

## **DIETARY HABITS AS INDEPENDENT PREDICTORS OF ANEMIA AMONG FEMALE ADOLESCENT STUDENTS AT SENIOR HIGH SCHOOL 1 AJIBARANG**

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### **ABSTRACT**

Anemia remains a major public health problem, affecting approximately 29.9% of adolescents globally. Dietary habits are a major modifiable risk factor; however, their role as an independent predictor in rural Southeast Asian settings is not yet fully documented. This study aimed to identify dietary habits and evaluate them as an independent predictor of anemia among female adolescents at Senior High School 1 Ajibarang, Central Java, Indonesia. A cross-sectional study was conducted involving 261 participants (aged 14–17 years) recruited through total sampling. Dietary habits were assessed using a semi-quantitative Food Frequency Questionnaire (FFQ), while anemia status was determined by hemoglobin levels measured via a Point of Care Testing (POCT) device. The prevalence of anemia was 41.0%, with 58.2% of respondents exhibiting poor dietary habits. Bivariate analysis showed a significant association between dietary habits and anemia ( $p = 0.027$ ; OR = 1.777; 95% CI: 1.067–2.962). The multivariate logistic regression analysis, adjusted for age and socioeconomic confounders, revealed that dietary habits emerged as the sole independent predictor of anemia ( $p = 0.024$ ). Respondents with poor dietary habits were 1.79 times more likely to be anemic compared to those with good habits (AOR = 1.793; 95% CI: 1.075–2.991). In conclusion, dietary habits are the primary independent predictor of anemia among female adolescents in this rural Indonesian setting.

**Keywords:** Female adolescent; Anemia; Dietary habits; Food Frequency Questionnaire (FFQ); Multivariate analysis

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## INTRODUCTION

Anemia remains a major global health challenge, characterized by low hemoglobin levels that disrupt oxygen transport (Dorland, 2020). For female adolescents (aged 12-14 years) and non-pregnant women (aged 15 years and older), the World Health Organization (WHO) defines anemia as a hemoglobin level  $<12.0$  g/dL, with severity classified as mild (11.0-11.9 g/dL), moderate (8.0-10.9 g/dL), and severe ( $< 8.0$  g/dL) (WHO, 2017). Globally, anemia affects 29.9% of women of reproductive age (WHO, 2025). Among the various etiologies, iron deficiency is the most dominant factor, accounting for approximately 50% of all anemia cases in women and reaching 66.2% specifically among adolescents (WHO, 2017; Gardner & Kassebaum, 2023). In Indonesia, the 2018 National Health Research (Riskesdas) reported a 32% prevalence among females aged 15-24 years, where the prevalence of anemia among adolescent girls in Central Java reached 32.5%, closely mirroring the national average (Ministry of Health of the Republic of Indonesia, 2019). This burden is even more pronounced in Banyumas Regency, where prevalence reached 36.7%, placing it among the top ten districts with the highest anemia rates in Central Java (Banyumas District Health Office, 2023). If left unaddressed, anemia in this group can impair cognitive function, academic performance, and overall quality of life. Furthermore, persistent anemia in young women increases the risk of adverse obstetric outcomes, such as preterm labor, low birth weight, and increased maternal and neonatal mortality (Ayele and Demisew, 2024).

Adolescence represents a phase of rapid biological and psychological maturation, traditionally categorized into early (12–15 years), middle (15–18 years), and late adolescence (18–21 years) (Santrock, 2021). This physical transition triggers heightened nutritional demands due to rapid pubertal growth spurts and the onset of menarche, which entails periodic menstrual blood loss. However, these elevated physiological needs are often compromised by a complex interplay of risk factors, leading to a high prevalence of iron deficiency. Anemia in female adolescents is a multifactorial condition driven by several interrelated factors, such as menstrual patterns, low nutritional status, socioeconomic barriers, educational status, infection (e.g., intestinal parasites), and dietary habits (Berhe et al., 2022; Wiafe et al., 2023).

Among these factors, dietary habits are the most critical modifiable factor in bridging the gap between heightened physiological iron needs and actual nutrient absorption, a relationship fundamentally governed by iron bioavailability. In rural Javanese settings like Ajibarang, the local diet is uniquely characterized by a high intake of plant-based proteins such as tempeh and tofu. While culturally significant, these foods are rich in phytic acid, a potent inhibitor that forms insoluble complexes with non-heme iron (Gibson et al., 2018). This inhibitory effect is often exacerbated by the frequent consumption of tannins (found in tea) and excessive calcium, which further restrict the absorption of already less-bioavailable iron sources. Conversely, the presence of enhancers, specifically Vitamin C and animal-based proteins, is crucial to counteract these inhibitors by promoting the reduction of ferric iron to the absorbable ferrous form. Shifting dietary patterns toward higher consumption of meat and eggs provides a vital protective effect, as heme iron possesses significantly higher bioavailability and remains relatively unaffected by phytates (Ma et al., 2023).

Unlike biological stressors such as menarche, dietary habits can be measured using a Food Frequency Questionnaire (FFQ) to capture a comprehensive profile of long-term nutritional intake. This assessment encompasses dietary diversity (variety of food groups consumed), frequency of food intake, and duration of these habits, which reflects the persistence of nutritional behaviours over time (Ma et al., 2023; Wiafe et al., 2023). The significance of dietary habits as a primary predictor of anemia is further underscored by Fantini et al. (2025), who found that 75% of students with good dietary habits maintained normal hemoglobin levels ( $p = 0.000$ ). Conceptually, dietary habits directly dictate the bioavailability of iron intake; persistent poor nutritional choices lead to the depletion of iron stores, which ultimately manifests as a decline in hemoglobin synthesis, culminating in iron deficiency anemia.

Despite these insights, a significant research gap remains in the local context of Ajibarang. Existing data are largely descriptive and fail to isolate dietary habits as an independent predictor using a comprehensive analytical approach. Furthermore, empirical evidence from rural Javanese settings remains scarce, leaving a void in understanding how unique local food cultures influence adolescent health. There is a critical need to evaluate whether the high reliance on plant-based proteins, coupled with low animal-based intake, serves as the primary driver of iron deficiency in this community. Consequently, this study aims to determine the relationship between dietary habits and the incidence of anemia among female adolescents students at Senior High School 1 Ajibarang. By utilizing multivariate analysis, this research seeks to identify the most dominant dietary factors, providing a robust empirical foundation for targeted school-based interventions and more effective regional adolescent health policies.

## METHOD

This quantitative study utilized an observational analytical method with a cross-sectional design, which was conducted in October 2025 at Senior High School 1 Ajibarang, Central Java. Ethical approval was obtained from the Faculty of Medicine, Jenderal Soedirman University (No. 101/KEPK/PE/IX/2025). A total sampling method was applied, involving 261 female students aged 14–17 years who provided written parental consent. Inclusion criteria were grade X female students who were present and consented, while those with chronic or hematologic diseases, recent treatment, transfusion history, or conditions affecting hemoglobin were excluded.

The independent variable, dietary habits, was assessed via a semi-quantitative Food Frequency Questionnaire (FFQ) covering 53 local food items (Table 1) consumed over the past month. For food items that support nutrient absorption (enhancers), scores were assigned as follows: 50 (>1 time/day), 25 (4–6 times/week), 15 (3 times/week), 10 (<3 times/week), 1 (1–3 times/month), and 0 (never). Conversely, the scoring was reversed for items that inhibit nutrient absorption (inhibitors). Total scores were dichotomized into good (>mean) and poor ( $\leq$ mean) dietary habits using the mean score as the cut-off (864).

Anemia status (the dependent variable) was defined according to WHO criteria as hemoglobin <12.0 g/dL and categorized dichotomously into anemia and non-anemia. Hemoglobin levels were measured using a point-of-care testing (POCT) device (Sejoy Hb Analysis System, Joytech Healthcare Co., Ltd., China) following standard operating procedures. The device was calibrated prior to use in accordance with manufacturer guidelines to ensure analytical accuracy and consistency. Potential confounders, including menstrual patterns, nutritional status, history of infection, and recent medical treatment,

were controlled through exclusion criteria, in addition to adjustment for age and socioeconomic status.

Data were analyzed using SPSS version 26.0. Univariate analysis was used to describe participant characteristics, while bivariate analysis (Chi-square or Fisher's Exact Test) assessed the association between dietary habits and anemia. The strength of association was reported as Odds Ratio (OR) with 95% Confidence Interval (CI). Multivariate logistic regression was performed to adjust for confounders, with statistical significance set at  $p < 0.05$ . Data quality was ensured through enumerator training, standardized procedures for blood sampling and questionnaire administration, and data cleaning to verify completeness, consistency, and accuracy.

Table 1. List of 53 food items assessed in the Food Frequency Questionnaire (FFQ)

Food group	Food Items in FFQ
Staple foods	Rice, noodles, corn, potatoes, cassava, rice vermicelli and white bread.
Animal-source protein	Beef, goat meat, chicken, chicken eggs, fresh fish, salted fish, shrimp, nuggets, and sausages.
Plant-based protein	Tempeh ( <i>tempe</i> ), Tofu ( <i>tahu</i> ), mung beans, and peanuts.
Fresh vegetables	Spinach, water spinach, cassava leaves, mustard greens, cabbage, cauliflower, broccoli, cucumber, long beans, and common beans.
Fresh fruits	Orange, papaya, apple, banana, and mango.
Milk and dairy products	Powdered milk, UHT milk, and yogurt.
Traditional and Fast food	Hamburger, pizza, <i>martabak</i> (stuffed pancake), <i>bakso</i> (meatball), <i>siomay</i> (steamed fish dumplings), <i>batagor</i> (fried fish dumplings), and <i>pempek</i> (savory fish cakes).
Snacks and sweets	Donuts, <i>gorengan</i> (fried snacks), cakes, pudding/jelly, and chocolate.
Beverages	Carbonated drinks ( <i>Coca-cola/Fanta/Sprite</i> ), <i>boba</i> (tapioca pearls), Thai tea, coffee, and tea.

## RESULT AND DISCUSSION

### Result

This observational study involved an accessible population of 274 female students at Senior High School 1 Ajibarang. A total of 13 students were excluded due to various medical conditions that could interfere with hemoglobin levels (including Tuberculosis, Urinary Tract Infection, seizures, and heavy menstrual bleeding), resulting in a final sample of 261 subjects who met the inclusion criteria.

Participant characteristics are summarized in Table 2. Most parents completed Senior High School (30.7%) and worked as laborers or farmers (49.0%). Notably, 81.2% of households earned between IDR 1,500,000 and 3,000,000 per month, reflecting a predominantly middle-to-low-income background. The sample represents a mid-adolescent population, primarily aged 15 (58.2%) and 16 (41.0%) years.

Table 2. Frequency Distribution of Respondent Characteristic

Characteristics	n (%)
Parents' Education Level	
- Elementary School or equivalent	75 (28.7)

- Junior High School or equivalent	70 (26.8)
- Senior High School or equivalent	80 (30.7)
- Bachelor's Degree/Diploma	36 (13.8)
Parents' Occupation	
- Civil Servant/Military/Police/Lecturer/Teacher	27 (10.3)
- Private Sector Employee	34 (13.0)
- Laborer/Farmer	128 (49.0)
- Others (Housewife, Merchant, Driver, Unemployed)	72 (27.6)
Monthly Parental Income	
- Rp 1.500.000 - 3.000.000	212 (81.2)
- Rp 3.000.000 - 5.000.000	32 (12.3)
- Rp 5.000.000 - 10.000.000	13 (5.0)
- >Rp 10.000.000	4 (1.5)
Age (years)	
- 14	1 (0.4)
- 15	152 (58.2)
- 16	107 (41.0)
- 17	1 (0.4)
Dietary Habits	
- Good	109 (41.8)
- Poor	152 (58.2)
Anemia category	
- Anemia	107 (41.0)
- Non-Anemia	154 (59.0)
<b>Total</b>	<b>261 (100.0)</b>

Based on the calculated mean score of 864, 109 students (41.8%) scored at or above the mean, while 152 students (58.2%) scored below the mean. This suggests that more than half of the participants may not have met their daily nutritional requirements. Furthermore, hemoglobin testing revealed that 41.0% of respondents were anemic, while 59.0% were non-anemic.

The association between dietary habits and anemia status is presented in Table 3. Statistical analysis using the Chi-square test yielded a p-value of 0.027 ( $p < 0.05$ ), indicating a significant relationship between dietary habits and the incidence of anemia. Respondents with poor dietary habits demonstrated a higher likelihood of being anemic compared to those with good habits (OR = 1.777; 95% CI: 1.067–2.962).

Table 3. Association between dietary habits and anemia status (n=261)

Dietary Habits	Anemia (n=107)	Non-anemia (n=154)	Total (n=261)	<i>p-value</i>	OR (95% CI)
Good	36 (13.8%)	73 (28.0%)	109 (41.8%)	0.027*	1.777
Poor	71 (27.2%)	81 (31.0%)	152 (58.2%)		(1.067-2.962)

To identify independent predictors of anemia, a multivariate logistic regression analysis was performed. For this model, variables were re-categorized to ensure statistical robustness: parental income was dichotomized into Low (< IDR 3,000,000) and High ( $\geq$  IDR 3,000,000); parental education was grouped into Low (Elementary to Junior High School) and High (Senior High School to Higher Education); and age was categorized into  $\leq 15$  and  $> 15$  years. The results, as summarized in Table 4, demonstrate that dietary habits

remain the only significant independent predictor of anemia ( $p = 0.024$ ). After adjusting for age and socioeconomic confounders, respondents with poor dietary habits were 1.79 times more likely to be anemic compared to those with good habits (AOR = 1.793; 95% CI: 1.075–2.991), while other variables showed no statistically significant associations ( $p > 0.05$ ).

Table 4. Multivariate Logistic Regression Analysis of Factors Associated with Anemia (n=261)

Variable	<i>p</i> -value	Adjusted OR (95% CI)
Dietary Habits (Poor vs good)	0.024	1.793 (1.075-2.991)
Parents' Education Level (Low vs High)	0.525	1.150 (0.738-1.791)
Parental Income (Low vs High)	0.391	1.231 (0.760-1.995)
Age ( $\leq 15$ years vs $> 15$ )	0.582	1.111 (0.765-1.612)

The prevalence of anemia in this study was 41.0%, reflecting a multifactorial condition driven by biological vulnerability and micronutrient deficiencies (Bhadra and Deb, 2020; WHO, 2023). In adolescent girls, rapid growth and menstruation-related blood loss often exceed dietary intake, leading to exhausted iron stores and impaired heme synthesis (Pasricha et al., 2021). Our analysis confirmed a significant association between dietary habits and anemia ( $p = 0.027$ ; OR=1.777), with 58.2% of respondents exhibiting poor dietary patterns. This age group is particularly susceptible as intake often fails to meet heightened metabolic demands (Siska and Masluroh, 2024).

## Discussion

The impact of dietary composition on anemia is both direct and indirect. High-carbohydrate diets, especially those rich in added sugars, may impair micronutrient absorption, a risk often seen in low-income settings where diets rely on low-bioavailability plant-based foods (Fentie et al., 2020). Furthermore, excessive fat consumption triggers pro-inflammatory cytokines that upregulate hepcidin production. Elevated hepcidin sequesters iron within macrophages and inhibits intestinal absorption, directly reducing available iron for hemoglobin synthesis (Mantadakis et al., 2020; Hardiansyah et al., 2024). In the Ajibarang context, the *nongkrong* (hanging out) culture further exacerbates this risk through the frequent consumption of iron inhibitors, such as tannins in tea and coffee, alongside nutrient-poor street foods (Butar, 2024).

The dietary choices of students in Ajibarang are significantly shaped by their socioeconomic profile. In this study, nearly half of the respondents' parents (49.0%) work as laborers or farmers within the lower-to-middle income bracket. On a global scale, this mirrors broader international trends where economic constraints and limited parental education serve as distal determinants of anemia. These factors create a systemic barrier to dietary diversity, limiting access to nutrient-dense food sources and increasing reliance on affordable but nutritionally deficient alternatives (Dibyanshu et al., 2026; Fu et al., 2024).

However, it is noteworthy that in this study, socioeconomic factors did not emerge as independent predictors in the multivariate model. This suggests a nuanced reality where dietary quality, rather than income alone, is the direct driver of anemia. This finding is consistent with Hasan Syah et al. (2025) in Bekasi and a large-scale meta-analysis

by Habtegiorgis *et al.* (2022), which both demonstrated that nutritional behavior and low dietary diversity are more proximal determinants than general socioeconomic status. In the Ajibarang context, this explains why an adolescent's specific dietary behavior—such as the high intake of iron inhibitors (e.g., tea) or low intake of enhancers—is a more precise predictor of anemia status than their parents' occupation or income.

Despite these socioeconomic influences, multivariate analysis (Table 4) revealed that dietary habits remain the only significant independent predictor ( $p = 0.024$ ; AOR=1.793; 95% CI:1.075–2.991). This finding aligns with research by Indartanti and Kartini (2014), which demonstrated that nutritional status based on BMI-for-age (IMT/U) does not significantly correlate with anemia ( $p = 0.289$ ). This suggests a "decoupling" of dietary behavior from both socioeconomic status and gross physical indicators. It emphasizes that adolescents with a normal or even overweight status remain highly vulnerable to deficiency if their specific intake of micronutrients, particularly iron and folate, is inadequate due to a "nutrition transition" toward westernized, ultra-processed diets. This global phenomenon, as synthesized by Habtegiorgis *et al.* (2022), confirms that even in diverse geographic settings, the lack of dietary variety remains a universal risk factor that transcends simple economic metrics.

Consequently, the interplay between household economic stability and individual nutritional behavior becomes a primary driver in shaping the risk profile for anemia in this population. However, it is important to acknowledge that this study has certain limitations, particularly the POCT with capillary blood, which is inherently less precise than venous blood analysis. The absence of a full iron panel, such as serum ferritin and transferrin saturation, also limits the ability to distinguish between different types of anemia. Therefore, future research should prioritize venous sampling and comprehensive biochemical indicators to provide a more definitive diagnosis of iron-deficiency anemia and a deeper understanding of its physiological drivers.

## CONCLUSION

This study concludes that dietary habits are the primary independent predictor of anemia among female adolescents in rural Central Java. The prevalence of anemia is high at 41.0% with 58.2% of respondents exhibiting poor dietary patterns. Multivariate analysis, adjusted for age and socioeconomic confounders, identifies dietary habits as the sole independent predictor of anemia ( $p = 0.024$ ; AOR = 1.793; 95% CI:1.075–2.991).

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