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Iron Supplement Consumption, Dietary Intake, Nutritional Status, and Anemia Among Adolescent Girls in Banawa, Donggala Regency

Nasrul[1*], Fahmi Hafid[2], Taqwin[1], Hikmah[3], Risma[4], Atika Nuswantari[2], Sarina Sariman[5]

[1] Department of Nursing, Poltekkes Kemenkes Palu, Indonesia
[2] Department of Nutrition, Poltekkes Kemenkes Surabaya, Indonesia
[3] Sekolah Menengah Pertama 3 Banawa, Donggala, Indonesia
[4] Sekolah Menengah Kejuruan 2 Banawa, Donggala, Indonesia
[5] Faculty of Health and Life Sciences, Management and Science University, Selangor, Malaysia

Corresponding Author Email: sahenasrul@gmail.com

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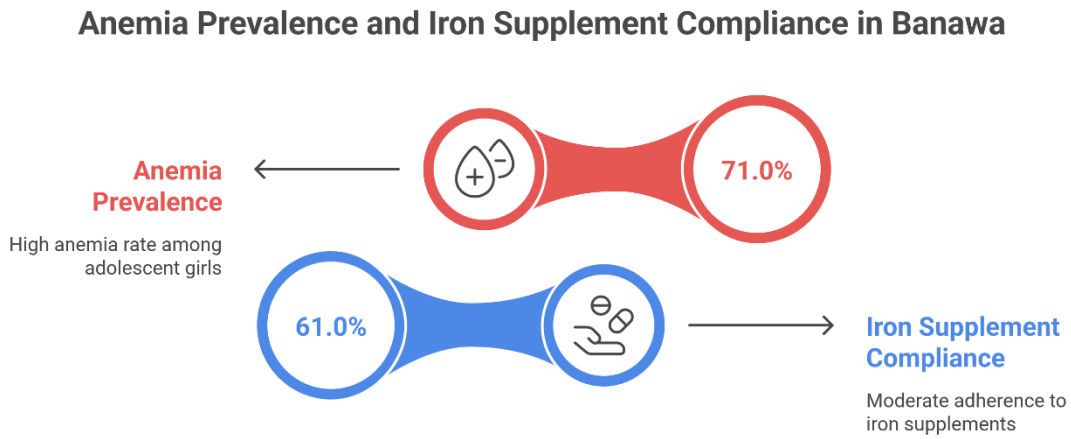
ABSTRACT

Anemia remains a critical public health concern among adolescent girls. This study investigates the association between iron supplement consumption, dietary intake, nutritional status, and anemia among adolescent girls in Banawa, Donggala Regency. A cross-sectional study was conducted involving 231 girls aged 12–15 years from two schools not yet implementing the *Aksi Bergizi program*. Data were collected via SQ-FFQ, anthropometry, and hemoglobin testing using POCT. The anemia prevalence was alarmingly high at 71.0%. While 61.0% of participants were compliant with iron supplementation, no significant association was found between compliance and anemia (p=0.743). Similarly, protein (p=0.823) and iron intake (p=0.201) were not significantly associated. However, vitamin C intake showed a strong association (p=0.001), highlighting its critical role in non-heme iron absorption. The findings underscore the need for integrated nutrition programs that promote vitamin C-rich foods alongside iron supplementation. School-based policies should be realigned to address this nutritional synergy.

Key Messages:

- Anemia prevalence among adolescent girls in Banawa is high (71.0%), indicating urgent need for targeted interventions.
- Vitamin C intake shows a significant association with anemia status, underscoring its role in iron absorption.
- Iron supplementation alone is insufficient; integrated strategies combining dietary education and compliance monitoring are essential.

GRAPHICAL ABSTRACT



INTRODUCTION

Improving the quality of research and new innovations and a deep understanding of adolescent health, including nutritional aspects are of special concern, especially for adolescent girls who are vulnerable to anemia (1). Adolescent health is an important aspect of public health development because adolescence is a sensitive transition period in human life(2–5). During this period, significant biological (6–8) and physiological changes occur, which require special attention especially in the nutritional aspect (9–11). Adolescent girls are one of the groups that are vulnerable to nutritional problems, especially related to the incidence of anemia (12–16). Various factors can contribute to the incidence of anemia in adolescent girls, such as Iron Supplement Consumption (17–19), dietary intake (20,21) such as protein intake (22,23), intake of iron-rich foods (24), intake of foods source of vitamin C (25–29), and intake of substances that inhibit iron absorption (30–32).

Globally, WHO estimates that 30% of women aged 15–49 are anaemic (33). In Indonesia, a study by F.S Sigit et al (2024) showed that adolescent girls in Karanganyar had anemia of 49% (34) Indonesian Health Survey (2023) aged 15-24 years is anemic by 15.5% (35) Study of Ashraf et al (2024) shows a prevalence of anemia of 71,5% (36). Studi Taqwin dkk (2025) di Palu City sebesar 67,6% (37). The study of Milan Das et al (2024) is 59.1% (36), the study of Jadaun et al (2024) is 48.5% (39). Study by A.D Fitripancari et al. (2023), anemia of adolescent girls in Depok by 13% (40). The findings of Ashraf et al. (2024) show that anemia in the age group of 14-18 years is 80.7% (36) and it turns out that the prevalence of anemia in women is higher than in men at 18.0% vs 14.4% (35). The findings show that there is variation in the prevalence of anemia between regions and between groups and between sexes.

The importance of handling anemia in adolescent girls is not only limited to individual health aspects but also has significant social and economic impacts (41,42). Anemia can lead to a decrease in the immune system (43,44), learning achievement (37), and stunting (45–50). The long-term impact of anemia can also impact the pregnancy and childbirth phases, increasing the risk of premature birth and maternal mortality (51).

Seeing the importance of this issue, the Indonesian government has launched a health transformation program that aims to improve the overall health status of the public. One of them is the national movement Nutritious Action (52–55), but it has not been implemented at SMP Negeri 3 Banawa and SMK Negeri 2 Banawa in Donggala Regency. The Nutritious Action Program is a multi-sectoral initiative to tackle anemia in adolescent girls through breakfast interventions and taking Blood Supplement Tablets (TTD) together in schools. This activity also includes nutrition education to encourage healthy eating and physical activity, as well as communication of relevant behavior changes. The implementation is integrated with TRIAS UKS, namely health education, health services, and fostering a healthy school environment(56).

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Nutrition programs need to be accompanied by implementation research to ensure effective interventions, especially in adolescents. In Donggala Regency, especially SMP Negeri 3 and SMK Negeri 2 Banawa, the Nutritious Action program has not been implemented. This absence is a unique opportunity to evaluate the anemia condition of adolescent girls without the influence of national intervention so that the results can be the basis for comparison. The absence of studies on the prevalence of anemia and the effectiveness of administering Blood Supplemental Tablets (TTD) in this region reinforces the urgency of the research. This study aims to examine the relationship between TTD consumption, nutritional intake, nutritional status, and anemia in adolescent girls in Banawa District, Donggala Regency. This study aims to examine the relationship between blood supplement tablet consumption, nutritional intake, nutritional status, and anemia in adolescent girls in Banawa, Donggala Regency.

METHODS

This study employed an analytical observational design with a cross-sectional approach, conducted between January and July 2025 in Banawa District, Donggala Regency, Central Sulawesi, Indonesia. The research sites included two educational institutions: SMP Negeri 3 Banawa (a junior high school) and SMK Negeri 2 Banawa (a vocational senior high school). These schools were selected due to their lack of implementation of the national iron supplementation program Aksi Bergizi, despite being located in areas with a potentially high prevalence of anemia among adolescent girls.

SMP Negeri 3 Banawa has a total of 355 students—185 males and 170 females—distributed across 10 academic classes. The school operates six days a week with morning sessions and is equipped with 13 classrooms, three laboratories, one library, and two student sanitation facilities. The school covers a land area of 18,900 square meters and holds an accreditation grade of A under the leadership of Principal Hikmah. Meanwhile, SMK Negeri 2 Banawa has 131 students—70 males and 61 females—also distributed in 10 classes. The school operates five days a week and is equipped with nine classrooms, one laboratory, one library, and two sanitation facilities. It spans 10,208 square meters, holds a B accreditation grade, and is headed by Principal Risma.

The study population consisted of all active female students at the two schools. A stratified sampling method was used to ensure proportional representation across different academic levels. The inclusion criteria included female students aged 12–15 years, enrolled in grades VII–IX, willing to participate, and with no history of medical conditions that could affect hemoglobin levels, such as hemoglobinopathies, helminth infections, malaria, cancer, tuberculosis, or HIV/AIDS. Exclusion criteria included those who were menstruating, ill, or absent at the time of data collection.

The main variables assessed were respondent characteristics, nutrient intake, nutritional status, and hemoglobin concentration. Nutrient intake was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) covering 40 food items based on the students' dietary intake over the previous three months. The Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) used in this study had been previously validated in adolescent populations with similar characteristics, ensuring its reliability for assessing nutrient intake in this context. Nutritional status was determined through anthropometric measurements, including body weight using a digital scale, height using a microtoise, and mid-upper arm circumference (MUAC). Hemoglobin levels were measured using Point of Care Testing (POCT), with anemia classified as hemoglobin levels <12 g/dL, following WHO standards.

Compliance with iron supplement consumption was assessed using a composite score derived from three questionnaire items. Total scores were compared to the median value: scores above the median were categorized as compliant, while those at or below the median were categorized as non-compliant. Nutrient adequacy was determined based on the Indonesian Recommended Dietary Allowances. Intakes were considered adequate if ≥80% of RDA and inadequate if <80%, for protein, iron, and vitamin C. The frequency of iron absorption inhibitors (e.g., tea, coffee, dairy) was classified as "infrequent" (≤2 times/week) or "frequent" (>2 times/week).

Nutritional status was further categorized based on Body Mass Index-for-Age Z-scores (BMI/Age Z-score) using the WHO AnthroPlus software. Classification followed the Regulation of the Indonesian Minister of Health No. 2 of 2020, which defines: (1) undernutrition as severely thin (<–3SD) and thin (–3SD

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to <–2SD); (2) normal (–2SD to +1SD); and (3) overnutrition, including overweight (+1SD to +2SD) and obesity (>+2SD). For analysis purposes, nutritional status was grouped into three categories: undernutrition, normal nutrition, and overnutrition.

Data collection was conducted through face-to-face interviews using the SQ-FFQ, anthropometric measurements, and capillary blood sampling to assess hemoglobin levels. All data collection was performed by trained research assistants under supervision to ensure consistency and accuracy.

Data analysis was conducted using SPSS Statistics version 25.0. Univariate analysis was performed to describe the distribution of demographic and clinical variables. Bivariate analysis, specifically the Chi-square test, was used to examine associations between independent variables (iron supplement compliance, nutrient intake, and nutritional status) and the dependent variable (anemia status). A p-value of <0.05 was considered statistically significant.

CODE OF HEALTH ETHICS

All procedures were conducted in accordance with ethical principles, and the study received ethical clearance from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia with Number : 101/UN27.06.11/KEP/EC/2025.

RESULTS

This study involved 231 adolescent girls aged 12 to 18 years from Banawa, Donggala Regency (Table 1). The average age was 13.98 years (SD = 1.495), indicating that most participants were in early to mid-adolescence. Body weight ranged from 25.9 kg to 76.0 kg, with a mean of 41.4 kg (SD = 8.0), while height ranged from 134.1 cm to 164.0 cm, with an average of 148.3 cm (SD = 5.2). These variations reflect differences in growth and nutritional status among participants. The mean Body Mass Index-for-Age Z-score (BMI/Age) was –0.47 (SD = 1.17), with a minimum of –3.77 and a maximum of 2.57, indicating that most respondents had a normal nutritional status, although some were classified as undernourished or overweight. Mid-upper arm circumference (MUAC) ranged from 18.0 cm to 33.0 cm, with an average of 22.6 cm (SD = 2.4), serving as an additional indicator of body composition and muscle mass. Hemoglobin levels, a key indicator of anemia, ranged from 7.00 g/dL to 16.60 g/dL, with a mean of 10.9 g/dL (SD = 1.6). This average suggests a high prevalence of anemia, highlighting the need for targeted nutritional and health interventions in this population.

Table 1. Characteristics of the respondents Nutritional Status and Anemia in Adolescent Girls in Banawa, Donggala Regency

Variable	n =231			
	Min	Max	Mean	SD
Age (years)	12	18	13.98	1.495
Weight (kg)	25.9	76.0	41.4	8.0
Height (cm)	134.1	164.0	148.3	5.2
Z-Score BMI/Age	-3.77	2.57	-0.47	1.17
Upper arm circumference (cm)	18.0	33.0	22.6	2.4
Hemoglobin (mg/dl)	7.00	16.60	10.9	1.6

Out of 231 respondents, 61.0% were compliant with iron supplement consumption, while 39.0% were not. Most participants had adequate protein intake (84.4%) and sufficient iron intake (64.5%) (Table 2). However, only 39.0% had adequate vitamin C intake. Additionally, 57.6% of respondents rarely consumed iron absorption inhibitors, while 42.4% consumed them frequently. In terms of nutritional status, 79.7% were categorized as having normal nutrition, 10.8% were undernourished, and 9.5% were overnourished. Regarding anemia status, only 29.0% were not anemic, whereas a significant majority (71.0%) were anemic. These findings indicate that anemia remains a major health concern among adolescent girls, despite the generally sufficient nutritional status and protein intake reported in this population.

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Table 2. Distribution of Respondent Frequency Based on Research Variables Iron Supplement Consumption, Nutritional Intake, Nutritional Status, and Anemia in Adolescent Girls in Banawa, Donggala Regency

Variable		n =231	%
Consumption of Iron Supplements	Compliant	141	61.0
	Non-compliant	90	39.0
Adequate intake of protein	Adequacy	195	84.4
	Not	36	15.6
Adequate intake of Iron	Adequacy	149	64.5
	Not	82	35.5
Adequate intake of Vitamin C	Adequacy	90	39.0
	Not	141	61.0
Intake Inhibitor Iron Consumption	infrequent	133	57.6
	Often	98	42.4
Nutritional Status	Normal	184	79.7
	Underweight	25	10.8
	Overweight	22	9.5
Anemia status	Non Anemia	67	29.0
	Anemia	164	71.0

Cross-tabulation analysis revealed no significant association between iron supplement compliance and anemia status (p=0.743), as 70.2% of compliant respondents still experienced anemia (Table 3). Similarly, protein intake (p=0.823) and iron intake (p=0.201) were not significantly related to anemia. In contrast, vitamin C intake showed a statistically significant relationship (p=0.001), where 78.7% of respondents with inadequate vitamin C intake were anemic. The frequency of iron absorption inhibitor consumption also showed no significant relationship (p=0.644), nor did nutritional status (p=0.819), although anemia prevalence remained high across all nutritional categories. These findings highlight that the most influential factor associated with anemia among adolescent girls in Banawa is adequate vitamin C intake, while other variables such as iron supplementation, protein and iron intake, inhibitor consumption, and nutritional status showed no significant associations.

Table 3. Cross-tabulation of research variables on iron supplement consumption, nutritional intake, nutritional status, and Anemia in Adolescent Girls in Banawa, Donggala Regency

Variable		n =231				n	p-value
		Non-Anemia		Anemia			
		n	%	n	%		
Consumption of Iron Supplements	Compliant	42	29,8	99	70,2	141	0.743
	Non-compliant	25	27,8	65	72,2	90	
Adequate intake of protein	Adequacy	56	28,7	139	71,3	195	0.823
	Not	11	30,6	25	69,4	36	
Adequate intake of Iron	Adequacy	39	26,2	110	73,8	149	0.201
	Not	28	34,1	54	65,9	82	
Adequate intake of Vitamin C	Adequacy	37	41,1	53	58,9	90	0.001
	Not	30	21,3	111	78,7	141	
Intake Inhibitor Iron Consumption	infrequent	37	27,8	96	72,2	133	0.644
	Often	30	30,6	68	69,4	98	
Nutritional Status	Normal	54	29,3	130	70,7	184	0.819
	Underweight	6	24,0	19	76,0	25	
	Overweight	7	31,8	15	68,2	22	

DISCUSSION

This study aims to evaluate the relationship between blood tablet consumption, nutritional intake, nutritional status, and the incidence of anemia in adolescent girls in the Banawa area, Donggala Regency. The findings of this study show that anemia is a serious public health problem among adolescent girls with a prevalence of 71%. This figure is much higher than the national prevalence of anemia for the age group

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of 15–24 years based on the 2023 Indonesian Health Survey which is at 15.5%, and is also higher than similar studies in other regions in Indonesia. This high prevalence is an indication that the interventions that have been carried out so far have not been fully effective in reducing the incidence of anemia among adolescent girls. This reinforces the urgency of context-specific interventions, particularly in areas where national programs like Aksi Bergizi remain unimplemented.

One of the important findings of this study is that the level of adherence to the consumption of iron supplements was not significantly related to anemia status (p=0.743). Although 61% of respondents were categorized as compliant in taking blood-boosting tablets, the incidence of anemia remained high in this group (70.2%), only slightly lower than in the non-compliant group (72.2%). These findings imply that adherence to the consumption of iron supplements does not automatically provide protection against anemia if it is not accompanied by other supporting factors such as adequate vitamin C intake, a diet that supports iron absorption, and the proper time of consumption of iron supplements. In addition, the possibility of low iron bioavailability in the consumption of iron supplements due to concurrent consumption with inhibitory substances such as tea, coffee, or foods high in calcium also needs to be considered. Iron supplementation interventions will be effective if they are followed by adequate education on the correct consumption method and the importance of supporting nutritional intake.

Iron is divided into two main forms, namely heme iron, which comes from animal sources and is absorbed by the body efficiently between 15 to 37 percent, and non-heme iron, which comes from plant foods with an absorption rate of about 5 percent. Vitamin C has an important role in increasing the absorption of non-heme iron by reducing the ferric shape to ferrous and reducing the inhibitory effects of phytate compounds and tannins. In low consumption patterns of animal products, adequate vitamin C intake is a key factor in optimizing iron absorption and preventing iron deficiency anemia (57) (58,59).

Furthermore, this study identified that only vitamin C intake had a significant association with the incidence of anemia (p=0.001). Meanwhile, the adequacy of protein intake (p=0.823) and iron (p=0.201) showed no statistically significant relationship. Only 39% of respondents were recorded to have adequate vitamin C intake, which indicates that most adolescent girls do not get adequate intake from fresh fruits and vegetables, which are the main sources of vitamin C. Vitamin C plays an important role in increasing the absorption of non-heme iron derived from plant foods commonly consumed by Indonesians. Thus, lack of vitamin C intake can be the main factor that inhibits adequate iron absorption, even though iron intake itself is quite adequate. Several studies show the benefits of vitamin C for iron absorption (23,25–27,29). In a school in Depok Indonesia, it was found that the prevalence of anemia of 13% was strongly related to vitamin C intake (p=0.0245) (29). Rani's study (2024) showed that the addition of guava to a diet of mung beans that contain moderate amounts of iron increases hemoglobin and reduces anemia but does not provide enough additional iron absorbed to increase iron stores in the body. Fortifying foods by incorporating vitamin C-rich fruits into iron-containing school meals can help ease the burden of anemia in children (28). The results showed that phytic acid, sodium silicate, or sodium oxalate decreased iron absorption from ferrous Fe, and ascorbic acid/vitamin C could counteract its inhibitory effects on ferrous iron absorption and thus increase ferrous iron absorption (30).

However, the results of a systematic review and meta-analysis study by Loganathan (2023) show that the administration of ferrous ascorbate or the combination of iron and oral vitamin C does not provide a significant increase in hemoglobin and serum ferritin levels. Combined estimates of standardized mean differences (SMDs) for the two interventions showed statistically insignificant results, with very low methodological quality of the evidence. Therefore, further research through clinical trials is needed to evaluate the effectiveness of oral vitamin C or ascorbate administration along with oral iron in participants with anemia (27).

This underscores the limited efficacy of supplementation alone when not complemented by supportive dietary practices. One key explanation is the bioavailability of iron, which is influenced by its chemical form. Most iron supplements and plant-based foods provide non-heme iron, which is poorly absorbed (~5%). In contrast, heme iron, found in animal sources, is absorbed at much higher rates (15–37%). Vitamin C plays a pivotal role in enhancing the absorption of non-heme iron by reducing it to its ferrous form and counteracting inhibitors like phytates and tannins—compounds common in cereal-based

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diets dominant in Indonesia.

The statistically significant association between vitamin C intake and anemia (p = 0.001) further reinforces its synergistic role in iron absorption. However, only 39% of respondents had adequate vitamin C intake, indicating limited access or low habitual consumption of fresh fruits and vegetables. Previous studies have similarly highlighted that fortifying school meals with vitamin C-rich fruits, such as guava or citrus, significantly enhances hemoglobin levels but not necessarily iron stores, especially in diets lacking in heme sources.

Beyond vitamin C, other unmeasured confounders could explain the persistent anemia despite adequate protein and iron intake. These include chronic inflammation (which affects iron metabolism via hepcidin regulation), vitamin B12 and folate deficiencies, and undiagnosed infections (e.g., helminths or malaria), all of which impair erythropoiesis. While these were acknowledged in the study's limitations, integrating them more explicitly in the discussion enriches the interpretation of the findings and provides direction for future investigations.

Interestingly, iron absorption inhibitor intake (e.g., tea, dairy, coffee) and nutritional status also did not show significant associations with anemia. This could be due to underreporting or the timing of consumption relative to iron intake. However, from a public health standpoint, dietary education on the timing of iron and inhibitor consumption remains crucial, even in the absence of a direct statistical link.

Regarding policy implications, the lack of Aksi Bergizi implementation in the study schools presents both a challenge and an opportunity. We recommend piloting an enhanced school-based intervention model informed by this study's findings. Such a model should integrate continued weekly iron supplementation, routine education on dietary enhancers and inhibitors, inclusion of local vitamin C-rich fruits (e.g., papaya, guava, citrus) in school meals or snacks, and monitoring compliance with both supplement intake and fruit consumption. This "Iron + C Synergy Model" could serve as a scalable strategy for anemia prevention in resource-limited settings where dietary diversity is constrained and national program reach is inconsistent.

Several other studies show that income has a strong effect on vitamin C intake while spending on fruits and vegetables is significantly associated with calcium intake. No association was found with the intake of other nutrients. Media-based education (flipcharts, leaflets) is effective in increasing knowledge and adherence to TTD consumption but has no impact on the diet of vitamin C sources. These findings underscore the need for an educational approach that considers economic factors and consumption behaviors to effectively address micronutrient deficiencies (57,60–63).

This condition shows the importance of paying attention to the interaction between nutrients in anemia prevention strategies. An approach that emphasizes only iron supplementation, without considering vitamin C intake as a factor supporting absorption, tends to be less effective. In addition, these findings underscore the importance of improving overall diet, including increased fruit and vegetable consumption, in nutritional interventions in adolescent girls.

Analysis of the consumption of iron absorption inhibitors, such as tea, coffee, and high-calcium foods, showed that there was no significant association with the incidence of anemia (p=0.644). However, 42.4% of respondents reported that they often consumed these inhibitory substances. Although the statistical results do not show significance, in the context of public health programs, the high frequency of consumption of inhibitory substances remains a concern. These substances are scientifically known to inhibit the absorption of iron, especially non-heme, which means that the habit of consuming these foods/beverages together or in the near future with iron-source foods or iron supplements can reduce the effectiveness of the nutritional interventions given. Therefore, education about the proper time of consumption for the consumption of iron supplements and iron-rich foods—separate from the consumption of tea, coffee, or milk—needs to be strengthened.

In terms of nutritional status, the majority of respondents were in the category of good nutrition (79.7%), while 10.8% experienced malnutrition and 9.5% included overnutrition. Statistical analysis showed that nutritional status was not significantly associated with the incidence of anemia (p=0.819). This suggests that anemia is not always related to macronutrient status (weight and height) as is often assumed in the general approach. A person with a normal nutritional status is even more likely to

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experience anemia if there is a deficiency of micronutrients such as iron, folic acid, vitamin B12, or vitamin C. On the other hand, those with poor nutritional status do not necessarily experience anemia if their iron intake is sufficient and absorbed properly.

These findings are in line with previous studies that showed that anemia status cannot be predicted solely from anthropometric indicators. Therefore, anemia detection and intervention programs in adolescent girls are not enough to rely only on weight and height data, but require hemoglobin examinations and more specific micronutrient consumption surveys.

The geographical and socio-economic conditions of the Banawa area also need to be considered in interpreting the results of this study. Donggala is an area with fairly heterogeneous demographic characteristics and limited access to quality health services, including nutrition education and consistent distribution of consumption of iron supplements. In addition, the absence of national programs such as Nutritious Action in the schools studied further clarifies the gap in the implementation of national health programs at the local level. In this context, the existence of supplementation and education programs must be tailored to local needs and conditions, with a multisectoral approach involving schools, health centers, parents, and community leaders.

The limitations in this study also need to be noted to put the results in the right context. The cross-sectional design of the study causes the causal relationship between the variables to be ascertained. In addition, the use of the method of collecting nutrition consumption data through SQ-FFQ which relies on respondents' memories for the last three months, has the potential for information bias. The absence of other supporting data such as serum ferritin levels, CRP, menstrual data, or infection history also limits the understanding of the etiology of anemia experienced by respondents. However, this study has the strength in terms of a large sample size and systematic analysis methodology, so that the results remain relevant as a basis for the preparation of policy and program interventions.

Overall, the results of this study show that the approach to managing anemia among adolescent girls needs to be carried out in an integrated and sustainable manner. Consumption of iron supplements must be combined with improved diet, increased vitamin C intake, reduced consumption of iron absorption inhibitors, and sustainable nutrition education. Intervention programs should involve various actors, ranging from health workers and teachers to families andlocal governments. Periodic evaluation of program effectiveness and student consumption behavior is also important to ensure that program objectives can be achieved.

CONCLUSION

The prevalence of anemia in adolescent girls in Banawa is very high, and only vitamin C intake shows a significant association with anemia status. Although the adherence to iron supplement consumption is relatively good, its effectiveness is influenced by other factors such as nutritional intake and consumption behavior. Future public health strategies to address adolescent anemia in Indonesia must shift from a single focus on iron supplementation to an integrated nutrition approach that prioritizes increasing vitamin C intake in food for optimal iron absorption. Follow-up research with a longitudinal approach and assessment of nutritional biomarkers is essential to identify causal factors and design more effective interventions.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. This research was conducted independently, without any financial, institutional, or personal influences that could bias the study design, analysis, or interpretation.

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