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Analysis of Nutritional Intake Determinants and Anemia Incidence in Adolescent Girls in Senior High Schools in Bone Bolango Regency

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ABSTRACT

Introduction: Anemia is a pathological state defined by a reduction in red blood cell mass, evidenced by decreased hemoglobin concentrations (<11 g/dL), hematocrit values, and erythrocyte counts. Preliminary data indicate that out of 3,073 adolescents screened for hemoglobin levels in Bone Bolango Regency, 225 were identified as anemic. This study aims to investigate the factors contributing to the prevalence of anemia among female high school students in this regency.
Method: This study was carried out in three schools in Tapa District, using a quantitative research design. The sample comprised 225 adolescent girls of reproductive age. Logistic regression analysis was used to examine the relationships between anemia incidence and several independent variables, including iron tablet consumption, iron intake, protein intake, vitamin C intake, vitamin B12 intake, zinc intake, meal frequency, and dietary diversity.
Results: The findings indicated that among the adolescent female population in Bone Bolango Regency, 77 individuals were anemic, whereas the remaining 148 presented with normal hemoglobin levels. Bivariate analysis revealed that iron intake was the only variable significantly associated with the occurrence of anemia, with no other factors demonstrating a statistically significant relationship.
Conclusion: This study demonstrates that iron intake is the primary determinant significantly associated with anemia among adolescent girls, showing a stronger influence than other nutritional factors and variables examined in the study.

Keywords: Adolescent girls, anemia, dietary diversity, iron intake, meal frequency

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Introduction

Anemia is defined as a reduction in red blood cell parameters, marked by hemoglobin levels below 11 g/dL.[1] Iron Deficiency Anemia (IDA) remains a global public health challenge, affecting approximately two billion individuals, 80% of whom reside in developing nations. Among pediatric populations, IDA impacts roughly 300 million children aged 6–59 months,[2] while anemia affects an estimated 600 million preschool and school-aged children globally. Although the prevalence among school-aged children declined from 18.8% in 1995 to 9.9% in 2010, the burden persists.[3]

Anemia remains a significant public health issue in Indonesia, particularly among young women. According to the 2023 National Health Survey (Survey Kesehatan Indonesia, SKI), the prevalence among adolescents aged 15–24 years stands at 14.6%, compared to 27.7% in pregnant women.[4] This burden is further emphasized by Riskesdas data, which reports that 30.2% of women of reproductive age experience anemia, with the prevalence peaking at 32% among adolescents aged 15–24 years.[5]

The prevalence of anemia among adolescent girls is 26.50%, while among women of reproductive age (WRA) it reaches 26.9%, indicating that anemia remains a significant public health issue in Indonesia.[6] Current prevention and control efforts are largely directed toward pregnant women, whereas early preventive measures targeting adolescent girls, who represent future mothers, have received relatively limited attention. Prioritizing preventive strategies among adolescents before they enter marriage may enhance the effectiveness and efficiency of anemia prevention programs.[7]

The high prevalence of anemia is predominantly attributed to inadequate intake of iron tablets and essential nutrients, including protein, vitamin C, vitamin B12, and zinc, relative to daily requirements. This nutritional deficit can be mitigated through dietary incorporation of iron-rich animal and plant-based foods.[8] Preliminary data from the Bone Bolango Regency Central Bureau of Statistics (BPS) for 2023 indicate that among 3,073 adolescents screened between January and September 2023, 224 were identified as anemic. Accordingly, this study aims to examine factors influencing anemia incidence among female high school students in the regency.

Methods

This quantitative cross-sectional study was conducted from January to May 2025 at three educational institutions in Tapa District: SMK Negeri 1 Bulango Selatan, SMA Negeri 1 Tapa, and Madrasah Aliyah Hubulo. All procedures of this research have been approved by the supervisor and comply with health research ethics which consist of respondent consent,

confidentiality, not harming respondents and fairness.

The target population consisted of 515 female students, from which the sample size was determined using the Slovin formula:[9]

$$n = \frac{\mathrm{N}}{1 + \mathrm{N(e)2}}$$

$$n = \frac{515}{1 + 515\ (5\%)2}$$

$$n = \frac{515}{1 + 515 \text{ x } 0{,}0025}$$

$$n = \frac{515}{2{,}2875} = 225 \text{ Respondents}$$

Based on this formula, a sample size of 225 was obtained. Proportional stratified random sampling was also used to determine the sample size from each school.

$$\frac{\text{Number of Teenagers in Each School}}{\text{Total Population}} x\ Number\ of\ Sample$$

Thus, the sample determination can be described as follows:

1) SMK Negeri 1 Bulango Selatan

$n_1 = \frac{216}{515}$ x 225 = 94 *Samples*

2) SMA Negeri 1 Tapa

$n_2 = \frac{256}{515}$ x225 = 112 *Samples*

3) Madrasah Aliyah Hubulo

$n_3 = \frac{43}{515}$ x 225 = 19 *Samples*

This study used both primary and secondary data sources. Primary data was obtained from observations, interviews, and questionnaires filled out by respondents, while secondary data was obtained from anemia case data in Bone Bolango Regency.

To ensure methodological transparency, the metrics and objective criteria used to measure the research variables are summarized in Table 1.

Data analysis proceeded in three stages. Univariate analysis was employed to describe participant characteristics, including age, class, school, anemia status, compliance with iron supplementation, nutrient intake (iron, protein, vitamin C, vitamin B12, zinc), eating frequency, and dietary diversity. Bivariate analysis using the chi-square test ($\alpha = 0.05$) examined associations between anemia incidence and each independent variable.

Subsequently, multivariate analysis was conducted to identify the factors most strongly associated with anemia.

Table 1. Operational definition and criteria of variables

No	Variable	Definition	Measuring Instrument	Criteria	Scale
1	**Dependent Variable** Anemia incident	A condition where the hemoglobin level in the blood is <12 mg/dl based on a blood test	Direct examination using the Finger Prick Method using a Hemoglobin measuring tool, the Easy Touch brand.	1.Anemia (If Hb Level< 12. mg/dL).[10]	Nominal
2	**Independent Variable** Consuming Iron Tablet	Taking supplemental iron tablets consisting of 60 mg of elemental iron and 0.400 mg of folic acid. Each adolescent is given four iron tablets per month, with the dosage being one tablet per week.[11]	questionnaires	1.Taking Iron Tablets, if the student is compliant with taking 4 Iron tablets per month. 2.Not taking Iron Tablets, if the student is compliant with taking ≥ 4 Iron tablets per month.[12]	Nominal
3	Fe Intake	The amount of iron in food consumed in 1 day is obtained from the results of a 24-	Food recall 1 x 24 Hour	1.Sufficient (≥80% RDA). 2.Insufficient (<80 % RDA).[14]	Ordinal

		hour recall and then compared with the RDA.[13]			
4	Protein Intake	The amount of protein in food consumed in 1 day is obtained from the results of a 24-hour recall and then compared with the RDA.[15]	Food recall 1 x 24 Hour	1.Sufficient (≥80% RDA). 2.Insufficient (<80% RDA).[14]	Ordinal
5	Vitamin C Intake	The amount of vitamin C in food consumed in 1 day is obtained from the results of a 24-hour recall and then compared with the RDA.[16]	Food recall 1 x 24 Hour	1.Sufficient (≥80% RDA). 2.Insufficient (<80% RDA).[14]	Ordinal
6	Vitamin B12 Intake	The amount of vitamin B12 in food consumed in one day is obtained from a 24-hour recall and then compared with the RDA.[13]	Food recall 1 x 24 Hour	1.Sufficient (≥50% RDA). 2.Insufficient (<50% RDA).[14]	Ordinal
7	Zinc Intake	The amount of zinc in food consumed in one day is obtained from a 24-hour recall and then	Food recall 1 x 24 hour	1.Sufficient (≥80% RDA). 2.Insufficient (<80% RDA).[14]	Ordinal

		compared with the RDA.[17]			
8	Meal Frequency	Daily eating frequency seen based on breakfast, lunch and dinner times.[18]	Food Frequency Questionnaire (FFQ)	1. Frequently ≥ 3 time per day. 2. Rarely < 3 time per day.[18]	Ordinal
9	Food Diversity	Dietary diversity is the number of different types of food consumed in a day.[19]	Food recall 1 x 24 hour	1. Diverse : ≥ 4 types. 2. Not Diverse : < 4 types.[19]	Ordinal

RDA: Recommende dietary allowance

Result

The respondents in this study were characterized by three variables: age, grade level, and school of origin, with a total of 225 female students. As shown in Table 2, the largest proportion of respondents was aged 17 years, with 82 individuals (36.4%), while the smallest proportion was in the 15-year-old age group, with 6 individuals (2.6%). Most participants were in grade XI, with 129 students (57.3%), and no respondents were from grade XII. In terms of school distribution, most respondents were from SMA Negeri 1 Tapa, with 112 students (50.2%), followed by 94 students from SMK Negeri 1 Bulango Selatan and 19 students from Madrasah Aliyah Hubulo.

Distribution of factors influencing anemia incidence among adolescent female students

Frequency distribution analysis was conducted on the questionnaire data to describe the distribution of respondents based on the variables under study (Table 3). The findings revealed that the sample provided information related to the incidence of anemia, iron tablet consumption, dietary intake of iron, protein, vitamin C, vitamin B12, and zinc, as well as meal frequency and dietary diversity. As presented in Table 3, among the 225 respondents, 148 individuals (65.8%) were classified as non-anemic, while the remaining 77 respondents (34.2%) were identified as anemic. Regarding iron tablet consumption, the majority of respondents (n = 196; 87.1%) reported not consuming iron supplements, whereas 29 respondents (12.9%) reported regular consumption. In terms of iron intake, 161 respondents (71.6%) were found to have inadequate iron consumption, while 64 respondents (28.4%) met

the recommended intake. Protein intake was adequate among 145 respondents (64.4%), while the remaining 80 respondents (35.6%) had insufficient protein intake. Regarding vitamin C, only 71 respondents (31.6%) demonstrated adequate intake, whereas 154 respondents (68.4%) were categorized as insufficient. Vitamin B12 intake was sufficient in the majority of respondents (n = 160; 71.1%), with the remaining 65 respondents (28.9%) categorized as insufficient. Zinc, an essential micronutrient, was inadequately consumed by 154 respondents (68.4%), while 71 respondents (31.6%) achieved adequate zinc intake. In terms of eating frequency, 144 respondents (64.0%) reported regular meal patterns, while the remaining 81 respondents (36.0%) were categorized as having infrequent meals. Dietary diversity was observed in 98 respondents (43.6%), whereas the majority (n = 127; 56.4%) had a less diverse dietary pattern.

Table 2. Baseline characteristics of respondents

Aspect	Frequency (N=225)	Percentage (%)
Age		
15	6	2.6
16	56	24.8
17	82	36.4
18	66	29.3
19	15	6.67
Grade		
X	96	42.6
XI	129	57.3
XII	0	0
School of Origin		
SMA Negeri 1 Tapa	112	50.2
SMK Negeri 1 Bulango Selatan	94	41.3
Madrasah Aliyah Hubulo	19	8.4

Relationship between iron tablet consumption and anemia incidence among female adolescents in senior high schools in Bone Bolango Regency

Based on Table 4, among the 29 respondents who consumed iron tablets, 20 individuals (13.51%) were not anemic. Among the 196 respondents who did not consume iron tablets, 128

individuals (86.49%) were also not anemic. The results of the Chi-square test produced a *p-value* of 0.698, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H_0 was accepted, indicating that iron tablet consumption had no statistically significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Relationship between iron intake and anemia in female adolescents in senior high schools in Bone Bolango Regency

Table 5 indicates that among the 64 respondents with adequate iron intake, 49 individuals (33.11%) were not anemic. In contrast, among the 161 respondents with inadequate iron intake, 99 individuals (66.89%) were not anemic. The Chi-square test results showed a *p-value* of 0.032, which is lower than the significance level (α = 0.05). Therefore, Ha was accepted, and H_0 was rejected, indicating a significant relationship between iron intake and the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Relationship between protein intake and anemia incidence among female adolescents in senior high schools in Bone Bolango Regency

Table 6 shows that among the 145 respondents with adequate protein intake, 97 individuals (65.54%) were not anemic. Meanwhile, among the 80 respondents with inadequate protein intake, 51 individuals (34.46%) did not experience anemia. The results of the Chi-square test produced a *p-value* of 0.634, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H_0 was accepted, indicating that protein intake had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Relationship between vitamin C intake and anemia in female adolescents in senior high schools in Bone Bolango Regency

Table 7 indicates that among the 71 respondents with adequate vitamin C intake, 51 individuals (34.46%) were not anemic. Among the 154 respondents with inadequate vitamin C intake, 97 individuals (65.46%) also did not experience anemia. The Chi-square test results produced a *p-value* of 0.194, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H_0 was accepted, indicating that vitamin C intake had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Table 3. Descriptive factors influencing anemia incidence among adolescent female students

Variable	Frequency (N=225)	Percentage
Incidence of Anemia		
Anemic	77	34.2
Non-Anemic	148	65.7
Iron Tablet Consumption		
Consumed	29	12.8
Not consumed	196	87.1
Iron Intake		
Adequate	64	28.4
Inadequate	161	71.5
Protein Intake		
Adequate	145	64.4
Inadequate	80	35.5
Vitamin C Intake		
Adequate	71	31.5
Inadequate	154	68.4
Vitamin B12 Intake		
Adequate	160	71.1
Inadequate	65	28.8
Zinc Intake		
Adequate	71	31.5
Inadequate	154	68.4
Eating Frequency		
Frequent	144	64
Infrequent	81	36
Food Diversity		
Diverse	98	43.5
Less Diverse	127	56.4

Table 4. Relationship between iron tablet consumption and the incidence of anemia (N=225)

Iron Tablet Consumption	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Not consumed	128	86.49	68	88.31	196	87.11	0.698^{NS}
Consumed	20	13.51	9	11.69	29	12.89	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Table 5. Relationship between iron intake and the incidence of anemia (N=225)

Iron Intake	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Inadequate	99	66.89	62	80.52	161	71.56	0.032*
Adequate	49	33.11	15	19.48	64	28.44	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. *significant at $P<0.05$

Table 6. Relationship between protein intake and the incidence of anemia (N=225)

Protein Intake	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Inadequate	51	34.46	29	37.66	80	35.56	0.634^{NS}
Adequate	97	65.54	48	62.34	145	64.44	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Table 7. Relationship between vitamin C intake and the incidence of anemia (N=225)

Vitamin C Intake	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Inadequate	97	65.54	57	74.03	154	68.44	0.194^{NS}
Adequate	51	34.46	20	25.97	71	31.56	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Relationship between vitamin B12 intake and anemia incidence among female adolescents in senior high schools in Bone Bolango Regency

Table 8 shows that among the 160 respondents with adequate vitamin B12 intake, 100 individuals (67.57%) were not anemic. Meanwhile, among the 65 respondents with inadequate vitamin B12 intake, 48 individuals (32.43%) did not experience anemia. The Chi-square test results produced a *p-value* of 0.104, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H₀ was accepted, indicating that vitamin B12 intake had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Table 8. Relationship between vitamin B12 intake and the incidence of anemia (N=225)

Vitamin B12 Intake	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Inadequate	48	32.43	17	22.08	65	28.89	0.104[NS]
Adequate	100	67.57	60	77.92	160	71.11	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Relationship between zinc intake and anemia incidence among female adolescents in senior high schools in Bone Bolango Regency

Table 9 indicates that among the 71 respondents with adequate zinc intake, 48 individuals (32.43%) were not anemic. Meanwhile, among the 154 respondents with inadequate zinc intake, 100 individuals (67.57%) did not experience anemia. The Chi-square test results produced a *p-value* of 0.695, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H₀ was accepted, indicating that zinc intake had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

The relationship between eating frequency and anemia incidence among female adolescents in senior high schools in Bone Bolango Regency

Table 10 shows that among the 144 respondents who reported frequent meal consumption, 97 individuals (65.54%) were not anemic. Meanwhile, among the 81 respondents who reported infrequent meal consumption, 51 individuals (34.46%) did not experience anemia. The Chi-square test results produced a *p-value* of 0.504, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H₀ was accepted, indicating that

meal frequency had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Table 9. Relationship between zinc intake and the incidence of anemia (N=225)

Zinc Intake	Anemia Incidence				N	%	*P*-value
	Non-anemic		Anemic				
	n	%	n	%			
Inadequate	100	67.57	54	70.13	154	68.44	0.695^{NS}
Adequate	48	32.43	23	29.87	71	31.56	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Table 10. Relationship between meal frequency and the incidence of anemia (N=225)

Meal Frequency	Anemia Incidence				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Inadequate	51	34.46	30	38.96	81	36.00	0.504^{NS}
Adequate	97	65.54	47	61.04	144	64.00	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Relationship between food diversity and the incidence of anemia in female adolescents in senior high schools in Bone Bolango Regency

Table 11 indicates that among the 98 respondents who consumed a varied diet, 59 individuals (39.86%) were not anemic. Meanwhile, among the 127 respondents who consumed a less varied diet, 89 individuals (60.14%) did not experience anemia. The Chi-square test results produced a *p-value* of 0.122, which is greater than the significance level (α = 0.05). Therefore, Ha was rejected, and H_0 was accepted, indicating that dietary diversity had no significant association with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency.

Correlation between iron intake and incidence of anemia

Table 12 presents the results of a multivariate analysis using logistic regression to examine the association between iron intake and the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency. Logistic regression analysis revealed that iron intake was significantly associated with the incidence of anemia (*P* = 0.033). The

negative coefficient (B = −0.716) indicates that higher iron intake is associated with a reduced likelihood of anemia. Specifically, the odds ratio (Exp(B) = 0.489) suggests that individuals with higher iron intake have a 51.1% lower risk of developing anemia compared to those with lower intake, after controlling for other variables in the model.

Table 11. Relationship between food diversity and the incidence of anemia (N=225)

Food Diversity	Incidence of Anemia				N	%	*P*-value
	Non-Anemic		Anemic				
	n	%	n	%			
Less diverse	89	60.14	38	49.35	127	56.44	0.122^{NS}
Diverse	59	39.86	39	50.65	98	43.56	
Total	**148**	**100**	**77**	**100**	**225**	**100**	

Chi-square test. NS: Not significant

Table 12. Logistic regression equation results

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	X_2	-.716	.337	4.522	1	.033	.489
	Constant	.248	.438	.320	1	.572	1,281

a. Variable(s) entered on step 1: X_2.

B: Regression coefficient, Df :Degrees of freedom of the test (1), Exp(B):Odds ratio (OR) value, S.E: Standard error of B, Sig.: *P*-value, Wald :Statistical test to test the significance of coefficient B

Discussion

Anemia incidence

Based on the findings, the majority of respondents were classified as non-anemic (n = 148; 65.8%), whereas 77 respondents (34.2%) were identified as anemic. Anemia among adolescent girls is often attributed to inadequate attention to iron intake, a daily diet lacking in iron-rich food sources, and a tendency to consume fast food or nutritionally poor foods. These observations align with the study by Akib and Sumarmi,[20] which reported that anemic adolescent girls commonly exhibit dietary habits characterized by low iron consumption.

Anemia remains one of the most prevalent nutritional disorders affecting adolescent girls. The condition, marked by reduced hemoglobin levels, manifests through symptoms such as fatigue, pallor, and diminished concentration. The substantial prevalence of anemia underscores the necessity of addressing dietary patterns, optimizing nutrient intake, and strengthening health education initiatives.[21]

The relationship between iron tablet consumption and anemia incidence

The analysis revealed no significant association between iron tablet consumption and anemia incidence. This finding may be attributed to suboptimal adherence among adolescent girls, who typically consume only two iron tablets per month rather than the recommended frequency of four times monthly. Furthermore, female students often refrain from taking iron supplements due to their unpalatable taste and perceived side effects, particularly nausea. Overall, compliance with iron supplementation remains markedly low among this population, influenced by multiple factors including boredom, laziness, and forgetfulness.

These findings are consistent with previous research by previous studies,[22] which reported that 82.2% of adolescent girls demonstrated non-compliance with iron tablet regimens prescribed by health professionals. Compliance, in this context, refers to the behavioral shift from non-adherence to adherence in accordance with established guidelines or instructions. Blood Supplement Tablets (Tablet Tambah Darah, TTD) are oral nutritional supplements formulated to enhance hematopoiesis and circulatory function. These supplements are available in tablet, caplet, or capsule form and may be obtained through two primary channels: government-managed programs or independent acquisition. The government-subsidized TTD Program distributes supplements to targeted populations via public health facilities. Conversely, independently obtained TTDs may be acquired with professional prescription or guidance from private healthcare facilities, pharmacies, or drug stores, or alternatively received as gifts from family members or other individuals.[23]

The relationship between iron intake and anemia incidence

The results demonstrated a statistically significant relationship between iron intake and anemia incidence. This association is supported by the finding that certain adolescents avoided vegetable consumption and exhibited irregular adherence to iron supplementation provided by health centers. This behavioral pattern may reflect a lack of perceived importance attributed to iron intake, potentially stemming from inadequate knowledge regarding anemia risks and preventive strategies. Additionally, approximately 35% of the study population resided independently in boarding facilities, which was associated with irregular dietary patterns.

The biological plausibility of this association can be justified where inadequate iron intake directly precipitates a decline in hemoglobin levels, thereby elevating an individual's susceptibility to anemia. These results are consistent with the findings of Warda and Fayasari, who reported that adolescent girls with poor iron intake faced a 35.283-fold higher risk of developing anemia compared to those with adequate iron consumption.[24]

The relationship between protein intake and anemia incidence

The analysis revealed no statistically significant relationship between protein intake and the incidence of anemia among adolescent girls. Several factors may contribute to inadequate protein consumption in this population. During early adolescence, females experience an accelerated growth phase that results in higher protein requirements compared to their male counterparts. However, findings from this study indicate that the types and quantities of food consumed by adolescent girls are often inconsistent with their age-specific nutritional needs. Dietary patterns observed among respondents included frequent consumption of tea or coffee, which is known to inhibit iron absorption and may indirectly affect hematological status. Additionally, some participants reported limited food availability at home, characterized by insufficient portions of staple foods and side dishes, or meals consisting predominantly of rice and vegetables. Protein-rich foods such as tempeh and tofu were typically consumed only during main meals, with larger quantities of carbohydrates and protein sources ingested just once daily. However, individuals with low protein intake but adequate consumption of iron and vitamin C were still able to maintain normal hemoglobin levels, suggesting that protein may not be a limiting factor for anemia in the presence of sufficient micronutrient intake. These findings are consistent with the research conducted by Fithria et al., which also reported no significant correlation between protein consumption and the occurrence of anemia in adolescent populations.[25]

The relationship between vitamin C intake and the anemia incidence

The analysis showed that vitamin C intake was not significantly associated with the incidence of anemia among adolescent girls. Vitamin C is known to enhance iron absorption by up to fourfold, as it forms soluble iron–ascorbate complexes that are more easily absorbed in the gastrointestinal tract. Therefore, the consumption of fresh fruits and vegetables rich in vitamin C is generally considered beneficial for the prevention of anemia.

The lack of a significant relationship between vitamin C intake and anemia in this study may be explained by the timing of consumption. The effectiveness of vitamin C in enhancing iron absorption largely depends on its simultaneous intake with iron-containing foods. When vitamin C is consumed separately from iron sources, such as several hours after meals, its role in facilitating iron absorption becomes minimal, thereby exerting little influence on anemia status.

These findings are consistent with the study by Ningsih,[26] which reported no significant association between vitamin C intake and anemia prevalence among adolescents at SMA Negeri 9 Padang. Physiologically, vitamin C acts as a catalyst in the conversion of ferric iron

(Fe^{3+}) to ferrous iron (Fe^{2+}), thereby facilitating its absorption in the alkaline environment of the duodenum and small intestine. The absorption of non-heme iron can increase up to four times when consumed together with vitamin C. In addition, vitamin C supports the mobilization of iron from transferrin in plasma to ferritin, which ultimately contributes to increased hemoglobin (Hb) levels.[14]

The relationship between vitamin B12 intake and anemia incidence

The findings of this study indicate that vitamin B12 intake was not significantly associated with the incidence of anemia. Many respondents reported frequent consumption of fast food and instant processed products, which generally contain low levels of vitamin B12. Limited nutritional knowledge may also contribute to respondents' lack of awareness regarding the importance of consuming foods rich in vitamin B12. The absence of a significant relationship between vitamin B12 intake and anemia may also be explained by other contributing factors. For instance, blood loss during menstruation often plays a more prominent role in the development of anemia among adolescent girls than vitamin B12 deficiency. Consequently, menstrual blood loss may have a greater influence on anemia incidence in this population.

The findings of the present study are consistent with those reported by Supriyadi et al., who investigated the relationship between vitamin B12 consumption and anemia incidence among schoolchildren at MI PUI Kota Cimahi and obtained a *P*-value of 0.329, indicating no statistically significant association between the two variables.[27] Vitamin B12 contributes to red blood cell formation and plays a role in facilitating the metabolic processes involved in iron absorption during hemoglobin synthesis. Its primary dietary sources are animal-based foods, which provide the vitamin in a form that is more readily absorbed compared to plant-derived sources.[14]

The relationship between zinc intake and anemia incidence

The analysis showed that zinc intake was not significantly associated with the incidence of anemia. This finding may be explained by the fact that although zinc plays a role in metabolic processes in the body, it is not a primary determinant of anemia. The most common form of anemia, particularly among adolescents, is iron deficiency anemia. Therefore, inadequate zinc intake does not necessarily lead to anemia if iron intake remains sufficient. These findings are consistent with the study by Abby et al.,[28] which reported no significant association between zinc intake and the incidence of anemia among adolescent girls at SMPN 8 Konawe Selatan.

Zinc functions as an antioxidant that protects red blood cells from oxidative damage caused by free radicals. It also contributes to the activity of enzymes involved in intestinal iron

absorption and the transport of iron within the body. When zinc levels are inadequate, the body's ability to utilize iron efficiently may decline. In addition, zinc supports enzymatic processes related to hemoglobin synthesis, the protein responsible for oxygen transport in red blood cells. Therefore, zinc deficiency can worsen anemia by impairing the production of healthy erythrocytes.[29]

The relationship between eating frequency and anemia incidence

The analysis results indicate that meal frequency was not significantly associated with the incidence of anemia. During adolescence, dietary patterns often shift toward increased consumption of fast food, which is typically high in fat, calories, and sodium but low in essential nutrients such as folic acid, fiber, and vitamin A. Although inadequate nutritional intake may contribute to the development of anemia, the consumption of nutritionally balanced foods in appropriate quantities plays a crucial role in maintaining overall physical health.

According to a study by Putera et al.,[30] anemia may arise from multiple factors. Other determinants that can contribute to the occurrence of anemia include parasitic infections, genetic conditions, and menstrual disorders. In particular, irregular menstrual patterns have been associated with a higher risk of anemia compared with regular menstrual cycles.

The relationship between dietary diversity and anemia incidence

The analysis results indicate that dietary diversity was not significantly associated with the incidence of anemia. Achieving balanced nutrition requires the consumption of a variety of foods, as no single food item contains all essential nutrients in adequate proportions. Therefore, dietary variety is important to help ensure that the body receives sufficient essential nutrients and to prevent nutritional deficiencies.[23] In principle, food consumption aims to supply the body with the necessary nutrients to replace those depleted through physical activity and other physiological processes. While dietary diversity influences the variety and quality of food intake, it does not necessarily determine the quantity of food consumed.[31] Therefore, maintaining a balance between diverse food choices and appropriate portion sizes is important for achieving adequate nutritional intake.

Variables most related to anemia incidence

Based on the results of the logistic regression analysis, a significance value of 0.033 (< 0.05) was obtained, indicating that iron intake is the variable most significantly associated with the incidence of anemia among adolescent girls in senior high schools in Bone Bolango Regency. Statistically, this variable often demonstrates a significant relationship because the biological mechanism is direct, as iron deficiency is a primary cause of anemia in adolescent girls who experience regular menstruation and therefore have higher iron requirements.

These findings are consistent with a previous study,[32] which reported a significant association between iron intake and the incidence of anemia among adolescent girls, most of whom had insufficient iron intake (<70% of the Recommended Dietary Allowance). Iron plays a crucial role in hemoglobin synthesis, and inadequate iron intake can impair the production of red blood cells. Adolescent girls frequently experience low iron intake due to restrictive dieting practices, limited consumption of iron-rich foods such as meat, or dietary patterns dominated by fast food.

Limitation

This study focuses on the incidence of anemia among female senior high school students in Bone Bolango Regency and examines a selected set of variables, including iron tablet consumption, iron intake, protein intake, vitamin C intake, vitamin B12 intake, zinc intake, meal frequency, and dietary diversity. While these variables represent key nutritional factors related to anemia, other biological, behavioral, or environmental factors may also contribute to anemia risk and were beyond the scope of the present analysis. Future studies may expand the range of variables to provide a more comprehensive understanding of anemia determinants in this population.

Conclusion

The prevalence of anemia among adolescent girls in senior high schools in Bone Bolango Regency is 34.2%, while 65.7% of respondents are not affected by anemia. The analysis further indicates that iron intake is significantly associated with the incidence of anemia among adolescent girls. In contrast, other variables examined in this study, namely iron tablet consumption, protein intake, vitamin C intake, vitamin B12 intake, zinc intake, meal frequency, and dietary diversity, do not demonstrate a significant association with anemia incidence. Among all variables analyzed, iron intake emerges as the factor most significantly related to the occurrence of anemia in adolescent girls attending senior high schools in Bone Bolango Regency.

Conflicts of Interest

Nothing to declare.

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