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Anemia and its predictors among neonates at Wachemo University teaching hospital, Central Ethiopia: a facility-based cross-sectional study

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Background: Neonatal anemia occurs when the blood contains lower hemoglobin levels or erythrocytes than normal. Maternal obstetric and neonatal clinical characteristics and other medical conditions can contribute to this condition.

Methods: A facility-based cross-sectional study of 277 infants was conducted from October 14, 2023, to January 2, 2024. Consecutive sampling techniques were employed to enroll 277 mothers and their neonates, resulting in a response rate of 96.18%. Face-to-face interviews were conducted to gather information on neonates' sex, sociodemographic characteristics, and nutritional status using a pre-tested structured questionnaire. A Mindray BC-3000Plus Hematology Analyzer was utilized to analyze the blood samples collected from the mothers and their neonates. All raw data were coded and entered into SPSS version 27 and analyzed using descriptive statistics, independent t-tests, and logistic regression. Statistical significance was established at a p-value of 0.05.

Results: The overall prevalence of neonatal anemia was 21.7% (60/277). Mean hemoglobin levels were significantly lower among neonates born to anemic mothers than among those born to non-anemic mothers [(12.26 $\pm$ 2.66) Vs (13.39 $\pm$ 1.59), p <0.001). The findings from this study also showed the protective effect of taking "iron and folic acid" supplementation during pregnancy on the development of neonatal anemia (Adjusted odds ratio [AOR] = 0.15, 0.07-0.34, p <0.001).

Conclusion: During pregnancy, taking "iron and folic acid" supplements can prevent the development of neonatal anemia. Maternal anemia is correlated with lower mean hemoglobin levels in neonates. Therefore, during antenatal care follow-up, policymakers should consider implementing maternal health education regarding infant anemia and relevant health interventions to reduce the incidence of infant anemia.

KEYWORDS

prevalence, neonatal anemia, iron and folic acid supplementation, risk factors, Ethiopia

Introduction

Neonatal anemia is when the blood contains less than 13.5 g/dl hemoglobin (1). The primary reasons for anemia in neonates include increased red blood cell breakdown, decreased erythropoiesis, and blood loss (2). In addition, other obstetric conditions include preterm birth, maternal iron deficiency during pregnancy, maternal anemia, blood loss after delivery, genetic disorders, low birth weight, and other neonatal conditions (3–6). The symptoms of neonatal anemia include pale skin, exhaustion, a fast heartbeat, and difficulty feeding (3).

In underdeveloped nations with inadequate interventional implementation programs, low iron intake, and inadequate infrastructure services for early detection and management of anemia at the level of health facilities, it becomes more prevalent (7, 8). Because breast milk contains little iron, infants under six months of age are particularly susceptible to anemia from their poor iron intake, and fast growth (9). They therefore mostly depend on iron from intrauterine life (10). When the mother, who supplies the fetal iron, is anemic, the situation is even more tragic. Anemia affects about 36.8% of pregnant women globally, 41.7% in Africa (11), and 22% of pregnant women in Ethiopia (11, 12).

Untreated anemia in neonates can lead to respiratory distress, sensorium depression, tissue hypoxia, stunted growth, chronic heart failure(CHF), viral infections, such as HIV/AIDS, and hepatitis due to repeated transfusions of blood products (13–15). In addition, the long-term implications of neonatal anemia include decreased neurocognitive development, growth failure, and increased vulnerability to infection at all ages (13, 14, 16). Given these factors, anemia is a contributing factor to infant morbidity and mortality (1, 17, 18).

There are insufficient data on neonatal anemia's prevalence and risk factors in various regions of Ethiopia. Some studies conducted in Ethiopia reported variable rates of neonatal anemia of 9% in Addis Ababa (19), 25% in Gondar (1), and 29.1% in Nekemte western Ethiopia (13). Thus, the current study assessed the prevalence of anemia in neonates at Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital in Central Ethiopia.

Materials and methods

Study area

The study was conducted at Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital (WUNEMMCSH), situated 232 km south of Addis Ababa, the capital city of Ethiopia, in Hossana, central Ethiopia. The hospital provides treatment, prevention, and rehabilitation services. These services are organized into case teams, including outpatient, inpatient, emergency, critical care, obstetrics, maternal-child health, orthopedics, oncology, and surgical departments. The hospital was selected due to its high patient and client attendance rate. This hospital serves residents of the Hadiya zone, as well as other zones and special woredas, including Gurage, Selte, Halab, and Kembata-Tembaro. The hospital provides 11580 delivery services annually (2023 annual facility reports). This institution is the sole referral hospital in the Hadiya region.

Study design, period, and participants

A facility-based cross-sectional study was conducted on neonates delivered at the obstetrics department of WUNEMMCSH from October 14, 2023, to January 2, 2024.

Source population

The source population for this study comprised all neonates delivered at the obstetrics department of WUNEMMCSH.

Study population

The study population comprised all neonates delivered at the obstetrics department of WUNEMMCSH during the data collection period, fulfilling the inclusion criteria.

Inclusion and exclusion criteria

The study included all neonates admitted to the WUNEMMCSH during the specified period who were born at or after 28 gestational weeks. However, the study excluded neonates and mothers with any medical conditions and neonates below 28 days of gestation.

Sampling techniques and sample size determination

Sample size determination

The single-population proportion formula was used to determine the minimum sample size required. The sample size was calculated to be 288 after adding 5% non-response, using the 23.2% prevalence of anemia in neonates from a study conducted in Northwest Ethiopia (20), a 5% margin of error, and a 95% confidence interval (CI) of 1.96.

Sampling techniques

All women and their neonates who fulfilled the eligibility requirements of the study were consecutively added to the sample until the required number of participants was reached.

Sociodemographic and clinical information

Face-to-face interviews were conducted to collect data on neonates' sex, sociodemographic characteristics, and maternal nutritional status using a pre-tested structured questionnaire. The questionnaire was initially developed in English, translated into Amharic, and subsequently back-translated into English to ensure consistency. After receiving training on the study objectives and data collection instruments, the midwives and ward nurses administered the questionnaire. Maternal clinical data, including antenatal care (ANC) follow-up, iron levels, gravidity, iron and folic acid supplementation during pregnancy, and the occurrence of antepartum hemorrhage, were extracted from maternal medical records. We used Mid-Upper Arm Circumference (MUAC) simple non-invasive measurement of nutritional status, which involves measuring the circumference of the mid-upper arm using a flexible tape, particularly in children under five years of age (21).

Blood sample collection and hemoglobin level determination

After delivery, approximately 3 mL of umbilical cord blood was obtained from the clamped umbilical cord. Cord blood samples were collected from the clamped cord, excluding the placenta by two midwifery professionals. To stop blood clotting, the obtained sample was quickly placed in a test tube containing ethylenediaminetetraacetic acid (EDTA) and gently mixed. After birth, 3 mL of venous blood was drawn from the mother using a disposable syringe after 24 hours postpartum. The Mindray BC-3000Plus Hematology Analyzer was used to analyze the complete blood count (CBC). A skilled laboratory technician strictly follows the standard operating procedures (SOP) when performing CBC.

Quality control of data

Data collectors received one day of instruction regarding ethical issues and data collection techniques before beginning data collection. A pre-test was conducted on 5% of the study sample, which comprised patients who were not included in the study. Consequently, the questions' coherence, completeness, and flow, as well as the time required to complete them, were examined. The primary investigator and supervisor (nursing head) performed routine oversight to guarantee that all the required data were correctly gathered. Laboratory SOPs were followed throughout specimen collection and CBC analysis to ensure the quality of the laboratory results. Therefore, blood was transferred to the EDTA tube wall and mixed well by gently inverting the tube eight to ten times after collection to prevent hemolysis. Labeling was performed on the samples, and the request forms had the same unique number after collection to avoid confusion. Before the patient sample analysis, the expiration date of the reagent was determined. A routine background run was conducted to reduce the background error of the hematology analyzer.

Data analysis

After coding, the raw data were imported into SPSS version 27 for analysis. The data were analyzed, and the participants' demographics were described using descriptive statistics. Independent tests were used to compare the hemoglobin levels of neonates according to maternal anemia status. Neonatal anemia was evaluated as a binary outcome of interest. Statistical relationships between the dependent and independent variables were ascertained using multivariate analysis and binary logistic regression. To account for potential confounders, a multivariate analysis was performed on the variables in the bivariate regression model linked to the dependent variable ($p < 0.25$). The degree of correlation between the occurrence of neonatal anemia and independent variables was assessed using the odds ratio (OR) with a 95% confidence interval and a p-value of 0.05, which was considered statistically significant.

Ethical consideration

Ethical approval was obtained from the Department of Medical Laboratory Sciences, School of Medicine and Health Sciences, Wachemo University: Ref No: MLS/3730/2023, Date: October 1, 2023. After ethical clearance was received, permission to conduct the research was obtained from the WUNEMMCSH. All participants were informed of the purpose of the study and their participation was voluntary. Written informed consent was obtained from the children's parents or guardians; the confidentiality of the information provided was assured. All laboratory investigations were performed using an established standard operating procedure (SOP).

Results

Socio-demographic characteristics

In total, 277 mothers and their newborns were included in this study, resulting in a response rate of 96.18%. The mean age of the mothers who gave birth to the neonates was 27.52 ± 1.29 years, with the majority of them (67.9%; 188/277) being between 25 and 29 years old. In addition, most of the mothers were from urban (183/277; 66.1%). Of the mothers, 88.8%(246/277) were married (Table 1).

Maternal and neonatal clinical characteristics

In this study, 65.7% (182/277) of patients underwent a check-up during antenatal care(ANC). Of the mothers, 29.6% (82/277) were primiparous and 72.2% (200/277) reported taking "iron and folic acid" supplements during pregnancy. Regarding the mode of delivery, 88.4% (245/277) of the mothers delivered their children via the vagina. Regarding maternal MUAC, 89.5% (248/277) of the mothers had MUAC ≥ 23 cm. Of the mothers who participated in the study, 24.9% (69/277) had anemia, with an Hgb value of less than 11 g/dl. The female-to-male ratio of the neonates was 0.56 to 1 (100/177), with only 11.2% (31/277) weighing less than 2.5 kg (Table 2).

TABLE 1 Socio-demographic characteristics of neonates' mothers at WUNEMMCSH, central Ethiopia, from October 14, 2023, to January 2, 2024.

Variables	Categories	Frequency	Percentage
Age group	≤ 24 years	38	13.7
	25-29 Years	188	67.9
	≥ 30 years	51	18.4
Residence	Urban	183	66.1
	Rural	94	33.9
Marital status	Unmarried	7	2.5
	Married	246	88.8
	Divorced	13	4.7
	Separated	6	2.2
	Widowed	5	1.8
Education status	Unable to read and write	43	15.5
	Primary	121	43.7
	Secondary	68	24.5
	above secondary	45	16.2
Occupation	Housewife	167	60.3
	Daily laborer	59	21.3
	Government employee	37	13.4
	Merchant	14	5.1

Prevalence of neonatal anemia

The neonate hemoglobin levels ranged from 4.8 g/dl to 17.9 g/dl, with a mean hemoglobin level of 13.1 g/dl ± 1.97. In this study, the overall prevalence of neonatal anemia was 21.7%(60/277). Mean hemoglobin levels were significantly lower among neonates born from anemic mothers than among those born from [(12.26 ± 2.66) Vs (13.39 ± 1.59), p <0.001)] (Figure 1).

Factors associated with neonatal anemia

The independent variables were analyzed using bivariate and multivariate logistic regression analyses. Multivariate logistic regression analysis showed that after adjusting for possible confounders, taking "iron and folic acid" supplements during pregnancy can decrease the chance of developing neonatal anemia (AOR = 0.15, 0.07-0.34, p <0.001). Maternal anemia, residence, follow-up, maternal occupation, bleeding during pregnancy, gravidity, maternal educational status, maternal MUAC, maternal age group, neonatal age, neonatal birth weight, and meat consumption were not significantly associated with neonatal anemia (Table 3).

TABLE 2 Socio-demographic characteristics and clinical data of the study participants at WUNEMMCSH, central Ethiopia, from October 14, 2023, to January 2, 2024.

Variables	Categories	Frequency	Percentage
Maternal anemia status	Yes	69	24.9
	No	208	75.1
Iron and Folic acid supplementation	Yes	200	72.2
	No	77	27.8
Maternal MUAC	≤ 23cm	248	89.5
	> 23cm	29	10.5
Bleeding during pregnancy	Yes	21	7.6
	No	256	92.4
Mode of delivery	Vaginal delivery	245	88.4
	Cesarean section	32	11.6
Presence of ANC	Yes	182	65.7
	No	95	34.3
Gravida	Primigravida	82	29.6
	Multigravida	195	70.4
Weekly red meat consumption	Yes	159	57.4
	No	118	42.6
Neonatal Gender	Male	177	63.9
	Female	100	36.1
Neonatal Birth weight	< 2.5 kg	31	11.2
	≥ 2.5 kg	246	88.8

Discussions

Anemia poses a significant public health concern in Africa, particularly in children aged 5 years, and is associated with substantial morbidity and mortality. The determinants of anemia in children under 5 years were sex, residence, maternal education level, and family size (22). Not only under five children anemia also affects neonates with significant health impacts. This health impact is particularly pronounced in Sub-Saharan Africa, where health infrastructure is inadequate (23). In Ethiopia, the prevalence of neonatal anemia is influenced by geographical factors, obstetric variables, and maternal characteristics (24). Neonatal anemia can be managed by red blood cell transfusion (25), but red blood cell transfusion is linked to a higher risk of necrotizing enterocolitis, the spread of infectious diseases, and adverse neurodevelopmental outcomes (25).

This study found that the prevalence of neonatal anemia was 21.6%. This finding agrees with the studies done in New York, which found 21% (6), and the Netherlands, which found 21% (26). Possible explanations for these similarities include the operationalization of the hemoglobin level cut-off point for

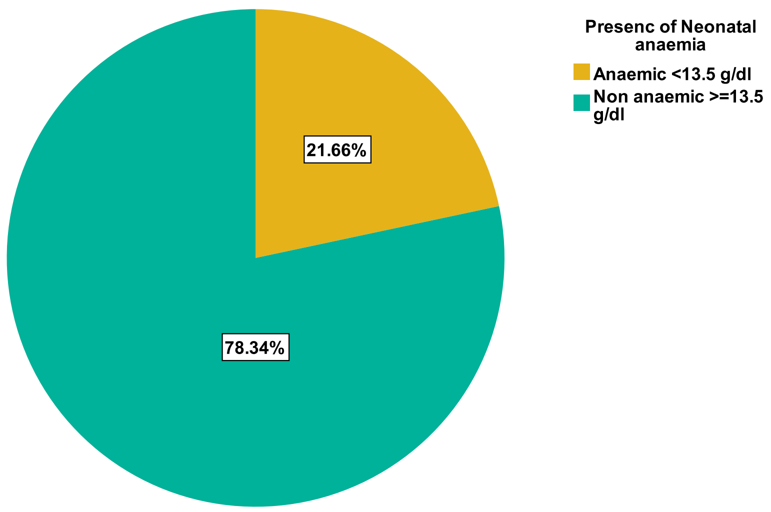

FIGURE 1
Prevalence of anemia among neonates delivered at the obstetrics department of WUNEMMCSH, Central Ethiopia.

neonates. Similar to our research, the study described above classified neonate anemia as having the 13.5 g/dl hemoglobin threshold. In contrast, this finding is greater than that of studies conducted in the USA 14% (6), 5.7% in Nepal (27), 11.7% in Iran (28), and in Addis Ababa Ethiopia 9% (19). The discrepancies in clinical characteristics, variations in sample size, and socioeconomic status among the study subjects could be the cause of these variations.

In contrast to our findings, a study done in Brazil 32.6% (29), Pakistan 79.3% (30), Iran 53% (31), Ghana 57.3% (18), Benin 61.1% (17), Ethiopia 29.1% (32) reported a higher prevalence of neonatal anemia. One potential explanation for the observed discrepancy between the present study and the Benin study could be attributed to the latter's exclusive inclusion of infants born to mothers infected with malaria, whereas the former also included neonates from uninfected mothers. The fetus acquires malaria parasites congenitally, which subsequently infiltrate the fetus's erythrocytes intracellularly. Consequently, this condition leads to an increased prevalence of infant anemia and decreased hemoglobin levels.

Depending on the differences in the modes of delivery of the research participants, this could account for the divergence from the Iranian study. Of the study participants, 88.4% (245/277) were born through the vagina, whereas all the study participants in Iran were born via cesarean section. In contrast to vaginal delivery, accidental incision of the placenta during cesarean delivery may result in hemorrhage, leading to anemia. A potential explanation for the discrepancy between the findings of the Addis Ababa study, Ethiopia, and the present study could be attributed to the former's exclusive inclusion of neonates with low birth weight. In contrast, the latter encompassed both low birth weight and normal weight neonates.

In this study, neonates born to mothers with anemia had significantly lower mean hemoglobin levels than those born to non-anemic mothers. One explanation for this finding could be that maternal anemia can increase the risk of developing severe neonatal anemia (33), and it is a risk factor for anemia among neonates (20). An increased chance of premature birth has been linked to maternal anemia, which can increase the risk of neonatal anemia as well. Given their shortened gestation time and immature erythrocyte production, premature neonates are more likely to develop anemia. Iron, folate, or vitamin B12 deficiencies are critical elements that can lead to maternal anemia (34). Anemia in infants can result from the fetus not receiving enough of these nutrients during development if the mother suffers from deficiency. Overall, maternal anemia can affect fetal health and increase the risk of neonatal anemia, including insufficient oxygen transfer, hereditary factors, nutritional deficiency, and preterm birth.

In the present study, pregnant women who take "iron and folic acid" supplements can decrease the chance of developing neonatal anemia. This finding is supported by findings from studies conducted in Italy, Iraq, and Peru (35–37). Mothers lacking iron supplementation during pregnancy have decreased maternal iron reserves; consequently, the quantity of placental iron transferred to the fetus is reduced, thereby increasing the risk of anemia among neonates (38).

Conclusions

Taking "iron and folic acid" supplements during pregnancy can reduce the risk of neonatal anemia. Maternal anemia significantly lowers hemoglobin levels in neonates. Therefore, during antenatal care follow-up, policymakers should consider maternal health education regarding infant anemia and relevant health care interventions to lessen the burden.

Due to constraints in research facilities and budget, this study did not evaluate micronutrient deficiency, thalassemia, or other hemoglobinopathies in study participants. These considerations may strengthen the findings of this study.

TABLE 3 Bivariable and Multivariate Binary Logistic Regression Analysis for Factors of Anemia among Neonate at WUNEMMCSH, Central Ethiopia, from October 14, 2023, to January 2, 2024.

Variables		Anemia status		Bivariate and multivariate analyses	
		Anemic	Non-Anemic	COR (95% CI)	AOR (95% CI)
Iron and Folic Intake	Yes	20 (10%)	180 (90%)	1	1
	No	40 (51.9%)	37 (48.1%)	0.1 (0.05-0.19)	0.15 (0.07-0.34)*
Residence	Urban	41 (22.4%)	142 (77.6%)	1	
	Rural	19 (20.2%)	75 (79.8%)	1.14 (0.62-2.10)	
Maternal MUAC	≤ 23 cm	57 (23%)	191 (77%)	0.39 (0.11-1.32)	
	> 23 cm	3 (10.3%)	26 (89.7%)	1	
Maternal occupation	Housewife	43 (25.7%)	124 (74.3%)	1.15 (0.34-3.87)	
	Daily laborer	7 (11.9%)	52 (88.1%)	2.97 (0.73-12.1)	
	Government employee	6 (16.2%)	31 (83.8%)	2.07 (0.48-8.83)	
	Merchant	4 (28.6%)	10 (71.4%)	1	
Bleeding during pregnancy	Yes	3 (14.3%)	18 (85.7%)	1.72 (0.49-6.04)	
	No	57 (22.3%)	199 (77.7%)	1	
Maternal education status	Unable to read and write	12 (27.9%)	31 (72.1%)	0.39 (0.13-1.18)	
	Primary	26 (21.5%)	95 (78.5%)	0.56 (0.22-1.47)	
	Secondary	16 (23.5%)	52 (76.5%)	0.50 (0.18-1.39)	
	above secondary	6 (13.3%)	39 (86.7%)	1	
Mode of delivery	Vaginal delivery	52 (21.2%)	193 (78.8%)	1	
	Cesarean Section	8 (0.25%)	24 (0.75%)	0.80 (0.34-1.90)	
Maternal anemia	Yes	33 (47.8%)	36 (52.2%)	0.16 (0.09-0.30)	0.49 (0.22- 1.07)
	No	27 (13%)	181 (87%)	1	1
ANC Follow-up	Yes	39 (21.4%)	143 (78.6%)	1	
	No	21 (22.1%)	74 (77.9%)	0.96 (0.52-1.75)	
Maternal age group	≤ 24 years	7 (18.4%)	31 (81.6%)	1	
	25-30 Years	39 (20.7%)	149 (79.3%)	.086 (0.35-2.11)	
	≥ 30 years	14 (27.5%)	37 (72.5%)	0.59 (0.21-1.66)	
Gravida	Primigravida	12 (15.9%)	70 (85.4%)	1	
	Multigravida	48 (24.6%)	147 (75.4%)	0.53 (0.26-1.05)	
Weekly meat consumption	Yes	35 (22%)	124 (78%)	0.95 (0.53-1.70)	
	No	25 (21.2%)	93 (78.8%)	1	
Neonatal gender	Male	35 (19.8%)	142 (80.2%)	1	
	Female	25 (25%)	75 (75%)	0.74 (0.41-1.32)	
Neonatal birth weight	< 2.5 kg	9 (29%)	22 (71%)	1	
	≥ 2.5 kg	51 (20.7%)	195 (79.3%)	0.64 (0.78-1.47)	

COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio; CI, Confidence Interval; * statistically significant at $p < 0.05$.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving humans were approved by Department of Medical Laboratory Sciences, School of Medicine and Health Sciences, Wachemo University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

KM: Conceptualization, Data curation, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing, Software, Supervision, Validation. WT: Data curation, Investigation, Methodology, Resources, Visualization, Writing – review & editing. DW: Methodology, Writing – original draft, Writing – review & editing. MA: Conceptualization, Methodology, Writing – review & editing. AM: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. ET: Conceptualization, Investigation, Methodology, Resources, Supervision, Writing – original draft. SG: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

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