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Prevalence and Predictors of Neonatal Mortality at Byumba Level II Teaching Hospital, Northern Rwanda: A Retrospective Cross-Sectional Study

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Abstract: **Introduction: Neonatal mortality remains a critical public health challenge in Rwanda, where neonates account for 44% of all under-five deaths and the Northern Province reports a neonatal mortality rate (NMR) of 22 deaths per 1,000 live births. Despite national progress in maternal and child health, facility-specific predictors of neonatal mortality in Gicumbi District have not been previously published. This study aimed to determine the prevalence and independent predictors of neonatal mortality at Byumba Level II Teaching Hospital.**

Methods: A retrospective cross-sectional study was conducted at Byumba Level II Teaching Hospital, Northern Province, Rwanda. A total of 234 neonatal records (from a systematically sampled frame of 239) were reviewed for the period April to September 2023. Data were extracted using a validated structured tool (reliability coefficient 0.92; content validity index [CVI] 0.78). Bivariate chi-square analysis identified variables significantly associated with neonatal mortality ($p < 0.05$), which were entered into multivariate binary logistic regression to calculate adjusted odds ratios (aOR) with 95% confidence intervals (CI), controlling for potential confounders.

Results: The prevalence of neonatal mortality was 6.7% (16/239). Most mothers (95.3%) were enrolled in Mutuelle de Santé health insurance, yet 57.1% attended only 1–3 antenatal care (ANC) visits. Remarkably, 61.6% of neonates had very low birth weight (≤1,500 g). Multivariate analysis identified five independent predictors of neonatal mortality: inadequate ANC attendance of 1–3 visits versus ≥4 (aOR = 3.806; 95% CI: 1.203–12.046; p = 0.019); placenta abruption (aOR = 7.719; 95% CI: 1.260–47.326; p = 0.047); home birth compared to hospital delivery (aOR = 21.283; 95% CI: 1.718–263.628; p = 0.017); respiratory distress (aOR = 3.886; 95% CI: 1.091–13.834; p = 0.036); and congenital anomalies (aOR = 5.538; 95% CI: 1.121–27.350; p = 0.023). Marital status, maternal age, neonatal gender, and birth weight category were not independently significant.

Conclusion: Neonatal mortality at Byumba Level II Teaching Hospital is predominantly driven by modifiable factors. Targeted interventions to increase ANC attendance beyond four visits, eliminate home births among high-risk pregnancies, and strengthen neonatal respiratory care and congenital anomaly management are urgent priorities. These findings fill a critical evidence gap for Northern Province Rwanda and provide a foundation for district-level programme planning aligned with Rwanda's Sustainable Development Goal 3.2 targets.

Keywords: **Neonatal mortality; Rwanda; Antenatal care; Home birth; Respiratory distress; Congenital anomalies; Sub-Saharan Africa.**

1. INTRODUCTION

The neonatal period the first 28 days of life represents the most vulnerable phase in a child's survival. Globally, an estimated 2.3 million neonates died in 2022, accounting for approximately 47% of all under-five deaths [1, 2]. The global neonatal mortality rate (NMR) declined from 37 per 1,000 live births in 1990 to 17 per 1,000 in 2022, but this reduction has been slower than declines in post-neonatal child mortality, indicating persistent structural and clinical challenges [1]. Sub-Saharan Africa bears a disproportionate share of this burden, recording an NMR of 27 per 1,000 live births more than twice the global average with preterm birth complications (35%), intrapartum-related events (24%), and neonatal sepsis (15%) as the leading contributors [1, 3].

Rwanda has achieved remarkable reductions in under-five mortality over the past two decades, declining from 196 per 1,000 live births in 2000 to 45 per 1,000 in 2020 [4]. However, neonatal mortality reduction has lagged, with neonatal deaths now constituting 44% of all under-five deaths nationally a proportion that signals an epidemiological shift toward the perinatal period [4]. The national NMR declined from 41 per 1,000 live births in 2000 to 20 per 1,000 in 2022, still far from the Sustainable Development Goal (SDG) 3.2 target of ≤12 per 1,000 live births by 2030 [5, 6]. Regional heterogeneity compounds this challenge: the Northern Province, where Byumba Level II Teaching Hospital is located, reports an NMR of 22 per 1,000 live births, slightly above the national average [7].

Rwanda's community-based interventions including near-universal Mutuelle de Santé health insurance coverage, community health worker networks, and strengthened Emergency Obstetric and Newborn Care (EmONC) services have expanded access to care [5, 8]. Nevertheless, facility-specific determinants of neonatal mortality at district-level hospitals in Rwanda remain incompletely characterised. The only published facility-based neonatal mortality study from Rwanda to date, by Nkundabaza et al. (2024) at Bushenge Provincial Hospital in the Western Province, reported a mortality rate of 8.9% with prematurity, extreme low birth weight, and low APGAR scores as principal predictors [9]. No comparable data exist for the Northern Province or for Gicumbi District, creating a critical evidence gap for district health management.

Risk factors documented in the broader East African and sub-Saharan African literature include inadequate ANC attendance [10], home and non-facility deliveries [11], placenta abruption [12], neonatal respiratory distress [13], and congenital anomalies [14]. Whether and to what degree these factors operate as independent predictors in the specific context of a Rwandan district-level hospital with its case mix, staffing, and referral patterns has not been established.

This study therefore aimed to: (1) determine the prevalence of neonatal mortality at Byumba Level II Teaching Hospital between April and September 2023; and (2) identify independent predictors of neonatal mortality through multivariate logistic regression analysis of maternal, obstetric, and neonatal clinical factors.

2. METHODS

Study design and setting

A retrospective cross-sectional study was conducted at Byumba Level II Teaching Hospital, located in Gicumbi District, Northern Province, Rwanda. Gicumbi District is predominantly rural, bordering Uganda to the north, and encompasses a catchment population characterised by limited road infrastructure and geographic barriers to tertiary care. Byumba Level II Teaching Hospital serves as the primary district referral hospital and provides neonatal unit services including basic resuscitation and supportive care. The study period covered April to September 2023 (six months).

Study population, eligibility, and sampling

The source population comprised all neonates (aged 0–28 days) who were delivered at, admitted to, or managed by Byumba Level II Teaching Hospital during the study period. **Inclusion criteria:** complete neonatal records with documented admission details and clinical outcome (discharged alive or died). **Exclusion criteria:** records with missing primary outcome data or critical clinical variables. Systematic random sampling was applied to the neonatal register to select 239 records. Of these, 234 (97.9%) met inclusion criteria and comprised the final analytic sample; five records were excluded due to incomplete data.

Sample size was determined using the formula $n = Z^2P(1-P)/d^2$, where $Z = 1.96$ (95% confidence level), $P = 0.089$ (estimated prevalence based on prior Rwanda data [9]), and $d = 0.035$ (desired precision), yielding a minimum of 228 records. A 5% non-response allowance was applied, reaching a target of 239.

Data collection instrument and procedure

A structured data extraction tool was developed to capture three domains: (a) *maternal sociodemographic characteristics* age, education level, marital status, health insurance type, and number of ANC visits attended; (b) *obstetric and intrapartum factors* parity, mode of delivery, place of birth, and obstetric complications (placenta abruption, placenta praevia, cord prolapse, premature rupture of membranes [PROM], hypertensive disorders, diabetes, labour induction, augmentation, and twin pregnancy); and (c) *neonatal clinical variables* APGAR scores at 0, 5, and 10 minutes; birth weight; cyanosis at admission; respiratory rate; oxygen saturation; and documented diagnoses (respiratory distress, congenital anomalies, neonatal sepsis, jaundice, necrotising enterocolitis [NEC], hypoxic ischaemic encephalopathy [HIE], and birth injuries).

Instrument content validity was established through expert panel review (content validity index [CVI] = 0.78), and internal consistency was confirmed by pilot testing (reliability coefficient = 0.92) [15, 16]. Data extraction was performed by trained data collectors who verified record completeness prior to inclusion. All records were de-identified using unique numerical codes before data entry.

Data analysis

Data were entered into and analysed using IBM SPSS Statistics Version 23.0. Descriptive statistics (frequencies and proportions) characterised the study population. Bivariate analysis using the chi-square test assessed associations between independent variable and neonatal mortality; variables with $p < 0.05$ were retained for multivariate modelling. Multivariate binary logistic regression was performed to calculate adjusted odds ratios (aOR) with 95% confidence intervals (CI), controlling for confounding. Statistical significance was set at $p < 0.05$ throughout.

Ethical considerations

Ethical approval was granted by the Institutional Review Board of Mount Kenya University and the Ethics and Research Committee of Byumba Level II Teaching Hospital. All procedures conformed to the ethical principles of the Declaration of Helsinki. Given the retrospective records-based design, a waiver of individual informed consent was obtained. Records were de-identified before analysis; data were stored on password-protected devices accessible only to the research team. No personal identifying information appears in any report from this study.

3. RESULTS

Sample characteristics

A total of 234 neonatal records were included in the final analysis (response rate 97.9%). Maternal characteristics are presented in Table 1. The overwhelming majority of mothers (95.3%) were enrolled in Mutuelle de Santé community health insurance; only 4.7% held Rwanda Social Security Board (RSSB) coverage. Despite near-universal insurance enrolment, 57.1% of mothers attended only 1–3 ANC visits during pregnancy, with 42.9% achieving the recommended four or more visits. Most mothers were aged ≤30 years (68.1%), married (80.6%), and had at least primary education (89.2%). Regarding neonatal characteristics, the gender distribution was near-equal (51.1% male, 48.9% female). Birth weight distribution revealed a striking burden of underweight neonates: 61.6% had very low birth weight (VLBW; ≤1,500 g), 18.6% had low birth weight (LBW; 1,500–2,499 g), and only 19.8% had normal birth weight (≥2,500 g).

Table 1: Sociodemographic and clinical characteristics of the study population (N = 234)

Variable	Frequency (n)	Percentage (%)
Maternal characteristics		
Health insurance		
RSSB	11	4.7
Mutuelle de Santé	223	95.3
Total	234	100
ANC visits attended		
1–3 visits	128	57.1
≥4 visits	96	42.9
Total	224	100
Maternal age		
≤30 years	156	68.1
≥31 years	73	31.9
Total	229	100
Marital status		

Variable	Frequency (n)	Percentage (%)
Married	187	80.6
Single	45	19.4
Total	232	100
Education level		
None	25	10.8
Primary	81	35.1
Secondary	103	44.6
University	22	9.5
Total	231	100
Neonatal characteristics		
Sex		
Male	123	51.1
Female	116	48.9
Total	239	100
Birth weight category		
Very low birth weight (≤1,500 g)	146	61.6
Low birth weight (1,500–2,499 g)	44	18.6
Normal birth weight (≥2,500 g)	48	19.8
Total	238	100

ANC: antenatal care; RSSB: Rwanda Social Security Board.

Prevalence of neonatal mortality

Of the 239 neonates in the sampling frame, 16 died during admission, yielding a neonatal mortality prevalence of 6.7% (16/239). A total of 223 neonates (93.3%) were discharged alive. No neonatal deaths were recorded among referred cases in this analysis period.

Bivariate analysis of factors associated with neonatal mortality

Results of bivariate analyses are presented in Table 2. Among sociodemographic and maternal factors, inadequate ANC attendance (1–3 visits) was significantly associated with neonatal mortality ($\chi^2 = 4.253$, $p = 0.039$): 4.9% of neonates whose mothers attended 1–3 visits died, compared with 0.9% in the ≥4 visits group. Maternal age, education, marital status, health insurance type, and parity did not reach statistical significance. Among obstetric factors, placenta abruption was significantly associated with neonatal mortality ($\chi^2 = 10.056$, $p = 0.002$); while rare (present in 2.2% of cases), 40% of neonates with placenta abruption died. Place of birth was significantly associated with mortality ($\chi^2 = 12.982$, $p = 0.002$), with home births carrying a markedly higher mortality proportion. Hypertension in pregnancy approached significance ($p = 0.054$) but did not cross the threshold. PROM, diabetes, cord prolapse, placenta praevia, augmentation, induction, and mode of delivery were all non-significant.

Among neonatal clinical factors, cyanosis at admission ($\chi^2 = 14.055$, $p < 0.001$), respiratory distress ($\chi^2 = 10.902$, $p = 0.001$), congenital anomalies ($\chi^2 = 6.732$, $p = 0.009$), HIE ($\chi^2 = 6.596$, $p = 0.010$), NEC ($\chi^2 = 27.36$, $p < 0.001$), and birth injuries ($\chi^2 = 13.996$, $p < 0.001$) were all significantly associated with mortality. APGAR scores demonstrated progressively stronger associations across time points: at birth ($\chi^2 = 14.53$, $p < 0.001$), at 5 minutes ($\chi^2 = 19.227$, $p < 0.001$), and most strongly at 10 minutes ($\chi^2 = 44.127$, $p < 0.001$), where 31.3% of neonates who died had scores of 1–5 compared with only 1.0% of survivors. Abnormal respiratory rate ($\chi^2 = 16.439$, $p < 0.001$) and critically low oxygen saturation ($\chi^2 = 24.475$, $p < 0.001$) were also significantly associated with mortality.

Table 2: Bivariate analysis of factors associated with neonatal mortality at Byumba Level II Teaching Hospital (N = 234)

Variable	Discharged alive n (%)	Died n (%)	Total n (%)	χ^2	p-value
Sociodemographic and maternal factors					
ANC visits attended					
1–3 visits	117 (52.2)	11 (4.9)	128 (57.1)	4.253	**0.039***
≥4 visits	94 (42.0)	2 (0.9)	96 (42.9)		
Total	211 (94.2)	13 (5.8)	224 (100)		
Maternal age					
≤30 years	149 (65.1)	7 (3.1)	156 (68.1)	3.403	0.065
≥31 years	65 (28.4)	8 (3.5)	73 (31.9)		
Education level					4 levels tested
Primary	75 (32.5)	6 (2.6)	81 (35.1)	1.873	0.599
Secondary	98 (42.1)	5 (4.2)	103 (44.6)		
University	20 (8.7)	2 (0.9)	22 (9.5)		
None	22 (9.5)	3 (1.3)	25 (10.8)		
Marital status					
Married	175 (75.4)	12 (5.2)	187 (80.6)	0.345	0.557
Single	41 (17.7)	4 (1.7)	45 (19.4)		
Obstetric factors					
Place of birth				12.982	0.002*
Hospital	198 (85.3)	9 (3.9)	207 (89.2)		
Health centre	20 (8.6)	1 (0.4)	21 (9.1)		
Home	4 (1.7)	6 (2.6)	10 (4.3) †		
Placenta abruption				10.056	0.002*
No	209 (92.5)	12 (5.3)	221 (97.8)		
Yes	3 (1.3)	2 (0.9)	5 (2.2)		
Hypertension in pregnancy				3.728	0.054
No	202 (87.4)	13 (6.6)	215 (93.1)		
Yes	13 (5.6)	3 (1.5)	16 (6.9)		
PROM				1.676	0.196
Parity ≥5 (vs. <5)				2.821	0.093
Twin pregnancy				0.698	0.403
Mode of delivery (C-section)					NS
Neonatal clinical factors					
Cyanosis at admission				14.055	<0.001*
No	202 (87.8)	8 (3.6) [discharged]			

Variable	Discharged alive n (%)	Died n (%)	Total n (%)	χ^2	p-value
Yes	19 (8.3)	7 (3.1) [died]			
Respiratory distress				10.902	0.001*
No	186 (80.5)	8 (3.5)	194 (84.0)		
Yes	37 (16.0)	9 (3.9)	46 (19.9)		
Congenital anomalies				6.732	0.009*
No	219 (94.8)	14 (6.1)	233 (100.9‡)		
Yes	4 (1.7)	2 (0.9)	6 (2.6)		
Hypoxic Ischaemic Encephalopathy				6.596	0.010*
APGAR score at 10 minutes 1–5				44.127	<0.001*
Scores 1–5 among deaths	1.0% of survivors	31.3% of deaths			
Abnormal respiratory rate (≥51)				16.439	<0.001*
Low oxygen saturation (<33%)				24.475	<0.001*
Neonatal gender (male vs. female)				0.899	0.343
Birth weight category				4.512	0.105

** p < 0.05; † includes 6 neonatal deaths from 10 home births (60% case-fatality); PROM: premature rupture of membranes; NS: not significant; ‡ rounding artefact from missing data.*

After controlling confounders, multivariate binary logistic regression identified five independent predictors of neonatal mortality (Table 3). Neonates whose mothers attended only 1–3 ANC visits had significantly higher odds of death compared with those attending ≥4 visits (aOR = 3.806; p = 0.019). Placenta abruption was associated with a nearly eight-fold increase in mortality risk (aOR = 7.719; p = 0.047). Home birth carried a dramatically elevated risk relative to hospital delivery (aOR = 21.283; 95% CI: 1.718–263.628; p = 0.017). Respiratory distress was an independent predictor (aOR = 3.886; p = 0.036), as was the presence of congenital anomalies (aOR = 5.538; p = 0.023). Health centre delivery was not significantly different from hospital delivery (aOR = 0.722; p = 0.765).

Variables that were significant in bivariate analysis but did not independently predict mortality in multivariate modelling included cyanosis at admission (aOR = 1.579; p = 0.644), HIE (aOR = 2.497; p = 0.362), APGAR scores at all time points, abnormal respiratory rate, and low oxygen saturation. NEC was retained in the model but produced extreme instability (aOR = 12.200; p = 0.999), likely reflecting perfect separation due to small cell counts (n = 2 NEC cases), and should be interpreted with caution.

Table 3: Multivariate binary logistic regression independent predictors of neonatal mortality at Byumba Level II Teaching Hospital

Variable (reference category)	aOR	95% CI Lower	95% CI Upper	p-value
ANC attendance				
≥4 visits (ref)	*1.000*			
1–3 visits	**3.806**	**1.203**	**12.046**	**0.019***
Placenta abruption				
No (ref)	*1.000*			
Yes	**7.719**	**1.260**	**47.326**	**0.047***
Place of birth				
Hospital (ref)	*1.000*			

Variable (reference category)	aOR	95% CI Lower	95% CI Upper	p-value
Health centre	0.722	0.085	6.129	0.765
Home	**21.283**	**1.718**	**263.628**	**0.017***
Respiratory distress				
No (ref)	*1.000*			
Yes	**3.886**	**1.091**	**13.834**	**0.036***
Congenital anomalies				
No (ref)	*1.000*			
Yes	**5.538**	**1.121**	**27.350**	**0.023***
Cyanosis at admission (Yes vs. No)	1.579	0.228	10.936	0.644
HIE (Yes vs. No)	2.497	0.349	17.875	0.362
APGAR score at 0 min (1–5 vs. 6–10)	0.767	0.673	3.903	0.786
APGAR score at 5 min (1–5 vs. 6–10)	0.693	0.162	2.961	0.675
APGAR score at 10 min (1–5 vs. 6–10)	1.670	0.082	5.786	0.999
Oxygen saturation (<33 vs. >68%)	0.134	0.014	1.290	0.082

** p < 0.05 (statistically significant, shaded rows); aOR: adjusted odds ratio; CI: confidence interval; ANC: antenatal care; HIE: hypoxic ischaemic encephalopathy. Note: NEC was retained in the full model but produced extreme instability (aOR = 12.200; p = 0.999) attributable to small cell counts and is excluded from this table.*

4. DISCUSSION

Principal findings and regional context

This study identified a neonatal mortality prevalence of 6.7% (16/239) at Byumba Level II Teaching Hospital the first facility-based neonatal mortality study from Gicumbi District and Northern Province, Rwanda. This rate is lower than the 8.9% reported at Bushenge Provincial Hospital in Western Rwanda [9] and comparable to the 7.1% from district hospitals in Zimbabwe [17], suggesting a broadly consistent burden across district-level facilities in the region. The difference from Bushenge is clinically meaningful and likely reflects differing case mixes: Nkundabaza et al. (2024) found extreme low birth weight (aOR = 14.4) and prematurity (aOR = 6.1) as principal predictors, whereas the present study identified a distinct set led by home birth and placenta abruption. This intra-Rwanda contrast suggests that national-level policies, while essential, cannot substitute for province- and district-specific epidemiological data when designing targeted interventions.

Inadequate ANC: insured but under-utilised

Mothers attending fewer than four ANC visits had nearly four times the odds of neonatal death (aOR = 3.806; p = 0.019), consistent with findings from Ethiopia (aOR = 0.35 for protective effect of ≥4 visits) [10] and a national Rwandan study where adequate ANC was negatively associated with neonatal mortality (aOR = 0.64; 95% CI: 0.46–0.89) [8]. What is particularly striking in the present setting is the paradox of near-universal insurance enrolment (95.3% on Mutuelle de Santé) alongside persistently low ANC completion: 57.1% of mothers attended fewer than the recommended four visits. This finding indicates that financial barriers are largely resolved in this population, and that the remaining barriers are structural, geographic, or behavioural including distance to facility, workload of rural women, perceived quality of care, and cultural norms around pregnancy disclosure. These factors cannot be addressed by insurance expansion alone and require active community health worker engagement and default-tracking systems targeting women who miss their second or third ANC appointment.

Home birth: the highest-magnitude modifiable risk

Home birth was associated with a 21-fold increase in neonatal mortality (aOR = 21.283; 95% CI: 1.718–263.628; p = 0.017). While the wide confidence interval reflects the small number of home birth deaths in this sample and should prompt cautious interpretation, the direction and magnitude are consistent with multi-country sub-Saharan African data reporting a 15.6-fold

home birth risk [11] and support the biological and logistical plausibility of this association. Home births eliminate access to skilled resuscitation, emergency obstetric care, and immediate neonatal assessment factors that are indispensable when complications such as asphyxia or birth injury arise. The continued occurrence of home births in 2023, despite Rwanda's longstanding conditional cash transfer and free maternity care policies, suggests persistent barriers including late-onset labour in remote areas, inadequate emergency transport infrastructure, and possibly cultural preferences for certain birth settings. Community-based strategies targeting these specific barriers, including strengthening community health worker capacity to identify high-risk pregnancies and facilitate timely referral, are urgently needed.

Placenta abruption: high impact, low frequency, high modifiability

Placenta abruption was independently associated with neonatal mortality (aOR = 7.719; p = 0.047), despite affecting only 2.2% of the sample. This high-impact, low-frequency pattern has critical implications for quality improvement: because individual clinicians encounter placenta abruption infrequently, institutional protocols and regular simulation-based training are more likely to standardise emergency response than experiential learning alone. Placenta abruption is associated with antepartum haemorrhage, placental insufficiency, and acute fetal hypoxia, all of which require immediate obstetric and neonatal intervention. Identifying high-risk pregnancies (hypertension, previous abruption, trauma, tobacco use) at ANC and ensuring these mothers deliver in a facility with EmONC capacity should be a specific clinical priority at Byumba Hospital.

Respiratory distress and congenital anomalies: neonatal-side determinants

Respiratory distress (aOR = 3.886; p = 0.036) and congenital anomalies (aOR = 5.538; p = 0.023) represent the neonatal-side predictors conditions that cannot be fully prevented by ANC or facility delivery policies, but whose mortality impact is highly modifiable through quality of immediate neonatal care. These findings align with those of Manzini et al. (2024) in rural Tanzania, who reported respiratory distress (aOR = 4.67; 95% CI: 3.27–6.69) and congenital abnormalities (aOR = 6.23; 95% CI: 3.45–11.27) as major contributors to neonatal mortality [13]. The 61.6% VLBW prevalence in this sample is a critical contextual amplifier: premature neonates with immature surfactant systems are inherently at high risk for respiratory distress syndrome, and the interaction between birth weight and respiratory mortality risk has been quantified as 2.8 times the base risk in comparable settings [18]. Upgrading CPAP capacity, ensuring functional neonatal resuscitation equipment, and conducting regular neonatal resuscitation training for frontline providers at Byumba Hospital are therefore both evidence-based and feasible priorities. For congenital anomalies, early prenatal screening (including folic acid supplementation to reduce neural tube defects), improved echocardiography access, and clear referral pathways for surgical correction are the appropriate intervention tier.

Variables not independently significant: clinical interpretation

Cyanosis at admission, APGAR scores at all time points, respiratory rate, and oxygen saturation were significant in bivariate analysis but did not independently predict mortality after controlling confounders. This is clinically interpretable: cyanosis and low APGAR scores are clinical manifestations of conditions (respiratory distress, asphyxia) rather than independent causal pathways. Once respiratory distress is retained in the model, the additional variance explained by cyanosis and APGAR score diminishes. These variables are valuable for clinical triage and monitoring but do not add independent predictive power beyond the diagnoses they reflect.

Limitations

This study has several limitations that should be considered when interpreting findings. First, the retrospective cross-sectional design precludes causal inference; temporal sequence between risk factors and outcome cannot be definitively established. Second, this is a single-institution study, and findings may not be generalisable to other facility types, provinces, or health system levels in Rwanda, though they are directly relevant to comparable district-level hospitals. Third, the small number of deaths (n = 16) creates statistical instability in some multivariate estimates, as reflected in the wide confidence interval for the home birth predictor and the model instability for NEC. Multivariate findings should be interpreted as hypothesis-generating for larger prospective studies. Fourth, routine medical records may under-document events occurring before hospital arrival, potentially underestimating the true burden of complications among home birth neonates. Fifth, qualitative dimensions family decision-making around place of birth, provider behaviour, and systemic quality gaps are not captured by the retrospective records approach and require complementary mixed-methods investigation.

5. CONCLUSION

This first facility-based neonatal mortality study from Gicumbi District, Northern Rwanda, identified a mortality prevalence of 6.7%, driven by five independent, modifiable predictors: inadequate ANC attendance, placenta abruption, home birth, respiratory distress, and congenital anomalies. The coexistence of near-universal health insurance coverage with persistently inadequate ANC utilisation in this population confirms that financial access alone is insufficient structural, geographic, and behavioural barriers require active, context-specific programmatic responses. Home birth, with its 21-fold adjusted mortality risk, is the highest-magnitude modifiable predictor and should be the focal point of community-based prevention efforts in Gicumbi District. Investment in EmONC protocols for placenta abruption management, CPAP capacity, and neonatal resuscitation training at Byumba Hospital represent the immediate clinical priorities. These findings provide district health managers and the Rwanda Ministry of Health with the facility-level evidence base needed to design targeted interventions aligned with SDG 3.2 neonatal mortality reduction targets.

LIST OF ABBREVIATIONS

ANC: Antenatal Care; aOR: Adjusted Odds Ratio; CI: Confidence Interval; CPAP: Continuous Positive Airway Pressure; CVI: Content Validity Index; EmONC: Emergency Obstetric and Newborn Care; HIE: Hypoxic Ischaemic Encephalopathy; LBW: Low Birth Weight; NEC: Necrotising Enterocolitis; NMR: Neonatal Mortality Rate; PROM: Premature Rupture of Membranes; RDHS: Rwanda Demographic and Health Survey; RSSB: Rwanda Social Security Board; SDG: Sustainable Development Goal; SPSS: Statistical Package for the Social Sciences; VLBW: Very Low Birth Weight; WHO: World Health Organisation.

DECLARATIONS

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Competing interests

The author declares that they have no competing interests.

Author contributions

CI conceived and designed the study, performed data collection, conducted data analysis and interpretation, drafted the manuscript, and approved the final version for submission.

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Data availability

The data that support the findings of this study are held at Byumba Level II Teaching Hospital and are not publicly available due to patient confidentiality restrictions. De-identified aggregate data are available from the corresponding author on reasonable request and subject to institutional approval.

Ethics approval

Ethical approval was obtained from the Institutional Review Board of Mount Kenya University and the Ethics and Research Committee of Byumba Level II Teaching Hospital. All research was conducted in accordance with the principles of the Declaration of Helsinki.

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