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The Relationship Between Diet and the Incidence of Anemia in Adolescent Girls at Sman 1 Sungai Raya Islands of Bengkayang Regency in 2026

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Abstract

Anemia remains a significant public health concern among adolescent girls, as rapid growth, menstrual blood loss, and inadequate dietary intake may increase the risk of iron deficiency and anemia. This study examined the association between dietary patterns and anemia among tenth-grade female students at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency, Indonesia, in 2026. An analytical observational study with a cross-sectional design was conducted. Of the 97 students in the study population, 71 respondents were selected using simple random sampling. Dietary patterns were assessed using a Food Frequency Questionnaire (FFQ), while hemoglobin concentrations were measured using a digital hemoglobinometer. Data were analyzed using Pearson's chi-square test with a significance level of $\alpha = 0.05$. Among the 71 respondents, 37 (52.1%) were classified as having inappropriate dietary patterns, while 11 (15.5%) were identified as having anemia. Cross-tabulation revealed that anemia occurred in 1 of 37 respondents (2.7%) with inappropriate dietary patterns and 10 of 34 respondents (29.4%) with appropriate dietary patterns. A statistically significant association was observed between dietary pattern classification and anemia status (Pearson's $\chi^2 = 9.654$; df = 1; $p = 0.002$). However, the unexpectedly higher prevalence of anemia among respondents classified as having appropriate dietary patterns highlighted the need for cautious interpretation, particularly regarding the dietary assessment criteria and potential confounding factors. Given the cross-sectional design, the findings did not establish a causal relationship between dietary patterns and anemia. The study underscored the importance of strengthening adolescent nutrition education, conducting routine hemoglobin screening, and undertaking further research using comprehensive dietary assessments to clarify the relationship between dietary intake and anemia risk among adolescent girls.

INTRODUCTION

Anemia remains a significant public health concern, particularly among adolescent girls. It is characterized by hemoglobin concentrations below established age- and sex-specific thresholds, resulting in reduced oxygen-carrying capacity of the blood and potentially affecting physical health, cognitive performance, academic achievement, productivity, and overall quality of life (Lybaws, Pratama and Wibowo, 2025; Sholeha and Sumarmi, 2025). Adolescence represents a particularly vulnerable developmental period because rapid physical growth, hormonal changes, and the onset of menstruation increase nutritional demands,

particularly the need for iron. These physiological changes, combined with inadequate dietary intake and unhealthy eating behaviors, may increase the susceptibility of adolescent girls to iron deficiency and anemia.

The burden of anemia remains substantial at both global and national levels. Data from the World Health Organization (WHO) cited in the manuscript indicate that anemia affects a considerable proportion of women of reproductive age, highlighting its persistent significance as a global public health challenge. Similarly, the 2023 Indonesian Health Survey reported anemia among adolescents aged 15–24 years, demonstrating the continued importance of addressing nutritional deficiencies within this population. Regional evidence from West Kalimantan and Bengkayang Regency further suggests that anemia remains a relevant local health concern requiring targeted preventive measures, improved nutritional awareness, and systematic monitoring among adolescent girls (Fauziyah and Ningsih, 2025; Kurniati and Krisdianto, 2026).

Dietary patterns represent an important modifiable factor associated with anemia among adolescent girls. Inadequate consumption of iron, protein, vitamin C, and other essential micronutrients may impair hemoglobin synthesis and contribute to nutritional deficiencies associated with anemia. Furthermore, frequent consumption of energy-dense, nutrient-poor processed and ready-to-eat foods may reduce the intake of iron-rich foods and other essential nutrients, potentially increasing vulnerability to anemia (Fatihah & Supratman, 2025). Adolescent dietary behaviors are also influenced by nutritional knowledge, family eating habits, peer relationships, social media exposure, cultural practices, and increasing independence in food selection during middle adolescence (Hanum and Maulida, 2023; Sya’bani Andriyani and Lusida, 2025). These interconnected influences emphasize the importance of examining dietary patterns within the broader behavioral and social context of adolescent nutrition.

The health consequences of anemia extend beyond hematological abnormalities and may significantly affect adolescents' physical well-being and educational performance. Common manifestations include fatigue, reduced physical endurance, impaired concentration, decreased cognitive functioning, and diminished learning capacity, which may negatively influence academic achievement and daily activities. Persistent anemia may also have implications for future reproductive and maternal health, particularly when nutritional deficiencies remain uncorrected. From a nutritional perspective, iron plays a fundamental role in hemoglobin synthesis and erythropoiesis, while adequate protein intake supports red blood cell production and vitamin C enhances the absorption of nonheme iron from plant-based foods. Consequently, the nutritional quality and diversity of adolescents' diets are important considerations in preventing iron deficiency and supporting healthy hematological function (Febriani et al., 2021; Sya'bani et al., 2025).

Preventing anemia among adolescent girls requires comprehensive strategies that extend beyond iron supplementation alone. Nutrition education, balanced dietary intake, food fortification, and consistent adherence to iron and folic acid supplementation programs represent complementary approaches to reducing anemia risk. Support from schools, families, healthcare providers, and local communities is also essential for encouraging healthier dietary behaviors and improving adolescents' understanding of nutritional requirements (Afriliya, 2025). School-based interventions are particularly relevant because educational institutions provide structured environments for delivering nutrition education, promoting healthy eating habits, facilitating anemia screening, and supporting preventive health programs. These interventions are especially important during adolescence, when individuals increasingly develop independent food preferences and dietary practices that may continue into adulthood.

The selection of SMAN 1 Sungai Raya Kepulauan in Bengkayang Regency, West Kalimantan, was based on the continuing concern regarding adolescent anemia in the region

and the reported limitations of routine hemoglobin monitoring among school-aged populations. Preliminary screening conducted on February 6, 2026, involving 30 students from SMAN 1 Sungai Raya Kepulauan and SMKN 1 Sungai Raya Kepulauan identified cases of mild and moderate anemia at both schools. Although these preliminary findings indicated the presence of anemia among the screened students, confirmation of iron-deficiency anemia would require additional indicators of iron status beyond hemoglobin measurements alone. Nevertheless, the screening results provided preliminary local evidence supporting the need for further investigation into the relationship between dietary patterns and anemia among adolescent girls at SMAN 1 Sungai Raya Kepulauan. Understanding this association is essential for informing targeted nutrition education, strengthening school-based anemia prevention programs, and improving adolescent nutritional health within the local educational setting.

Table 1. Relevant Previous Research

Yes	Name & Year of Publication	Title	Research Methods	Research Results
1	Galluchi Grevinsyah, Alwan Romzi, Prasetyo Hadi (2023)	The Relationship between Diet and the Incidence of Anemia in Adolescents at SMA X Private Bekasi	Descriptive with quantitative approach and *cross sectional design*	There was a relationship between diet and the incidence of anemia in adolescents at SMA X Private Bekasi (*p-value* 0.023 < 0.05)
2	Hani Ruliyani, Linda Amalia, Afianti Sulastri (2025)	The Relationship between Diet and the Incidence of Anemia in School Adolescents at SMPN Bandung City	Quantitative, descriptive correlational, *cross sectional design*	There was a relationship between diet and the incidence of anemia in adolescent girls due to unbalanced diet (p = 0.000; OR = 0.261)
3	Syifa Aulia Nur Fitriani, Elida Soviana (2025)	The Relationship between Breakfast Habits and *Fast Food Consumption* with Nutritional Status in Adolescents in Sukoharjo, Central Java	Observational with *cross-sectional design*	There was a relationship between breakfast habits (p = 0.019; r = -0.267) and frequency of *fast food consumption* (p = 0.002; r = 0.344) with adolescent nutritional status
4	- Hartati Deri Manila, Aprimayona Amir (2020)	The Relationship between Diet and the Incidence of Anemia in Adolescent Girls in Class X of SMA Murni Padang	Analytical survey with *cross sectional design*, questionnaire and Hb check tool	There was a relationship between diet and the incidence of anemia in adolescent girls (p = 0.028 < 0.05)
5	Mirza Nabilah Kurnia Agustina (2025)	The Relationship between Diet and the Incidence of Anemia in Adolescent Girls at SMPN 2 Gedangan Sidoarjo	*Cross-sectional* and correlative with quantitative design; Hemocue and questionnaire	There was a significant association between diet and the incidence of anemia (p = 0.001 < α = 0.05)

Source: Compiled from the studies cited in the table.

Previous studies have identified statistically significant associations between dietary patterns, eating behaviors, and anemia or nutritional status among adolescents (Galluchi Grevinsyah et al., 2023; Ruliyani et al., 2025; Fitriani & Soviana, 2025; Manila & Amir, 2020; Agustina, 2025). These studies have examined various aspects of adolescent nutrition,

employing different research designs, sampling methods, dietary assessment instruments, and health outcome measurements. As summarized in Table 1, the findings demonstrate sustained research interest in the relationship between dietary factors and adolescent health outcomes. However, variations in geographical settings, participant characteristics, dietary assessment methods, and anemia measurement procedures highlight the need for context-specific investigations to better understand the association between dietary patterns and anemia among adolescent girls.

The research gap lies in the limited empirical evidence examining the association between dietary patterns and anemia specifically among tenth-grade female students in the Sungai Raya Kepulauan area using both dietary assessments and direct hemoglobin measurements. To address this gap, the present study investigated adolescent girls at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency, by combining a Food Frequency Questionnaire (FFQ) with hemoglobin measurements obtained using the EasyTouch GCHb monitoring system. The novelty of this study lies primarily in its geographical and population-specific focus and the combined application of dietary assessment and objective hemoglobin measurement within the local school setting. Rather than claiming to establish a previously unexplored relationship, this research contributes context-specific empirical evidence that may support targeted nutrition education, school-based anemia screening, and the development of more appropriate anemia prevention strategies for adolescent girls in Sungai Raya Kepulauan.

Table 2. Theoretical Framework of Factors Related to the Incidence of Anemia (Khomsan et al. , 2025)

Concept	Description	Remarks
Teenagers	Characteristics of adolescents: stages, characteristics and changes	Unresearched
Anemia	Concept of anemia: classification and causes; impact and prevention	Researched
Diet	Daily nutritional needs, diet assessment, and FFQ	Researched

Source: Adapted from Khomsan et al. (2025), as cited in the manuscript.

The conceptual framework of this study was based on the premise that anemia among adolescent girls is associated with increased physiological iron requirements and dietary intake. Middle adolescence is characterized by rapid physical growth, increased nutritional demands, menstrual blood loss, and greater independence in food selection, making dietary adequacy particularly important for maintaining optimal hemoglobin concentrations and preventing nutritional deficiencies (Bawono, 2023; Aprillia, Gufran and Yarni, 2024; Atiqah, 2024). Inadequate consumption of iron-rich foods and nutrients essential for erythropoiesis may increase susceptibility to anemia, particularly among adolescent girls experiencing increased physiological demands. The theoretical relationships among adolescent characteristics, dietary patterns, and anemia status are presented in Table 2, providing a conceptual basis for examining the association between dietary behaviors and anemia in the study population.

Based on this conceptual framework, the study aimed to identify dietary patterns, determine the prevalence of anemia, and examine the association between dietary patterns and anemia status among tenth-grade female students at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency. The research hypothesis proposed a statistically significant association between dietary patterns and anemia status among adolescent girls. The findings were expected to provide context-specific empirical evidence to inform school-based nutrition education, strengthen routine hemoglobin screening, and support the development of targeted anemia prevention strategies. Furthermore, the study sought to establish a foundation for future research employing more comprehensive dietary assessment methods and longitudinal study

designs to better understand the temporal relationships between dietary intake, nutritional status, and anemia among adolescent girls.

METHODS

This study employed an analytical observational design with a cross-sectional approach to examine the association between dietary patterns and anemia status among adolescent girls (Zulfikar, 2024). Data on dietary patterns and anemia status were collected simultaneously at a single point in time (Abduh, 2023). The study was conducted among tenth-grade female students at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency, on June 11, 2026, at 9:00 a.m. Western Indonesian Time (WIB).

The study population consisted of 97 tenth-grade students at SMAN 1 Sungai Raya Kepulauan. The sample size was calculated using Slovin's formula, \(n = N/(1 + Ne^2)\), resulting in a sample of 71 respondents. Participants were selected using simple random sampling to provide each eligible student with an equal probability of selection. The inclusion criteria were female students enrolled in the tenth grade during the study period, within the middle- to late-adolescent age range, present during data collection, and willing to participate after providing informed consent. Students who were absent because of illness or other reasons, declined participation, or withdrew from the study were excluded.

The independent variable was dietary pattern, while the dependent variable was anemia status, assessed at the time of data collection. Dietary patterns were examined as a potential factor associated with anemia among adolescent girls (Bagus, 2024; Sagaf and Ndaomanu, 2025). The relationships between the study variables were established based on the conceptual framework described by (Nopiah and Indah, 2024), as presented in Table 3.

Table 3. Research Concept Framework

Independent Variables		Dependent Variable
Diet	→	Incidence of anemia

Source: Research framework developed by the authors, 2026.

The operational definition is designed to simplify the process of data collection, processing, and analysis so that the resulting data is measurable and ready to be processed (Sumbodo, 2024; Susanti, 2024). The operational definition of the research variables is presented in Table 4.

Table 4. Operational Definition

Yes	Variable	Operational Definition	How to Measure	Measuring Instruments	Measurement Results	Scale
1	Diet	Adolescent girls' eating habits include the frequency of meals, types of iron-rich foods, and daily iron intake assessed using the FFQ questionnaire	Filling out a diet questionnaire in *paper form*	Questionnaire	0 = Not suitable (score ≤12) 1 = Compliant (score >12) (Kataren, 2018)	Nominal

Yes	Variable	Operational Definition	How to Measure	Measuring Instruments	Measurement Results	Scale
2	Anemia	The condition of Hb levels in the blood of adolescent girls based on the results of the examination using digital hemoglobinometer	Direct measurement of hemoglobin	Easy Touch *test kit*	0 = Anemia (Hb <12 g/dL) 1 = No anemia (Hb ≥12 g/dL)	Nominal

Source: Research instrument and operational definitions, 2026.

Data were collected simultaneously at a time through two main methods, namely the *Food Frequency Questionnaire* (FFQ) questionnaire to measure the type, amount, and frequency of consumption of nutrients (specifically iron, protein, and vitamin C), and the examination of hemoglobin levels using a digital hemoglobinometer to determine the classification of anemia (Hb <12 g/dL). FFQ is a method for assessing the frequency of food consumption over a certain period of time that is generally longer, with the principle that a long-term average dietary pattern is conceptually more important than daily intake measured over 24 hours (Meriwati, 2023). The research instrument is a tool used by researchers in collecting data so that the results are more thorough, complete, and systematic (Ernawati and Setiawan, 2021). The instruments used consist of a personal data questionnaire (name, age, address, cellphone number, height, and weight), a diet questionnaire containing 25 questions with a choice of yes or no answers, and SOPs for checking hemoglobin levels with tools and materials in the form of cotton alcohol, sterile lancers, hemoglobin sticks, *haemometers*, and *handscoons*.

The diet questionnaire refers to the questionnaire of Galluchi, Grevinsyah, Alwan, Romzi, and (Fattah and Prasetyo, 2023) in a study on the relationship between diet and the incidence of adolescent anemia at Bekasi Private High School. The results of previous tests showed that the instrument had good validity and reliability with *a Cronbach Alpha coefficient* of 0.682 (≥ 0.6), so the researcher applied this questionnaire without conducting a re-validity test. The assessment of diet used a scoring system referring to (Yolanda Riski, 2018), namely the appropriate answer was given a score of 1 and the inappropriate answer was given a score of 0, with a value limit that refers to the principle of 50% of the total maximum score (Kataren, 2018).

Data processing includes *editing*, *scoring*, *coding*, *tabulatting*, and *cleaning* stages (Sumbodo *et al.* , 2024). Diet is coded 0 = not appropriate (score ≤12) and 1 = appropriate (score >12), while anemia is coded 0 = anemia (Hb <12 g/dL) and 1 = non-anemia (Hb ≥12 g/dL). Univariate analysis was carried out using a frequency distribution with the formula P = (f/N) × 100%, where P is the percentage, f is the frequency, and N is the total respondent. The percentage interpretation follows the guidelines of Wahyu and Wibowo (2023), namely 0% (none), 1–25% (a small part), 26–49% (almost half), 50% (half), 51–75% (most), 76–99% (almost all), and 100% (all respondents) (Wahyu and Wibowo, 2023).

Bivariate analysis used *the Chi-Square* test with a cross-table of 2×2 (Table 5) to assess the relationship between diet as an independent variable and the incidence of anemia as a dependent variable, with a significance level of α = 0.05 and a 95% confidence interval. If in contingency table 2×2 an expected value (E) <5 is found, the test used is *Fisher Exact*, while if there is no value of E <5, *Continuity Correction* is used. The analysis was carried out computerized to ensure the accuracy of the calculation and obtain *a p* value as the basis for decision-making; if *p* is <0.05, H0 is rejected which means that there is a meaningful

relationship between diet and the incidence of anemia, while if *p* is ≥0.05, H0 fails to be rejected (Fauzi *et al.* , 2023).

Table 5. Bivariate Analysis Cross Table

Diet	Anemia (Hb <12 g/dL)	No Anemia (Hb ≥12 g/dL)	Total
Inappropriate	a	b	A+B
Conform	c	d	C+D
Total	A+C	B+D	N

Source: Research data processed by the authors, 2026.

The research was carried out through the preparation stage (submission of titles, preliminary studies, literature studies, preparation and examination of proposals, licensing, and preparation of Hb *Easy Touch* GCHb examination instruments and tools), implementation stages (sample determination, research explanation and informed consent signing, filling out questionnaires with researcher assistance, and examining Hb levels), data processing and analysis using the SPSS program, and report preparation stages. The limitations of the study include differences in the writing of respondents' names when matching hemoglobin data with questionnaires so that manual verification is required, as well as the use of FFQ without additional methods such as 24-hour recall or *food records* which have the potential to cause memory bias and the tendency to answer according to social norms.

RESULTS AND DISCUSSION

This research was carried out at SMAN 1 Sungai Raya Kepulauan, one of the schools in the coastal area of Bengkayang Regency, West Kalimantan Province, which implements the Independent Curriculum at the X, XI, and XII levels with teaching and learning activities in the morning for five days a week. Based on the main data on education for the even semester of the 2025/2026 school year, this school has 457 students consisting of 199 male students and 258 female students, divided into 14 study groups with 25 teachers, the student-to-teacher ratio of 19, and the student-to-study group ratio of 33 people. This school has 14 classrooms, 7 laboratories, and 1 library with a total land area of 13,107 m².

Univariate analysis was conducted to describe the diet and incidence of anemia in adolescent girls at SMAN 1 Sungai Raya Kepulauan Bengkayang Regency. The distribution of the frequency of the respondents' diets is presented in Table 6.

Table 6. Distribution of Diet among Adolescent Girls at SMAN 1 Sungai Raya Islands, Bengkayang Regency

Diet	Frequency (n)	Percentage (%)
Inappropriate	37	52,1
Conform	34	47,9
Total	71	100,0

Source: Research data processed by the authors, 2026.

Table 6 shows that of the 71 respondents, most of them had an inappropriate diet, namely 37 people (52.1%), while almost half of the respondents had an appropriate diet, namely 34 people (47.9%). The incidence of anemia was determined based on the hemoglobin levels of

respondents who were categorized as anemia and non-anemia according to the threshold value for adolescent girls, as presented in Table 7.

Table 7. Distribution of Frequency of Anemia Incidence in Adolescent Girls at SMAN 1 Sungai Raya Islands, Bengkayang Regency

Incidence of Anemia	Frequency (n)	Percentage (%)
Anemia	11	15,5
No anemia	60	84,5
Total	71	100,0

Source: Research data processed by the authors, 2026.

Table 7 shows that of the 71 respondents, a small percentage experienced anemia, namely 11 people (15.5%), while almost all other respondents did not experience anemia, namely 60 people (84.5%). Bivariate analysis was carried out to determine the relationship between diet and the incidence of anemia in adolescent girls using *the Chi-Square* test, with the results as presented in Table 8.

Table 8. The Relationship between Diet and the Incidence of Anemia in Adolescent Girls at SMAN 1 Sungai Raya Islands Bengkayang Regency

Yes	Diet	Anemia				Total		*p-value*
		Yes (n)	%	No (n)	%	n	%	
1	Inappropriate	1	2,7	36	97,3	37	100	
2	Conform	10	29,4	24	70,6	34	100	0,002
	Total	11	15,5	60	84,5	71	100	

Source: Research data processed by the authors, 2026.

Based on Table 8, almost all respondents with inappropriate diets did not experience anemia, namely 36 people (97.3%), while in respondents with an appropriate diet there was a small percentage who experienced anemia, namely 10 people (29.4%). The results of *the Chi-Square* test (Pearson *Chi-Square* = 9.654; df = 1) obtained *a p-value* = 0.002 (<0.05), with no cells having an expected value of less than 5 (minimum expectation value 5.27). This shows that Ha is accepted, so there is a significant relationship between diet and the incidence of anemia in adolescent girls at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency.

Diet of Young Girls at SMAN 1 Sungai Raya Kepulauan

The results of the univariate analysis showed that most of the respondents had an inappropriate diet, namely 37 respondents (52.1%), while respondents with an appropriate diet amounted to 34 people (47.9%). This finding indicates that more than half of the respondents have not implemented a good and balanced diet according to nutritional recommendations for adolescents. Theoretically, diet is formed by three main components, namely the type of food consumed, the amount or portion of food, and the frequency and schedule of meals throughout the day, which together determine the adequacy of daily nutrient intake including iron. The diet questionnaire in this study assessed the three components through twenty-five statements that included the regularity of meal times, breakfast habits, snack habits, vegetable and fruit consumption, and the respondents' perception of their own diet (Hasan, 2025).

The assessment of diet through the twenty-five statements is basically an operationalization of the principles of diversity and regularity in balanced nutrition guidelines,

although it does not quantitatively measure the daily nutritional intake of respondents (Rahayu and Alriessyane, 2023). Adolescent eating behavior can also be understood through socioecological models, which place individual behavior as the result of layered interactions between personal factors (knowledge and taste preferences), interpersonal (family and peer habits), physical environment (availability and price of snacks around school), and policies (such as the Free Nutritious Meal program). The four levels work simultaneously, so that inappropriate diets in more than half of the respondents are most likely the result of an interaction of various factors, rather than a mere reflection of the wrong individual choices (Rahmawati *et al.* , 2025). It should be noted that the diet categories in this study were determined based on the combined scores of all statements, so a high percentage of positive answers on one item did not necessarily reflect the overall diet of the respondents.

The first pattern is related to the regularity of mealtimes. Only 46.5% of respondents ate three meals a day, only 23.9% stated that they always try to maintain a regular diet, and 71.8% admitted that they often eat late. This data illustrates that the regularity of meal times is still a major challenge, as it is stated that adolescents tend to ignore eating regularity due to busy school activities and other activities (Rahmawati *et al.* , 2025). Eating regularity functions to maintain the stability of blood glucose levels and ensure that the distribution of nutrient intake occurs evenly throughout the day (Yolanda Riski, 2018), while irregular eating causes long intake of intake that has the potential to reduce total daily energy intake and micronutrients, including iron (Ruliyani, Amalia and Sulastri, 2025).

The second pattern is related to breakfast habits. Most respondents (62.0%) have been accustomed to eating breakfast before school and 67.6% eat breakfast before 7:00 a.m., but the breakfast menu tends to be dominated by carbohydrate sources alone (64.8%). As many as 77.5% of respondents stated that breakfast increases study concentration, a finding that reinforces the importance of breakfast as a contributor to 15–30% of adolescents' daily nutritional needs (Rahmawatie, Rizal and Syabrina, 2025). A carbohydrate-based breakfast meets short-term energy needs, but contributes less to iron intake because the iron content in rice and white bread is relatively low compared to animal protein sources, so the addition of eggs, meat, or fish has the potential to increase the contribution of breakfast to daily iron adequacy (Sardi, 2025). Adolescents who are used to eating breakfast with a limited menu need to compensate for iron deficiency through lunch and dinner, compensation that does not always occur if the next menu has similar variations (Solhan, 2020). Breakfast is thus one of the most strategic intervention points because it can be controlled by families at home.

The third pattern is related to snack habits at school. As many as 76.1% of respondents admitted to snacking frequently, while only 40.8% were selective in choosing snacks; the habit of consuming instant noodles (38.0%) and fast food (39.4%) was also found, and only 54.9% of respondents brought lunch from home. Bringing provisions provides greater control over the quality and cleanliness of food because it can be adjusted to individual nutritional needs (Wibisana, 2023; Ulrahmah and Maysura, 2026). School snacks and fast food are generally classified as processed foods with high energy density but low micronutrient density, so high consumption has the potential to replace the main food portion that is richer in iron and protein; The phenomenon of excess energy that goes hand in hand with a lack of micronutrients is known as *hidden hunger* (Ramayani *et al.* , 2025). Stalls and traders around the school generally sell practical, durable, and affordable foods that are more often in the form of processed foods high in flour and sugar, so that with limited pocket money, the availability of snacks becomes a strong determinant of student consumption regardless of their nutritional

knowledge, and improving snack habits also requires regulating food supply in the school environment (Damayanti, 2025).

The fourth pattern is related to the consumption of vegetables, fruits, and water. Daily consumption of vegetables and fruits was only reported by 50.7% of respondents, and the consumption of 2.5 liters of water per day was only fulfilled by 42.3% of respondents. Vegetables and fruits are a source of vitamin C which reduces ferrous iron (Fe^{3+}) to ferrous form (Fe^{2+}) which is more easily absorbed by the small intestine, so that the lack of intake reduces the absorption efficiency of non-heme iron and increases the risk of iron deficiency anemia even though the total iron intake is sufficient (Patel, Nayan and Maheshvari, 2025; Hardiansyah, Aulia and Sugiyanti, 2024). Fluid sufficiency also supports the transport of iron through blood plasma, so the combination of low consumption of vegetables, fruits, and water indicates a diet that is less oriented towards fresh food and relies more on processed foods and packaged drinks that are easily accessible in schools (Ulrahmah, Zahara and Maysura, 2026).

The fifth pattern is related to the gap between understanding and behavior. Some respondents are active in organizations or extracurriculars (46.5%) and have other activities such as tutoring (29.6%), but only 16.9% stated that these activities affect their diet, while almost all respondents (97.2%) agree that a good diet affects daily activities. This gap between knowledge and practice is commonly explained through the *Knowledge-Attitude-Practice* (KAP) framework, which emphasizes that nutrition knowledge is not automatically followed by behavioral changes without the support of positive attitudes, practical skills, and a facilitating environment (Audina, Naswa and Widriyani, 2025). The five patterns reinforce each other; adolescents who often eat late tend to rely on fast food snacks, while adolescents who rarely bring provisions are more dependent on school snacks that are low in vegetables and animal protein (Ayuningtyas *et al.* , 2022), so diet improvement interventions will be more effective if they are designed to be integrated and target several aspects simultaneously (Mikawati *et al.* , 2024).

Prevalence of Anemia in Adolescent Girls at SMAN 1 Sungai Raya Kepulauan

The results showed that a small percentage of respondents experienced anemia, namely 11 people (15.5%), while almost all other respondents did not experience anemia, namely as many as 60 people (84.5%). This prevalence is not too high when compared to the proportion of adolescent girls who have an inappropriate diet, which actually reaches more than half of the respondents. Anemia reflects the presence of systemic disorders due to iron deficiency, blood loss, or impaired red blood cell production (Danarsih, Kusumawardani and Ariningtyas, 2024), and the determination of anemia status in this study has referred to the WHO threshold, namely hemoglobin levels below 12 g/dL (Helmyati *et al.* , 2023).

The researcher assessed that the relatively low prevalence of anemia in this study is inseparable from the role of government programs, especially the provision of Blood Supplement Tablets (TTD) with a minimum of 60 mg of iron and 400 mcg of folic acid which are routinely distributed through educational institutions as part of the School Health Business (UKS) (Ministry of Health of the Republic of Indonesia, 2020). Schools generally provide TTD to all students on a weekly basis regardless of individual nutritional status or diet, so that the supplementation may still help meet the iron needs of respondents whose diets are not suitable. The government also implements iron fortification in widely consumed foods such as rice, wheat flour, cooking oil, and snacks (Siska and Masluroh, 2024; Sidik, 2025). The combination of TTD supplementation and food fortification is what researchers say also explains why the prevalence of anemia is not as high as the proportion of adolescents with inappropriate diets.

The figure of 15.5% still requires serious attention, considering that anemia can reduce immunity, fitness, thinking agility, learning achievement, and productivity, and if it continues until pregnancy, it can increase the risk of Stunted Fetal Growth (PJT), premature birth, Low Birth Weight (BBLR), stunting, childbirth bleeding, and neonatal pain and death (Jubaedah *et al.* , 2025). The pathophysiology of iron nutrient anemia begins with a decrease in iron reserves (ferritin) which continues with a decrease in transferin saturation until finally marked by low hemoglobin levels (Pratiwi, Hositanisita and Rahayu, 2025). This gradual process is often unnoticed by adolescents, so early detection through periodic hemoglobin levels checks at school using an accurate, practical, and fast digital hemoglobinometer is important (Ruliyani, Amalia and Sulastri, 2025).

The Relationship between Diet and the Incidence of Anemia in Adolescent Women

The results showed that of the 37 respondents with an inappropriate diet, almost all of them did not experience anemia (36 people; 97.3%) and only 1 person (2.7%) experienced anemia, while of the 34 respondents with an inappropriate diet, 10 people (29.4%) experienced anemia and 24 people (70.6%) did not have anemia. The results of *the Chi-Square* test obtained *a p-value* of 0.002 (p <0.05), so that Ha was accepted and H0 was rejected, which proves that there is a statistically significant relationship between diet and the incidence of anemia in adolescent girls at SMAN 1 Sungai Raya Kepulauan. These findings are in line with the theory that diet is one of the main determinants of fulfilling nutritional status, including the adequacy of iron which plays an important role in the formation of hemoglobin, because diet determines the type and amount of nutrients that actually enter the body every day (Hasan *et al.* , 2025).

The results of this study are in line with a number of previous studies that found a significant relationship between diet and the incidence of anemia in adolescents, including research by Prasetyo Hadi (2023) at SMA X Private Bekasi (p = 0.023), Ruliyani, Amalia and Sulastri (2025) at SMPN Bandung City (p = 0.000), Manila and Amir (2020) at SMA Murni Padang (p = 0.028), and Agustina (2025) at SMPN 2 Gedangan Sidoarjo (p = 0.001). The variation in *the p-value* showed that the strength of the statistical relationship could differ depending on population characteristics, sample size, and dietary measurement instruments, but the consistency of the relationship direction across comparative studies reinforced the generalization that dietary determinants of anemia status were relatively consistent across geographic locations and adolescent education levels.

Reviewing the questionnaire items, regularity of meal times was the main component assessed. A total of 46 respondents (64.8%) stated that their diet (breakfast, lunch, dinner) went regularly, but only 33 respondents (46.5%) ate three meals a day, only 17 respondents (23.9%) always tried to keep their diet regular, and 51 respondents (71.8%) often ate late. A regular diet allows the intake of iron sources to be distributed more evenly throughout the day. The human body also has circadian rhythms that affect the secretion of hunger and satiety regulating hormones; irregular eating disrupts this rhythm so that it encourages the consumption of large portions in a short period of time which makes it difficult to absorb nutrients, as well as increasing the tendency to choose foods that are high in calories but low in micronutrients (Solhan, 2020).

The biochemical aspects of iron absorption are also relevant to explain this relationship. Heme iron sourced from animal proteins has a much higher bioavailability than non-heme iron from plant foods, because it is absorbed through special transporter pathways in the small intestine without being greatly affected by the composition of other foods (Ayuningtyas *et al.* , 2022). The absorption of non-heme iron is strongly influenced by *enhancers* such as vitamin

C and inhibitors such as calcium, phylate, tannins, and oxalate in tea, coffee, and dairy products, so that an appropriate diet does not necessarily guarantee functional iron adequacy if the iron source is dominated by non-heme iron without the support of *enhancers* (Patel, Nayan and Maheshvari, 2025). A menu that combines animal protein with green vegetables and fruits high in vitamin C, such as fish or eggs with spinach and oranges, theoretically results in higher iron absorption, while this research instrument assesses each type of food separately without assessing the combination of its presentation (Ayuningtyas *et al.* , 2022).

It was also found that 29.4% of respondents (10 out of 34 people) with a diet that was classified as appropriate still experienced anemia. The appropriate category was formed from a combined score of 25 statements that assessed the regularity and frequency of eating behavior in general, without specifically assessing the combination or iron content of the diet. A total of 46 respondents (64.8%) stated that their breakfast was dominated by carbohydrates, and that such a menu contributed much lower iron than breakfast accompanied by eggs or other animal products, even though both were recorded as breakfast (Sardi *et al.* , 2025). In addition, 50 respondents (70.4%) consumed milk every day, even though calcium competed with iron on the same *divalent metal transporter* on the surface of small intestinal cells, so milk consumption along with a menu of iron sources can inhibit the absorption of non-heme iron (Ulrahmah, Zahara and Maysura, 2026). The principle of giving a time break for milk consumption from the main menu is rarely understood because milk is generally perceived as safe to consume at any time (Rahayu and Alriessyane, 2023).

Snack habits are also relevant to be studied: 54 respondents (76.1%) often snack at school, only 29 respondents (40.8%) selectively choose snacks, 27 respondents (38.0%) often eat instant noodles, and 28 respondents (39.4%) often eat fast food, while only 39 respondents (54.9%) bring lunch from home. Meals from home have nutritional advantages because the composition of the menu can be consciously determined including animal protein sources, processed with more controlled cooking methods, and indirectly limits exposure to high-sugar and low-nutrient snacks in the school environment (Ulrahmah, Zahara and Maysura, 2026). Most respondents (88.7%) also take vitamin supplements in the morning, but the type of supplement is not detailed so it cannot be interpreted as compliance with the TTD program; The effectiveness of TTD itself is highly dependent on adherence to routine consumption, because mild side effects such as nausea or stool discoloration are often the reason for adolescents to stop consumption (Ministry of Health, 2020).

A total of 48 respondents (67.6%) felt that their food intake had met balanced nutrition, even though only 50.7% actually consumed vegetables and fruits every day. This perception gap is related to the limitations of nutritional literacy, where adolescents tend to assess their diet based on satiety or habits, rather than meeting nutritional needs objectively. The *Health Belief Model* framework explains that behavioral changes are influenced by the perception of vulnerability, severity, benefits, and barriers; respondents already have a good perception of benefits (Audina, Naswa and Widriyani, 2025), but the perception of susceptibility to anemia and the perception of barriers may not have been adequately formed, so nutrition education needs to build awareness of personal vulnerability and provide practical solutions to the obstacles faced by adolescents (Tambuwun and Punuh, 2021).

Based on the WHO classification, the prevalence of anemia as a public health problem is relatively mild if it is below 20%, moderate in the range of 20–39.9%, and severe if it reaches 40% or more, so that the proportion of 15.5% in this study is classified as a mild public health problem that still requires treatment with an appropriate intervention scale (Ministry of Health

of the Republic of Indonesia, 2023). This research instrument does not include the assessment of menstrual cycles or volume, compliance with TTD consumption, or other clinical conditions such as worm infections or chronic diseases that in theory also affect hemoglobin levels and can explain some cases of anemia in groups with appropriate diets. Self-report-based instruments also have the potential to be influenced by *recall bias* and *social desirability bias* which can cause the proportion of appropriate diet to be slightly higher than the actual condition (Kataren, 2018). Further research is recommended to use longitudinal designs, more objective intake recording methods such as 24-hour recall or *food records*, as well as examination of iron status biomarkers such as serum ferritin to detect iron deficiency earlier (Meriwati *et al.* , 2023).

The significance of the relationship in this study needs to be interpreted according to *a cross-sectional design*, which allows the identification of statistical associations but cannot confirm the exact direction of the cause-and-effect relationship, so the interpretation still refers to the established framework of nutrition theory regarding the role of diet in anemia status. The practical implications of these findings are relevant for schools, health workers, and families. Schools can strengthen integrated nutrition education in teaching and learning activities, not limited to the provision of food through the Free Nutritious Eating program (Mikawati *et al.* , 2024). Health workers can strengthen the TTD supplementation program accompanied by education on the combination of iron consumption with vitamin C sources and consumption avoidance along with inhibiting iron absorption, while families need to be actively involved because eating at home is not affordable for school intervention (Ministry of Health, 2020).

Improving the diet of adolescent girls should ideally be designed in layers at four levels: at the individual level, adolescents are equipped with practical knowledge about menu combinations that support iron absorption; at the family level, parents are involved in the provision of a more varied breakfast and lunch menu; at the school level, the regulation of the type of snacks in the canteen and around the school is strengthened accompanied by the integration of nutrition education in a sustainable manner; and at the policy level, the Free Nutritious Meal and TTD programs continue to be evaluated and strengthened in scope according to the nutritional adequacy figures of adolescents (Ministry of Health of the Republic of Indonesia, 2019). This layered approach is in line with the socioecological model of eating behavior and is believed to have more potential to result in improvements in sedentary diets than a single intervention, while emphasizing that improving the nutritional status of adolescent girls requires a comprehensive approach that includes aspects of knowledge, food availability, and support for the family and school environment (Audina, Naswa and Widriyani, 2025).

CONCLUSION

Based on the findings of this study involving 71 adolescent girls at SMAN 1 Sungai Raya Kepulauan, Bengkayang Regency, in 2026, it was concluded that more than half of the respondents (37 students; 52.1%) had dietary patterns classified as inappropriate, while 11 respondents (15.5%) were identified as having anemia. Pearson's chi-square test revealed a statistically significant association between dietary patterns and anemia status ($p = 0.002$). However, the findings should be interpreted cautiously because the prevalence of anemia was higher among respondents classified as having appropriate dietary patterns than among those with inappropriate dietary patterns. This unexpected distribution highlights the need to consider potential limitations in dietary assessment and unmeasured confounding factors. Furthermore, the cross-sectional study design did not establish a causal relationship between dietary patterns

and anemia. Nevertheless, the findings provided context-specific evidence regarding adolescent nutritional health and underscored the importance of comprehensive dietary assessment, routine hemoglobin monitoring, and targeted anemia prevention programs in school settings.

Based on these findings, schools are encouraged to implement regular nutrition education programs in collaboration with local community health centers (puskesmas), using educational counseling, school bulletin boards, and other accessible communication channels to promote balanced dietary practices, raise awareness of anemia's potential effects on health and academic performance, and improve students' understanding of iron-rich food sources. The Singkawang Midwifery Academy is encouraged to incorporate the findings into teaching materials, clinical training, and community service activities related to adolescent reproductive health and nutrition. Adolescent girls are advised to maintain regular meal patterns, avoid skipping breakfast, and consume a balanced diet containing iron-rich foods, including red meat, poultry, fish, legumes, and dark green leafy vegetables. They should also be encouraged to consume vitamin C-rich foods to enhance nonheme iron absorption and avoid drinking tea or coffee with iron-rich meals because certain compounds in these beverages can inhibit iron absorption. Future research should employ longitudinal designs and more comprehensive dietary assessment methods while accounting for potential confounding factors, including menstrual blood loss, iron supplementation, dietary iron absorption inhibitors, infection and inflammatory status, and physical activity levels. Such investigations would provide a more comprehensive understanding of the factors associated with anemia and support the development of evidence-based prevention strategies for adolescent girls.

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CONFLICT OF INTEREST

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GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

The author uses generative artificial intelligence (Claude, Anthropic) to help reconstruct and summarize the Scientific Paper manuscript into a journal article format. All data, analysis, and interpretation come from the author's research, and the author has reviewed and takes full responsibility for the content of this article.

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