

ANEMIA DETERMINANT MODEL IN ADOLESCENT GIRLS: EMPIRICAL ANALYSIS BASED ON LOGISTIC REGRESSION

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ABSTRACT

Anemia is a condition in which the body lacks sufficient red blood cells and/or hemoglobin. In women, a hemoglobin level of less than 12.0 g/100 ml is considered an indication of anemia. It is a major global public health problem in both developed and developing countries. This study aimed to determine the relationship between Body Mass Index (BMI), Upper Arm Circumference (MUAC), Iron Tablet Intake (Fe), and Level of Knowledge on the occurrence of anemia in adolescent girls at the Asy Syifa Islamic Boarding School in Balikpapan City. This study was an analytical study with a cross-sectional design. This study was conducted in Balikpapan City from March to June 2025. The subjects were all 12th grade female students at the Asy Sifa Islamic Boarding School in Balikpapan. Data were collected through questionnaires and HB, BMI, and MUAC examinations. Data analysis used logistic regression. The results of the analysis with the logistic regression test concluded that there was an inverse effect between adolescent girls' knowledge and the risk of anemia (OR = 0.42, CI = 0.70-2.50, p = 0.342). There is a positive influence between Lila and the risk of anemia (OR=6.07, CI=1.47-24.92, p=0.012), compliance in consuming Fe tablets (OR=3.91, CI=1.06-14.35, p=0.0039), and BMI (OR=4.64, CI=1.23-17.50, p=0.023) with the risk of anemia. Anemia in adolescent girls is influenced by LILA, Compliance in consuming Fe tablets and BMI. CI=1.47-24.92, p=0.012), compliance in consuming Fe tablets (OR=3.91, CI=1.06-14.35, p=0.0039), and BMI (OR=4.64, CI=1.23-17.50, p=0.023) with the risk of anemia. Anemia in adolescent girls is influenced by LILA, Compliance in consuming Fe tablets and BMI.

Keywords: adolescent girl; anemia; determinant

INTRODUCTION

Anemia is a condition in which the body lacks sufficient red blood cells and/or hemoglobin. In women, a hemoglobin level of less than 12.0 g/100 ml is considered an indication of anemia. It is a major global public health problem in both developed and developing countries (Warner & Weyand, 2022). Among the types of anemia, iron deficiency anemia is most common in early adolescence and is caused by increased nutritional needs due to rapid growth rates among adolescent girls, exacerbated by menstruation (Sudfeld et al., 2020). Globally, approximately 1.2 billion people are adolescents, 90% of whom live in low- or middle-income countries (Kassebaum et al., 2015).

The World Health Organization (WHO) defines adolescents as the age group between 10 and 19 years, with the second-fastest growth rate after infancy (Ummah, 2019). This is a period of rapid growth, and 45% of skeletal growth, 15%–25% of adult height, and up to 37% of total bone mass are achieved during this period. This rapid growth increases the iron requirements for hemoglobin in the blood and myoglobin in muscles. They are a vulnerable group for anemia due to the increased iron requirements to support their rapid growth and mental development and to replace losses due to menstruation (Abbaspour et al., 2014). Adolescent girls are at high risk for anemia due to the physical and physiological changes that place higher demands on their nutritional needs. The resulting anemia can cause cognitive impairment in animals and humans, with damage to brain

mitochondria being the underlying cause associated with impairments in attention span, intelligence, sensory perception, emotion, and behavior.

METHOD

This study was conducted using a cross-sectional design. It was conducted from January to July 2024 at senior high schools in Balikpapan City. The population was female students in grades 10, 11, and 12 at two schools: Asy Syifa Islamic Boarding School Balikpapan and SMK N 2 Balikpapan. This study excluded every adolescent girls reported having specific diseases such as cancer or severe anemia, menstruating, pregnant or had previously been pregnant.

The instruments used in this study consisted of physical measuring instruments and questionnaires to collect data according to the research variables. For Anemia examination (Hb <12 g/dL) using a digital Hb meter, Body Mass Index (BMI) using a digital scale and stadiometer, Upper Arm Circumference using a special LILA meter. For the level of knowledge using a true-false questionnaire with a Cronbach's alpha score of 0.756 and Compliance with Iron (Fe) Tablet Intake with a self-report questionnaire. Data analysis is stated with Odds Ratio (OR) by using the logistic regression on the confidence rate of 95% ($\alpha = 0.05$). The whole analysis was done by using STATA 13.

The study was assessed by the Health Research Ethics Committee of Sari Mutiara Indonesia University No. 3272/F/KEP/USM/II/2025. This study was conducted based on the specified criteria, which include explaining the study benefits and the respondents right, protecting the privacy of respondents, and upholding aspects of fairness and the principle of openness by explaining research procedures and informed consent. Written informed consent was given to participate.

RESULT AND DISCUSSION

Univariate Analysis Results

The univariate description of the research variables explains the general description of the research data for each research variable including age, knowledge, LILA, compliance with FE tablet consumption, BMI, and anemia.

Table 1.
Results of Univariate Analysis of Anemia Determinant Characteristics

Variabel	Kategori	n	%
Age	17	42	63.64
	18	21	31.82
	19	2	4.55
Knowledge	Tinggi	11	16.67
	Rendah	55	83.33
MULA	Normal	37	56.06
	KEK	29	43.94
Kepatuhan Konsumsi Tablet FE	Patuh	25	47.88
	Tidak Patuh	41	62.12
IMT	Gizi Baik	25	37.88
	Gizi Buruk	41	62.12
Anemia	Tidak Anemia	26	39.39
	Anemia	40	60.61

Based on table 1, it was found that most of the respondents were in the 17 years age group as many as 42 (63.64%), had low knowledge as many as 6 (9.09%), had LILA with KEK Category as many

as 29 (43.49%), FE tablet intake was mostly non-compliant as many as 41 (62.12%), BMI was Less than 21 (31.82%) and Overweight 20 (31.82%), and experienced anemia as many as 40 (60.61%).

BIVARIATE AND MULTIVARIATE ANALYSIS RESULTS

In bivariate and multivariate analysis, it used the Logistic Regression test by looking at the Crude OR and Adjusted OR values that are significantly related if the p-value <0.05. Bivariate and multivariate results in Table 2 show about the results of the relationship between several dependent variables and the independent variables studied.

Table 2.

The relationship between several dependent variables and the independent variables studied.

Variabel	Kategori	Kejadian Anemia		Nilai p	OR
		Anemia	Tidak Anemia		
Pengetahuan	Tinggi	8 (6.7%)	3 (4.3%)	0.367	0.8123
	Rendah	32 (33.3%)	23 (21.7%)		
Lila	Normal	15 (22.4%)	22 (14.6%)	0.0001	14.200
	KEK	25 (17.6%)	4 (11.4%)		
Kepatuhan Konsumsi Tablet FE	Patuh	10 (15.2%)	15 (9.8%)	0.007	7.157
	Tidak Patuh	30 (24.8%)	11 (16.2%)		
IMT	Gizi Baik	8 (15.2%)	17 (9.8%)	0.0001	13.793
	Gizi Buruk	32 (24.8%)	9 (16.2%)		

Based on table 2, respondents who have low knowledge mostly experience anemia as many as 32 respondents (33.3%). The results of the statistical analysis obtained a p value = 0.367, it was concluded that there was no relationship between the knowledge of adolescent girls and anemia in adolescent girls. In the LILA variable, respondents who have LILA with KEK mostly experience anemia as many as 25 respondents (17.6%), and the statistical value obtained p = 0.0001, it was concluded that there is a relationship between LILA with KEK and adolescent girls who experience anemia. The OR value obtained 14.20 means that adolescent girls who have LILA with KEK have a 14-fold risk of experiencing anemia. In the variable of fulfilling the consumption of FE tablets, it was found that 30 respondents were non-compliant and experienced anemia (24.8%) with a statistical result of p = 0.007, it can be concluded that there is a relationship between fulfilling the consumption of FE tablets and the incidence of anemia in adolescent girls. The OT value obtained 7.157, which means that adolescent girls who do not comply with consuming FE tablets have a 7-fold risk of experiencing anemia. In the BMI variable, it was found that most of the respondents who had Malnutrition and Obesity experienced anemia, amounting to 32 respondents (24.8%) with the statistical test results obtained p = 0.0001. It was concluded that there was a significant relationship between malnutrition and the incidence of anemia in adolescent girls.

The results of the logistic regression equation can be described There is an inverse (negative) effect between adolescent girls' knowledge and the risk of anemia, but this effect is not statistically significant. Adolescent girls with high knowledge have a half-fold lower risk of anemia than those with low knowledge (OR=0.42, CI=0.70-2.50, p=0.342).

There is a strong positive effect between MULA and the risk of anemia, and this effect is statistically significant. Adolescent girls with MULA less than 23.5 cm have a 6.07 times greater risk of anemia than adolescents with normal MULA (OR=6.07, CI=1.47-24.92, p=0.012). There is

a strong positive effect between adherence to iron tablet consumption and the risk of anemia, and this effect is statistically significant. Adolescent girls who did not adhere to iron tablet consumption had a 3.91 times greater risk of developing anemia than adolescents who did (OR=3.91, CI=1.06-14.35, p=0.0039). There was a strong positive effect between adherence to good nutrition and anemia, and this effect was statistically significant. Adolescent girls with poor nutrition had a 4.64 times greater risk of developing anemia than adolescent girls with good nutrition (OR=4.64, CI=1.23-17.50, p=0.023).

Table 3.
Logistic Regression Results of Determinants of Anemia with the Risk of Anemia in Adolescent Girls

Variabel Independent	OR	CI		P
		Lower	Upper	
Pengetahuan	0.42	0.70	2.50	0.342
LILA	6.07	1.47	24.92	0.012
Kepatuhan konsumsi tablet Fe	3.91	1.06	14.35	0.039
IMT	4.64	1.23	17.50	0.023
Likelihood P=	-30.625			0.0001

There was an inverse (negative) effect between adolescent girls' knowledge and the risk of anemia, but this effect was not statistically significant. Adolescent girls with high levels of knowledge had a half-fold lower risk of anemia than those with low levels of knowledge (OR=0.42, CI=0.70-2.50, p=0.342). According to the researchers, knowledge can influence the occurrence of anemia in adolescents. Adolescents who have good knowledge about a balanced nutritional menu that benefits the body will pay more attention to the food they consume, thereby reducing the risk of anemia. Furthermore, adolescents with minimal knowledge about anemia, its signs, effects, and prevention also result in them consuming foods with low iron content, thus not meeting their iron intake needs.

The effect of MUAC on the risk of anemia. Logistic regression results showed that MUAC was a confounding variable influencing the relationship between knowledge and iron supplement intake and the incidence of anemia. Adolescent girls with MUAC categorized as KEK (Certainly Chronic Energy Deficiency) were at greater risk of anemia compared to those with normal MUAC. Physiologically, a low MUAC reflects malnutrition and low energy/protein reserves, which are associated with inadequate nutrient intake (especially iron, protein, and vitamins that support erythropoiesis), thus increasing susceptibility to anemia. Several studies support MUAC as an important anthropometric indicator of anemia in adolescent girls. A literature review indicates that MUAC and BMI are recommended as initial assessments to screen nutritional status and estimate the risk of anemia in adolescent girls (Yunita et al., 2024).

A study in Pekanbaru found that adolescent girls with low MUAC (<22 cm) had a nearly twofold higher risk of anemia (PR=1.95; 95% CI: 1.05–3.60) after controlling for other variables (Putri et al., 2025). A study in Donggala also reported that MUAC <23.5 cm was a risk factor for anemia in adolescent girls (Subagyo et al., 2023). In a population of women aged 19–49 years in Indonesia, the combination of low BMI and low MUAC increased the odds of anemia by nearly threefold (aOR=2.83; 95% CI: 2.19–3.68) (Nainggolan et al., 2022). Findings in India showed that every 1 cm increase in MUAC was associated with a 0.11 g/dL increase in Hb levels, confirming a linear

relationship between somatic growth (including MUAC) and hemoglobin levels (Ahankari & Fogarty, 2020).

Practically, the results of this study confirm that MUAC can be used as a simple screening tool to identify adolescent girls at high risk of anemia in schools and health facilities. Recommended interventions include nutrition education, increased intake of a balanced, nutritious diet, and iron supplementation in groups with MUAC <23.5 cm, as recommended by various studies highlighting the role of nutritional status in adolescent anemia (Putri et al., 2025), (Yunita et al., 2024), (Subagyo et al., 2023), (Nainggolan et al., 2022), (Sari et al., 2022), (Fauziah et al., 2024).

The Effect of Iron Tablet Compliance on the Risk of Anemia. Logistic regression results show a strong positive effect between iron tablet compliance and the risk of anemia in adolescent girls. The OR value = 3.91 (95% CI: 1.06–14.35; $p = 0.0039$) means that adolescent girls who are non-compliant with iron tablet consumption have a risk of anemia approximately 3.9 times greater than those who are compliant. The confidence interval does not cross 1 and the p value <0.05 indicate that the effect is statistically significant.

Biologically, adherence to iron tablet consumption plays a crucial role in maintaining adequate iron reserves and hemoglobin synthesis. Non-compliance can result in insufficient iron supply to meet increased needs due to growth and menstrual blood loss, increasing the risk of iron deficiency anemia. Various studies support these findings. A study in Jambi reported that adolescent girls who did not regularly take iron tablets had the highest proportion of anemia (92.3%) and there was a significant relationship between adherence to iron tablet consumption and the incidence of anemia ($p=0.000$). 3 Another study on female students in Bondowoso also found a significant relationship between adherence to iron tablet consumption and hemoglobin/anemia levels (Feriyanti et al., 2022). A study in Yogyakarta showed that non-adherence to iron tablet consumption was closely associated with high rates of anemia in adolescent girls ($p=0.000$) (Ruqoiyah, 2020).

A cohort study at Praya Tengah 1 State Senior High School showed that adolescent girls who did not consume iron tablets had a 6.35-fold greater risk of anemia than those who did (RR=6.35; $p<0.001$) (Muqarrobun et al., 2025). Several other studies in Indonesia also found a consistent relationship between adherence to iron supplementation (TTD) and the incidence of anemia in adolescent girls in various regions (Suffara, 2025). Systematic reviews confirm that adherence to iron supplementation is a key factor in the success of adolescent anemia prevention programs (Tabita et al., 2023) (Feriyanti et al., 2022). Thus, the OR=3.91 result in this study is in line with previous evidence that non-compliance with Fe tablet consumption is an important risk factor for anemia in adolescent girls, and strengthens the recommendation to improve compliance through education, school and family support, and regular monitoring of the iron tablet (TTD) program.

The Effect of BMI on the Risk of Anemia. The results showed a strong positive relationship between nutritional status and the incidence of anemia in adolescent girls, with an OR of 4.64 (95% CI: 1.23–17.50; $p=0.023$). This means that adolescent girls with poor nutrition have a risk of anemia approximately 4.6 times greater than those with good nutrition, and this relationship is statistically significant. These findings align with various studies showing that poor nutritional status is a significant risk factor for anemia in adolescents. Research in Tarakan reported that nutritional status was significantly associated with the incidence of anemia in adolescent girls; being severely underweight, underweight, or obese increased the risk of anemia, although

adolescents with a normal BMI could still experience anemia (Noviyanti et al., 2024). Another study in Yogyakarta also found a significant association between nutritional status and anemia in adolescent girls ($p=0.001$) (Athala & Khofiyah, 2025). Research in Hangtuh Tarakan even concluded that poor nutritional status increased the risk of anemia by approximately fourfold, a magnitude consistent with the OR of 4.64 in this study.

Biologically, malnutrition (either undernutrition or excess) can lead to micronutrient deficiencies (especially iron, folate, and vitamin B12), which play a direct role in hemoglobin formation. A meta-analysis in Ethiopia showed that low BMI and inadequate dietary intake were associated with an increased risk of anemia in adolescent girls (Berhe et al., 2022). A longitudinal study in Malaysia also showed that adolescents who did not meet the daily iron intake requirement had a significantly higher risk of anemia and iron deficiency anemia (Krishnan et al., 2021). In Indonesia, a study in Pekanbaru showed that low mid-upper arm circumference and certain nutritional status were associated with an almost doubled risk of anemia (Putri et al., 2025).

In addition to nutritional status, diet quality and dietary diversity also mediate this relationship. Research on adolescent girls in West Java showed that low diet quality (low DQI-A) was associated with lower hemoglobin levels and a higher prevalence of anemia (Id et al., 2020). A recent meta-analysis also confirmed that low dietary diversity increases the odds of anemia in children and adolescents (OR=1.7) (Li et al., 2025). Thus, the OR=4.64 result in this study is consistent with the evidence that adolescents with malnutrition have a much higher risk of anemia, and supports the importance of nutritional improvement interventions, increasing food quality and diversity, as well as nutrition education and iron supplementation in adolescent girls (Id et al., 2020) (Krishnan et al., 2021) (Li et al., 2025) (Berhe et al., 2022).

CONCLUSION

This study concludes that anemia among adolescent girls at Asy-Syifa Islamic Boarding School in Balikpapan is significantly influenced by nutritional and behavioral factors. Upper Arm Circumference (MUAC), compliance with iron (Fe) tablet consumption, and Body Mass Index (BMI) were found to have a statistically significant association with the incidence of anemia. Adolescent girls with MUAC <23.5 cm were 6.07 times more likely to experience anemia, those who were non-compliant with iron tablet consumption had a 3.91 times greater risk, and those with poor nutritional status (abnormal BMI) had a 4.64 times higher risk of anemia. Although knowledge level showed an inverse relationship with anemia risk, this association was not statistically significant. These findings indicate that anthropometric indicators and adherence to iron supplementation play a more decisive role in determining anemia risk than knowledge alone. Therefore, efforts to prevent anemia in adolescent girls should prioritize improving nutritional status, strengthening iron supplementation compliance programs, and implementing routine MUAC and BMI screening in schools. Integrated interventions involving nutrition education, dietary improvement, and regular monitoring of iron tablet consumption are essential to effectively reduce the prevalence of anemia among adolescent girls.

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