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# Macronutrient, nutritional status, and anemia incidence in adolescents at Islamic boarding school*

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**ABSTRACT**

***Background:*** *Anemia occurs due to the body's loss of red blood cells and decreased iron absorption. Globally, it is known that the prevalence of anemia is 1.62 billion, with the majority of anemia sufferers being a group of women who are not pregnant, as many as 468.4 million people. In addition, the highest prevalence of anemia in the group of school-age girls is 47.4%, while in men, only 12.7%.* ***Objective:*** *This study aims to determine the correlation between macronutrients and nutritional status with the anemia accident in adolescents at Islamic Boarding schools.* ***Methods:*** *This study used a case-control design with matching criteria aged 15-19 years, not menstruating, not fasting. Sampling with quota sampling of late adolescents with a population of 15-19 years 1,359 people, anemic case sample of 46 people and control without anemia 46 people, intake questionnaire using the SQ-FFQ, statistical test with Chi-Square.* ***Results:*** *There was a significant relationship between macronutrient intake [energy p=0.048; OR=3.3 (CI 0.965-11.28), protein p=0.036; OR=3.98 (CI 1.018-15.57)] and nutritional status [p=0.024; OR=5.35 (CI 1.088-26.32)] with anemia incidence. Less energy intake has a risk of 3.3 times anemia, lack of protein intake has a risk of 3.98 times, and malnutrition has a risk of anemia of 5.35 times.* ***Conclusions:*** *There was a significant correlation between energy, protein intake, and nutritional status with anemia incidents. Nutritional status has the strongest association with anemia.*

**KEYWORDS:** *anemia; energy intake; nutritional status; protein intake*

## INTRODUCTION

Anemia is a health problem causes chronic illnes that has a major impact on health, economy, and social. According to World Health Organization (WHO) 2013, the prevalence of anemia in the world is 40-88% with the highest incidence of anemia in adolescent girls, especially in developing countries at 53.7% [1]. Based on to Indonesian Ministry of Health 2018, the prevalence of anemia in Indonesia is 48.9% in pregnant women and 84.6% in pregnant women aged 15-24 years, adolescents are the age with the most anemia. Anemia is a less of hemoglobin levels, erythrocyte, and hematocrit counts so that the number of erythrocytes and / or circulating hemoglobin levels cannot fulfill their function of delivered oxygen to body tissues [2]. Anemia is characterized by hemoglobin levels less than 13.5 g/dl in adult men and less than 11.5 g/dl in adult women [3].

According to WHO, 40% maternal mortality in developing countries associated with anemia in pregnancy and most of due to iron deficiency. Previous research, result that childbirth in pregnant women who suffer from anemia iron deficiency is found 12-28%

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fetal death, 30% perinatal mortality, and 7-10% neonatal mortality rate [3]. In pregnancy, anemia occurs relatively because the blood of pregnant woman is hemodiluted with an increase volume 30-40% which peaks with age gestation 32-34 weeks. Increases the number of red blood cells 18-30%, haemoglobin about 19%. If the mothers haemoglobin befor pregnancy is around 11%, the occurrence of hemodilution will result physiological pregnant anemia, and maternal haemoglobin at risk decreased to 9,5-10%. After childbirth, the placenta is detached and the mother is at risk of experiencing iron loss of about 900 mg. During breastfeeding, mothers still need optimal physical health in order to prepare breast milk for the growth and development of their babies. In anemia, breastfeeding may not be possible well executed [4].

Anemia occurs due to several factors including bleeding from an accident or menstruation, worms or infections disease, and lack of nutrient intake, especially iron and other substances that can increase absorption of iron such as vitamin C and protein. Lack of this nutrient can increase risk of anemia. Anemia caused by malnutrition usually experienced by young women who influenced by the availability of food and the food habbit [5]. Adolescents tend to want an ideal body shape while less nutritional knowledge. They deliberately reduce food intake till less than needed [6]. Anemia due to lack of nutrient intake is characterized by hemoglobin synthesis disorder. The nutrients concerned are protein, pyridoxine (vitamin B6) which has a role as a catalyst in the synthesis of heme in the hemoglobin molecule, besides iron (Fe) is also a one of the nutritional components in the formation of haemoglobin [7].

Pondok Modern Darussalam Gontor Campus 1 is a large Islamic Boarding School in the city of Ngawi which uses a boarding school system so that it has food management to meet the nutritional needs of students. Every day, the kitchen prepares 3 meals with a system of taking staple foods and vegetables that the students can take themselves and the side dishes are proportioned by the kitchen staff. The santri snack can be obtained from buying in canteens and supermarkets in boarding school. This is related to the diet, portion and nutritional adequacy of the santri which affect the health status of the santri. Research related to nutrition in Islamic Boarding School has been widely carried out, but those specifically assessing nutrient intake and nutritional status associated with anemia are still rare.

## METHOD

### Study design and participants

This type of research is analytic observational with a case-control research design. This research was conducted at Pondok Modern Darussalam Gontor Campus 1 from March to October 2020. The population in this study were all female adolescents 15-18 years, totaling 1359 people. The calculation of the sample size was used hypothesis test for an odds ratio with the formula: $P_1$ = probability of case group (0,70); $P_2$ = probability of control group (0,40); $Z_{1-\alpha}$ = level of signifiance (95%); and $Z_{1-\beta}$ = power of signifiance (80%); 95% significance level and 80% power [8]. Based on this formulas, obtained a total sample of 84 people with the case group 42 people and the control group was 42 people. To anticipate drop out, add 10% to 46 people in each group. The sampling technique was quota sampling who met the inclusion criteria [9]. Inclusion criteria was 15-18 years of age, already menstruating, not menstruating, no pain, and not fasting when checking hemoglobin, do not have a history of blood disorders, do not have a history of malaria, worms and diabetes, are willing to be respondents and follow the research until it is finished. This research has graduated from the Ethics Commission for public health research with number of ethics 2930 / B.2 / KEPK-FKUMS / III / 2020 which was endorsed by the Muhammadiyah University Surakarta.

### Measures

The variables examined in this study were protein intake, energy intake, nutritional status, and anemia status. The tools used are weight measurement with digital scales with the CAMRY mode brand: EB9003, height measurement using a microtoice. Hb measurement using the easytouch GCHB type ET-321 made in Taiwan, blood lancet, test chip, pen lancing device, alcohol swab, and hemoglobin strips. Before taking data, the researcher

carried out permission to take secondary data at the female Gontor 1 data center, then sorted secondary data for students aged 15-18 years, then carried out weight measurements, Hb checks, and SQ-FFQ data on students, then processed data according to the inclusion criteria.

*Nutritional status*. The category of nutritional status based on body mass index for age (BMI / U) refers to the z-score set by the Indonesian Ministry of Health [10]. The nutritional status category based on the z-score consists of malnutrition (-3 SD to ≤-2 SD), normal (-2 SD to ≤1 SD), overweight (1 SD to ≤2 SD), and obesity (> 2 SD) [11]. Blood pressure variables, both systolic and diastolic, were classified into hypotension (<90/60 mm Hg), normal (90 / 60-119 / 79 mm Hg), prehypertension (120 / 80-139 / 89 mm Hg), and hypertension (≥140 / 90 mm Hg) [12].

*Anemia*. Hb levels as an indicator of anemia were categorized into non-anemia (≥12 g/dL), mild anemia (11-11.9 mg/dL), moderate anemia (8-10.9 mg/dL), and severe anemia (<8 g/dL) [13]. The Hb measuring instrument used was the Easy Touch GCHb type ET-321 made in Taiwan, blood lancet, test chip, pen lancing device, alcohol swab, and hemoglobin strips. The procedure for using it, the fingertip to be shot with the needle is cleaned with an alcohol swab, the needle is shot and pressed so that blood comes out. The blood is touched on the side edge of the strip then after the blood has soaked up to the end of the strip and there is a beep sound, the results can be seen for a few seconds on the screen.

*Macronutrient*. Energy and nutrient intake data were assessed using a semi quantitative food frequency questionnaire (SQ-FFQ) for the last 3 months during the intervention period. The nutrients assessed are protein. The level of energy and nutrient adequacy is calculated by comparing the intake data with the 2019 nutritional adequacy rate [14].

### Data analysis

To analyze the relationship between macronutrient (energy and protein) intake and nutritional status with the incidence of anemia in female students, it was used Chi-Square statistical test and used SPSS 16 program.

## RESULTS

Pondok Modern Darussalam Gontor Campus 1 is one of the schools with a boarding system, this boarding school located in the Mantingan area, more precisely located in the Sambirejo Mantingan Ngawi area, which has a land area of 25 hectares $m^2$. Modern Darussalam Gontor for girls 1st is one of the schools that is quite well known among the community, Modern Darussalam Gontor for girls 1st has 29 buildings, while for classes there are 10 buildings [15]. The number of santri aged 15-18 years is 1,359 people, for the intake of respondents has been provided by the kitchen section with a menu cycle of 7 days, the activities carried out by the respondents are school until noon. The subjects in this study were 92 late adolescents aged 15-18 years old who lived in Islamic boarding schools. Mean of haemoglobin in the case group was 13.99±1.28 g/dl with min, max was 12.2 g/dl and 17 g/dl, whereas mean of haemoglobin in the control group was 11.05±0.98 g/dl with min, max was 8.1 g/dl, 12 g/dl.

According to **Table 1,** it can be seen that the majority of students were 16 years old (47.8%); who have normal nutritional status was 71.7% in anemia group

**Table 1. Characteristic of student age 15-18 years old**

| Variable | Anemia (n=46) | | Non anemia (n=46) | |
|---|---|---|---|---|
| | n | % | n | % |
| Age (years) | | | | |
| 15th | 1 | 2.2 | 1 | 2.2 |
| 16th | 22 | 47.8 | 22 | 47.8 |
| 17th | 17 | 37 | 17 | 37 |
| 18th | 6 | 13 | 6 | 13 |
| Nutritional status | | | | |
| Malnutrition | 9 | 28.3 | 2 | 10.9 |
| Normal | 37 | 71.7 | 44 | 89.1 |
| Diastole | | | | |
| Abnormal | 34 | 73.9 | 37 | 80.4 |
| Normal | 12 | 26.1 | 9 | 19.6 |
| Systole | | | | |
| Abnormal | 41 | 89.1 | 43 | 93.5 |
| Normal | 5 | 10.9 | 3 | 6.5 |
| Energy intake | | | | |
| Less | 42 | 91.3 | 35 | 76.1 |
| Enough | 4 | 8.7 | 11 | 23.9 |
| Protein intake | | | | |
| Less | 43 | 93.5 | 36 | 78.3 |
| Enough | 3 | 6.5 | 10 | 21.7 |

**Table 2. Correlation between macronutrient and nutritional status with anemia**

| Variabel | Anemia | | Non anemia | | OR (95% CI) | *p-value* |
|---|---|---|---|---|---|---|
| | n | % | n | % | | |
| Energi | | | | | | |
| Less | 42 | 91.3 | 35 | 76.1 | 3.30 (0.965 – 11.28) | 0.048 |
| Enough | 4 | 8.7 | 11 | 23.9 | | |
| Protein | | | | | | |
| Less | 43 | 93.5 | 36 | 78.3 | 3.98 (1.018 – 15.57) | 0.036 |
| Enough | 3 | 6.5 | 10 | 21.7 | | |
| Nutritional status | | | | | | |
| Underweight | 9 | 28.3 | 2 | 10.9 | 5.35 (1.088 – 26.32) | 0.024 |
| Normal | 37 | 71.7 | 44 | 89.1 | | |

and 89.1% in non anemia group; abnormal diastole was 73.9% in anemia group and 80.4% in non anemia group; have normal tidal systole was 89.1% in anemia group and 93.5% in non anemia group, Majority of energy and protein intake of female students was inadequate. According to **Table 2** it can be seen that there was a significant relationship between macronutrient intake (energy and protein) and nutritional status with the incidence of anemia in adolescents ($p$= 0.048, $p$= 0.036, $p$= 0.024).

## DISCUSSION

There is a significant relationship between energy and the incidence of anemia in the pesantren ($p$=0.048; OR=3.3; CI 0.96 – 11.28). If it is adjusted to the energy needs according to the recommended dietary allowances (RDA), the energy intake of the students is less than the need due to several factors, including the respondents often skip the meal schedule because the food menu is not in accordance with the respondent's taste and is accompanied by the activities of the students who are so dense that the energy intake is not in accordance with their supposed needs. The OR value shows that respondents with energy intake less than their needs are 8 times more at risk of anemia than respondents with sufficient energy intake. The results of this study are in line with Agustina's research, which states that there was a significant correlation between energy adequacy and anemia ($p$= 0.047) due to the habit of adolescents skipping breakfast [16]. In the Aritonang and Albiner study, also stated that there was a significant relationship between energy intake and the incidence of anemia ($p$<0.005) and 65.4% of respondents have adequate energy intake [17].

Energy intake is very important for adolescents for growth, either. Energy is formed from macronutrients and micronutrients. Both are very important for adolescent growth because with the balance of substances consumed by adolescents, adolescents will get enough energy for everyday life. An unbalanced energy intake can lead to obesity or thinness because in malnutrition, you are more at risk of developing anemia [18]. Sugar, especially fructose and sorbitol is one of the nutrients that can increase iron absorption. Fructose and sorbitol function as ligands so that they can prevent the binding of non-heme iron to the inhibitory component and increase its availability [19]. Intake of complex carbohydrates has been reported to enhance the bioavailability of iron. Consumption of iron supplements together with galactooligosaccharides (GOS) can increase the diffusion solubility of ferrous fumarate. The absorption of iron in women who were given ferrous fumarate and GOS supplements was higher than those who were only given iron supplements. Consumption of GOS can reduce serum ferritin so that it can increase iron bioavailability [20]. In contrast to carbohydrate consumption, a high-fat diet is thought to increase the risk of anemia due to the breakdown of red blood cells. In non-HDL cholesterol can cause hemolysis in erythrocytes, while an increase in HDL can increase the size and number of erythrocytes and platelets [21].

In the protein variable, it was also found that there was a significant relationship between protein intake and the incidence of anemia in adolescents ($p$=0.036;

OR=3,98; CI 1,018 – 15,57). The protein intake of respondent's was low and less than the RDA requirement. According to the results of the interview, this was due to the fact that the menu available in the dormitory was more vegetable protein than animal protein. The OR value shows that respondents with less protein intake are 6 times more risk to have anemia than respondents with sufficient protein intake. This study was also in line with Sholihah's research, which said that there was a significant relationship between protein and the incidence of anemia in adolescents ($p$=0.001; OR=30.333; CI 3.433-26.7988), as evidenced by the level of protein consumption of adolescents who are not anemia higher than adolescents with anemia [22]. Protein plays an important role in adolescence because in adolescence the need for protein increases for a faster growth process [23].

One of the nutrients that has an important role is protein. Protein is useful as a building and regulatory agent, besides protein also regulates human health by providing molecular precursors of amino acids and also functions as a component in body cells, protein also has a role in the transportation of iron to the spinal cord for the formation of red blood cells. Protein intake, especially animal protein helps increase iron absorption, therefore low protein intake can affect Hb levels to be less, so it can lead to anemia [24].

The nutritional status variable also showed that there was a significant relationship between nutritional status and the incidence of anemia in Islamic boarding schools ($p$<0.000; OR=5.35; CI 1,088 – 26,32). Even though most respondents have normal nutritional status, respondents are still at risk of developing anemia because the intake they consume has not met their needs according to the RDA, especially for protein, energy, and iron. The result showed that respondents with malnutrition status are 1.1 times more at risk of anemia than respondents with normal nutritional status.

Angraini and Sofwan's research stated that there was a significant relationship between chronic energy deficiency and the incidence of anemia in adolescents ($p$= 0.020), respondents in this study met nutritional intake standards, had sufficient and even high energy or macronutrient intake, foods that are consumed contain more carbohydrates and fats, but, 95.6% of responden had a low iron intake. This condition perhaps cause of risk of anemia, especially iron-deficiency anemia [25].

This result of this study is different from research conducted by Gasong. According to Gasong research, said that there was no significant relationship between nutritional status and the incidence of anemia among adolescent girls in Kupang ($p$=0.004). The results showed a correlation between nutritional status and the occurrence of weak and insignificant anemia. The correlation test results showed a relationship (2-tailed) between nutritional status and anemia incidence of 0.916 (>0.05), meaning that there was no significant relationship between nutritional status variables with the incidence of anemia [26]. The results of this study are different from research conducted by Jho which said that there was no significant relationship between nutritional status and the incidence of anemia in adolescents who are in dormitories ($p$=0.205), because the intake consumed by students in the dormitory has met the appropriate needs with RDA [27]. The condition in the research conducted by Jho was different from this study, because food management system in this study was taken food by student themself. This cause different of intake every person. In the Indartanti study, said that there was no significant relationship between nutritional status and the incidence of anemia in adolescent girls ($p$=0.289), because most of the subjects had normal nutritional status with adequate intake of macro nutrient [28].

It is hoped that this research can provide knowledge about anemia and anemia prevention, so that young women can be motivated to change their lifestyle and eating habits as well as increase the awareness of young women about health and the future. As with other case control studies, this research also has a hemoglobin check that does not use laboratory checks with ferritin checking. Checking hemoglobin using a ferritin check will have more accurate results. This research has advantages in the questionnaire used, namely the SQ-FFQ questionnaire, the SQ-FFQ questionnaire is a questionnaire that can be used as daily intake data and can also be used as dietary data. It is hoped that the next researchers will add several other factors related to the incidence of anemia. Relevant institutions are expected to pay more attention to the intake of students by moving the part in charge of the

dormitory to monitor their schedules, and provide a more diverse menu so that the protein obtained is not only more vegetable protein but balanced with animal protein intake. Attention is given so that the anemia group is reduced and even there is no anemia group.

## CONCLUSIONS

There was significant correlation energy, protein intake, and nutritional status with anemia incidents. Nutritional status has a strongest association with anemia (OR=5,35).

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*Declaration of conflicting interests*

The authors declare that they have no competing interests.

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