

Regional disparities and health system determinants of perinatal mortality in seven tertiary referral maternity hospitals in Niger: A multicenter hospital-based study

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Abstract

Background

This study aimed to quantify regional variation in perinatal mortality across seven tertiary referral maternity hospitals in Niger and identify modifiable maternal, clinical, and health-system determinants associated with perinatal mortality.

Methods

We conducted a retrospective multicenter hospital-based study including all births occurring at ≥ 28 weeks of gestation in seven tertiary referral maternity hospitals in Niger between January 1, 2023, and December 31, 2024. Perinatal death was defined as stillbirth or early neonatal death within the first seven days of life. Maternal, obstetric, and neonatal characteristics were extracted from standardized hospital records. Factors associated with perinatal mortality were identified using modified Poisson regression with robust variance estimation, accounting for clustering at the hospital level. Adjusted risk ratios (aRRs) with 95% confidence intervals (CIs) were estimated.

Results

Among 46,215 births, 7,819 perinatal deaths occurred, corresponding to a perinatal mortality rate of 169.2 per 1,000 births. Stillbirths accounted for 68.8% of all perinatal deaths. After multivariable adjustment, lack of formal maternal education (aRR 1.65; 95% CI 1.58–1.72), inadequate antenatal care attendance (aRR 2.78; 95% CI 2.71–2.84), prematurity (aRR 4.80; 95% CI: 4.27–5.33), low birth weight (aRR 4.13 ; 95% CI 3.87–4.39), rural residence (aRR 1.47; 95% CI 1.41–1.53), and referral to a tertiary hospital (aRR 2.16; 95% CI 2.01–2.31) were independently associated with an increased risk of perinatal mortality. The crude association between cesarean delivery and perinatal mortality was no longer statistically significant after adjustment.

Conclusion

Perinatal mortality remains a major public health challenge in tertiary referral maternity hospitals in Niger. Strengthening the quality of antenatal care, improving referral systems, expanding access to comprehensive emergency obstetric and newborn care, and optimizing the management of preterm and low-birth-weight infants are essential to reduce preventable perinatal deaths. This large multicenter study provides robust contemporary evidence to inform maternal and newborn health policies in Niger and similar low-resource settings.

BACKGROUND

Perinatal mortality, which includes stillbirths and early neonatal deaths, remains a major public health concern worldwide [1]. According to the World Health Organization (WHO), approximately 4.5 million perinatal deaths occur annually, with the vast majority occurring in low- and middle-income countries which alone account for 98% of perinatal deaths worldwide [1, 2]. Sub-Saharan Africa bears a disproportionate burden of this mortality because of limited access to quality maternal and neonatal healthcare services [3]. The African region, of which Niger is a part, has the highest rate of perinatal mortality, with an average rate of 41.8‰ births in the West African country [4].

Perinatal mortality is considered a sensitive indicator of the quality of obstetric and neonatal care, as well as the socioeconomic development of a country [5]. Although substantial progress has been achieved globally over recent decades, the decline in perinatal mortality has been slower in many African countries, including Niger [5–8].

Several maternal, fetal, neonatal, and healthcare-related factors have been associated with perinatal mortality. These include inadequate antenatal care, prematurity, low birth weight, hypertensive disorders of pregnancy, intrapartum complications, neonatal infections, delayed referral, and poor access to emergency obstetric and neonatal care [5, 7, 9].

Despite sustained international efforts to reduce preventable perinatal deaths, contemporary multicenter evidence describing regional variation in perinatal mortality and the contribution of health system factors remains scarce in Niger and across the Sahel. Most available studies are single center or focus primarily on individual level risk factors, providing limited information on variations between referral hospitals and the organization of perinatal care. Understanding these disparities is essential for identifying modifiable weaknesses in referral pathways and emergency obstetric and newborn care. Therefore, this multicenter hospital-based study aimed to quantify regional variation in perinatal mortality across seven tertiary referral maternity hospitals in Niger and to identify maternal, clinical, and health system determinants associated with perinatal mortality.

MATERIALS AND METHODS

Study design and setting

We conducted a retrospective multicenter hospital-based study using routinely collected maternity and neonatal records from seven tertiary maternity hospitals in Niger: Issaka Gazoby Maternity Hospital in Niamey and the Mother and Child Health Centers (MCHCs) of Agadez, Tahoua, Tillabéry, Diffa, Maradi, and Zinder. These facilities are the highest-level public referral hospitals in their respective regions and provide comprehensive emergency obstetric and neonatal care. They receive complicated obstetric and neonatal cases referred from primary and secondary healthcare facilities across the country.

Study period

The study was conducted over a two-year period, from 1 January 2023 to 31 December 2024.

Study participants

The study population comprised all eligible births (live births and stillbirths) at or beyond 28 + 0 weeks of gestation (based on last menstrual period or early ultrasound when available) recorded in the seven participating tertiary maternity hospitals during the study period.

The unit of analysis was the newborn. In the cases of multiple pregnancies, each fetus/newborn was considered separately for outcome.

Definition of perinatal mortality

For this study, perinatal mortality was defined as the sum of stillbirths (fetal death at $\geq 28 + 0$ weeks of gestation or with birth weight $\geq 1,000\text{g}$. Occurring before or during delivery) and early neonatal death (death of live-born infants within the first seven completed days of life)[1].

The outcome was measured as facility-based perinatal mortality, including stillbirths and early neonatal death occurring before discharge or within 7 days of live as in-hospital births.

Eligibility criteria

Inclusion criteria

We included all births that fulfilled the following criteria

delivery occurring between 1 January 2023 and 31 December 2024;

gestational age ≥ 28 completed weeks, irrespective of the place of antenatal care;

newborns delivered alive or stillborn in one of the seven participating hospitals.

Exclusion criteria

The following records were excluded

births occurring at < 28 completed weeks of gestation;

gestational age unknown and birth weight $< 1,000\text{g}$;

neonatal deaths occurring after the seventh completed day of life;

medical records with missing information on the primary outcome or essential study variables;

duplicate records identified during data verification.

Sample size

No formal sample size calculation was performed because this study used a complete enumeration (census) of all eligible births recorded in the participating hospitals during the study period.

Overall, 46,215 births met the eligibility criteria and were included in the final analysis. Among them, 7,819 newborns experienced perinatal death, whereas 38,396 survived beyond the first seven completed days of life (Fig. 1).

Data sources and data collection

Data were retrospectively extracted from multiple routine hospital sources, including delivery registers, maternity records, neonatal registers, partographs, operating theatre registers, and individual medical records.

A standardized data abstraction form was developed before data collection and used uniformly across the seven participating hospitals. Data collectors were trained obstetricians and senior midwives who received standardized instructions regarding variable definitions and data extraction procedures.

Variables collected included maternal socio-demographic characteristics (age, educational level, occupation, place of residence (urban/rural), referral status, parity), obstetric characteristics, antenatal care (ANC), gestational age at delivery, mode of delivery, pregnancy and delivery complications (retroplacental hematoma, hypertensive disorders of pregnancy, uterine rupture, obstructed labour, chorioamnionitis, premature rupture of membranes and others), newborn characteristics (sex, birth weight), and perinatal outcome (live birth, stillbirth or early neonatal death).

ANC attendance was categorized according to WHO recommendations as: no ANC visit, 1–3 ANC visits, and ≥ 4 ANC visits.

Birth weight was categorized as: <1500 g, 1500–2499 g, and ≥ 2500 g.

Gestational age was classified into four categories: 28–32 weeks, 33–36 weeks, 37–41 weeks, and ≥ 42 weeks of gestation.

To ensure data quality, completed abstraction forms were reviewed daily by the principal investigators. Data consistency was verified before database entry, and duplicate records or obvious inconsistencies were resolved by checking the original medical records.

Variables

The dependent variable was perinatal death (yes/no). Independent variables were grouped into maternal (age, education, occupation, residence, referral status, number of ANC visit), obstetric (parity, pregnancy complications, mode of delivery), and neonatal (sex, gestational age, birth weight, Apgar score) factors.

Outcome measures

The primary outcome was the perinatal mortality rate, defined as the number of stillbirths plus early neonatal deaths per 1,000 total births during the study period.

Secondary outcomes included: distribution of stillbirths and early neonatal deaths; causes of perinatal mortality; maternal, obstetric and neonatal factors associated with perinatal mortality.

Stillbirths and early neonatal deaths were also described separately to distinguish obstetric conditions associated with stillbirths from causes of early neonatal death.

Statistical analysis

Data were entered, cleaned and analyzed using SPSS Statistics version 27.0. Continuous variables were summarized as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on data distribution. Categorical variables were summarized as frequencies and percentages.

The perinatal mortality rate was calculated as the number of stillbirths plus early neonatal deaths per 1,000 total births.

Bivariable analyses were performed to compare maternal, obstetric and neonatal characteristics between newborns with and without perinatal death. Pearson's chi-square test or Fisher's exact test was used for categorical variables, whereas Student's t-test was used for continuous variables, as appropriate.

Because perinatal mortality was a relatively common outcome in this study population, modified Poisson regression with robust variance estimation was used instead of logistic regression to estimate adjusted risk ratios (aRRs) and their 95% confidence intervals (95% CIs), thereby avoiding overestimation of the magnitude of associations. Robust standard errors were used to account for clustering of observations within hospitals.

Variables with a P-value < 0.20 in bivariable analyses, together with variables considered clinically relevant based on previous literature, were entered into the multivariable model.

Reference categories were predefined before modelling: formal education; urban residence; ≥ 4 ANC visits; direct admission; gestational age ≥ 42 weeks; birth weight ≥ 2500 g; vaginal delivery.

Variables considered to be consequences of the outcome or lying directly on the causal pathway, including the Apgar score, were not included in the multivariable model.

Multicollinearity among explanatory variables was assessed using the variance inflation factor (VIF), and no evidence of problematic collinearity was identified.

Cases with missing values for variables included in the regression model were excluded using complete-case analysis. Statistical significance was defined as $P < 0.05$.

Ethical considerations

Ethical approval

for this study was obtained from the Institutional Review Board the Faculty of Health Sciences, Abdou Moumouni University, Niamey, Niger (Reference No. 000863/2AUA/FSS/SS).

Given the retrospective design of the study and the use of routinely collected, fully anonymized hospital data, the requirement for informed consent to participate was waived by the Institutional Review Board.

RESULTS

General characteristics of the study population

Marked regional disparities in perinatal mortality were observed across the seven participating tertiary referral maternity hospitals, with rates ranging from 119.2 to 263.6 per 1,000 births (Fig. 2 and Table 1). Overall, 46,215 births were included, among which 7,819 perinatal deaths occurred, corresponding to a perinatal mortality rate of 169.2 per 1,000 births.

Of the perinatal deaths, 5,379 (68.8%) were stillbirths and 2,440 (31.2%) were early neonatal deaths.

Regional distribution of perinatal mortality

Perinatal mortality rates varied considerably across the different regions.

The highest rates were observed in Zinder (263.6‰) and Niamey (176.5‰), whereas the lowest rates were observed in Agadez (119.2‰) and Diffa (120.7‰). The variation in the perinatal mortality rate across Niger's regions is presented in Table 1.

The magnitude of inter-hospital variation suggests that differences in perinatal outcomes cannot be explained solely by individual maternal or neonatal characteristics. Instead, these findings indicate substantial heterogeneity in referral patterns, case severity, and the organization of comprehensive emergency obstetric and newborn care across participating hospitals.

Table 1
Variation of perinatal mortality rate across Niger's regions

Region	Total births	Perinatals deaths	Stillbirths	Early neonatal deaths	Perinatals mortality rate
Agadez	4267	509	411	98	119.2‰
Diffa	4175	504	393	111	120.7‰
Tillabéry	1773	239	136	103	134.7‰
Maradi	9422	1344	902	442	142.6‰
Tahoua	3980	610	380	230	153.3‰
Niamey	15436	2725	1744	981	176.5‰
Zinder	7162	1888	1413	475	263.6‰
Total	46215	7819	5379	2440	169.2‰

Maternal and obstetric characteristics

The mean maternal age was 27.4 ± 3.2 years (range: 13–52 years old) in the perinatal deaths group, compared to 28.4 ± 2.7 years (range: 15–48 years old) in mothers who had not experienced perinatal deaths. The largest age group represented in perinatal deaths mothers group was 20–34 year olds (59.5%) compared to 71.4% in the life infant group ($P = 0.01$).

The majority of mothers in perinatal deaths group had no formal education (74.9% vs 61.5%) and were unemployed (85.1% vs 64.3%). More than half of mothers in perinatal deaths group originated from rural areas (54.2% vs 48%) and were referred from peripheral healthcare facilities (79.4% vs 36.7%). The distance traveled by these patients to reach the place of care varied between 23 and 949 kilometers, or 15 minutes to 12 hours by road. Also, 44.1% (3452 cases) of those did not have access to medical transportation.

The mean parity was 3.4 ± 1.2 (range: 1–14) in the perinatal deaths group compared to 2.7 ± 1.03 (range: 1–9) in the life infant group ($P = 0.06$).

Regarding antenatal care, the average number of ANC visits was 2.1 ± 1.4 (range: 0–7) in mothers with perinatal deaths, compared to 3.6 ± 2.7 (range: 0–9) in the life infant group ($P < 0.001$). The mean birth weight was 3225.15 ± 25.3 g (range: 1150 g to 5240 g). Preterm birth (48.5% vs 19.6%) and birth weight less than 2,500g (48.6% vs 22.0%) were more frequent among perinatal deaths group.

Among early neonatal deaths, Apgar score 1–6 at 5 minute, was observed in 80.4% of cases, and 48.7% died in the first day after birth.

Table 2 presents the baseline characteristics of the study population according to perinatal outcome.

Causes of perinatal mortality

The leading causes of early neonatal death were birth asphyxia (48%), complications of prematurity (26.9%), neonatal infections (18.8%), neonatal hemorrhage (3.2%), and congenital malformations (2.5%).

Among stillbirths, the most frequent associated obstetric conditions were placental abruption (43.5%), peripartum asphyxia (20.2%), hypertensive disorders of pregnancy (17.3%), chorioamniotitis (9%), and uterine rupture (4.7%).

Table 3 presents the causes of perinatal mortality.

Factors associated with perinatal mortality

In bivariate analyses, maternal age ($P = .01$), educational level ($P = 0.003$), number of ANC visits ($P < 0.001$), referral status ($P < 0.001$), gestational age ($P < 0.001$), mode of delivery ($P = 0.003$), and birth weight ($P < 0.001$) were significantly associated with perinatal mortality.

Perinatal mortality was significantly higher among: mothers without formal education (19.9% vs 11.7%), mothers without ANC visits compared to ≥ 4 ANC visits (33% vs 7%), mothers who experienced preterm deliveries (33.4% vs 11.6%), and newborns with birth weight $< 2,500\text{g}$ (44.9% vs 11.7%).

In multivariable modified Poisson regression analysis, lack of formal maternal education (aRR 1.65; 95% CI 1.58–1.72; $P < 0.001$), rural residence (aRR 1.47; 95% CI 1.41–1.53; $P < 0.001$), lack of antenatal care visit (aRR 2.78; 95% CI 2.71–2.84; $p < 0.001$), referral status (aRR 2.16; 95% CI 2.01–2.31; $P < 0.001$), prematurity (aRR 4.80; 95% CI 4.27–5.33; $P < 0.001$), and low birth weight (aRR 4.13 ; 95% CI 3.87–4.39; $P < 0.001$) remained independently associated with increased perinatal mortality. Mode of delivery was not independently associated with mortality after adjustment (aRR 1.18; 95% CI: 0.75–1.61; $P = 0.23$).

Table 4 presents the factors associated with perinatal mortality among 46,215 births in bivariable and multivariable analysis.

Table 2
Baseline characteristics of the study population according to perinatal outcome.

Variables	Total births (N = 46,215)	Perinatal deaths (n = 7,819)	Live births (n = 38,396)	P
Maternal age (years)				0.01
< 20	6552 (14.2)	1606 (24.5)	4946(75.5)	
20–34	32081(69.4)	4656 (14.5)	27425(85.5)	
≥ 35	7582(16.4)	1557 (20.5)	6025(79.5)	
Education level				0.003
No formal education	29459 (63.7%)	5860 (19.9%)	23599 (80.1%)	
Schooling	16756 (36.3%)	1959 (11.7%)	14797 (88.3%)	
Parity				0.06
Primiparous	9540 (20.6%)	2169 (22.7%)	7371 (77.3%)	
Pauciparous	11054 (24%)	1797 (16.2%)	9257 (83.8%)	
Multiparous	17490 (37.8%)	1857 (10.6%)	15633 (85.4%)	
Grande multiparous	8131 (17.6%)	1986 (24.4%)	6145 (75.6%)	
ANC visits				
0	7657 (16.5%)	2534 (33%)	5123 (67%)	< 0.001
1–3	22449 (48.6%)	4079 (18.2%)	18370 (81.8%)	
≥ 4	16109 (34.9%)	1206 (7.5%)	14903 (92.5%)	
Gestational age				
28–32 weeks	4003 (8.7%)	2011 (50.2%)	1992 (49.8%)	< 0.001
33–36 weeks	7327 (15.8%)	1778 (24.3%)	5549 (75.7%)	
37–41 weeks	18247 (39.5%)	1790 (9.8%)	16457 (90.2%)	
≥ 42 weeks	16638 (36%)	2240 (13.5%)	14398 (86.5%)	
Mode of delivery				0.003
Vaginal	29224 (63.2%)	3679 (12.6%)	25545 (87.4%)	
Caesarean section	16991 (36.8%)	4140 (24.4%)	12851 (75.6%)	
Referral status				< 0.001
ANC : Antenatal care ; P : p-value of crude model				

Variables	Total births (N = 46,215)	Perinatal deaths (n = 7,819)	Live births (n = 38,396)	P
Referred	20285 (43.9%)	6206 (30.6%)	14079 (69.4%)	
Direct admission	25930 (56.1%)	2119 (8.2%)	23811 (91.8%)	
Birth weight				< 0.001
< 1500g	1863 (4.0%)	1508 (80.9%)	355 (19.1%)	
1500g-2499g	6594 (14.3%)	2292 (34.8%)	4302 (65.2%)	
≥ 2500g	37758 (81.7%)	4019 (10.6%)	33739 (89.4%)	
ANC : Antenatal care ; P : p-value of crude model				

Table 3
Causes of perinatal deaths in seven referral maternity hospitals in Niger (N = 7819)

Variables	Number of case	Percent (%)
A) Obstetric conditions associated with stillbirths (n = 5379)		
Placental abruption	2339	43.5
Peripartum asphyxia	1088	20.2
Hypertensive disorders	932	17.3
Chorioamnionitis	484	9.0
Uterine rupture	253	4.7
Malformation (MTP)	88	1.6
Others	195	3.6
B) Cause of early neonatal deaths(n = 2440)		
Birth asphyxia	1171	48.0
Prematurity complications	657	26.9
Neonatal infection	458	18.8
Neonatal hemorrhage	78	3.2
Congenital malformation	60	2.5
Others	16	0.7
MTP : Medical termination of pregnancy		

Table 4

Factors associated with perinatal mortality among 46,215 births in seven referral maternity hospitals in Niger: modified Poisson regression analysis with robust variance estimates.

Variables	All newborns (n = 46,215)	Perinatal deaths (n = 7,819)	Live newborns (n = 38,396)	cRR	95% CI	aRR	95% CI	P
Maternal education								
No formal education	29459 (63.7%)	5860 (19.9%)	23599 (80.1%)	1.70	[1.62–1.78]	1.65	[1.58–1.72]	< 0.001
Schooling	16756 (36.3%)	1959 (11.7%)	14797 (88.3%)	1 (Ref)		1 (Ref)		
Mother residence								
Rural residence	22685 (49%)	4238 (18.7%)	18447 (81.3%)	1.23	[1.18–1.28]	1.47	[1.41–1.53]	< 0.001
Urban residence	23530 (51%)	3581 (15.2%)	19949 (84.8%)	1 (Ref)		1 (Ref)		
ANC visits								
0	7657 (16.5%)	2534 (33%)	5123 (67%)	4.42	[4.15–4.71]	2.78	[2.71–2.84]	< 0.001
1–3	22449 (48.6%)	4079 (18.2%)	18370 (81.8%)	2.43	[2.28–2.58]	1.93	[1.87–1.98]	< 0.001
≥ 4	16109 (34.9%)	1206 (7.5%)	14903 (92.5%)	1 (Ref)		1 (Ref)		
Referral status								
Referred	20285 (43.9%)	6206 (30.6%)	14079 (69.4%)	3.74	[3.58–3.92]	2.16	[2.01–2.31]	< 0.001
Direct admission	25930 (56.1%)	2119 (8.2%)	23811 (91.8%)	1 (Ref)		1 (Ref)		
Gestational age								
28–32 weeks	4003 (8.7%)	2011 (50.2%)	1992 (49.8%)	5.12	[4.85–5.40]	4.80	[4.27–5.33]	< 0.001
33–36 weeks	7327 (15.8%)	1778 (24.3%)	5549 (75.7%)	2.47	[2.33–2.63]	1.78	[1.38–2.18]	< 0.001
cRR : Crude Risk Ratio; aRR : Adjusted Risk Ratio; CI : Confidence interval, ANC : Antenatal care, P : p-value of adjusted model ; Ref : Reference								

Variables	All newborns (n = 46,215)	Perinatal deaths (n = 7,819)	Live newborns (n = 38,396)	cRR	95% CI	aRR	95% CI	P
Maternal education								
37–41 weeks	18247 (39.5%)	1790 (9.8%)	16457 (90.2%)	1 (Ref)		1 (Ref)		
≥ 42 weeks	16638 (36%)	2240 (13.5%)	14398 (86.5%)	1.37	[1.29–1.46]	1.13	[0.97–1.29]	0.34
Mode of delivery								
Vaginal	29224 (63.2%)	3679 (12.6%)	25545 (87.4%)	1 (Ref)		1 (Ref)		
Caesarean section	16991 (36.8%)	4140 (24.4%)	12851 (75.6%)	1.94	[1.86–2.01]	1.18	[0.75–1.61]	0.23
Birth weight								
< 1500g	1863 (4.0%)	1508 (80.9%)	355 (19.1%)	7.60	[7.33–7.89]	4.13	[3.87–4.39]	< 0.001
1500g–2499g	6594 (14.3%)	2292 (34.8%)	4302 (65.2%)	3.27	[3.12–3.41]	1.44	[1.36–1.52]	< 0.001
≥ 2500g	37758 (81.7%)	4019 (10.6%)	33739 (89.4%)	1 (Ref)		1 (Ref)		
cRR : Crude Risk Ratio; aRR : Adjusted Risk Ratio; CI : Confidence interval, ANC : Antenatal care, P : p-value of adjusted model ; Ref : Reference								

DISCUSSION

Principal findings

Beyond documenting a high perinatal mortality rate, this study demonstrates substantial regional variation in perinatal mortality across tertiary referral maternity hospitals in Niger. These differences persisted despite all participating facilities representing the highest level of obstetric referral within the national health system, suggesting that health-system factors, referral pathways, and differences in case mix contribute importantly to perinatal outcomes. In addition to confirming the contribution of established maternal and neonatal determinants, our findings highlight the need to strengthen health-system performance as a central component of strategies aimed at reducing preventable perinatal deaths.

This multicenter hospital-based study also demonstrated that perinatal mortality remains a major public health challenge, with a rate of 169.2 per 1,000 births, substantially exceeding recent global and regional estimates [1–4]. Stillbirths accounted for nearly two-thirds of all perinatal deaths, emphasizing the persistent burden of intrapartum fetal deaths in low-resource settings [2, 5–7, 10–13].

After adjustment using modified Poisson regression with robust variance estimation, maternal education, antenatal care attendance, prematurity, low birth weight, and referral status were independently associated with perinatal mortality, whereas the crude association with mode of delivery was no longer statistically significant after adjustment. The use of adjusted risk ratios rather than odds ratios provides more appropriate and interpretable effect estimates for this common outcome, reducing the risk of overestimating associations.

These findings indicate that perinatal mortality in Niger results from a complex interaction between maternal socioeconomic conditions, access to quality healthcare, referral pathways, and neonatal vulnerability. Women with limited education and inadequate antenatal care were more likely to experience adverse perinatal outcomes, highlighting the influence of social determinants on maternal health-seeking behaviour and access to skilled obstetric care. Similarly, prematurity and low birth weight emerged as strong predictors of mortality, reflecting the vulnerability of newborns requiring specialized neonatal management. Importantly, these variables should be interpreted as proximal clinical determinants within the pathway leading to perinatal death rather than as isolated causal factors.

Another important finding is the independent association between referral status and perinatal mortality. Given the referral role of the participating hospitals, this association most likely reflects delayed access to comprehensive emergency obstetric and neonatal care rather than the quality of care provided at tertiary facilities. Together, these findings underscore that reducing perinatal mortality requires interventions extending beyond delivery care alone, including improvements in maternal education, antenatal care quality, timely referral systems, and evidence-based management of high-risk pregnancies and vulnerable newborns.

Overall, our findings provide contemporary multicenter evidence identifying modifiable factors associated with perinatal mortality in Niger. These results may help guide clinicians, policymakers, and public health authorities in prioritizing interventions aimed at improving maternal and newborn survival and accelerating progress toward achieving the Sustainable Development Goal (SDG) 3.2 [2, 4].

Regional disparities and health-system perspective

One of the most important findings of this study is the marked variation in perinatal mortality observed across the seven participating referral hospitals. Such differences are unlikely to be explained exclusively by biological characteristics of mothers or newborns. Rather, they probably reflect differences in referral pathways, delays in accessing comprehensive emergency obstetric care, availability of neonatal resuscitation, blood transfusion capacity, staffing, and local organization of maternal and newborn services. Similar inter-hospital variation has been reported in multicenter studies conducted in other sub-

Saharan African countries, where health-system performance strongly influences perinatal survival [6, 7]. These findings suggest that reducing perinatal mortality requires not only improving clinical management but also strengthening referral systems, emergency transportation, and equitable access to comprehensive obstetric and newborn care throughout the country.

Comparison of our findings with previous studies

The perinatal mortality rate of 169.2 per 1,000 births observed in this study remains substantially higher than recent global and regional estimates, confirming that perinatal mortality continues to be a major public health challenge in sub-Saharan Africa [1–4]. According to the World Health Organization (WHO) and the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), although significant progress has been achieved in reducing neonatal mortality and stillbirths globally, improvements have been considerably slower in low-income countries, particularly in sub-Saharan Africa, where limited access to quality maternal and newborn healthcare continues to impede progress toward Sustainable Development Goal (SDG) 3.2 [1–4, 23].

Compared with previous African studies, the perinatal mortality rate reported here is higher than those observed in referral hospitals in Ethiopia and Tanzania [5–7]. Similar determinants including inadequate antenatal care, low maternal educational attainment, prematurity and low birth weight have consistently been identified across these studies, suggesting that the mechanisms underlying adverse perinatal outcomes remain largely comparable throughout the region. Differences in mortality rates are likely explained by variations in referral systems, case mix, availability of comprehensive emergency obstetric and neonatal care, and the overall performance of national health systems [10].

The particularly high mortality observed in our study should also be interpreted in light of the study setting. Unlike population-based surveys, this investigation was conducted exclusively in seven tertiary referral maternity hospitals, which receive women with severe obstetric complications and critically ill newborns transferred from lower-level facilities. Consequently, the study population represents a high-risk referral cohort rather than the general obstetric population. This referral pattern inevitably increases the proportion of pregnancies complicated by fetal distress, placental abruption, obstructed labor, hypertensive disorders, uterine rupture, extreme prematurity, and severe neonatal conditions, all of which substantially increase the likelihood of perinatal death.

Our findings are nevertheless consistent with previous reports from Niger indicating that perinatal mortality remains persistently high despite recent improvements in maternal and newborn health services. Direct comparison with earlier national studies should, however, be interpreted cautiously because of differences in study design, case definitions, study periods, and levels of healthcare facilities. Importantly, the present study includes 46,215 births from seven referral hospitals, providing one of the largest contemporary multicenter assessments of perinatal mortality conducted in Niger.

Another noteworthy observation is the variation in perinatal mortality between participating hospitals. Similar heterogeneity has been described in multicenter studies from other African countries and

probably reflects differences in referral pathways, delays in accessing emergency obstetric care, availability of skilled birth attendants, neonatal resuscitation capacity, blood transfusion services, and neonatal intensive care resources [6, 7]. These findings emphasize that improving perinatal survival requires strengthening not only clinical management but also the organization of referral systems and the quality of emergency obstetric and newborn care across the entire health system.

Overall, our results are consistent with the broader international literature showing that preventable perinatal deaths remain concentrated in low-resource settings where socioeconomic disadvantage, delayed access to care, and limited availability of comprehensive emergency obstetric and neonatal services continue to compromise maternal and newborn survival [1–7].

Interpretation of associated factors

Maternal education

Maternal education remained independently associated with perinatal mortality, with newborns of women without formal education experiencing a significantly higher risk of death than those born to educated mothers. Similar associations have been consistently reported in Ethiopia and other sub-Saharan African countries, where maternal education is recognized as a key social determinant of maternal and newborn health [5, 7, 9, 11, 12, 14]. Education probably influences perinatal survival through several interconnected pathways, including improved health literacy, greater autonomy in healthcare decision-making, earlier recognition of pregnancy complications, and increased utilization of antenatal care and skilled birth attendance. Nevertheless, maternal education should not be interpreted as a direct biological determinant of perinatal mortality but rather as a proxy for broader socioeconomic conditions, including household income, healthcare accessibility, and women's empowerment. Consequently, despite multivariable adjustment, residual socioeconomic confounding cannot be completely excluded. These findings support continued investment in female education and community-based maternal health education programmes as complementary strategies to improve maternal healthcare utilization and reduce preventable perinatal deaths [1, 5, 7, 15].

Antenatal care attendance

Adequate antenatal care attendance was independently associated with a lower risk of perinatal mortality, consistent with findings from Ethiopia and Tanzania [5–7]. This finding is consistent with the well-established role of antenatal care in improving maternal and neonatal outcomes through the early identification and management of pregnancy-related complications, health education, preventive interventions, and timely referral of high-risk pregnancies [1, 2, 20].

Regular antenatal care facilitates early identification and management of hypertensive disorders, maternal infections, fetal growth restriction, anemia, and other pregnancy complications before irreversible fetal compromise occurs [1, 20–22]. However, the observed association should be interpreted in the context of healthcare quality, as the number of antenatal visits alone does not necessarily reflect the effectiveness of the care provided. Because this retrospective study relied on

routinely collected records, antenatal care was categorized according to documented visits rather than the content or quality of services received. Therefore, our findings primarily reflect healthcare utilization rather than quality of care. Improving both early antenatal care attendance and the quality of evidence-based antenatal interventions remains essential for reducing preventable perinatal mortality in low-resource settings [1, 5–7].

Prematurity

Prematurity was one of the strongest predictors of perinatal mortality, in agreement with previous African studies and recent global estimates identifying complications of prematurity among the leading causes of neonatal death [1–6, 16]. The increased mortality observed among preterm newborns is biologically plausible because of respiratory immaturity, impaired thermoregulation, metabolic instability, and increased susceptibility to infection. However, prematurity should be interpreted as a proximal clinical determinant rather than an isolated causal factor, as it frequently results from underlying maternal and placental disorders, including hypertensive diseases, infections, placental insufficiency, and multiple pregnancy. Consequently, reducing prematurity-related mortality requires interventions across the continuum of maternal and newborn care, including prevention and treatment of maternal complications, timely referral of high-risk pregnancies, antenatal corticosteroid administration when indicated, effective neonatal resuscitation, Kangaroo Mother Care, and improved access to specialized neonatal services [1–3, 6, 19].

Low birth weight

Low birth weight remained independently associated with perinatal mortality after adjustment for potential confounders, consistent with findings from Tanzania, Ethiopia, and international reports [1–6, 17, 18]. Similar to prematurity, low birth weight represents a marker of fetal vulnerability resulting from multiple maternal, placental, and fetal conditions rather than an isolated cause of death. Although closely related, prematurity and low birth weight are distinct clinical entities, and both retained independent associations with mortality in our analysis. The high burden of low birth weight observed among perinatal deaths probably reflects the concentration of complicated pregnancies managed within tertiary referral hospitals. These findings emphasize the importance of improving maternal nutrition, preventing hypertensive disorders and fetal growth restriction, and strengthening essential newborn care, including thermal protection, breastfeeding support, Kangaroo Mother Care, infection prevention, and appropriate respiratory support for vulnerable newborns [1, 6].

Mode of delivery

Although cesarean delivery was associated with perinatal mortality in the crude analysis, this association was no longer statistically significant after multivariable adjustment, suggesting that the initial association was largely explained by the severity of the underlying obstetric conditions. Similar observations have been reported in referral hospitals across sub-Saharan Africa, where emergency cesarean sections are predominantly performed for fetal distress, obstructed labor, placental abruption, severe hypertensive disorders, and other life-threatening complications [5–7]. Consequently, the

observed crude association most likely reflects confounding by indication rather than an adverse effect of cesarean delivery itself [24, 25]. This finding also illustrates the importance of using modified Poisson regression with robust variance estimation, which provides more appropriate estimates for common outcomes than logistic regression and reduces the risk of exaggerated effect estimates [18]. Our results therefore should not be interpreted as evidence that cesarean delivery increases perinatal mortality but rather that it represents a marker of severe obstetric complications requiring timely emergency intervention.

Referral status and rural residence

Referral status and rural residence remained independently associated with perinatal mortality, highlighting the important contribution of health system factors to adverse pregnancy outcomes. Similar findings have been reported in multicenter African studies, where women referred to tertiary hospitals experienced poorer perinatal outcomes because referral often occurred after severe maternal or fetal compromise had already developed [5–7]. This association is best interpreted within the framework of the Three Delays Model, whereby delays in seeking care, reaching an appropriate facility, and receiving definitive treatment contribute to preventable maternal and perinatal deaths [24, 25]. Because all participating hospitals are tertiary referral centres, the observed association probably reflects referral bias and the concentration of the most severe obstetric emergencies rather than differences in the quality of care provided after admission. Strengthening referral pathways, improving communication between health facilities, expanding comprehensive emergency obstetric and newborn care at district level, and reducing transportation delays should therefore constitute major priorities for reducing preventable perinatal mortality in Niger [1, 6, 7, 27].

Causes of perinatal mortality

In the present study, stillbirths accounted for approximately two-thirds of all perinatal deaths, while birth asphyxia, complications of prematurity, and neonatal infections were the leading causes of early neonatal mortality. This pattern is consistent with the epidemiology of perinatal mortality observed across sub-Saharan Africa, where most deaths remain attributable to preventable obstetric and neonatal conditions despite recent improvements in maternal and child health services [1, 4, 28].

Among stillbirths, the most frequently documented associated obstetric conditions were placental abruption, hypertensive disorders of pregnancy, uterine rupture, pripartum asphyxia, and other severe intrapartum complications. These conditions are well-recognized antecedents of fetal hypoxia and intrauterine death and have consistently been identified as major contributors to stillbirths in low-resource settings [7, 29].

Birth asphyxia was the leading cause of early neonatal death in our cohort. This finding agrees with recent estimates from the World Health Organization (WHO) and the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), which identify intrapartum-related hypoxic events as one of the

three principal causes of neonatal mortality worldwide, together with complications of prematurity and neonatal infections [1, 27]. Similar observations have been reported in Ethiopia and Tanzania, where inadequate intrapartum fetal monitoring, delayed recognition of fetal distress, prolonged labor, and limited neonatal resuscitation capacity were identified as major contributors to early neonatal deaths [5, 6].

Complications related to prematurity constituted another major cause of neonatal death in our study. This observation is expected because preterm newborns are particularly vulnerable to respiratory distress syndrome, apnea, hypothermia, sepsis, feeding difficulties, and intracranial hemorrhage, especially in settings where access to neonatal intensive care, continuous positive airway pressure (CPAP), surfactant therapy, and advanced respiratory support remains limited [19]. Likewise, neonatal infections continued to represent an important cause of death, reflecting persistent challenges related to infection prevention, early diagnosis, and timely antibiotic treatment in resource-constrained maternity and neonatal units.

The predominance of these preventable causes indicates that many perinatal deaths are potentially avoidable through improvements in the continuum of maternal and newborn care [1, 19, 30].

CLINICAL AND PUBLIC HEALTH IMPLICATIONS

The findings of this multicenter study have important implications for clinical practice and maternal–newborn health policies in Niger and other low-resource settings. The identification of modifiable factors associated with perinatal mortality indicates that substantial improvements in newborn survival are achievable through coordinated interventions across the continuum of care, from pregnancy to the early neonatal period.

From a clinical perspective, strengthening the quality of antenatal care should be a priority. Early identification of women at increased risk of adverse pregnancy outcomes including hypertensive disorders, maternal infections, fetal growth restriction, and threatened preterm birth would facilitate timely referral to facilities capable of providing comprehensive emergency obstetric and newborn care. Equally important are improvements in intrapartum fetal surveillance, timely obstetric intervention when clinically indicated, and wider implementation of evidence-based neonatal practices, including neonatal resuscitation, Kangaroo Mother Care, prevention of hypothermia and neonatal infections, and appropriate respiratory support for preterm and low-birth-weight infants. These interventions are supported by current World Health Organization (WHO) recommendations and remain among the most effective strategies for reducing preventable perinatal deaths in resource-constrained settings [1–3].

Our findings also underscore the need to strengthen the referral system. Delays in recognizing obstetric emergencies, initiating referral, and accessing definitive care continue to contribute substantially to adverse perinatal outcomes. Improving communication between health facilities, expanding emergency transportation, ensuring the continuous availability of blood transfusion and emergency obstetric services, and strengthening district-level comprehensive emergency obstetric and newborn care are

essential components of an effective referral network. Routine perinatal death audits should also be integrated into hospital quality-improvement programmes to identify avoidable factors and guide corrective actions.

Beyond the health sector, the independent association between maternal education and perinatal mortality highlights the importance of intersectoral policies that promote female education, women's empowerment, and community awareness of pregnancy danger signs. Such interventions may improve healthcare-seeking behaviour, increase utilization of antenatal and delivery services, and reduce delays in accessing skilled obstetric care, particularly in rural communities.

Finally, this study provides robust contemporary multicenter evidence that can support national strategies aimed at reducing preventable perinatal mortality. Future prospective multicenter studies incorporating standardized assessment of referral pathways, quality of obstetric and neonatal care, and health system performance are needed to better identify modifiable determinants of perinatal death and evaluate interventions capable of accelerating progress toward achieving Sustainable Development Goal 3.2 [1, 4, 23].

The substantial variation observed between referral hospitals indicates that national quality-improvement initiatives should extend beyond clinical protocols to include regular benchmarking of perinatal outcomes across maternity hospitals. Routine comparison of hospital-specific perinatal mortality indicators could facilitate identification of best practices and health-system deficiencies, thereby supporting targeted interventions to improve maternal and newborn survival.

STUDY STRENGTHS

This study has several important strengths. To our knowledge, it is one of the largest multicenter hospital-based studies of perinatal mortality conducted in Niger, including 46,215 births from seven tertiary referral maternity hospitals across the country. The multicenter design enhances the external validity of the findings within the national referral system and provides a more comprehensive assessment of regional variations in perinatal outcomes than previous single-center studies.

Another major strength is the inclusion of all eligible births during the study period using a census approach, minimizing selection bias and improving the precision of the estimated perinatal mortality rate and associated risk estimates. Unlike previous studies that focused exclusively on perinatal deaths, our analysis included all births, allowing perinatal mortality to be evaluated as the primary outcome within a clearly defined study population and ensuring consistency in the unit of analysis.

Methodologically, the use of modified Poisson regression with robust variance estimation enabled direct estimation of adjusted risk ratios, an approach considered more appropriate than logistic regression for common outcomes such as perinatal mortality. In addition, adjustment for a broad range of maternal, obstetric, and neonatal characteristics reduced the potential influence of measured confounding factors.

Finally, the study was conducted and reported in accordance with the STROBE Statement, thereby improving methodological transparency, reproducibility, and comparability with other observational studies. Collectively, these strengths provide robust contemporary evidence to inform clinical practice, public health policies, and future research aimed at reducing preventable perinatal mortality in Niger.

Another important strength is the use of an analytical framework in which perinatal mortality was evaluated among all births rather than restricting the analysis to perinatal deaths alone. This approach provides more valid estimates of associations and avoids the selection bias inherent in case-only analyses.

STUDY LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, its retrospective design relied on routinely collected hospital records, making the analysis susceptible to incomplete documentation, variable data quality, and potential information bias. Although standardized data extraction procedures were implemented, the accuracy of the findings depended on the completeness of the original medical records.

Second, the study was conducted exclusively in seven tertiary referral maternity hospitals, where pregnancies complicated by severe maternal or fetal conditions are disproportionately managed. Consequently, the estimated perinatal mortality rate should not be interpreted as representative of the general obstetric population in Niger. Rather, it reflects the burden of perinatal mortality among women receiving comprehensive emergency obstetric and newborn care within the national referral system. This referral pattern may also have contributed to the strong associations observed for referral status, prematurity, and low birth weight.

Third, although modified Poisson regression with robust variance estimation was used to adjust for major maternal, obstetric, and neonatal characteristics, residual confounding cannot be completely excluded. Important determinants such as maternal socioeconomic status, nutritional status, quality and content of antenatal care, timing and indication for referral, intrapartum fetal monitoring, decision-to-delivery interval, and availability of neonatal intensive care interventions were not consistently documented in routine hospital records and therefore could not be included in the analysis. Furthermore, although robust standard errors were used to account for clustering at the hospital level, the relatively small number of participating hospitals may have limited our ability to fully capture between-hospital variability.

Fourth, prematurity and low birth weight should be interpreted as proximal clinical determinants of perinatal mortality rather than direct causal factors, as both frequently arise from underlying maternal and placental disorders. Consequently, the adjusted risk ratios reported in this study represent measures of association and should not be interpreted as evidence of causality.

Finally, antenatal care exposure was classified according to the number of documented visits because detailed information on the content and quality of antenatal services, including implementation of the

current WHO eight-contact model, was unavailable in the retrospective records. Therefore, our findings primarily reflect antenatal care utilization rather than the quality of care received.

Despite these limitations, the large multicenter design, inclusion of all eligible births, use of an analytical framework based on the entire birth cohort, and application of modified Poisson regression with robust variance estimation provide robust and clinically relevant evidence on the determinants of perinatal mortality in Niger. These findings offer a valuable basis for strengthening maternal and newborn health policies and prioritizing interventions aimed at reducing preventable perinatal deaths.

CONCLUSION

This multicenter hospital-based study demonstrates that perinatal mortality remains a major public health challenge in tertiary referral maternity hospitals in Niger and reveals substantial regional disparities despite a common referral-level of care. These findings indicate that health system performance and referral pathways are likely to play a major role in explaining variations in perinatal outcomes.

These findings suggest that meaningful reductions in perinatal mortality will require integrated interventions across the continuum of maternal and newborn care. Strengthening the quality of antenatal care, improving timely referral to comprehensive emergency obstetric and newborn care, expanding evidence-based management of preterm and low-birth-weight infants, and addressing broader social determinants of maternal health should constitute national priorities. Because many of the identified factors are potentially modifiable, targeted improvements in healthcare delivery and health system organization may substantially reduce preventable perinatal deaths.

Although causal relationships cannot be inferred from this observational study, the large multicenter design, inclusion of all births, and use of an analytical approach appropriate for a common outcome provide robust contemporary evidence to inform clinical practice and maternal-newborn health policies in Niger. Future prospective multicenter studies incorporating standardized assessment of healthcare quality, referral pathways, and perinatal care processes are warranted to better identify modifiable determinants of perinatal mortality and support progress toward achieving Sustainable Development Goal 3.2.

Beyond identifying individual maternal and neonatal determinants, this study provides contemporary multicenter evidence highlighting opportunities to strengthen referral systems, improve quality of emergency obstetric and newborn care, and reduce preventable perinatal deaths across Niger.

Declarations

AUTHOR CONTRIBUTIONS

M.O, H.S.D. and M.N : Study's conception and design, data collection, manuscript drafting, draft review, and manuscript finalisation.

M.C.Y., I.A.A., Z.S.L., S.O.G., S.G., and R.M.G : Data collection, formal analysis, interpretation and review.

All authors read and approved the final manuscript.

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CONFLICT OF INTERESTS STATEMENT

The authors declare no competing interests.

CONSENT FOR PUBLICATION

Not applicable.

ETHICS APPROVAL

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of the Faculty of Health Sciences of Abdou Moumouni University, Niamey, Niger (Reference No. 000863/2AUA/FSS/SS).

CONSENT TO PARTICIPATE

Given the retrospective design of the study and the use of routinely collected, fully anonymized hospital data, the need for consent to participate was waived by the Institutional Review Board (IRB) of the Faculty of Health Sciences of Abdou Moumouni University (Reference No. 000863/2AUA/FSS/SS).

DATA AVAILABILITY STATEMENT

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

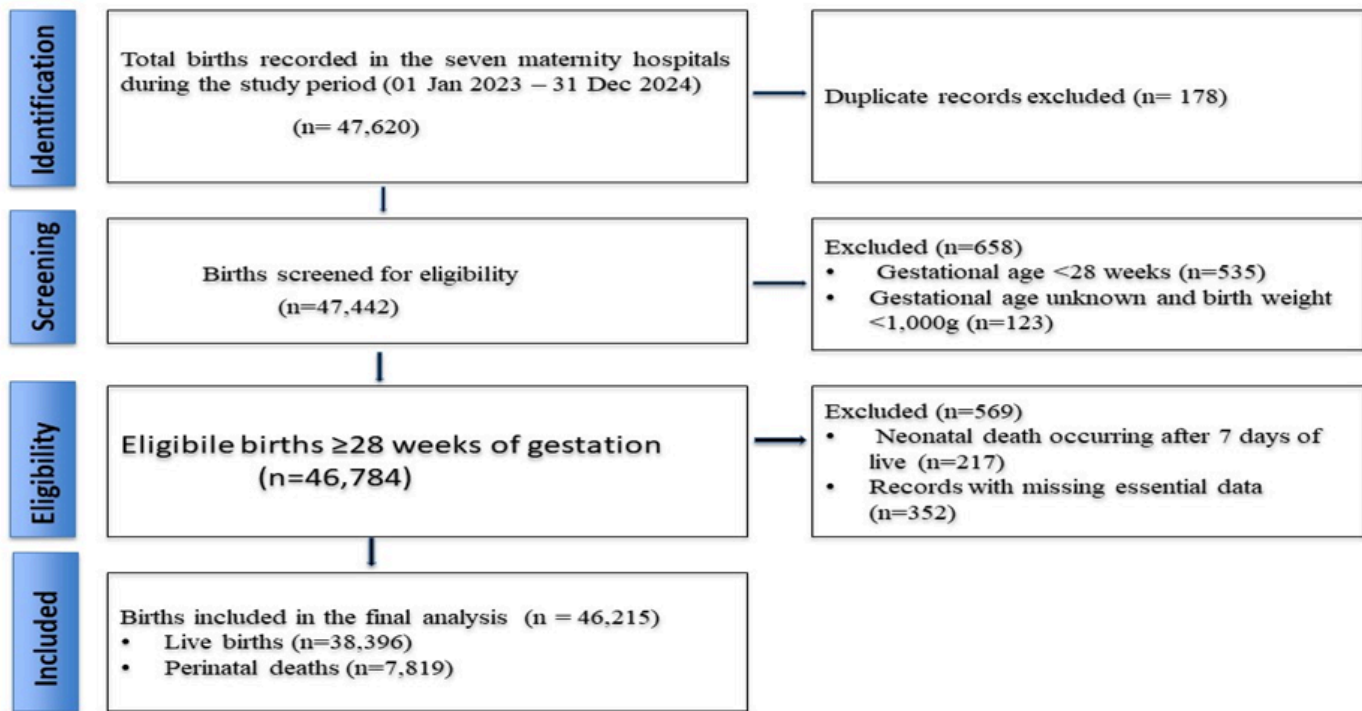
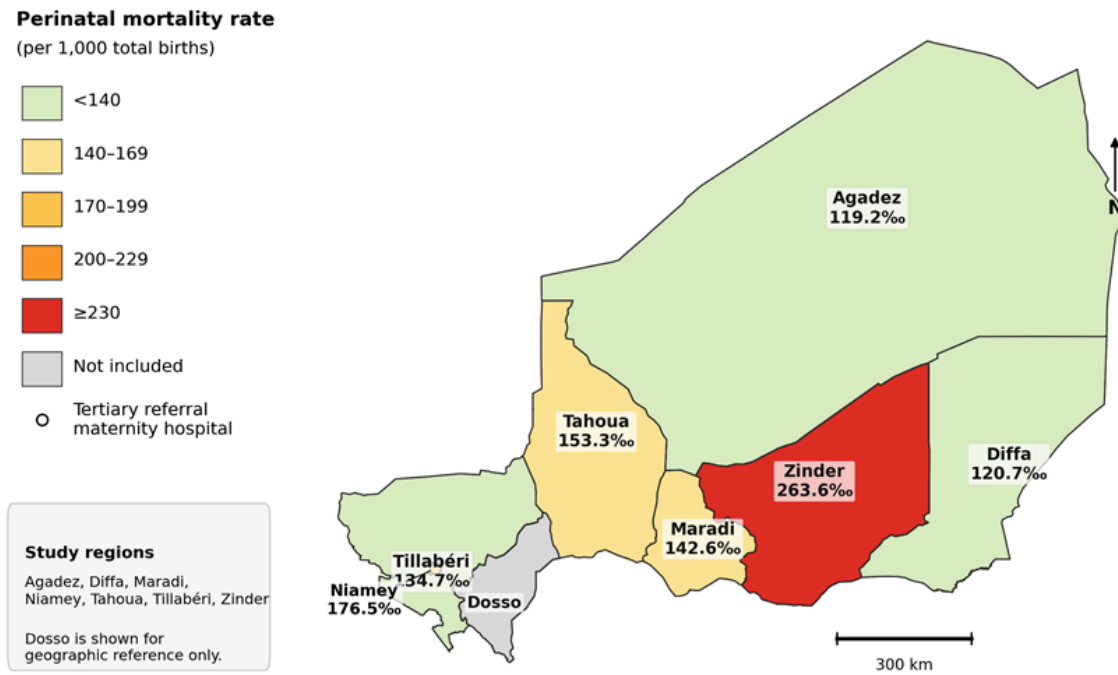


Figure 1

STROBE flow diagram for study population selection

Figure 2. Regional variation in perinatal mortality across seven tertiary referral maternity hospitals in Niger, 2023–2024



Rates are per 1,000 total births at ≥28 weeks of gestation or birth weight ≥1,000 g. Administrative boundaries: HDX/OCHA Niger ADM1.

Figure 2

Regional variation in perinatal mortality across seven tertiary referral maternity hospitals in Niger 2023–2024