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Major causes and associated factors of anemia among neonates admitted to the five comprehensive and specialized hospitals of Northwest Amhara region in Ethiopia (2023): Cross sectional study

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ABSTRACT

Background: Anemia is a common hematological problem in the neonatal admissions. Understanding the major causes and factors contributing to neonatal anemia is needed to identify interventions that can reduce neonatal morbidity and mortality. Evidence about the prevalence and contributing factors of anemia in neonates are limited in Ethiopia particularly in the Amhara region, so knowing the prevance and contributing factors may reduce the long-term, untreated complications of anemia.

Methods: A cross-sectional study design was conducted from October 1 to 31, 2023, and systematic random sampling was used to select a sample of 1004 participants. Data was collected by interviewing mothers and reviewing neonates' medical. The collected data was entered using Epi-Data version 4.2.0 and exported to STATA version 14 for analysis. Variables that have a P-value <0.25 in a bivariable were entered into a multivariable logistic regression model to control for confounder and statistical significance was declared at p-value <0.05.

Result: A total of 991 participants were recruited into the study. The prevalence of anemia among neonates admitted to the neonatal intensive care unit was found 25.13 % (95 % CI: 20.52 29.35 %). Antepartum hemorrhage [(AOR: 2.69, 95 %CI: (1.62 4.49)], RH incompatibility [AOR: 3.11; 95 %CI (2.08 4.64)], subgaleal hemorrhage [(AOR: 2.77, 95 %CI: (1.83 4.21], traditional uvuloctomy [AOR: 2.92; 95 %CI (2.06 4.14)] were factors significantly associated with anemia.

Conclusions: To deplete the burden of neonatal anemia better to eliminate traditional uvuloctomy and give special attention to neonates diagnosed with RH incompatibility, subgaleal hemorrhage, mothers who had antepartum hemorrhage.

1. Introduction

Anemia is defined as a hematocrit (HCT) level below 2 standard deviations measured for the respective age and sex of a neonate (Von Lindern and Lopriore, 2014; ROBERT, 2020). During the neonatal period, there are different pictures based on gestational age and postnatal age fluctuations in blood counts. At neonatal age, anemia can be found both in laboratory and clinical settings (asymptomatically). Blood loss decreases red blood cell (RBC) generation, and accelerated RBC destruction is the main factor contributing to anemia (ROBERT, 2020; Simion et al., 2013).

Anemia in the neonatal period is mostly observed in preterm infants and infants born with very low birth weights. Regarding the complications of anemia, neonates can have congestive heart failure (CHF) and

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possibly repeated blood product transfusions, and this practice can be a potential route of transmission for different infectious diseases, including HIV/AIDS, hepatitis, and other diseases (Simion et al., 2013; Girelli et al., 2015; Kalteren et al., 2021a; Bennaoui et al., 2020).

Neonatal anemia is a common occurrence in Neonatal Intensive Care Units (NICU) worldwide. It was found that newborns with anemia who received RBC transfusions had higher rates of morbidity and death and were more likely to require hospital readmission within the first year of life (Kassebaum et al., 2014; Allali et al., 2017). Its prevalence is very high in sub-Saharan Africa, ranging from 23 % to 66 % (Brabin et al., 2004).

Anemia in neonatal infants is a complex problem and has a unique blood picture owing to variations in hematological profiles (Lokeshwar et al., 2003). It can be a severe or acute life-threatening event, that causes impairment in brain development, delays in brain maturation, poor school performance and work capacity in later years, stunted growth and organ hypoxia, and poor cognitive and social-emotional development (Ewusie et al., 2014; Arora et al., 2015; Zhang et al., 2016; Kalteren et al., 2018, 2021b).

A recent global study estimated that approximately 2.4 million infants died during the neonatal period. Around seven thousand newborn deaths every day account for 47 % of all child deaths younger than five years. Despite Ethiopia's efforts to reduce neonatal mortality, it has increased from 29 to 33 per 1000 live births from 2016 to 2019. Neonatal anemia is recognized as the most significant contributor to neonatal mortality (Sahile et al., 2022; Fmoh, 2021; Sunil et al., 2018).

The occurrence of anemia in the intensive care unit typically indicates the disease progression. Neonates requiring red blood cell transfusion have higher mortality rates, and longer hospital stays for recovery are associated with high costs and economic burdens on households, the general public, and health protection systems. To decrease the problem and boost the endurance of neonates, the World Health Organization (WHO) is working with the Ministry of Health and other partners with the goal of the 2030 SDG which is to reduce neonatal mortality by at most 12 deaths per 1000 live births by stopping preventable neonatal deaths (Organization(WHO), 2020). although neonatal anemia is very common, there is limited information on the major causes and factors that are significant for neonatal anemia in the Amhara regional state of Ethiopia.

Therefore, determining the prevalence and associated factors can be utilized as evidence for relevant stakeholders to address the issues and possible factors of neonatal anemia.

2. Methods and materials

2.1. Study design, period, and area

A multi-center institutional-based cross-sectional study was conducted among neonates admitted to the five Comprehensive and Specialized Hospitals of the Northwest Amhara Region from December 1 to December 31, 2023. In the Northwest Amhara region, there are five comprehensive and specialized hospitals (CSH). These were the University of Gondar CSH, Felege Hiwot CSH, Tibebe Ghion CSH, Debre Tabor CSH, and Debre Markos CSH. These hospitals have special units, such as the NICU, and the major services performed in the NICU include general neonatal care services, routine prescription of a complete blood count, and blood transfusion.

2.2. Source and study populations

All neonates with their mothers who were admitted to the NICU of Northwest Amhara Region Comprehensive and Specialized Hospitals were the source population, and all neonates with their mothers who were admitted to the NICU of Northwest Amhara Region Comprehensive and Specialized Hospitals during the study period were included.

2.3. Inclusion and exclusion criteria

Neonates with mothers admitted to the NICU of the Northwest Amhara region in comprehensive and specialized hospitals during the study period were included, whereas mothers who were critically ill and treated in other wards and whose complete blood count laboratory investigation of the neonate was not performed were excluded.

2.4. Sample size determination

The sample size was calculated by using a single population proportion formula by taking the prevalence of neonatal anemia at 30.1 % (Tilahun et al., 2022a), a 95 % confidence interval, a 3 % margin of error, and a 10 % non-response rate.

By applying the formula : $n = \frac{(Za/2)^2 \text{ x } p(1-p)}{d^2}, n$

$$= \frac{(1.96)^2 \text{ x } 0.31(1-0.31)}{(0.03)^2} = 913$$

Where; n = sample size, $z_{\alpha/2}$ = the corresponding Z score of 95 % CI, d = margin of error

p = estimated proportion.

By adding a 10 % non-response rate the final sample size was 1004.

The total population size used to estimate the sample size based on monthly admissions from all hospitals was 1836.

2.5. Sampling techniques and procedures

This study was conducted in five specialized hospitals in the Northwest Amhara region. The average baseline data at one-year admission were obtained from each hospital to consider the available data. Then the sample size was allocated to each hospital based on the average number of neonate admissions per month. The sampling interval was then determined by dividing the average monthly admission by the desired sample size of each hospital (K ≈ 2). The overall sample was taken proportionally from all hospitals. The first participant was randomly selected at the beginning of the data collection period, and then each participant was selected using a systematic random sampling technique that was repeated every two intervals until the required sample size was obtained (Fig. 1).

2.6. Study variables

2.6.1. Dependent variable

Neonatal anemia (Yes: if the HCT value less than 45 %or No: if the HCT value greater than or equal to 45 %/) (Robert, 2020).

2.6.2. Independent variables

Socio-demographic characteristics of the mother and the neonate (i.e., maternal age, residence, educational status, marital status, occupational status and sex of the baby), **maternal and obstetric-related variables** (i.e., parity, ANC follow-up, mode of delivery, place of delivery, Rhesus (Rh) incompatibility, ABO incompatibility, malaria infection, maternal anemia, APH, GDM and vegetable consumption), **neonatal-related variables** (i.e., type of pregnancy, gestational age, weight for gestational age, birth weight, sepsis, subgaleal hemorrhage, traditional uvulectomy, jaundice and cephalohematoma).

2.6.3. Specific definitions

Preterm baby: newborns delivered before 37 weeks of GA (Robert, 2020).

Low birth weight: an infant birth weighing less than 2500 g (Robert, 2020).

Small for Gestational age: A newborn was considered to have a birth weight less than the 10th percentile for gestational age based on

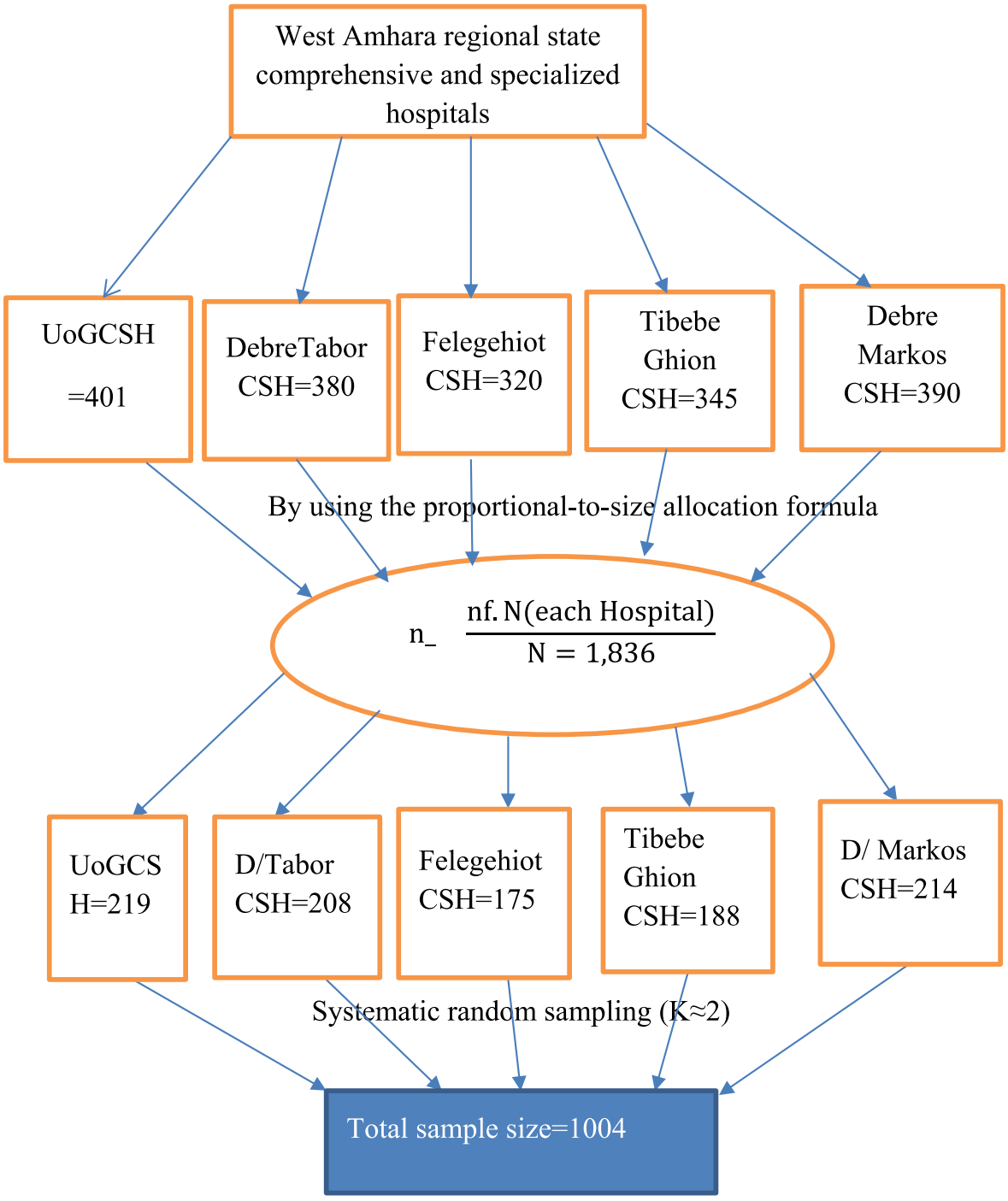

Fig. 1. Schematic diagram of sampling procedure of major causes and factors associated with neonatal anemia among neonates admitted to NICU of Northwest Amhara region five comprehensive and specialized hospitals, Northwest Ethiopia, 2023

the growth chart (Robert, 2020).

Rh incompatibility: when the mother's blood type is Rh negative and the neonates' blood type is Rh positive.

ABO incompatibility: when the mother's blood type is O and the neonate's blood type is other than O.

Vegetable consumption: when the mother eats vegetables at least once per week.

2.6.4. Data collection tools and techniques

The data collection tool was adapted by reviewing related literature and adopted from validated standards, such as Ethiopian demographic health survey checklists. It was prepared in English and translated into the Amharic language and then retranslated to English by language experts for consistency and flow, while for clinical variables (chart review checklists), an English version was developed. The questionnaire comprised questions on the socio-demographic characteristics of the mother and neonates, maternal-related factors, neonatal-related factors, and clinical co-morbidities of the neonate. Before data collection began, the validity and reliability of the instrument were checked and commented upon by research experts. After written informed consent was obtained from the mothers, data were collected by interviewing the mothers and reviewing neonates' medical records.

2.6.5. Data quality assurance

Data were collected by five BSc neonatal nurses and supervised by three MSc nurse professionals after one day of training on how to collect data and explain unclear questions and eligibility criteria, as well as the purpose of the study and confidentiality of client information. A pretest was carried out on 5 % of the sample size, and then correction and modification were undertaken before the actual data collection time. The study participants were fully informed about the aims of the study and assured that the information obtained from them would only be for research purposes, and the information obtained was anonymized and coded. The completed questionnaires were checked and supervised daily for completeness and consistency of the responses.

2.6.6. Data processing, analysis, and presentation

Data were checked, coded, and entered into Epi-Data version 4.6.0 and exported to STATA version 14 for analysis. The socio-demographic characteristics and other factors of the respondents were analyzed using descriptive statistics (percentage, mean, and standard deviations). A bivariable logistic regression analysis was performed to find the association of each independent variable with the outcome variable. All variables that showed a significant relationship in the bivariable logistic regression analysis ($p < 0.2$) were included in the final multivariable analysis model to control for confounding factors and to determine the independent effects of the different factors on the occurrence of anemia. The adjusted odds ratio (AOR) with a 95 % confidence interval (CI) was calculated, and a p-value of <0.05 was considered statistically significant. The goodness of model fitness was tested by the Hosmer and Lemeshow tests, and the model was fitted. The variance inflation factor was used to test multicollinearity (VIF = 1.23). Finally, the results were interpreted and presented in the form of tables, figures, and texts using frequency and summary statistics such as mean and percentage to describe the study population with relative variables and were discussed with previous results.

Patient and public involvement in this study: The study participants/public were not directed to be involved in the design, conduct, reporting, or dissemination of this study.

3. Result

A total of 991 participants were recruited into the study with a response rate of 98.7 %.

3.1. Socio-demographic and behavioral characteristics

The mean age of the mothers was 28.8 (±6.3SD) years, ranging from 18 to 45 years. Of those respondents, 35.22 % (349) of the mother's age belonged to the age groups of less than or equal to 24 years, and more than half (54.9 %) of the study participants were from urban residences. Less than half (44 %) of the mothers had a diploma or higher educational status, and around 43 % of mothers were housewives. The majority of the mothers were married (83.4 %), and more than half of the neonates (57.4 %) were females (Table 1).

3.2. Maternal and obstetric-related factors

Out of the respondents, nearly two-thirds (62.6 %) of mothers were multipara, most of them (98.9 %) had ANC follow-up, and out of them (56.5 %) had 4 and above visits. Most mothers were delivered at health facilities, and more than half (57.5 %) of them gave birth via SVD. Around 15 % and 3.43 % of the study participants had RH incompatibility and ABO incompatibility, respectively. Almost 6 % of mothers had both gestational diabetes mellitus and malaria infection, and 9 % of mothers had APH. Regarding maternal dietary habits, 12.5 % of mothers had vegetable consumption habits (Table 2).

Table 1
Socio-demographic and behavioral characteristics of the mothers with their neonates admitted to NICU of Northwest Amhara region five comprehensive specialized hospitals, Northwest Ethiopia, 2023 (n = 991).

Variables	Category	Frequency(n = 991)	Percentage
Sex of Neonate	Male	422	42.58
	Female	569	57.42
Mothers Age	≤24 years	349	35.22
	25–29 years	337	34.01
	≥30 years	305	30.78
Residence	urban	545	54.99
	rural	446	45.01
Marital status	Single	38	3.83
	Married	832	83.96
	Widowed	81	8.17
	Divorced	40	4.04
Educational status	No formal education	107	10.80
	Primary	193	19.48
	Secondary	255	25.73
	College and above	436	44.00
Occupation status	Government Employee	241	24.32
	Private employee	142	14.33
	Merchant	137	13.82
	Daily labor	47	4.74
	House Wife	424	42.79

Table 2
Maternal and obstetric-related factors of neonatal anemia in NICU of Northwest Amhara region five comprehensive specialized hospitals, Northwest Ethiopia, 2023 (n = 991).

Variables	Category	Frequency(n = 751)	Percentage
Parity	Primi para	371	37.44
	Multi-para	620	62.56
ANC visit	No	10	1.01
	1-3 times	421	42.48
	≥4 times	560	56.51
Place of delivery	Home	77	7.77
	Health institution	914	92.23
Mode of delivery	SVD	570	57.52
	Assisted vaginal delivery	70	7.06
	Cesarean section	351	35.42
RH incompatibility	Yes	152	15.34
	No	839	84.66
ABO incompatibility	Yes	34	3.43
	No	957	96.57
Malaria infection	Yes	61	6.16
	No	930	93.84
Maternal anemia	Yes	103	10.39
	No	888	89.61
APH	Yes	85	8.58
	No	906	91.42
GDM	Yes	59	5.95
	No	932	94.05
vegetable consumption	Yes	124	12.51
	No	867	87.49

3.3. Neonatal-related factors

Of the 991 newborns, 85.67 % were singletons, and more than two-thirds of them (71.4 %) had a gestational age of 37 weeks and above. More than two-thirds (68.7 %) of the newborns had a birth weight of 2500 g or more, and 85.7 % of the newborns were appropriate for gestational age. In terms of neonatal comorbidities, more than one-third (34.5 %) of neonates had sepsis, 16.9 % had subgaleal hemorrhage, 25.4 % had traditional uvuloctomy, and 11.7 % had cephalhematoma (Table 3).

Table 3
Neonatal-related factors of neonates admitted to NICU of Northwest Amhara region five comprehensive specialized hospitals, Northwest Ethiopia, 2023 (n = 991).

Variables	Category	Frequency(n = 991)	Percentage
Birth weight	<2500 g	310	31.28
	≥2500 g	681	68.72
Gestational Age	<37 weeks	283	28.56
	≥37 weeks	708	71.44
Weight for gestational age	AGA	849	85.67
	SGA	110	11.10
	LGA	32	3.23
Number of index pregnancy	Singleton	849	85.67
	Twin	125	12.61
	Triple or more	17	1.72
Sepsis	Yes	342	34.51
	No	649	65.49
Cephalhematoma	Yes	116	11.71
	No	875	88.29
Subgaleal hemorrhage	Yes	168	16.95
	No	823	83.05
Jaundice	Yes	250	25.23
	No	741	74.77
Traditional uvulectomy	Yes	252	25.43
	No	739	74.57

3.4. Major causes of anemia

The main primary causes of anemia among neonates in the study area were RH incompatibility (48.68 %), traditional vulvectomy (43.65 %), and subgaleal hemorrhage (40.47 %) (see Fig. 2).

3.5. Prevalence of neonatal anemia

An institution-based cross-sectional study in the northwest part of the Amhara region stated that 25.13 % (95 % CI: 20.52–29.35 %) of newborns were anemic.

3.6. Factors associated with neonatal anemia

The bivariable logistic regression analysis revealed that the following factors were associated with neonatal anemia: marital status, educational status, parity, vegetable consumption, RH incompatibility, ABO incompatibility, gestational diabetes mellitus, antepartum hemorrhage, maternal anemia, neonatal weight, gestational age, neonatal sepsis, subgaleal hemorrhage, jaundice, and traditional vulvectomy. However, after performing a multivariable logistic regression analysis, the following factors remained significantly associated with neonatal anemia: RH incompatibility, antepartum hemorrhage, subgaleal hemorrhage, and traditional vulvectomy.

Neonates born from mothers with antepartum hemorrhage were 2.7 times more likely to have anemia as compared to neonates born from mothers without antepartum hemorrhage [(AOR: 2.69, 95 %CI: 1.62 4.49)]. Neonates with RH incompatibility had 3.1 times higher odds of developing anemia compared to neonates without RH incompatibility [AOR: 3.11; 95 %CI: 2.08–4.64]. Similarly, neonates who experienced subgaleal hemorrhage were approximately 2.8 times more likely to develop anemia as compared to those who did not have subgaleal hemorrhage [AOR: 2.77, 95 %CI: 1.83 4.21]. Moreover, neonates who underwent traditional uvuloctomies were approximately 3 times more likely to develop anemia as compared to neonates who did not undergo traditional uvuloctomies [AOR: 2.92; 95 %CI: 2.06–4.14] (Table 4).

4. Discussion

The prevalence of neonatal anemia in this study is consistent with previous studies conducted in Ethiopia, specifically in Gondar and Nekemte (25 % and 29.1 %) (Tiruneh et al., 2020; Dereje et al., 2021), Nigeria (26.4 %) (Omunakwe et al., 2021), and Europe (29.3 %) (Ru et al., 2018). But this study finding is also lower than with studies conducted in in Ethiopia (30.1 %) (Tilahun et al., 2022b), Benin (61.1 %) (Koura et al., 2012), Ghana (57.3 %) (Laar et al., 2013), Turkey (47.7

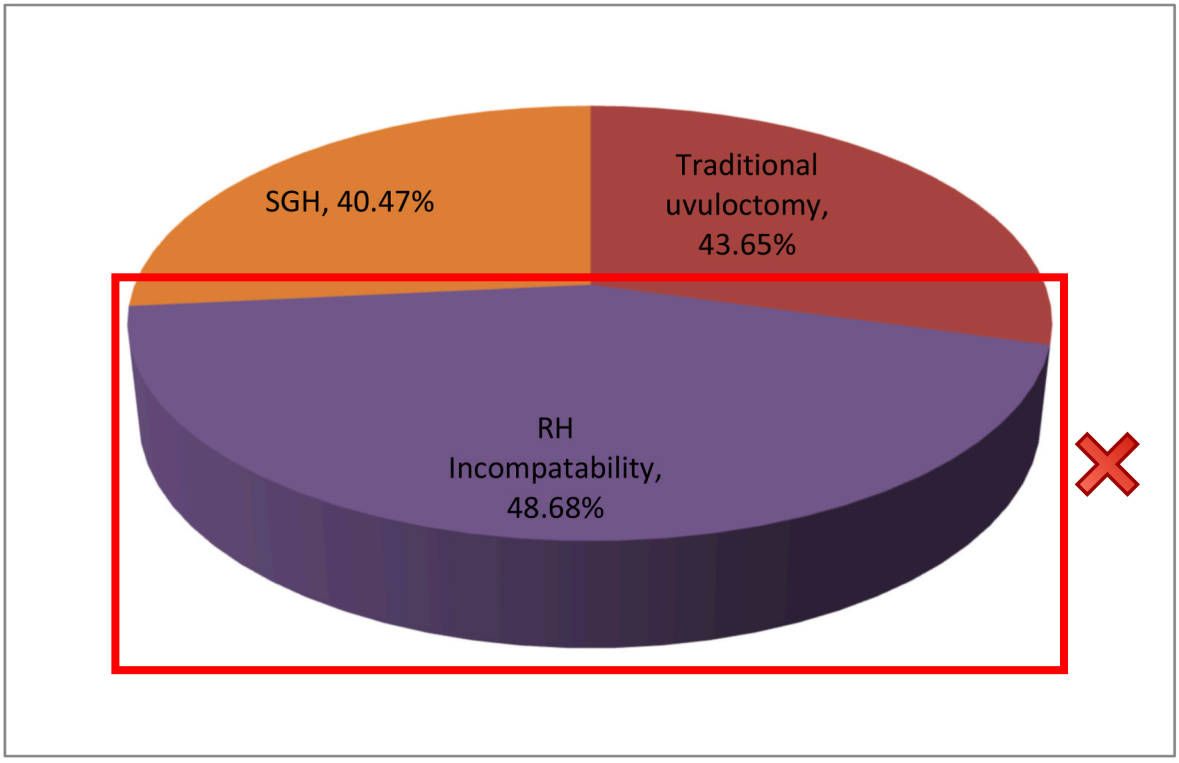

Fig. 2. Distribution of the major cause of anemia among neonates admitted to NICU of Northwest Amhara region comprehensive specialized hospitals, Northwest Ethiopia, 2023 (n = 991).

Table 4
Binary logistic regression and multivariable logistic regression of neonatal anemia among neonates admitted to neonatal intensive care units in Northwest Amhara region five comprehensive specialized hospitals, Northwest Ethiopia, 2023

Variables	Categories	Anemia		COR (95 % CI)	AOR (95 % CI)
		Yes	No		
Marital status	Married	202	630	1.00	1.00
	Single	8	30	0.83 (0.37 1.84)	1.26 (0.50 3.15)
	Widowed	24	57	1.31 (0.79 2.17)*	0.917(0 0.51 1.64)
	Divorced	15	25	1.87 (0.96 3.61)	1.39(0 0.66 2.93)
Educational status	Diploma and above	109	327	1.00	1.00
	No formal education	33	74	1.33 (0.84 2.12)	1.23 (0.72 2.08)
	Primary	55	138	1.19 (0.81 1.74)	1.02 (0.67 1.58)
	Secondary	52	203	0.76 (0.53 1.12)*	0.71 (0.46 1.08)
Parity	Primi	75	296	1.00	1.00
	Multi	174	446	1.53 (1.13 2.09)*	1.41 **(**0.99 2.0**)**
Vegetable consumption	Yes	40	84	1.00	1.00
	No	209	658	1.49 (0.99 2.25)*	0.71 (0.44 1.12)
Gestational diabetes mellitus	No	228	704	1.00	1.00
	Yes	21	38	1.71 (0.98 2.96)*	1.31 (0.70 2.47)
Antepartum hemorrhage	No	211	695	1.00	1.00
	Yes	38	47	2.66 (1.69 4.19)*	**2.69 (1.62 4.48)****
Maternal anemia	No	214	668	1.00	1.00
	Yes	35	68	1.62 (1.05 2.52)*	1.06 (0.64 1.755)
Birth weight	≥2500gms	194	487	1.00	1.00
	<2500gms	55	255	0.54 (0.38 0.75)*	0.67 (0.38 1.04)
Gestational Age	≥37wks	201	507	1.00	1.00
	<37wks	48	235	0.52 (0.36 0.73)*	1.01 (0.60 1.69)
Jaundice	No	177	564	1.00	1.00
	Yes	72	178	1.28 (0.93 1.77)*	1.31 (0.91 1.90)
Sepsis	No	173	476	1.00	1.00
	Yes	76	266	1.78 (0.57 1.07)*	0.69 (0.47 1.00)
Subgaleal_ Hemorrhage	No	181	642	1.00	1.00
	Yes	68	100	2.41 (1.70 3.42)*	**2.77 (1.83 4.20)****
Ttraditional_Uvulectomy	No	110	142	1.00	1.00
	Yes	139	600	3.34 (2.45 4.55)*	**2.92 (2.06 4.13)****
RH Incompatibility	No	175	664	1.00	1.00
	Yes	74	78	3.59 (2.51 5.15)*	**3.11 (2.08 4.64)****
ABO Incompatibility	No	237	720	1.00	1.00
	Yes	12	22	1.65 (0.81 3.39)*	1.95 (0.87 4.34)

Key; 1.00 = Reference, * = statistically significant by COR at p-value <0.2,** = statistically significant by AOR at p-value <0.05.

%) (Dane et al., 2013), Iran (53 %) (Baharvand et al., 2018) and Brazil (32.5 %) (de Sá et al., 2015). The possible justifications might be due to the study population differences. The previous study in Ethiopia focused solely on sick newborns (Tilahun et al., 2022b), while the studies in Benin, Turkey, and Brazil concentrated exclusively on neonates born to anemic mothers (Koura et al., 2012; Dane et al., 2013; de Sá et al., 2015). The Ghana study specifically examined neonates born to HIV-positive mothers (Laar et al., 2013), and the Iran study, which focused on the effect of mode of delivery (cesarean section delivery) on neonatal blood parameters, whereas all neonates, regardless of maternal factors and mode of delivery, were used in the current study.

On the contrary, the finding of this study is higher than those of studies carried out in Ethiopia (9 %, 20.2 %) (Terefe et al., 2015; Tigabu Kebede et al., 2020), and Iran (11.7 %) (Mamoury et al., 2015). The variation might be due to the difference in the sample size they used is much lower than the current study (Terefe et al., 2015; Mamoury et al., 2015). A small sample size compared to a larger one can result from random variation, missed cases, or selection bias. Small samples may not accurately reflect the true distribution of a condition, leading to underestimation. Additionally, rare cases might be overlooked by chance, and statistical fluctuations can make prevalence appear lower. Consequently, studies with larger sample sizes typically report more accurate and often higher prevalence rates than those with smaller samples (Hajian-Tilaki, 2011).

The study revealed that newborns born from mothers with antepartum hemorrhage were 2.7 times more likely to have anemia when compared to those born from mothers without antepartum hemorrhage. The finding was similar to different studies conducted in Ethiopia, specifically in Gondar (Tilahun et al., 2022a), Korea (Jang et al., 2011), and the United States (Schneiderman and Balayla, 2013). This could be because of antepartum hemorrhage which is described as bleeding from the placenta before the birth of the baby. When there is bleeding from the placenta before delivery, it can interrupt the normal transfer of blood, and the baby's red blood cell count and hemoglobin levels may drop, leading to anemia (Tweddell et al., 2023; Bruinsma et al., 2022; Halici-Ozturk et al., 2022).

Additionally, significant bleeding associated with vasa previa can lead to massive bleeding in the fetus and mother when the membranes around the fetus rupture. As a result, the hematocrit value in the newborn may be lower than normal, indicating anemia (Silver, 2015).

The odds of anemia were approximately 2.8 times higher among neonates who experienced subgaleal hemorrhage as compared with those who did not have subgaleal hemorrhage. This finding was supported in Ethiopia (Tilahun et al., 2022a; Alebachew et al., 2020). Because the subgaleal space contains a network of blood vessels, and when these vessels are damaged, blood can leak into the surrounding tissue and accumulate in the subgaleal space, leading to the formation of a hematoma (localized collection of blood) which leads to anemia (Lee et al., 2018a, 2018b).

Those neonates who had RH incompatibility had approximately three times higher odds of anemia when compared with neonates without RH incompatibility. This is supported by a study carried out in Australia (Tyndall et al., 2020). This may be because when the mother's blood type is Rh negative and her fetus' blood type is Rh positive, Rh antibodies made in a woman's body can cross the placenta and attack

fetal red blood cells. This can cause a serious type of anemia in the fetus and neonates in which red blood cells are destroyed faster than the body can replace them (Pegoraro et al., 2020).

Lastly, neonates with traditional uvulectomy had 2.9 times higher odds of anemia than those without traditional uvulectomy. The finding was supported in Ethiopia and Tanzania (Alebachew et al., 2020; Sawe et al., 2015). Excessive bleeding during or after the procedure can result in blood loss and raise the risk of infection. Infections can cause systemic inflammation and impair red blood cell formation and life expectancy. Furthermore, traditional uvulectomy delays obtaining necessary medical treatment or measures, which may result in anemia (Sawe et al., 2015; Adoga and Nimkur, 2011).

4.1. Strengths and limitations

Data was collected through face-to-face interviews which could be able to decrease information bias and the study was conducted in a multi-center which covers a broad population, which improves its generalizability. The study participants are homogeneous, as all hospitals adhere to the same management guidelines are the strength of this study. Its cross-sectional design does not establish a temporal relationship between the outcome and independent variables. Future researchers should consider conducting a longitudinal study to address this limitation.

5. Conclusions

In this study, the prevalence of anemia among neonates admitted to the neonatal intensive care unit was slightly high. The result of this study proved that antepartum hemorrhage, RH incompatibility, subgaleal hemorrhage, and traditional uvulectomy were factors associated with the increasing risk of neonatal anemia.

Data availability statement

Data are available on reasonable request.

Ethical approval and consent to participate

Ethical clearance was obtained from the Institutional Review Board (IRB) of the Debre Tabor University with reference number of RP/274/23. A permission letter of administrative approval was obtained from each hospital administrator before the data collection. Finally, both written and verbal informed consent was obtained from the mothers after explaining all the purposes, benefits, confidentiality of the information, and the voluntary nature of participation in the study before the data collection. All methods were carried out following the Declaration of Helsinki and relevant guidelines and regulations. The names and/or identification numbers of the study participants were not recorded on the data collection tool. All data were kept strictly confidential and used only for this study's purposes.

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Conflicts of interest

The authors declared that no conflicts of interest.

Abbreviations and acronyms;

AIDS: Acquired Immune Deficiency Syndrome, ANC: Antenatal Care, APH: Antepartum Hemorrhage, AOR: Adjusted Odd Ratio, CSH: Comprehensive and Specialized Hospital, GDM: Gestational Diabetes, HCT: Hematocrit, HIV: Human Immune Virus, NICU: Neonatal Intensive Care Units, RBC: Red Blood Cell, USA: United State Of America, WHO: World Health Organization.

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