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Survival Status and Its Predictors Among Neonates Admitted in Byumba Level Two Teaching Hospital, In Rwanda

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Abstract
Neonatal mortality remains a major public health concern in Rwanda, accounting for over 42% of under-five deaths despite notable progress in child health. This study aimed to identify key predictors of neonatal survival among 385 neonates admitted to Byumba Level Two Teaching Hospital between May and October 2024. A prospective cohort design was employed, with data analyzed using SPSS v28, Kaplan-Meier survival curves, and Cox proportional hazards models. Results showed a neonatal survival rate of 89.9%, while 10.1% died. Maternal education level, antenatal care attendance, low APGAR scores, multiple gestations, resuscitation at birth, respiratory support, and absence of Kangaroo Mother Care were significantly associated with mortality. Neonatal infections were the strongest predictor of death (AHR = 16.306; $p < 0.001$), followed by low birth weight (AHR = 0.325; $p = 0.008$). These findings highlight the urgent need for targeted, evidence-based interventions to improve neonatal outcomes and guide health policy in Rwanda.

Keywords: Admitted neonates, Predictors, Neonates, Neonates Survival

1 Introduction

The neonatal period the first 28 days of life is the most critical and vulnerable stage for a child's survival due to the heightened risk of complications such as prematurity, birth asphyxia, infections, and congenital anomalies (UNICEF, 2023). These risks are further exacerbated by maternal health conditions, limited neonatal care services, and inadequate access to quality healthcare. Addressing these issues is essential for achieving Sustainable Development Goal 3, which aims to end preventable deaths of newborns and children under five by 2030 (WHO, 2023). Globally, neonatal mortality has declined more slowly than overall under-five mortality. Between 1990 and 2020, neonatal deaths decreased by only 2.6% annually, with approximately 2.4 million neonates dying in 2020 alone translating to nearly 6,500 daily deaths (WHO, 2024). Around 47% of all under-five deaths now occur during the neonatal period. The majority of these deaths 98% occur in low- and middle-income countries, especially in Sub-Saharan Africa, which holds the highest neonatal mortality rate globally (27 per 1,000 live births) and accounts for 44% of global neonatal deaths. For example, in 2021, Lesotho reported 36 neonatal deaths per 1,000 live births, whereas Libya recorded only 6 (Global Economy, 2021).

Despite effective interventions such as Kangaroo Mother Care (KMC), early initiation of breastfeeding, and specialized neonatal units, neonatal mortality remains high in parts of Africa 26.5% in Mogadishu and 40.2% in Lusaka. In Rwanda, neonatal mortality declined marginally from 20 per 1,000 live births in 2015 to 19 in 2020 a modest 5% reduction over five years (NISR, 2020). This slow progress indicates that current strategies are insufficient and require enhancement through evidence-based approaches. Best practices to reduce neonatal mortality include strengthening antenatal, intrapartum, and postnatal care, timely diagnosis, adequate staffing of skilled providers, access to essential supplies, and efficient referral systems (Tekelab, Melku, & Mossie, 2019; Kebaya, Mwaniki, & Mbugua, 2018). In Rwanda, rural healthcare facilities like Byumba Level Two Teaching Hospital are pivotal in providing neonatal care but often face limitations in resources and infrastructure. However, there is limited data on neonatal survival outcomes and contributing factors at this facility.

Understanding the determinants of neonatal survival is critical for designing context-specific interventions that improve outcomes. Despite ongoing national efforts, gaps remain in evidence on predictors of neonatal mortality in rural Rwandan settings, especially among hospitalized neonates. Prior studies have often generalized neonatal mortality without addressing survival status or the unique factors influencing it in rural hospitals. This study seeks to fill that gap by evaluating the survival outcomes of neonates admitted to the Neonatology Unit at Byumba Level Two Teaching Hospital, located in Gicumbi District, Northern Province. The hospital serves a predominantly rural population where access to neonatal services remains limited. By identifying survival rates and predictors of mortality among admitted neonates, the study aims to support targeted policy formulation, improve quality of care, and contribute to the national and global agenda for reducing neonatal mortality. The paper objectives are to determine the survival status of neonates admitted to the Neonatology Unit at Byumba Level Two Teaching Hospital, Gicumbi, Rwanda, and to identify independent predictors of neonatal mortality among admitted newborns.

2. Review of Literature

2.1 Empirical Literature

2.1.1 Survival Status of Neonates Admitted to Neonatology

The literature reveals significant regional disparities in neonatal survival, with survival probabilities varying widely across geographic locations. Globally, neonates in countries with the highest neonatal mortality rates are about fifty-six times less likely to survive the first month of life than those in countries with the lowest rates (Heuveline, 2022). Analysis of Demographic and Health Survey (DHS) data from Burundi found that 56.5% of neonates born with fetal distress died, compared to 49% without distress (Mugisha, 2025). Sub-Saharan Africa exhibits the highest neonatal mortality rate worldwide at 27 deaths per 1,000 live births, followed by regions such as South-East Asia and the Eastern Mediterranean with 24.3 and 26.6 deaths respectively (Grady et al., 2017; WHO, 2022). A systematic review by Bitew et al. (2020) reported an incidence rate of 24.53 neonatal deaths per 1,000 person-days in NICUs across Sub-Saharan Africa, with early neonatal mortality rates averaging 0.51 per 1,000 neonatal days and late neonatal mortality at 5.09 per 1,000 days. Similarly, a prospective study in eastern Ethiopia found that 20% of admitted neonates did not survive their neonatal period (Desalew et al., 2020). Abera et al. (2021) documented an 18.34% neonatal mortality rate in Wollega University Referral Hospital's NICU. Rwanda's neonatal mortality rate was estimated at 19 deaths per 1,000 live births in 2015, increasing to 23 per 1,000 in 2021 (NISR et al., 2020).

2.1.2 Predictors of Neonatal Survival Status

Several studies identify key predictors influencing neonatal survival. Timely initiation of breastfeeding is critical; neonates breastfed immediately after birth have a 2.44 times higher likelihood of survival (Ayalew et al., 2024). Conversely, delayed exclusive breastfeeding beyond one hour significantly reduces survival chances (AHR=3.572; 95% CI: 1.255–10.165). APGAR scores are also pivotal; neonates scoring 5 or above at five minutes post-delivery have thrice the odds of survival compared to those scoring below 5 (Reddy et al., 2023). Antenatal care (ANC) utilization improves survival probabilities substantially. Mothers adhering to recommended ANC visits demonstrate a 34% increased neonatal survival rate (HR=0.66; 95% CI: 0.54–0.80) (Doku & Neupane, 2017). Prolonged hospital stays beyond five days' correlate with reduced neonatal mortality risk (AOR=0.23; 95% CI: 0.08–0.66) (Tekelab et al., 2019). Urban birth locations confer a survival advantage, with neonates born in urban settings twice as likely to survive compared to rural-born counterparts; home births increase mortality risk by 3.3 times relative to institutional deliveries (Norris et al., 2022).

Maternal factors also influence outcomes: neonates born to mothers with fewer than five pregnancies have a 75% higher survival chance compared to those from mothers with higher parity (Khurmi et al., 2017). Advanced maternal age (≥35 years) triples the risk of adverse neonatal outcomes (Schummers et al., 2018). Multiple births carry elevated mortality risks; twins and triplets have higher mortality than singletons, with survival improving with gestational age (Esteves-Pereira et al., 2021). Short interpregnancy intervals are linked to increased neonatal mortality (Yilak et al., 2024). Clinical complications remain dominant drivers of neonatal mortality. Birth asphyxia, prematurity, low birth weight, and infections significantly decrease survival rates (Ali et al., 2024). In Nepal, verbal autopsies highlighted sepsis (47%), birth asphyxia (16.6%), preterm birth (13.3%), and low birth weight (5%) as leading causes of neonatal death (Erchick et al., 2022). In Northern Ethiopia, infections accounted for 35% of late neonatal deaths, with hypoxia and prematurity contributing 23% each. Other causes included birth defects, meconium aspiration syndrome, respiratory distress, and birth hypoxia (Tasew et al., 2018; Urubuto et al., 2021). Hypothermia markedly reduces survival, with neonates exhibiting low body temperature having 2.6 to 3 times lower survival probabilities than normothermic infants (Tasew et al., 2018; Urubuto et al., 2021). Maternal conditions such as pregnancy-induced hypertension and diabetes also increase neonatal mortality risk fivefold and nearly fivefold respectively, while HIV-positive mothers' neonates face a sixfold increased risk (Getaneh et al., 2020; Dessu et al., 2020). Conversely, Kangaroo Mother Care and early exclusive breastfeeding significantly improve survival outcomes (Dessu et al., 2020). Maternal complications such as placental and umbilical cord issues, pregnancy-related disorders, and other underlying medical conditions also contribute substantially to neonatal mortality (Nelson et al., 2021). These findings underscore the multifactorial nature of neonatal survival determinants and highlight critical intervention points to improve neonatal outcomes globally and regionally.

2.2 Theoretical Framework

Health belief model, developed in the 1950s by Rosenstock and colleagues, is a psychological framework used to understand and predict health-related behaviors. It focuses on individuals' perceptions of susceptibility to illness, severity of the condition, benefits of preventive actions, and barriers to taking those actions (Champion & Skinner, 2018). When individuals perceive high risk and serious consequences, and believe that the benefits of action outweigh the barriers, they are more likely to engage in health-promoting behaviors. Cues to action, such as health reminders, and self-efficacy, the confidence to perform actions influence behavior change (Glanz, Rimer, & Viswanath, 2018). Albert Bandura's social cognitive theory complements HBM by emphasizing the interaction of personal, behavioral, and environmental factors. SCT highlights self-efficacy and observational learning, where individuals adopt behaviors by observing others (Islam et al., 2021). In neonatal care, SCT supports empowering caregivers through education and role modeling, improving practices like early breastfeeding and thermal care (Khan et al., 2021). This study primarily uses HBM to understand caregivers' and health workers' behaviors affecting neonatal survival. By addressing perceived risks, benefits, barriers, and enhancing self-efficacy, interventions can effectively promote practices that reduce neonatal mortality in Rwanda.

2.3 Conceptual Framework

Figure 2.1 illustrates the conceptual framework guiding this study, with neonatal survival as the dependent variable. It identifies four key independent variable categories influencing neonatal outcomes: sociodemographic factors, obstetric and gynecological conditions, neonate healthcare factors, and maternal medical conditions. Maternal age, education, and residence affect healthcare access, while obstetric factors include antenatal visits and delivery complications. Neonatal factors involve birth weight and infections, and maternal conditions cover hypertension and diabetes. Neonatal mortality prevention policies act as mediators, shaping how these factors impact survival by promoting essential newborn care and clinical practices. This framework supports analyzing the complex interactions affecting neonatal survival.

Independent variable

1. **Sociodemographic Predictors**
   - i. Maternal age
   - ii. Maternal education
   - iii. Residence (urban vs. rural)
   - iv. Access to healthcare services
   - v. Place of delivery (home vs. health facility)
   - vi. Gestational age at birth
   - vii. Birth weight

2. **Obstetric and Gynecological Predictors**
   - i. Parity (number of previous births)
   - ii. Multiple birth (twins, triplets, etc.)
   - iii. Number of antenatal care (ANC) visits
   - iv. Prolonged labor
   - v. Premature rupture of membranes (PROM)
   - vi. Onset of labor (spontaneous or induced)
   - vii. Administration of antenatal steroids
   - viii. Mode of delivery (vaginal, cesarean, etc.)
   - ix. HIV status
   - x. Hypertensive disorders during pregnancy
   - xi. Maternal anemia
   - xii. Diabetes mellitus
   - xiii. Sexually transmitted infections (STIs)
   - xiv. Other pre-existing medical conditions

3. **Neonatal Condition Predictors**
   - i. Gestational age at admission
   - ii. Age at admission
   - iii. Gender of the newborn
   - iv. Birth weight
   - v. Primary cause(s) of admission
   - vi. Breastfeeding initiation within 1 hour
   - vii. Use of Kangaroo Mother Care (KMC)
   - viii. Postnatal care received
   - ix. Complications during hospital stay:
     - a. Newborn hypoglycemia
     - b. Neonatal sepsis or infection
     - c. Respiratory distress
     - d. Neonatal anemia
     - e. Neonatal jaundice
   - x. Length of hospital stay
   - xi. Cause of mortality (if applicable)
   - xii. Time of death (early vs. late neonatal period)

Dependent variable

Neonatal Survival

Intervening or Mediating variables

Policy of preventing and reducing neonatal mortality

3 Research Methodology

This study employed a prospective cohort design with a quantitative approach to investigate factors influencing neonatal survival among neonates admitted to the neonatal ward at Byumba Level Two Teaching Hospital in Gicumbi District, Rwanda. Conducted from May to October 2024, the prospective cohort design allowed real-time data collection and enabled the assessment of temporal relationships between exposures (e.g., medical conditions, interventions) and neonatal survival outcomes (Nasa et al., 2021). This approach provided in-depth insights into how risk factors affected neonates over the critical first 28 days of life. Byumba Level Two Teaching Hospital, established in 1947, is one of Rwanda's oldest hospitals, situated 62 kilometers from Kigali and serving mainly an agrarian population in a temperate climate. With a capacity of 249 beds and a staff of 278, it is a key healthcare provider in the Northern Province.

The study population included all neonates admitted to the neonatal unit within the first 28 days of life during the study period. A total sample size of 385 neonates was determined using Epi Info's population proportion formula, based on critical predictors such as APGAR scores, hypothermia, breastfeeding initiation time, antenatal care attendance, and birth weight (Dessu et al., 2018; Limaso et al., 2020; Tolossa et al., 2022). Systematic sampling was used to select participants to minimize bias and ensure representativeness. Data collection utilized an adapted structured questionnaire developed from literature and the WHO Verbal Autopsy checklist (WHO, 2022). Information on socio-demographic, maternal, obstetric, and neonatal factors was gathered. Mothers were interviewed at admission, and neonates underwent daily clinical assessments for up to 28 days. Follow-up continued post-discharge via phone calls or home visits by Community Health Workers to confirm survival status. Data collectors received training to ensure quality and consistency, with cross-checking for accuracy throughout the process.

Reliability of the instrument was confirmed with a Cronbach's Alpha of 0.72, indicating acceptable internal consistency (Zohrabi et al., 2013). Content validity was established through expert review, yielding a content validity index of 0.8. A pilot study involving 15% of the sample further validated the questionnaire, resulting in a reliability coefficient of 0.86. Data were coded, cleaned, and entered into Epi-Data, then analyzed using SPSS version 28. Initial data checks included frequency distributions and cross-tabulations. Survival analysis employed Kaplan-Meier curves to estimate neonatal survival probabilities, while differences across categorical variables were tested using the log-rank test. The Cox Proportional Hazards Regression Model identified factors associated with survival time, with proportional hazards assumptions verified via log-minus-log plots and global tests. Both crude and adjusted hazard ratios with 95% confidence intervals were reported, considering p-values <0.05 statistically significant. Ethical approval was obtained from Mount Kenya University's Ethical Review Board, and authorization for data collection was granted by Byumba Level Two Teaching Hospital. Informed consent was sought from mothers after explaining study objectives, risks, and benefits. Participants' confidentiality and voluntary participation were emphasized, with data securely managed to protect privacy. Measures were taken to minimize risks and ensure ethical conduct throughout the research process.

4 Presentation of Findings

4.1 Socio-Demographic Characteristics

Details concerning the socio-demographic characteristics of study participants among neonates are displayed in the Table 4.1 below:

Table 4. 1: Socio-Demographic of Participants

Variable	Frequency	Percentage
Gender		
Male	228	59.2
Female	157	40.8
Total	385	100.0
Age		
Below 19	8	2.1
19-24	77	20.0
25-29	205	53.2
30-34	58	15.1
Above and equal to 35	37	9.6
Total	385	100.0
Education Level		
None	4	1.0
Primary	50	13.0
Secondary	189	49.1
University	142	36.9
Total	385	100.0
Residence		
Rural	283	73.5
Urban	102	26.5
Total	385	100.0
Place of Delivery		
Home	5	1.3
Health Post	14	3.6
Health Center	130	33.8
Ambulance	29	7.5
Hospital	207	53.8
Total	385	100.0
Age at Admission		
7 days and low	362	94.0
Above 7 days	23	6.0
Total	385	100.0
Gestation age		
Premature birth	238	61.8
Normal term birth	147	38.2
Total	385	100.0
Birth weight		
Low birth weight	230	59.7
Normal weight	155	40.3
Total	385	100.0
Gestational Age of newborn		
Below 32 weeks (Very preterm)	46	11.9
32-36 weeks (Preterm)	180	46.8
37-42 weeks (Term)	135	35.1
(Above 42 weeks (Post term)	24	6.2
Total	385	100.0

Table 4.1 presents demographic details for 385 neonates and their mothers. Males comprised 59.2% (228) of the neonates, while females represented 40.8% (157). Most mothers were aged 25–29 (53.2%), followed by 19–24 (20%), 30–34 (15.1%), 35+ (9.6%), and under 19 (2.1%). Education levels showed 49.1% had secondary, 36.9% university, 13% primary, and 1% no education. Rural residents dominated (73.5%). Birth locations included hospitals (53.8%), health centers (33.8%), ambulances (7.5%), health posts (3.6%), and homes (1.3%). Most neonates (94%) were admitted within one week. Notably, 59.7% had low birth weight, and 61.8% were preterm.

4.2 Presentation of Findings

4.2 Presentation of Findings: Findings were presented using figures and tables, showing survival outcomes and key predictors of neonatal mortality among admitted newborns.

4.2.1 The Survival Status of Neonates

This information was illustrated through Figures 4.1, 4.2, and 4.3, as well as Tables 4.2 and 4.3, which collectively present the survival outcomes of the admitted neonates.

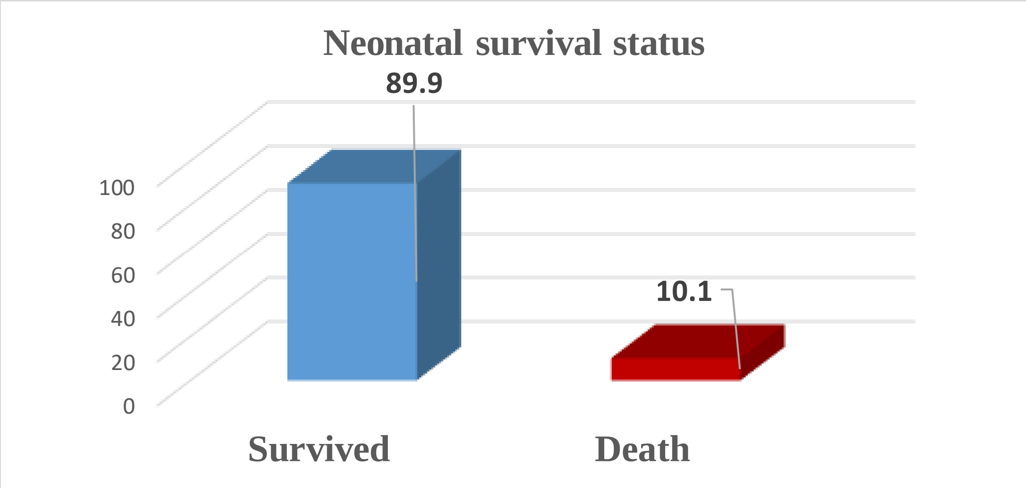

Figure 4. 1: Survival status of neonates admitted in neonatology of Byumba

Figure 4.2 illustrates neonatal survival outcomes at Byumba Level Two Teaching Hospital, showing an 89.9% survival rate and 10.1% mortality. Kaplan-Meier analysis revealed higher neonatal survival among those whose mothers received adequate antenatal care (ANC), highlighting its importance.

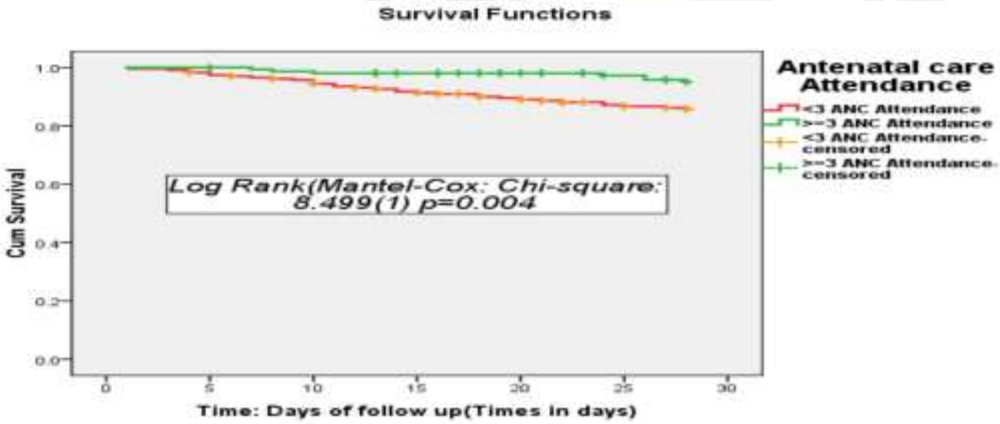

Figure 4. 2: Survival status among neonates admitted to neonatology modeled by ANC

Figure 4.3 reveals that maternal attendance of three or more ANC visits significantly improves neonatal survival. The Kaplan-Meier curve shows higher survival probabilities in this group. The log-rank test (χ^2 = 8.499, p = 0.004) confirms statistical significance.

Table 4.2: Mean Estimate of Test of Equality of Survival Distribution Among Neonates Admitted to Neonatology

Variable	Mean estimate	95%CI		Chi-square(df)	P-value
Antenatal care		Lower	Upper	8.499(1)	0.004
< 3ANC attendance	25.978	25.228	26.728		
>=3 ANC Attendance	26.599	27.071	28.028		

Table 4.2 presents mean survival estimates based on antenatal care (ANC) attendance among neonates admitted to Byumba Level Two Teaching Hospital. A chi-square value of 8.499 (df=1, p=0.004) indicates a statistically significant difference in survival times. Neonates whose mothers attended three or more ANC visits had a higher mean survival estimate (26.599; 95% CI: 27.071–28.028) compared to those with fewer than three visits (25.978; 95% CI: 25.228–26.728), Additionally, a Kaplan-Meier plot assessed how neonatal infection levels influenced survival outcomes. This analysis revealed that higher infection severity corresponded with lower survival probabilities, emphasizing the critical impact of infections on neonatal mortality in the study setting.

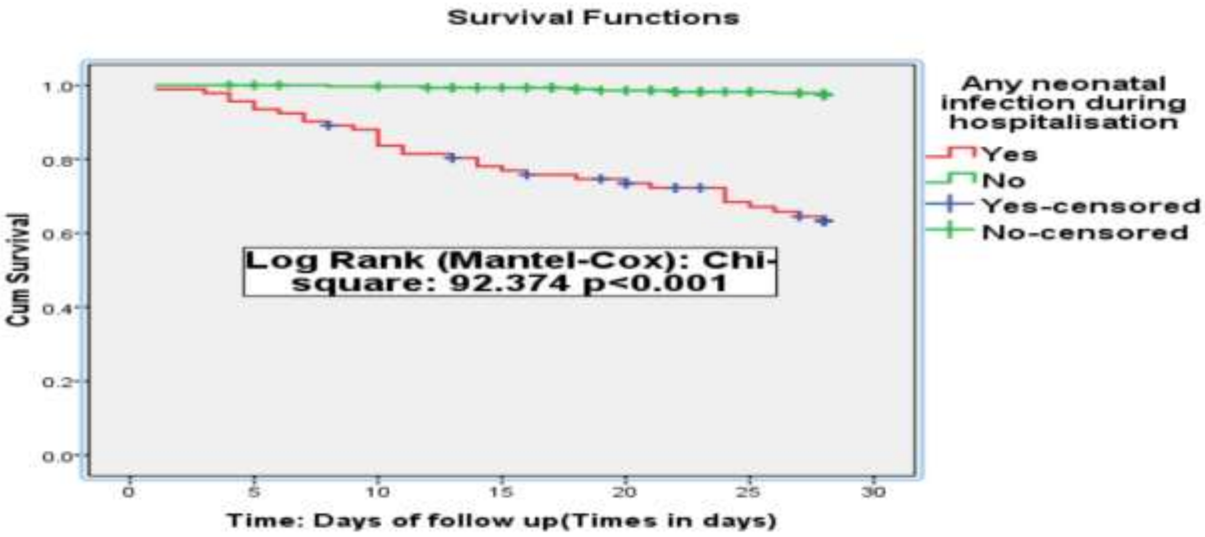

Figure 4.3: Survival Status Among Neonates Admitted To Neonatology Modeled By Neonatal Infection

Figure 4.3 illustrates the impact of neonatal infections on survival outcomes. The Kaplan-Meier survival curves reveal that neonates without infections maintained significantly higher survival probabilities across the 30-day period, while those with infections showed a steep decline in survival. The survival curve for non-infected neonates remained near 1.0, indicating better outcomes. A log-rank test confirmed this difference as statistically significant (Chi-square = 92.374, p < 0.001), underscoring infection as a critical determinant of neonatal mortality.

Table 4.3: Mean Estimate of Test of Equality of Survival Distribution Between Presence and Non-Presence of Infection Among Neonates Admitted to Neonatology

Variable	Mean estimate	95%CI		Chi-square(df)	P-value
Neonatal infection		Lower	Upper	92.374(1)	<0.001
Yes	22.834	21.091	24.567		
No	27.777	27.559	28.995		

Table 4.3 presents the mean survival estimates for neonates based on infection status. A significant difference in survival distributions was observed, with a chi-square value of 92.374 (df = 1) and a p-value < 0.001. Neonates without infection had a higher mean survival estimate of 27.777 days (95% CI: 27.559–28.995), compared to 22.834 days (95% CI: 21.091–24.567) for infected neonates, confirming infection's adverse impact on neonatal survival.

4.2.2 Predictors of the Neonatal Mortality Among Neonates

The second objective of the study focused on identifying key predictors of neonatal survival among infants admitted to the neonatology unit at Byumba Level Two Teaching Hospital in Gicumbi District, Rwanda. Tables 4.4 through 4.7 systematically present these predictors, offering a comprehensive analysis of the variables contributing to neonatal mortality. These findings help highlight the most influential clinical and demographic factors affecting newborn survival within the hospital setting.

Table 4.4: Bivariate Analysis of Socio-Demographic Factors Linked with Neonatal Deaths Among Neonates

Variable	Factors associated with Neonatal mortality			P-value
	Survived (%)	**Death n (%)**	**Total (%)**	
Level of Education				**0.002**
None	2(0.5)	2(0.5)	4(1.0)	
Primary	41(10.6)	9(2.3)	50(13.0)	
Secondary	168(43.6)	21(5.5)	189(49.1)	
University	135(35.1)	7(1.8)	142(36.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
Residence				0.372
Rural	252(65.5)	31(8.1)	283(73.5)	
Urban	94(24.4)	8(2.1)	102(26.5)	
Total	346(89.9)	39(10.1)	385(100.0)	
Age				**0.006**

Below 19	8(2.1)	0(0.0)	8(2.1)	
19-24	73(19.0)	4(1.0)	77(20.0)	
25-29	189(49.1)	16(4.2)	205(53.2)	
30-34	46(11.9)	12(3.1)	58(15.1)	
35 and above	30(7.8)	7(1.8)	37(9.6)	
Total	346(89.9)	39(10.1)	385(100.0)	
Place of Delivery				0.783
Home	5(1.3)	0(0.0)	5(1.3)	
Health Post	13(3.4)	1(0.3)	14(3.6)	
Health Center	119(30.9)	11(2.9)	130(33.8)	
Ambulance	25(6.5)	4(1.0)	29(7.5)	
Hospital	184(47.8)	23(6.0%)	207(53.8)	
Total	346(89.9)	39(10.1)	385(100.0)	

Table 4.4 presents the bivariate analysis examining the relationship between sociodemographic factors and neonatal mortality among infants admitted to Byumba Level Two Teaching Hospital. The analysis indicates statistically significant associations between neonatal death and both maternal education level ($p = 0.002$) and maternal age ($p = 0.006$). Mothers with secondary education comprised 49.1% of the sample, and those aged 25–29 represented 53.2%. However, no significant relationship was found between neonatal mortality and either the mother's place of residence ($p = 0.372$) or the location of delivery ($p = 0.783$).

Table 4.5: Bivariate analysis of ANC and neonatal factors linked with Neonatal

Variable	Factors associated with Neonatal mortality			P-value
	Survived (%)	**Death n (%)**	**Total n (%)**	
Antibiotic for prophylaxis for PROM				0.432
Yes	120(31.2)	16(4.2)	136(35.3)	
No	226(58.7)	23(6.0)	249(64.7)	
Total	346(89.9)	39(10.1)	385(100.0)	
Steroids during pregnancy				**<0.001**
Yes	106(27.6)	8(2.1)	114(29.7)	
No	134(34.9)	6(1.6)	140(36.5)	
Na	106(27.6)	24(6.2)	130(33.9)	
Total	346(90.1)	38(9.9)	384(100.0)	
Any comorbidities				**<0.001**
Yes	296(76.9)	24(6.2)	320(83.1)	
No	50(13.0)	15(3.9)	65(16.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
Temperature at admission				**<0.001**
36.5-37.5	214(55.6)	11(2.9)	225(58.4)	
Above 37.5	90(23.4)	18(4.7)	108(28.1)	
Below 36.5	42(10.9)	10(2.6)	52(13.5)	
Total	346(89.9)	39(10.1)	385(100.0)	
Causes of Neonatal admission				0.535
Birth Asphyxia	3(0.8)	2(0.5)	5(1.3)	
Congenital Malformation	7(1.8)	1(0.3)	8(2.1)	
Early ONS	13(3.4)	1(0.3)	14(3.6)	
Hypoglycemia	2(0.5)	0(0.0)	2(0.5)	
Infection risk	19(4.9)	2(0.5)	21(5.5)	
LBW	22(5.7)	3(0.8)	25(6.5)	
Late ONS	4(1.0)	0(0.0)	4(1.0)	
Neonatal Jaundice	4(1.0)	1(0.3)	5(1.3)	
Others*(Hep inf, anaemia and	2(0.5)	0(0.0)	2(0.5)	
Pneumonia	6(1.6)	0(0.0)	6(1.6)	
Prematurity	220(57.1)	21(5.5)	241(62.6)	
RVI Exposed	4(1.0)	0(0.0)	4(1.0)	
Respiratory distress syndrome	24(6.2)	3(0.8)	27(7.0)	
Severe Birth Trauma	5(1.3)	2(0.5)	7(1.8)	

VLBW	11(2.9)	3(0.8)	14(3.6)	
Total	346(89.9)	39(10.1)	385(100.0)	
Respiratory support				**0.008**
Yes	199(51.7)	31(8.1)	230(59.7)	
No	147(38.2)	8(2.1)	155(40.3)	
Total	346(89.9)	39(10.1)	385(100.0)	
Any neonatal infection during hospitalization				**<0.001**
Yes	60(15.6)	32(8.3)	92(23.9)	
No	286(74.3)	7(1.8)	293(76.1)	
Total	346(89.9)	39(10.1)	385(100.0)	
Time of antibiotics				**<0.001**
Yes	177(46.0)	4(1.0)	181(47.0)	
No	169(43.9)	35(9.1)	204(53.0)	
Total	346(89.9)	39(10.1)	385(100.0)	
Discharge				**<0.001**
Cured	340(88.3)	3(0.8)	343(89.1)	
Dead	0(0.0)	36(9.4)	36(9.4)	
Other	6(1.6)	0(0.0)	6(1.6)	
Total	346(89.9)	39(10.1)	385(100.0)	
Length of stay in hospital				0.268
>5 days	276(71.7)	34(8.8)	310(80.5)	
<5 days	70(18.2)	5(1.3)	75(19.5)	
Total	346(89.9)	39(10.1)	385(100.0)	
Causes of neonatal mortality				**<0.001**
None	346(89.9)	0(0.0)	346(89.9)	
Birth Asphyxia	0(0.0)	1(0.3)	1(0.3)	
Brain damage	0(0.0)	1(0.3)	1(0.3)	
Congenital Malformation	0(0.0)	1(0.3)	1(0.3)	
Heart failure	0(0.0)	1(0.3)	1(0.3)	
Hypoglycemia	0(0.0)	1(0.3)	1(0.3)	
Infection	0(0.0)	8(2.1)	8(2.1)	
Neonatal Jaundice	0(0.0)	2(0.5)	2(0.5)	
Prematurity	0(0.0)	9(2.3)	9(2.3)	
Respiratory distress	0(0.0)	3(0,8)	3(0,8)	
Sepsis	0(0.0)	3(0,8)	3(0,8)	
Unknown	0(0.0)	3(0,8)	3(0,8)	
heart failure	0(0.0)	2(0.5)	2(0.5)	
heat failure	0(0.0)	1(0.3)	1(0.3)	
hypoglycaemia	0(0.0)	1(0.3)	1(0.3)	
jaundice	0(0.0)	1(0.3)	1(0.3)	
unspecified	0(0.0)	1(0.3)	1(0.3)	
Total	346(89.9)	39(10.1)	385(100.0)	
ANC				**0.004**
<3 ANC Attendance	201(52.2)	32(8.3)	233(60.5)	
>=3 ANC Attendance	145(37.7)	7(1.8)	152(39.5)	
Total	346(89.9)	39(10.1)	385(100.0)	

Table 4.5 presents a bivariate analysis exploring the relationship between antenatal care, clinical variables, and neonatal mortality at Byumba Level Two Teaching Hospital. Significant associations were found with steroid administration during pregnancy ($p < 0.001$), maternal comorbidities ($p < 0.001$), high temperature at neonatal admission ($p < 0.001$), neonatal infections ($p < 0.001$), delayed antibiotic initiation ($p < 0.001$), respiratory support need ($p = 0.008$), and antenatal care attendance ($p = 0.004$). However, no significant links were observed with PROM prophylaxis ($p = 0.432$), cause of admission ($p = 0.535$), or hospital stay length ($p = 0.268$), emphasizing the importance of timely clinical interventions.

Table 4.6: Bivariate analysis of Obstetrical, maternal and fetal factors linked with Neonatal deaths

Variable	Factors associated with Neonatal mortality			P-value
	Survived (%)	Death n (%)	Total (%)	
Parity				**0.010**
Primiparous	103(26.8)	4(1.0)	107(27.8)	
Multiparous	243(63.1)	35(9.1)	278(72.2)	
Total	346(89.9)	39(10.1)	385(100.0)	
Mode of delivery				0.059
Normal(svd)	87(22.6)	9(2.3)	96(24.9)	
Assisted	89(23.1)	4(1.0)	93(24.2)	
Cesarean	170(44.2)	26(6.8)	196(50.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
APGAR at 1st Minute				0.117
Above 5	133(34.5)	10(2.6)	143(37.1)	
Below 5	213(55.3)	29(7.5)	242(62.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
APGAR at 5th				**<0.001**
Above 5	296(76.9)	21(5.5)	317(82.3)	
Below 5	50(13.0)	18(4.7)	68(17.7)	
Total	346(89.9)	39(10.1)	385(100.0)	
Multiple Birth				**<0.001**
Yes	41(10.6)	23(6.0)	64(16.6)	
No	305(79.2)	16(4.2)	321(83.4)	
Total	346(89.9)	39(10.1)	385(100.0)	
Gestation age				0.115
More than 42 weeks	36(9.4)	2(0.5)	38(9.9)	
Between 37 and 42 weeks	102(26.5)	7(1.8)	109(28.3)	
Between 34 and 36 weeks	152(39.5)	19(4.9)	171(44.4)	
Between 28 and 33 weeks	48(12.5)	8(2.1)	56(14.5)	
Less than 28 weeks	8(2.1)	3(0.8)	11(2.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
Presence of Prolonged Rupture of Membrane				**<0.001**
Yes	109(28.3)	31(8.1)	140(36.4)	
No	237(61.6)	8(2.1)	245(63.6)	
Total	346(89.9)	39(10.1)	385(100.0)	
Labor Onset				0.663
Spontaneous	185(48.1)	20(5.2)	205(53.2)	
Induced	9(2.3)	0(0.0)	9(2.3)	
C/Section before onset	138(35.8)	18(4.7)	156(40.5)	
Unknown	14(3.6)	1(0.3)	15(3.9)	
Total	346(89.9)	39(10.1)	385(100.0)	
Gestational Age of newborn				0.150
Extremely preterm (under 32 weeks)	45(11.7)	1(0.3)	46(11.9)	
Preterm (32-36 weeks)	163(42.3)	17(4.4)	180(46.8)	
Full term (37 to 42 weeks)	118(30.6)	17(4.4)	135(35.1)	
Post-term (over 42 weeks)	20(5.2)	4(1.0)	24(6.2)	
Total	346(89.9)	39(10.1)	385(100.0)	
Age at Admission				**0.009**
7 days and low	329(85.5)	33(8.6)	362(94.0)	
Above 7 days	17(4.4)	6(1.6)	23(6.0)	
Total	346(89.9)	39(10.1)	385(100.0)	
Weight				0.334

>4500 mg	101(26.2)	15(3.9)	116(30.1)	
2500-4500 mg	34(8.8)	5(1.3)	39(10.1)	
<2500 mg	211(54.8)	19(4.9)	230(59.7)	
Total	346(89.9)	39(10.1)	385(100.0)	
Gender				**0.015**
Male	212(55.1)	16(4.2)	228(59.2)	
Female	134(34.8)	23(6.0)	157(40.8)	
Total	346(89.9)	39(10.1)	385(100.0)	
Resuscitation at birth				0.061
Yes	167(43.4)	25(6.5)	192(49.9)	
No	179(46.5)	14(3.6)	193(50.1)	
Total	346(89.9)	39(10.1)	385(100.0)	
Breastfeed within 1 hour				**<0.001**
Yes	239(62.1)	14(3.6)	253(65.7)	
No	107(27.8)	25(6.5)	132(34.3)	
Total	346(89.9)	39(10.1)	385(100.0)	
PNA				0.104
Yes	131(34.0)	20(5.2)	151(39.2)	
No	215(55.8)	19(4.9)	234(60.8)	
Total	346(89.9)	39(10.1)	385(100.0)	
Kangaroo Mother Care				0.256
Yes	91(23.6)	7(1.8)	98(25.5)	
No	255(66.2)	32(8.3)	287(74.5)	
Total	346(89.9)	39(10.1)	385(100.0)	
Gestation age 1=Prematurity 2=Normal				**0.041**
Premature birth	208(54.0)	30(7.8)	238(61.8)	
Normal term birth	138(35.8)	9(2.3)	147(38.2)	
Total	346(89.9)	39(10.1)	385(100.0)	
Birth weight				0.139
Low birth weight	211(54.8)	19(4.9)	230(59.7)	
Normal weight	135(35.1)	20(5.2)	155(40.3)	
Total	346(89.9)	39(10.1)	385(100.0)	

Table 4.6 displays bivariate analysis of obstetric, maternal, and fetal factors associated with neonatal mortality at Byumba Level Two Teaching Hospital. Significant factors included parity (p = 0.010), with higher deaths among multiparous mothers (9.1%) than first-timers (1.0%); prolonged rupture of membranes (p < 0.001) linked to increased mortality (8.1%); multiple births (p < 0.001); low five-minute APGAR scores (p < 0.001); delayed breastfeeding initiation (p < 0.001); prematurity (p = 0.041); neonatal gender (p = 0.015); and admission age (p = 0.009). Mode of delivery, birth weight, and resuscitation were not statistically significant but showed mortality trends.

Table 4.7: Multivariate Cox Regression Analysis of Predictors of Neonatal Deaths Among Newborn Admitted to Neonatology of Byumba Level Two Teaching Hospital, Gicumbi, Rwanda

Variable	CHR	95%CI	P value	AHR	95%CI	P value
Gender						
Male	**1***					
Female	2.193	1.159-4.152	0.01	-	-	-
Education Level						
No education	13.039	2.702-62.922	**0.001**	19.329	3.033-123.196	**0.002**
Primary level	3.975	1.480-10.675	**0.006**	4.365	1.481-12.865	**0.008**
Secondary level	2.333	0.992-5.488	0.052	4.347	1.741-10.855	**0.002**
University	1*					
ANC Attendance						
>=3 ANC visit	1*					
<3 ANC visit	3.160	1.395-7.159	**0.006**	3.576	1.456-8.780	**0.005**
Parity						

Primiparous	1*					
Multiparous	2.744	0.972-7.742	**0.049**	0.187	0.056-0.625	**0.006**
APGAR 1st Minute						
Above 5	1*					
Below 5	2.800	1.276-6.144	**0.01**	4.251	1.627-11.110	**0.003**
APGAR 5th Minute						
Above 5	1*					
Below 5	4.400	2.343-8.261	**<0.001**	-	-	-
Multiple Birth						
No	1*					
Yes	9.379	4.881-18.024	**<0.001**	3.264	1.587-6.714	**0.001**
Resuscitation at birth						
No	1*					
Yes	8.745	4.615-16.570	**<0.001**	2.527	1.209-5.281	**0.014**
Kangaroo Mother Care						
Yes	1*					
No	1.231	0.702-3.321	**0.02**	0.395	0.162-.960	**0.040**
Respiratory support						
No	1*					
Yes	2.790	1.282-6.070	**.010**	2.548	1.109-5.854	**0.028**
Neonatal infection during hospitalization						
No	1*					
Yes	18.158	8.005-41.190	**<0.001**	16.306	6.801-39.094	**<0.001**
Birth weight						
Normal	1*					
Low	1.712	0.904-3.241	**0.01**	0.325	0.141-0.750	**0.008**
Gestation age						
Term Birth	1*					
Premature birth	1.470	1.045-2.069	**0.027**	-	-	-
PROM						
No	1*					
Yes	7.290	3.350-15.863	**<0.001**	-	-	-
Any comorbidities						
No	1*					
Yes	3.311	1.736-6.313	**<0.001**	-	-	-
Age at Admission						
>7 days	1*					
<=7 days	2.942	1.233-7.021	**0.01**	-	-	-
Breastfeed within 1hr						
Yes	1*					
No	3.827	1.988-7.365	**<0.001**	-	-	-
If the antibiotics started on time						
Yes	1*					
No	8.473	3.011-23.844	**<0.001**	-	-	-

The Cox regression analysis in Table 7 identified key predictors of neonatal mortality. In bivariate analysis, female neonates had a higher crude hazard ratio (CHR = 2.193; 95% CI: 1.159–4.152; p = 0.01) than males, but this was not significant in multivariate analysis. Maternal education was strongly protective: mothers without formal education had the highest adjusted hazard ratio (AHR = 19.329; 95% CI: 3.033–123.196; p = 0.002), with decreasing risk for primary and secondary education compared to university education. Fewer than three ANC visits increased mortality risk (AHR = 3.576; p = 0.005). Low APGAR scores, multiple births, resuscitation, respiratory support, and absence of Kangaroo Mother Care also predicted higher mortality. Neonatal infection was the strongest predictor (AHR = 16.306; p < 0.001), while low birth weight reduced survival (AHR = 0.325; p = 0.008).

5 Discussion of Findings

5.1 Demographic Characteristics of Respondents

This study found a higher proportion of male neonates admitted (59.2%) compared to females (40.8%), consistent with findings from the University Teaching Hospital of Kigali (57%) (Uwiringiyimana et al., 2021) and Ethiopia (60.5%) (Tewabe et al., 2021). The male predominance is often attributed to greater biological vulnerability, including susceptibility to respiratory distress and infections (Lawn et al., 2014). Conversely, a Nigerian study showed a more balanced gender ratio with a slight male predominance (Ekwochi et al., 2018), highlighting regional variation. Over half of the neonates (53.8%) were born in hospitals, reflecting good institutional delivery uptake, although deliveries in ambulances (7.5%) and at home (1.3%) indicate persisting access challenges. This pattern mirrors Rwanda's ongoing improvements in maternal health infrastructure (Tuyisenge et al., 2020) but contrasts with rural Uganda and Nepal, where home births remain prevalent (Waiswa et al., 2015; Khanal et al., 2014). Notably, 94% of neonates were admitted within the first week, emphasizing the critical nature of early neonatal complications such as birth asphyxia and sepsis (Mwaniki et al., 2017; Worku & Ayele, 2019). High prematurity (61.8%) and low birth weight (59.7%) rates were observed, consistent with other regional studies (Mukamurigo et al., 2020; Mmbaga et al., 2016), underscoring the need for targeted antenatal and maternal care interventions.

5.2 Survival Status of Neonates

The neonatal mortality rate (NMR) of 10.1% at Byumba Level Two Teaching Hospital reflects a relatively effective neonatal care system, comparable to Kigali's CHUK (11.3%) and lower than Muhima District Hospital (12.5%) (Uwiringiyimana et al., 2021; Mukamurigo et al., 2020). These rates suggest successful early detection, management, and referral protocols within Rwanda's healthcare framework. In contrast, higher mortality rates in Uganda (19.1%) and Tanzania (21.3%) highlight disparities often related to limited neonatal care access and higher perinatal risks (Waiswa et al., 2015; Mmbaga et al., 2016). India (15.2%) and Ethiopia (17%) also report higher NMRs, indicating that Rwanda's decentralized health system may enhance survival outcomes (Kumar et al., 2018; Tewabe et al., 2021). While higher than global averages (WHO, 2022), this mortality rate aligns with expectations for hospitalized neonates, reinforcing the importance of skilled birth attendance and essential newborn care.

5.3 Predictors of Neonatal Mortality

Low APGAR scores at one minute were linked to a 4.25-fold increased mortality risk, corroborating Nigerian (Udo et al., 2021) and Nepali (Karki et al., 2020) findings. This underscores the vital importance of immediate neonatal assessment and resuscitation in resource-limited settings. Kangaroo Mother Care (KMC) was protective; neonates receiving KMC had better survival, consistent with Bangladeshi and South African studies showing KMC's mortality reduction benefits through thermoregulation and breastfeeding support (Haider et al., 2021; Bergh et al., 2017). Neonatal infection was the strongest mortality predictor (AHR = 16.306), mirroring evidence from Pakistan and Ethiopia emphasizing the critical role of infection control and timely treatment (Zaidi et al., 2019; Mekonnen et al., 2020). Low birth weight also significantly increased mortality risk, echoing Kenyan and Brazilian research linking low birth weight to poor neonatal outcomes (Wanjala et al., 2021; Leal et al., 2019). These findings collectively highlight the necessity of strengthening maternal nutrition, prenatal care, skilled delivery, infection prevention, and immediate postnatal interventions to improve neonatal survival in Rwanda and similar contexts.

6 Conclusions and Recommendations

The study concluded that neonatal survival at Byumba Level Two Teaching Hospital is relatively high, with an overall survival rate of 89.9%. However, key factors significantly influencing neonatal mortality included low APGAR scores at one minute, absence of Kangaroo Mother Care (KMC), neonatal infections, and low birth weight. These findings highlight the critical importance of timely, quality neonatal care, especially during the first week of life, when most admissions occur. To reduce neonatal deaths further in Rwanda, infection prevention must be strengthened, KMC widely promoted, delivery services enhanced, and early identification and management of at-risk neonates ensured.

Recommendations: Ministry of Health should integrate comprehensive antenatal care to detect risks early and facilitate referrals, strengthen community awareness to promote facility-based deliveries and timely neonatal care. Byumba Level Two Teaching Hospital should provide continuous training on neonatal resuscitation and early risk detection, especially for low APGAR and low birth weight neonates, eeinforce KMC implementation to improve outcomes for premature and underweight infants, prioritize infection prevention, early diagnosis, and prompt treatment within the neonatology unit. Further research should target late-onset neonatal infections, evaluate infection control effectiveness, assess maternal health education impact, and extend studies to multiple Rwandan hospitals for broader insights.

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