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# Dietary patterns and menstrual cycle: incidence of anemia in female adolescents in Bondowoso Regency

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**ABSTRACT**

**Background**: Anemia is one of the three significant nutritional burdens being addressed in Indonesia. The risk of anemia in female adolescents is ten times higher than in male adolescents because female adolescents are menstruating. Most causes of anemia include protein, iron, and vitamin C deficiencies, as well as irregular menstrual cycles.

**Objective**: This study aims to analyze the correlation between dietary patterns, the menstrual cycle, and the incidence of anemia among female adolescents at Bondowoso Vocational High School 1.

**Materials and Methods**: This study used a cross-sectional design with a sample of 116 female adolescents aged 15–18 at Bondowoso Vocational High School 1, selected through simple random sampling. Interviews were conducted with respondents who completed observation sheets on their menstrual cycles and diets using the SQ-FFQ form. Hemoglobin levels were measured using a digital hemoglobin check tool, and researchers collaborated with healthcare professionals authorized to perform hemoglobin level tests. The analyses used were univariate and bivariate, with the chi-square test and Fisher's Exact test.

**Results**: The study showed that protein intake was insufficient (78.4%), while iron intake (74.1%) and vitamin C intake (71.6%) were sufficient. And there was no correlation between protein intake and the incidence of anemia (OR = 1.855 (CI 95% = 0.772 – 4.452; p-value 0.443). The menstrual cycle and anemia showed a significant correlation (OR = 2.489 (CI 95% = 1.053 – 5.883; p-value 0.035). Iron intake and anemia showed a significant correlation (OR = 2.888 (CI 95% = 1.204 – 6.923; p-value 0.015), and vitamin C intake also showed a correlation with anemia ( OR = 2.807 (CI 95% = 1.193 – 6.603; p-value 0.016).

**Conclusion**: Iron intake, vitamin C, and the menstrual cycle are related to the incidence of anemia. Monitoring and evaluation of regular iron and folic acid supplementation, emphasizing socialization about the "Aksi Bergizi Program" nutrition action programs through balanced nutrition, and building social support schemes for reproductive health among female adolescents are necessary.

***Keywords***: *Anemia; dietary habit; female adolescent; menstrual cycle*

## BACKGROUND

Anemia is one of the three significant nutritional burdens addressed in Indonesia: anemia, malnutrition, and obesity.[1] Anemia is a condition characterized by low hemoglobin (Hb) levels and red blood cell counts relative to normal values, typically defined as ≤12 g/dl in women.[2] World Health Organization (WHO) data for 2021 showed that anemia in women aged 15 to 49 reached 29.9%. The Global Burden of Disease report stated that 25% of the world's population is affected by anemia, which accounted for over 2 billion cases in 2023. The report of the World Health Organization in 2023 showed that 30% of women of reproductive age, 15-49 years, have anemia, and adolescent females are at a higher risk of anemia, specifically in low and middle-income countries.[3] Another study on adolescent health and well-being indicators across 195 countries and territories reported that the prevalence of anemia among adolescent females was 40% in multiburden countries, representing 188 million people out of 467 million.[4] The risk of anemia in female adolescents is ten times higher than in adolescent boys because female adolescents experience menstruation.[5]

Adolescence is a golden period of optimal growth and development, during which adolescents have essential physical and psychological needs. Female adolescents undergo physiological and psychological growth that forms the foundation for adulthood, particularly biological well-being during their reproductive years.[6] Furthermore, if malnutrition occurs, such as anemia, in this phase of female adolescence, it can affect almost the entire life cycle of the female adolescent in childbearing age, pregnancy, and children, specifically in developing countries.[7] Anemia can affect adolescents' immunity and concentration, leading to dizziness, fatigue, and difficulty breathing, which may affect school performance and social-emotional development. Anemia negatively impacts the educational and economic well-being of adolescents and is associated with the

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cause of disability adjusted life years among adolescents.[8] The long-term impact of anemia can include the risk of maternal death due to bleeding during childbirth, premature birth, and low birth weight (LBW).[9]

Several factors cause anemia in female adolescents, such as inadequate diet leading to an insufficient intake of nutrients, irregular menstrual cycles, lack of consumption of ferrous iron and folic acid supplement tablets, and bleeding.[10] The most common causes of anemia are nutrient deficiencies, such as protein, iron, and vitamin C. Iron plays a role in the formation of hemoglobin, and protein helps distribute iron during hemoglobin formation. Consuming vitamin C can accelerate iron absorption.[11,12] A study of female adolescents using the Diet Quality Index for Adolescents found that higher food quality and quantity can elevate hemoglobin levels. Changes influence the quality and quantity of food consumed in eating behavior.[13] Previous research has shown that the percentage of unhealthy eating behaviors among female adolescents is higher than among boys. This is related to female adolescents who feel they will gain weight easily, leading them to engage in inappropriate diets, such as restricting their food intake without considering their body's needs.[14] Changes in eating behavior in adolescents are influenced by both external and internal factors. External factors include the size and characteristics of family members, peers, and the mass media, as well as individual knowledge and experience. Internal factors include physiological needs, body image, self-concept, individual values and beliefs, food selection and meaning, psychosocial factors, and health.[15]

Other factors that cause anemia, namely a short menstrual cycle and a relatively long menstrual period, will result in more blood loss, increasing the risk of experiencing anemia. Anemia occurs during menstruation when there is heavy bleeding and prolonged frequency, resulting in blood loss and a reduction in hemoglobin. Previous research in female adolescents showed that the highest incidence of anemia occurs during menstruation. Previous research has shown that irregular menstruation and long cycles increase the risk of anemia, as menstruation results in 50–80cc of blood loss and 30–40 mg of iron loss.[16] A normal menstrual cycle is in the range of 21 – 35 days; outside this range, it is classified as having a menstrual cycle disorder.[17] Menstrual cycle disorders are common in adolescents due to hormonal instability, and they can impact the levels of hemoglobin.[18,19]

The incidence of anemia among female adolescents in urban areas is quite high, at 67.8%. The high prevalence of anemia in urban areas is a result of changes in consumption behavior due to easy access to food, the influence of social media, and socio-cultural factors. However, this is not accompanied by a corresponding increase in the quality and quantity of nutritious food.[20,21] According to the 2018 Riset Kesehatan Dasar Indonesia, the prevalence of anemia among female adolescents aged 15 to 24 years was 32%. Data from the East Java Provincial Health Service in 2020 showed that the prevalence of anemia among female adolescents was 42%.[22] Bondowoso District Health Service screening results in 2023 showed that 46.3% of female adolescents had anemia. According to the screening results, anemia among female adolescents in the Kademangan Community Health Center area was 40.5%. Among female adolescents in Senior High Schools, the rate was 35.61% (292 female students); in Junior High Schools, it was 51.5% (130 female students).[23] Anemia screening in 2024 showed that Bondowoso Vocational High School 1 had the highest case rate among schools in the Kademangan region, affecting 13% of 204 female students. Although Bondowoso Vocational High School 1 shows a lower percentage than other schools, its large population makes it a critical target for intervention. Most existing research on anemia in female adolescents has focused on general prevalence, with limited exploration into the interaction between nutritional factors and menstrual health in a specific educational setting. Therefore, this study aims to analyze the correlation between dietary patterns, the menstrual cycle, and the incidence of anemia among female adolescents at Bondowoso Vocational High School 1.

## MATERIALS AND METHODS

A cross-sectional study was conducted at Bondowoso Vocational High School 1 from March to June 2024. The population of this study was 578 female students from classes 10, 11, and 12. Sample size was calculated using a statistical power analysis program (Sample Size), with a chi-square ($\chi 2$) test, 95% confidence level, 5% margin of error. The minimal sample size was 104; the final sample was 116 female adolescents, taking into account the drop-out response among respondents. A sample of 116 respondents covering grades 10, 11, and 12 was obtained using simple random sampling techniques. The sample was selected by fulfilling the inclusion criteria: being 15-18 years old, not menstruating at the time of the research data collection, present when the research was conducted, and willing to be a respondent with the approval of informed consent and signed by respondents and teachers before the beginning of the research process.

Respondents with a history of blood transfusion, currently being treated for anemia, worms, and thalasemia were excluded.

We collected data on dietary patterns, menstrual cycles, and anemia from respondents. Data were collected through primary methods, including interviews and observations. Dietary patterns data on the frequency of food intake, protein, vitamin C, and iron intake were collected using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) for the last month. The SQ FFQ form included lists of 38 sources of protein and iron (including iron and folic acid supplements) and 50 sources of vitamin C (including vitamin C supplements). The SQ FFQ form was based on the Indonesian Food Composition Table 2017. It was modified through market surveys to be appropriate for the target population of female adolescents in the Bondowoso region. Respondents then selected one of the appropriate consumption-frequency options: never, twice a month, once or twice a week, three to six times a week, once a day, or more than once a day. Respondents also reported their usual portion size for each food item, either in household measurements or as the amount consumed per meal. The researcher then converted the data to weight (grams) and used SPSS to calculate the estimated intake of protein, iron, and vitamin C. The frequency of food ingredient data from the SQ-FFQ was categorized into three types: frequently (1x/day, >1x/day, 3-6x/week), rarely (1-2x/month, 2x/month), and never. The protein intake data from the SQ-FFQ were categorized into three types: high (>110% of the Recommended Dietary Allowance), normal (90-110% of the Recommended Dietary Allowance), and low (<90% of the Recommended Dietary Allowance). The vitamin C and iron intake data from the SQ-FFQ were categorized as adequate (>77% of the Recommended Dietary Allowance) or inadequate (<77% of the Recommended Dietary Allowance).[24]

Menstrual cycles of respondents were measured through interviews and a menstrual cycle observation sheet for the previous three months, as well as a menstrual calendar application (Flo). The researcher asked the respondents their names, ages, and classes. The researcher conducted interviews with the respondents, asking whether menstruation was regular in the last three months, how many times they menstruated in one month, how many days menstruation lasted in one cycle, and the menstrual cycle length during the last three months. In addition, the researcher asked them to show them the menstrual calendar (Flo) app they used to track their menstrual cycles. The researcher then observed the respondents' menstrual cycles over the past three months, recorded them on an observation sheet, and calculated the average menstrual cycle length. The menstrual cycle was categorized into two types: regular menstrual cycle (the average menstrual cycle length over 3 months was 21-35 days) and irregular menstrual cycle (the average menstrual cycle length over 3 months was <21 days or >35 days).[25] Anemia was determined by measuring respondents' hemoglobin levels using a digital hemoglobin meter (Easy Touch) and classifying them into two categories: normal (hemoglobin levels ≥12 g/dl) and anemia (hemoglobin levels <12 g/dl).[26] Researchers were assisted by health workers from the Kademangan Public Health Center.

The analyses used are univariate and bivariate. Univariate analysis aims to describe the characteristics of each variable. Bivariate analysis was performed using the chi-square test in SPSS. If the chi-square test was not met, Fisher's Exact Test was used. If the p-value is <α (0.005), then there is a significant correlation between the independent variables (dietary patterns, menstrual cycle) and the dependent variables (anemia). This research has been ethically approved by the Health Research Ethics Commission, Faculty of Dentistry, Jember University, under No. 2452/UN25.8/KKEPK/DL/2024.

## RESULTS

Table 1 shows the characteristics of female adolescents in this study. Most respondents were 16 years old (45.7%), and the largest class was 10th grade (49.1%). The majority of respondents were normal or not anemic (70.7%), and their hemoglobin levels were greater than 12 g/dl.

**Table 1. Characteristics of Female Adolescents at Bondowoso Vocational High School 1**

| Individual Characteristics | n | Percentage (%) |
|---|---|---|
| **Age (years)** | | |
| 15 | 2 | 1.7 |
| 16 | 53 | 45.7 |
| 17 | 29 | 25.0 |
| 18 | 32 | 27.6 |
| **Class** | | |
| Class 10 | 57 | 49.1 |
| Class 11 | 29 | 25.0 |
| Class 12 | 30 | 25.9 |
| **Incidence of anemia** | | |
| Anemia | 34 | 29.3 |
| Normal | 82 | 70.7 |

Table 2 shows the most frequently consumed protein and iron sources: tempeh (89.7%) and tofu (87.1%). Respondents also consume foods high in protein and iron, such as chicken liver, chicken intestines, and shrimp. The vitamin C-rich foods most commonly consumed by respondents were spinach (49.1%) and kale (40.5%). Respondents also consumed foods high in vitamin C, namely katuk leaves, cassava leaves, and green mustard greens.

**Table 2. Frequency of Food Ingredients**

| Variable | Often | | Seldom | | Never | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| **Source of Protein and Iron** | | | | | | |
| Tempeh | 104 | 89.7 | 10 | 8.6 | 2 | 1.7 |
| Tofu | 101 | 87.1 | 11 | 9.5 | 4 | 3.4 |
| Chicken's liver | 5 | 4.3 | 47 | 40.5 | 64 | 55.2 |
| Beef floss | 5 | 4.3 | 42 | 36.2 | 69 | 59.5 |
| Shrimp | 12 | 10.3 | 52 | 44.8 | 52 | 44.8 |
| **Source of Vitamin C** | | | | | | |
| Spinach | 57 | 49.1 | 37 | 31.9 | 22 | 19.0 |
| Swamb cabbage | 47 | 40.5 | 56 | 48.3 | 13 | 11.2 |
| Katuk leaves | 7 | 6.0 | 12 | 10.3 | 97 | 83.6 |
| Cassava leaves | 7 | 6.0 | 40 | 34.5 | 69 | 59.5 |
| Mustard greens | 21 | 18.1 | 50 | 43.1 | 45 | 38.8 |

In Table 3, most respondents have a poor protein intake (78.4%), with an average protein adequacy of 63.96% of the Recommended Dietary Allowance.

**Table 3. Distribution of Protein Intake**

| Protein Intake | n | Percentage (%) | Mean(%) | Median(%) | Minimum(%) | Maximum(%) |
|---|---|---|---|---|---|---|
| Low | 91 | 78.4 | | | | |
| Normal | 15 | 12.9 | 63.96 | 56.15 | 23.2 | 189.6 |
| High | 10 | 8.6 | | | | |

Table 4 shows that most respondents have adequate iron (74.1%) and vitamin C (71.6%), with the average percentage of iron adequacy being 121.677% of the Recommended Dietary Allowance and the average percentage of vitamin C adequacy being 109.248% of the Recommended Dietary Allowance.

**Table 4. Distribution of Iron and Vitamin C Intake**

| Nutrient Intake | Inadequate | | Adequate | | Mean(%) | Median(%) | Minimum(%) | Maximum(%) |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | | | | |
| Iron | 30 | 25.9 | 86 | 74.1 | 121.677 | 119.762 | 37.3 | 380.9 |
| Vitamin C | 33 | 28.4 | 83 | 71.6 | 109.248 | 97.187 | 2.3 | 380.2 |

Table 5 shows that the average menstrual cycle of respondents over the last three months was classified as normal (72.4%). The average menstrual cycle length among respondents is 29.5 days, with the shortest cycle being 14.5 days and the longest 41 days.

**Table 5. Distribution of Menstrual Cycles**

| Menstrual Cycle | n | Percentage (%) | Mean(days) | Median(days) | Minimum(days) | Maximum(days) |
|---|---|---|---|---|---|---|
| Irregular | 32 | 27.6 | 29.586 | 30.5 | 14.5 | 41.0 |
| Regular | 84 | 72.4 | | | | |

The research results in Table 6 show an analysis of the correlation between protein intake and anemia and obtained an expected count of less than 5 (33.3%), so the Fisher's Exact Test was carried out and showed a p-value of 0.443, which means there is no correlation between protein intake and the incidence of anemia and obtained OR = 1.855 (CI 95% = 0.772 – 4.452). Analysis of the correlation between iron intake and anemia in female adolescents at Bondowoso Vocational High School 1 showed a p-value of 0.015 ($p < 0.05$), indicating a significant correlation between iron intake and the incidence of anemia, with OR = 2.888 (95% CI = 1.204 – 6.923). The results of the analysis of the correlation between vitamin C intake and the incidence of anemia in female adolescents at Bondowoso Vocational High School 1 showed that the chi-square test showed a p-value of 0.016 ( $p < 0.05$), which means that there was a correlation between vitamin C intake and the incidence of anemia with an OR value = 2.807 ( 95% CI = 1.193 – 6.603). And the analysis of the correlation between the menstrual cycle and the incidence of anemia. The results of the chi-square test showed a p-value of 0.035, indicating a correlation between the menstrual cycle and the incidence of anemia in female adolescents at Bondowoso Vocational High School 1, with an OR = 2.489 (95% CI = 1.053–5.883).

**Table 6. Correlation between protein, iron, vitamin C intake, and menstrual cycle with anemia**

| Variable | | Anemic Status | | | | *p-value* | OR CI 95% |
|---|---|---|---|---|---|---|---|
| | | Anemia | | Not Anemic | | | |
| | | n | % | n | % | | |
| **Nutrient intake** | | | | | | | |
| Proteins | Low | 31 | 26.7 | 67 | 57.8 | Ref | 1.855 (0.772 - 4.452) |
| | Normal | 2 | 1.7 | 6 | 5.2 | 0.443 | |
| | High | 1 | 0.9 | 9 | 7.8 | | |
| Iron | Inadequate | 14 | 12.1 | 16 | 13.8 | Ref | 2.888 (1.204- 6.923) |
| | Adequate | 20 | 17.2 | 66 | 56.9 | 0.015 | |
| Vitamin C | Inadequate | 15 | 12.9 | 18 | 15.5 | Ref | 2.807 (1.193-6.603) |
| | Adequate | 19 | 16.4 | 64 | 55.2 | 0.016 | |
| **Menstrual cycle** | | | | | | | |
| Menstrual cycle | Irregular | 14 | 12.1 | 18 | 15.5 | Ref | 2.489 (1.053-5.883) |
| | Regular | 20 | 17.2 | 64 | 55.2 | 0.035 | |

## DISCUSSION

Adolescents were individuals aged 10 to 19 years, according to the World Health Organization's definition.[27] Adolescence is a transition from childhood to adulthood that entails specific nutritional needs and is the most vulnerable phase in the life cycle. Most respondents are in grade 10, on average 16 years old, in the middle adolescent phase. Adolescents often face various challenges because they are experiencing a growth spurt and development, with many changes occurring both physically and emotionally.[28] Emotional changes that occur in adolescents can influence several aspects of their lives, including changes in eating behavior.[29] Adolescents are experiencing increased nutritional needs to support physiological changes and reproductive maturity. Therefore, adolescents are vulnerable to nutritional problems, including anemia, which is often caused by an unbalanced diet.[2]

Based on research findings, respondents' eating patterns regarding iron and folic acid supplementation can elevate iron intake and reduce the risk of anemia in female adolescents. Most causes of anemia are due to diet, namely deficiencies in nutrients such as protein, iron, and vitamin C.[11] Female adolescents, specifically those aged 10-19 years old, are susceptible to anemia due to diets that do not concern themselves with the quality and quantity of food. [30] Previous research stated that female adolescents tend to like unhealthy food compared to boys because they are dissatisfied with their body image and condition, which affects their health. [31] Adolescents' food consumption that is inadequate to their needs occurs because some adolescents are already familiar with their body image. Consequently, female adolescents take better care of their bodies so they don't

get overweight. [6,29] On the other hand, some adolescents prioritize eating a lot as long as they are complete, so they often consume foods high in fat and sugar.[31] This happens because of the influence of social media and social culture, and is supported by easy access to food. Apart from diet, anemia in female adolescents can also be caused by menstruation every month. Menstruation for a long duration or with a large volume of blood will cause a decrease in the amount of blood containing hemoglobin. [19]

Tempeh is a fermented product made from soybeans and other types of beans. Tempeh is the type of food most frequently consumed by respondents, 100 g of which contains 24.5 g of protein and 4.9 mg of iron.[32] Additionally, tofu is also the second most frequently consumed food by respondents. Tofu made from soybean juice contains 9.7 g of protein and 4.1 mg of iron per 100 g.[32] These foods are sources of protein, classified as vegetable protein, whereas the type of protein absorbed more quickly by the body is animal protein.[33] Several types of high-protein, iron-rich animal-source foods are rarely, if ever, consumed by respondents, including chicken liver, beef floss, and shrimp. Chicken liver contains 27.4 g of protein and 15.8 mg of iron in 100 g; beef floss contains 18 g of protein and 12.3 mg of iron in 100 g; and 100 g of shrimp contains 21 g of protein and 8 mg of iron.[21,32] The study results showed that the majority of respondents' heme iron intake was lower than their non-heme iron intake, and their plant iron intake was higher than their animal iron intake. These results agree with those of another study, which concludes that female adolescents are commonly reported to have too low protein and iron intakes, while their iron requirements are actually much higher than those of male adolescents.[34] Dietary restraints may lead to reduced meat intake and, consequently, lower iron intake. Moreover, adolescents are likely to have poor dietary habits, including high consumption of fast foods that typically have high energy content and low nutrient density, directly influencing their nutritional status, including iron status.[35,36]

According to the Recommended Dietary Allowance (RDA), female adolescents aged 16 – 18 need 65 g of protein.[37] Proteins or macromolecules formed from amino acids function as maintainers of body tissue and damaged cells, are a source of energy, and play a role in forming hemoglobin.[38] The type of protein consumed and absorbed more quickly by the body is animal protein, because it contains more complex amino acid profiles than vegetable protein.[39] Protein intake must be balanced according to age to support metabolic processes and ensure protein functions operate optimally.[40] Changes in adolescents' eating behavior can affect their protein intake. This occurs due to several factors, namely the number of family members and family characteristics, peers, social media, and the ease of access to food, which lead adolescents to consume various foods.[6,29] Therefore, as a way to prevent anemia, female adolescents are advised to consume various types of protein, both animal and vegetable, to support their nutritional needs.

The types of food that are sources of vitamin C are primarily found in fruits and vegetables. Spinach and kale are sources of vitamin C that respondents often consume. A hundred gram of spinach contains 41 mg of vitamin C, 0.9 g of protein, and 3.5 mg of iron.[32] 100 g of kale contains 17 mg of vitamin C, 3.4 g of protein, and 2.3 mg of iron.[32] If consumed frequently, the vitamin C in vegetables can reduce the risk of anemia by helping the body absorb iron more quickly when forming hemoglobin.[41] Respondents also consumed foods high in vitamin C, but rarely, namely katuk leaves, cassava leaves, and mustard greens. 100 g of *Sauropus androgynus (L.) Merr* leaves contain 164 mg of vitamin C, 6.4 g of protein, and 3.5 mg of iron.[32] The nutritional content in 100 g of cassava leaves is 103 mg of vitamin C, 6.2 g of protein, and 1.3 mg of iron. [32] Mustard greens in 100 g contain 102 mg of vitamin C, 2.3 g of protein, and 2.9 mg of iron. [32] Respondents are classified as rarely consuming green vegetables, which are also high in iron. Therefore, it can affect their body's health. If consumed with relatively low frequency, it can affect a person's intake, increasing the risk of nutritional deficiencies, including anemia.[42]

Sufficient intake of vitamin C is needed for the body to support one of the roles of vitamin C, namely, accelerating iron absorption while forming hemoglobin.[41] The recommended intake of vitamin C for female adolescents aged 15 years is 65 g, and for those aged 16-18 years is 75 g, according to the RDA. The lack of consumption of vitamin C-rich fruits and vegetables is indirectly related to hemoglobin formation, which accelerates iron absorption in the intestine.[39] Another study showed that adequate vitamin C intake among female adolescents can create an acidic environment, thereby promoting the conversion of ferric iron to ferrous iron, which is more readily absorbed in the small intestine. Furthermore, the absorption of non-heme iron increases fourfold with the presence of vitamin C in the diet.[43,44] Apart from the vitamin C content in vegetables and fruit, there is tannin content in several foods, which, when consumed together with food sources of protein and iron, can inhibit iron absorption.[45] Therefore, female adolescents are advised to consume a balanced, nutritious diet to help their metabolism function optimally.

Most respondents' adequate iron intake may be affected by some consuming blood supplement tablets once a week and by a lack of food sources of iron, such as animal side dishes, vegetable side dishes, and green vegetables. The recommended iron intake for female adolescents aged 15–18 years is 15 g.[37] Iron is a mineral that plays a significant role in hemoglobin production.[12] A lack of iron stores from dietary iron intake will cause the body to use existing iron reserves; if these reserves are insufficient, low iron intake will decrease hemoglobin.[11,39] Hemoglobin carries oxygen from the lungs to the rest of the body. If the hemoglobin level is low, erythrocytes cannot deliver oxygen to the body's tissues, making the body prone to weakness, fatigue, lethargy, laziness, inattentiveness, and other symptoms of anemia.[39]

Menstruation is a process of shedding the uterine wall, resulting in bleeding due to the absence of fertilization in the uterus.[46] The menstrual cycle is the number of days from the first day of menstruation to the first day of menstruation in the following month.[18,46] The average length of the menstrual cycle is 21 – 35 days, and it is classified as having a menstrual cycle disorder if, in the last three months, the average menstrual cycle is classified as less than 21 days or more than 35 days.[18,46] In this study, anemic and non-anemic respondents had regular menstrual cycles, but 27.6% of anemic respondents experienced longer menstrual durations and heavier menstrual flows than their non-anemic counterparts. Heavy menstrual bleeding can affect the body's ability to maintain adequate hemoglobin levels, worsen menstrual flow, disrupt menstrual cycles with heavy bleeding, and cause abnormalities in the frequency, volume, regularity, and duration of menstruation, which can contribute to a higher risk of anemia.[16] Furthermore, chronic iron deficiency can disrupt the regulation of the normal menstrual cycle, leading to longer periods. Long menstrual periods can be both a cause and a consequence of anemia, along with other broader symptoms such as hair loss, fatigue, dizziness, and overall poor health, which in turn impacts their quality of life.[7,22] Disruption of the menstrual cycle can be related to nutritional status and diet; foods that are high in calories, fat, and sugar can affect estrogen production during ovulation, causing menstrual cycle disorders. [47] Menstrual cycles that are relatively short and menstrual cycles that occur more frequently during female adolescence can cause bleeding to last longer, resulting in less blood-containing hemoglobin.[17] Therefore, balanced nutrition is needed for female adolescents, who are susceptible to nutritional deficiencies, and to support the monthly production of hemoglobin during menstruation.

This study's results show no correlation between protein intake and the incidence of anemia. The analysis of iron and vitamin C intake and the incidence of anemia among female adolescents at Bondowoso Vocational High School 1 shows a correlation. The role of protein in anemia is to help transport iron during hemoglobin formation.[48] Other studies that align with this research indicate no correlation between protein intake and the incidence of anemia.[49] This research states that the consumption of vegetable protein is higher than that of animal protein. Other similar studies show no correlation between protein intake and the incidence of anemia.[50] This is related to the protein consumed, which is classified as a vegetable protein and contains fewer amino acids than animal protein, so it is not absorbed as quickly by the body.[5] Apart from that, vegetable protein is classified as non-heme iron, and its absorption is lower than that of heme iron, which is found in many animal proteins.[50] Other studies that do not align with this study state that insufficient protein intake can inhibit iron conversion, resulting in low hemoglobin levels.[40] Protein, as an iron transporter in the body, carries various types of proteins, consisting of transferrin and ferritin, which support iron absorption in the small intestine. Transferrin contains iron, and its function is to transport iron into the bone marrow, which is a place to form hemoglobin.[40]

Other studies that align with this study show a correlation between iron intake and the incidence of anemia.[39] This research recommends consuming sufficient high-quality iron to ensure optimal hemoglobin formation in the body. Adequate iron intake can help the body use it when iron stores are insufficient.[39] This research aligns with prior studies showing that iron intake is associated with anemia among female adolescents.[40] Other similar studies state that hemoglobin levels are related to iron intake.[41] In this study, respondents consumed plant protein sources more often than animal protein sources because plant protein was relatively cheaper, resulting in a relatively low protein intake.[41]

Iron plays a significant role in the formation and increase of hemoglobin in erythrocytes.[51] In the body, most iron consists of 65% in hemoglobin and 30% in ferritin. Iron combines with plasma beta-globulin upon intestinal absorption, forming apotransferrin, which is then carried in plasma.[5] Excess iron in the blood is stored in body cells, especially hepatocytes and bone marrow. In the cytoplasm, proteins combine with iron, namely apoferritin and ferritin, and are formed. After the active period of iron (approximately 120 days), the iron is destroyed, and the hemoglobin released by the cells is then digested by macrophages (monocytes). Iron is also released to form new hemoglobin or stored in the liver as ferritin.[5,52]

Apart from iron and protein, vitamin C supports iron absorption by changing ferrous ions ($Fe^{3+}$) into a form that is more easily absorbed, namely ferric ions ($Fe^{2+}$).[39,51] Process of change: Iron ions become more accessible to absorb at a higher pH in the duodenum and small intestine.[41] Other studies that are not in line with this study show no correlation between vitamin C intake and the incidence of anemia. Vitamin C is quickly destroyed by heat and air exposure, so the vitamin C content in food can decrease during improper processing, such as cooking or washing.[39]

This research analysis shows a correlation between the menstrual cycle and the incidence of anemia. Other studies that align with this study show a correlation between the menstrual cycle and the incidence of anemia.[53] This study states that short menstrual cycles and prolonged bleeding will result in more blood loss during menstruation, resulting in a risk of anemia. Other similar research shows a correlation between the menstrual cycle and anemia.[27] Respondents in the study had long menstrual cycles, so they were at risk of suffering from anemia because women menstruate every month, resulting in a loss of 50-80cc of blood and 30-40 mg of iron during menstruation.[53] The results of this study are similar to those of other studies showing a correlation between the menstrual cycle and anemia.[54] This was because the respondents experienced menstrual pattern disorders, which included the menstrual cycle, length of menstruation, and amount of menstrual blood.[54,55] In addition, another study showed that 85% of menstrual cycles in adolescents remain anovulatory, which is considered physiological due to the immaturity of the gonadal axis. The immaturity of the hypothalamic-pituitary-ovarian axis, follicular persistence in anovulatory cycles, occurs more frequently in the first few years after menarche as a cause of uterine bleeding.[25,56] Furthermore, if irregular menstruation persists, one cause is insufficient release of GnRH and LH, and disruption of the regulatory cycle feedback mechanism, with irregular rises and falls in estrogen levels, a prolonged estrogen phase, or a disturbed estrogen-progestogen balance.[7,57] The limitations of this study were that we could not analyze dietary inhibitors such as coffee and tea, which may be associated with anemia in female adolescents. Furthermore, the observation period for identifying menstrual cycle disorders was only three months.

## CONCLUSIONS

The incidence of anemia among female adolescents was higher in this study than in the screening data. This is probably due to the small sample size from Bondowoso Vocational High School 1, where the prevalence of anemia is higher. Related factors for anemia in this study were iron and vitamin C intake, and the menstrual cycle in female adolescents. Monitoring and evaluation of regular iron and folic acid supplementation, emphasizing socialization regarding the nutritional action program "Aksi Bergizi Program" through balanced nutrition, building social support schemes for reproductive health, specifically the menstrual cycle, among female adolescents, and conducting research to determine the cause of anemia are necessary. Bondowoso Vocational High School 1 should start comprehensive health education, specifically for female adolescents, on nutrition and reproductive health, as anemia is detrimental to health and has long-term effects. Further research into food inhibitors of hemoglobin absorption, observation of the menstrual cycle for at least 6 months, and assessment of medical factors associated with anemia were necessary to develop comprehensive interventions to address anemia in female adolescents.

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## CONFLICT OF INTEREST

The authors declared no conflict of interest.

## DECLARATION USE AI

The authors declared that Generative AI was not used in the creation of this manuscript.

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