Analysis of the Relationship between Adolescent Anemia and Micronutrient Intake

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Abstract: According to the World Health Organization (WHO), anemia cases in adolescent girls reached 53.7%. RISKESDAS data in 2018 also showed an increase in anemia cases in adolescents aged 15-24 years by 18.4% to 48.9%. Anemia is a health disorder that is prone to occur in adolescent girls due to lack of hemoglobin in the body. This study aims to determine and analyze the relationship between anemia in adolescent girls and micronutrient intake. The method used was a literature review, critically reviewing previously published findings from Pubmed and Science Direct with certain inclusion criteria. The results showed that the intake of certain micronutrients such as iron, zinc, vitamin B12, vitamin B6, and copper had a significant association with the incidence of anemia in adolescent girls. The association between one or more micronutrients related to iron formation and absorption can lead to anemia. Iron, as the main component in the formation of hemoglobin, can interfere with the absorption of hemoglobin if it does not occur properly.In conclusion, micronutrient intake affects the incidence of anemia in adolescent girls. Impaired absorption and formation between nutrients can interfere with hemoglobin formation, causing anemia.

1 INTRODUCTION

Anemia is a condition where the blood has a decreased ability to transport oxygen due to low hemoglobin concentration in the blood. Anemia can be caused by various factors, such as nutrition, genetics, and cellular abnormalities. Based on nutritional problems, anemia is classified into several types, one of which is iron deficiency anemia. Such anemia can occur when the body does not have enough iron to produce hemoglobin. Iron deficiency anemia is one of the anemia that is often found in adolescents, especially adolescent girls.

Adolescence is a transitional phase from children to adulthood which involves the processof growth and development, both in terms of physical, psychological, and emotional. Based on the Nutrition Adequacy Table (AKG) states that the iron requirement of female adolescentswith an age range of 13-29 years is 26 mg per day. Where this figure is a higher value for its needs compared to the iron needs of adolescent boys of the same age. In adolescent girls, iron intake is not only used for growth and development, but also used to replace iron lost through blood loss during menstruation. Therefore, the high need for iron in girls will ultimately havea greater risk of anemia.

According to the *World Health Organization* (WHO), cases of anemia in adolescent girls in 2019 were around 29.9%. Meanwhile, based on data from the Ministry of Health's Basic Health Research (Riskesdas), cases of anemia in adolescents aged 15-24 years have increased from 2013 to 2018 from 18.4% to 32%.

2 METHODS

This research method uses a literature review method that focuses on analyzing the relationship between adolescent girls' anemia and micronutrient intake. This research was conducted by collecting data from

various sources, including relevant journals and research reports. The data collected was then systematically analyzed to find the relationship between anemia of adolescent girls and micronutrient intake. Data collection techniques in this study include collecting data in the form of relevant literature sourced from journals and research reports related to this topic. Data were analyzed using descriptive analysis techniques to get an overview and quantitative analysis to find relationships between variables. This study was conducted with the aim of knowing the relationship between anemia of adolescent girls and micronutrient intake and providing recommendations to improve the nutritional quality of adolescent girls.
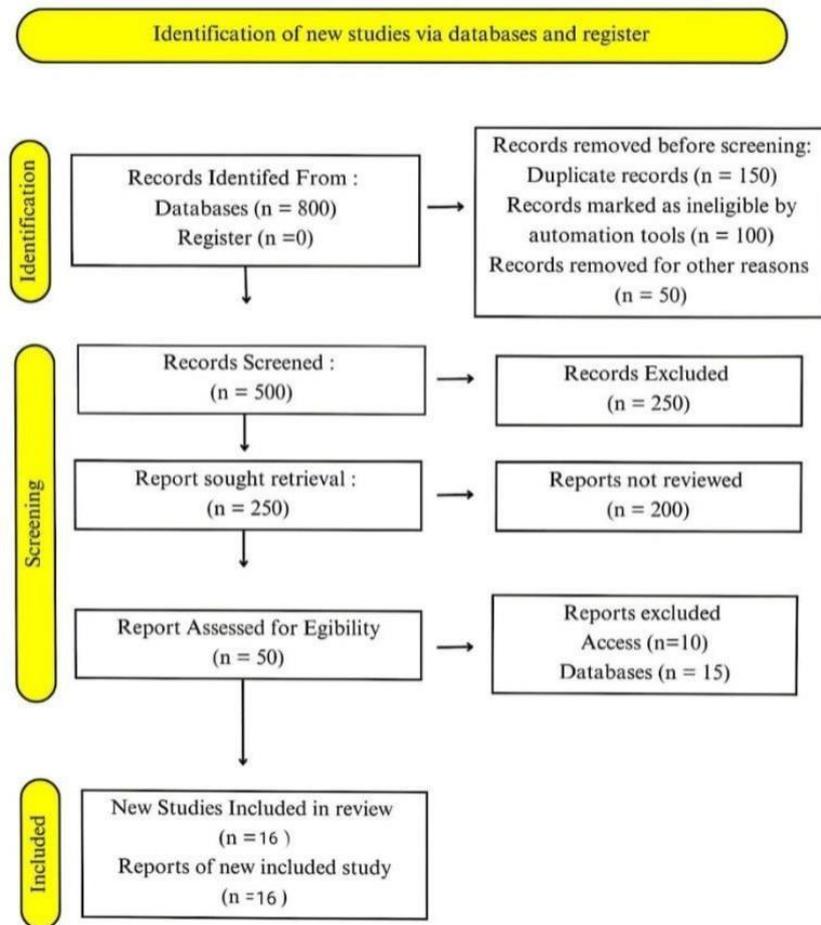

Figure 1: Journal Search Prism

3   RESULTS

Table 1: Journal Analysis Table

No	Research Title	Name/ Year	Research Methods	Research Results
1	Relationship between Iron Intake and Anemia Status of Adolescent Girls in Bogor City	Tyas Permatasari, Dodik Briawan, Siti Madanijah / (2020)	This study was conducted using a cross sectional research design. Data collected included food consumption using the semi-quantitative Food	Based on the results of the study, it was found that the incidence of anemia in adolescent girls in Bogor City was 20.9% of 172 subjects, namely there were 36 adolescents who experienced anemia. There were two incidences of anemia, namely mild anemia as

No	Research Title	Name/ Year	Research Methods	Research Results
			Frequency Questionnare (FFQ) method, hemoglobin levels analyzed using the cyanmethemoglobin method, and anemia status which was divided into 2 namely anemia and not anemia.	many as 32 subjects (88.8%) and moderate anemia as many as 4 subjects (11.1%). In this study, anemia status was determined using hemoglobin indicators. Based on the results of hemoglobin levels, it can be determined that the classification of mild anemia is 10-11.9 g/dl, moderate anemia is 7-9.9 g/dl, and severe anemia is <7 g/dl. Subjects with moderate category can have an impact on their immune status and ognitive function. The most dominant factor of the problem of anemia in adolescents is related to food patterns of iron sources. Total consumption of animal side dishes in adolescent girls in Bogor City is still relatively low. The average consumption of animal side dishes in the subjects of this study still reached 39%. As for the consumption of vegetable side dishes, it only reached 31.2%, and the consumption of vegetables and fruits was still relatively low, namely vegetables 30.95 ± 1.91 and fruits 39.65 ± 30.17.
2	Iron Intake, Vitamin C and Blood Addition Tablet Consumption Associated with the Incidence of Anemia among Adolescent Girls of SMPIT Majmaul Bahrain Bogor	Sarah Alfiah, Nunung Cipta Dainy	The results of the study were then analyzed univariately to determine the frequency distribution and characteristics of each variable. Bivariate analysis using the Chi-Square test to determine the relationship between iron intake, vitamin C, compliance with TTD consumption and knowledge about anemia with the incidence of anemia in adolescent girls.	Based on the results of the study, it can be found that the prevalence of anemia among adolescent girls at Majmaul Bahrain IT Junior High School is 54.7%. Most respondents had iron intake in the deficient category (54.7%), vitamin C intake in the deficient category (51.6%), there were 62.3% of respondents who were not compliant in consuming TTD (Blood Additive Tablets), and 61.1% of respondents with poor knowledge. Based on the results of the level of compliance and low knowledge of respondents, it is due to the lack of educational efforts to students related to anemia by schools and local health centers. Most of the adolescent girls at Majmaul Bahrain IT Junior High School were found to be anemic. There are several factors that can cause anemia, namely food intake, knowledge, and compliance with taking blood supplement tablets. This can be seen from the results of the study which prove that most respondents on all variables are included in the less category. This proves that there is a significant correlation between iron intake, vitamin C with the incidence of anemia in adolescent girls at Majmaul Bahrain IT Junior High School.
3	The relationship of Fe tablet administration to increased hemoglobin levels in adolescent girls at risk of anemia	Asriullah Jabbar, et al (2024)	Quantitative with cross sectional. The cross sectional research method will study the relationship between independent factors and dependent factors with measurements made with instantaneous observation at the same time. The bivariate data analysis using Pearson ChiSquare	Based on the analysis conducted from 91 respondents, the highest respondent data for bivariate analysis of Fe tablet administration with increased hemoglobin levels is the category of increased hemoglobin levels with complete Fe tablet administration. The results of respondents who experienced an increase in hemoglobin levels with complete Fe tablet administration were 52 people, and with incomplete Fe tablet administration were 4 people. In respondents who did not experience an increase in hemoglobin levels with

No	Research Title	Name/ Year	Research Methods	Research Results
				complete Fe tablet administration as many as 7 people and incomplete Fe tablet administration as many as 5 people.
4	Adolescent girls' knowledge about taking FE tablets during menstruation with anemia	Catur Setyorini, Durrotun Nafisah, Fitria Kurniastuti (2023)	quantitative with a cross sectional approach and data analysis using Pearson ChiSquare	Based on the results of the study, 64 respondents (59.3%) who had knowledge about Fe tablet consumption during menstruation in the good category, 60 people (55.6%) of them did not suffer from anemia. While from 39 respondents (36.1%) who had knowledge about Fe tablet consumption during menstruation with sufficient category, 29 people (26.9%) of them did not suffer from anemia. Based on the results of chi-square analysis, the results of P Value < α (0.001 < 0.05) indicate a significant relationship between the two variables.
5	The Relationship between Intake of Iron, Zinc and Folic Acid with the Incidence of Anemia in Adolescent Girls at SMAN 1 North Kampar in 2021	Puspita Sari (2022)	The analysis used was univariate analysis and bivariate analysis. Univariate analysis was used to explain and describe each characteristic of each variable using iron, zinc, folic acid intake, and the incidence of anemia. While bivariate analysis was used to see the relationship between independent variables and dependent variables with the chi-square test.	Based on the analysis conducted on 81 students, it was found that more than 50% of students had insufficient iron intake (50 students), zinc intake (53 students), and folic acid intake (58 students). 53 students experienced anemia and less than 50% of students experienced pale skin (41 students), pale eyelids (35 students), lethargic body (36 students), and easily broken nails (9 students). In the bivariate analysis, it was found that 50% of students had anemia with insufficient iron intake, 22% of students did not have anemia with sufficient iron intake, more than 50% of students had anemia with sufficient zinc intake, and 50% of students had anemia with sufficient folic acid intake.
6	Relationship between Vitamin C and Vitamin B12 Intake and the Incidence of Suspected Anemia in Adolescent Girls in Sukoharjo Regency	Sunarti Hanapi, et al (2019)	The analysis used was univariate analysis and bivariate analysis. Univariate analysis was conducted to describe the variables of vitamin C intake, vitamin B12 intake, and the incidence of suspected anemia.	Based on the analysis conducted on 110 adolescent girls, it was found that 57.3% of vitamin C intake was in the deficient category where respondents consumed the most sources of vitamin C from spinach and 61.8% of vitamin B12 intake was in the deficient category with the most sources of vitamin B12 in domestic chicken eggs. In this study, the non-suspect anemia category was 65.5%.
7	Relationship between nutritional status and the incidence of anemia in adolescent girls	Gusman Virgo (2020)	In the study, two analyses were carried out, namely data analysis of subject data (univariate) which was used to identify subject age, weight, height, z score based on IMT / U, hemoglobin levels, protein intake, iron, vitamin C, vitamin B12 and folate. And the second analysis is bivariate analysis with the Chi Square test to determine the relationship between nutritional status and the incidence of anemia in adolescent girls	Based on the results of the study based on IMT/U, the average z-score value was 0.97 ± 1.18 SD, with the lowest value of -3.03 and the highest value of 2.64. The z-score value shows the nutritional status of the subjects: very thin 1 person (1.1%), thin 3 people (3.3%), normal 66 people (73.3%), obese 14 people (15.6%), and 6 people (6.7%). Hemoglobin levels showed that the lowest was 9.9 grams/dL and the highest was 14.9 grams/dL, with a mean of 12.6 ± 1.29 SD, and 24 of them (26.7%) were anemic. The calculated intake of protein, iron, vitamin C, vitamin B12, and folate showed that 63.3% of the girls had iron intake that was less than the requirement, while most of the girls had adequate intake of protein, vitamin C, vitamin B12, and folate. There was no significant relationship between nutritional

No	Research Title	Name/ Year	Research Methods	Research Results
			aged 12-14 years then continued multivariate analysis with logistic regression test.	status and the incidence of anemia in adolescent girls; one person (25%) was underweight and three people (50%) were obese.
8	Relationship between Nutritional Status and Anemia in Adolescent Girls at SMA PGRI 4 Banjarmasin	Hutari Puji Astuti, Christiani Bumi Pangesti (2022)	This study uses a non-parametric statistical test, namely the chi square test to see the relationship between nutritional status variables and the incidence of anemia in adolescent girls at PGRI 4 Banjarmasin High School. The aim is to determine whether or not there is a relationship between nutritional status and the incidence of anemia in adolescent girls at PGRI 4 Banjarmasin High School.	The results of the research in this journal have 2 tables containing that adolescent girls with normal nutritional status have the highest number, namely 80.6%. While the least amount is thin nutritional status 9%. And fat nutritional status at a percentatse of 10.4%.In table 2 explains that most of the research respondents experienced anemia, namely 62.7%. With the number of students around 42 people. And 25 children did not suffer from anemia, namely 37.3%.
9	Relationship between intake of zinc, copper, and vitamin B6 with the incidence of anemia in students at SMA Muhammadiyah 10 GKB	Fithria Nurul Azizah, et al (2023)	The data collected from the research results were then processed using the SPSS statistical program with several stages including coding, entry, cleaning, and analyzing. Furthermore, data analysis was carried out and presented in tabular form with the pearson correlation test.	The results of this study showed there was a significant relationship between zinc intake (sig = 0.002), copper (sig = 0.539), and vitamin B6 (sig = 0.001) with hemoglobin levels in adolescent girls at SMA Muhammadiyah 10 GKB.
10	Vitamins A administration factor	Puspita Adriani (2019)	Relationship between Iron Source Consumption and Anemia Among Junior and Senior High School Adolescent Girls in Bantul.	Judging from the average iron intake of adolescent girls as much as 22.88 mg/ day which means it meets the needs that should be. However, from the results of data collection most of the adolescent girls as many as 110 people (55.56%) have iron intake that is still lacking (<15mg / day) this is influenced by the frequency of iron intake of adolescent girls who are mostly only 1-2x a week and the amount of consumption is also low and the types of food consumed are less diverse.

4   DISCUSSIONS

Adolescence is a transition period from childhood to adulthood with an age range of 10 - 19 years. Based on research from Riskesdas in 2018, the prevalence of anemia in adolescents was 32%. This shows that 3-4 out of 10 adolescents suffer from anemia. Anemia can occur due to factors of eating habits that are not optimal so that they do not meet nutritional intake. In addition, physical activity is also one of the factors causing anemia. This is because, the habit of adolescents who lack exercise so that the intake of nutrients is not balanced with the energy expended. One of the main causes of anemia in adolescents is a lack of nutritional intake from food which includes iron, vitamin C, protein, vitamin B12, zinc, and folic acid.

Anemia

Anemia is one of the health problems that often occurs in children around the world, especially in developing countries, namely Indonesia. Anemia is caused by iron deficiency in the patient's body. It is known that 30% of the world's population is anemic and most of them are found in developing countries. Anemia is a condition where the body lacks hemoglobin. Hemoglobin is a metalloprotein, a protein that contains iron in red blood cells. The iron is responsible for transporting oxygen from the lungs to the rest of the body. Anemia is one of the conditions that often occur in adolescent girls. This can be caused by various factors, namely nutritional status, menstruation, and socioeconomics. Anemia can have an impact on reducing endurance, resulting in the body being susceptible to health problems.

Epidemiologically, the highest incidence of anemia is found in late infancy and early childhood. This is due to iron deficiency during pregnancy and accelerated childhood growth accompanied by low iron intake from food. In addition, anemia also occurs in adolescence due to rapid growth and development, inadequate iron intake and aggravated by blood loss due to menstruation in adolescent girls. In general, adolescent girls will experience menstruation every month. During menstruation, adolescent girls are more at risk of anemia. In addition, poor dietary habits in adolescent girls can also be a factor in anemia. Iron deficiency occurs because the body needs more than is available in food. When a person is born, the body has only a small amount of iron, but as an adult, the amount becomes more. To keep the amount in balance, children need to absorb about 0.8 mg of iron every day until the age of 15. But since only a small amount is absorbed by the body, a person needs foods that contain about 8-10 mg of iron every day.

The World Health Organization (WHO) in the world health statistics in 2021 shows that the prevalence of anemia in women of reproductive age (15-49 years) in the world is around 29.9%. Meanwhile, the prevalence of anemia in non-pregnant women aged 15-49 years is 29.6%, which includes the adolescent age category. Based on the results of the 2018 Riskesdas report, it shows that anemia is a major health problem that often occurs in adolescents, especially adolescent girls. This can be influenced by non-optimal nutritional intake habits and lack of physical activity.

Anemia is a condition where the Hemoglobin (Hb) level in the blood is lower than the normal level for groups of people based on age and gender. In adolescent women the normal Hb level is 12-15 gr/dl. Based on WHO in 2017 anemia is a condition of the body in which the number of red blood cells and their oxygen lifting capacity are insufficient to meet the physiological needs of the body. The physiological needs of a person's body vary depending on age, gender, place of residence, smoking behavior, and stage of pregnancy. In general, anemia occurs due to lack of knowledge about anemia, iron, folic acid, vitamin B12, and vitamin A deficiency. Some other causes are acute and chronic inflammation, parasite infection, congenital disorders that affect hemoglobin synthesis, and lack of red cell production.

The incidence of anemia in adolescent girls can cause fatigue, decreased learning concentration, so that it can affect learning achievement and can reduce work productivity. The high prevalence of anemia in adolescents if not handled properly, it will continue into adulthood and will contribute greatly to maternal mortality, premature birth and low birth rate. One of the interventions conducted by the government to reduce the prevalence of anemia in adolescent girls is the use of tablets containing iron and folic acid supplements through the provision of blood supplement tablets (TTD). Other sources of TTD include health facilities, schools, and individual initiatives. The target objective of the TTD program at the school level is to reach the upper grades of junior high school, high school, and equivalent, as well as women outside school as a strategic initiative to solve the nutrition cycle problem. Blood supplement tablets are included in the government program, namely the Prevention and Control of Anemia in Adolescent Girls and Women of Childbearing Age (WUS) Program, one of the specific objectives is to increase the fulfillment of TTD consumption in adolescent girls, so as to reduce the prevalence of anemia in adolescent girls. The preliminary study conducted by the researcher was to interview five main informants, namely adolescent girls regarding anemia and some of the related symptoms identified. Of the five adolescent girls, four of them experienced the five Ls (weak, lethargic, tired, and lunglai), while one adolescent girl only occasionally had difficulty coping with them, even though she had enough sleep (6-8 hours/day). The researchers also conducted conjunctival examinations on five primary reports and found that four of the adolescents had conjunctival warning signs. Five primary reports and found that four out of five adolescents had warning signs of pallor

Micronutrient Intake of Adolescent Girls

Folic Acid

Folic acid, also known as vitamin B9, is one of the eight water-soluble B vitamins that the body does not store in large amounts and requires a regular supply through food or supplements to maintain normal levels. Folic acid plays a role in red blood cell formation and growth which can be obtained by eating green vegetables and liver. Folic acid also plays a role in the process of nucleo protein synthesis which is key to the formation and production of normal red blood grains in the bone marrow, (Besuni et al., 2013). The substances needed by the bone marrow for hemoglobin formation are metals (such as iron, manganese, cobalt, zinc, copper), vitamin B12, vitamin B6, vitamin C, vitamin E, folic acid, thiamine, riboflavin, pantothenic acid, protein, hormones such as erythropoetin, androgens, and thyroxine. Red blood cell production can be disrupted if digestion does not function properly (malabsorption) or stomach disorders so that nutrients are not absorbed, (Saptyasih et al., 2016).

Folic acid also plays a role in DNA synthesis and amino acid metabolism where in this case the work of folic acid is related to the work of vitamin B12. Vitamin B12 works to convert folic acid into an active form, in normal function folic acid plays a role in the metabolism of all cells including cells of the gastrointestinal tract, bone marrow, and nerve tissue, (Marissa, 2021). Folic acid is needed in biochemical reactions involving the removal of one carbon unit in amino acid interconversions such as the conversion of homocysteine to methionine and serine to glycine in the synthesis of purine DNA precursors. In the process of DNA formation, folic acid plays an important role in nucleotide synthesis, (Besuni et al., 2013). The final maturation of red blood cells requires folic acid, the more and the longer the intake of folic acid will further increase hemoglobin levels.

The average intake of folic acid in pregnant women and fertile women aged 10-19 years according to the standard Nutritional Adequacy Score is 400 micrograms / day or the same as two glasses of milk. Folic acid plays an important role during pregnancy, but before pregnancy, consuming folic acid is highly recommended in order to prevent anemia and reduce the risk of NTD (Neural Tube Defects), as well as an antidepressant. Folic acid deficiency in girls, as adults will not experience menstruation. Whereas in pregnant women, it can increase the risk of anemia so that the mother is easily tired, tired, lethargic, pale,

and can cause miscarriage. In fetuses with pregnant women, folic acid deficiency can cause disability in babies who are born. Babies will experience defects in the brain and spinal cord, babies are born with cleft lip, down syndrome, babies are born with low body weight, babies experience blood coagulation disorders, and so on, (Devianty, 2013). Folic acid deficiency over a long period of time can also cause a decrease in the formation of hemoglobin levels will interfere with the process of cell division and tissue growth which can cause serious health problems.

Folic acid sources are found in green vegetables, fruits, nuts, eggs, wheat and milk, and beef liver. Green vegetables have a high folic acid content of around 100-200 micrograms such as kangkong, spinach, broccoli, cassava leaves, and so on. Beans are a source of protein and rich in fiber which contains 8-17% protein, 100 grams of iron, 100 grams of calcium, and rich in folic acid as much as 700- 100 micrograms. Fruits that are rich in folic acid are avocados, oranges, bananas, and strawberries.

Iron

Average- Iron is an essential microelement needed by the body. Iron is a mineral that plays a role in the formation of red blood cells (synthesizes hemoglobin) and as a component to form myoglobin, a protein that carries oxygen to the muscles, forms collagen, a protein found in bones, connective tissue, and cartilage, and plays a role in the formation of enzymes. Iron also plays a role in the body's defense system, (Besuni et al., 2013). Substances play a role in the synthesis of hormones and nuerotransmitters in the body including dopamine, serotonin, and norepinephrine. In thyroid hormone synthesis, iron plays a role as part of the enzyme thyroid peroxidase as a co-factor in catalyzing the activity of the enzyme thyroperoxidase (TPO). The TPO enzyme is involved in catalyzing the first two reactions of thyroid hormone biosynthesis, (Mulyantoro et al., 2017).

Individual iron requirements differ depending on various factors including age, gender, level of physical activity, and health status. Children, adolescents, and pregnant women require higher iron intake due to rapid growth and development. Adolescent girls require increased iron intake due to menstruation, (Sintya Purnayanti, 2019). The average iron intake in accordance with the standard Nutrient Adequacy Rate (AKG) for women aged 10-19 years is 20 micrograms / day or about 15-18 milligrams. Insufficient iron intake will not directly affect hemoglobin levels because the body has iron reserves

stored in the liver. In addition, adequate vitamin C intake helps the absorption of iron more optimally. Hemoglobin formation is influenced by iron levels as a constituent of heme and is influenced by protein, (Pinasti et al., 2020). Iron storage in several organs can fulfill the need for red blood cell formation in the bone marrow. If iron storage is reduced and the intake of iron consumed is low, the balance of iron in the body is disturbed, resulting in decreased hemoglobin levels which cause iron nutritional anemia. The condition of iron anemia is indicated by a decrease in hemoglobin and ferritin levels in plasma. (Alamsyah, 2018).

Iron deficiency causes the body to be unable to produce hemoglobin effectively, leading to disruptions in oxygen and carbon dioxide transportation that can interfere with normal cellular function. Iron deficiency leads to anemia because the need for iron intake does not match the need to synthesize and produce erythrocytes. Iron deficiency anemia is characterized by inappropriate hemoglobin synthesis due to a lack of iron that plays an important role in the body, resulting in a lack of erythrocyte capacity that transports oxygen to body cells and tissues. One of the causes of iron deficiency anemia is characterized by businesslike symptoms such as shortness of breath, lethargy, dizziness, and pale conjunctiva, (Azizah, 2020). Iron deficiency in adolescent girls has an impact on neurodevelopment and behavior such as decreased motor activity, impaired cognitive function, and decreased social interaction. Iron deficiency can also reduce fitness levels, concentration power, memory, and immunity which results in low learning ability and impacts learning achievement, (Arima et al., 2019).

Food sources that are rich in iron are green vegetables such as spinach, mustard greens, kale, green beans, peanuts and their preparations, seafood such as shrimp and shellfish, eggs, and grain products. Iron from animal sources is more easily absorbed by the body compared to iron from plant sources. In increasing iron absorption, it is recommended to consume food sources rich in vitamin C, (Nabilla et al., 2022). Iron absorption can be influenced by several factors including caffeine, calcium, and polyphenols in the and coffee.

Vitamin B12

Vitamin B12 or cobalamin is a water-soluble vitamin that plays an important role in DNA synthesis, erythrocyte formation, carbohydrate, protein, and fat metabolism, and plays a role in nerve maintenance.

This vitamin is synthesized by bacteria and is found in animal protein sources but not in vegetables. Vitamin B12 cannot be synthesized by humans, therefore vitamin B12 intake is obtained through food, especially food sources from animals. Vitamin B12 plays an important role in nerve myelination, brain development, and cognitive function, (Salsabila, 2020). Vitamin B12 is needed in the synthesis of hemoglobin, a protein in red blood cells that transports oxygen from the lungs to the rest of the body. Without sufficient vitamin B12, the formation of red blood cells is disrupted where the red blood cells are immature and accumulate in the spinal cord, which can cause pernicious anemia. Pernicious anemia is another form of nutritional anemia where the digestive tract is unable to absorb vitamin B12, (Sa'Adah, 2018). Adequate intake of vitamin B12 will increase hemoglobin levels in the blood through the metabolism of protein, fat, and folic acid which requires the role of vitamin B12 by synthesizing hemoglobin and red blood cells. Hemoglobin synthesis requires succinyl-CoA. Vitamin B12 acts as a cofactor in the synthesis of hemoglobin in the formation of energy derived from the breakdown of fat and protein, (Pinasti et al., 2020).

The need for vitamin B12 in each individual differs according to several factors such as age, gender, physical activity, and health status. The daily requirement of vitamin B12 is about 2.4-2.8 micrograms for adults and adolescent girls. However, the need for vitamin B12 will increase in pregnant and lactating women as well as someone with media conditions that interfere with the absorption or metabolism of vitamin B12. In adolescents, vitamin B12 helps in the conversion of carbohydrates, proteins, and fats into energy needed for daily activities and growth. In this sense, vitamin B12 plays an important role in maintaining balanced energy levels during adolescent growth and development. Vitamin B12 deficiency is not very common as the body still stores this vitamin for a long period of time, about five years. Commonly used investigations are low serum vitamin B12 levels or megaloblastic bone marrow. To determine vitamin B12 deficiency can be assessed by assessing homocysteine and methylmalonic acid, (Salsabila, 2020).

The main sources of vitamin B12 are poultry meat, fish, eggs, cheese, shrimp, shellfish, and dairy products. Sources of vitamin B12 are found naturally in animal products and are produced by microorganisms present in the animal's body. Plant-based sources of vitamin B12 are found in cereal products. Vitamin sources also come from

supplements because many elderly people cannot naturally absorb vitamin B12, so vitamin B12 needs are obtained from fortified foods or supplements, (Lestari & Ambarwati, 2023).

Zinc

Zinc is the main mineral in the formation of more than 300 enzymes needed in wound healing, helps cell reproduction, maintains vision, maintains adult fertility and child growth processes, stimulates immunity, and can prevent free radicals. Zinc is also a key component in maintaining healthy skin and preventing skin diseases. Zinc is involved in cell division, cell differentiation, and regulation of DNA synthesis, playing an important role during the growth and development of children, adolescents, and pregnant and lactating women. Zinc also plays a role in the formation of red blood cells and in the synthesis and degradation of carbohydrates, proteins, fats, and nucleic acids. Zinc affects iron metabolism by assisting carbonic anhydrase, which stimulates gastric HCL production, thereby increasing hemoglobin levels. Zinc transportation in the body is albumin, the more zinc content the more the amount of albumin increases. Increasing the amount of albumin can accelerate the production of fibrin mesh as blood clotting. The body absorbs zinc by combining blood elements such as antibodies, plasma proteins, electrolytes, complement, and water into the vascular space, (Jamhariyah, 2019).

Zinc also plays a role in heme synthesis because zinc is related to the activity of the enzyme alpha-aminolevulinic acid dehydratase (ALAD), which catalyzes heme synthesis. Zinc supplementation can increase Fe and hemoglobin levels, but also reduce parasitemia, (Hutasoit & Kurniati, 2020). Zinc requirements vary depending on age, body weight, level of physical activity, and health conditions. In general, the daily zinc requirement for adolescent girls is around 8-9 milligrams. Food sources that are rich in zinc are animal foods such as beef, fish, chicken liver, eggs, oysters, nuts, spinach, milk and its products, and dark chocolate, (Prastia, 2022). Zinc needs can also be met with zinc supplementation as an addition to the zinc content for daily needs. Supplements that are absorbed in digestion require the help of a conveyance (albumin) and occur in the upper part of the small intestine, more precisely the duodenum.

Zinc deficiency results in growth failure and the most affected organs are gastrointestinal, epidermal system, immune, central nervous, skeletal, and reproductive. Lack of zinc intake can affect iron metabolism because zinc acts as a cofactor in the retinol oxidation reaction. Low plasma retinol concentration is associated with decreased iron and hemoglobin. Not only that, zinc deficiency also affects IGF-1, growth factor, and GH binding protein RNA. These hormones will gradually decrease growth leading to weight gain. During growth, rapid tissue synthesis occurs which can result in low serum and plasma zinc. Zinc deficiency inhibits bone formation and bone mineralization. In addition, it can inhibit growth hormone metabolism, resulting in decreased IGF-1, (Prastia, 2022). Insufficient intake occurs due to insufficient zinc supply which can be caused by factors such as dislike of eating foods rich in zinc, impaired absorption, and increased zinc demand and secretion.

Vitamin B6

Vitamin B6 or pyridoxine is one of the water-soluble B-complex vitamins and has an important role in body functions. Vitamin B6 plays a role in several metabolic processes including carbohydrate, protein, and fat metabolism. The body requires this vitamin for the reaction of more than 100 enzymes, immune function, and brain development during pregnancy. In addition, vitamin B6 acts as a cofactor in essential enzymatic reactions of the body. The body uses vitamin B6 to convert nutrients into energy, for the formation of red blood cells, the formation of DNA and RNA, and to prevent excess amino acids that can increase the risk of cardiovascular disease, (Nasution, 2024).

Vitamin B6 also plays an important role in the synthesis of neurotransmitters, chemicals used by the nervous system to send signals between nerve cells including serotonin, dopamine, and norepinephrine which play a role in mood regulation, sleep, and stress response. Vitamin B6 acts as a catalyst in the synthesis of heme in the hemoglobin molecule. Adolescent girls who experience menstruation need to pay attention to iron intake, because blood loss during menstruation can increase the need for vitamin B6 because this nutrient plays a role in iron absorption, so it is important to ensure adequate intake to maintain blood health and prevent anemia, (Astuti & Kulsum, 2020). According to the Institute of Medicine (Rachmawati & Haristiani, 2021)the recommended daily intake (RDA) of vitamin B6 in adolescent girls is about 1.2-1.3 milligrams/day. This requirement depends on age, level of physical activity, and overall health.

Vitamin B6 deficiency leads to impaired production of neurotransmitters that contribute to mental health issues such as depression, anxiety, and sleep disorders. Vitamin B6 deficiency will also interfere with protein metabolism and hemoglobin formation. In this case, it is necessary to overcome the deficiency by consuming food sources rich in vitamin B6. Food sources rich in vitamin B6 are wheat/oats, chicken meat, nuts, eggs, seeds, fresh fruits, and green vegetables, (Mafaza et al., 2023).

Copper

Copper is one of the minerals needed by the body for metabolic processes at the cellular level. Copper plays a role in bone health, preventing infection, iron metabolism, immune function, cellular respiration, and defense against free radicals. Copper and iron metabolism are linked, so copper deficiency causes disturbances in the iron mobilization process, leading to anemia. Even though it is needed in small amounts, copper intake is very important for the health of the body. Copper plays a role in preventing anemia because it helps in iron absorption, releases iron stores from ferritiles in the liver, and stimulates hemoglobin synthesis, (Ransun et al., 2021).

Copper plays a role in the absorption of iron, another essential mineral required for the formation of hemoglobin. A lack of copper intake can impair the body's ability to absorb and use iron effectively, which can also contribute to the occurrence of anemia. Copper intake requirements for adolescent girls vary depending on age, physical activity level, and overall health condition. In general, the daily intake for adolescent girls is around 0.7 to 1.3 milligrams/day, according to the nutritional guidelines issued by health agencies.

Copper deficiency can affect the body's ability to form hemoglobin effectively, which in turn can lead to anemia. Without enough copper, the human body cannot produce an adequate amount of hemoglobin to transport oxygen throughout the body. Over time, this can lead to anemia symptoms such as fatigue, dizziness, and shortness of breath. Copper deficiency can occur simultaneously with iron deficiency. The combination of copper and iron deficiency can make the anemia condition more severe and difficult to overcome.

Relationship of Micronutrients with Anemia in Adolescent Girls

The study showed a significant relationship between micronutrient intake and the incidence of anemia. This occurs due to disturbances in the absorption and formation of iron, which is the main component in the formation of red blood cells (hemoglobin). Anemia is a condition of reduced hemoglobin levels. Adolescent girls are particularly at risk of anemia because they experience menstruation and are likely to lose iron. Food sources of iron consist of heme iron from animal foods and non- heme iron from plant foods. Micronutrients, especially iron, can have a significant impact on hemoglobin production in the body. the amount of iron that is still lacking in the diet occurs because most Indonesians still consume vegetables which are sources of non-heme iron. Hemoglobin is needed to carry oxygen throughout the body, if hemoglobin is insufficient there will be a decrease in the capacity of the blood to carry oxygen throughout the body.

Known inhibitors of iron absorption in foods are tannins, phytates, polyphenolic compounds and calcium. Cereals are one of the phytate compounds that can be found. This compound is a major inhibitor of iron absorption because there is phytic acid content that can bind iron so that the bioavailability of iron absorption decreases in the human body. tannin can form complex bonds chemically because tannin can bind iron, aluminum, and calcium. If iron is bound, the iron contained in food will be difficult to absorb. The body will experience anemia when iron deficiency can interfere with the process of red blood cell formation.

According to the Ministry of Health of the Republic of Indonesia No. HK. 03.03/0595/2016 regarding the provision of Blood Addition Tablets to adolescent girls in junior and senior high school educational institutions through UKS. Adolescents are required to consume Blood Addition Tablets because every month they experience menstruation. The provision of Blood Addition Tablets serves to replace iron lost during the menstrual period and increase iron intake from food intake.

5 CONCLUSIONS

In conclusion, the study showed that knowledge and iron consumption are very important in preventing and managing iron nutritional anemia in adolescent

girls. Insufficient iron consumption can increase the likelihood of anemia. Another cause of the onset of nutritional anemia in adolescent girls is the lack of knowledge and attitude towards anemia. And knowledge about iron nutritional anemia is very important to prevent and overcome anemia. Good knowledge about anemia can help adolescent girls choose foods with high nutrition and high iron. For now, most adolescent girls have sufficient knowledge about iron nutritional anemia, but still need to be improved. As a form of prevention and overcoming iron nutritional anemia in adolescent girls, it is necessary to improve the knowledge and attitudes of adolescent girls about anemia. As well as the consumption of iron tablets that can help prevent and overcome iron nutritional anemia in adolescent girls.

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