

Prevalence, Morphological Types, and Associated Factors of Neonatal Anemia at a Rural Referral Hospital, Uganda

Martha Amoding¹, Joachim Ndawula¹, Bright Hajusu¹, Isaac Morunyang¹, Christopher Lakwera¹, Robert Wagubi¹, Clinton Olong², Elizabeth A John³, Enoch Muwanguzi¹, Benson Okongo¹

¹Department of Medical Laboratory Science, Mbarara University of Science and Technology, Mbarara City, Uganda; ²Department of Pathology and Clinical Laboratories, Uganda Cancer Institute – Regional Cancer Centre, Gulu, Uganda; ³Department of Microbiology and Parasitology, University of Dodoma, Dodoma, Tanzania

Correspondence: Benson Okongo, Department of Medical Laboratory Science, Mbarara University of Science and Technology, P.O. BOX 1410, Mbarara City, Uganda, Tel +256 778 557 867, Fax +256-485-20782, Email bokongo@must.ac.ug

Purpose: This study aimed to determine the prevalence, morphological classification, and factors associated with anemia among neonates at Soroti Regional Referral Hospital neonatal unit.

Patients and Methods: We conducted a hospital-based cross-sectional study among 239 neonates between June and August 2025. Data on sociodemographic characteristics of neonates and mothers were collected using structured questionnaires and a review of medical records. Venous blood was collected from mothers during labor and cord blood was collected within 30 minutes of delivery or in situation where cord blood was not collected, then venous blood was collected from neonates. Hemoglobin estimation was done using a Nihon Kohden automated analyser. Neonates with umbilical cord hemoglobin <13 g/dL and mothers with venous blood haemoglobin <11 g/dL were classified as anemic. For anemic neonates, Giemsa-stained blood smears were examined to determine morphological type of anemia and screen for malaria parasites. Bivariate and multivariate logistic regression analysis were employed to identify factors associated with neonatal anemia, with a p-value ≤0.05 considered statistically significant.

Results: The median age for neonates in days was 1 day and ranged from 0 to 27 days. The prevalence of neonatal anemia was 11.7% (95% CI: 7.6–15.8). Normocytic normochromic anemia was the most frequent morphological type (78.6%), followed by normocytic hypochromic (10.7%) and microcytic hypochromic anemia (10.7%). Multivariate analysis identified four factors independently associated with neonatal anemia: maternal history of anemia (AOR: 5.39 [95% CI: 1.15–25.32], p=0.033), lack of iron-folate supplementation during pregnancy (AOR: 6.62 [95% CI: 2.23–19.7], p=0.001), infrequent consumption of fruits and vegetables (AOR: 6.52 [95% CI: 1.23–34.48], p=0.027), and the presence of maternal anemia at delivery (AOR: 5.48 [2.11–14.21], p<0.001).

Conclusion: This study confirms that neonatal anemia is a persistent health issue in eastern Uganda. The identified risk factors are primarily rooted in maternal health and nutrition. Our findings underscore the imperative for integrative antenatal strategies that combine nutritional education, promotion of iron-folate supplementation, and proactive management of maternal anemia to effectively reduce the burden of neonatal anemia.

Keywords: neonatal anemia, prevalence, morphological types, determinants, Uganda

Introduction

Neonatal anemia is a major, globally recognized public health problem associated with significant short- and long-term morbidity.¹ Annually, approximately 15 million infants are born preterm, with over 60% of these births occurring in Africa and South Asia. Preterm infants are particularly vulnerable to a range of health complications, including neonatal anemia.² Globally, an estimated 40% of neonates experience anemia at some point during the neonatal period, with a disproportionately high burden in developing countries where maternal health and nutrition are often suboptimal.³ For instance, in Afghanistan, a prevalence of 26.8% was reported, with higher rates observed among preterm and low-birth-weight infants.⁴

The prevalence of neonatal anemia across sub-Saharan Africa is notably high and variable, with reported rates ranging from 23% to 66%.⁵ A study in Gabon by Sugino and Horiuchi (2025) found an overall anemia prevalence of 52% among neonates, which increased sharply to 88.9% in infants aged 8 to 15 days.⁶ In Ethiopia, prevalence rates vary between 23.2% and 30.1%, as evidenced by studies from Jimma Medical Center (26.4%) and the University of Gondar (30.1% among hospitalized newborns).^{7,8} Similarly, high rates have been documented in Zambia (72.4%, with 2.5% classified as severe) and Cameroon (32.9%).^{9,10}

During gestation, hematopoiesis starts from the yolk sac, later liver, then bone marrow but at birth, it only happens in the bone marrow.¹¹ Hemoglobin level ranges between 14.9 g/dL and 23.7 g/dL at birth but rapidly falls to 9.5–11 g/dL by 9–11 weeks postnatal but most studies consider cord hemoglobin concentration < 13 g/dL for definition of anemia in neonates.¹¹

The etiology of neonatal anemia is multifactorial, with key contributors including maternal health status, gestational age, birth weight, and specific perinatal complications. According to results from a meta-analysis data and a study from Ethiopia, maternal anemia is a consistently significant risk factor for neonatal anemia among infants of anemic mothers.^{3,7} Gestational age is also critically important; preterm neonates exhibit markedly higher anemia rates (41.3%) compared to their term counterparts (23%).^{4,12} Further, contributing factors are obstetric complications, such as antepartum hemorrhage, and neonatal conditions like sepsis.^{4,12} The mode of delivery may also play a role, as caesarean sections have been associated with different iron exposure and higher neonatal morbidity compared to vaginal deliveries.^{13,14}

A broader health system and socio-economic factors exacerbate the risk. These include a lack of antenatal care, with one study noting that 10% of babies born to mothers without antenatal visits were anemic¹⁵ and significant intrapartum bleeding due to complications like placental abruption.¹⁶ In low-income settings, limited access to maternal healthcare, low rates of postnatal follow-up, delayed initiation of breastfeeding, and low birth weight further compound the problem.¹⁷

The consequences of neonatal anemia are profound, impacting both immediate health and long-term development. Short-term sequelae include respiratory distress, increased susceptibility to infections, fatigue, and poor feeding.¹⁸ If untreated, the condition can lead to lasting impairments, including cognitive delays, developmental challenges, and difficulties in learning and social interaction throughout childhood and into adulthood.³ Management of severe cases may require iron supplementation or blood transfusion, while prevention strategies fundamentally rely on good maternal nutrition, particularly adequate intake of iron and folic acid.^{19,20}

The significant mortality associated with neonatal anemia presents a considerable public health challenge, especially in resource-limited settings. In Uganda, for example, over 5% of neonatal deaths are attributed to anemia.²¹ Given the high burden and severe outcomes, there is a critical need for localized data to inform effective prevention and management strategies. Therefore, this study aimed to determine the prevalence, associated factors, and morphological classification of neonatal anemia at Soroti Regional Referral Hospital in Uganda.

Materials and Methods

Study Site

This study was conducted at Soroti Regional Referral Hospital (SRRH), a 274-bed public tertiary facility in Soroti City, Eastern Uganda (1°42'58.0"N, 33°36'47.0" E). SRRH serves as a referral center for a predominantly semi-urban and rural population across eight districts, providing comprehensive maternal and neonatal services. Its role as a central hub for complex cases, including documented instances of neonatal anemia, made it a pertinent site for this investigation.

Study Design

This was a cross-sectional study conducted to determine the prevalence of anemia and its associated factors among neonates at Soroti Regional Referral Hospital.

Study Population

The study population consisted of all neonates born and admitted at Soroti Regional Referral Hospital.

Inclusion Criteria

- All neonates born and admitted at SRRH

Exclusion Criteria

- Neonates with lethal congenital anomalies
- Jaundiced neonates

Sample Size Determination

The sample size was calculated using the Kish-Leslie (1965) single population proportion formula to estimate the prevalence of neonatal anemia. Assumptions made were the prevalence of neonatal anemia at 17%,²² critical value corresponding to 95% confidence interval (= 1.96) and margin of error at 5%.

Hence,

$$n=217$$

To compensate for potential participant attrition, the sample size was increased by 10%, yielding a final calculated sample size of 239 neonates.

Sampling Procedure

A consecutive sampling method was utilized, where every eligible neonates born and admitted to the maternity ward, neonatal intensive care unit, or postnatal clinic at SRRH were enrolled in the study. Recruitment continued until the final calculated sample size was attained.

Data Collection

Sociodemographic and clinical data were collected using a structured questionnaire, adapted from the WHO Maternal and Neonatal Health Survey Tool, and a review of neonatal medical records. Data captured included neonatal characteristics (sex, gestational age, birth weight), maternal socio-demographics (age, education, income), obstetric history (parity, mode of delivery, antenatal care, malaria/HIV status, mid-upper arm circumference), and maternal nutritional interventions (iron-folic acid supplementation, deworming).

Anthropometric and Clinical Measurements

Maternal nutritional status was assessed using mid-upper arm circumference (MUAC) and Body Mass Index (BMI). MUAC was measured with a non-stretchable tape, classifying mothers as undernourished (MUAC <23 cm) or adequately nourished (MUAC ≥23 cm). BMI was calculated from height and weight measured during the postpartum recovery period and categorized per World Health Organization (WHO) standards. For all 239 neonates, birth weight was measured using a calibrated digital scale, with the reported value representing the average of two measurements. Gestational age was determined primarily from the maternal last menstrual period (LMP), with the Ballard Score applied when the LMP was deemed unreliable.

Laboratory Procedures

Cord blood was collected from the umbilical cord vein for neonates within 30 minutes of delivery into EDTA coated microtainer tubes. In a situation where cord blood was not collected within the set time, then a venous blood sample was collected from neonates. A complete blood count was immediately performed using a Nihon Kohden analyzer (Nihon Kohden Corporation, Tokyo Japan).

Neonatal anemia was defined as cord blood or venous blood hemoglobin concentration <13 g/dL. For all anemic neonates, thin and thick blood smears were prepared, Giemsa-stained, and examined microscopically to characterize the anemia and screen for malaria parasites morphologically.

Venous blood samples were collected from mothers during labor and measured using a point-of-care hemoglobin machine (HemoCue) and the hemoglobin concentrations of < 11.0 g/dL was taken as anemic.

Quality Control

A multi-faceted quality assurance protocol was implemented to safeguard data integrity and analytical precision. All data collection instruments were piloted on a cohort of twelve neonates at Atatur Hospital to evaluate clarity, cultural appropriateness, and time requirements. Findings from this pilot phase informed subsequent refinements to the questionnaire and the standardization of anthropometric protocols for mid-upper arm circumference (MUAC) and body mass index (BMI).

To ensure analytical reliability, all laboratory equipment was calibrated daily, and control samples were run in strict adherence to standard operating procedures (SOPs) prior to processing study specimens. Research staff received comprehensive training on these SOPs for complete blood count (CBC) analysis, including practical demonstrations to confirm competency.

A systematic data management strategy was employed to minimize error. This included a double-data entry system, where all raw data were independently entered twice into Microsoft Excel and cross-verified for discrepancies. Furthermore, research responsibilities were strategically allocated between midwives and research assistants to optimize workflow and maintain strict adherence to the study protocol throughout the data collection period.

Data Analysis

Data management and analysis were conducted using Microsoft Excel and STATA version 16.0. All data underwent double-entry, completeness checks, and cleaning in Excel to ensure accuracy. The cleaned dataset was subsequently imported into STATA for statistical analysis. Shapiro–Wilk test was used to test for normality for continuous variables. Descriptive statistics were computed, with categorical variables summarized as frequencies and percentages and presented using pie charts and bar graphs. Continuous variables were presented as means with standard deviations or medians with interquartile ranges if they were normally distributed or not normally distributed respectively. To identify factors associated with neonatal anemia, bivariate logistic regression analysis model was developed and factors found associated as well as factors with p value <0.1 were adjusted for confounding effect at multivariate logistic regression analysis. The level of significance was a p -value of ≤ 0.05 .

Ethical Approval

Ethical approval for this study was obtained from the Faculty Research Committee (FRC), (MUST/MLS/25-015U), Faculty of Medicine of Mbarara University of Science and Technology. Prior to data collection, administrative clearance was secured from the management of Soroti Regional Referral Hospital. This study complied with the 1975 Declaration of Helsinki. Informed consent was obtained from all participants' mothers using forms translated into the local language. To ensure a comprehensive understanding, the consent procedure was supplemented with a detailed verbal explanation in the local language. The study adhered to the principle of voluntary participation, assuring all individuals that withdrawal would not affect their current or future medical care. All collected data were anonymized and stored securely, with access restricted to the principal investigators to guarantee confidentiality.

Results

Baseline Characteristics of the Study Participants (N=239)

The study enrolled 239 neonates with a median age of 1 day (IQR: 1–2 days). As summarized in [Table 1](#), most participants were male (50.6%), born at term (72.8%), and had a birth weight ≥ 2500 grams (82.0%). The vast majority were delivered in a hospital setting (94.6%) and via vaginal delivery (66.5%).

Maternal Sociodemographic and Clinical Characteristics

The median maternal age was 25 years (IQR: 21–29). As detailed in [Table 2](#), most mothers were married (84.9%), had attained a primary level of education (48.5%), and self-identified as peasant farmers (55.7%). The majority resided in rural areas (64.9%), were multiparous (62.8%), and had attended antenatal care (90.4%).

Table 1 Baseline Characteristics of the Study Participants (N=239)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	121	50.6
	Female	118	49.4
Gestational age	Preterm	23	9.6
	Term	174	72.8
	Post term	42	17.6
Birth weight	<2500 grams	43	18.0
	≥2500 grams	196	82.0
Place of delivery	Home	2	0.8
	Health Centre	11	4.6
	Hospital	226	94.6
Mode of delivery	Vaginal	159	66.5
	Assisted vaginal	15	6.3
	Caesarean	65	27.2

Table 2 Maternal Sociodemographic and Clinical Characteristics

Variable	Category	Frequency (n)	Percentage (%)
Maternal age (years)	≤24	119	49.8
	25–29	72	30.1
	≥30	48	20.1
Maternal marital status	Married	202	84.9
	Single	35	14.7
	Separated	1	0.4
Education level	No formal education	12	5.0
	Primary	116	48.5
	Secondary	96	40.2
	Tertiary	15	6.3
Occupation	Unemployed	56	23.4
	Peasant farmer	133	55.7
	Professional	23	9.6
	Self employed	27	11.3
Place of residence	Rural	155	64.9
	Urban	84	35.1
Parity	Primiparous	89	37.2
	Multiparous	150	62.8
ANC attendance	Yes	216	90.4
	No	23	9.6
Iron supplementation	Yes	210	87.9
	No	29	12.1
Maternal anemia	No	230	96.2
	Yes	9	3.8

Prevalence of Neonatal Anemia

The prevalence of neonatal anemia was 11.7% (95% CI 7.6–15.8), affecting 28 of the 239 study participants (Figure 1).

Morphological Classification of Neonatal Anemia

Normocytic normochromic anemia was the predominant morphological type among anemic neonates at Soroti Regional Referral Hospital, accounting for 78.6% (22/28) of cases. This was followed by normocytic hypochromic and microcytic anemia, each comprising 10.7% (3/28) of cases (Figure 2).

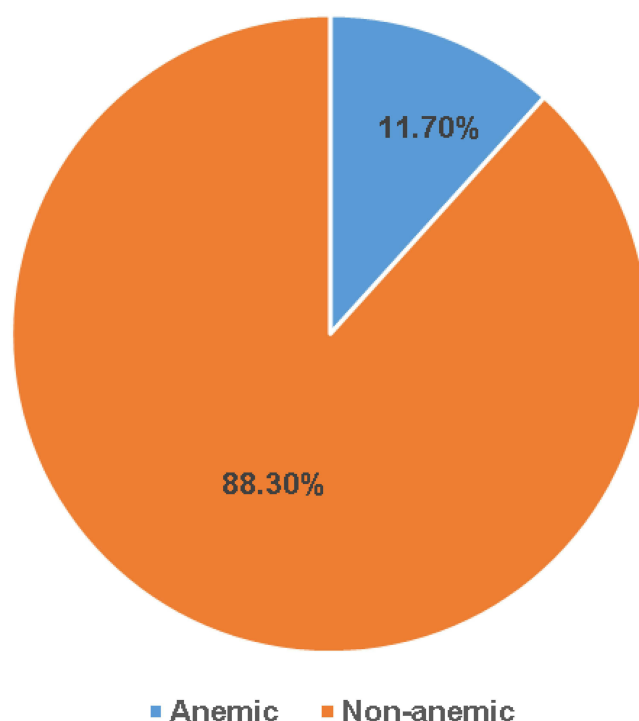


Figure 1 Pie chart showing prevalence of neonatal anemia.

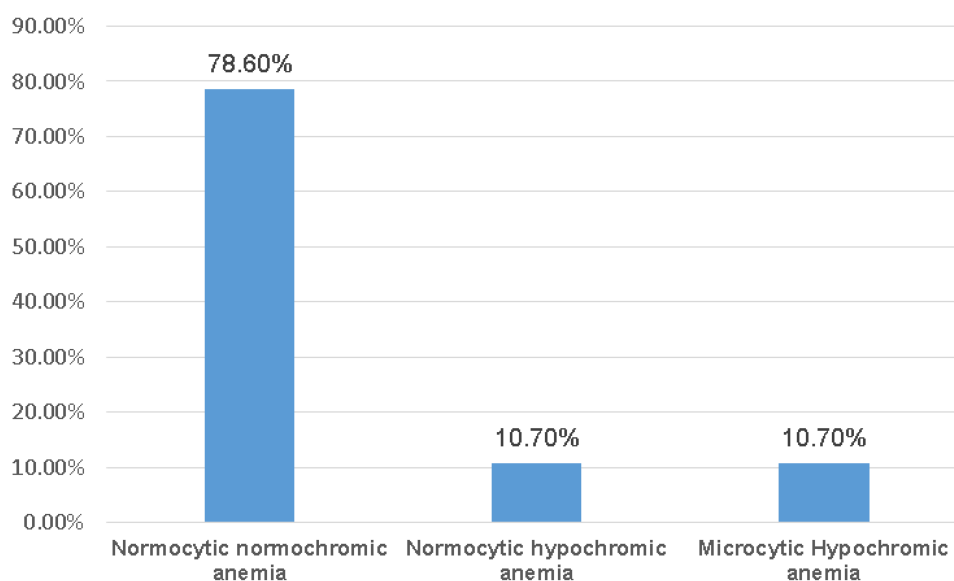


Figure 2 Bar graph showing morphological classification of neonatal anemia.

Factors Associated with Neonatal Anemia

Bivariate and multivariate logistic regression analyses were employed to assess the association between neonatal anemia and various factors, including sex, birth weight, gestational age, mode of delivery, and multiple maternal characteristics (Table 3). In the bivariate analysis, two factors were significantly associated with neonatal anemia: inadequate intake of vegetables and fruits during pregnancy ($p=0.035$) and the presence of maternal anemia ($p<0.001$).

Variables associated with neonatal anemia in bivariate analyses ($p<0.1$) were advanced to a multivariate logistic regression model. After adjustment for potential confounders, four factors emerged as independently associated with

Table 3 Bivariate Logistic Regression Analysis of Factors Associated with Neonatal Anemia

Variable	Category	Crude Odds Ratio	95% Confidence Interval	P value
Sex	Male	Ref		
	Female	1.27	0.41–3.90	0.674
Birth weight	<2500 grams	Ref		
	≥2500 grams	0.61	0.16–2.42	0.486
Gestational age	Preterm	Ref		
	Term	0.90	0.12–6.45	0.915
	Post term	0.60	0.05–7.33	0.692
Mode of delivery	Vaginal	Ref		
	Assisted vaginal	0.73	0.07–8.30	0.803
	Caesarean	0.41	0.10–1.62	0.202
Maternal age (years)	≤24	Ref		
	25–29	2.89	0.70–11.98	0.143
	≥30	0.41	0.06–2.97	0.380
Marital status	Married	Ref		
	Single or separated	2.21	0.51–9.53	0.287
Occupation	Unemployed	Ref		
	Peasant farmer	1.30	0.29–5.87	0.731
	Professional	0.59	0.03–11.20	0.728
	Self employed	0.36	0.04–3.57	0.385
Place of residence	Rural	Ref		
	Urban	0.37	0.08–1.76	0.213
Parity	Primiparous	Ref		
	Multiparous	3.01	0.65–13.92	0.159
Antenatal attendance	Yes	Ref		
	No	1.40	0.17–11.66	0.756
History of anemia during pregnancy	No	Ref		
	Yes	5.46	0.72–41.73	0.102
Iron or folate supplementation during pregnancy	Yes	Ref		
	No	2.66	0.40–17.68	0.311
History of malaria infection during pregnancy	No	Ref		
	Yes	1.88	0.59–6.02	0.284
Any chronic illness	No	Ref		
	Yes	3.75	0.18–79.07	0.396
Vegetables/fruit consumption	Daily	Ref		
	1–3 times a week	1.52	0.25–9.22	0.651
	4–6 times a week	1.42	0.24–8.52	0.698
	Rarely/never	1.26	0.17–72.38	0.035*
Neonatal infection	No	Ref		
	Yes	0.545	0.03–9.40	0.676
Mother dewormed during pregnancy	Yes	Ref		
	No	1.11	0.24–5.07	0.894
Exposure to environmental pollutants	No	Ref		
	Yes	0.87	0.21–3.61	0.850
Income level	Low	Ref		
	Moderate	0.62	0.09–4.13	0.621
Distance to hospital	<5km	Ref		
	5–10km	0.43	0.08–2.37	0.330
	>10km	1.26	0.21–7.63	0.805
Maternal anemia	No	Ref		
	Yes	11.65	3.17–42.81	<0.001*

Note: * Significant.

Table 4 Multivariate Logistic Regression Analysis of Factors Associated with Neonatal Anemia

Variable	Category	Adjusted Odds Ratio	95% Confidence Interval	P value
History of anemia during pregnancy	No	Ref		
	Yes	5.39	1.15–25.32	0.033*
Iron or folate supplementation during pregnancy	Yes	Ref		
	No	6.62	2.23–19.70	0.001*
Consumption of vegetables/fruits	Daily	Ref		
	1–3 times a week	2.35	0.53–10.49	0.262
	4–6 times a week	2.47	0.58–10.56	0.221
	Rarely/never	6.52	1.23–34.48	0.027*
Maternal anemia	Non-anemic	Ref		
	Anemic	5.48	2.11–14.21	<0.001*

Note: * Significant.

neonatal anemia: a history of anemia during pregnancy (aOR [95% CI], $p=0.033$), iron or folate supplementation during pregnancy ($p=0.001$), inadequate consumption of vegetables and fruits during pregnancy ($p=0.027$), and the presence of maternal anemia at delivery ($p<0.001$) (Table 4).

Discussion

This study determined the prevalence and associated factors with neonatal anemia at Soroti Regional Referral Hospital. The overall prevalence was 11.7%. This finding is consistent with studies from south-western Uganda (17%) and Iran (11.7%), likely reflecting similarities in diagnostic criteria and study design.^{22,23}

However, the prevalence in our setting is lower than the findings reported in Ethiopia (23.2%–30.1%), Afghanistan (26.8%), Brazil (32.6%), and the USA (21%), yet higher than the 5.7% reported in Nepal,^{4,7,12,24,25} respectively.

Furthermore, the prevalence observed in the present study is considerably lower than the 57.2% found in a cohort from Bonassama, Douala, Cameroon.²⁶ These disparities may be attributed to differences in socioeconomic status, the clinical profiles of the study populations (eg, proportion of preterm births), and rates of cesarean section, which is an independent risk factor for fetal blood loss.¹²

A primary finding of this study is the strong association between maternal and neonatal anemia. Neonates born to mothers with a history of anemia or who were anemic at delivery were significantly more likely to be anemic, a finding well-supported by existing literature.^{8,12} The pathophysiological basis for this is the direct transfer of iron from mother to fetus via placental transferrin; depleted maternal iron stores directly compromise fetal iron accretion, leading to impaired hematopoiesis.

Furthermore, a lack of iron or folate supplementation during pregnancy was a potent risk factor, increasing the odds of neonatal anemia by 6.6 fold. This aligns with a study from Ethiopia and underscores the critical role of prenatal micronutrient supplementation in safeguarding neonatal iron status.¹² Similarly, inadequate consumption of iron-rich foods, such as vegetables and fruits, was independently associated with neonatal anemia, corroborating findings that maternal diet is a key modifiable determinant of newborn health.⁸ Animal source protein was not significant in this current study, but it is known to contain complete protein and essential amino acids which are well absorbed by the digestive system and high consumption plays a role in anemia management due to its positive effect on body iron status and blood hemoglobin levels.²⁷

Morphologically, normocytic normochromic anemia was the most prevalent type (78.6%), followed by normocytic hypochromic and microcytic hypochromic anemia. This pattern is consistent with a study from Tanzania.² However, a significant gap in the literature on the morphological classification of neonatal anemia limits more in-depth comparative analysis.

This study establishes a significant burden of neonatal anemia at Soroti Regional Referral Hospital, predominantly the normocytic normochromic type. The findings conclusively identify maternal health as the primary determinant, with maternal anemia, a lack of iron/folate supplementation, and poor dietary intake emerging as key independent risk factors.

The findings underscore that neonatal anemia is a significant public health issue in this setting, largely determined by modifiable maternal factors. This identifies pregnancy as a critical window for intervention.

Key strategic recommendations are threefold: Strengthen antenatal care by ensuring universal screening for maternal anemia, guaranteeing the effective distribution and adherence to iron-folic acid supplements, and providing robust nutritional counselling.

Advocate for policy support to better integrate maternal nutrition programs into routine healthcare services, thereby ensuring consistent access to supplements and education for at-risk populations and investigate the etiological causes of the predominant morphological types of anemia identified and conduct longitudinal studies to assess the long-term neurodevelopmental outcomes of anemic neonates and the intervention strategies.

Limitations of the Study

The interpretation of these findings should be considered in light of several limitations. The hospital-based, cross-sectional design may limit the generalizability of the results to the broader community and prevent the inference of causality from the observed associations. Furthermore, despite multivariate adjustment, residual confounding from unmeasured variables (eg, inherited disorders, specific nutrient deficiencies) remains possible. Data on key exposures, such as dietary habits and supplement adherence, were susceptible to recall bias. Finally, the morphological classification of anemia lacked etiological specificity, as confirmatory tests to identify underlying causes were not performed. The use of both cord and venous blood for analysis is a potential limitation. As cord blood hemoglobin concentrations are known to be physiologically higher than venous blood, this may have introduced a degree of measurement variability and potentially led to a slight underestimation of the true anemia prevalence in our cohort.

Conclusion

This study reported the prevalence of neonatal anemia at Soroti Regional Referral Hospital at 11.7%. The predominant morphological class of neonatal anemia is normocytic normochromic anemia, a pattern often associated with acute etiologies. The findings conclusively demonstrate that neonatal anemia is associated with maternal anemia, lack of iron-folate supplementation, and poor dietary intake of fruits and vegetables. Further studies as well as iron and folate supplementation during pregnancy, consumption of animal and plant source protein, and screening of pregnant women for anemia during pregnancy are highly recommended.

Acknowledgments

The successful completion of this study was made possible by the support and cooperation of several institutions and individuals. We sincerely thank the administration of Soroti Regional Referral Hospital for their permission and facilitation. Our profound gratitude goes to the mothers and neonates who generously participated in this study. We are deeply appreciative of the unwavering support from the Senior Nursing Officer in charge of the neonatal ward and the laboratory staff, whose assistance was crucial during data collection. We also acknowledge the Research Ethics Committee of Soroti Regional Referral Hospital for their ethical guidance and approval.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Chaudhary N, Jassar R, Singh R. Neonatal anemia. *newborn*. 2022;1(3):263–270. doi:10.5005/jp-journals-11002-0027
2. Kalezi ZE, Kisenge R, Naburi H, Simbila AN, Mkony M, Leyna G. Prevalence of anaemia and associated factors among preterm infants at six weeks chronological age at Muhimbili National Hospital, Dar es Salaam, Tanzania: a cross-sectional study. *Pan Afr Med J*. 2023;44(1). doi:10.11604/pamj.2023.44.193.31190
3. Zhao B, Sun M, Wu T, Li J, Shi H, Wei Y. The association between maternal anemia and neonatal anemia: a systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2024;24(1):677. doi:10.1186/s12884-024-06832-1
4. Aslamzai M, Danish Y, Hakimi T, Jawadi B. Evaluation of the factors associated with anemia in neonates admitted to the neonatal unit of Maiwand teaching hospital: a cross-sectional study. *Glob Pediatr*. 2024;8:100164. doi:10.1016/j.gpeds.2024.100164
5. Oluwafemi RO, Bello EO, Oluwafemi TM, Onoja RE, Adeleye OJ. Prevalence and outcomes of neonatal anaemia in university of medical sciences teaching hospital, Akure. *Int J Res Med Sci*. 2025;13(3):1019. doi:10.18203/2320-6012.ijrms20250661

6. Sugino Y, Horiuchi S. Knowledge and dietary habits regarding anemia of pregnancy in the Republic of Gabon. *Japan J Nurs Sci.* **2025**;22(1): e12634. doi:10.1111/jjns.12634
7. Tilahun D, Yimer MA, Zamanuel TG. High magnitude of neonatal anemia among sick newborns admitted to University of Gondar comprehensive specialized Hospital, Northwest Ethiopia. *J Blood Med.* **2022**;Volume 13:293–302. doi:10.2147/JBM.S361675
8. Berihun GA, Tesfaye G, Adissu W, et al. Prevalence and associated factors of anemia among newborns at Jimma Medical Center, South-west Ethiopia. *J Blood Med.* **2024**;Volume 15:129–140. doi:10.2147/JBM.S443312
9. Mah EM, Tague DAK, Yondjeu OJ, Nkwelle I, Nengom J, Meguize CA. Determinants of anemia in premature newborns and the immediate outcome at the mother and child center of the chantal BIYA Foundation, Cameroon. *J Med Res.* **2021**;7(5):146–149. doi:10.31254/jmr.2021.7506
10. Ogah AO, Mwando C, Chanda K, Nganjo S. Factors determining hemoglobin levels in vaginally delivered term newborns at public hospitals in Lusaka, Zambia. *medRxiv.* **2024**;2024.08.11.24311826.
11. Kumar K, Nagar N, Sarnadgouda P. Anemia in new born. *J Infec Antibio.* **2018**;1(1):101.
12. Alamneh TT, Tilahun SF, Beyene MB, Fekadu SA, Assem AS, Kassa SF. Prevalence and associated factors of anemia among newborns at Tibebe Ghion Specialized Hospital, Northwest Ethiopia. *Int J Gene Med.* **2022**;15:6465. doi:10.2147/IJGM.S365817
13. Dereje I, Etefa T, Gebremariam T, Getaye A, Tunta A, Gerbi A. Prevalence of anemia and associated factors among term newborns in nekemte specialized hospital, western Ethiopia. *J Multidiscip Healthc.* **2021**;Volume 14:2607–2615. doi:10.2147/JMDH.S326962
14. Wondie WT, Zeleke KA, Wubneh CA. Incidence and predictors of mortality among low birth weight neonates in the first week of life admitted to the neonatal intensive care unit in Northwestern Ethiopia comprehensive specialized hospitals, 2022. Multi-center institution-based retrospective follow-up study. *BMC Pediatric.* **2023**;23(1):489. doi:10.1186/s12887-023-04319-0
15. Migamba SM, Kisaakye E, Komakech A, et al. Trends and spatial distribution of neonatal sepsis, Uganda, 2016–2020. *BMC Pregnancy Childbirth.* **2023**;23(1):770. doi:10.1186/s12884-023-06037-y
16. Sokou R, Gounari EA, Tsantes AG, et al. Bridging the evidence-to-practice gap: advancing neonatal blood transfusion. A narrative review of recent guidelines. *Blood Rev.* **2025**;71:101282. doi:10.1016/j.blre.2025.101282
17. Kasine Y, Babenko-Mould Y, Regan S. Translating continuing professional development education to nursing practice in Rwanda: enhancing maternal and newborn health. *Int J Afr Nurs Sci.* **2018**;8:75–81. doi:10.1016/j.ijans.2018.03.001
18. Mohamed K, Tadesse W, Woldesenbet D, et al. Anemia and its predictors among neonates at Wachemo University teaching hospital, Central Ethiopia: a facility-based cross-sectional study. *Front Hematol.* **2025**;4:1550664. doi:10.3389/frhem.2025.1550664
19. Johnson HM, Mitchell KB. Breastfeeding and breast cancer: managing lactation in survivors and women with a new diagnosis. *Ann Surg Oncol.* **2019**;26(10):3032–3039. doi:10.1245/s10434-019-07596-1
20. Kumar C, Peruri G, Plakkal N, et al. Short-term outcome and predictors of survival among neonates with moderate or severe hypoxic ischemic encephalopathy: data from the Indian neonatal collaborative. *Indian Pediatrics.* **2022**;59(1):21–24. doi:10.1007/s13312-022-2413-9
21. Edelson PK, Cao D, James KE, et al. Maternal anemia is associated with adverse maternal and neonatal outcomes in Mbarara, Uganda. *J Matern Fetal Neonatal Med.* **2023**;36(1):2190834. doi:10.1080/14767058.2023.2190834
22. Ngonzi J, Tibaijuka L, Mwanje Kintu T, et al. Prevalence and risk factors for newborn anemia in Southwestern Uganda: a cross-sectional study. *Anemia.* **2024**;2024(1):5320330. doi:10.1155/2024/5320330
23. Mamoury G, Hamedy A, Akhlaghi F. Cord hemoglobin in newborns in correlation with maternal hemoglobin in northeastern Iran. *Iran J Med Sci.* **2015**;28(4):166–168.
24. de Sá SA, Willner E, Pereira TAD, de Souza VR, Boaventura GT, de Azeredo VB. Anemia in pregnancy: impact on weight and in the development of anemia in newborn. *Nutricion hospitalaria.* **2015**;32(5):2071–2079. doi:10.3305/nh.2015.32.5.9186
25. Timilsina S, Karki S, Gautam A, Bhusal P, Paudel G, Sharma D. Correlation between maternal and umbilical cord blood in pregnant women of Pokhara Valley: a cross sectional study. *BMC Pregnancy Childbirth.* **2018**;18(1):70. doi:10.1186/s12884-018-1697-1
26. Koum DK, Essomba NE, Epame MGN, Mangamba LME, Ndombo PK. Profil Épidémiologique, Clinique, Biologique et Évolutif de l'Anémie Néonatale à l'Hôpital de District de Bonassama/Douala, Cameroun. *Health Sci Dis.* **2018**;19(3).
27. Wagiu Basrowi R, Sundjaya T, Pratiwi D, et al. Harnessing the power of proteins in modulation of miRNAs for targeting Iron deficiency Anemia: opinion for future implications and strategies. *Front Nutr.* **2025**;12:1535498. doi:10.3389/frnut.2025.1535498