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Determinants of Anemia Occurance In Adolescent Girls

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Abstract

Anemia among adolescent girls is a global health problem affecting physical health, academic performance, and well-being. Increased iron requirements during adolescence are often unmet due to poor dietary intake, irregular menstruation, low adherence to iron supplementation, limited physical activity, and unfavorable socioeconomic conditions. This study aimed to analyze the association between these factors and anemia among adolescent girls in Pekalongan Regency and to identify the most influential factor. A quantitative cross-sectional study was conducted with 190 respondents selected through cluster random sampling. Data were collected using questionnaires and digital hemoglobin measurements and analyzed using univariate, Chi-square, and multiple logistic regression tests. Most respondents had poor dietary intake (77.9%), irregular menstruation (68.9%), low adherence to iron tablets (60.5%), insufficient physical activity (74.7%), and low socioeconomic status (52.1%). More than half (54.2%) were anemic. Bivariate tests found that all variables were significantly related to the prevalence of anemia ($p<0.05$). With a 95% CI The results showed dietary pattern (OR=19.194), menstrual pattern (OR=8.910), Fe tablet consumption (OR=4.517), physical activity (OR=3.585), and economic status (OR=5.161). Multivariate analysis identified dietary pattern as the most dominant factor associated with anemia (OR=19.194; $p<0.001$). Dietary habits are the strongest determinant of anemia among adolescent girls. Prevention efforts should prioritize balanced nutrition, reproductive health education, improved adherence to iron supplementation, regular physical activity, and awareness of affordable nutritious foods.

Keywords: *determinants, anemia, female adolescents*

INTRODUCTION

Anemia remains a major global public health problem, particularly among vulnerable populations such as children, pregnant women, and adolescent girls. The World Health Organization reported that approximately 30% of women aged 15–49 years worldwide experience anemia, indicating that anemia continues to be a significant nutritional and reproductive health challenge (World Health Organization, 2023). In Indonesia, anemia in adolescent girls is still a public health concern, with a prevalence of 15.5% among females aged 15–24 years (Silangen, 2025). Adolescent girls are considered a high-risk group because rapid growth during adolescence increases nutritional requirements, especially iron, while menstrual blood loss further elevates the risk of iron deficiency anemia.

This condition can have major effects on adolescents, including disturbances in physical growth, cognitive and intellectual development, academic performance, and daily productivity. Over the long term, anemia that persists until pregnancy may increase the likelihood of various obstetric complications, premature birth, babies being born with low birth weight, and even neonatal mortality (Kemenkes, 2022). Therefore, prevention and early identification of anemia among adolescent girls are essential to improve future maternal and child health outcomes.

The occurrence of anemia among adolescent girls is influenced by multiple interrelated factors. Previous studies have identified inadequate dietary intake of iron-rich foods, abnormal menstrual patterns, low adherence to iron supplementation, high levels of physical activity, and low socioeconomic status as important determinants of anemia (Budiarti et al., 2021); (Vironika et al., 2024). Adolescents from low-income families are more vulnerable due to limited access to nutritious foods and healthcare services. In addition, menstruation increases iron requirements, making adolescent girls more susceptible to iron deficiency (Yunarsih & Antono, 2017). Although the Indonesian government has implemented a weekly iron supplementation program for adolescent girls through schools since 2015, adherence to iron consumption remains low. Nurjanah and Azinar (2023). reported that only 1.4% of adolescents consumed iron according to the recommended guidelines despite wide program coverage.

The Indonesian government has carried out a weekly iron supplementation program in schools since 2015, supported by the National Movement for Nutritional Action, which involves activities such as collective iron tablet intake, nutritional counseling, and healthy breakfast programs (Helmyati et al., 2024); (Kemenkes, 2022). Data from the Pekalongan District Health Office in 2024 indicated that the prevalence of anemia among adolescent girls was 3.5%, distributed across 27 public health center service areas. The aim of this study is to identify the determinants of anemia occurrence in adolescent girls in Pekalongan District.

Although a number of previous studies have investigated individual factors associated with anemia, studies that simultaneously assess various determinants among adolescent girls in Pekalongan District through multivariate analysis are still limited. Analyzing these factors simultaneously is important because anemia is a multifactorial condition, and the interaction among nutritional, behavioral, biological, and socioeconomic factors may affect the risk of anemia differently in each setting. Identifying the most influential determinants may help support more focused and effective intervention strategies for adolescent girls.

Therefore, this study was conducted to investigate the factors related to anemia among adolescent girls in Pekalongan District, including eating habits, menstrual patterns, adherence to iron tablet consumption, physical activity, and family economic conditions, through multivariate analysis to determine the factors with the greatest influence on anemia status.

METHODS

Reseach Design

This study used a non-experimental quantitative approach with a cross-sectional design. The study was carried out at MAN Pekalongan and SMK Muhammadiyah Kedungwuni from June to August 2025. The study population included all female adolescents aged 15–19 years from 12 senior high schools or equivalent institutions in the working area of Puskesmas Kedungwuni 1, with a total of 3,073 students. Sampling was conducted using the cluster random sampling method, taking 20% from 12 schools in the working area of Kedungwuni I Health Center in Pekalongan Regency, resulting in 2 schools, namely MAN Pekalongan 278 and SMK Muhammadiyah Kedungwuni 86. These two locations represent the population in Kedungwuni District because they have heterogeneous respondent characteristics. The sample size was determined based on the Slovin formula with a 5% margin of error for a population of 364, resulting in 190 respondents, with samples taken proportionally from each school (MAN Pekalongan 145, SMK Muhammadiyah Kedungwuni 45). Furthermore, sampling was conducted using simple random sampling.

Variables

Independent variables: consist of four variables, including eating patterns, menstrual patterns, physical activity, and economic status. The eating pattern variable is defined as the eating habits most frequently consumed, including types of food that contain iron or inhibit iron absorption and the frequency of meals consumed by adolescents, which can increase the risk of anemia over a period of 1 month. The menstrual pattern variable is the habit of the menstrual cycle, which includes the frequency, duration, and volume of

blood during menstruation that affects the risk of anemia. The iron tablet consumption variable refers to the habit of taking iron supplements by assessing the frequency of iron tablet intake during the past month, which may influence the risk of anemia. The physical exercise variable refers to participation in activities such as Kegel exercises, aerobics, floor exercises, yoga, and Pilates performed within one week, which may affect the incidence of anemia. The family economic status variable refers to the level of family economic well-being measured by the total household income during the previous month. Family income includes fixed salaries, income from business, social assistance, and other sources of income. The dependent variable is anemia status, defined as a condition where hemoglobin levels in the blood are less than 12 g/dL.

Research instruments and measurement methods

The measurement of all independent variables used a closed-ended questionnaire containing respondent identities. Dietary patterns were measured using the Food Frequency Questionnaire (FFQ) approach, with a frequency consumption scale for various types of foods associated with the risk of anemia, using a scoring system based on consumption frequency with 10 questions. The dietary pattern assessment used food frequency categories consisting of never, 1–3 times/month, 1–3 times/week, 4–6 times/week, and daily. Foods that help prevent anemia were scored from 0 for never to 4 for daily consumption, whereas foods that inhibit iron absorption were scored in reverse order. The maximum score was obtained by multiplying the number of items by the highest score and then converting it into a percentage. Dietary patterns were classified as good if the score was >80%, sufficient if 60–80%, and poor if <60%. The measurement of the menstrual pattern variable is measured with questions about the cycle, duration, and menstrual volume, with categories divided into abnormal menstrual patterns if: Menstrual frequency is less than 21 days, menstruation duration is more than 7 days, blood volume exceeding >6 changes of regular pads per day or >5 changes of night pads per day (if any one of these is abnormal, it is still considered abnormal). The normal menstrual pattern category must meet all the elements: menstrual frequency within the range of 21–35 days, menstruation duration of 3–7 days, and blood volume <5 changes of regular pads per day or <4 changes of night pads per day.

Measurement of the variable of consumption patterns of iron tablets with closed-ended questions about the frequency of iron tablet consumption consisting of never (score 0 = non-compliant), 1-4 times (score 1 = less compliant), 4 times or more per week (score 2 = compliant). Measurement of the physical exercise variable is based on three main questions, namely whether the respondent engages in physical exercise (yes, score 1 and no, score 0), frequency of physical exercise in one week (1 time = 1 point, 2-3 times = 2 points, 4-5 times = 3 points, and more than 5 times = 4 points), and duration of each exercise session (less than 15 minutes = 1 point, 15-30 minutes = 2 points, 31-60 minutes = 3 points, and more than 60 minutes = 4 points).

The overall score results are categorized as low physical exercise (score 0-3) if the respondent does not exercise/engages in exercise with low frequency and duration, and as moderate physical exercise (score 4-8) if the frequency is medium to high.

Variable of Economic status measurement is conducted through questions about family income, which is classified into 2 categories: low economic status if income is below the Regional Minimum Wage (UMR) and sufficient economic status if income is above the UMR. Variable of Anemia status measurement is carried out through hemoglobin examination by taking capillary blood by researchers and enumerators on midwives/midwife candidates who already have competence in hemoglobin testing using a digital device brand Mission Hb. Categories are divided into non-anemia if Hb ≥12 mg/dL and anemia if Hb ≤12 mg/dL.

Instrument Validity and Reliability

The measuring instrument in this study is a device used for examining hemoglobin levels, namely the digital device of the Mission HB brand, which has been calibrated and proven to be valid and reliable. The validity test of the questionnaire was conducted on 40 female adolescents at SMK Muhammadiyah Bligo who have the same characteristics as the research population. The testing was carried out using the SPSS 26.0 program with the product moment correlation technique, which is stated to be valid if the calculated r value > table r = 0.320 and invalid if the calculated r value < table r = 0.320. The validity test of the dietary pattern questionnaire for all questions (10 questions) was declared valid with calculated r values for all questions > 0.320. The menstrual pattern questionnaire with 3 questions was all valid (>0.320), the iron tablet consumption pattern questionnaire with 1 question obtained a calculated r value of 1.000 (>0.320) and was therefore declared valid, the physical exercise questionnaire with 2 questions had calculated r values of 0.941 and 0.964 (>0.320), and the economic status questionnaire with 1 question had a calculated r value of 1.000 (>0.320). The reliability test using Cronbach's Alpha method is declared reliable if the value >0.6. The reliability test results for the dietary pattern questionnaire obtained a Cronbach's Alpha value of 0.692, the menstrual pattern 0.626, and the physical exercise questionnaire 0.867, so all questionnaires were declared reliable.

Data analysis consisted of univariate analysis to describe the distribution of variables, bivariate analysis using the Chi-Square test, and multivariate analysis with multiple logistic regression to identify the dominant factors associated with anemia incidence. This study received ethical approval from the Ethics Research Committee of Muhammadiyah University of Pekajangan Pekalongan on June 3, 2025, with approval number 124/KEP-UMPP/IV/2025.

RESULT

The respondent characteristic data were presented based on class and age

Table 1. Respondents Characteristic

Characteristics	F	%
Age		
16 years	28	14,7
17 years	136	71,6
18 years	22	11,6
19 years	4	2,1
Class		
10	32	16,8
11	158	83,2

Based on Table 1, The characteristics of the respondents showed that most adolescent girls were 17 years old (71.6%), followed by 16 years old (14.7%), 18 years old (11.6%), and 19 years old (2.1%), with a standard deviation of 0.37. Based on grade level, the majority were in 11th grade (83.2%), while 16.8% were in 10th grade, with a standard deviation of 0.59. These findings indicate that the respondents were relatively homogeneous in terms of both age and grade level.

Table 2. Frequency Distribution Variable of Diet Pattern, Menstrual Pattern, Fe Tablet Consumption, Physical Exercise, Economic Status, Anemia Status

Variable	F	%
Diet Pattern		
Low	148	77,9
Moderate	42	22,1
Good	0	0
Menstrual Pattern		
Not Normal	131	68,9
Normal	59	31,1
Fe Tablet Consumption Pattern		
Disobedient	115	60,5
Less Obedient	50	26,2
Compliant	25	13,2
Physical Exercise		
Low	142	74,7
Enough	48	25,3
Economic Status		
Low Status	99	52,1
Status Sufficient	91	47,9
Anemia Status		
Anemia	103	54,2
Not Anemic	87	45,8
Total	190	100

Based on table 2, most respondents were found to have poor dietary patterns (77.9%). In addition, more than half of the respondents had irregular menstrual patterns (68.9%) and showed low compliance in consuming iron tablets (60.5%). Most respondents were also found to have low levels of physical activity (74.7%). Overall, 54.2% of the respondents were found to be anemic.

Table 3. The Association of Dietary Patterns, Menstrual Pattern, Iron Tablet Consumption, Physical Activity, and Economic Status with Anemia Incidence among Adolescent Girls

Variable		Anemia Status				Total		p	OR	CI 95% Lower-Upper
		Anemia		Not Anemic						
		n	%	n	%	N	%			
Diet Pattern	Less	99	66,9	49	33,1	148	100	<0,001	19,194	6,481-56,841
	Enough/Good	4	9,5	38	90,5	42	100			
Menstrual Pattern	Not Normal	91	69,5	40	30,5	131	100	<0,001	8,910	4,273-18,581
	Normal	12	20,3	47	79,7	59	100			
Fe Tablet Consumption Pattern	Disobedient/ Less Obedient	97	58,8	68	41,2	165	100	0,001	4,517	1,714-11,901
	Compliant	6	24	19	76	25	100			
Physical Exercise	Low	88	62	54	38	142	100	<0,001	3,585	1,784-7,206
	Enough	15	31,3	33	68,8	48	100			
Economic Status	Low Status	72	72,7	27	27,3	99	100	<0,001	5,161	2,778-9,588
	Status Sufficient	31	34,1	60	65,9	91	100			
Total		103	100	87	100	190	100			

Based on the bivariate analysis using the Chi-square test presented in Table 3, all independent variables were found to have significant associations with anemia among adolescent girls. Unhealthy dietary patterns were significantly related to anemia incidence (p=0.000), with an odds ratio (OR) of 19.194 (95% CI: 6.481–56.841). These findings indicate that adolescents with poor eating habits were about 19 times more likely to develop anemia than those with adequate or healthy dietary patterns. Irregular menstrual patterns were significantly associated with anemia (p=0.000), with an odds ratio (OR) of 8.910 (95% CI: 4.273–18.581). This indicates that adolescents with irregular menstrual patterns were about 8.9 times more likely to experience anemia. Compliance with iron tablet consumption was significantly associated with anemia (p=0.001). Adolescents who were not compliant in taking iron tablets had a 4.5 times higher risk of experiencing anemia (OR=4.517; 95% CI: 1.714–11.901). Low physical activity was significantly associated with anemia (p=0.000), with an OR of 3.585 (95% CI: 1.784–7.206). Similarly, low economic status also showed a significant relationship with anemia (p=0.000), with an OR of 5.161 (95% CI: 2.778–9.588).

Tables 4. The Effects of Dietary Patterns, Menstrual Patterns, Iron Tablet Consumption, Physical Activity, and Economic Status on Anemia Incidence among Adolescent Girls

Variable	Exp (B)	CI 95%		p	Nagelkerke R Square
		Lower	Upper		
Diet Pattern	0,096	0,030	0,313	0,000	0,459
Menstrual Pattern	0,240	0,099	0,584	0,002	
Fe Tablet Consumption Pattern	0,925	0,259	3,311	0,905	
Physical Exercise	0,391	0,165	0,924	0,032	
Economic Status	0,388	0,183	0,824	0,014	

Based on Table 4, the results of multiple logistic regression analysis showed that a good dietary pattern significantly reduced the risk of anemia by 9,4% (Exp(B))=0,096; p=0,000), normal menstrual patterns by 76% (Exp(B))=0,240; p=0,002), good physical exercise by 60,9% (Exp(B))=0,391; p=0,032), while good economic status lowered the risk by 61.2% (Exp(B)=0.388; p=0.014). In contrast, iron tablet consumption reduced the risk by 7.5%, although the result was not statistically significant (Exp(B)=0.925; p=0.905). The results of the multivariate statistical test with logistic regression differ from the results of the bivariate chi-square statistical test due to different coding techniques. The anemia status variable code in the bivariate analysis uses code 1 for anemia and 2 for non-anemia, while in the multivariate analysis it uses code 1 for anemia and 0 for non-anemia. The Nagelkerke R Square value of 0.459 indicates that 45,9% of the variation in the occurrence of anemia can be explained by these five variables, more than half of the variation may be explained by factors not included in the model, such as nutritional status, BMI, infection, parasitic disease, sleep patterns, inflammatory conditions, genetic hemoglobin disorders, and dietary inhibitors or enhancers of iron absorption.

DISCUSSION

The Relationship Between Eating Patterns and the Incidence of Anemia in Adolescent Girls

This study found that poor dietary patterns were the strongest determinant of anemia among adolescent girls. Adolescents with poor dietary patterns had a significantly higher risk of anemia compared to those with healthy dietary habits. The results of the study showed that most respondents (77.9%) had poor dietary patterns and were 19 times more likely to experience anemia compared to adolescents with good dietary patterns (p=0.000; OR=19.194; 95% CI=6.481–56.841). Inadequate nutritional intake, especially insufficient iron consumption, can directly interfere with the process of hemoglobin formation. According to the theory of hematopoiesis, iron plays an important role as a major component in hemoglobin synthesis, and iron

deficiency can impair oxygen transport throughout the body (Khonsary, 2017). Iron absorption is affected by its bioavailability, in which heme iron derived from animal-based foods is absorbed more efficiently (15–35%) than non-heme iron (2–20%). In addition, the intake of tea or coffee containing tannins and polyphenols may inhibit iron absorption (Yulia Warda & Adhila Fayasari, 2021).

This finding is in line with previous studies that reported a significant association between dietary patterns and the incidence of anemia (Dzul Istiqomah Hasyim, 2018). (UNICEF, 2021) Previous studies also highlight the importance of consuming iron, folic acid, vitamins, and animal protein to help prevent anemia in adolescents. Dietary habits among adolescents can be influenced by limited nutritional knowledge, negative body image, and unhealthy dieting behaviors (Niswah et al., 2021). External influences such as peer pressure, the popularity of fast food, modern lifestyle trends, social media exposure, and financial limitations can also contribute to unhealthy dietary habits among adolescents (Chung et al., 2021); (Dewi et al., 2023). Therefore, unhealthy eating habits among adolescents are shaped not only by individual factors but also by social, cultural, and economic influences. As a result, efforts to prevent anemia need to involve comprehensive strategies, including nutrition education, family support, and better access to nutritious and affordable foods. These findings suggest that dietary improvement should become a major focus of anemia prevention programs. School-based nutrition education, healthy school meal promotion, and family involvement are important strategies to improve iron intake among adolescent girls.

The Relationship Between Eating Patterns and the Incidence of Anemia in Adolescent Girls

Abnormal menstrual patterns were significantly associated with anemia in this study. Adolescents with abnormal menstruation had a substantially higher risk of anemia compared to those with normal menstrual cycles. Excessive menstrual bleeding can gradually reduce the body's iron stores and increase the risk of iron deficiency anemia (Almatsier, 2016). This finding is consistent with previous research (Sari et al., 2022) which identified abnormal menstrual patterns as a predictor of anemia among adolescents in Jatinangor. Theoretically, based on the concept of hematopoiesis (Khonsary, 2017), iron plays an essential role in hemoglobin synthesis, therefore excessive iron loss during menstruation can interfere with erythrocyte formation. (World Health Organization, 2016) also states that adolescent girls are more susceptible to anemia because iron requirements increase during periods of growth and menstruation. Menstrual patterns can also be affected by several factors, including stress levels, nutritional status, and physical activity. Increased stress may interfere with the hypothalamic–pituitary–ovarian system and contribute to ovulation disturbances (Jha et al., 2020). Adolescents who have either underweight or overweight body mass index (BMI) are more prone to experiencing irregular menstrual cycles (Itriyeva, 2022). A study conducted in Sidoarjo even reported that stress has a stronger association with menstrual cycle disturbances compared to BMI (Qulistan Balqis Ulwani

et al., 2025). Thus, irregular menstrual patterns are influenced not only by heavy menstrual bleeding but also by psychological conditions and nutritional status, both of which can further increase the risk of anemia among adolescent girls.

The Relationship Between Iron Tablet Consumption Patterns and Anemia Incidence in Adolescent Girls

In the bivariate analysis, non-adherence to iron tablet consumption was significantly associated with anemia. However, after adjustment in the multivariate analysis, iron tablet consumption was no longer a significant predictor. This result is consistent with studies (Aji & Kurniawati, 2024) and (Anjarwati & Ruqoiyah, 2020) which also identified a significant relationship between compliance in taking iron tablets and anemia among adolescents. However, the findings showed that some adolescents still experienced anemia despite being compliant, while others did not develop anemia even though they were non-compliant. This suggests that additional factors such as dietary habits, nutritional status, and menstrual patterns also contribute to the occurrence of anemia.

Compliance with iron (Fe) tablet consumption remains low worldwide, with reports indicating that it is still below 26% (Silitonga et al., 2023). Common obstacles include forgetting to take the tablets, experiencing side effects, or the belief that supplementation is not needed (Siabani & Arya, 2018). Support from teachers, parents, and peers has been found to improve adherence, particularly when schools carry out programs of taking iron tablets together along with health education, with an odds ratio greater than 7 (None et al., 2020). Indonesian Ministry of Health through the National Action for Nutrition Movement also highlights the importance of institutional support in implementing weekly iron supplementation programs. Therefore, although iron (Fe) tablets play an important role in preventing anemia, their effectiveness is strongly determined by adolescents' compliance, as well as the presence of social support, health education, regular distribution, and continuous monitoring. Improvement efforts should not only emphasize the provision of tablets but also focus on innovative approaches to increase acceptance and adherence among adolescents.

The Relationship Between Physical Exercise and the Incidence of Anemia in Adolescent Girls

This study identified a significant association between low physical activity and anemia. Adolescents with lower physical activity levels were more likely to experience anemia compared to physically active adolescents. Physical activity is recognized to influence iron metabolism, where high-intensity exercise can stimulate erythropoietin (EPO) production, enhance red blood cell formation, and reduce hepcidin levels, thereby improving iron absorption in the body (Chaput et al., 2020). In addition, a study by (Fitria & Yulita, 2021) found that regular physical exercise may help increase hemoglobin levels in adolescent girls.

The low level of physical activity among respondents may be associated with a heavy academic workload, particularly in 11th grade, which limits the time available for exercise. This is consistent with findings from (Galeano-Rojas et al., 2024) and (Liu et al., 2025) which report that academic stress can reduce physical activity levels, even though exercise is known to help lower stress, improve sleep quality, and support mental health. (WHO, 2020) also notes that sedentary behavior, prolonged gadget use, and limited access to sports facilities contribute to low physical activity levels among adolescents. Therefore, physical exercise is important not only for maintaining physical fitness but also for helping prevent anemia through both physiological and psychosocial pathways. Adolescent girls who are physically active and regularly participate in sports tend to have better hemoglobin levels compared to those with lower activity levels.

The Relationship Between Economic Status and the Incidence of Anemia in Adolescent Girls

Low economic status was significantly associated with anemia in this study. Adolescents from lower-income families had a higher likelihood of experiencing anemia compared to those from economically stable households. This is consistent with the theory that socioeconomic status influences a family's capacity to fulfill nutritional requirements, obtain health services, and purchase supplements, which in turn indirectly affects hemoglobin levels through dietary patterns (Rahmadani et al., 2023). A study by (Towantja & Ferianto, 2024) also found that families with incomes below the minimum wage are more likely to choose inexpensive foods that are high in carbohydrates but low in iron content, which can increase the risk of anemia.

In this context, limited economic conditions can restrict adolescents' access to heme iron sources such as red meat and liver, which are more easily absorbed by the body. However, there are still affordable non-meat options that contain iron, including tempeh, tofu, legumes, spinach, moringa leaves, and anchovies. A study (Rahmadona, 2022) research indicates that simple preparation methods, such as steaming tempeh or beef liver for around 10 minutes, may help retain iron content better compared to boiling. In addition, the absorption of non-heme iron can be improved when consumed together with vitamin C–rich foods like guava or oranges (Ayupir, 2021). These results suggest that although limited economic conditions can increase the risk of anemia, nutrition education-based interventions remain important. Health professionals can contribute by educating families on how to make use of locally available, affordable, yet nutritious food sources. Through this approach, families with lower income can still fulfill adolescents' iron requirements and help reduce the likelihood of anemia.

The Influence of Eating Patterns, Menstrual Patterns, Iron Tablet Consumption, Physical Exercise, and Economic Status on the Occurrence of Anemia in Adolescent Girls

The results of the multivariate analysis indicated that, among the five examined variables, four had a significant influence on anemia occurrence, namely dietary patterns, menstrual patterns, physical activity, and economic status, whereas iron tablet consumption was not found to be statistically significant. The most influential factor is dietary pattern (Exp(B)=0.096; p<0.001), indicating that adolescents with good eating habits have a 90.4% lower risk of developing anemia. These results highlight the importance of heme iron intake from animal-based foods, which is absorbed more efficiently than non-heme iron, as well as the role of vitamin C in enhancing absorption and the inhibitory effect of polyphenols found in tea and coffee on iron uptake (Moustarah & Daley, 2025); (WHO, 2025).

Menstrual patterns also showed a significant association (Exp(B)=0.240; p=0.002), indicating that adolescents with regular menstrual cycles have a 76% lower risk of experiencing anemia. Excessive menstrual bleeding can interfere with hematopoiesis and lead to a decrease in hemoglobin levels (Fitria & Yulita, 2021); (Khonsary, 2017). Physical activity was found to reduce the risk of anemia by 60.9% (Exp(B)=0.391; p=0.002). This is because regular exercise can lower hepcidin levels and stimulate erythropoietin production, thereby supporting the formation of red blood cells (Coimbra et al., 2017). Economic status was also identified as a significant factor (Exp(B)=0.388; p<0.001), showing that adolescents from financially stable families have a 61.2% lower risk of anemia, largely because they have better access to nutritious food (Dzul Istiqomah Hasyim, 2018).

Meanwhile, iron (Fe) tablet consumption (Exp(B)=0.925; p=0.905) did not show a significant effect after adjustment with other variables, suggesting that its effectiveness is largely affected by adherence, timing of intake, and interactions with food or beverages (Salim et al., 2025); (Nurjanah & Azinar, 2023). The Nagelkerke R Square value of 0.459 indicates that the five variables account for 45.9% of the variation in anemia incidence, while the remaining proportion is influenced by other factors not included in the model. Overall, dietary patterns were identified as the most dominant factor, followed by menstrual patterns, physical activity, and economic status as significant contributors. Therefore, anemia prevention programs for adolescent girls should prioritize nutrition education, menstrual health monitoring, promotion of regular physical activity, and strengthening family economic conditions as part of a comprehensive approach.

CONCLUSION

This study indicates that the majority of adolescent girls in Pekalongan Regency exhibit poor dietary habits, irregular menstrual patterns, low compliance with iron tablet consumption, insufficient physical activity, and originate from low-income families, which contributes to more than half of the respondents being affected by anemia. Bivariate analysis showed that dietary patterns, menstrual patterns, iron tablet consumption, physical activity, and economic status were all significantly associated with anemia incidence. However, the multivariate analysis revealed that only dietary patterns, menstrual patterns, physical activity, and economic status remained significant predictors, while iron tablet consumption did not show an independent effect. Dietary patterns were identified as the most dominant factor, with adolescents who have good eating habits showing a 90.4% lower risk of anemia compared to those with poor dietary patterns. Therefore, adolescent girls are advised to improve their consumption of balanced and nutritious foods and maintain regular physical activity. Schools and health centers are expected to enhance nutrition education programs and carry out routine hemoglobin (Hb) screening. Future research is recommended to explore school-based interventions that integrate nutrition education, iron tablet distribution, and health promotion activities.

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