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Research Article

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Neonatal Mortality and Its Associated Factors in Gisenyi Hospital, Rubavu District, Rwanda: A Cross- Sectional Study

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ABSTRACT

Background: Neonatal mortality remains a critical global health issue, particularly in sub-Saharan Africa, where preventable causes are prevalent. In Rwanda the neonatal mortality still accounts for a substantial portion and exceeds the SDG target. This study aims to determine the prevalence and associated factors among neonates admitted at the neonatology department at Gisenyi district hospital in western Rwanda.

Methods: The hospital-based cross-sectional study used a retrospective descriptive review of 753 neonates and their mothers' records systematically sampled between May 1st, 2024, and June 30th 2024. The quantitative data on sociodemographic, obstetric, and clinical characteristics variables were extracted from maternal and neonatal clinical charts and registers. Data were double entered in a pretested data collection tool, cleaned and analyzed using STATA 17. Logistic regression analyses using odds rations with 95% con dence interval (C. I) were applied to assess the association between factors associated with neonatal mortality. The adjusted odds ratios (AoR) has been done to assess other neonatal mortality determinants variables. Data was analysed using statistical software, Stata version 17.0

Results: There were 136 ,18% (95% CI: 15.3–27.2%) among them 421, 55.2% were male. Mothers associated factors were mothers aged 25–34 years (aOR = 7.97; 95% CI: 1.7–35.70). Unemployed mothers had 2.5 times higher odds (aOR = 2.52; 95% CI: 1.08–5.87), and public (aOR = 2.26; 95% CI: 1.82–6.27). Multi-gravida mothers (aOR = 5.89; 95% CI: 3.42–10.13). Zero antenatal care visits (aOR = 0.27; 95% CI: 0.12–0.58) and fewer visits (1–2 visits, aOR = 0.33; 95% CI: 0.17–0.64), neonates born before 32 weeks of gestational age (aOR = 2.90; 95% CI: 1.76–4.80), The neonates admitted within 24 hours (aOR = 6.17; 95% CI: 2.16–17.67). Hypothermic neonates (aOR = 2.02; 95% CI: 1.28–3.19) and the Apgar scores ≤ 3 (aOR = 10.24; 95% CI: 2.71–38.75) were strongly associated with higher mortality.

Conclusion: In this study, the neonatal mortality remains alarmingly high, driven by both maternal and neonatal risk factors. More than 30% recorded deaths were due to prematurity complications Strengthening antenatal care utilization, early identi cation of high-risk pregnancies, and improving the management of preterm and low Apgar score neonates are essential steps toward reducing preventable neonatal deaths as main associated factors.

Keywords: Associated Factors, Neonatal Mortality, Newborns, Prevalence, Rubavu, Rwanda

Abbreviations

ANC	-	Antenatal care visit
AoR	-	Adjusted odds ratio
Apgar score	-	Appearance (Skin color), pulse (heart rate), grimace (refl ex irritability), activity (muscle tone), andrespiratory (breathing rate and efforts)
GDH	-	Gisenyi district hospital
NMR	-	Neonatal mortality rate
RDS	-	Respiratory distress syndrome
SDG	-	Sustainable Development Goals
STATA	-	Statistical software for data science
WHO	-	World Health Organization

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Introduction

Neonatal mortality, as de ned by the World Health Organization (WHO), refers to deaths among live-born infants within the rst 28 completed days of life. It is further categorized into early neonatal deaths (occurring within the rst seven days) and late neonatal deaths (from day 8 to day 28 of life) [1]. Despite global progress in reducing child mortality, neonatal deaths remain a major public health challenge, particularly in low- and middle-income countries. Globally, approximately 4.8 million children under ve died in 2023, with 2.3 million of these deaths occurring during the neonatal period [2,3]. Sub-Saharan Africa carries the highest burden, accounting for over 1.2 million (40%) neonatal deaths annually, equivalent to around 13,000 deaths per day or nearly nine deaths every minute [4]. The region also has the highest neonatal mortality rate (NMR) at 27 deaths per 1,000 live births, followed by Central and Southern Asia with an NMR of 21 per 1,000 live births [5]. According to the Millennium Development Goal Gap Analysis, nearly two-thirds of neonatal deaths in sub-Saharan Africa are attributed to preventable causes [6-9].

Rwanda has made notable progress in reducing under- ve mortality, declining from 44 deaths per 1,000 live births in 2000 to 19 per 1,000 in 2020 [10]. However, this gure remains above the Sustainable Development Goal (SDG) target of 12 per 1,000 live births by 2030 [11]. Achieving this goal requires intensi ed efforts to identify and address factors contributing speci cally to neonatal mortality. Neonatal outcomes are in uenced by a complex interplay of maternal, neonatal, and health system- related factors. A 2024 facility-based study in Somalia identi ed several factors associated with neonatal mortality, including neonatal sex, antenatal care (ANC) attendance, tetanus toxoid immunization, mode of delivery, sepsis, tetanus, pneumonia, breastfeeding challenges, and prematurity [12, 13]. Similarly, research from Indonesia revealed that maternal education, occupation, decision-making autonomy regarding healthcare, quality of antenatal care, and delivery complications signi cantly in uenced neonatal survival [14, 15]. A study conducted in Ghana also emphasized the importance of ANC attendance, neonatal sex, and immediate skin-to-skin contact as predictors of neonatal mortality, many of which are preventable with improved health system practices [16].

Rubavu District, located in Rwanda's Western Province, is served by a Gisenyi hospital that acts as the primary referral center for surrounding health facilities. While national policies and programs targeting neonatal health are in place, local data on neonatal mortality and its contributing factors remain scarce. According to the Rwanda Biomedical Center (2024), more localized evidence is needed to guide targeted and context-speci c interventions.

This study aimed to determine the prevalence of neonatal mortality and identify associated factors among neonates admitted to Gisenyi District Hospital. The ndings are expected to provide critical insights for healthcare providers, policymakers, and program implementers to strengthen neonatal care services in the district and contribute to the national efforts toward achieving the SDG target

Materials and Methods

Study Design

This is a hospital-based cross-sectional study and collected the quantitative data through retrospective descriptive review of 753 neonatal medical records of admitted neonates to the neonatology department from May 1st 2024, and June 30th 2024.

Study Setting

The study was conducted at the neonatal department of Gisenyi district hospital located in Rubavu District, Western Province of Rwanda. The hospital lies along the shores of Lake Kivu and situated approximately 2 kilometers from the Lacoriniche Border Post and about 153.6 kilometers from Rwanda's capital city, Kigali.

Gisenyi Hospital is one public hospital that provide the neonatal care services to the whole Rubavu district populations (approximately 403,662 district total population), and hospital act as referral to both public and private peripheral health facilities or surrounding communities that refer neonates requiring advanced care.

With reference to the hospital records, Gisenyi hospital neonatology department on average, admits 1,500 neonates annually equal to 125 per month and approximately 31 neonates per week.Of the admitted neonates 64% are born at Gisenyi hospital and 6% referred from the surrounding communities.

Study Population

The study population included neonates who were admitted to the neonatology department at Gisenyi District Hospital during the study period. Only neonates admitted who survived for at least 28 days. Furthermore, only records of mothers who delivered live-born at a gestational age of 28 weeks and above, either within the hospital (inborn) or referred (out born) between May 2019 and June 2024, were considered an eligible participant and included in the nal dataset.

Study Measures

Any neonate admitted to the neonatology department who died during the neonatal period was considered as neonatal death. Social demographic characteristics of mothers whose neonates were admitted to neonatology, including mothers' age, address (Urban vs Rural), profession, possession of health insurance, and marital status. Pregnancy and gynecological characteristics such as gestation at delivery time, mode of delivery for current child, gravidity, parity. Antenatal care visits. Other variables of interest include the admitted neonates' records at delivery time such as appearance, pulse, grimace, activity, and respiratory (Apgar) score at 10min, birth weight categories, age of neonate at death in days, gender, neonatal morbidities such as respiratory distress syndrome (RDS) and neonatal sepsis.

Data collection

Using a pretested developed data extraction tool and modi ed from a similar study data were collected by a trained team consisting of ve professional nurses and one medical doctor [17]. Before data collection, all team members underwent a comprehensive four-day training to ensure familiarity with the study objectives, data abstraction tools, and ethical considerations.

Neonatal characteristics were extracted from individual neonatal medical record charts, while maternal data were obtained from hospital delivery registers, maternal admission les, and medical charts. The data abstraction process for each participant took

approximately 15 to 20 minutes. To maintain data quality and consistency, the principal investigator conducted daily reviews of completed data forms. This included cross-checking entries for completeness, accuracy, and internal consistency, with any discrepancies addressed promptly through consultation with the data collection team.

Statistical Analysis

All collected data were initially entered into Microsoft Excel 2016 for cleaning, coding, and validation, and subsequently exported to STATA version 17 for statistical analysis. Descriptive statistics were used to summarize the sociodemographic, obstetric, and clinical characteristics of the neonates admitted to neonatology and their mothers. Frequencies and percentages were calculated to determine the overall prevalence of neonatal mortality. To identify factors associated with neonatal mortality, a binary outcome coded as 1 for deceased neonates and 0 for survivors, a multivariable logistic regression analysis was performed. Before model building, multicollinearity among independent variables was assessed using the Variance In ation Factor (VIF), and variables with a VIF ≥ 10 were excluded. A stepwise selection approach was used to construct the nal model, retaining variables with statistical relevance and clinical plausibility. Adjusted odds ratios (aORs) with corresponding 95% con dence intervals (CIs) and p-values were reported to indicate the strength and signi cance of associations. A p- value of < 0.05 was considered statistically signi can't.

Results

Socio-Demographic Characteristics of Participants

In this study, 753 neonates admitted to the neonatology department participated. Most mothers were aged 24 years and below (74.7%), and 82.2% resided in rural areas. A signi can't proportion had only primary-level education (55.8%), while 22.4% had no formal education. 84.2% were farmers and legally married mothers (64%). Additionally, 93.5% had medical insurance (Table 1).

Table 1: The mothers' socio-demographic characteristics whose newborns were admitted to neonatology, 2019–2024

Characteristic	Frequency, n = 753	Percentage, %
Mother's age		
24 years and below	563	74.7
25–34 Years	152	20.2
35 years and above	38	5.1
Mother's professional (n = 753)		
Farmer	634	84.2
Business owner	44	5.9
Unemployed	41	5.4
Public servant	28	3.7
Vocational work	6	0.8
Mother's highest level of education (n = 753)		
No formal education	169	22.4
Primary level	420	55.8
Secondary level	141	19.2
University level and above	20	2.7
Mother's marital status (n = 753)		
Legal married	482	64
Single	199	26.2
Cohabited	72	9.5
Medical insurance (n = 753)		
No	49	6.5
Yes	704	93.5
Residence for study participants (n = 753)		
Rural	618	82.2
Urban	135	17.8

Obstetrics and Gynecological Characteristics of Mothers of Neonates Admitted to Gisenyi Hospital

Nearly half of the mothers were primigravida (49.6%), and 46.4% were Primipara. Most deliveries were vaginal (71%), with cesarean sections accounting for 28.1%. A signi cant proportion of mothers (35.7%) delivered preterm, with 22.3% giving birth before 32 weeks of gestation. Regarding antenatal care, 15.1% of mothers had no ANC visits, while nearly half (49.1%) attended 3–4 antenatal care visits (Table 2).

Table 2: Obstetrics and gynecological characteristics of mothers whose newborns were admitted at Gisenyi DH hospital

Characteristic	Frequency, n = 753	Percentage, %
Gravidity; (n = 753)		
Multi-gravida	380	50.4
Primi-gravida	373	49.6
Parity (n = 753)		
Multi-para	404	53.6
Primi-para	349	46.4
Mode of delivery (n = 753)		
Vaginal delivery	535	71
Cesarean	211	28.1
Assisted vaginal delivery	7	0.9
Place for delivery (n = 753)		
Hospital	484	64.2
Health center	223	29.6
Home delivery	46	6.11
Gestational age (n = 753)		
< 32 weeks	169	22.3
33–37 weeks	251	33.4
> 37 weeks	333	44.3
Number of ANCs done (n = 753)		
No ANC	113	15.1
1–2 ANC	224	29.6
3–4 ANC	370	49.1
5 ANC and above	46	6.2

Characteristics of Neonates at Admission to the Neonatology Department, Gisenyi District Hospital.

Most neonates (79.6%) were admitted within the rst 24 hours of life, and 84.2% were received in the unit within that time. Low birth weight was common, affecting 45.4% of neonates, and 55.7% were born preterm (before 37 weeks of gestation). Hypothermia was observed in 41.7% of neonates at admission. Although most neonates (84.2%) had Apgar scores ≥ 7 at 10 minutes, the neonatal mortality rate remained notable at 18.1% (Table 3).

Table 3: Characteristics of neonates at admission to neonatology department

Characteristic	Frequency, n = 753	Percentage, %
Age of neonates at admission (n = 753)		
0–24 hours	600	79.6
1–7 days	25	3.4
8–28 days	128	17.0
Gender of neonate (n = 753)		
Male	421	55.2
Female	332	44.8
Body temperature at admission (n = 753)		
Hypothermia (< 36°C)	314	41.7
Normothermia (36°C-37.5°C)	395	52.4
Hyperthermia (> 37.5°C)	44	5.9
Gestational age (n = 753)		
< 32 weeks	169	22.3
33–37 weeks	251	33.4
> 37 weeks	333	44.3
Birth weight (n = 753)		
Low (< 2500mg)	342	45.4
Normal (2500mg-4000mg)	377	50.1
Overweight (above 4000mg)	34	4.6
Apgar scores rst (10 Minutes)		
≤ 3 Apgar score	12	1.6
4–6 Apgar score	107	14.2
≥ 7 Apgar score	634	84.2
Time to admission to neonatology unit (n = 753)		
Admitted within 24 hours	634	84.2
Admitted after 24 hours	119	15.8
Neonate discharge outcome (n = 753)		
Alive	617	81.9
Died	136	18.1

Prevalence of Neonatal Mortality, Cause of Admission, and Cause of Death at Discharge Among Neonatesadmitted to Gisenyi District Hospital

The neonatal mortality rate was 18% (95% Con dence Interval: 15.3–27.2%), indicating that nearly one in ve admitted newborns did not survive during the study period. The most common cause of neonatal admission to the neonatology unit was complications related to prematurity, accounting for 38.4% of all admissions. Notably, prematurity complications also emerged as the leading cause of neonatal mortality at discharge, contributing to 30.2% of the deaths. This underscores the urgent need for improved case management and enhanced quality of care for preterm infants. Interestingly, while 13.3% of neonatal deaths were attributed to neonatal pneumonia, there were no recorded cases of neonatal admission primarily due to pneumonia. This discrepancy suggests the possibility of nosocomial (hospital-acquired) infections, emphasizing the need to strengthen infection prevention and control (IPC) practices within the neonatal care environment (Figure 1).

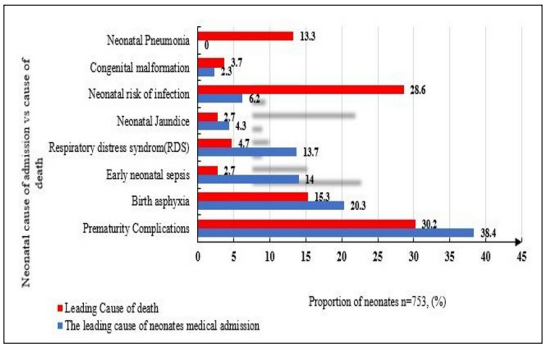

Figure 1: Medical cause of admission to neonatology and Cause of death at discharge, 2019-2024

Multivariable Factors Associated with Neonatal Mortality Among Admitted Neonates to the Neonatologyunit.

The mother's socio-demographic factors are associated with neonatal mortality

Neonates born to mothers aged 25–34 years were nearly eight times more likely to die compared to those born to mothers aged 35 years and above (aOR = 7.97; 95% CI: 1.7–35.70; p = 0.005). In terms of occupation, unemployed mothers had about 2.5 times higher odds of neonatal mortality (aOR = 2.52; 95% CI: 1.08–5.87; p = 0.030), while those working as public servants had 2.3 times higher odds (aOR = 2.26; 95% CI: 1.82–6.27; p = 0.010) compared to farmers. Interestingly, single and cohabiting mothers had 91% (aOR = 0.09; p < 0.001) and 93% (aOR = 0.07; p < 0.001) lower odds of experiencing neonatal death, respectively, compared to legally married mothers. Other variables such as education level, place of residence, and medical insurance status showed no statistically signi cant association with neonatal mortality (Table 4).

Table 4: Multivariable logistic regression of maternal social demographic factors associated with neonatal mortality

Characteristics	cOR (95%CI)	P-value	aOR (95%CI)	P-value
Mother's age group				
35 years old and above	1.00		1.00	
≤ 24 years old	2.93(0.69–12.44)	0.143	2.69(0.61–11.80)	0.188
25–34 years old	10.20(2.36–44.02)	< 0.001	7.97(1.7–35.70)	0.005*
Mother's occupation				
Farmer	1.00		1.00	
Business owner	1.71(0.84–3.51)	0.137	2.08(0.92–4.70)	0.076
Unemployed	2.13(1.05–4.31)	0.035	2.52(1.08–5.87)	0.030*
Public servant	2.44(1.07–5.54)	0.033	2.26(1.82–6.27)	0.010*
Vocational work	1.03(0.11–8.91)	0.978	1.12(0.12–10.27)	0.916
Mother's education				
University level and above	1.00		1.00	
No formal education	0.87(0.29–2.54)	0.800	0.62(0.16–2.29)	0.478
Primary level	0.59(0.21–1.73)	0.338	0.72(0.44–1.184)	0.198
Secondary level	0.57(0.18–1.72)	0.320	0.57(0.29–1.09)	0.093
Mother's marital status				
Legal married	1.00		1.00	
Single	0.08(0.03–0.19)	< 0.001	0.09(0.04–0.23)	< 0.001*
Cohabited	0.07(0.01–0.32)	< 0.001	0.07(0.01–0.33)	< 0.001*
Medical insurance				
Yes	1.00		1.00	
No	2.01(0.78–5.17)	0.147	2.04(0.73–5.66)	0.171
Residence for study participants				
Urban	1.00		1.00	
Rural	2.01(0.78–5.17)	0.147	1.36(0.75–2.48)	0.305
cOR; crude Odds Ratio, aOR; adjusted Odds Ratio, *P ≤ 0.05 at multivariable analysis				

Gynecology-obstetrical factors higher odds of mortality compared to those born to primi-gravida mothers (aOR = 5.89; 95% CI: 3.42–10.13; p < 0.001). Similarly, neonates born to multi-para mothers (those with multiple deliveries) had about twice the odds of neonatal death compared to those born to primi-para mothers (aOR = 2.01; 95% CI: 1.19–3.36; p = 0.008). Gestational age also played a critical role, with neonates born before 32 weeks having almost three times higher odds of death compared to full- term neonates (aOR = 2.90; 95% CI: 1.76–4.80; p < 0.001). The number of antenatal care (ANC) visits was also a signi cant factor, with no ANC visits associated with 73% lower odds of neonatal survival (aOR = 0.27; 95% CI: 0.12–0.58; p < 0.001), and fewer ANC visits (1–2 visits) associated with 67% lower odds (aOR = 0.33; 95% CI: 0.17–0.64; p < 0.001). Other variables, such as mode of delivery and place of delivery, did not show a signi cant impact on neonatal mortality (Table 5).

Table 5: Multivariable logistic regression of the gynecology-obstetrical factors associated with neonatal mortality(n = 753)

Characteristics	cOR (95%CI)	P-value	aOR (95%CI)	P-value
Gravidity				
Primi-gravida	1.00		1.00	
Multi-gravida	2.29(1.55–3.39)	0.001	5.89(3.42–10.13)	< 0.001*
Parity	10.20(2.36–44.02)	< 0.001	7.97(1.7–35.70)	0.005*
Primi-para	1.00		1.00	
Multi-para	1.11 (0.76–1.62)	0.565	2.01(1.19–3.36)	0.008*
Mode of delivery	1.71(0.84–3.51)	0.137	2.08(0.92–4.70)	0.076
Vaginal delivery	1.00		1.00	
Cesarian	1.12(0.12–9.54)	0.923	0.95(0.55–1.63)	0.867
Assisted vaginal delivery	1.41(0.16–11.86)	0.750	0.96(0.65–14.23)	0.981

Place for delivery				
Hospital	1.00		1.00	
Home delivery	0.78(0.61–1.40)	0.723	1.18(0.73–3.04)	0.717
Health center	0.92(0.34–1.81)	0.572	1.18(0.46–3.02)	0.510
Gestational age	0.57(0.18–1.72)	0.320	0.57(0.29–1.09)	0.093
> 37 weeks	1.00		1.00	
< 32 weeks	4.18(2.62–6.64)	< 0.001	2.90(1.76–4.80)	< 0.001*
33–37 weeks	1.56(0.96–2.51)	0.068	1.38(0.83–2.29)	0.213
Number of mother's antenatal care visit done	0.07(0.01–0.32)	< 0.001	0.07(0.01–0.33)	< 0.001*
5 ANC and above	1.00		1.00	
No ANC	0.26(0.12–0.56)	< 0.001	0.27(0.12–0.58)	< 0.001*
3–4 ANC	0.01(0.0–0.03)	< 0.001	0.00(0.00-0.04)	< 0.001*
1–2 ANC	0.31(0.16–0.58)	< 0.001	0.33(0.17–0.64)	< 0.001*
cOR; crude Odds Ratio, aOR; adjusted Odds Ratio, *P ≤ 0.05 at multivariable analysis				

The admitted Neonate-Related Factors Associated with their Mortality, n = 753

Neonates admitted within the rst 24 hours of life had over six times higher odds of mortality compared to those admitted between 8 and 28 days (aOR = 6.17; 95% CI: 2.16–17.67; p < 0.001). Neonates with hypothermia at admission had twice the odds of neonatal mortality compared to those with normothermia (aOR = 2.02; 95% CI: 1.28–3.19; p = 0.002). In contrast, hyperthermia was not signi cantly associated with mortality (aOR = 2.79; 95% CI: 0.78–9.93; p = 0.113). Apgar scores at 10 minutes were a strong predictor of mortality, with neonates scoring ≤ 3 having over 10 times the odds of death compared to those with an Apgar score ≥ 7 (aOR = 10.24; 95% CI: 2.71–38.75; p < 0.001), and those scoring 4–6 having three times higher odds (aOR = 3.07; 95% CI: 1.50–6.28; p = 0.002). Neonates who stayed in the hospital for 7 days or more had 3.45 times higher odds of mortality compared to those who stayed less than 7 days (aOR = 3.45; 95% CI: 1.33–8.95; p = 0.010). Other factors such as gender, birth weight, and admission time showed no signi cant association with neonatal mortality (Table 6).

Table 6: Multivariable logistic regression of the neonate-related factors associated with neonatal mortality

Characteristics	cOR (95%CI)	P-value	aOR (95%CI)	P-value
Neonate's age group at admission to the neonatology Unit				
8–28 days	1.00	Ref	1.00	Ref
0–24 hours	7.03(2.82–17.54)	< 0.001	6.17(2.16–17.67)	< 0.001*
1–7 days	1.00(0.11-9.00)	0.994	1.17(0.11–11.78)	0.891
Gender of admitted neonate				
Male	1.00	Ref	1.00	Ref
Female	1.15(0.79–1.67)	0.441	1.13(0.48–1.34)	0.562
Body temperature at admission to the neonatology unit				
Normothermia (36°C-37.5°C)	1.00	Ref	1.00	Ref
Hypothermia (< 36°C)	2.98(2.01–4.41)	< 0.001	2.02(1.28–3.19)	0.002*
Hyperthermia (> 37.5°C)	1.06(0.40–2.84)	0.894	2.79(0.78–9.93)	0.113
Birth weight before admission to the neonatology unit				
Normal (2500mg-4000mg)	1.00	Ref	1.00	Ref
Low (< 2500mg)	1.72(1.16–2.56)	0.005	0.75(0.44–1.30)	0.315
Overweight (above 4000mg)	1.43(0.64–3.12)	0.379	0.60(0.23–1.58)	0.305
Apgar scores at rst 10 Minutes after birth				
≥ 7 Apgar score	1.00	ref	1.00	Ref
≤ 3 Apgar score	5.04(1.66–15.29)	0.004	10.24(2.71–38.75)	< 0.001*
4–6 Apgar score	2.20(1.14–4.23)	0.18	3.07(1.50–6.28)	0.002*
Admission time				
Admitted within 24 hours	1.00	ref	1.00	Ref
Admitted after 24 hours	1.74(0.96–3.15)	0.065	1.12(0.53–2.36)	0.747

Hospital stay				
Below 7 days	1.00	Ref	1.00	Ref
8 days and above	5.82(2.54–13.29)	< 0.001	3.45(1.33–8.95)	0.010*
cOR; crude Odds Ratio, aOR; adjusted Odds Ratio, *P ≤ 0.05 at multivariable analysis				

Discussion

The neonatal mortality prevalence of 18% observed in this study is alarmingly high and signi cantly exceeds both global and regional estimates. According to the World Health Organization (2023), the global neonatal mortality rate stood at approximately 17 deaths per 1,000 live births, while Sub- Saharan Africa recorded a higher rate of about 27 per 1,000 live births, yet both gures remain markedly lower than the 180 deaths per 1,000 live births reported here [18, 4]. This discrepancy likely re ects the hospital-based nature of the study, where the sample comprises neonates already at elevated risk due to clinical complications necessitating admission. Similar facility-based studies in comparable low- resource settings have reported lower but still concerning mortality rates; for instance, a study in Ethiopia found a rate of 20%, while one in Uganda reported 17% [19-20].

The strong association between maternal age and neonatal mortality draws attention to the often- overlooked risks within the 25–34 age bracket, which is typically considered a lower-risk reproductive age group [21].The signi cantly higher odds of mortality among neonates born to women in this age group, compared to older mothers, may re ect disparities in birth preparedness, care-seeking behaviors, or undetected obstetric complications [22, 23]. Contrary to traditional assumptions that older maternal age confers greater perinatal risk, some studies, particularly those from resource-limited settings, suggest that older mothers may bene t from accumulated maternal experience, improved self-e cacy in navigating health services, and greater household decision-making power [24, 25].

A study done in Nigeria has revealed that an employment status emerged as another key determinant, with higher mortality among neonates of unemployed and public servant mothers compared to those of farmers [26]. While public employment often implies better socioeconomic positioning, it may also come with higher stress levels, longer working hours, or reduced time for postnatal care. Conversely, farming mothers may bene t from extended familial support networks and the proximity to home-based caregiving environments [27, 28]. These ndings mirror those from Sub-Saharan Africa, where maternal employment, especially in non- exible formal sectors, has been associated with suboptimal early neonatal outcomes [29]. Interestingly, the data revealed that single and cohabiting mothers had lower odds of neonatal death than their legally married counterparts. This counterintuitive result may suggest that unmarried mothers, especially in the context of strong community-based maternal support, may receive more focused care or engage more consistently with health systems due to perceived vulnerability [30]. Alternatively, cultural and legal marital norms may obscure underlying socioeconomic or gender dynamics that compromise care access in formally married households [28].

Parity and gravidity remain well-established risk factors in perinatal health literature. The elevated risk of neonatal mortality among neonates born to multigravida and multiparous mothers is consistent with ndings from similar low-income settings. These risks may stem from uterine fatigue, reduced placental e ciency, or complacency in seeking skilled birth care among women with previous childbirthexperience [31, 32]. Additionally, repeated pregnancies without optimal spacing may deplete maternal nutritional reserves, adversely affecting neonatal outcomes [33, 34].

Globally the prematurity continues to be a dominant contributor to neonatal deaths, and this study rea rms its devastating impact in a district hospital setting. The markedly higher mortality risk for neonates born before 32 weeks of gestation aligns with WHO reports, which highlight that extremely preterm births have limited survival prospects in low-resource facilities due to inadequate respiratory support, infection control, and thermal regulation [35, 36]. The timing of admission also proved critical; early admission (within 24 hours of life) likely signals critical neonatal distress at birth, which may overwhelm the limited capacity of district-level neonatal units [37].

In Rwanda, the Antenatal care utilization remains one of the strongest predictors of neonatal survival38. In this study, the reduced survival odds among mothers with no or limited ANC visits underscore systemic gaps in early detection of high-risk pregnancies. This reinforces WHO's recommendation of at least eight ANC contacts during pregnancy to facilitate timely identi cation and management of complications [39]. In many rural settings, barriers such as transport, cultural beliefs, and low health literacy limit ANC engagement, placing neonates at elevated risk even before birth [40]. In present study, the thermal instability at admission, especially hypothermia, emerged as another critical determinant. Neonatal hypothermia is both a marker and a mediator of poor outcomes, often re ecting inadequate postnatal thermal care, especially among low birth weight and premature neonates [41].

Although hyperthermia was not statistically signi can't in this analysis, its presence may still signal underlying infection, which, in resource-limited settings, is a frequent but often underdiagnosed contributor to neonatal mortality [42].

Apgar scores at 10 minutes served as a powerful prognostic marker [43]. The gradient of mortality risk across Apgar score categories reinforce the value of immediate postnatal assessment and resuscitation efforts [44]. In settings like Gisenyi DH, where neonatal resuscitation capacity may be constrained, low Apgar scores could re ect delayed or ineffective interventions at birth. Investment in neonatal resuscitation training and equipment remains a low-cost, high-impact strategy that could signi cantly reduce early neonatal deaths. Finally, the increased odds of mortality among neonates who stayed in the hospital for 7 days or more could be indicative of nosocomial complications, late-onset infections, or underlying congenital conditions that required prolonged management [45]. It also highlights a

subgroup of neonates who initially survived the critical early window but later succumbed to complications, emphasizing the need for robust infection control, nutritional support, and close monitoring throughout the neonatal period This study had one key limitation. As a hospital-based study conducted at Gisenyi District Hospital, the ndings may not fully represent neonatal mortality trends in the general population, especially in rural or home-birth settings [46]. However, Gisenyi DH is the main referral hospital in the region and receives a high volume of neonatal admissions from various catchment areas, thereby offering a reasonably broad picture of facility-based neonatal outcomes.

Conclusion

Despite signi can't improvements in the health system and rapid declines in neonatal mortality in Rwanda, the ndings of this study revealed a high neonatal mortality rate of 18% at the hospital, highlighting a critical burden within the facility-based neonatal care system and case management. Several maternal, neonatal, and clinical factors were signi cantly associated with this mortality, including younger maternal age (25–34 years), lack of antenatal care, preterm birth (< 32 weeks), low Apgar scores, early neonatal admission (within 24 hours), and neonatal hypothermia. These ndings underscore the multifaceted nature of neonatal mortality and emphasize the urgent need for comprehensive and well-informed policies, guidelines, and system-level improvements. with targeted interventions across the continuum of maternal and newborn care that address the key risk factors identi ed in this study, especially in rural areas. Health workers at both primary and referral levels should be trained to identify the neonatal cause of death danger signs, and the management of preterm births early. Additionally, community health workers and local leaders should intensify maternal health education campaigns to promote timely antenatal care and facility-based deliveries.

Study Strengths and Limitations

This study encompasses inborn and outborn multicenter-level data from all public health facilities that referred their neonates to the Gisenyi district Hospital neonatology department. Therefore, it re ects the district's public health system structure in neonate case management. The identi ed factors associated with neonatal deaths (Maternal and neonatal factors) and the general recommendations derived from this study were relevant and applicable to all public health facilities. Despite that, the study utilized only medical records of neonates and their mothers found at the hospital, which may not capture all factors in uencing neonatal mortality. Consequently, the results might not be entirely representative of the community, as deaths in the community were not counted, and their cause was not assessed. This limitation could lead to an underrepresentation of the total number of deaths within the district. Given the rising number of premature neonatal deaths, there is a pressing need for a prospective, community- based study to thoroughly examine maternal factors.

Declarations

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Authors Contributions

Innocent NTIRUSHWAMABOKO conceived the study's idea, designed the methodology, developed the questionnaire, analyzed the data, and wrote the manuscript. Hinda Ruton supervised the study, contributed to the study design and results interpretation. Bibiane Uwamahoro assisted with the study design and the interpretation of the results. Associate Professor Aline Umubyeyi was provided the constructive feedback on the manuscript and critically reviewed the manuscript, supported the study design, assisted in data analysis and results interpretation.

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Data Availability Statement

The original contributions presented in this study are included in the article and/or the Supplementary Material. The dataset used in this study is stored securely and is available upon reasonable request. Interested parties are encouraged to contact the corresponding author for access or further inquiries.

Ethical Consideration

This study utilized secondary data from human participants and received approval from the University of Rwanda's Human Research Institutional Review Board (IRB) under Reference Number CMHS/IRB/458/2024 of May 2025. Furthermore, ethical clearance was granted by the Ethical Committee of the Rwanda Ministry of Health and the Gisenyi District Hospital research committee, which permitted the study investigator to access both neonatal and maternal data. Both research committees were assured that the collected data would remain anonymous, all data securely stored and accessed only by authorized study personnel. Informed consent was obtained as requested by the ethics committee. The need for consent was waived for the study, including newborns and their mothers, under hospital data access approval with reference No: 053/2024 of 07/06/2024 and University of Rwanda Human Research Institutional Review Board data access approval letter No130/UR-CMHS/SPH/2024. This research was conducted under the Declaration of Helsinki.

Consent for Publication

Not applicable

Competing interests

The author(s) declared no potential con icts of interest related to this manuscript's research, authorship, or publication.

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