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Article

Prevalence and Determinants of Anemia Among Women of Reproductive Age and Children Under Five in Tajikistan

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Abstract

Introduction: Anemia is a global public health concern affecting mainly women of reproductive age (WRA) and preschoolers (PSC, 6-59 months) due to their higher demand for iron. The etiology of anemia is multifactorial, and nutritional anemia is the most common type worldwide and is predominantly due to deficiencies in iron, vitamin B12, and folate. This study aimed to assess the associated factors, etiology, and prevalence of anemia among WRA and preschoolers in the GBAO region in Tajikistan. **Methods:** We conducted a cross-sectional study in the GBAO province of Tajikistan between April 2021 and September 2021, enrolling 500 WRA and 500 children aged 6-59 months from six districts of the GBAO region. The survey was administered through a structured questionnaire at the household level, and information was collected on sociodemographic characteristics, reproductive history, dietary intake, nutritional status, and maternal factors. Blood and stool samples were also collected for micronutrient deficiencies and helminthic infections. Data analysis began with univariate analysis, followed by multivariate logistic regression in Stata (version 18). **Results:** Biochemical assessment of 473 WRA and 390 preschoolers was conducted; 17.3% of WRA and 15.4% of PSC were anemic. After adjustment, the following factors were positively associated with anemia in WRA living in the GBAO region; body mass index (overweight (OR 0.313, p value 0.020), gravidity (OR 0.326, p value 0.009), low ferritin (OR 8.549, p value <0.001), elevated serum transferrin receptor levels (OR 4.817, p value <0.001) and Vitamin B12 deficiency (OR 0.18, p value 0.050). In contrast, in children, maternal education (OR 2.35, p value 0.029), maternal anemia (OR 4.998, p value 0.001), age under 2 years (OR 2.6, p value 0.016), and low ferritin (OR 5.67, p value <0.001) showed a positive association with anemia. **Conclusions:** Anemia in women was strongly associated with low ferritin, high STFR, gravidity, BMI, and vitamin B12; in children, with maternal education, maternal anemia, age <24 months, and low ferritin. These findings underscore the urgent need for locally tailored interventions, both in the short term and the long term.

Keywords: anemia; women of reproductive age; children under 5; prevalence; etiological determinant; Tajikistan

Background

Anemia is characterized by low levels of hemoglobin (HB), in which the number of red blood cells are inadequate to satisfy the physiological requirements of the body [1]. This condition has become a global public health concern, it can be identified when the HB levels in the blood are decreased to a predetermined threshold of (12.0 g/dl) in women of reproductive ages (WRA, 15-49 years) and (<11.0 g/dl) in young children aged 6-59 months, thereby impairing the ability of the blood to transport oxygen to the body [2]. This crucial matter has gained global attention owing to its impact on various groups of individuals, mainly women in their reproductive years (aged 15-49) and young children (aged 6-59 months). Anemia continues to threaten women during pregnancy and can be associated with a heightened risk of maternal mortality that can lead to preterm delivery, low birth weight, and cognitive development difficulties [3]. The etiology of anemia is complex; its prevalence and reasons extend substantially worldwide based on population groups, geographical location, socioeconomic status (SES), and other factors [4]. The population primarily residing in rural households with low socioeconomic status and having inadequate necessities of life, including proper sanitation and safe water provision, is more susceptible to anemia [5]. Furthermore, micronutrient deficiencies, particularly iron, folate, and vitamin B12 deficiencies, can also be common causes of anemia among women in reproductive years and pre-school age children (PSC-6-59 months) [6,7].

The World Health Assembly has set a goal to reduce the burden of anemia among WRA to 50% by 2025 [8]. According to the 2019 findings of the World Health Organization, at a global scale, anemia was prevalent in 29.9% of women of reproductive age and in 39.8% of children aged 6-59 months [5] [9]. Anemia accounts for maternal and neonatal deaths of 2.5 million to 3.4 million deaths worldwide [10]. Additionally, many estimates indicate a significant prevalence of anemia in women and young children, especially in low and middle-income countries (LMICS) [11]. Anemia affects developing countries in disproportionate numbers, with a burden of 89% in Asian and sub-Saharan African countries [3]. In addition, Kazakhstan, a landlocked country in Central Asia, in 2019 reported anemia prevalence of 29% in WRA and 23% in preschool-age children (PSC-6-59 months) [12]. Furthermore, Uzbekistan, another country in Central Asia, reported an anemia prevalence of 25% in WRA, while 22% preschool children (6-59 months) had anemia [13]. Like other low- to middle-income countries, Tajikistan, geographically located in Central Asia, bears the burden of anemia. According to the national nutritional survey 2016 (NNS 2016) conducted in Tajikistan, 25.8% of WRA (15-49 years) and children aged 6-59 months were found to have anemia [14]. In addition, as per the NNS 2016 Tajikistan, among the various regions of Tajikistan, the Gorno-Badakhshan Autonomous Oblast (GBAO) exhibited a notable prevalence of anemia (31.8%) in WRA (15-49 years), whereas 43.4% of anemia prevalence in young children (6-59 months) was noticed [14]. The underlying causes of anemia among WRA and children are evaluated as multifactorial, as there is limited available data about factors associated with anemia in Tajikistan; therefore, this study has performed a survey on WRA, childhood anemia, and its determinants in which the prevalence of anemia, associated factors of anemia, and its etiology are discussed.

Methods

Survey Design

The cross-sectional survey was conducted at the household level in Gabo, Tajikistan. The data was collected from mothers (WRA-15-49 years, n=500) and their preschool-age children (6-59 months, n=500) over the period of six months between April 2021 and September 2021. This survey was

conducted in 6 districts of the GBAO region (Khorog, Murghab, Roshtkala, Rushan, Shugnan, Ishkisham). Apart from assessing anemia, other proposed indicators associated with anemia were also collected, followed by micronutrient deficiencies, socioeconomic status, demographic, dietary intake, and other maternal factors.

Sample Size and Sampling Design

The study employed a two-stage cluster design, with villages serving as enumeration blocks and as primary sampling units (PSUs). In addition, households from the village were selected as secondary sampling units (SSUs). Villages were selected from available preceding lists in the area. To achieve the primary objectives at the 5% significance level and 80% power, a total sample of 500 WRA was selected. From each household, a mother and her youngest child were chosen for the survey and blood sampling. The study aimed to produce district-specific data and sampled 22 villages (2 per district), with approximately 20 households per village.

Biochemical Assessment

Blood samples were collected from WRA (n=473) and preschool age children (PSC-6-59 months, n=390) for the assessment of anemia. A standardized methodology was employed to collect a blood sample via venipuncture for biochemical evaluation of hemoglobin. A trained phlebotomist collected 3 ml of whole blood from the participant, centrifuged, and separated the serum at the field site, which was then transported to the lab for storage at 2-8 °C. The samples were then transported to the AKMC laboratory in Khorog under cold chain conditions. In addition, stool samples were collected from the mother-baby dyad for the detection of helminthic infections.

In WRA (15-49 years) and children (6-59 months), anemia was defined as hemoglobin levels <12g/dl and <11g/dl, respectively. It is important to note that hemoglobin levels were altitude adjusted, along with ferritin levels and IDA, which were adjusted for CRP and AGP. [15] Furthermore, the survey data had collected using handheld devices via the computer-assisted Personal Interview (CAPI) technique; however, in areas where CAPI could not be used due to security concerns, data collection was conducted using the Paper-Based Interview (PAPI) approach. A structured household questionnaire was administered, including sociodemographic, nutrition, and reproductive information.

Ethical Consideration

Informed consent was obtained from study participants; however, written informed consent was obtained prior to blood collection.

Measurement of Variables

Outcome Variable

Anemia was defined as low hemoglobin levels.

Explanatory Variable

According to literature and biological understanding, explanatory variables were incorporated into the analysis, including various socioeconomic, demographic, and health factors associated with WRA, as well as children's nutritional status. Common associated factors included maternal age and education, household economic status (wealth quintile), food insecurity, dietary intake, micronutrient deficiencies, worm infestation, women's BMI, reproductive determinants, and other laboratory investigations.

Statistical Analysis

All data analyses were conducted in STATA version 18. Since anemic status was the primary outcome measure, women and children with available hemoglobin results were included in the study analysis. The frequencies, along with percentages, were reported for selected predictors. The analysis started with a simple univariate analysis followed by a multivariate logistic regression. Unadjusted odds ratios with their 95% CIs were reported for the bivariate analysis. Variables significant at $p<0.25$ were considered for inclusion in the multivariate model. The Type 1 error was set at 0.05. The model estimates are presented as adjusted odds ratios (AORs) with 95% CIs.

Results

Characteristics of Women of Reproductive age (WRA,15-49 Years)

A total of 500 women of reproductive age (15-49 years) were enrolled for this study in six districts of the GBAO region, among all districts, Shugnan exhibited one-fifth of WRA in the region; conversely, other districts demonstrated an equal proportion. In particular, WRAs in the 30-34 age group were the highest (32.8%) among the sampled population (Table 1), whereas only 2.6% were identified in the 45-49 age group. Most of these women were married (97.8%), and 40.2% had higher education. In terms of occupation, the majority of WRA reported as a formal employee (39.4%). In contrast, nearly one-third of women were reported to be unemployed (28.2%), and one-fourth of WRA were reported to be housewives (24.8%).

When exploring housing characteristics, approximately 79% had access to improved drinking water sources. However, the majority of households (91.8%) had access to improved sanitation facilities. In addition, the food insecurity status indicated that 41.6% of households were food secure; conversely, 13.2% were moderately food insecure

Table 1. Background characteristics of women of reproductive age (15-49 years).

Women’s background characteristics	
	Overall
Total	500
District:	
Roshtkala	80 (16.0%)
Shugnan	100 (20.0%)
Ishkashim	80 (16.0%)
Murghob	80 (16.0%)
Rushan	80 (16.0%)
Khorog town	80 (16.0%)
Age groups:	
20-24	26 (5.2%)
25-29	107 (21.4%)
30-34	164 (32.8%)
35-39	124 (24.8%)
40-44	66 (13.2%)
45-49	13 (2.6%)
Currently Married:	
Yes	489 (97.8%)
No	11 (2.2%)
Education:	
None	1 (0.2%)
Incomplete secondary (grade 9)	24 (4.8%)
Secondary (grade 11)	165 (33.0%)

Technical college	98 (19.6%)
Incomplete higher education	10 (2.0%)
Higher education	201 (40.2%)
Others	1 (0.2%)
Occupation:	
University student	2 (0.4%)
Housewife	124 (24.8%)
Trader (shop, market)	5 (1.0%)
Business	3 (0.6%)
Self-employed in agriculture and non-agriculture sector	14 (2.8%)
Formal employee	197 (39.4%)
NGO employee	9 (1.8%)
Seasonal worker	2 (0.4%)
Unemployed	141 (28.2%)
Retired	1 (0.2%)
Others	2 (0.4%)
Household Characteristics	
<i>Drinking Water Sources</i>	
Improved sources	396 (79.2%)
Unimproved sources	104 (20.8%)
<i>Sanitation Facilities</i>	
Improved sanitation facility	459 (91.8%)
Unimproved sanitation facility	41 (8.1%)
<i>Food Insecurity Status</i>	
Food Secure	208 (41.6%)
Mild food insecure	111 (22.2%)
Moderate food insecure	66 (13.2%)
Severe food insecure	115 (23.0%)

Of the enrolled women of reproductive age, 473 women were assessed for anemia. Among the districts of the GBAO region, 20.0% of WRA in Shugnan had anemia; conversely, Ishkashim (12.0%) reported the lowest proportion of women with anemia. It was noticed that among the social class of enrolled women, mothers belonging to the middle class (22.1%) suffered from anemia than the richest class.

Moreover, we found that nearly one-fourth (23.1%) of Women of Reproductive Age (WRA) who suffered from anemia were younger than 25 years old. In contrast, older women aged 45-49 years had the lowest prevalence, with only 8.3% suffering from anemia.

Almost half of the enrolled WRA had low ferritin levels (51.9%), which contributed to their anemia. In addition, 46.0% of women had elevated serum transferrin receptor (STFR) levels. Furthermore, nearly 18.2% women who experienced food insecurity were also found to be anemic. Maternal education showed almost similar proportions in anemic women, with them being less educated (16.5%) than those who achieved higher education (18.6%). Moreover, nearly one-fifth (17.2%) of women who received antenatal care (ANC) were observed to be anemic.

Factors Associated with Anemia (Women of Reproductive age 15-49 Years)

Table 2 presents the bivariate and multivariable analyses of the association between various factors of anemia among WRA (15-49 years) in the GBAO region. Among socioeconomic factors, districts, wealth quintiles, and household food insecurity do not show any association with anemia.

Table 2. Factors associated with anemia among non-pregnant women at age 15-49 years.

	N	Anemia (<12 gm/dL)	Normal (>= 12 gm/dL)	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Total	473	N=82(17.3%)	N=391(82.7%)				
Household factors							
District							
Roshtkala	75	15 (20%)	60 (80%)	Ref.			
Shugnan	94	19 (20%)	75 (80%)	1.013 (0.475-2.161)	0.973		
Ishkashim	78	9 (12%)	69 (88%)	0.522 (0.213-1.278)	0.155		
Murghob	67	12 (18%)	55 (82%)	0.873 (0.376-2.027)	0.752		
Rushan	79	12 (15%)	67 (85%)	0.716 (0.311-1.652)	0.434		
Khorog town	80	15 (19%)	65 (81%)	0.923 (0.416-2.048)	0.844		
Wealth Index(quintiles)							
Poorest	193	29 (15.0%)	164 (85.0%)	0.845 (0.488-1.463)	0.549		
Middle	95	21 (22.1%)	74 (77.9%)	1.357 (0.733-2.513)	0.332		
Richest	185	32 (17.3%)	153 (82.7%)	Ref.			
Household food insecurity							
Food Secure	198	32 (16.2%)	166 (83.8%)	Ref.			
Food Insecure	275	50 (18.2%)	225 (81.8%)	1.153 (0.708-1.876)	0.567		
Maternal factors							
Age groups							
20-24	26	6 (23.1%)	20 (76.9%)	Ref.		Ref.	
25-29	99	18 (18.2%)	81 (81.8%)	0.741 (0.26-2.107)	0.574	0.406 (0.092-1.788)	0.233
30-34	161	28 (17.4%)	133 (82.6%)	0.702 (0.258-1.906)	0.487	0.51 (0.126-2.07)	0.346
35-39	112	21 (18.8%)	91 (81.3%)	0.769 (0.275-2.151)	0.617	0.914 (0.211-3.959)	0.904
40-44	63	8 (12.7%)	55 (87.3%)	0.485 (0.15-1.571)	0.228	0.817 (0.156-4.287)	0.812
45-49	12	1 (8.3%)	11 (91.7%)	0.303 (0.032-2.85)	0.296	-	
Maternal Education							
Less than Higher education	285	47 (16.5%)	238 (83.5%)	0.863 (0.533-1.398)	0.550		
Higher and above education	188	35 (18.6%)	153 (81.4%)	Ref.			
Body Mass Index							
Normal	291	58 (19.9%)	233 (80.1%)	Ref.		Ref.	
Under wight	42	7 (16.7%)	35 (83.3%)	0.803 (0.34-1.901)	0.618	1.426 (0.405-5.016)	0.581
Overweight	100	11 (11.0%)	89 (89.0%)	0.497 (0.249-0.989)	0.046	0.314 (0.118-0.833)	0.020
obese	38	6 (15.8%)	32 (84.2%)	0.753 (0.301-1.887)	0.545	0.479 (0.111-2.069)	0.324

Minimun Dietry Diversity for Women							
MDDW>=5	346	60 (17.3%)	286 (82.7%)	Ref.			
MDDW<5	127	22 (17.3%)	105 (82.7%)	0.999 (0.584-1.709)	0.996		
Iron folic acid supplementation							
Yes	385	67 (17.4%)	318 (82.6%)	Ref.			
No	88	15 (17.0%)	73 (83.0%)	0.975 (0.527-1.804)	0.936		
ANC visit							
Yes	436	75 (17.2%)	361 (82.8%)	Ref.			
No	37	7 (18.9%)	30 (81.1%)	1.123 (0.476-2.653)	0.791		
Number of pregnancies							
<4	281	55 (19.6%)	226 (80.4%)	Ref.		Ref.	
>=4	192	27 (14.1%)	165 (85.9%)	0.672 (0.407-1.111)	0.122	0.326 (0.141-0.758)	0.009
Number of deliveries							
<4	376	66 (17.6%)	310 (82.4%)	Ref.			
>=4	97	16 (16.5%)	81 (83.5%)	0.928 (0.51-1.688)	0.806		
Ferritin							
Low Ferritin (<12 ng/mL)	79	41 (51.9%)	38 (48.1%)	13.05 (6.973-24.424)	<0.001	8.549 (3.791-19.276)	<0.001
Normal (>=12 ng/mL)	275	21 (7.6%)	254 (92.4%)	Ref.		Ref.	
Folic acid							
Deficient (<3 ng/ml)	241	41 (17.0%)	200 (83.0%)	1.058 (0.614-1.823)	0.840		
Not Deficient (>=3 pg/ml)	154	25 (16.2%)	129 (83.8%)	Ref.			
Transferrin receptor levels							
Normal (<=4.4)	317	30 (9.5%)	287 (90.5%)	Ref.			
Elevated (>4.4 mg/L)	87	40 (46.0%)	47 (54.0%)	8.142 (4.628-14.325)	<0.001	4.817 (2.107-11.014)	<0.001
Vitamin B12							
Deficient (<191 pg/ml)	47	4 (8.5%)	43 (91.5%)	0.409 (0.142-1.178)	0.098	0.18 (0.033-0.998)	0.050
Not Deficient (>=191 pg/ml)	367	68 (18.5%)	299 (81.5%)	Ref.		Ref.	
Worm infestation							
Worm infestation	66	9 (13.6%)	57 (86.4%)	0.772 (0.364-1.638)	0.501		
No Worm infestation	383	65 (17.0%)	318 (83.0%)	Ref.			

Among maternal factors, age groups were not statistically significant. However, the likelihood of anemia appeared to increase with age. As age increased, the odds of anemia among women aged 35-39 years were 8.6% lower (OR 0.914, p-value 0.904). Similarly, the odds for women in the 40-44 age bracket showed a negative association (OR 0.817, p-value 0.912) when compared to women in the 20-24 age bracket.

The nutritional status of WRA, as characterized by body mass index, showed a positive association. Overweight women showed a statistically significant difference (OR 0.314, p-value 0.020) compared with mothers with a normal BMI. Women who had four or more pregnancies also have a positive association (OR 0.326, p-value 0.009) compared to women with fewer than four pregnancies.

Additionally, we observed a robust association between low ferritin levels and anemia. Women with low ferritin levels were 8.549 times more likely to be anemic than those with normal ferritin levels (OR 8.549, P value <0.001). Elevated serum transferrin receptor (STFR) levels also indicated a higher odd of anemia in women than in those with normal STFR levels, with this association being statistically significant (OR 4.817, P value <0.001). In examining other micronutrient deficiencies, a significant association was found between vitamin B12 deficiency and anemia. Women with vitamin B12 deficiency had an increased likelihood of anemia (OR 0.18, P value 0.050) compared to those with normal vitamin B12 levels.

Other factors that did not show any association include maternal education, minimum dietary diversity, Iron-Folic supplementation, antenatal visits, number of deliveries (parity), and helminth infestations. Table 2 Factors associated with anemia among non-pregnant women at age 15-49 years.

Characteristics of Pre-School Age Children (PSC,6-59 Months)

Approximately 500 pre-school age children (PSC, aged 6-59 months) were enrolled in the anemia study from various districts in the GBAO region. About one-fifth of these PSC belonged to the Shugnan district, while the remaining districts exhibited an equal distribution. Regarding gender distribution, there was a nearly even split between male (50.4%) and female (49.6%) children. The 36-47 months age group had the highest representation, while only 8.2% fell within the 6-11 months bracket.

Table 3. Background characteristics of PSC-6-59 months.

Total	Overall 500 (100.0%)
District:	
Roshtkala	80 (16.0%)
Shugnan	100 (20.0%)
Ishkashim	80 (16.0%)
Murghob	80 (16.0%)
Rushan	80 (16.0%)
Khorog town	80 (16.0%)
Gender:	
Male	252 (50.4%)
Female	248 (49.6%)
Age groups:	
6-11 months	41 (8.2%)
12-17 months	55 (11.0%)
18-23 months	64 (12.8%)
24-35 months	116 (23.2%)
36-47 months	122 (24.4%)
48-59 months	102 (20.4%)

A total sample of 390 pre-school age children (6-59 months) were assessed for anemia, district-specific data reveals nearly one-fifth (19%) of anemic children in Roshtkala , whereas the lowest proportion was reported by Rushan. Of the selected PSCs (6-59 months), nearly one-third (36.8%) were reported to be anemic, with their mothers belonging to the 20-24 age bracket. In addition, a higher proportion of anemia was seen in PSC (6-59 months) born to mothers with less education (18.1%) than those born to mothers with higher education (11.7%). Furthermore, 33.8% of children born to mothers with low maternal hemoglobin (<12g/dl) were reported anemic; in addition, around one fourth (25.4%) of children were born to mothers with low ferritin levels. When assessing anemia by gender, a substantial difference was observed: male children had a higher anemia rate (17.0%) than female children (13.9%). In addition, nearly one fourth (26.5%) of children less than 2 years old were reported with anemia. Moreover, around one third (32.0%) of children were reported to have low ferritin levels. It was further noted that a significant number of children were categorized as having vitamin B12 (85.7%) and folic acid (84.6%) deficiency.

Factors Associated with Anemia (PSC- 6-59 Months)

Table 4 represents no association between household factors. However, the odds of getting anemia among PSC (6-59 months) born to mothers aged 45-49 years were 7.17 times higher (OR 7.174, P value 0.140) than those born to mothers in the 20-24 age bracket. In addition, it was noted that maternal education and maternal hemoglobin were significantly associated; the odds of anemia in children born to less educated mothers were more than twice those of children born to educated mothers (OR 2.35, P value 0.029); however, the association remained significant. Similarly, maternal hemoglobin was significantly associated with anemia among the children (OR 4.998, P value 0.001). Furthermore, children born to mothers with low ferritin levels had a 34.5% lower likelihood of developing anemia (OR 0.655, p value 0.380) than those born with normal ferritin levels. Moreover, the association between body mass index was found to be insignificant. PSC (6-59 months) born to overweight mothers (OR 0.554, p value 0.203) showed a negative association compared to those born to mothers with a normal body mass index.

Other anemia-associated risk factors in children were age groups and ferritin levels. It was observed that the odds of developing anemia in children under 2 years were more than 2 times higher (OR 2.6, p value 0.016) than in older children (24-59 months), thereby showing statistical significance. It is worth noting that a strong association between anemia and ferritin was observed in PSC; however, the association remained statistically significant (OR 5.67, p value <0.001). Furthermore, the association with other factors that remained insignificant included vitamin B12, folic acid, stunting, wasting, and helminthic infestations.

Table 4. Factors associated with anemia among preschool-age children (6-59 months).

Characteristics	N	Anemia (<11 gm/dL)	Normal (>= 11 gm/dL)	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
	390	N=60(15.4%)	N=330(84.6%)				
Household factors							
District							
Roshtkala	72	14 (19%)	58 (81%)	Ref.			
Shugnan	66	9 (14%)	57 (86%)	0.654 (0.262-1.631)	0.363		
Ishkashim	60	10 (17%)	50 (83%)	0.829 (0.338-2.028)	0.681		
Murghob	35	6 (17%)	29 (83%)	0.857 (0.298-2.462)	0.775		
Rushan	79	10 (13%)	69 (87%)	0.6 (0.248-1.453)	0.258		
Khorog town	78	11 (14%)	67 (86%)	0.68 (0.287-1.614)	0.382		
Wealth Index(quintiles)							
Two poorest	168	26 (15.5%)	142 (84.5%)	0.971 (0.527-1.789)	0.925		
Middle	77	11 (14.3%)	66 (85.7%)	0.884 (0.406-1.926)	0.756		
Two Richest	145	23 (15.9%)	122 (84.1%)	Ref.			
Household food insecurity							
Food Secure	159	25 (15.7%)	134 (84.3%)	Ref.			
Food Insecure	231	35 (15.2%)	196 (84.8%)	0.957 (0.548-1.673)	0.878		
Maternal factors							
Maternal Age groups							
20-24	19	7 (36.8%)	12 (63.2%)	Ref.		Ref.	
25-29	83	11 (13.3%)	72 (86.7%)	0.262 (0.085-0.809)	0.020	0.799 (0.16-3.99)	0.784
30-34	132	18 (13.6%)	114 (86.4%)	0.271 (0.094-0.778)	0.015	0.636 (0.139-2.898)	0.558
35-39	93	13 (14.0%)	80 (86.0%)	0.279 (0.093-0.838)	0.023	0.551 (0.117-2.589)	0.450
40-44	54	8 (14.8%)	46 (85.2%)	0.298 (0.09-0.987)	0.048	0.519 (0.094-2.846)	0.450
45-49	9	3 (33.3%)	6 (66.7%)	0.857 (0.161-4.554)	0.856	7.174 (0.525-98.092)	0.140
Maternal Education							
Less than Higher education	227	41 (18.1%)	186 (81.9%)	1.671 (0.93-3.001)	0.086	2.35 (1.09-5.07)	0.029
Higher and above education	163	19 (11.7%)	144 (88.3%)	Ref.		Ref.	
Maternal Haemoglobin							
Anemia deficiency (<12 gm/dL)	65	22 (33.8%)	43 (66.2%)	3.797 (2.052-7.025)	<0.001	4.998 (2.019-12.373)	0.001

Normal (≥ 12 gm/dL)	320	38 (11.9%)	282 (88.1%)	Ref.		Ref.	
Maternal Ferritin							
Low Ferritin (<12 ng/mL)	67	17 (25.4%)	50 (74.6%)	1.599 (0.81-3.156)	0.176	0.655 (0.255-1.684)	0.380
Normal (≥ 12 ng/mL)	233	34 (14.6%)	199 (85.4%)	Ref.		Ref.	
Body Mass Index							
Normal	230	41 (17.8%)	189 (82.2%)	Ref.		Ref.	
Under wight	34	4 (11.8%)	30 (88.2%)	0.615 (0.205-1.84)	0.384	0.42 (0.091-1.93)	0.265
Overweight	91	10 (11.0%)	81 (89.0%)	0.569 (0.272-1.191)	0.135	0.554 (0.223-1.376)	0.203
Obese	33	5 (15.2%)	28 (84.8%)	0.823 (0.3-2.259)	0.706	0.516 (0.136-1.958)	0.331
Child's factors							
Gender							
Male	188	32 (17.0%)	156 (83.0%)	Ref.			
Female	202	28 (13.9%)	174 (86.1%)	0.784 (0.452-1.361)	0.388		
Age groups							
<24 months	102	27 (26.5%)	75 (73.5%)	2.782 (1.573-4.919)	<0.001	2.6 (1.197-5.647)	0.016
≥ 24 months	288	33 (11.5%)	255 (88.5%)	Ref.		Ref.	
Ferritin							
Low Ferritin (<12 ng/mL)	77	24 (32.0%)	51 (68.0%)	5.429 (2.901-10.157)	<0.001	5.67 (2.647-12.145)	<0.001
Normal (≥ 12 ng/mL)	252	20 (9.7%)	187 (90.3%)	Ref.		Ref.	
Vitamin B12							
Deficient (<191 pg/ml)	28	24 (85.7%)	4 (14.3%)	0.861 (0.286-2.594)	0.790		
Not Deficient (≥ 191 pg/ml)	296	248 (83.8%)	48 (16.2%)	Ref.			
Folic acid							
Deficient (<3 ng/ml)	272	230 (84.6%)	42 (15.4%)	0.913 (0.358-2.328)	0.849		
Not Deficient (≥ 3 pg/ml)	36	30 (83.3%)	6 (16.7%)	Ref.			
Stunting (Height for Age)							
Normal	311	50 (16.1%)	261 (83.9%)	Ref.			
Stunting	60	8 (13.3%)	52 (86.7%)	0.803 (0.36-1.794)	0.593		
Under weight (Weight-for-age)							
Normal	345	55 (15.9%)	290 (84.1%)	Ref.			
Under weight	33	4 (12.1%)	29 (87.9%)	0.727 (0.246-2.151)	0.565		
Wasting (Weight-for-length/height)							
Normal	365	58 (15.9%)	307 (84.1%)	Ref.			
Wasting	13	1 (7.7%)	12 (92.3%)	0.441 (0.056-3.458)	0.436		



Worm infestation					
Worm infestation	133	22 (16.5%)	111 (83.5%)	1.213 (0.676-2.174)	0.518
No Worm infestation	242	34 (14.0%)	208 (86.0%)	Ref.	
Ever given Iron Syrup in the last six months					
Yes	260	42 (16.2%)	218 (83.8%)	Ref.	
No	130	18 (13.8%)	112 (86.2%)	0.834 (0.459-1.516)	0.552

Discussion

The prevalence of anemia in our study among WRA (15-49years) and PSC (6-59months) was found to be lower (17.3% and 15.4%, respectively), than the reported findings in the GBAO province (WRA 31.8% and PSC 43.4%) as per the NNS 2016 Tajikistan [14]. Among the significant results, low ferritin levels and elevated serum transferrin receptor (STFR) levels were strongly associated with anemia in WRA; however, in PSC (6-59 months), exploring maternal factors revealed a strong statistical association with less educated mothers and maternal anemia. In addition, children under 24 months of age showed a more than 2-fold higher risk of developing anemia as compared to the children in the 24-59 age bracket. Similar findings related to anemia were found to be consistent in Bangladesh, where children less than two years old were found to be at risk [16]. It is worth noting that low ferritin levels in children were also associated with a stronger anemia in this study.

Among other significant factors, a statistically significant association was observed in women with vitamin B12 deficiency. Moreover, it was observed that WRA body mass index (BMI) was associated with anemia. In contrast, higher-than-normal BMI in women was found to be statistically significant. However, women with four or more pregnancies showed substantial results.

As discussed earlier, low ferritin levels in both WRA and preschoolers (6-59 months) were associated with a higher prevalence of anemia. Serum ferritin levels correlate well with total body iron stores [17]. A study conducted in Gambia demonstrated that low ferritin levels were associated with anemia in WRA and in children under 5 years of age. [5]. In one of the studies in rural parts of India, comparable to our findings, low ferritin levels in preschoolers showed a positive association with anemia [18]. Moreover, our study revealed that children born to mothers with less maternal education and maternal anemia had a significant risk of being anemic. Another survey of anemia in children from India and Bangladesh showed consistent results of maternal anemia and less maternal education, which also showed a strong association [16,18]. Globally, nutrition efforts strongly prioritize the first 1000 days as a critical window period for growth and development, which is a significant issue in the early days of a child's life [18]. According to another study in Uzbekistan, the prevalence of low ferritin levels in WRA was reported to be the highest in the region of Karakalpakstan with (63.9%) [19], which is close to our findings in WRA (51.9%) in GBAO, Tajikistan.

Another study from Pakistan (NNS 2018) found low ferritin levels among children under 5 years of age; therefore, risk factors for iron deficiency anemia in children under five were identified. [20]. Iron deficiency anemia can also be developed in conditions like stomach ulcers, or any sources of slow, chronic bleeding (colon cancer, uterine cancer, hemorrhoids, intestinal polyps etc.) [17]. Another study elsewhere reported that individuals with inflammatory conditions such as chronic heart failure, chronic kidney disease, or inflammatory bowel disease can also have a high risk of iron deficiency [21]. A study conducted in Sweden also showed that low ferritin levels were associated with the risk of developing inflammatory bowel syndrome [22].

Of the other significant results mentioned above, elevated STFR levels showed a high prevalence and strong association with anemia in WRA. Serum transferrin receptor (STFR) is another indicator of iron status, as it is derived from developing red blood cells and reflects the intensity of erythropoiesis and the demand for iron. As the iron stores are exhausted, the concentration of STFR is significantly increased in iron deficiency anemia, which indicates severe iron insufficiency [17]. Clinical studies have shown that STFR is less affected by inflammation than serum ferritin. STFR is a specific marker for iron deficiency that enables the estimation of functional iron deficit once the iron stores are depleted [17].

As discussed above, the other nutritional deficiencies identified in this study also showed that vitamin B12 deficiency was associated with an increased risk of anemia, which is one of the etiological factors of anemia. It is essential to understand that anemia caused by vitamin B 12 often goes unnoticed and unaddressed [23]. Another anemia study conducted in northern India showed a substantial number of women were reported to have a vitamin B12 deficiency [23]. A few other previous anemia studies conducted in Sri Lanka among WRA also demonstrated a low prevalence of

B12 deficiency [24]. Another study, elsewhere, demonstrated that patients suffering from impaired absorption also had vitamin B deficiencies [25]

This study aims to highlight the need to implement policies and programs that support interventions such as micronutrient supplementation, food fortification, and maternal education and prevention of infectious diseases among children under 5 years and WRA in the GBAO region, Tajikistan. The strength of this study is the adjustment of altitude for serum hemoglobin and serum ferritin adjusted for inflammation by using CRP and AGP biomarkers. However, it is essential to consider multiple limitations; a small sample size can affect research outcomes, limiting the generalizability of the results to a larger population [26]. In addition, altitude dwellings were the second most apparent limitation of this study; further, the mountain communities are identified as the most vulnerable to climate change. Mountain societies in developing and low-income countries (LMICs) are susceptible to the constraints imposed by their natural environments and geographical locations [27]. Yet another study identified the central Asian countries of Tajikistan and Kyrgyzstan as vulnerable to climate [27]. It was further revealed that most mountain communities reside in Tajikistan's southeastern region, specifically in the GBAO province [27].

Conclusions

Our study revealed that anemia was significantly associated with low ferritin, elevated STFR, higher gravidity, vitamin B12 deficiency, and higher BMI in women. Among children <5 years, anemia was associated with low ferritin levels, age <2 years, maternal anemia, and lower maternal education. These factors likely contribute to poor maternal and fetal outcomes. The relative roles of nutritional causes (iron and other micronutrient deficits) versus non-nutritional causes (infections, environmental factors, hemoglobinopathies) remain unclear. We therefore recommend large-scale micronutrient supplementation, food fortification, maternal education, and family planning initiatives, along with short- and long-term community- and facility-based interventions. Further research should define the primary causes—iron deficiency, other nutritional deficiencies, diseases/infections, and hemoglobinopathies—to better target prevention for mothers and children.

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