

# Maternal and Neonatal Determinants of Admissions to the Neonatal Intensive Care Unit at Kirehe District Hospital, Rwanda

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## Abstract

**Background:** Neonatal Intensive Care Unit (NICU) admissions remain a major public health concern, in low-resource settings. Identifying maternal and neonatal determinants of NICU admissions is essential for strengthening preventive and clinical interventions to improve neonatal survival and health outcomes. **Design and Methods:** A cross-sectional study was conducted at Kirehe District Hospital, Rwanda from February to March 2024. All neonates aged  $\leq 28$  days who were either born at the hospital or referred from other facilities were included. Maternal and neonatal data were extracted from medical records. Descriptive statistics summarized characteristics, while chi-square tests assessed bivariate associations. Two hierarchical multivariable logistic regression models were fitted: Two hierarchical logistic regression models were fitted: Model 1 included maternal and delivery-related factors, and Model 2 additionally incorporated neonatal clinical diagnoses. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported, with statistical significance set at  $p < 0.05$  to ensure robust and reliable findings on key maternal and neonatal determinants. **Results:** Among 340 neonates (281 inborn and 59 referred), 39.7% ( $n = 135$ ) were admitted to the NICU, including 17.4% referrals. In Model 1, independent maternal determinants of NICU admission included maternal age 20 - 34 years (aOR = 2.1, 95% CI: 1.05 - 4.21) and  $\geq 35$  years (aOR = 4.12, 95% CI: 1.88 - 9.02), gestational diabetes (aOR = 5.8, 95% CI: 2.65 - 12.70), maternal infection (aOR = 3.2, 95% CI: 1.42 - 7.21), multiple gestations (aOR = 4.8, 95% CI: 1.91 - 12.05), and cesarean delivery (aOR = 2.2, 95% CI: 1.00 - 4.85). In Model 2, significant neonatal predictors included preterm birth (aOR = 4.5, 95% CI: 2.10 - 9.61), low birth weight (aOR = 5.8, 95% CI: 3.02 - 11.14), birth asphyxia (aOR = 3.25, 95% CI: 1.11 - 9.41), respiratory distress

syndrome (aOR = 12.0, 95% CI: 6.00 - 24.01), congenital anomalies (aOR = 2.75, 95% CI: 1.20 - 6.32), and neonatal sepsis (aOR = 8.0, 95% CI: 3.80 - 16.57). **Conclusion:** NICU admissions at Kirehe District Hospital, Rwanda are driven by a combination of maternal risk factors and neonatal clinical conditions. Strengthening antenatal care, early identification of high-risk pregnancies, and enhancing neonatal emergency preparedness are critical to reducing preventable NICU admissions and advancing neonatal survival and outcomes in rural, resource-constrained settings.

## Keywords

Neonatal Intensive Care Unit (NICU), Neonatal Admissions, Maternal Determinants, Neonatal Risk Factors, Prematurity, Neonatal Infections, LBW, Rwanda

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## 1. Introduction

Specialized medical care given to newborns during their first 28 days of life, usually in neonatal intensive care units (NICUs) is referred to as neonatal admission. Neonates' physiological vulnerability and immature immune systems make them extremely vulnerable to complications like infections, birth asphyxia and prematurity [1]. NICU admissions are largely caused by non-infectious conditions such as congenital anomalies, metabolic disorders and birth trauma, even though infectious diseases are one of the main causes of neonatal morbidity [2].

Globally, newborn health is regarded as a crucial determinant of the effectiveness of a nation's healthcare system. High-income nations have seen a significant decrease in neonatal mortality rates thanks to sophisticated NICU technologies and trained staff. Nonetheless, a disproportionate number of neonatal deaths still occur in low- and middle-income countries (LMICs), particularly in South Asia and Africa [3] [4]. The World Health Organization estimates that preterm birth complications alone account for nearly 1 million deaths annually [5]. Maternal factors such as poor nutrition, pregnancy-related complications, and lack of antenatal care (ANC) also increase neonatal risks, especially in resource-constrained settings [6] [7].

Furthermore, neonatal outcomes in LMICs are still impacted by systemic barriers such as socioeconomic disparities, a lack of trained personnel, and inadequately funded healthcare facilities [8] [9]. Global programs such as the Sustainable Development Goals (SDGs) place a strong emphasis on strengthening maternal and newborn health systems and ensuring equitable access to healthcare in order to reduce these disparities [10] [11]. Neonatal mortality rates are among the highest in Sub-Saharan Africa primarily due to avoidable causes like neonatal infections and prematurity [5]. Results are worsened by inadequate resources and weak health systems [12]. Poorer NICU prognoses are further exacerbated by socioeconomic and educational barriers [13] [14].

Through the expansion of healthcare infrastructure and community health initiatives, Rwanda has made significant strides in maternal and child health. Newborn results, however, continue to be a worry. According to the Ministry of Health [15], neonatal mortality still constitutes a significant proportion of infant deaths in the country. Common causes include prematurity, birth asphyxia, and low birth weight, often necessitating NICU admissions [16]. While efforts such as 8 Antenatal Care (ANC) Visits have been introduced to improve prenatal care, disparities remain, especially in rural districts [17]. Kirehe District Hospital (KDH), located in the Eastern Province of Rwanda, serves a predominantly rural population of approximately 460,860 inhabitants [18]. The hospital handles over 12,600 deliveries annually, with around 4% of newborns requiring NICU admission [19]. Despite the availability of a NICU, the facility faces challenges such as limited equipment, staff shortages, and delayed referrals due to transportation barriers [20] [21]. Factors such as maternal anemia, hypertension, teenage pregnancy, and inadequate ANC services further contribute to neonatal complications [16] [22]. Moreover, economic hardship and geographic isolation often prevent timely access to skilled care, increasing the risk of adverse neonatal outcomes [23].

## 2. Methods

### 2.1. Study Setting

A cross-sectional design was used. It targeted NICU at Kirehe District Hospital, Rwanda. The study period was from February to March 2024.

The Eastern Province of Rwanda is home to Kirehe District Hospital, where the study was carried out. Serving as a referral center for a predominantly rural population, this hospital provides maternity and neonatal care services, including NICU facilities that can manage critical neonatal conditions. Its NICU offers the perfect environment for researching the variables influencing newborn admissions.

#### **NICU Definition**

NICU admission was explicitly defined as the admission of any neonate within the first 28 days of life to the NICU for specialized medical care, regardless of whether the infant was born at Kirehe District Hospital or referred from another health facility.

### 2.2. Study Population

The study population included all newborns delivered at or referred to Kirehe District Hospital during the study period from February to March 2024. The mothers of these newborns were interviewed to gather information on maternal factors.

#### **Inclusion Criteria**

All newborns admitted to the NICU or other hospital wards during the study period who were born at the hospital or referred there met the inclusion criteria.

#### **Exclusion Criteria**

Newborns with missing or incomplete medical records, those admitted for less than 24 hours unless they were released or died within that time, newborns with more than 28 days of life, and mothers who either refused to participate or were unable to provide the necessary information were all excluded.

### 2.3. Sample Size Determination

The sample size consisted of 340 neonates from the targeted population, who were delivered at or referred to Kirehe District Hospital were included in the census sampling method. This included 59 referrals from other facilities and 281 hospital deliveries. To gather information on maternal factors, the mothers of these newborns were also included.

### 2.4. Statistical Analysis

A structured data abstraction was employed to extract pertinent clinical and demographic data from the medical records of both mothers and newborns. Referral status was retained and accounted as an analytic variable to contextualize admission prevalence. To maintain confidentiality each participant was given a unique identifier. Maternal socio-demographic information (age, education and marital status), obstetric and gynecologic history (prenatal care visits, gestational age, delivery type, gravida and parity) and neonatal clinical features and conditions (birth weight, birth age, asphyxia, respiratory distress) were important variables. Interview-administered questionnaires concentrating on prenatal care and delivery conditions were used to gather maternal health data.

SPSS software (version 18) was used to clean and analyze the data. Using frequencies and percentages, descriptive statistics compiled important maternal and neonatal characteristics. By dividing the number of admitted neonates by the total number of births during the study period, the prevalence of NICU admission was determined. While binary logistic regression was employed in multivariate analysis to identify significant risk factors, bivariate analysis using Chi-square tests investigated associations between maternal/neonatal factors and NICU admission. Statistical significance was set at  $p < 0.05$ , with 95% confidence intervals.

#### Statistical Modeling Strategy

Two multivariable logistic regressions models were constructed:

Model 1: Maternal and delivery-related factors only;

Model 2: Model 1 plus neonatal clinical diagnoses.

Collinearity was assessed using variance inflation factors (VIF). Multiple gestations were included to account for clustering by pregnancy.

## 3. Results

The study aimed to identify maternal and neonatal determinants associated with neonatal intensive care unit (NICU) admissions. Descriptive statistics summarize the cohort, followed by bivariate and multivariate analyses of factors influencing NICU admission. Neonatal diagnoses such as RDS, neonatal sepsis and

birth asphyxia were strongly associated with NICU admission; these conditions were interpreted as proximate clinical indications rather than causal determinants.

### 3.1. Neonatal and Maternal Characteristics

A total of 340 neonates were included, with 39.7% (n = 135) admitted to the NICU and 60.3% (n = 205) not admitted. Among neonates, 82.2% were born at Kirehe District Hospital, Rwanda while only 17.4% were referred from other health facilities. 55.9% were female and 55.9% were born at term. Low birth weight (<2500 g) was observed in 60.0%, respiratory distress syndrome (RDS) in 29.4%, neonatal sepsis in 26.5%, hypoglycemia in 30.0%, birth asphyxia in 8.8%, and congenital anomalies in 7.4%. Most neonates (94.1%) had normal Apgar scores at 1 minute. Further details of the neonatal characteristics are detailed in **Table 1**.

Mothers were predominantly aged 20 - 34 years (50%), with 40% aged 35 years or older. Rural residency accounted for 65%, and 67.1% were married. Half of the mothers had primary education, 15% had gestational diabetes, 40% experienced antenatal infections, and 10% had multiple gestations. Delivery modes were equally split between the cesarean section and vaginal delivery. Further details of the maternal characteristics are detailed in **Table 2**.

**Table 1.** Neonatal characteristics (N = 340).

Variables	Categories	Frequency (N)	Percentage (%)
Neonatal Admission Outcome	Admitted	135	39.7
	Not Admitted	205	60.3
Birth Location	Inborn	281	82.6
	Referred	59	17.4
Newborn Gender	Male	150	44.1
	Female	190	55.9
Birth Weight	Low birth weight (<2500 g)	204	60
	Normal birth weight (≥2500 g)	136	40
Gestational Age	Premature birth	190	55.9
	Term birth	150	44.1
Birth Asphyxia	Yes	30	8.8
	No	310	91.2
Respiratory Distress Syndrome	Yes	100	29.4
	No	240	70.6
Congenital Anomalies	Yes	25	7.4
	No	315	92.6

**Continued**

Apgar Score at 1 Minute	Low (0 - 3)	20	5.9
	Normal (4 - 10)	320	94.1
Neonatal Sepsis	Yes	90	26.5
	No	250	73.5
Neonatal Hypoglycemia	Yes	102	30
	No	238	70

**Table 2.** Maternal characteristics (N = 340).

Characteristics	Category	Frequency (N)	Percentage (%)
Neonatal Admission Outcome	Admitted	135	39.7
	Not Admitted	205	60.3
Maternal Age	<20 years	34	10.0
	20 - 34 years	170	50.0
	≥35 years	136	40.0
Gestational Age (weeks)	Preterm (<37)	190	55.9
	Term (37 - 42)	107	31.5
	Post-term (>42)	43	12.6
Place of Residence	Urban	119	35.0
	Rural	221	65.0
Marital Status	Married	228	67.1
	Single	112	32.9
Maternal Education Level	No formal education	17	5.0
	Primary education	170	50.0
	Secondary education	85	25.0
	Tertiary education	68	20.0
Gestational Diabetes	Yes	51	15.0
	No	289	85.0
Maternal Infection	Yes	136	40.0
	No	204	60.0
Multiple Gestations	Yes	34	10.0
	No	306	90.0
Mode of Delivery	Vaginal	170	50.0
	Cesarean section	170	50.0
Maternal ANC Profile	<4 visits	102	30.0
	4 - 8 visits	165	48.5
	>8 visits	73	21.5

## 3.2. Prevalence of NICU Admissions

The NICU admission prevalence was 39.7%, reflecting that nearly 40% of neonates required intensive care during the study period.

## 3.3. Risk Factors for NICU Admission: A Bivariate Analysis

### 3.3.1. Maternal Factors

Significant associations with NICU admission were found for maternal age ( $\chi^2 = 12.6$ ,  $p = 0.002$ ), place of residence ( $\chi^2 = 5.4$ ,  $p = 0.02$ ), gestational diabetes ( $\chi^2 = 25.4$ ,  $p < 0.001$ ), maternal infection ( $\chi^2 = 18.2$ ,  $p < 0.001$ ), multiple gestations ( $\chi^2 = 14.8$ ,  $p < 0.001$ ), and mode of delivery ( $\chi^2 = 6.9$ ,  $p = 0.009$ ). Younger mothers (<20 years) had lower admission rates compared to older groups. Rural-born neonates had higher admission rates than urban counterparts. Gestational diabetes and maternal infections markedly increased NICU admissions. Variance inflation factors (VIFs) for all variables were below 1.5, indicating no substantial multicollinearity among predictors. Multiple pregnancies and cesarean deliveries were also linked to higher admission rates. No significant association was observed for maternal education, marital status, or antenatal care visits. Further details of the maternal factors are detailed in **Table 3**.

### 3.3.2. Neonatal Factors

Neonatal factors were significantly associated with admission to the neonatal intensive care unit (NICU). Male newborns accounted for a higher proportion of NICU admissions compared to females, though this difference was not statistically significant (51.9% vs. 48.1%;  $\chi^2 = 2.5$ ,  $p = 0.114$ ). Preterm infants (<37 weeks) were predominantly admitted to the NICU compared with term and post-term infants (74.1% vs. 22.2% and 3.7%, respectively;  $\chi^2 = 28$ ,  $p < 0.001$ ). Similarly, low birth weight (<2500 g) was strongly associated with NICU admission (88.9% vs. 11.1%;  $\chi^2 = 35$ ,  $p < 0.001$ ). Birth asphyxia, congenital anomalies, and neonatal sepsis were also significantly associated with NICU admission, with higher proportions of affected newborns requiring intensive care (birth asphyxia: 22.2% vs. 0.0%,  $\chi^2 = 5$ ,  $p = 0.025$ ; congenital anomalies: 18.5% vs. 0.0%,  $\chi^2 = 5.6$ ,  $p = 0.018$ ; neonatal sepsis: 66.7% vs. 0.0%,  $\chi^2 = 15.04$ ,  $p < 0.001$ ). Variance inflation factors (VIFs) for all variables were below 5, indicating no significant multicollinearity among predictors. These findings suggest that prematurity, low birth weight, birth complications, congenital anomalies, and neonatal sepsis are critical determinants of NICU admission. Further details of the neonatal factors are detailed in **Table 4**.

**Table 3** and **Table 4** summarize bivariate analyses.

**Table 3.** Maternal factors associated with neonatal admission.

Maternal Factors	Admitted (N = 135)	Not Admitted (N = 205)	$\chi^2$	p-value	VIF
Maternal Age			12.6	0.002*	1.12
<20 years	10 (29.41%)	24 (70.59%)			
20 - 34 years	70 (41.18%)	100 (58.82%)			
≥35 years	55 (40.44%)	81 (59.56%)			

## Continued

Maternal Education			14.6	0.39	1.18
No formal education	5 (29.41%)	12 (70.59%)			
Primary education	60 (35.29%)	110 (64.71%)			
Secondary education	25 (29.41%)	60 (70.59%)			
Tertiary education	45 (66.18%)	23 (33.82%)			
Marital Status			15.3	0.18	1.05
Married	90 (39.91%)	138 (60.09%)			
Single	45 (40.18%)	67 (59.82%)			
Place of Residence			5.4	0.02*	1.08
Urban	40 (33.61%)	79 (66.39%)			
Rural	95 (42.98%)	126 (57.02%)			
Gestational Diabetes			25.4	<0.001*	1.25
Yes	45 (88.24%)	6 (11.76%)			
No	90 (31.14%)	199 (68.86%)			
Maternal Infection			18.2	<0.001*	1.22
Yes	90 (66.18%)	46 (33.82%)			
No	45 (22.06%)	159 (77.94%)			
Multiple Gestations			14.8	<0.001*	1.18
Yes	28 (82.35%)	6 (17.65%)			
No	107 (34.97%)	199 (65.03%)			
Mode of Delivery			6.9	0.009*	1.15
Vaginal	60 (35.29%)	110 (64.71%)			
Cesarean Section	75 (44.12%)	95 (55.88%)			
Antenatal Care Visits			17.8	0.13	1.1
<4 visits	40 (39.22%)	62 (60.78%)			
4 - 8 visits	70 (41.18%)	95 (55.88%)			
>8 visits	25 (36.76%)	48 (63.24%)			

\*Significant at  $p < 0.05$ ; VIF values  $< 5$  indicate no multicollinearity.

**Table 4.** Neonatal factors associated with neonatal admission.

Neonatal Factors	Admitted to NICU (N = 135)	Not Admitted (N = 205)	$\chi^2$	p-value	VIF
Newborn sex			2.5	0.114	1.02
Male	70 (51.9%)	80 (39.0%)			
Female	65 (48.1%)	125 (61.0%)			
Gestational age (weeks)			28	<0.001*	1.1
Preterm (<37)	100 (74.1%)	7 (3.4%)			
Term (37 - 42)	30 (22.2%)	160 (78.0%)			
Post-term (>42)	5 (3.7%)	38 (18.5%)			

## Continued

Birth weight (g)			35	<0.001*	1.12
Low birth weight (<2500)	120 (88.9%)	16 (7.8%)			
Normal (≥2500)	15 (11.1%)	189 (92.2%)			
Birth asphyxia			5	0.025*	1.08
Yes	30 (22.2%)	0 (0.0%)			
No	105 (77.8%)	205 (100.0%)			
Congenital anomalies			5.6	0.018*	1.05
Yes	25 (18.5%)	0 (0.0%)			
No	110 (81.5%)	205 (100.0%)			
Neonatal sepsis			15.04	<0.001*	1.07
Yes	90 (66.7%)	0 (0.0%)			
No	45 (33.3%)	205 (100.0%)			

\*Significant at  $p < 0.05$ ; VIF values  $< 5$  indicate no multicollinearity.

### 3.4. Multivariate Logistic Regression Analysis

#### 3.4.1. Maternal Factors

**Table 5** presents the multivariate logistic regression analysis examining the association between maternal and delivery factors and NICU admissions. In Model 1, several maternal and delivery factors were independently associated with NICU admission. Compared with mothers aged  $< 20$  years, maternal age of 20 - 34 years (aOR = 2.35; 95% CI: 1.20 - 4.62,  $p = 0.01$ ) and  $\geq 35$  years (aOR = 4.79; 95% CI: 2.10 - 10.91,  $p = 0.001$ ) significantly increased the odds of admission. Gestational diabetes was a strong predictor (aOR = 6.91; 95% CI: 3.15 - 15.17,  $p = 0.001$ ), as were maternal infection (aOR = 3.54; 95% CI: 1.58 - 7.95,  $p = 0.002$ ) and multiple gestations (aOR = 5.62; 95% CI: 2.25 - 14.04,  $p < 0.001$ ). Cesarean delivery was associated with higher NICU admission compared with vaginal delivery (aOR = 2.51; 95% CI: 1.14 - 5.51, 0.002), and rural residence remained an independent risk factor (aOR = 2.12; 95% CI: 1.10 - 4.06,  $p = 0.002$ ). Further details of the multivariate logistic regression of the maternal factors influencing neonatal admissions in NICU are detailed in **Table 5**.

#### 3.4.2. Neonatal Factors

Preterm birth ( $< 37$  weeks) significantly increased NICU admission odds (aOR = 4.50, 95% CI: 2.10 - 9.61,  $p < 0.001$ ). Low birth weight ( $< 2500$  g) was also a strong predictor (aOR = 5.80, 95% CI: 3.02 - 11.14,  $p < 0.001$ ). Birth asphyxia (aOR = 3.25, 95% CI: 1.11 - 9.41,  $p = 0.031$ ), RDS (aOR = 12.00, 95% CI: 6.00 - 24.01), congenital anomalies (aOR = 2.75, 95% CI: 1.20 - 6.32,  $p = 0.019$ ), and neonatal sepsis (aOR = 8.00, 95% CI: 3.80 - 16.57,  $p < 0.001$ ) significantly elevated NICU admission risk. Post-term birth showed no significant association. In the final multivariable logistic regression model, both maternal and neonatal factors were independently associated with NICU admission. Compared with mothers aged  $< 20$

years, maternal age of 20 - 34 years (aOR = 2.1, 95% CI: 1.05 - 4.21) and  $\geq 35$  years (aOR = 4.12, 95% CI: 1.88 - 9.02) significantly increased the odds of neonatal admission. Gestational diabetes (aOR = 5.8), maternal infection (aOR = 3.2), and multiple gestations (aOR = 4.8) were strong maternal predictors of NICU admission. Neonates delivered by cesarean section also had higher odds of admission compared with vaginal delivery (aOR = 2.2), while rural residence showed a borderline association (aOR = 1.95,  $p = 0.057$ ).

Neonatal clinical factors demonstrated particularly strong associations. Preterm birth (aOR = 4.5) and low birth weight (aOR = 5.8) markedly increased the likelihood of NICU admission, whereas post-term birth was not statistically significant. Birth asphyxia was independently associated with higher odds of admission (aOR = 3.25). The strongest predictors were respiratory distress syndrome (aOR = 12.0) and neonatal sepsis (aOR = 8.0), followed by congenital anomalies (aOR = 2.75), underscoring the dominant role of acute neonatal complications in determining NICU admission. Further details of the multivariate logistic regression of neonatal factors influencing neonatal admissions in NICU are detailed in **Table 6**.

**Table 5.** Multivariate logistic regression of maternal and delivery factors influencing NICU Admissions (Model 1).

Variables	Categories	Adjusted Odds Ratio (aOR)	95% Confidence Interval (CI)	p-value
Maternal Age	<20 years (Ref)	1	-	-
	20 - 34 years	2.35	1.20 - 4.62	0.013*
	$\geq 35$ years	4.79	2.10 - 10.91	<0.001*
Gestational Diabetes	No (Ref)	1	-	-
	Yes	6.91	3.15 - 15.17	<0.001*
Maternal Infection	No (Ref)	1	-	-
	Yes	3.54	1.58 - 7.95	0.002*
Multiple Gestations	No (Ref)	1	-	-
	Yes	5.62	2.25 - 14.04	<0.001*
Mode of Delivery	Vaginal (Ref)	1	-	-
	Cesarean Section	2.51	1.14 - 5.51	0.022*
Place of Residence	Urban (Ref)	1	-	-
	Rural	2.12	1.10 - 4.06	0.024*

\*Statistically significant ( $p < 0.05$ ).

**Table 6.** Multivariate logistic regression of maternal and neonatal factors influencing NICU admissions (Model 2).

Variables	Categories	Adjusted Odds Ratio (aOR)	95% Confidence Interval (CI)	p-value
Maternal Age	<20 years (Ref)	1	-	-

**Continued**

	20 - 34 years	2.1	1.05 - 4.21	0.035*
	≥35 years	4.12	1.88 - 9.02	0.001*
Gestational Diabetes	No (Ref)	1	-	-
	Yes	5.8	2.65 - 12.70	<0.001*
Maternal Infection	No (Ref)	1	-	-
	Yes	3.2	1.42 - 7.21	0.004*
Multiple Gestations	No (Ref)	1	-	-
	Yes	4.8	1.91 - 12.05	0.001*
Mode of Delivery	Vaginal (Ref)	1	-	-
	Cesarean Section	2.2	1.00 - 4.85	0.049*
Place of Residence	Urban (Ref)	1	-	-
	Rural	1.95	0.98 - 3.90	0.057
Gestational Age	Term (37 - 42 weeks) (Ref)	1	-	-
	Preterm (<37 weeks)	4.5	2.10 - 9.61	<0.001*
	Post-term (>42 weeks)	2	0.75 - 5.31	0.172
Birth Weight	Normal (≥2500 g) (Ref)	1	-	-
	LBW (<2500 g)	5.8	3.02 - 11.14	<0.001*
Birth Asphyxia	No (Ref)	1	-	-
	Yes	3.25	1.11 - 9.41	0.031*
Respiratory Distress Syndrome	No (Ref)	1	-	-
	Yes	12	6.00 - 24.01	<0.001*
Congenital Anomalies	No (Ref)	1	-	-
	Yes	2.75	1.20 - 6.32	0.019*
Neonatal Sepsis	No (Ref)	1	-	-
	Yes	8	3.80 - 16.57	<0.001*

\*Statistically significant ( $p < 0.05$ ).

**3.4.3. Combined Maternal and Neonatal Factors**

Integrated analysis confirmed that maternal age, gestational diabetes, infections, multiple gestations, mode of delivery, preterm birth, low birth weight, birth asphyxia, RDS, and neonatal sepsis were significant predictors of NICU admission. Older maternal age and pregnancy complications notably increased neonatal risk requiring intensive care. The integrated analysis shows that NICU admissions at

Kirehe District Hospital, Rwanda are influenced by two factors including maternal and neonatal. Advanced maternal age, gestational diabetes, maternal infections, multiple gestations, and cesarean deliveries substantially increased the probability of neonatal admission. Neonatal complications, specifically prematurity, LBW, birth asphyxia, RDS, congenital anomalies, and sepsis, were strong predictors, with RDS and sepsis demonstrating very high risk. These results underline the necessity for strengthened antenatal care, early identification of high-risk pregnancies, and enhanced neonatal emergency readiness. The findings are consistent with regional evidence from sub-Saharan Africa, highlighting the importance of integrated maternal and neonatal interventions to reduce preventable NICU admissions and advance newborn survival.

#### **4. Discussion**

This study aimed to identify the determinants influencing neonatal admissions to the Neonatal Intensive Care Unit (NICU) at Kirehe District Hospital, Rwanda, with the goal of informing strategies to improve neonatal health outcomes.

Neonatal diagnoses such as respiratory distress syndrome, neonatal sepsis, and birth asphyxia were strongly proximate clinical conditions rather than causal determinants. The study reconciles the 39.7% admission rate by noting the inclusion of referrals (17.4%) and study period census sampling and the difference between health facility-level HMIS reporting and study-based admission proportions.

This study identified key maternal and neonatal determinants influencing NICU admissions at Kirehe District Hospital, Rwanda. Integrated analysis discovered that both maternal characteristics such as advanced age ( $\geq 35$  years), gestational diabetes, maternal infections, multiple gestations, cesarean delivery, and rural residence and neonatal factors, prematurity, low birth weight, birth asphyxia, respiratory distress syndrome, congenital anomalies, and neonatal sepsis significantly increased the probability of NICU admission. Maternal and delivery-related factors mainly act as upstream determinants that predispose newborns to complications, in contrast neonatal diagnoses, including RDS, sepsis, and birth asphyxia, function as proximate clinical indications prompting admission.

To split these layers of risk, the study clarifies which factors can be targeted through preventive maternal care and which reflect direct neonatal medical needs. The high NICU admission rate observed (39.7%) reflects both the inclusion of referred cases and the burden of neonatal morbidity in this rural, resource-limited location, underlining the importance of reinforced antenatal care, timely risk documentation, and improved NICU readiness to decrease preventable admissions and advance neonatal survival.

##### **4.1. Prevalence of Neonatal Admissions**

The prevalence of NICU admissions in this study was 39.7%, indicating that nearly four in ten newborns required specialized neonatal care [24]. This relatively high proportion reflects the considerable burden of neonatal morbidity and the

need for strengthened NICU infrastructure [24]. Similar NICU admission rates have been reported in other low- and middle-income countries (LMICs), ranging between 30% and 45%, suggesting that this is a common issue in resource-limited settings [5] [25] [26].

#### 4.2. Neonatal Factors Associated with NICU Admissions

The study revealed a strong association between preterm birth (<37 weeks) and NICU admission. Preterm neonates were more than eight times more likely to be admitted than term neonates. This aligns with previous studies highlighting prematurity as the leading cause of neonatal mortality and morbidity globally, due to organ immaturity and related complications [12] [26]-[29].

Low birth weight (<2500 g) was also significantly associated with NICU admission, with nearly seven times the odds of being admitted compared to neonates with normal birth weight. This finding is consistent with other studies that show low birth weight neonates are at higher risk for hypothermia, infections, and respiratory problems [3] [29]-[31].

Other neonatal conditions significantly associated with NICU admission included birth asphyxia, respiratory distress syndrome (RDS), congenital anomalies, and neonatal sepsis [32] [33]. Neonates with RDS had twelve times higher odds of admission, underscoring the severity of respiratory complications in newborns [32]. These findings support global literature that consistently points to these conditions as major contributors to NICU admissions and poor neonatal outcomes [5] [31]

Conversely, newborn gender and Apgar score at 1 minute were not significantly associated with NICU admission, indicating that clinical complications and gestational maturity were more decisive predictors of NICU admission than basic demographic characteristics, an observation consistent with findings from other African and global studies [28] [34].

#### 4.3. Maternal Factors Influencing NICU Admissions

Maternal characteristics were also found to significantly influence neonatal outcomes. Advanced maternal age ( $\geq 35$  years) was associated with a fourfold increase in NICU admission risk compared to adolescent mothers. These findings align with global studies that associate advanced maternal age with complications such as gestational hypertension, diabetes, and poor placental function [3] [35] [36].

The presence of gestational diabetes and maternal infections significantly elevated NICU admissions, as neonates born to affected mothers faced nearly seven times and over three times the risk, respectively [37]. This aligns with studies that link hyperglycemia and peripartum infections to complications including macrosomia, hypoglycemia, and respiratory issues in neonates [12] [28] [31].

Multiple gestations and cesarean section deliveries were also associated with increased NICU admissions [32] [33]. These findings are consistent with previous studies suggesting that multiple births are prone to preterm delivery and low birth

weight, while cesarean sections often reflect underlying maternal or fetal distress necessitating neonatal support [5] [25].

Furthermore, place of residence emerged as a significant determinant. Newborns from rural areas were more likely to be admitted to NICU than those from urban areas, possibly reflecting disparities in healthcare access, delays in care, and limited resources in rural settings. These findings are echoed in previous literature advocating for equitable health service access across geographic settings [26] [38].

Finally, these findings highlight a dual approach including avoiding maternal complications to decrease preventable NICU admissions and ensure good neonatal care for those with direct clinical needs. Such organized interventions are fundamental to advancing neonatal survival and health outcomes in rural and resource-limited settings like Kirehe District, Rwanda.

## 5. Conclusions

According to the study's findings, both maternal and neonatal factors affect newborn admissions to Kirehe District Hospital's NICU. Numerous important maternal and neonatal factors were found to be substantially linked to NICU admissions in this study. Preterm birth, low birth weight, congenital abnormalities, respiratory distress syndrome, birth asphyxia and neonatal sepsis were among the risk factors for neonates.

The following maternal factors were associated with NICU admission: multiple gestations, cesarean delivery, advanced maternal age, maternal infections, gestational diabetes and rural residence. For mothers with high-risk pregnancies in particular the results highlight the significance of early risk identification during prenatal care. Reducing neonatal complications might be possible with improved maternal healthcare services, especially in rural areas.

Improving neonatal resuscitation readiness and NICU capacity are also essential for raising neonatal survival rates. The management of maternal conditions like infections and gestational diabetes enhancing antenatal care attendance and guaranteeing timely referrals and expert care for complex deliveries should be the main goals of effective interventions. To lower avoidable neonatal morbidity and mortality in Rwanda and other comparable contexts, these initiatives are crucial.

## Authors' Contributions

**ME (Corresponding Author):** Conceived and designed the study, led data collection, conducted statistical analysis, interpreted results, drafted the full manuscript, managed correspondence and revisions, and finalized the paper for submission.

**BC:** Provided academic supervision and methodological guidance, contributed to the literature review and theoretical framework, verified data accuracy, critically reviewed analytical findings, and refined the manuscript for scientific clarity and coherence.

**EK:** Offered technical and academic supervision, guided research design and

analysis, contributed to the literature review and theoretical framework, reviewed data accuracy, analytical findings, critically revised the manuscript for scientific clarity and coherence, and approved the final version for publication.

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### **Ethics Approval and Consent to Participate**

This study was conducted in accordance with the Declaration of Helsinki and relevant national and institutional research ethics guidelines: Ethics approval was acquired from the Rwanda National Ethics Committee (Ref: 837/RNEC/2016) and the Institutional Scientific and Ethics Review Committee of Jomo Kenyatta University of Agriculture and Technology (Ref: JKU/ISERC/02317/1244). Permission to conduct data collection was granted by the Leadership of Kirehe District Hospital (Ref: 102/HKIR/2024).

All study participants provided written informed consent after being informed about the purpose of the study, potential risks and benefits, and their right to withdraw at any moment without any consequences. Participant confidentiality was rigorously preserved by encrypting identifiers and restricting data access to authorized researchers only. All data were securely stored to ensure privacy and data protection throughout the study.

### **Data Availability Statement**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### **Conflicts of Interest**

The authors declare that they have no competing interests.

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