

DETERMINANTS OF ANEMIA AMONG ADOLESCENT GIRLS AT SMA NEGERI 3 BENGKULU: A CROSS-SECTIONAL STUDY

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ABSTRAK


Anemia pada remaja putri masih menjadi tantangan kesehatan masyarakat yang belum sepenuhnya teratasi, terutama karena kondisi ini berdampak luas pada berbagai aspek kehidupan remaja, mulai dari terhambatnya tumbuh kembang, menurunnya daya konsentrasi saat belajar, berkurangnya produktivitas harian, hingga timbulnya risiko gangguan pada sistem reproduksi. Tujuan dari studi ini adalah mengidentifikasi faktor-faktor yang menentukan kejadian anemia di kalangan siswi SMA Negeri 3 Kota Bengkulu. Studi dirancang menggunakan metode observasional analitik berpendekatan potong lintang (*cross-sectional*). Sebanyak 131 siswi kelas X dengan rentang usia 15 hingga 17 tahun dipilih sebagai partisipan melalui teknik pengambilan sampel acak sederhana. Kadar hemoglobin diukur secara langsung menggunakan alat *Hb meter* berbasis *rapid test*. Variabel yang diteliti meliputi status gizi, kondisi kekurangan energi kronik, lama hari menstruasi, kecukupan asupan zat gizi, tingkat kepatuhan dalam mengonsumsi suplemen tablet tambah darah, serta sejauh mana dukungan yang diperoleh dari teman sebaya. Pengolahan data menggunakan uji *chi-square* untuk analisis bivariat dan regresi logistik berganda metode *backward Wald* untuk analisis multivariat. Studi ini menemukan bahwa satu dari empat responden (25,2%) terkonfirmasi mengalami anemia. Melalui pemodelan multivariat, terungkap bahwa empat faktor secara bermakna memengaruhi kejadian anemia, yakni status gizi, lama menstruasi, kecukupan asupan protein, dan keberadaan dukungan sosial dari teman sebaya, dengan status gizi menempati posisi sebagai prediktor paling kuat. Dengan demikian, intervensi pencegahan anemia hendaknya diprioritaskan pada perbaikan status gizi secara menyeluruh, peningkatan konsumsi protein yang memadai, pemantauan pola dan durasi siklus menstruasi, serta pemberdayaan jaringan teman sebaya sebagai agen dukungan kesehatan di lingkungan sekolah.

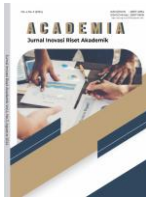
Kata kunci: anemia, remaja putri, status gizi, lama menstruasi, dukungan teman sebaya

ABSTRACT

Anemia among adolescent girls remains a public health challenge that has not been fully resolved, particularly because this condition has wide-ranging impacts on various aspects of adolescents' lives from impaired growth and development, decreased concentration during learning, reduced daily productivity, to an increased risk of reproductive system disorders. The aim of this study was to identify the determinants of anemia among female students at SMA Negeri 3 Bengkulu City. The study was designed using an analytical observational method with a cross-sectional approach. A total of 131 tenth-grade students aged 15 to 17 years were selected as participants through simple random sampling. Hemoglobin levels were directly measured using a rapid-test-based Hb meter. The variables examined included nutritional status, chronic energy deficiency, duration of menstruation, adequacy of nutrient intake, level of compliance in consuming iron supplement tablets, and the extent of peer support received. Data were analyzed using the chi-square test for bivariate analysis and the backward Wald method of multiple logistic regression for multivariate analysis. The study found that one in four

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respondents (25.2%) was confirmed to have anemia. Through multivariate modeling, it was revealed that four factors significantly influenced the occurrence of anemia nutritional status, duration of menstruation, adequacy of protein intake, and the presence of social support from peers with nutritional status emerging as the strongest predictor. Therefore, anemia prevention interventions should prioritize comprehensive improvement of nutritional status, increased consumption of adequate protein, monitoring of menstrual patterns and duration, as well as empowerment of peer networks as health support agents within the school environment.

Keywords: anemia, adolescent girls, nutritional status, duration of menstruation, peer support

INTRODUCTION

Anemia continues to be a pressing public health challenge among adolescent girls worldwide, with global prevalence among those aged 10–19 years standing at 29.9%, while Indonesia reports a comparable figure of 31.7% (World Health Organization, 2025; Kementerian Kesehatan Republik Indonesia, 2023). The adolescent phase represents a pivotal developmental window marked by accelerated physical growth, heightened nutritional demands, and profound physiological and psychological transitions. Adolescent girls face heightened susceptibility to anemia due to cyclical blood loss through menstruation, elevated iron requirements, suboptimal dietary intake, and poor eating behaviors, particularly habitual consumption of fast food with minimal micronutrient value.

The consequences of anemia extend beyond individual health, casting a broader shadow on human resource quality. In adolescent girls, anemia can diminish productivity, compromise cognitive performance, and generate long-term reproductive health vulnerabilities. Furthermore, it risks perpetuating intergenerational health challenges, including elevated susceptibility to obstetric complications, maternal morbidity and mortality, and stunted child growth and development. Despite the rollout of iron supplementation initiatives, their impact has been constrained by poor adherence, inadequate nutrition literacy, and weak monitoring infrastructure within school environments (Kementerian Kesehatan Republik Indonesia, 2023).

On the global stage, anemia continues to impose a substantial health burden on women and adolescent girls. The Global Anaemia Estimates documented that over 571 million women between the ages of 15 and 49 were affected by anemia. Among adolescent girls aged 10–19 years, the worldwide prevalence reached 29.9%, with the most severe burdens concentrated in South Asia and Sub-Saharan Africa. Progress toward the global ambition of halving anemia rates by 2030 has been achieved by only a fraction of nations (World Health Organization, 2025). A systematic review and meta-analysis by Habtegiorgis et al. (2022) reinforced that anemia among adolescent girls constitutes a considerable public health burden, interwoven with nutritional, sociodemographic, and health-related determinants. Wiafe et al. (2023) further established that dietary practices, female sex, menstruation, parasitic infections, and limited educational attainment ranked among the foremost risk factors for iron deficiency anemia in adolescents across developing nations. Complementing this evidence, Zhu et al. (2021) demonstrated through a large follow-up study in rural western China that female adolescents were significantly more likely to experience anemia compared to their male counterparts, with nutritional status, maternal education, and dietary patterns particularly inadequate flesh food consumption emerging as key associated factors, underscoring the multifactorial nature of adolescent anemia across diverse low-resource settings.

Within Indonesia, anemia persists as an unresolved public health concern. The 2023 Indonesian Health Survey disclosed that anemia prevalence among adolescents stood at 31.7%, reflecting that roughly three to four in every ten Indonesian adolescents were affected



(Kementerian Kesehatan Republik Indonesia, 2023). At the subnational level, anemia among adolescent girls constitutes a notable concern in Bengkulu Province, where data from the Bengkulu Provincial Health Office recorded a prevalence of 21.22% among adolescent girls in 2023 (Dinas Kesehatan Provinsi Bengkulu, 2023).

At the community level, anemia among adolescent girls warrants targeted attention. Bengkulu City was identified as one of the higher-burden areas within Bengkulu Province. Screening efforts by the Bengkulu City Health Office at SMA Negeri 3 Bengkulu in 2024 revealed that 37.1% of tenth-grade female students were anemic (Dinas Kesehatan Provinsi Bengkulu, 2024). Preliminary insights gathered from teachers, school health personnel, students, and community health workers pointed to several potential contributing factors, including poor dietary habits, frequent fast food consumption, low intake of iron-dense foods such as animal-source proteins and vegetables, tea or coffee consumption following meals, and poor adherence to prescribed iron supplements.

A growing body of literature highlights that anemia in adolescent girls is shaped by a constellation of factors encompassing dietary behavior, nutritional status, menstrual characteristics, health knowledge, supplementation adherence, and social determinants. Habib et al. (2020) found that anemia in this population was driven not solely by biological and nutritional conditions, but also by broader societal forces. Musfira & Hadju (2024) similarly reported associations between anemia status and dietary patterns, knowledge, menstrual cycle characteristics, and adherence to iron supplementation. Yuliawati et al. (2023) demonstrated that both anemia-related knowledge and iron tablet adherence were linked to hemoglobin levels in adolescent girls. Dhurde et al. (2024) established that iron deficiency served as a predictor of anemia severity among school-attending adolescent girls, with nutritional status and dietary habits particularly low consumption of non-vegetarian foods and green leafy vegetables emerging as significant contributors.

Further evidence underscores the relevance of nutritional and sociodemographic dimensions. Wemakor et al. (2023) identified household income, infectious disease burden, smoking behavior, and nutritional status as risk-elevating factors for anemia among adolescent girls. Additionally, Zuraida et al. (2020) demonstrated that targeted nutrition education among anemic adolescent girls meaningfully improved caloric, iron, protein, and fat intake. A subsequent study by Zuraida et al. (2023) found that nutrition education, reinforced by active engagement from mothers and teachers, produced meaningful gains in knowledge, attitudes, dietary behavior, supplementation adherence, and hemoglobin status. The value of peer-based approaches has also gained recognition; Lutfiasari et al. (2023) confirmed through systematic review that peer group interventions effectively promoted anemia prevention behaviors among adolescents. In the Indonesian context specifically, Indriasari et al. (2024) found through qualitative inquiry with high school female students that comprehensive knowledge about the causes, consequences, and prevention of anemia alongside active support from family members and teachers was essential to improving awareness and participation in anemia prevention programs, reinforcing the critical interplay between social support networks and adolescent health behavior.

While existing literature has explored various anemia-related determinants, local evidence from SMA Negeri 3 Bengkulu City remains scarce. Moreover, prior investigations have largely examined nutritional, menstrual, behavioral, or social factors in isolation, leaving the simultaneous contributions of nutritional status, menstrual duration, protein intake, and peer support insufficiently explored, especially within this specific school context. The novelty of this study lies in its integrated examination of biological, nutritional, and social determinants



by concurrently analyzing nutritional status, menstrual duration, protein intake, and peer support among adolescent girls at SMA Negeri 3 Bengkulu City. Accordingly, this study sought to identify the determinants of anemia in this population and to generate evidence supporting the design of targeted, school-based anemia prevention strategies.

METHODS

Study Design and Setting

This study utilized a quantitative observational analytic design with a cross-sectional approach. This design was chosen given its capacity to measure dependent and independent variables simultaneously, rendering it efficient in terms of time, cost, and practical feasibility for investigating anemia and its associated determinants within a school-based population. The cross-sectional approach was applied to evaluate relationships between anemia status and multiple independent variables, encompassing nutritional factors, menstrual characteristics, dietary intake, behavioral factors, and social determinants among adolescent girls. The study was carried out at SMA Negeri 3 Kota Bengkulu, Bengkulu Province, Indonesia, spanning January through April 2026.

Population and Sample

The target population comprised all 10th-grade female students enrolled at SMA Negeri 3 Kota Bengkulu in 2026, ranging in age from 15 to 17 years, with a total of 220 students. Sample size determination followed the Lemeshow formula for population proportion estimation incorporating finite population correction. The reference anemia proportion of 37.1% was drawn from the 2024 anemia screening data of 10th-grade female students at the same institution. A 95% confidence level was applied, corresponding to a Z-value of 1.96, an expected proportion of 0.371, a complementary proportion of 0.629, and a margin of error of 0.059. The preliminary sample size was derived using the formula below:

$$n_0 = \frac{Z^2 p(1-p)}{d^2}$$
$$n_0 = \frac{(1.96)^2(0.371)(0.629)}{(0.059)^2} = 257.53$$

Because the total population was finite, the sample size was adjusted using the finite population correction formula:

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$
$$n = \frac{257.53}{1 + \frac{257.53 - 1}{220}} = 118.89$$

After adding a 10% allowance for possible non-response or incomplete data, the minimum sample size was:

$$n = 118.89 + 10\% = 130.78$$

Accordingly, the final sample size was rounded up to 131 respondents. Participant selection employed simple random sampling, ensuring each eligible student had an equal probability of inclusion. Inclusion criteria required participants to be female students enrolled in grade X, willing to participate, and having previously experienced menstruation. Students were excluded if they were absent on data collection days, had chronic illnesses or hematological conditions capable of influencing hemoglobin levels, or were consuming



medications or supplements beyond the school-based iron supplementation program that could potentially confound hemoglobin measurements.

Variables and Measurements

The dependent variable was anemia status among adolescent girls. Anemia determination was performed through hemoglobin measurement using venous blood samples analyzed with an Hb meter rapid test device operated by trained health personnel. Respondents were classified as anemic when hemoglobin levels fell below <12 g/dL and non-anemic when levels reached ≥ 12 g/dL, consistent with established cut-off criteria for non-pregnant adolescent girls. Independent variables encompassed knowledge of nutrition and anemia, nutritional status, chronic energy deficiency, menstrual duration, protein intake, vitamin C intake, iron intake, iron tablet supplementation adherence, and peer support. Knowledge of nutrition and anemia was captured through a structured questionnaire adapted from Zuraida et al. (2020), addressing the definition, etiology, signs and symptoms, consequences, prevention strategies, and nutrient sources pertaining to anemia.

Nutritional status was determined through anthropometric assessment. Body weight was recorded using a digital scale with 0.1 kg precision, and height was obtained via microtoise with 0.1 cm precision. Body mass index was subsequently computed and converted to BMI-for-age z-scores in accordance with World Health Organization growth reference standards. For descriptive purposes, nutritional status was classified as severely thin, thin, normal, overweight, or obese. For bivariate and multivariate analyses, nutritional status was dichotomized into good and poor categories, wherein normal BMI-for-age z-scores corresponded to good nutritional status, while severely thin, thin, overweight, and obese classifications were grouped as poor or non-normal nutritional status.

Chronic energy deficiency was evaluated through mid-upper arm circumference measurement taken on the left arm at the midpoint between the acromion and olecranon processes. A MUAC reading of <23.5 cm indicated chronic energy deficiency, whereas ≥ 23.5 cm indicated its absence. Menstrual duration was assessed via structured questionnaire and categorized as normal when bleeding persisted for 3–7 days, and abnormal when it lasted either <3 days or >7 days. Dietary intake covering protein, vitamin C, and iron was captured through two 24-hour dietary recalls conducted separately on a school day and a weekend day. Protein intake adequacy was assessed against the 2019 Indonesian Recommended Dietary Allowance, with intake meeting $\geq 80\%$ of the recommendation considered adequate and $<80\%$ considered inadequate. The reference protein requirement for adolescent girls aged 15–17 years was set at 65 g/day. Vitamin C and iron intake were similarly classified as adequate or inadequate using the same reference standard.

Iron tablet supplementation adherence was evaluated through questionnaire items on tablet consumption frequency over the preceding three months. Respondents consuming at least 75% of the recommended tablets were classified as adherent, while those falling below this threshold were classified as non-adherent. Peer support was assessed using a dedicated peer support questionnaire, with aggregate scores categorized as either poor or good peer support.

Data Collection Procedures

Data collection proceeded systematically following the acquisition of informed consent from all participants. Prior to commencement, the researcher thoroughly briefed respondents on the study aims, procedures, anticipated benefits and risks, confidentiality safeguards, and the voluntary nature of involvement. A team of trained health professionals comprising a general practitioner, nutritionists, nurses, midwives, and a medical laboratory technologist assisted with data collection to uphold measurement accuracy and objectivity. Hemoglobin



assessment was performed on venous blood samples. Anthropometric data encompassed body weight, height, and mid-upper arm circumference measurements. Structured questionnaires gathered information on nutritional and anemia knowledge, menstrual duration, iron tablet adherence, and peer support. Dietary intake was assessed through two 24-hour dietary recalls representing both school-day and weekend eating patterns.

Validity and Reliability

The knowledge questionnaire was adapted from Zuraida et al. (2020) and subjected to validity and reliability testing prior to main study deployment. Validity was evaluated using the Pearson Product Moment correlation among 58 respondents sharing characteristics with the target population. The original instrument comprised 30 items, of which 24 were retained as valid based on calculated *r*-values exceeding the *r*-table threshold of 0.2586; the remaining 6 items were eliminated. The final knowledge instrument thus consisted of 24 validated items. Reliability assessment of the refined questionnaire yielded a Cronbach's alpha of 0.8547, reflecting satisfactory internal consistency.

The peer support and iron tablet adherence questionnaires were adapted from pre-existing instruments and contextualized for adolescent girls and anemia prevention; however, independent validity and reliability testing for these tools was not undertaken in this study. Menstrual duration was measured through structured factual items on the number of bleeding days and classified using predefined criteria, and was therefore not treated as a multi-item psychometric scale necessitating internal consistency evaluation.

Data Analysis

Analysis was conducted across three levels: univariate, bivariate, and multivariate. Univariate analysis characterized the frequency and percentage distribution of each variable. Bivariate analysis employed the chi-square test to examine associations between individual independent variables and anemia status. Variables yielding a *p*-value <0.25 in bivariate testing were advanced as candidates for multivariate modeling. Multiple logistic regression using the backward Wald method was applied in multivariate analysis to determine the most influential anemia determinants. Findings were reported as adjusted odds ratios, 95% confidence intervals, and *p*-values, with statistical significance set at *p* <0.05. Model adequacy was evaluated through the Hosmer-Lemeshow test, and explanatory capacity was quantified using Nagelkerke *R*-square.

Ethical Considerations

Ethical clearance was secured from the Health Research Ethics Committee of Politeknik Kesehatan Kementerian Kesehatan Tanjungkarang, bearing ethical exemption number 127/KEP-TJK/II/2026, issued on February 20, 2026. The study upheld core ethical principles throughout, including informed consent, anonymity, confidentiality, voluntary participation, and respondents' unconditional right to withdraw at any stage without adverse consequences.

RESULTS AND DISCUSSION

Results

This study enrolled a total of 131 adolescent girls. Hemoglobin examination findings indicated that 33 respondents (25.2%) met the criteria for anemia, while the remaining 98 respondents (74.8%) were classified as non-anemic. These figures suggest that anemia among adolescent girls at SMA Negeri 3 Bengkulu City remains a concern warranting public health attention. When interpreted against standard public health classification thresholds for anemia prevalence, the proportion observed in this study falls within the moderate public health problem category. Bivariate analysis revealed statistically significant associations between

anemia status and all examined independent variables, namely knowledge of nutrition and anemia, nutritional status, chronic energy deficiency, menstrual duration, protein intake, vitamin C intake, iron intake, iron tablet supplementation adherence, and peer support. As a result, all variables met the eligibility threshold for entry as candidates into the multivariate logistic regression model.

Participants comprised 131 tenth-grade female students, with ages ranging from 15 to 17 years. The predominant age group was 16 years, accounting for 67.2% of respondents, followed by those aged 15 years (30.5%) and 17 years (2.3%). A summary of respondent demographic characteristics is presented in Table 1.

Table 1. Characteristics of Respondents

Characteristics	Category	n	%
Grade	Tenth grade	131	100.0
Age	15 years	40	30.5
	16 years	88	67.2
	17 years	3	2.3
Total		131	100.00

Table 2 presents the frequency distribution of the dependent and independent variables. Based on hemoglobin examination, 33 respondents (25.2%) were classified as anemic, while 98 respondents (74.8%) were non-anemic. Most respondents had poor knowledge of nutrition and anemia (68.7%), normal nutritional status based on BMI-for-age (67.9%), chronic energy deficiency based on MUAC (55.0%), normal menstrual duration (71.8%), poor vitamin C intake (80.2%), poor iron intake (77.1%), non-adherence to iron tablet consumption (77.9%), and good peer support (73.3%).

Table 2. Frequency Distribution of Study Variables

Variable	Category	n	%
Anemia status	Anemia (Hb <12 g/dL)	33	25.2
	Non-anemia (Hb ≥12 g/dL)	98	74.8
Knowledge of nutrition and anemia	Poor (≤55%)	90	68.7
	Moderate (56–75%)	41	31.3
	Good (≥76%)	0	0.0
Nutritional status	Severely thin (< -3 SD)	0	0.0
	Thin (-3 SD to < -2 SD)	25	19.1
	Normal (-2 SD to +1 SD)	89	67.9
	Overweight (> +1 SD to +2 SD)	13	9.9
	Obese (> +2 SD)	4	3.1
	CED/MUAC <23.5 cm	72	55.0
	Non-CED/MUAC ≥23.5 cm	59	45.0
Duration of menstruation	Normal (3–7 days)	94	71.8
	Abnormal (<3 or >7 days)	37	28.2
Protein intake	Severe deficit (<70% RDA)	65	49.6
	Moderate deficit (70–79% RDA)	26	19.8
	Mild deficit (80–89% RDA)	13	9.9
	Normal (90–119% RDA)	24	18.3
	Excessive (≥120% RDA)	3	2.3
Vitamin C intake	Inadequate (<77% RDA)	105	80.2
	Adequate (≥77% RDA)	26	19.8

Variable	Category		
Iron intake	Inadequate (<77% RDA)	101	77.1
	Adequate (≥77% RDA)	30	22.9
Adherence to iron tablets	Non-adherent (<75%)	102	77.9
	Adherent (≥75%)	29	22.1
	Poor (≤59.8)	35	26.7
	Good (≥59.9)	96	73.3
TOTAL		131	100

After presenting the univariate findings, bivariate analysis was conducted to examine the association between each independent variable and anemia status. The bivariate analysis showed that all independent variables were significantly associated with anemia among adolescent girls, including knowledge of nutrition and anemia, nutritional status, chronic energy deficiency, duration of menstruation, protein intake, vitamin C intake, iron intake, adherence to iron tablet consumption, and peer support. Therefore, all variables met the criteria for inclusion in the multivariate logistic regression model.

The final multiple logistic regression model showed that four variables remained significantly associated with anemia, namely nutritional status, duration of menstruation, protein intake, and peer support. The Hosmer-Lemeshow test showed a significance value of 0.780, indicating that the model had a good fit with the data. The Nagelkerke R-square value was 0.757, suggesting that the model explained 75.7% of the variation in anemia among adolescent girls.

Table 3. Results of Multiple Logistic Regression Analysis of Determinants of Anemia among Adolescent Girls (n = 131)

Variable	B	SE	Wald	p-value	Adjusted OR	95% CI	Interpretation
Nutritional status	2.805	0.709	15.654	<0.001	16.527	4.118–66.322	Significant
Duration of menstruation	2.307	0.762	9.162	0.002	10.043	2.255–44.727	Significant
Protein intake	1.333	0.600	4.939	0.026	3.793	1.171–12.292	Significant
Peer support	2.509	0.816	9.460	0.002	12.296	2.485–60.843	Significant

Note. Multiple logistic regression using the backward Wald method. Model fit: Hosmer-Lemeshow test p = 0.780; Nagelkerke R² = 0.757. Adjusted OR = adjusted odds ratio; CI = confidence interval. The constant was not presented because it is not interpreted as a determinant variable.

Discussion

This study found that 25.2% of adolescent girls at SMA Negeri 3 Bengkulu City experienced anemia. This finding indicates that anemia remains an important health problem in the school setting. Adolescent girls are particularly vulnerable to anemia because adolescence is a period of rapid growth, increased nutritional requirements, and physiological blood loss through menstruation (Kementerian Kesehatan Republik Indonesia, 2023 World Health Organization, 2025). Anemia in this age group may affect learning concentration, physical endurance, productivity, and future reproductive health; therefore, school-based prevention programs are essential.

The final multivariate model showed that nutritional status, duration of menstruation, protein intake, and peer support were significantly associated with anemia status. The model had good fit based on the Hosmer-Lemeshow test and explained 75.7% of the variation in



anemia status based on Nagelkerke R-square. These findings indicate that anemia among adolescent girls is not determined by a single factor, but by the interaction of nutritional, biological, behavioral, and social determinants. This is consistent with previous studies showing that anemia among adolescents is influenced by dietary patterns, nutritional status, menstrual factors, knowledge, adherence to iron supplementation, and social support (Musfira & Hadju, 2024; Wemakor et al., 2023; Yuliawati et al., 2023).

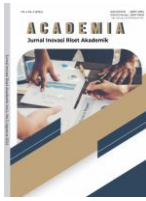
Nutritional status was identified as the most dominant determinant in this study. Adolescents with good nutritional status had higher odds of not experiencing anemia compared with those with poor nutritional status. This result is biologically plausible because nutritional status reflects the adequacy of macro- and micronutrient intake required for hemoglobin synthesis and red blood cell formation. Adequate nutritional status supports the availability of essential nutrients such as iron, protein, folate, vitamin B12, and other micronutrients involved in erythropoiesis (Hall & Hall, 2021; World Health Organization, 2025). Conversely, poor nutritional status may indicate insufficient nutrient intake, which can impair hemoglobin formation and increase susceptibility to anemia.

This finding is in line with Wemakor et al., (2023), who reported that nutritional status was significantly associated with anemia among adolescent girls. It is also supported by studies showing that adolescents with inadequate nutritional intake are more likely to have lower hemoglobin levels. Therefore, anemia prevention should not rely solely on iron supplementation, but should also include broader strategies to improve nutritional status through balanced dietary intake, regular nutritional monitoring, and nutrition education.

Duration of menstruation was also significantly associated with anemia status. Adolescents with normal menstrual duration had greater odds of not experiencing anemia compared with those with abnormal menstrual duration. This finding supports the physiological explanation that prolonged menstruation may increase blood loss and reduce iron stores. If the iron loss is not compensated by adequate dietary intake or iron supplementation, hemoglobin levels may decline and anemia may occur (World Health Organization, 2025). Similar findings were reported by Musfira & Hadju, (2024), who found that menstrual factors were related to anemia status among adolescent girls.

The association between menstrual duration and anemia highlights the importance of menstrual health education in school-based anemia prevention programs. Adolescents need to understand normal and abnormal menstrual patterns, including the duration and amount of bleeding. Early recognition of prolonged menstruation can help students seek appropriate health consultation and prevent repeated iron depletion. Therefore, anemia prevention programs should integrate nutritional education with reproductive health education. Protein intake was another significant factor associated with anemia status. Adolescents with adequate protein intake had higher odds of not experiencing anemia compared with those with inadequate protein intake. This is supported by Rahman (2024), who emphasized the importance of school-based nutritional education and regular meal practices as part of anemia prevention among adolescent girls. Protein plays an important role in hemoglobin synthesis, red blood cell structure, and iron transport in the body. Inadequate protein intake may interfere with hemoglobin formation and reduce the body's ability to maintain normal red blood cell production (Hall & Hall, 2021). In addition, animal-based protein sources often contain heme iron, which has higher bioavailability than non-heme iron from plant-based sources.

This result is consistent with Zuraida et al., (2020), who showed that nutrition education among adolescent girls with anemia improved calorie, iron, protein, and fat intake. It also supports the view that improving dietary quality is an important component of anemia



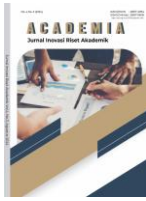
prevention. Thus, school-based programs should encourage adolescents to consume affordable and locally available protein sources, such as eggs, fish, poultry, tempeh, tofu, and legumes. Improving protein intake may strengthen anemia prevention, especially when combined with adequate iron intake and reduced consumption of iron absorption inhibitors such as tea or coffee after meals.

Peer support was also significantly associated with anemia status. Adolescents with good peer support had greater odds of not experiencing anemia compared with those with poor peer support. This finding suggests that anemia prevention is not only influenced by biological and nutritional factors, but also by the social environment. During adolescence, peers play an important role in shaping attitudes, food choices, and health-related behaviors. Peer support may encourage adolescents to consume nutritious foods, remind each other to take iron tablets, and increase awareness of anemia prevention.

This finding is relevant to the PRECEDE–PROCEED framework, which explains that health behavior is influenced by predisposing, enabling, and reinforcing factors (Green & Kreuter, 2005). In this study, peer support can be understood as a reinforcing factor that strengthens healthy behavior among adolescent girls. This is also consistent with Zuraida et al., (2023), who found that support from the school and social environment contributed to improved knowledge, attitudes, adherence to iron supplementation, and hemoglobin status among adolescent girls. Therefore, peer-based strategies such as peer educators, student health groups, and peer reminder systems may be useful in strengthening anemia prevention programs.

Interestingly, several variables that were significant in the bivariate analysis did not remain in the final multivariate model, including knowledge, chronic energy deficiency, vitamin C intake, iron intake, and adherence to iron supplementation. This finding does not necessarily indicate that these variables are not important in anemia prevention. Rather, their effects may have been attenuated after being analyzed simultaneously with stronger variables in the model. One possible explanation is the presence of confounding or overlapping effects among nutritional and behavioral variables. For example, chronic energy deficiency is closely related to overall nutritional status, while iron intake, vitamin C intake, and protein intake may represent broader dietary quality. When nutritional status and protein intake were included in the same model, the independent contribution of iron and vitamin C intake may have been reduced. Similarly, knowledge and adherence to iron supplementation may influence anemia indirectly through dietary behavior, supplement-taking habits, and peer support rather than showing an independent direct effect in the final model.

This result differs from several previous studies that found knowledge, iron intake, and adherence to iron supplementation to be significantly associated with anemia among adolescent girls. Yuliawati et al. (2023) reported that knowledge about anemia and adherence to iron tablet consumption were related to hemoglobin levels, while Rahman et al. (2024) emphasized the importance of knowledge, attitude, practice, and dietary behavior in anemia prevention among school-going adolescent girls. Zuraida et al. (2020) also showed that nutrition education could improve calorie, iron, protein, and fat intake among adolescent girls with anemia, and Zuraida et al. (2023) found that educational and school-based support improved knowledge, attitudes, adherence to iron supplementation, and hemoglobin status. The difference between these studies and the present findings may be explained by differences in study population, measurement methods, variable categorization, and the use of multivariate adjustment. In this study, all respondents came from the same grade level and school environment, with a relatively homogeneous age range of 15–17 years. Such homogeneity may reduce variation in knowledge, access to school-based iron supplementation, and exposure to health information. In addition,



the high proportion of inadequate dietary intake and non-adherence to iron tablet consumption may have limited the ability of these variables to show independent effects after stronger determinants, such as nutritional status, menstrual duration, protein intake, and peer support, were included in the model. Therefore, these variables should still be considered relevant for anemia prevention, although they were not retained as independent determinants in the final multivariate model.

Overall, the findings show that anemia among adolescent girls is a multifactorial problem involving nutritional, biological, behavioral, and social determinants. This is supported by Habib et al., (2020), who emphasized that societal determinants also contribute to anemia among adolescent girls, indicating that anemia prevention should not focus only on individual dietary intake but also on the broader social environment.

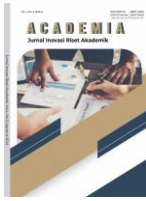
These findings support the need for integrated school-based interventions that combine nutritional assessment, balanced diet education, menstrual health education, iron supplementation monitoring, and peer support programs. Similar recommendations were proposed by Rahman et al. (2024), who suggested school-based nutritional education, lunch programs with iron supplementation, and improvements in supportive school health environments to reduce anemia among adolescent girls.

Overall, the findings show that anemia among adolescent girls is a multifactorial problem involving nutritional, biological, behavioral, and social determinants. Nutritional status emerged as the most dominant factor, while menstrual duration, protein intake, and peer support also played important roles. This finding is supported by Habib et al. (2020), who emphasized that societal determinants also contribute to anemia among adolescent girls. These findings support the need for integrated school-based anemia prevention strategies.

The findings of this study have several practical implications for school-based anemia prevention programs. First, regular screening of hemoglobin levels and nutritional status should be strengthened among adolescent girls to identify students at higher risk of anemia. Second, nutrition education should not only emphasize iron supplementation but also focus on improving overall dietary quality, particularly adequate protein intake and consumption of iron-rich foods. Third, menstrual health education should be integrated into school health programs to help students recognize abnormal menstrual patterns, including prolonged menstrual duration, which may increase the risk of iron depletion. Fourth, peer support should be incorporated into anemia prevention strategies through peer educators, student health groups, or peer reminder systems for iron tablet consumption. Collaboration among schools, community health centers, parents, and local health authorities is needed to ensure that anemia prevention programs are implemented consistently and sustainably.

This study presents several notable strengths. First, anemia status was objectively determined through direct hemoglobin measurement rather than reliance on self-reported symptomatology, thereby enhancing the accuracy of outcome ascertainment. Second, simple random sampling was employed, affording every eligible student an equal probability of selection and minimizing selection bias. Third, the study adopted a multidimensional analytical framework, simultaneously examining nutritional, menstrual, dietary, behavioral, and social determinants of anemia through multiple logistic regression. This approach yields a richer and more holistic understanding of the factors shaping anemia risk among adolescent girls in school-based settings.

Notwithstanding these strengths, several limitations merit acknowledgment. First, the inherent nature of the cross-sectional design wherein exposure and outcome variables are measured concurrently precludes the establishment of causal directionality between



independent variables and anemia status. Findings should therefore be interpreted as evidence of statistical association rather than causation. Second, dietary intake assessment relied on two 24-hour dietary recalls, a method inherently vulnerable to recall bias, as respondents may not have accurately retrieved details regarding the type or quantity of food previously consumed. Third, data on iron tablet adherence, menstrual duration, and peer support were gathered through self-report, introducing the possibility of social desirability bias, whereby participants may gravitate toward responses perceived as more socially favorable. Fourth, given that data collection was confined to a single senior high school, the extent to which findings can be generalized to adolescent girls in other school environments or geographic contexts remains uncertain. Future investigations adopting longitudinal designs with larger, more heterogeneous samples are encouraged to validate these findings and more rigorously delineate the underlying causal mechanisms.

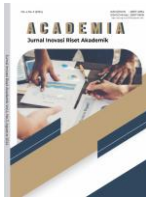
CONCLUSION

This study analyzes the determinants of anemia among 131 tenth-grade female students at SMA Negeri 3 Bengkulu City using a cross-sectional design. The findings show that the prevalence of anemia is 25.2%, which falls into the category of a moderate public health problem based on WHO standard classification. Based on the multivariate logistic regression analysis using the backward Wald method, four variables were found to significantly contribute to the occurrence of anemia among adolescent girls: nutritional status (Adjusted OR = 16.527; 95% CI: 4.118–66.322; $p < 0.001$), peer support (Adjusted OR = 12.296; 95% CI: 2.485–60.843; $p = 0.002$), menstrual duration (Adjusted OR = 10.043; 95% CI: 2.255–44.727; $p = 0.002$), and protein intake (Adjusted OR = 3.793; 95% CI: 1.171–12.292; $p = 0.026$). Nutritional status was the most dominant factor in the final model. The regression model demonstrated good fit (Hosmer–Lemeshow $p = 0.780$) and explained 75.7% of the variation in anemia occurrence (Nagelkerke $R^2 = 0.757$).

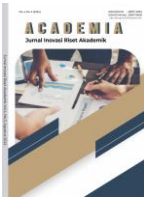
These findings confirm that anemia in adolescent girls is a multifactorial issue involving nutritional, biological, behavioral, and social dimensions. Therefore, anemia prevention efforts need to be implemented comprehensively through regular screening of nutritional status and hemoglobin levels, nutrition education emphasizing adequate protein intake and iron-rich foods, reproductive health education related to menstrual cycles and duration, and strengthened peer support through peer educator programs and school-based youth health groups. Collaboration among schools, community health centers, parents, and local health authorities is essential to ensure that anemia prevention programs are implemented consistently and sustainably.

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