Prevalence and factors associated with neonatal mortality at masaka district hospital, Rwanda: a cross-sectional study

Arlette Nzeyimana[1,*], Amanuel Kidane Andegirogish[1]

[1]*School of Health Sciences, Mount Kenya University, Kigali, Rwanda*

ABASTRACT

INTRODUCTION: Neonatal mortality remains a pressing global concern, with millions of infants losing their lives each year. However, there was a lack of specific information regarding the prevalence of neonatal mortality and associated factors at Masaka District Hospital (DH). This study aimed to determine neonatal mortality prevalence and associated factors at Masaka DH.

METHODS: A cross-sectional study among 385 neonates using structured observational checklist for data collection. A multivariable logistic regression analysis was used to assess the independent factors associated with neonatal mortality.

RESULTS: Of 385 (54% male and 46% female) neonates, 41 (10.6%) died. The major causes of admission were prematurity 28.5% followed by infection 19.9% and perinatal asphyxia 17.6%. Major causes of death were prematurity accounting for 43.9% and perinatal asphyxia at 29.3%. After adjustment, Apgar Score at 5- and 10-minutes (AOR: 16.37, 95% CI: 5.90-45.40, p-value<0.001), (AOR: 3.55, 95% CI: 0.98-12.79, p-value = 0.032) respectively, gestational age AOR: 0.08, 95% CI: 0.02-0.26), p-value <0.001), Birth weight (AOR:127.01, 95% CI:27.93-577.46), p-value<0.001) were significantly associated with neonatal mortality. Maternal conditions did not show a significant association after adjusting for other variables AOR:2.04 ,95% CI:0.55-7.49, p-value 0.282. Neonates born to mothers who attended antenatal care had significantly lower odds of mortality compared to those whose mothers did not attend (AOR: 0.35, CI: 95% CI: 0.13-0.90, p-value =0. 030).

CONCLUSION: Low birth weight, low Apgar scores, prematurity, lack of antenatal care visit were significantly associated with neonatal mortality at Masaka DH.

***Corresponding author:**
Arlette Nzeyimana
Email: nzeyimanaarlette5@gmail.com
Department of Public Health, School of Health Sciences, Mount Kenya University, Kigali, Rwanda

Received: August 19, 2024
Accepted: September 20, 2024
Published: September 24, 2024

Cite this article as: Nzeyimana et al. Prevalence and factors associated with neonatal mortality at masaka district hospital, Rwanda: a cross-sectional study *Rw. Public Health Bul. 2024. 5 (3): 44-54. https://dx.doi.org/10.4314/rphb.v5i3.6*

INTRODUCTION

Neonatal mortality remains a pressing global concern, with 2.6 millions of infants losing their lives each year [1]. Tragically, a significant portion of these deaths occurs within the first day of life, contributing to the alarming statistics. Despite progress in reducing mortality rates for older children, neonatal deaths persist at an alarming rate of 7,000 per day [2,3]. These deaths are primarily due to complications like prematurity, perinatal asphyxia, and various infections. To address this ongoing crisis, a comprehensive and systematic approach is required, as single interventions often

fall short [2].
The postnatal period widely recognized as the most critical in a person's life when it comes to disease. However, many of these diseases are preventable with proper measures, such as immunization, hygiene, and proper nutrition [4]. During the initial day of life, a newborn faces a significantly higher risk of mortality compared to the rest of the neonatal period. Around half of all neonatal deaths occur within this critical 24-hour timeframe, and a staggering 75% of deaths happen within the first week. Moreover, infants born into economically disadvantaged households are more than 1.4 times susceptible to mortality within the first 28 days compared to those born into wealthier families [5].
Rwanda has achieved significant progress in reducing child mortality rates in the last decades. Specifically, the country has reduced neonatal deaths from 37 to 20 per 1000 births and under-5 deaths from 152 to 50/1000 live births between 2005 and 2015 [4] .Despite attempts to reduce child mortality in Rwanda, the rates still differ greatly across the country, much like in other areas of Sub-Saharan Africa that lack resources [5]. In Rwanda, the mortality rate for children is largely linked to poverty, with 84 out of every 1000 live births in the poorest wealth quintile compared to 40 out of every 1000 in the wealthiest quintile. Additionally, maternal education plays a role with 89 out of every 1000 children born to mothers without an education passing away compared to 43 out of every 1000 children born to women with secondary education or higher. Lastly, residence also plays a factor with rural areas having a mortality rates of 70 out of every 1000 live births compared to 51 out every 1000 live birth in urban areas [6].
The disease patterns and outcomes in neonates are crucial indicators for planning appropriate healthcare to improve nursing and medical care [7]. The rates of neonatal morbidity and mortality are useful indicators of the efficiency and effectiveness of the healthcare delivery system. Therefore, this study aimed to determine neonatal mortality prevalence and associated factors at Masaka District Hospital (DH).

METHODS

Research design

This study used a cross-sectional research design which involved collecting data at a specific point in time to all neonates admitted at Masaka DH from 1st January to 31st December 2021.

Setting

The study was carried out at Masaka District Hospital, situated in the Masaka neighborhood within Kigali, the capital and largest city of Rwanda. Positioned approximately 17 kilometers (11 miles) to the East of Kigali's Central Business District, the hospital serves as a crucial healthcare facility in this urban setting.

Population, sample size and sampling techniques

The target population consisted of 1318 neonates who were admitted to Neonatal Ward during from 1st January 2021 to 31st December 2021. The sample size for this study was 385 neonates. The desired sample size was determined by using Cochran's formula [8].

$$n = z^2pq / d^2$$

Where: n: is the required sample size, z: The Z score, which corresponds to the desired level of confidence (95% confidence corresponds to a Z-score of approximately 1.96), p: the estimated proportion of the population that has the attribute for studying (0.5 can be used for a conservative estimate, assuming a 50-50 split) ,q: the complement of p, which is equal to 1-p and d: the desired margin of error, which represents how much willing to allow the estimate to vary (0.05 for a 5% margin of error).
$n = (1.96^{\wedge 2} *0.5*0.5) / (0.05^{\wedge 2}) = 384.16$
Therefore, rounding up to the nearest whole number, the estimated sample size using the Cochran's formula was approximately 385.
A systematic random sampling technique was employed to select neonates from the study population of 1318, ensuring each participant had an equal opportunity for inclusion. The sampling interval, calculated by dividing the total population (1318) by the sample size (385), was approximately 3.43. To initiate the sampling process, a random start point was chosen by selecting a neonate at random from the first three neonates.

Data collection instruments and procedures

An observational structured checklist was employed as the primary data collection instrument. It consisted of predefined categories, variables, and items that the observers assessed and recorded during their observations. The checklist covered essential factors related to neonatal mortality, including birth weight, gestational age, mode of delivery, place of delivery, diagnosis to admission time, congenital abnormality, Apgar scores, maternal age, antenatal care visits, gravida, maternal health conditions and neonatal death(yes/no). A representative sample of neonates was randomly selected from the hospital's records, ensuring equal chances of inclusion for all neonates. A team of trained observers made direct observations of the selected neonates, systematically recording relevant information using the observational structured checklist. The observers received comprehensive training on the checklist tool, ethical considerations, and data collection techniques. Their followed a standardized protocol and maintained ongoing communication with the researcher to address any challenges and ensure adherence to the study guidelines. The collected data was carefully recorded and subjected to quality control measures to ensure accuracy and consistency.

Data analysis

The data, were first entered in Excel where they were coded and cleaned. Then, the data were exported and analyzed in SPSS Statistics software version 22 and presented in tables. Frequencies and percentages as well as chi-square test ($p<0.05$) were used to determine the association between neonatal mortality and the independent variables. Multivariable logistic regression was performed to adjust for confounding variables and to determine independent variables. All variables with $p<0.05$ in bivariate analysis were treated together in multiple logistic regression analysis. The strength of association was determined using adjusted odds ratio and 95% confidence intervals (CI).

Ethical considerations

Ethical clearance with reference number 780/MSK/DH/2023, was received for this study from Masaka Ethical Review Board. Throughout the study, strict measures were implemented to ensure the confidentiality and privacy of all participants. Data were securely stored and accessible only to authorized personnel. Additionally, strict protocols were in place to maintain the anonymity of participants, with all data anonymized to protect the identities of individuals involved.

RESULTS

Socio-demographic characteristics

In a study of 385 neonates, key findings include a slightly higher percentage of males (54%) compared to females (46%). The majority of neonates were full-term (64.4%), with 35.6% being preterm. Normal birth weight was predominant (58.2%), while 41.8% had low birth weight. Apgar scores indicated good neonatal vitality, with scores of 80% at 1 minute, 84.7% at 5 minutes, and 94.3% at 10 minutes. Congenital abnormalities were rare, affecting only 1.8% of neonates. Most deliveries occurred in hospitals (71.7%), with 41% delivered by Cesarean Section and 59% via spontaneous vaginal delivery. Maternal characteristics showed that 69.1% of mothers were aged 14-29 years, 66.2% were married, and 65.7% had primary education. Details on these findings are further elaborated in Table 1.

Causes of admission

As shown in Table 2, Prematurity emerges as the leading cause, constituting 28.5% of admissions, followed closely by perinatal asphyxia, accounting for 17.6%. Neonatal jaundice is another significant contributor, representing 17.4% of case. Infections, contributing to 19.9% of admissions. Congenital malformations are relatively infrequent, comprising 2.1% of admissions. Hyperthermia, hypoglycemia, and respiratory distress syndrome collectively contribute to the diverse array of factors leading to neonatal admissions (2.6%, 3.4%, and 8.3% respectively) (Table 2)

Causes of neonatal mortality

The result revealed that the primary causes of neonatal mortality in the analyzed population were dominated by prematurity, accounting for 43.9% of deaths, followed by perinatal asphyxia at 29.3%. Infections contribute significantly to mortality at 19.5%, while congenital malformations and respiratory distress syndrome play comparatively smaller roles at 4.9% and 2.4%, respectively (Table 2).

Prevalence of neonatal mortality

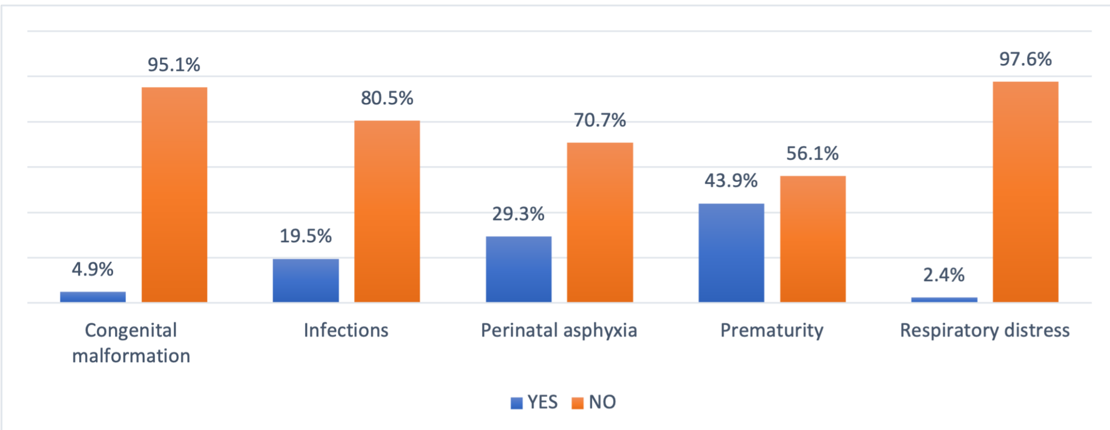
The study at Masaka District Hospital in 2021 found that the overall prevalence of neonatal mortality among 385 neonates was 10.6%, indicating that approximately 1 in 10 neonates did not survive. Key findings highlighted that maternal education, prenatal care, and neonatal factors like

Table 1: *Demographic and Clinical Characteristics of neonates admitted in Masaka DH*

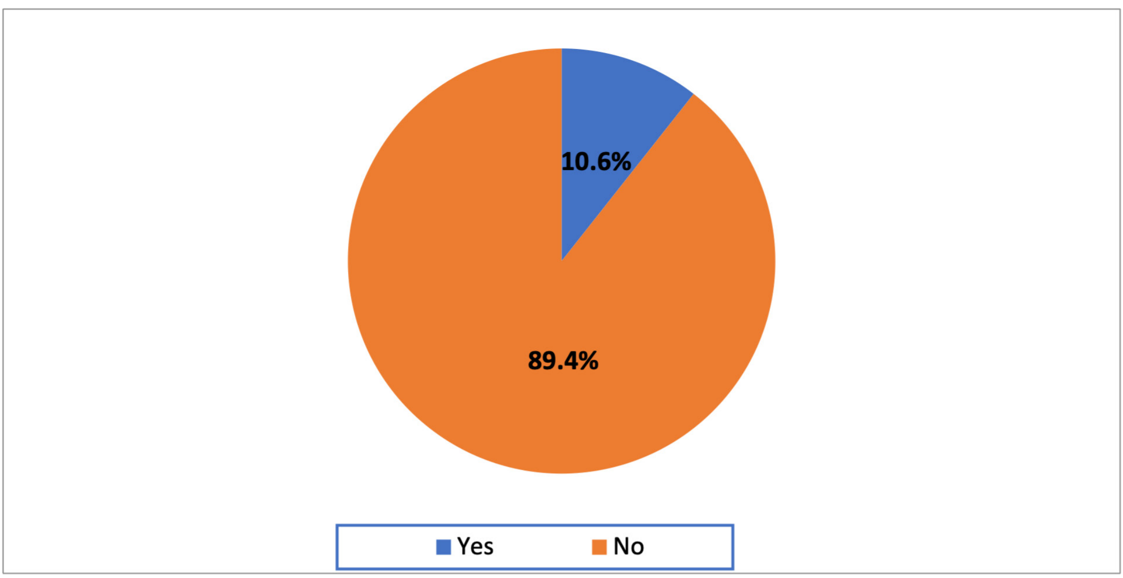
Variables		**Frequency**	**Percentage**
Neonatal Gender	Male	208	54.0
	Female	177	46.0
Gestational Age	Preterm (>=37 weeks)	137	35.6
	Full-term	248	64.4
Birth weight	Low birth weight	161	41.8
	Normal	224	58.2
Apgar Score (1 min)	Good Vitality (>=7)	307	80.0
	Poor Vitality (<7)	78	20.0
Apgar Score (5 min)	Good Vitality (>=7)	326	84.7
	Poor Vitality (<7)	59	15.3
Apgar Score (10 min)	Good Vitality (>=7)	363	94.3
	Poor Vitality (<7)	22	5.7
Congenital abnormalities	Yes	7	1.8
	No	378	98.2
Place of delivery	Health center	109	28.3
	Hospital	276	71.3
Mode of delivery	Caesarian Section	158	41.0
	Spontaneous Vaginal delivery	227	59.0
Maternal age	14-29	266	69.1
	30-45	119	30.9
Mother's marital status	Single	130	33.8
	Married	255	66.2
Educational Level	Primary	253	65.7
	Secondary and above	132	34.3
Occupation Status	Unemployed	134	34.8
	Employed	251	65.2
Insured	Yes	376	97.7
	No	9	2.3
Residence	Urban	297	77.1
	Rural	88	22.9
Antenatal Visit	Yes	313	81.3
	No	72	18.7
Maternal Conditions	Abnormal	26	6.8
	Normal	359	93.2
Gravidity	First	167	43.4
	Multi	218	56.6

Table 2: *Causes of Admissions to the Neonatal Ward*

Causes of Admission		Percentage
Perinatal asphyxia	68	17.6
Prematurity		28.5
Congenital malformation	8	2.1
Jaundice	67	17.4
Infection	77	19.9
Hyperthermia	10	2.6
Hypoglycemia	13	3.4
Respiratory distress syndrome	32	8.3



Figures 1: *Causes of neonatal mortality*



Figures 2: *Prevalence of the mortality*

Table 3: *Prevalence of neonatal mortality at Masaka DH*

Variables		**Neonatal Deaths**	
		Frequency	**%**
Marital status	Single	13	3.37
	Married	28	7.27
Educational Level	Primary	24	6.23
	Secondary and above	17	4.41
Maternal Conditions	Normal	34	8.83
	Abnormal	7	1.81
Antenatal Visit	Yes	28	7.27
	No	13	3.37
Gravidity	First	18	4.67
	Mulity	23	5.97
Maternal age	14-29	27	7.01
	30-45	14	3.63
Occupation Status	Unemployed	15	3.89
	Employed	26	6.75
Insured	Yes	40	10.38
	No	1	0.25
Residence	Urban	34	8.83
	Rural	7	1.81
Neonatal Gender	Male	22	5.71
	Female	19	4.93
Gestational Age	Preterm	23	5.97
	Full-term	18	4.67
Place of delivery	Heath center	13	3.37
	Hospital	28	7.27
Congenital abnormalities	Yes	1	0.27
	No	40	10.38
Mode of delivery	Cesarian Section	20	5.19
	Vaginal delivery	21	5.45
Birth Weight	Low birthweight	36	9.35
	Normal	5	1.29
Apgar Score (1min)	Poor vitality	13	3.37
	Good vitality	28	7.27
Apgar Score (5min)	Poor vitality	25	6.49
	Good vitality	16	4.15
Apgar Score (10min)	Poor vitality	11	2.85
	Good vitality	11	2.85

gestational age and birth weight significantly influenced mortality rates. Neonates born to mothers with primary education, those who did not attend antenatal care, preterm infants, and those with low birth weight had notably higher mortality rates. Additional details on these and other factors

Table 4: *Bivariate explorations of neonatal, socio-economic and maternal variables to predict neonatal mortality.*

Variables		Yes (%)	No (%)	Chi-square	P-Value
Marital status	Married	28(7.27)	227(58.9)	0.087	0.768
	Single	13(3.37)	117(30.38)		
Educational Level	Secondary and above	17(4.41)	115(29.87)	1.049	0.306
	Primary	24(6.23)	229(59.48)		
Antenatal Visit	Yes	28(7.27)	285(74.02)	5.105	0.024
	No	13(3.37)	59(15.32)		
Gravidity	First	18(4.67)	149(38.70)	0.005	0.943
	Mulity	23(5.97)	195(50.64)		
Maternal age	14-29	27(7.01)	223(57.92)	0.014	0.907
	30-45	14(3.63)	121(31.42)		
Occupation status	Employed	26(6.75)	225(58.44)	0.064	0.800
	Unemployed	15(3.89)	119(30.90)		
Neonatal gender	Female	19(4.93)	155(40.25)	1.091	0.296
	Male	22(5.71)	189(49.09)		
Maternal conditions	Normal	34(8.83)	320(83.11)	5.044	0.025
	Abnormal	7(1.81)	24(6.23)		
		34(8.83)	263(68.31)	0.871	0.351
Residence	Urban	7(1.81)	81(21.03)		
	Rural	18(4.67)	230(59.74)	8.185	0.004
		23(5.97)	114(29.61)		
Gestational age	Full-term	28(7.27)	248(64.41)	0.261	0.610
	Preterm	13(3.37)	96(24.93)		
Place of delivery	Hospital	21(5.45)	206(53.50)	1.137	0.286
	Health center	20(5.19)	138(35.84)		
Mode of delivery	Vaginal				
	Cesarian section				
Apgar score (1min)	Good vitality	28(7.27)	279(72.46)	3.722	0.054
	Poor vitality	13(3.37)	65(16.88)		
Apgar score(5min)	Good vitality	16(4.15)	310(80.51)	73.695	<0.001
	Poor vitality	25(6.49)	34(8.83)		
Apgar score(10min)	Good vitality	11(2.85)	333(86.49)	37.972	<0.001
	Poor vitality	11(2.85)	30(7.79)		
Birth Weight	Normal	5(1.29)	219(56.88)	39.884	<0.001
	Low birth weight	36(9.35)	125(32.46)		

are provided in Table 3.

Factors associated with neonatal mortality at Masaka DH

The Bivariate analysis identified key factors associated with neonatal mortality. Antenatal care was particularly significant, with mothers who attended antenatal visits showing a lower neonatal mortality rate ($\chi^2 = 5.105$, $p = 0.024$). Maternal health conditions also had a significant impact, with neonates born to mothers with health issues showing higher mortality rates ($\chi^2 = 5.044$, $p = 0.025$). Preterm birth and low birth weight were major risk factors, with preterm infants and those with low birth weight exhibiting significantly higher mortality rates (gestational age: $\chi^2 = 8.185$, $p = 0.004$; birth weight: $\chi^2 = 39.884$, $p < 0.001$).

Additionally, the Apgar scores at 5- and 10-minutes post-birth were strongly associated with neonatal mortality, with lower scores correlating with higher mortality (Apgar score at 5 minutes: $\chi^2 = 73.695$, $p < 0.001$; Apgar score at 10 minutes: $\chi^2 = 37.972$, $p < 0.001$). In contrast, factors such as marital status, educational level, gravidity, maternal age, occupation status, neonatal gender, and residence did not show significant associations with neonatal mortality (Table 4).

The multivariate analysis revealed significant associations between neonatal mortality and several key factors. The Apgar score, a critical measure of newborn health, showed strong associations at both the 5-minute and 10-minute marks. Infants with poor vitality at 5 minutes had significantly higher odds of mortality (AOR = 16.37, 95% CI: 5.90-45.40, $p < 0.001$), and this risk remained elevated for those with poor vitality at 10 minutes (AOR = 3.55, 95% CI: 0.98-12.79, $p = 0.032$).

Antenatal care (ANC) visits were identified as a protective factor, with mothers who did not attend ANC being 2.857 times more likely to experience neonatal mortality compared to those who received care (AOR = 2.85, 95% CI: 1.10-7.36, $p = 0.030$). This finding underscores the critical role of maternal healthcare during pregnancy in improving neonatal survival rates.

Low birth weight and preterm birth were also strongly associated with increased neonatal mortality. Infants with low birth weight had significantly higher odds of mortality (AOR = 127.01, 95% CI: 27.93-577.46, $p < 0.001$), and preterm infants were at a notably higher risk of death compared to full-term infants (AOR = 0.08, 95% CI: 0.02-0.26, $p < 0.001$). However, maternal conditions did not show a significant association with neonatal mortality in this analysis (AOR = 2.04, 95% CI: 0.55-7.49, $p = 0.282$) (Table 5).

Table 5: *Multivariate logistic regression output for neonatal and maternal variables*

Variables	COR	AOR (CI at 95%)	p-value
Apgar Score			
At 5min			
Good Vitality	1*		
Poor vitality	14.24(6.93-29.28)	16.37(5.90-45.40)	<0.001
At 10min			
Good vitality	1*		
Poor vitality	11.10(4.44-27.72)	3.55(1.98-12.79)	0.032
Antenatal Care Visit			
Yes	1*		
No	2.24(1.09-4.58)	2.85(1.10-7.36)	0.030
Gestational Age			
Full-term	1*		
Preterm	2.54(1.32-4.90)	0.08(0.02-0.26)	<0.001

**Reference category; COR: Crude odds ratio; AOR: Adjudted odds ratios*

DISCUSSION

The study intended to address two specific objectives of the prevalence of neonatal mortality and the associated factors with it at Masaka DH. The findings revealed that the prevalence of neonatal mortality among the 385 neonates in the sample was notably high at 10.6%. This indicates that approximately 1 in 10 neonates experienced mortality, emphasizing the importance of understanding and addressing the determinants of neonatal health. Despite being conducted within a single hospital, this prevalence was higher than the national rate in Rwanda, which was 29.7 deaths per 1,000 live births [9]. The difference in prevalence could be attributed to variations in sample size and study context.

The study's prevalence was also higher compared to findings from other African countries such as Nigeria and Afghanistan, with 32 and 14 early neonatal deaths per 1,000 live births, respectively [10]. This discrepancy highlights the need for localized interventions and the potential impact of hospital-specific factors, such as quality of care and available resources.

Regarding factors associated with neonatal mortality, several key insights were identified. Firstly, the Apgar score, a fundamental measure of newborn health, demonstrated significant associations at both the 5-minute and 10-minute marks. Infants with poor vitality at 5 minutes exhibited notably higher odds of mortality compared to those with good vitality, underscoring the critical importance of immediate assessment and intervention to address newborn health issues post-birth. This finding aligns with studies conducted in India, Saudi Arabia, Bangladesh, and Washington, which indicated that a poor Apgar score at 5 minutes had a strong effect on the risk of neonatal mortality [5]. The implication is clear: immediate postnatal care and resuscitation efforts should be prioritized to improve Apgar scores and reduce mortality.

Secondly, the study highlighted the protective effect of antenatal care (ANC) visits against neonatal mortality. Infants whose mothers received ANC had significantly lower odds of mortality compared to those whose mothers did not receive ANC. This finding is consistent with other studies [11]. Both bivariate and multivariate analyses revealed that the more often a woman attends an ANC for routine checkups, the less the neonatal mortality, aligning with previous research indicating that even one antenatal visit reduces the risk of neonatal mortality by 39% in Sub-Saharan Africa [12]. The implication is that increasing access to and utilization of ANC services is crucial in reducing neonatal mortality rates.

The study also revealed significant associations between gestational age, birth weight, and neonatal mortality, findings that resonate with global research [13]. Preterm infants were found to have substantially higher odds of mortality compared to full-term infants, highlighting the critical role of gestational age in neonatal outcomes. This aligns with studies from diverse regions, including Nairobi, where similar associations were reported. Additionally, infants with low birth weight faced significantly increased odds of mortality compared to those with normal birth weight, underscoring the vulnerability of low-birth-weight infants. This finding is consistent with research conducted in Nigeria, Indonesia, and Brazil, suggesting that low birth weight is a significant risk factor for neonatal mortality globally [13,[14]. The implication is that interventions aimed at preventing preterm births and improving birth weights, such as maternal nutrition and prenatal care, should be prioritized.

Gender differences were also observed, with the risk of neonatal mortality being lower for female infants compared to male infants. This finding is consistent with a previous study in Uganda [15]. Studies conducted in India and Pakistan also confirmed that neonatal mortality risks were higher among male infants than their female counterparts [16]. This may be due to biological differences, with female neonates having a stronger immune system due to genetic differences. Newborn girls have a biological advantage in survival over newborn boys [17], implicating that understanding these gender-based differences can help tailor interventions and resource allocation to those most at risk.

Despite the absence of statistically significant associations with certain variables, such as maternal conditions, age, and occupation, the study acknowledges the potential presence of complex interdependencies among these factors, warranting further exploration. This recognition emphasizes the need for nuanced, multidimensional approaches in understanding the intricate web of determinants influencing neonatal mortality. The implication is that future research should delve deeper into maternal factors and their indirect effects on neonatal outcomes.

Lastly, the analysis highlighted the predominant causes of neonatal admissions, with infections, respiratory distress syndrome (RDS), jaundice, and perinatal asphyxia collectively contributing to over 60% of admissions. This substantial proportion emphasizes the urgency for targeted interventions addressing these primary causes. The implication is that efforts to reduce neonatal mortality should prioritize strategies aimed at preventing and managing these prevalent conditions, thereby contributing to improved overall neonatal health outcomes.

The study faced some limitations that should be noted. The findings of the study are limited in their applicability and may only be pertinent to Masaka DH, lacking generalizability to other healthcare facilities or regions with distinct healthcare systems, infrastructure, and patient populations. The nature of a cross-sectional study restricts the verification of cause-effect relationships. Notably, the presentation of socioeconomic status, encompassing household income and food security, as predominant risk factors associated with neonatal mortality in developing nations, particularly in Africa, was absent from the study.

It is crucial to acknowledge that this study was confined to documented cases, potentially resulting in an underrepresentation of neonatal deaths occurring outside the specified region.

CONCLUSION

Low birth weight, low Apgar scores, prematurity, lack of antenatal care visit were significantly associated with neonatal mortality at Masaka. Healththcare providers should focus on early identification and monitoring of risk factors through routine screenings and follow standardized management protocols for preterm and low birth weight infants, providing education to expectant mothers about the importance of antenatal care and the risks associated with these conditions is essential. Health policymakers should develop and implement policies that ensure access to quality antenatal care, allocate resources to enhance maternal and neonatal health services, and conduct public health campaigns to raise awareness about the importance of antenatal care. Public health organizations can support this effort by organizing training programs for healthcare providers, supporting research on maternal and neonatal health, and engaging communities to promote awareness. Lastly, non-governmental organizations (NGOs) and advocacy groups should provide support services to pregnant women, advocate for improved maternal health policies, and collaborate with various stakeholders to enhance healthcare programs and initiatives. By addressing these areas, a comprehensive strategy can be developed to reduce neonatal mortality and improve outcomes for at-risk pregnancies.

REFERENCES

[1] G. J. Chan et al., “Estimates of Stillbirths, Neonatal Mortality, and Medically Vulnerable Live Births in Amhara, Ethiopia,” JAMA Netw. Open, vol. 5, no. 6, p. e2218534, Jun. 2022, doi: 10.1001/jamanetworkopen.2022.18534.

[2] D. Y. Ehret, J. K. Patterson, and C. L. Bose, “Improving Neonatal Care,” Clin. Perinatol., vol. 44, no. 3, pp. 567–582, Sep. 2017, doi: 10.1016/j.clp.2017.05.002.

[3] World Bank, “Despite remarkable progress, 15,000 children and 800 women still die every day mostly of preventable or treatable causes.” [Online]. Available: https://blogs.worldbank.org/en/opendata/despite-remarkable-progress-15000-children-and-800-women-still-die-every-day-mostly

[4] H. Magge et al., “The All Babies Count Initiative: Impact of a Health System Improvement Approach on Neonatal Care and Outcomes in Rwanda,” Glob. Health Sci. Pract., vol. 8, no. 3, p. 000.2-000, Sep. 2020, doi: 10.9745/GHSP-D-20-00031.

[5] D. You et al., “Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation,” The Lancet, vol. 386, no. 10010, pp. 2275–2286, Dec. 2015, doi: 10.1016/S0140-6736(15)00120-8.

[6] F. Chao, D. You, J. Pedersen, L. Hug, and L. Alkema, “National and regional under-5 mortality rate by economic status for low-income and middle-income countries: a systematic assessment,” Lancet Glob. Health, vol. 6, no. 5, pp. e535–e547, May 2018, doi: 10.1016/S2214-109X(18)30059-7.

[7] I. Wolfe et al., “Health services for children in western Europe,” The Lancet, vol. 381, no. 9873, pp. 1224–1234, Apr. 2013, doi: 10.1016/S0140-6736(12)62085-6.

[8] R. A. Robb, “G. Cochran, Sampling Techniques (John Wiley & Sons, 2nd edition, 1963), ix+413 pp., 72s.,” Proc. Edinb. Math. Soc., vol. 13,

no. 4, pp. 342–343, Dec. 1963, doi: 10.1017/S0013091500025724.
[9] NISR, "The 2019-20 Rwanda Demographic and Health Survey (RDHS)," 2020.
[10] L. Liu et al., "Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals," The Lancet, vol. 388, no. 10063, pp. 3027–3035, Dec. 2016, doi: 10.1016/S0140-6736(16)31593-8.
[11] H. F. Wolde, K. A. Gonete, T. Y. Akalu, A. G. Baraki, and A. M. Lakew, "Factors affecting neonatal mortality in the general population: evidence from the 2016 Ethiopian Demographic and Health Survey (EDHS)—multilevel analysis," BMC Res. Notes, vol. 12, no. 1, p. 610, Dec. 2019, doi: 10.1186/s13104-019-4668-3.
[12] T. Tekelab, C. Chojenta, R. Smith, and D. Loxton, "The impact of antenatal care on neonatal mortality in sub-Saharan Africa: A systematic review and meta-analysis," PLOS ONE, vol. 14, no. 9, p. e0222566, Sep. 2019, doi: 10.1371/journal.pone.0222566.
[13] T. Triggs, K. Crawford, J. Hong, V. Clifton, and S. Kumar, "The influence of birthweight on mortality and severe neonatal morbidity in late preterm and term infants: an Australian cohort study," Lancet Reg. Health - West. Pac., vol. 45, p. 101054, Apr. 2024, doi: 10.1016/j.lanwpc.2024.101054.
[14] H. Blencowe et al., "National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis," Lancet Glob. Health, vol. 7, no. 7, pp. e849–e860, Jul. 2019, doi: 10.1016/S2214-109X(18)30565-5.
[15] R. M. Kananura et al., "The neonatal mortality and its determinants in rural communities of Eastern Uganda," Reprod. Health, vol. 13, no. 1, p. 13, Dec. 2016, doi: 10.1186/s12978-016-0119-y.
[16] Z. H. Aghai et al., "Gender variations in neonatal and early infant mortality in India and Pakistan: a secondary analysis from the Global Network Maternal Newborn Health Registry," Reprod. Health, vol. 17, no. S3, p. 178, Dec. 2020, doi: 10.1186/s12978-020-01028-0.
[17] S. Subedi et al., "Does higher early neonatal mortality in boys reverse over the neonatal period? A pooled analysis from three trials of Nepal," BMJ Open, vol. 12, no. 5, p. e056112, May 2022, doi: 10.1136/bmjopen-2021-056112.