyses

Variables	Death	RR	95% CI	p
Prematurity				
Yes	142 (47.5%)	2.1	[1.8 ; 2.4]	<0.001
No	221 (22.9%)			
Hypotrophy				
Yes	152 (43.6%)	1.9	[1.6 ; 2.2]	<0.001
No	211 (23.1%)			
Respiratory distress				
Yes	295(45.9%)	4.2	[3.3 ; 5.3]	<0.001
No	68 (10.9%)			
Hypoxic-ischemic encephalopathy (Sarnat II/ III)				
Yes	137 (53.3%)	2.4	[2; 2.8]	<0.001
No	226(22.4%)			
Neonatal infections				
Yes	154 (28%)	0.95	[0.8; 1.14]	0.600
No	209(29.3%)			
Neonatal jaundice				
Yes	29 (30.9%)	1.10	[0.8; 1.50]	0.600
No	334(28.6%)			
Neonatal anemia				
Yes	104(36.4%)	1.40	[1.1 ; 1.7]	0.001
No	259(26.5%)			
Malformations				
Yes	31 (32%)	1.1	[0.8 ; 1.5]	0.500
No	332(28.5%)			
Hemorrhagic disease				
Yes	17 (43.6%)	1.5	[1.02; 2.2]	0.040
No	346(28.2%)			

3.3.4 Therapeutic Data

Self-medication and gavage practices (RR = 1.1 [0.5, 2.1, p=0.700] in the home newborn were not associated with neonatal mortality.

The risk of death was significantly higher with the use of oxygen therapy (RR=4.4 [3.5, 5.5]; p< 0.001) and blood transfusion (RR=1.8 [1.4, 2.3]; p< 0.001) in the newborn.

3.3.5 Logistic Regression

In multivariate analysis, the factors independently associated with the death of hospitalized newborns were: prematurity, hypotrophy, the existence

of respiratory distress, moderate or severe hypoxic-ischemic encephalopathy, cyanosis, impaired consciousness, abnormalities in primary reflexes, transfusion practice in the newborn, delivery outside the Mother and Child University Hospital and insufficient prenatal consultations (Table VIII).

Table VIII: Factors associated with hospital neonatal mortality at the Mother and Child University Hospital of N'Djamena (Chad), 2021: Multivariate analyses

Factor	ORa	95% CI	p
Prematurity	3.37	[2.27 ; 5.04]	< 0.001
Hypotrophy	2.32	[1.63 ; 3.31]	< 0.001
Respiratory distress	2.97	[2.06 ; 4.30]	< 0.001
Hypoxic-ischemic encephalopathy (Sarnat II or III)	1.85	[1.20 ; 2.88]	< 0.001
Cyanosis	2.67	[1.60 ; 4.51]	< 0.001
Disorder of consciousness	2.05	[1.41 ; 2.98]	< 0.001
Anaemia	1.37	[0.90 ; 2.05]	0.140
Blood transfusion	2.23	[1.13 ; 4.42]	0.020
Hemorrhagic disease	2.08	[0.86 ; 5.02]	0.100
Primary reflex abnormalities	3.69	[2.46 ; 5.58]	< 0.001
Hyperthermia	0.59	[0.32 ; 1.03]	0.07
Childbirth outside the Mother and Child University Hospital	2.93	[2.09 ; 4.14]	< 0.001
Number of ANCs<4	1.42	[1.02 ; 1.98]	0.040

4. DISCUSSION

Neonatal deaths are a major health concern. This study, conducted in a referral hospital in a low-income country, was used to determine mortality in hospitalized newborns and the associated factors.

4.1 In-Hospital Neonatal Mortality

The neonatology department of the Mother and Child University Hospital of N'Djamena had a cumulative death incidence of 28.7% [26.4%; 31.3%]. Compared to data from other authors, this result highlights the differences between health structures in developing countries.

The neonatal mortality recorded in the neonatology department of the Mother and Child University Hospital in N'Djamena can be superimposed on the results reported by Makoura *et al*., at the Souro-Sanou University Hospital in Bobo Dioulasso (Burkina Faso) in 2019 (27.88%)[14], and Kambale *et al*., in Bukavu (Democratic Republic of Congo) in 2016 (26.6%) [7]. However, it is much higher than the results of other authors in Africa, including Rotovoarisoa *et al*., in Madagascar in 2020 (12.74%) [15], Abdala Kingwengwe *et al*., at the Kindu Referral Hospital (DRC) in 2019 (15%) [16], Houssou *et al*., in Benin in 2020 (18.7%) [17], Mashake *et al*., in Goma (DRC) in 2019 (19.7%) [18], Zoungrana-Yaméogo *et al*., at the Tengandogo University Hospital (Burkina Faso) in 2021 (19.72%) [19], Kouakou *et al*., at the Cocody University Hospital (Côte d'Ivoire) in 2016 (20%) [20], Kedy Koum *et al*., in 2015 [4], Noukeu *et al.*, in 2021 [21], in Douala (Cameroon) with 20.3 and 20.2% respectively. Mouganza *et al*., in Lubumbashi (DRC) in 2019 found an incidence of neonatal deaths of 40.04% [22], which is rather much higher than the result of the present study. Although there is a disparity between countries, neonatal mortality remains high in sub-Saharan African countries. The high neonatal mortality in our context highlights the inadequacy of the country's health structures in neonatal care. This high mortality in a referral facility suggests a more worrying situation in provincial health facilities, when we know that the technical platform remains limited and that the care of the newborn in the delivery room is often inadequate.

Newborns hospitalized in the neonatal department are hospitalized for various neonatal complications that contribute to neonatal deaths to varying degrees. At the Mother and Child University Hospital of N'Djamena, newborns were hospitalized mainly for neonatal respiratory distress, neonatal infection, hypotrophy, prematurity, neonatal anaemia, and moderate or severe hypoxic-ischaemic encephalopathy. These various complications, in particular neonatal infections, prematurity, asphyxia, and respiratory distress, are also reported in varying proportions by different authors as the main reasons for hospitalization of newborns [4-24]. The existence of these various complications could be explained in the Chadian context by inadequate follow-up of the pregnancy and inadequate management of labour and newborn in the delivery room. This observation is related to the frequency of adjustment disorders, resuscitation in the delivery room, and the large number of insufficiently monitored pregnancies in the present study.

Among the various neonatal complications, the most lethal were hypoxic-ischemic encephalopathy, prematurity, respiratory distress, and hemorrhagic disease of the newborn. For many authors, prematurity, infections, and asphyxia are considered to be the leading causes of neonatal death in referral hospitals [4-23]. Chelo *et al*., also reported that asphyxia and prematurity

are the leading causes of neonatal death in a level I maternity ward in Yaoundé, Cameroon [25].

Thus, prevention through optimal management of pregnancy and labor and better management of various complications in the neonatology department would reduce neonatal mortality in the Chadian context.

4.2 Factors Associated with In-Hospital Neonatal Mortality

Identifying the factors associated with neonatal death is an essential step in improving newborn care and, therefore, survival. Univariate and multivariate analyses were performed to identify them in this study. The analyses showed that the factors independently associated with the death of newborns hospitalized at the Mother and Child University Hospital of N'Djamena were prematurity, hypotrophy, the existence of respiratory distress, moderate or severe hypoxic-ischemic encephalopathy, cyanosis, impaired consciousness, abnormalities of primary reflexes, the practice of transfusion in the newborn, delivery outside the Mother and Child University Hospital and insufficient antenatal consultations. These different factors, therefore, include obstetric and neonatal factors and morbidities of the newborn in the hospital.

At the obstetrical level, factors related to both the mother and the course of pregnancy and delivery were associated with high neonatal mortality in univariate analysis. Thus, the risk of death was significantly higher in newborns of mothers younger than 18 years of age, while the age group over 35 years of age was not significantly associated with newborn death in univariate analysis. Adolescent girls, because of the immaturity of their pelvis, are often exposed to the risk of obstructed deliveries that can be the cause of problems adapting to extrauterine life in newborns. This could explain the association between young maternal age and newborn death in the present study. Dystructed delivery has been reported by Tina *et al*., as a factor associated with neonatal mortality [26]. Santos *et al*., also found an association between young maternal age (10-19 years) and neonatal death, but contrary to our result, advanced maternal age was a risk factor [6]. The association between advanced maternal age and neonatal death has also been highlighted by other African authors [5-27].

Other obstetric factors associated with neonatal death at the Mother and Child University Hospital of N'Djamena include insufficient pregnancy follow-up, an Apgar score of less than 7 at the 5th minute of life, and the need for resuscitation at birth. In multivariate analysis, inadequacy of prenatal follow-up and delivery outside the Mother and Child University Hospital were significantly associated with death, as reported by most authors [8-27]. Thus, a well-monitored pregnancy would make it possible to identify risk situations and ensure optimal care, thus reducing neonatal morbidity and mortality.

The place of delivery is another factor impacting the survival of the newborn. Newborns born outside the Mother and Child University Hospital of N'Djamena had a higher risk of death compared to those born in the maternity department of the Mother and Child University Hospital. This result could be explained by the inadequacy of the technical platform of other health facilities, inadequate care in the delivery room, suboptimal transfer conditions, and the distance traveled to reach the reference facility. This situation would be more deleterious for premature and hypotrophic patients who require specific transfer conditions to increase their chance of survival. The results of this study confirm those of the other authors that births outside the reference maternity ward are a risk factor for neonatal death in the neonatal departments of the reference hospitals [4-21].

Extrauterine adjustment disorders and resuscitation at birth, which are common in the present study, have also been variously reported by authors as risk factors for neonatal mortality [4-19]. These observations underline the need for regular monitoring of deliveries in order to reduce the frequency of adjustment disorders and thus neonatal mortality.

The association between other obstetric factors, such as the type of pregnancy, the mode of delivery, the gestational age, the parity of mothers, and neonatal death has not been established at the Mother and Child University Hospital of N'Djamena, although some authors have highlighted it. For Santos *et al*., in Brazil, multiple pregnancy, primiparity and vaginal delivery are risk factors for newborn death [6]. The association between vaginal delivery and neonatal death has also been reported by Houssou *et al*., [17]. However, with regard to parity, Noria *et al*., instead found an association between multiparity and neonatal death [5]. The differences observed are related to country-specific conditions.

Other authors have also reported that the type of presentation, not assessed in this study, is associated with neonatal mortality. Kedy Koum *et al*., found that breech delivery was associated with neonatal death [4]. Khan *et al*., on the other hand, found that a presentation other than cephalic was a risk factor for newborn death [28].

With regard to neonatal characteristics, various factors have been highlighted. Thus, in univariate analysis, the risk of death was significantly higher in newborns admitted during the first 24 hours of life, females, with a weight of less than 2500g, a Silverman score ≥5, with cyanosis, a disturbance of consciousness, and abnormalities of primary reflexes. This association remained significant for disorders of consciousness and abnormalities of primary reflexes in multivariate

analysis. Low weight (< 2500 g) was not included in the multivariate analysis since it was already represented by hypotrophy and prematurity. The same is true of Silverman's score assessing respiratory distress.

Other authors have demonstrated the association between these different factors and neonatal death in different ways. For example, low weight has been reported as a risk factor for neonatal death by Khan *et al*., [28], Houssou *et al.,* [17], Zoungrana *et al*., [19], Noukeu *et al*., [21], Kedy Koum *et al*., [4], Garcia *et al*., [8], Noria *et al*., [5], and Katamea *et al*., [26]. These results highlight the vulnerability of low birth weight newborns during the first 4 weeks of life, both in N'Djamena and in other developing countries. The same is true of the disorders of consciousness reported by Khan *et al*., [28], and Noukeu *et al*., [21].

In addition to the factors identified in these different studies, abnormality of primary reflexes and cyanosis have been identified as factors independently associated with hospital neonatal mortality in the neonatology department of the Mother and Child University Hospital of N'Djamena. These different factors are danger signs that should alert the practitioner in their daily practice. They should be taken into account in order to anticipate the care of the newborn.

Among neonatal pathologies, prematurity, hypotrophy, neonatal respiratory distress, and encephalopathy were factors independently associated with neonatal death in the neonatology department of the Mother and Child University Hospital of N'Djamena. Prematurity reported by various other authors is one of the main risk factors for neonatal mortality in hospitals [4–27]. This would be related to her immaturity and the many associated neonatal complications. Silé *et al*., had highlighted a high mortality rate in premature babies hospitalized in the Neonatology Department of the Mother and Child University Hospital; their survival was linked to the absence of neonatal complications [29]. The role of these neonatal complications is increased by the inadequacy of the technical platform of the various hospitals in N'Djamena, which does not allow for optimal care along the care pathway for mothers and their newborns. Thus, improving the overall management of prematurity would reduce neonatal mortality.

Hypotrophy is another factor that weakens the newborn, as highlighted in the present study. The latter can concern both premature babies and term newborns [12]. Special attention should be given to these newborns with a view to reducing neonatal death.

Another important factor associated with the death of the newborn in the neonatology department of the Mother and Child University Hospital is the existence of neonatal respiratory distress. This neonatal complication is all the more lethal when it occurs in a preterm setting [29]. This result highlights the problem of neonatal respiratory distress management at the Mother and Child University Hospital of N'Djamena. It was evident that with a limited field and a poorly trained staff, one could not expect a better result. Managing newborn distress should be a priority among approaches to reducing neonatal mortality in N'Djamena.

In addition to respiratory distress, moderate or severe encephalopathy should be another point of attention for the practitioner because of its high frequency in hospitalization in the neonatology department of the Mother and Child University Hospital. It reflects inadequate management of labour and newborn birth. The results of this study confirm those of other authors that perinatal asphyxia is a risk factor for neonatal mortality [4-17].

The final logistic regression model did not demonstrate the association between neonatal hemorrhagic disease, neonatal anaemia, and significant neonatal death in univariate analysis. These complications, which have been little explored in other studies, nevertheless require attention to their management in the neonatology department of the Mother and Child University Hospital of N'Djamena.

In contrast to some studies that have found a significant association between neonatal infections and neonatal death [4-17], neonatal infections were not significantly associated with the death of newborns hospitalized in the neonatology department of the Mother and Child University Hospital of N'Djamena. This result could be explained by the implementation of an algorithm for the management of neonatal infections in the neonatology department in 2019, which improved the care of the newborn [13]. Similarly, the association between the presence of congenital malformation and neonatal death has not been demonstrated in newborns hospitalized at the Mother and Child University Hospital of N'Djamena, contrary to the data of other authors [6-21]. This difference could be linked to the type of malformations encountered in the different structures.

From a therapeutic point of view, the use of transfusion in cases of anaemia was significantly associated with the death of newborns hospitalised at the Mother and Child University Hospital of N'Djamena, thus highlighting the involvement of anaemia in the occurrence of neonatal deaths. Better exploration of this complication with a view to appropriate and early management will reduce the incidence of neonatal deaths.

4.3 Limitations of the Study

The main limitation of the study is the retrospective collection of data. Thus, the variables of the study remain limited to those contained in the medical

records, with the risk of missing data. However, most of the variables considered had a small proportion (<5%) of missing data. These data mainly concerned maternal age and the Apgar score at the 5th minute. These elements did not have a major impact on the results of this study due to the sample size.

5. CONCLUSION

Hospital neonatal mortality is high in the neonatology department of the Mother and Child University Hospital of N'Djamena, with a cumulative incidence of 28.7% in 2021. Hospitalized newborns had many pathologies, the main ones being respiratory distress, neonatal infections, prematurity, hypotrophy, anemia, and hypoxic-ischemic encephalopathy.

The most lethal pathologies were moderate or severe hypoxic-ischemic encephalopathy, prematurity, respiratory distress, hypotrophy, and hemorrhagic disease of the newborn.

The factors independently associated with the death of newborns hospitalized at the Mother and Child University Hospital of N'Djamena were prematurity, hypotrophy, the existence of respiratory distress, moderate or severe hypoxic-ischemic encephalopathy, cyanosis, impaired consciousness, abnormalities of primary reflexes, the practice of transfusion in the newborn, delivery outside the maternity department of the Mother and Child University Hospital and the inadequacy of prenatal consultations.

The reduction of neonatal mortality would require the implementation of maternal and neonatal health actions based on the risk factors for neonatal death identified.

Additional studies in peripheral structures would enable us to identify the main obstacles and conditions for implementing these various actions, which would improve maternal, newborn, and child health indicators.

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