



Original Article

Protein Intake Influences the Incidence of Anemia in Female Students at Sidoarjo Islamic Middle School

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ABSTRACT

Anemia is a health problem that can occur in all age groups from toddlers to old age. Young women are susceptible to suffering from anemia because they experience a menstrual cycle every month. This study aims to determine the influence of age, menstrual pattern, nutritional adequacy rate (energy adequacy rate and protein adequacy rate), and nutritional status on the incidence of anemia in female students at Sidoarjo Islamic Middle School. The design of this research is observational analytic with a cross sectional approach. The population was female students at Sidoarjo Islamic Middle School with a sample size of 53 people. The independent variables in this study were age, menstrual pattern, nutritional adequacy rate (energy adequacy rate and protein adequacy rate), and nutritional status; and dependent variable is anemia. Data collection was carried out by checking Hb and Hct levels, measuring body weight and height, and filling out questionnaires. The collected data was analyzed using path analysis using smart Partial Least Square (PLS). There is a significant effect of protein adequacy on hemoglobin (Hb) levels. Female students with adequate protein intake tend to have better Hb levels, which play a role in preventing anemia. Therefore, meeting optimal protein needs is very important to support blood health and prevent health problems in female students.



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INTRODUCTION

Anemia is an indicator of poor nutrition and poor health. This is problematic in itself, but can also impact other global public health problems such as stunting and wasting, low birth weight.^{1,2} Anemia is a condition in which the number of red blood cells or the concentration of hemoglobin in them is lower than normal. Hemoglobin is needed to carry oxygen and if there are too few or abnormal red blood cells, or not enough hemoglobin, there will be a decrease in the blood's capacity to carry oxygen to the body's tissues. This causes symptoms such as fatigue, weakness, dizziness and shortness of breath. The optimal hemoglobin concentration required to meet physiological needs varies based on age, gender, altitude of residence, smoking habits and pregnancy status.^{1,3}

The prevalence of anemia in women aged 15-49 years worldwide was 29.9% in 2019.⁴ Based on Rikesdas 2018, the prevalence of anemia in teenagers is 32%, meaning that 3-4 out of 10 teenagers suffer from anemia. This is influenced by suboptimal nutritional intake habits and lack of physical activity.⁵ Based on data from the East Java Province Department of Women's Empowerment, Child Protection and Population, the number of adolescent girls who suffer from

anemia is 23 percent and 12 percent of adolescent boys.⁶ Meanwhile, in Sidoarjo, 32.9 percent of teenagers suffer from anemia.⁷

Anemia has three main causes: underproduction of red blood cells, high rates of red blood cell destruction, and blood loss.⁸ Adolescent girls and women of childbearing age suffer from anemia more easily, because: 1) Adolescent girls who enter puberty experience rapid growth so that their need for iron also increases to increase their growth; 2) Young women often follow the wrong diet aimed at losing weight, including reducing the intake of animal protein which is needed for the formation of blood hemoglobin. Insufficient energy intake plays a role in the occurrence of anemia. The main energy source is carbohydrates; and 3) Adolescent girls and women of childbearing age who menstruate will lose blood every month so they need twice as much iron during menstruation. Adolescent girls and women of childbearing age also sometimes experience menstrual disorders such as menstruation that is longer than usual or menstrual blood that comes out more than usual.^{9,10}

There has been quite a lot of research on anemia and its determinant factors. Research conducted by Kaimudin, N.Lestari, H.Afa (2017) concluded that there is a significant relationship between nutritional status and the incidence of anemia in adolescent girls, there is a significant relationship between the level of vitamin A intake and the incidence of anemia in adolescent girls, and there is significant relationship between the level of vitamin C intake and the incidence of anemia in adolescent girls.¹¹ The results of research by Isati & Hastono (2016) concluded that there was a relationship between father's occupation, frequency of eating of adolescent girls, consumption habits of iron absorption inhibitors (tea/coffee), consumption of iron absorption enhancers (Vitamin C) and the incidence of iron nutritional anemia.¹² Satriani (2018) concluded that low family income, menstrual cycle, length of menstruation, nutritional intake, and BMI are determinants or factors that influence the occurrence of anemia in students.¹³ This study examines the impact of age, menstrual pattern, nutritional adequacy rates (energy adequacy rate and protein adequacy rate), and nutritional status on the incidence of anemia, both directly and indirectly, using path analysis. The research was conducted among female students at Sidoarjo Islamic Middle School.

METHODS

This type of research is observational analytic with a cross sectional approach which is used to determine the influence of menstrual patterns and nutritional intake on the incidence of anemia in female students at Sidoarjo Islamic Middle School in March 2024. The sample in this research was female students in grade 8 of Sidoarjo Islamic Middle School who were taken using a random sampling method and met the research criteria. The research criteria are as follows: 1) Inclusion criteria: a) Ever menstruated, b) Have no history of long-standing infectious disease (≥ 2 weeks), c) Do not suffer from blood disorders (leukemia, thalassemia), d) Not suffering from a chronic disease that affects red blood cell production (chronic kidney disease), and e) Willing to be a respondent; and 2) Exclusion criteria: a) Not currently in Sidoarjo Regency at the time of research and b) Was sick at the time of conducting the research. The sample size is determined based on the formula from Slovin. Because the population is 76 female students, the minimum sample is 63.87 rounded to 64 students.

The variables in this research include the following independent variables and dependent variables: 1) Independent variable are: age, menstrual pattern, nutritional adequacy rate (energy adequacy rate and protein adequacy rate), and nutritional status; and 2) Dependent variable is anemia. The instrument used in data collection is Fora 6 Plus, which is a tool that can measure 3 parameters simultaneously in 1 peripheral blood sample, namely measuring blood sugar levels, hemoglobin levels and hematocrit levels. Apart from the For a 6 Plus, the tools used are a weight scale and a microtoa to measure body height. Nutritional adequacy rates were measured using a 24-hour food recall questionnaire. Data on menstrual patterns and age of respondents were measured using a questionnaire. The data collection procedures in this research are as follows: 1) Permit to Hall of national and political unity, Director of Poltekkes Kemenkes Surabaya, and Principal of Sidoarjo Islamic Middle School, 2) Identify the population, 3) Sample selection, 4)

Provide informed consent, 5) Measure Hb and Hct levels, 6) Identify age, menstrual patterns, nutritional intake and nutritional status, and 7) Data analysis and report creation. Data analysis uses descriptive analysis using percentages. The data was also subjected to path analysis using Partial Least Square (PLS).

RESULTS

This research was conducted at Sidoarjo Islamic Middle School on Jl. Pahlawan III Sidoarjo, Sidokumpul, Sidoarjo District. Sidoarjo Islamic Middle School was founded on January 5 1976 with proof of registration from the regional office of the East Java Province Department of Education and Culture in the field of general secondary education Number: 1231/PMU/7610/77 which has the status of a private school under the auspices of the Walisongo Nahdlatul Ulama Education Organizing Agency. Sidoarjo and has been accredited A.

Sidoarjo Islamic Middle School has a land area of 2,340 m² and a building area of 1,332 m². Located around residential areas with conducive and strategic environmental conditions. The boundaries of Sidokumpul sub-district are to the north bordering Magersari sub-district, to the east bordering Gabahan sub-district, to the west bordering Jati sub-district.

Sidoarjo Islamic Middle School has 14 classrooms used for learning facilities for grades 7, 8, and 9, 1 laboratory, 1 library, 1 school health room, 1 counseling guidance room, and 2 student sanitation rooms. The school has 28 teaching staff, including a Principal. There is 1 canteen room, and outside the school, food is sold by vendors.

Table 1. Age, menstrual patterns, energy adequacy rate, protein adequacy rate, nutritional status, and anemic incident of female students at Sidoarjo Islamic Middle School, March 2023

Characteristics	n = 53	%
Age		
14 years	36	67.92
15 years	17	32.08
Menstrual patterns		
Normal	31	58.49
Abnormal	22	41.51
Energy adequacy rate		
Mild deficit	25	47.17
In Accordance	24	45.28
More	4	7.55
Protein adequacy rate		
Moderate deficit	4	7.55
Mild deficit	6	11.32
Good	43	81.13
Nutritional status		
Thin	17	32.08
Normal	22	41.51
Fat	14	26.41
Anemic incident (Hb levels)		
Not anemic (≥ 120 mg/dl)	17	32.08
Mild anemia (110-119 mg/dl)	16	30.19
Moderate anemia (80-109 mg/dl)	17	32.08
Severe anemia (< 80 mg/dl)	3	5.66

Table 1 presents that of the 53 teenage girls, 67.92% were 14 years old and the rest were 15 years old; 58.49% had normal menstrual patterns. The energy adequacy rate is 47.17% in the mild deficit category, while the protein adequacy rate is 81.13% in the good category. The nutritional status is 41.51% in the normal category. Thirty two point zero eight percent of emale students at Sidoarjo Islamic Middle School are not anemic, the rest have anemia ranging from mild to severe.

The influence of age, menstrual pattern, nutritional adequacy rate, and nutritional status on Hb levels and Hct levels was analyzed using path analysis with the Partial Least Square (PLS)

approach. The purpose of this analysis is to examine the magnitude of the contribution of the causal relationship or influence between the variables age, menstrual pattern, nutritional adequacy rate, and nutritional status on Hb levels and Hct levels as shown by the path coefficient in the path diagram. Figure 1 shows the results of the analysis of the causal relationship between variables (initial model) and Figure 2 shows the results of the analysis of the causal relationship between variables (final model).

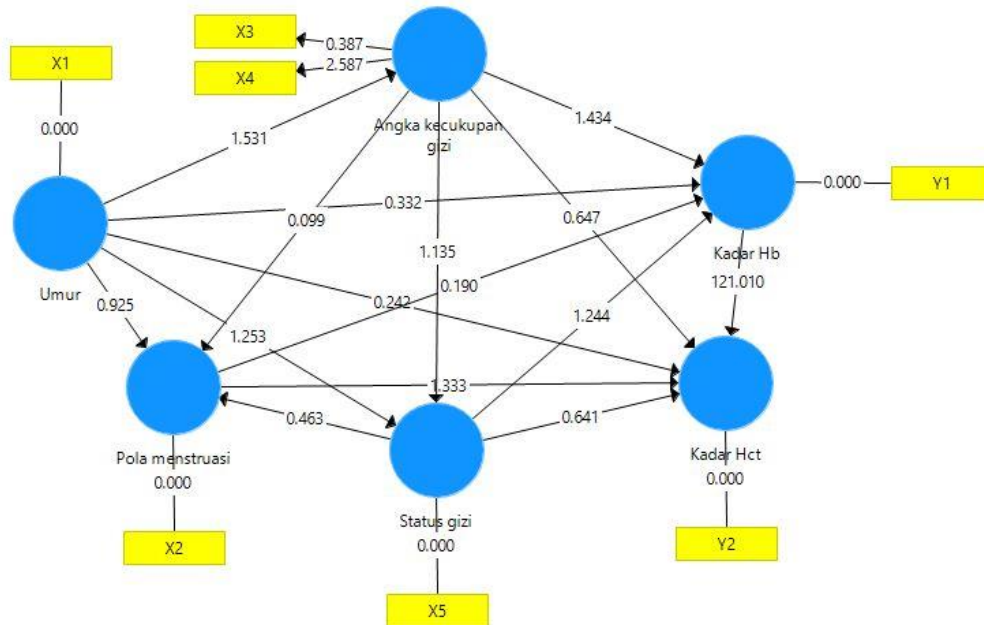


Figure 1. Initial model of the influence of age, menstrual pattern, nutritional adequacy rate, and nutritional status on Hb levels and Hct levels in female students at Sidoarjo Islamic Middle School

Figure 1 show that there is a significant influence between the variable Hb levels and Hct levels, while none of the other variables have a significant influence.

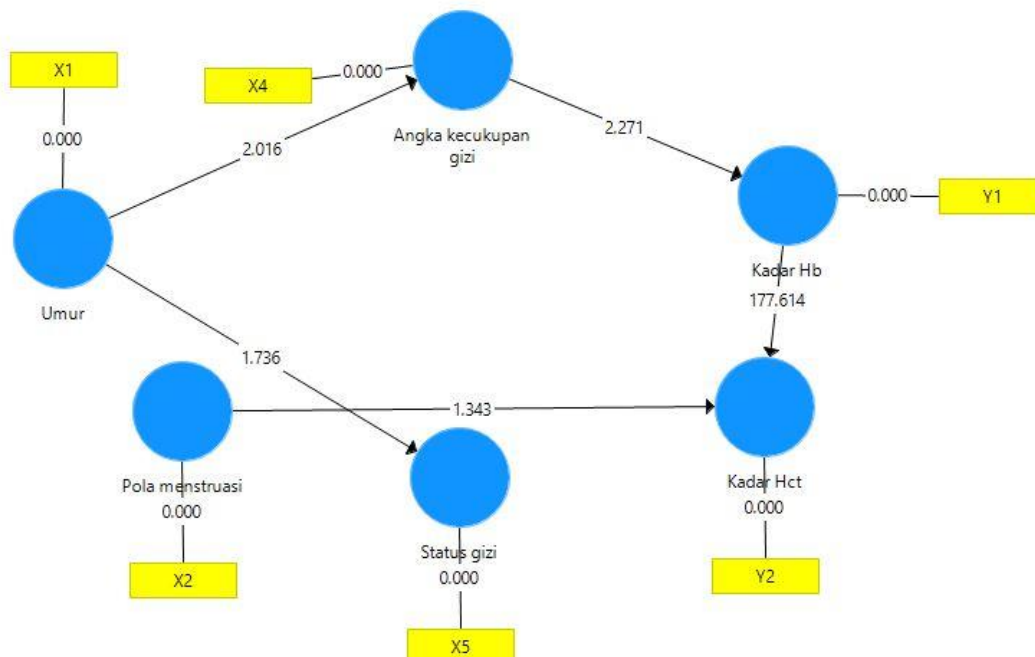


Figure 2. Final model of the influence of age, menstrual pattern, nutritional adequacy rate, and nutritional status on Hb levels and Hct levels in female students at Sidoarjo Islamic Middle School

Figure 2 show that there is a significant influence between age and nutritional adequacy rate ($t = 2.016$), between nutritional adequacy rate and Hb levels ($t = 2.271$), and between Hb levels and Hct levels ($t = 177.6140$). There is no effect significant relationship between age and nutritional status ($t = 1.736$), and between menstrual patterns and Hct levels ($t = 1.343$). Age has an effect on Hb levels which in turn affects Hct levels through nutritional adequacy rate.

DISCUSSION

The results of the study showed that 41.51% of female adolescents had abnormal menstrual patterns, in this case the amount of menstrual blood was more than usual. These results are in line with research conducted by Dineti et al. (2022) which shows that 51.67% of adolescent girls experience abnormal menstrual patterns. Abnormal menstrual patterns, in which the amount of menstrual blood is greater than normal, can cause a lack of blood volume or changes in the concentration of blood components. One of the consequences of a lot of blood coming out of menstruation is a decrease in Hb levels which is an indicator of anemia.

The normal menstrual cycle lasts 21-35 days, 2-8 days is when menstrual blood comes out, which ranges from 20-60 ml per day. Research shows that only 2/3 of adult women have normal menstrual cycles. This menstrual cycle involves the hypothalamus-pituitary-ovary complex.^{15,16}

During menstruation a woman will lose around 30 to 100 mL of blood, but there are also those who lose up to two or three times that amount but still show no clinical or laboratory signs of anemia, so it can be considered not to be a disorder or disease. However, bleeding that is too much, the bleeding period is too long, or unusual bleeding occurs should receive special attention and a gynecologist should be consulted.^{15,17}

The energy adequacy rate of female students of Sidoarjo Islamic Middle School was 47.17% in the mild deficit category, while the protein adequacy rate was 81.13% in the good category. These results indicate better nutritional adequacy rates compared to the results of research conducted by Rokhmah et al. (2017). Research by Rokhmah et al. (2017) showed results that 71% of young women had inadequate levels of energy sufficiency, and 67% showed inadequate levels of protein sufficiency. This can be caused by different environmental conditions. This research was conducted in junior high schools where students did not live in dormitories or boarding houses, while research conducted by Rokhmah et al. (2017) the respondents were high school students who lived in Islamic boarding schools. Female students who live in Islamic boarding schools will find it more difficult to get food that suits their tastes because their activity schedules are busier and access to culinary delights is more limited.

Although the results of this study show better nutritional adequacy figures compared to research conducted by Rokhmah et al. (2017), but these results are still far from ideal numbers. Efforts need to be made to increase nutritional adequacy rates for adolescent girls.

Suboptimal nutrition is associated with poor health, and increases the risk of infectious and non-communicable diseases such as cardiovascular disease (heart and blood vessel disease, hypertension and stroke), diabetes and cancer. The growth phenomenon during adolescence demands high nutritional needs in order to achieve maximum growth potential. Not meeting nutritional needs during this period can result in delayed sexual maturation and inhibition of linear growth. Especially for young women, more attention must be paid to their preparation before marriage.^{19,20}

The nutritional status of female students at Sidoarjo Islamic Middle School is 41.51% in the normal category, 32.08% in the thin category, and 26.41% in the obese category. The results of this study are almost the same as the results of research by Muhayati & Ratnawati (2019) which showed that 56.4% of young women had a normal BMI, 33% had an insufficient BMI, and 10.6% had an excess BMI. This condition, namely nutritional status that is less than half of the normal category, must receive more attention from various parties, especially schools and health agencies.

It is hoped that nutrition education, especially for teenagers who have unique characteristics, can form habits regarding the practice of fulfilling nutrition and healthy living and

then contribute to achieving ideal nutritional status. Education can be delivered through learning methods that are relevant to their age, whether through intracurricular, co-curricular or extracurricular education. Ideal nutritional status is very necessary, especially for young women who when they grow up will take on the role of mother.^{19,22}

Nutritional intake to provide balanced nutrition for the body can prevent anemia, especially for teenagers, by applying the principle of food diversity, not consuming only one type of food. If you are forced to eat instant food, it must be within appropriate limits and it is best to consult with a nutritionist or nutritionist first.

The results of the study showed that 32.08% of female students at Sidoarjo Islamic Middle School were not anemic, the rest had anemia ranging from mild to severe. The results of this study are almost the same as the results of research by Muhayati & Ratnawati (2019) which showed that 46.8% of young women were not anemic. This condition, namely the condition of anemia in young women, which is more common than those who are not anemic, needs serious attention.

Anemia can disrupt brain function in teenagers. Most studies find that anemia is associated with poor concentration and learning memory in children and adolescents. A study states that there is a decrease in IQ of 1.73 points for every 1 g/L decrease in hemoglobin. Anemia and reduced brain function are directly related to lower income in the future.^{19,23} Cases of anemia are very prominent in school children, especially adolescent girls. Adolescent girls are at high risk of suffering from anemia because during this period there is an increase in iron requirements due to growth and menstruation.²⁴

Teenage girls who menstruate will lose a lot of blood every month, this must be balanced with adequate nutritional intake. Apart from that, you should also avoid foods that inhibit iron absorption, such as tea and coffee. Young women are also advised to drink milk containing iron and consume blood supplements with a rule of 1 tablet per week.

The results of the study showed that there was a significant influence on the nutritional adequacy rate, namely the protein adequacy rate affected the Hb level. This shows that the protein adequacy rate affects the incidence of anemia. These results are in line with research conducted by Ayu et al. (2019) which shows that there is a relationship between protein intake and hemoglobin levels with the direction of the relationship between the variables being positive, namely the higher the protein intake, the higher the hemoglobin levels.

Protein is a very important nutrient for the body because apart from functioning as a source of energy in the body, it also functions as a building and regulating substance. One of the functions of protein is to help form hemoglobin, a blood component that is important for binding oxygen and distributing it to every tissue in the body. However, this function can only occur when the protein combines with heme iron. Protein also functions in transporting nutrients, such as vitamins, blood sugar, minerals, oxygen and cholesterol, throughout the bloodstream. Protein is also useful for storing nutrients, one of which is ferritin, which is a type of protein that functions to store iron needs in the body.^{35,36}

Protein plays an important role in transporting iron in the body. Lack of protein intake will result in hampered iron transport resulting in iron deficiency.²⁸ Apart from that, protein also functions to form blood plasma. The types of proteins that make up blood plasma are globulin and albumin. Blood plasma itself is a component whose job is to carry electrolytes, vitamins, glucose and amino acids throughout the body.²⁹

Iron balance is maintained by controlling the levels and function of iron transport proteins. Transferrin is the main plasma iron transporter that binds two iron molecules (Fe 3+). Transferrin is usually saturated between 20 and 30% with iron.^{30,31}

Under normal circumstances, iron in food is reduced by cytochrome B (DcytB) to iron (Fe 2+) at the apical border of duodenal enterocytes, and transported into cells via divalent metal transporter-1 (DMT1). DMT1 expression was highest in the duodenum and decreased towards the large intestine. Dietary heme iron is absorbed into enterocytes via heme carrier protein-1 or heme carrier protein-1 (HCP1). In enterocytes, heme is degraded by heme oxygenase and iron is released into the cytosol. Free iron, referred to as labile cell iron (LCI), is stored in cells by ferritin or exported to plasma by ferroportin (FPN). As enterocytes recycle every three days, the iron stored in the enterocytes is lost in the feces. This and the very small amounts of iron excreted

through bile are the only natural mechanisms for eliminating iron in humans and result in a loss of 1-2mg per day.^{30,32}

In the cytosol, labile cellular iron (LCI) binds to ferritin or is exported in the Fe 2+ state to plasma via FPN. Ferritin is a multimeric iron storage protein found in animal and plant cells as well as fungi and bacteria, and can bind approximately 4500 iron molecules. Iron is incorporated into ferritin as Fe 2+, but is rapidly oxidized to Fe 3+ within the ferritin shell by H-ferritin ferroxidase. The main function of ferritin in cells is to protect them from iron toxicity. Small amounts of ferritin are released in plasma by macrophages as L-ferritin via the lysosomal secretory pathway.^{41,44}

Transferrin (Tf) is the main iron transport protein and binds two ferric iron molecules. Transferrin-bound iron (TBI) is the main source of iron available to cells under normal conditions. Holotransferrin binds to the homologous transferrin receptors, Transferrin receptor protein 1 (TfR1) and transferrin receptor protein 2 (TfR2), and is endocytosed. In the acidic environment of lysosomes, Fe 3+ is released from transferrin (Tf), and exits the lysosomes via DMT1 into the cytosol. For transfer into the cytosol to occur, Fe 3+ must be reduced to the iron form, Fe 2+. Iron can also be transported out of endosomes via the metallic iron transporter, zinc-regulated transporters (ZRT)/iron-regulated transporter (IRT)-like protein 14 (ZIP14).^{30,34}

The proteins found in hemoglobin and myoglobin function in binding oxygen and transporting oxygen. Hemoglobin also transports H+ and CO2. Apart from carrying oxygen from the lungs to the tissues, hemoglobin also carries H+ and CO2 from the tissues to the lungs and kidneys for excretion. In cells, organic fuel is oxidized by mitochondria to form CO2, water and other substances. The formation of CO2 increases H+ levels in tissues because hydration of CO2 produces H2CO3, a weak acid which dissociates to form H+ and HCO3.^{38,44}

Adequate protein intake, which meets nutritional adequacy levels, is very necessary for young women to prevent anemia, especially iron deficiency anemia. If young women as mothers-to-be suffer from anemia, this will increase the risk of the future baby experiencing growth and development disorders, including stunting.

CONCLUSION

There is a significant effect of protein adequacy on the incidence of anemia. Adequate protein intake is an important factor in overcoming and preventing anemia. There is a need to increase knowledge about nutrition among female students at Sidoarjo Islamic Middle School and real efforts to improve nutrition for female students at Sidoarjo Islamic Middle School, for example by providing additional food. Further research needs to be carried out with a longitudinal approach to provide a more comprehensive picture of the risk factors and long-term impact of anemia in adolescent girls.

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