ARTÍCULO ORIGINAL

Gac Méd Caracas 2023;131(4):820-828
DOI: 10.47307/GMC.2023.131.4.5

Determinants of Anemia in Adolescent Women at Makassar

Determinantes de la Anemia en Mujeres Adolescentes en Makassar

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SUMMARY

Background: *Anemia is one of the most common nutritional deficiency disorders which is a serious global public health problem, especially in developing countries, which is estimated to reach 30 %. Anemia is especially prevalent among adolescent girls. The prevalence of anemia according to the World Health Organization (WHO), 2017 ranges from 40-88 %. The results of Basic Health Research (Riskesdas) data in 2018 indicate that the prevalence of anemia increased from 37.1 % in Riskesdas 2013 to 48.9 % in 2018. The purpose of the study was to assess the determinants of anemia in adolescent girls aged 14-17 years at State High School (SMAN) 9 Makassar, Indonesia.* **Methods**: *The study was conducted at a State Senior High School in Makassar. With cross-sectional design. A total of 211 adolescent girls were selected by proportional random sampling. Hemoglobin levels were measured using the Easy Touch GCU tool. Measurements of weight with a digital scale and height with a Microtoise height meter. Intake of fat, carbohydrate, protein, iron, folic acid, cobalamin, and ascorbic acid was obtained by 2×24-hour recall method and then calculated with nutrisurvey. Bivariate analysis used a Chi-Square test and multivariate with multiple logistic regression test.* **Results**: *Respondents who were anemic were 115 people (54.5 %). The results of the bivariate analysis showed that significant variables with anemia were protein (P=0.056; OR=1.783), iron (P=0.003; OR=2.386), cobalamin (P=0.027; OR=2.675), and ascorbic acid (P=0.010; OR=2.103). The results of multivariate analysis showed that the most influential variables on the incidence of anemia were Iron and cobalamin.* **Conclusion**: *Iron and cobalamin intake are the most influential variables in the incidence of anemia in adolescent girls at Senior High School Makassar.*

Keywords: *Anemia, adolescent girls, macronutrient intake, micronutrient intake.*

DOI: https://doi.org/10.47307/GMC.2023.131.4.5

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Recibido: 1 de septiembre 2023
Aceptado: 22 de septiembre 2023

RESUMEN

Antecedentes*: La anemia es uno de los trastornos por deficiencia nutricional más comunes y supone un grave problema de salud pública mundial, especialmente en los países en desarrollo, que se estima que alcanza el 30 %. La anemia es especialmente frecuente entre las adolescentes. La prevalencia de anemia según la Organización Mundial de la Salud (OMS) 2017 oscila entre el 40 % y el 88 %. Los resultados de los datos de la Investigación Básica en Salud (Riskesdas) en 2018 indican que la prevalencia de anemia aumentó del 37,1 % en Riskesdas 2013 al 48,9 % en 2018. El propósito del estudio fue evaluar los determinantes de la anemia en adolescentes de 14 a 17 años en la Escuela Secundaria Estatal (SMAN) 9, Makassar, Indonesia.* **Métodos***: El estudio se realizó en Escuela secundaria superior, distrito de Rappocini. Con diseño transversal. Se seleccionó un total de 211 muestras de mujeres jóvenes por muestreo aleatorio proporcional. Los niveles de hemoglobina se midieron con la GCU Easy Touch, las medidas de peso con una balanza digital y la altura con un medidor de altura Microtoise. La ingesta de grasas, carbohidratos, proteínas, hierro, ácido fólico, cobalamina y ácido ascórbico se obtuvo mediante el método de recordatorio de 2 × 24 horas y luego se calculó mediante una nutriencuesta. El análisis bivariado se realizó mediante la prueba de Chi-Cuadrado y multivariante con pruebas de regresión logística múltiple.* **Resultados***: Los encuestados que presentaban anemia fueron 115 personas (54,5 %). Los resultados del análisis bivariado encontraron que las variables fueron significativas con la incidencia de anemia proteica (P=0,056; OR=1,783), hierro (P=0,003; OR=2,386), cobalamina (P=0,027; OR=2,675), y ácido ascórbico (P=0,01; OR=2,103). Los resultados del análisis multivariado mostraron que las variables que más influyeron en la incidencia de anemia fueron el hierro y la cobalamina.* **Conclusión***: La ingesta de hierro y cobalamina es la variable que más influye en la incidencia de anemia en mujeres jóvenes en Escuela Secundaria Superior.*

Palabras clave*: Anemia, mujeres jóvenes, ingesta de macronutrientes, ingesta de micronutrientes*

INTRODUCTION

Nutritional deficiencies and poor eating habits established during adolescence can have long-term consequences, including delayed sexual maturation, loss of final adult height, increased disease susceptibility in adulthood, and the risk of giving birth to a generation with nutritional problems (1).

Growth failure and micronutrient inadequacy, during childhood and adolescence can delay growth and create a high risk of chronic diseases in adulthood. Inadequate nutritional needs, both macronutrients and micronutrients, can cause sub-optimal physical growth, decreased intelligence, decreased work productivity, and decreased endurance, which can result in high rates of infectious diseases and even death. One of the nutritional problems that is still faced by Indonesian people is anemia, which is one of the most common nutritional deficiency disorders being a serious global public health problem leading to low birth weight including morbidities and mortalities of mothers and children in addition to negative consequences on the cognitive and physical development of children, and poor productivity in adults (2).

One of the six global targets for 2025 is a 50 % reduction in the problem of anemia in women of childbearing age (WUS). Currently, anemia is still a public health issue in Indonesia and the trend is increasing. Intervention for anemia needs to be done early during the period of a teenager's life. Interventions during the pregnancy phase tend to be late (3).

Basic Health Research (RISKESDAS) has shown an increase in the prevalence of anemia in the youth group of 15-24 years, from 18.4 % in 2013 to 32 % in 2018. The World Health Organization (WHO), in 2020, recognized iron deficiency anemia as the most common nutritional deficiency in the world and affects 33 % of non-pregnant women, 40 % of pregnant women, and 42 % of adolescents worldwide (4).

According to Briawan, nutritional anemia is caused by iron deficiency, and also deficiency of vitamin A, ascorbic acid, folic acid, or cobalamin, but it is generally assumed that 50 % of anemia cases are caused by iron deficiency. Iron deficiency in general can occur due to increased demand for iron in the body. Anemia, mainly caused by insufficient intake of food sources of iron, is the most common nutritional disorder and generally occurs in young women (5).

The emergence of anemia can be caused by the depletion of iron stores that may result from blood

loss, decreased intake, impaired absorption, or increased demand, irregular and unbalanced with the adequacy of the nutritional sources needed by the body including energy intake, protein intake, carbohydrate intake, fat intake, ascorbic acid, and especially lack of food sources that contain iron and folic acid. Additional factors that can cause anemia are deficiency of folic acid, deficiency of vitamins B12 (cobalamin) and vitamin C (ascorbic acid), chronic disease, nutritional status, length of menstruation, educational level of parents, level of knowledge, and economic level (6).

Iron is essential to produce hemoglobin. Intake of macronutrients such as protein plays a role in iron storage and transportation. Apart from iron intake, micronutrients such as folic acid and vitamin B12 are also related to body hemoglobin levels. Food intake needs to be considered related to the amount of nutritional intake that enters the body (7).

Data show the high prevalence of anemia and indicate several factors that cause anemia in young girls such as parents' education, family income, nutritional status, nutritional intake, physical activity, menstrual patterns, and eating patterns. In this regard, little is known about the prevalence of anemia in adolescents in Rappocini District, Makassar City, especially at the Senior High School of Makassar. Based on the Central Bureau of Statistics, Rappocini Subdistrict is one of the subdistricts with the poorest households or middle and lower socioeconomic households. Secondary data from Basic Education Data indicate that Rappocini Subdistrict is the Subdistrict with the highest number of students. Thus, this study aimed to assess the determinants of anemia in adolescent girls aged 14-17 years at State High School (SMAN) 9 Makassar, Indonesia.

METHODS

This research was conducted using the observational method using a cross-sectional design. Was conducted at senior high school Makassar, Rappocini District in August-February 2023. The population was students of class X and XI at Senior High School Makassar. The total number was 449 students. The sample in this study is representative of the population and meets the inclusion criteria. Sampling was obtained based on the calculation of the Slovin formula (8), and 211 respondents were selected using proportional random sampling. Data collection was performed by 2x24 hour recall which was carried out in no sequence and the value of hemoglobin levels was obtained from venous blood sampling with an easy touch digital device. Bivariate data analysis used the Chi-Square test and multivariate analysis, was performed using multiple linear regression tests.

RESULTS

As shown in Table 1, out of 211 respondents, most adolescent girls were in the age category of 16 years as many as 89 people (42.2 %), and the lowest age value was in the age category of 14 years, as many as 21 people (10.0 %).

Most of the nutritional status of adolescent girls was in the good nutrition category as many as 133 people (63.0 %) and the less nutritional status was in the overnutrition category as many as 8 people (3.8 %).

Meanwhile, adolescent girls who experienced anemia were 115 people (54.5 %) and not anemic as many as 96 people (45.5 %).

Table 1

Table of characteristics of respondents

Age	**n**	**%**
14	21	10
15	79	37.4
16	89	42.2
17	22	10,4
Nutritional Status		
Good Nutrition	133	63
Malnutrition	53	25.1
Overnutrition	8	3.8
Obesity	17	8.1
Anemia Incidence		
Anemia (<12 g/dL)	115	54.5
Not Anemia (<12 g/dL)	96	45.5
Total	211	100

Source: Primary Data, 2023

Based on Table 2, the distribution of macronutrient intake in young girls at Senior High School Makassar was, in fat intake 163 (77.3 %) respondents experienced deficient fat intake. For carbohydrates, there were 195 (92.4 %) respondents who experienced deficient intake while 16 (7.6) had a normal intake. The respondents who were deficient in protein were 148 people (70.1 %).

As for micronutrients, for iron intake 133 (63.0 %) respondents were deficient in iron intake. For folic acid, 211 (100 %) respondents had deficient intake. As for Cobalamin, 187 (88.6 %) respondents presented a deficient intake. For Ascorbic acid, there were 141 (66.8 %) respondents whose intake was deficient.

Table 2

Distribution of Macro and Micro Intake in Young Girls at SMAN 9 Makassar

Macronutrients Intake	**N**	**%**
Fat		
Less	163	77.3
Enough	48	22.7
Carbohydrate		
Less	195	92.4
Enough	16	7.6
Protein		
Less	148	70.1
Enough	63	29.9
Micronutrients Intake		
Iron		
Less	133	63.0
Enough	64	30.3
Folic Acid		
Less	211	100
Enough	0	0
Cobalamin		
Less	187	88.6
Enough	24	11.4
Ascorbic acid		
Less	141	66.8
Enough	70	33.2
Total	211	100.0

Source: Primary Data, 2023.

According to Table 3, the variables that were statistically significant in the incidence of anemia were protein in macronutrients, and iron, cobalamin, and ascorbic acid for micronutrients. The results of the study showed that from a total of 148 female adolescents with insufficient protein intake, 87 (58.8 %) had anemia, while 61 (41.2 %) did not manifest anemia. The results of the Chi-Square test obtained a $p = 0.056$ (OR: 1.783), $p<0.05$, which means that Ha is accepted and H0 is rejected so that it can be concluded that there is a relationship between protein intake and the incidence of anemia. Adolescent girls who have a deficiency in protein intake are 1.783 times more at risk of developing anemia than female adolescents who have sufficient protein intake.

Iron deficiency intake was shown in a total of 133 adolescent girls, from which 83 (62.4 %) experienced anemia and 50 (37.6 %) did not present anemia. In the group with an adequate level of iron intake, 32 people (41.0 %) showed anemia. Chi-Square test results obtained $p=0.003$ (OR: 2.386), $p<0.05$, which means Ha is accepted and H0 is rejected so it can be concluded that there is a relationship between iron intake and the incidence of anemia. Adolescent girls who have deficient iron intake are 2.386 times more at risk of presenting anemia than adolescent girls who have adequate iron intake.

In addition, a total of 187 adolescent girls experienced a deficit of cobalamin intake, and from those 107 (57.2 %) experienced anemia. While from a total of 24 persons with a sufficient level of cobalamin intake, there were 8 people (33.3 %) who presented anemia. Chi-Square test results obtained a of $p = 0.027$ (OR: 2.675) $p<0.05$ which means Ha is accepted and H0 is rejected so it can be concluded that there is a relationship between cobalamin intake and the incidence of anemia. Adolescent girls who have less cobalamin intake are 2.675 more at risk of anemia than adolescent girls who have sufficient cobalamin intake.

As for a total of 134 adolescent girls who experienced a deficient intake of ascorbic acid, anemia intake was present in 82 (61.2 %), while in 77 people who had sufficient levels of ascorbic acid intake still 33 people (42.9 %) experienced anemia. Chi-Square test results obtained $p = 0.010$ (OR: 2.103) $p<0.05$, which means Ha is accepted and H0 is rejected so it can be concluded

Table 3

Relationship of independent variables with Anemia Incidence

Variable	Anemia Incident						P-value	OR	95 % CI
	Anemia		Not Anemia		Total				
	n	%	n	%	n	%			Lower-Upper
MACRO-NUTRIENTS									
Fat									
Not Enough	94	57.7	69	42.3	163	100	0.089	1.752	0.915-3.353
Enough	21	43.8	27	56.3	48	100			
Carbohydrate									
Not Enough	108	55.4	87	44.6	195	100	0.369	1.596	0.571-4.459
Enough	7	43.8	9	56.3	16	100			
Protein									
Not Enough	87	58.8	61	41.2	148	100	0.056	1.783	0.983-3.232
Enough	28	44.4	35	56.6	63	100			
MICRO-NUTRIENTS									
Iron									
Not Enough	83	62.4	50	37.6	133	100	0.003	2.386	1.347-4.226
Enough	32	41.0	46	59.0	78	100			
Cobalamin									
Not Enough	107	57.2	80	42.8	187	100	0.027	2.675	1.091-6.558
Enough	8	33.3	16	66.7	24	100			
Ascorbic acid									
Not Enough	82	61.2	52	38.8	134	100	0.010	2.103	1.190-3.716
Enough	33	42.9	44	57.1	77	100			

*Chi-Square Test.

that there is a relationship between ascorbic acid intake and the incidence of anemia. Adolescent girls who have less ascorbic acid intake are 2.103 more at risk of anemia than adolescent girls who have sufficient ascorbic acid intake is sufficient.

The multiple logistic regression results are presented in Table 4. Show that in Step 1, the variable that has an association with the incidence of anemia in adolescent girls is protein for macronutrient intake ($p = 0.05 < 0.05$). As for micronutrients, there is an association with the incidence of anemia among adolescent girls with iron ($p = 0.003 < 0.05$), vitamin B12 ($p = 0.032 < 0.05$), and ascorbic acid ($p = 0.010 < 0.05$).

Table 4

Results of Multivariate Analysis of the Most Influential Variable with the Incidence of Anemia

Variable	Coef	Std. Err	Wald	P-value	OR	95 % CI	
						ower	Upper
Step I							
Macronutrient Intake							
Fat	0.561	0.331	2.862	0.091	1.752	0.915	3.353
Protein	0.578	0.304	3.627	0.057*	1.783	0.983	3.232
Micronutrient intake							
Iron	0.870	0.292	8.895	0.003*	2.386	1.347	4.226
Cobalamin	0.984	0.458	4.625	0.032*	2.675	1.091	6.558
Ascorbic acid	0.734	0.291	6.539	0.010*	2.103	1.190	3.716

*Regresion Logistik Test

The multiple logistic regression analysis results are shown in Table 5. In Step 2, it can be seen that the variable has a p<0.05 the micronutrient intake variables are iron and cobalamin, so the logistic regression results are considered as the final stage. This means that these variables are considered the most influential variables in the occurrence of anemia in adolescent girls at senior high school in Makassar.

Adolescent girls with insufficient iron intake had a 2.531 times greater risk (95 % CI: 1.396-4.590) of anemia compared to those with sufficient intake. As for cobalamin, adolescent girls with insufficient Vitamin B12 intake had a 2.532 times greater risk (95 % CI: 0.990-6.480) of anemia compared to adolescents with sufficient intake.

Table 5

Results of Multivariate Analysis of Variables Most Influential with the Incidence of Anemia

Variable	Coef	Std. Err	Wald	P-value	OR	95 % CI	
						Lower	Upper
Step II							
Micronutrient- Intake							
Iron	0.929	0.304	9.347	0.002*	2.531	1.396	4.590
Cobalamin	0.929	0.479	3.756	0.053	2.532	0.990	6.480
Cons	-3.189	1.017	9.821	0.002*	0.041		

*Regression Logistic Test.

DISCUSSION

Nutritional status is considered a physiological state of an individual, which results from the relationship between nutrient intake and requirements, and from the body's ability to digest, absorb, and use these nutrients (9). This study was undertaken to assess the relationship between macro- and micronutrient intake and the prevalence of anemia in adolescent girls at a Superior High School. It was found that from a total of 211 adolescent girls, 115 people (54,5 %) experienced anemia, while 96 respondents (45.5 %) did not. Most of the respondents showed deficient categories of nutrient intake (fat, carbohydrates, protein, iron, folic acid, vitamin B12, and vitamin C).

There was no relationship between fat intake and the incidence of anemia. Fat is a source of energy for growth and activity. Low fat intake will result in unfulfilled energy, besides that low animal fat intake will also affect iron and zinc intake. This is because animal food is a source of iron and zinc (10). This study is in line with research conducted by Kurniasih et al., who found that there is no relationship between fat intake and the incidence of anemia (7).

For carbohydrate intake, the results obtained with the Chi-Square test indicate that there is no relationship between carbohydrate intake and the incidence of anemia. So it is concluded that there is no significant relationship between carbohydrate intake and hemoglobin levels and the higher the carbohydrate content, the lower the hemoglobin level, and vice versa (7). Carbohydrates are the main source of energy for the needs of cells and body tissues. There are some tissues such as the nervous system and erythrocytes that only use carbohydrates as a source of energy (11).

There was a relationship between protein intake and the incidence of anemia. Protein plays an important role in iron transportation

in the body. A deficit of protein intake will cause iron transportation to be inhibited so that iron deficiency will occur. Iron absorption that occurs in the small intestine is assisted by protein transporters, namely transferrin, and ferritin. Transferrin contains ferrous iron which functions to transport iron to the bone marrow for hemoglobin formation (12). This research is in line with research conducted on adolescent girls at SMA Negeri 7 Bengkulu City in 2022, where it was found that of 17 adolescent girls with insufficient protein intake, 14 adolescent girls (82.4 %) suffered from anemia. While out of 18 adolescent girls with sufficient protein intake, there were 2 adolescent girls (11.1 %) suffering from anemia. This data demonstrated that there is a relationship between protein intake and the incidence of anemia (13).

As for iron micronutrients, in the present study, it was shown that there was a relationship between iron intake and the incidence of anemia. Hemoglobin is a complex compound of iron. It is the protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs. It is made up of four protein molecules (globulin chains) that are connected. Some factors that can affect hemoglobin levels in the body include gender, age, diet, and systemic diseases. Hemoglobin levels in the body must be at the threshold of normal values if a person's hemoglobin level decreases (<12 gram/dL) it can lead to anemia (14). Adequate iron stores will fulfill the need for red blood cell formation in the bone marrow.

This study is in line with the study of Rahfiludin et al., who stated that there is a correlation between iron and hemoglobin levels due to the lack of consumption of animal foods that contain iron with higher bioavailability (15). Similarly, Sholicha et al., at SMA 1 Gresik, showed that there is a relationship between iron intake and anemia (16). Furthermore, Azizah, in the Jatinangor area found that respondents who did not meet iron adequacy reached 93.6 % (88 people) and those who met iron adequacy were 6.4 % (6 people) (17).

Since iron is required for a number of diverse cellular functions, a constant balance between iron uptake, transport, storage, and utilization is required to maintain iron homeostasis. When the amount of iron stores is reduced and the intake of iron consumed is low, the balance of iron is disturbed, as a result, the hemoglobin level drops below the normal value resulting in iron nutritional anemia. Iron deficiency anemia arises when the balance of iron intake, iron stores, and the body's loss of iron are insufficient to fully support the production of erythrocytes. Iron deficiency anemia rarely causes death, but the impact on human health is significant. Iron deficiency anemia symptoms are usually nonspecific. Red blood cells tend to be microcytic and hypochromic, and iron stores are low, as shown by low serum ferritin and low serum iron levels with high serum total iron-binding capacity (10).

It was found that there was a relationship between cobalamin intake and the incidence of anemia with the Chi-Square test of a $p<0.027$ ($p<0.05$). These results are in concordance with Ayuningtyas et al., who in a study of 58 female students indicated that there are differences in cobalamin intake based on anemia status ($p=0.004$) (18). Also, the results are in line with Nasution et al., in their study performed on 116 adolescent girls, in which they concluded that the most dominant factors influencing the incidence of anemia in junior high school girls were the average intake of cobalamin and nutritional knowledge scores. Cobalamin intake and good nutritional knowledge can reduce the incidence of anemia in adolescent girls by 2.04 times and 1.65 times, respectively (19).

Cobalamin has a function that is closely related to folate or folic acid. Cobalamin is needed to convert folate into its active form. Folate deficiency will cause impaired maturation of erythrocyte nuclei, resulting in blood cells of abnormal shape and size. Cobalamin is one of the most essential vitamins in adolescence, as its function is closely related to the formation of red blood cells. Cobalamin deficiency is generally caused by poor absorption. This vitamin deficiency can lead to pernicious anemia, which is the result of poor absorption of cobalamin. The condition of the body with a deficit of cobalamin will cause a disturbance in the bone marrow which causes the bone marrow to be unable to produce erythrocyte cells normally and causes limitations on hemoglobin transport (20). Cobalamin intake

is closely related to the formation of blood cells in the body. The more cobalamin intake in adolescent girls will be directly proportional to the hemoglobin level in their blood, and vice versa, the less cobalamin content in the body will cause low hemoglobin levels in the blood. Cobalamin deficiency in adolescents is generally caused by the lack of cobalamin sources such as liver, meat, shrimp, and shellfish. Minimal intake of animal-source foods will cause a cobalamin deficit because cobalamin is most commonly found in animal-source foods (20).

For ascorbic acid, the Chi-Square test results showed a $p< 0.010$, indicating that there is a relationship between ascorbic acid intake and the incidence of anemia. These results are in concordance with research conducted on 28 students (87.5 %) showing that they did not experience anemia when there was an ascorbic acid intake. Their results showed that there was no relationship between ascorbic acid intake and the incidence of anemia ($p>0.05$). Ascorbic acid facilitates iron absorption by forming a chelate with ferric iron at an acid pH that remains soluble at the alkaline pH of the duodenum. Absorption of iron in non-heme form increases fourfold in the presence of ascorbic acid because ascorbic acid moves iron from transferrin in the plasma to liver ferritin. This is why ascorbic acid indirectly affects hemoglobin levels. Deficiency of ascorbic acid intake increases susceptibility to infections due to the antioxidant function of ascorbic acid (16).

In the multivariate analysis, it was found that the most influential variables with the incidence of anemia among adolescent girls at senior high school Makassar were Iron and Cobalamin intake.

CONCLUSION

1. There was a relationship between macro-nutrient intake (protein) and the incidence of anemia among adolescent girls at Senior High School Makassar.
2. There was a relationship between the intake of micronutrients (iron, cobalamin, and ascorbic acid) with the incidence of anemia among adolescent girls at Senior High School Makassar.
3. Intake of iron and cobalamin are the most influential variables on the incidence of anemia in adolescent girls at Senior High School, in Makassar, Indonesia.

Suggestions

1. It is recommended an intervention by sectors related to increasing the intake of nutrients affecting anemia such as protein, iron, folic acid, cobalamin, and ascorbic acid, as with high bioavailability in the diet of young women, implementing food diversification, iron supplementation, and increasing knowledge about iron-rich food sources. The program iron tablet supplementation in young women should be a priority program.
2. For the prevention of anemia, it is recommended the continuous evaluation of hemoglobin blood levels in the School Health Unit, counseling about anemia, and correct consumption patterns related to the consumption of food sources.
3. Young women should be advised to take part in counseling activities about health, actively seek information on health and balanced nutritional food from the media and be more aware of the importance of consuming food sources that prevent anemia.

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