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EARLY DETECTION OF ANEMIA IN ADOLESCENT GIRLS THROUGH NUTRITIONAL STATUS EXAMINATION AND IRON PANEL ANALYSIS (TIBC, SERUM IRON, IRON SATURATION)

Ririn Handayani[1], Ernawati Anggraeni[2], Yuni Handayani[3], Melati Puspita Sari[4], Yuningsih[5]
[1]Bachelor of Midwifery, Faculty of Health Sciences, dr. Soebandi University, Indonesia
[2]Bachelor of Midwifery, Faculty of Health Sciences, dr. Soebandi University, Indonesia
[3]Bachelor of Midwifery, Faculty of Health Sciences, dr. Soebandi University, Indonesia
[4]Bachelor of Midwifery, Faculty of Health Sciences, dr. Soebandi University, Indonesia
[5]Bachelor of Midwifery, Faculty of Health Sciences, dr. Soebandi University, Indonesia
Correspondence address: Ririn Handayani
Email: ririnhandayani89@uds.ac.id

ABSTRACT

Introduction. The panel iron analysis is an effort made to screen for anemia in adolescent girls. Adolescents with anemia can experience disturbances in growth and development, behavioral changes, and motor disturbances. In Jember district found that on average 30-40% of female students suffer from anemia. Anemia screening is an effort made to maintain the health of adolescents so that they can grow and develop in accordance with their growth and developmental stages. **Aims.** The purpose of this study is the early detection of anemia in adolescent girls. **Methods.** This research is an analytical descriptive study with a cross-sectional approach. Data collection was by examining nutritional status and iron panel examination results. The sampling method was accidental, involving 21 female students. The research was conducted in March 2023. Data analysis used frequency distribution. **Result.** The results showed that some students were undernourished (42.9%) and severely malnourished (4.8%); 18 students (85.7%) were classified as KEK. Meanwhile, from the iron panel analysis, 10 students (47.6%) had abnormal serum iron levels, 6 students (28.6%) had abnormal transferrin saturation levels, and the majority of the respondents, 20 students (95.2%), had normal TIBC. **Conclusion.** The conclusion from this study is that there are still many adolescent girls, especially in the school environment, who are undernourished to severely malnourished. This result correlates with the iron panel analysis which found that some adolescent girls were diagnosed with iron-deficiency anemia, characterized by a decrease in serum iron, transferrin, and iron reserves levels, accompanied by an increase in the TIBC.

Keywords: Anemia, Adolescent, Serum Iron, TIBC, Transferrin Saturation

INTRODUCTION

Anemia in adolescents, especially adolescent girls, is a health issue that urgently requires special attention because they are prospective mothers who will give birth to the nation's next generation (Muliani, 2023). Adolescent girls are susceptible to anemia due to the natural loss of significant amounts of blood each month (Jaelani, Simanjuntak and Yuliantini, 2015). Anemic conditions can reduce productivity, thus affecting their academic performance (Muliani, 2023).

The occurrence of anemia in adolescents will persist into adulthood and will become a problem during pregnancy and childbirth (Rafiqi, Matondag and Fevria, 2022). Anemia in pregnant women can increase the risk of preterm birth, AKI and AKB, and infectious diseases (Ministry of Health RI, 2022). Riskesdas 2013 data show that the prevalence of anemia in WUS aged 15 years and older is 22.7% (Ministry of Health, 2018). In East Java, especially among students, the incidence of anemia is still quite high. In Jepara district, specifically at SMK Islam Jepara, out of 80 students, 56 were found to have anemia (Cholifah, Himawan and

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Menstruasi, 2020). A survey in Jember district found that on average 30-40% of female students at SMAS Unggulan BPPT Darus Sholah suffer from anemia, which is attributed to the lack of regular iron tablet consumption among adolescents, especially during menstruation (Aini, 2020).

Adolescent girls are at high risk of anemia because they are in a phase of growth that requires higher nutritional intake, including iron. Furthermore, the loss of iron excreted by adolescents every month due to menstruation contributes to this risk (Ministry of Health, 2018). Several factors that influence the incidence of anemia include lifestyle such as smoking, alcohol consumption, breakfast habits, economic status and demographic conditions, education level, age and gender (Arya et al., 2022).

The impact of anemia on adolescent girls includes stunted growth, vulnerability to infections, reduced physical fitness/ vitality, and a negative effect on academic performance. This is because anemia in adolescent girls can decrease their concentration in studies (Kurniati, 2020). Adolescent girls with anemia to achieve lower academic performance compared to those without anemia (Samson and Fischer, 2022).

Prevention and control of anemia non-pharmacologically can be achieved through the consumption of foods rich in iron and vitamin C, which support iron absorption. Beetroot and guava are rich in vitamins, minerals, and active compounds; they can be consumed in juice form and have the potential to prevent and control anemia (Nurma Astrid Utami, 2022). Pharmacological prevention of anemia is done by providing Iron Supplement Tablets to adolescent girls, implemented through School Health Units in educational institutions, by determining a shared Iron Tablet consumption day. The recommended dose is one tablet every week throughout the year (Ministry of Health, 2022). Rahmadi (2018) stated that there was a significant difference between the nutritional status of female high schools students who received iron tablets and those without the iron supplement tablet program.

Anemia is an abnormal condition and the cause must be sought. In the treatment of iron deficiency anemia, laboratory examinations play a role in screening, establishing a diagnosis, and monitoring the success of therapy *(Arya et al.*, 2022). In the management of iron-deficiency anemia, laboratory tests play a role in screening, establishing a diagnosis, and monitoring the success of therapy. One such laboratory test is the biochemical examination. This biochemical test can detect iron deficiency before anemia occurs (Ningrum, Setiati and Sari, 2023). In this study, a biochemical examination of iron panel levels in adolescent girls was conducted as an early detection effort for iron-deficiency anemia in adolescents. The purpose of this study is the early detection of anemia in adolescent girls.

METHODS

The research employs a descriptive analytic method with a cross-sectional approach. The research was carried out at SMK Baitul Hikmah Tempurejo because, from the results of a preliminary study by researchers, it was found that some young women at SMK Baitul Hikmah complained that they were often dizzy, tired and had difficulty concentrating because they were sleepy during the learning process. The research began in March 2023 with a population of all female students at SMK Baitul Hikmah Tempurejo, totaling 72 students. The sampling technique was accidental, involving 21 respondents. The inclusion criteria for this research are female students of SMK Baitul Hikmah who are willing to participate as respondents, not currently experiencing menstruation, not currently ill, and not currently taking anemia medication. Data collection was

done by examining nutritional status through measurements of height (TB), weight (BB), and upper arm circumference (LILA). The measurement outcomes are subsequently sorted into groups using the BMI-for-age cutoffs specified in the Regulation of the Minister of Health of the Republic of Indonesia Number 2 Year 2020, which outlines the Standards for Child Anthropometry. Meanwhile, the iron panel data were obtained from the results of the iron panel analysis conducted by SIMA Laboratory. The results are presented by frequency distribution table and bar diagram.

Nutritional Status Examination

Nutritional status examination is conducted on adolescent girls to obtain an overview of their nutritional status. The examination involves anthropometric measurements, including weight (BB), height (TB), and LILA. The measurement outcomes are subsequently sorted into groups using the BMI-for-age cutoffs specified in the Regulation of the Minister of Health of the Republic of Indonesia Number 2 Year 2020, which outlines the Standards for Child Anthropometry. The Body Mass Index by Age (BMI/U) for children aged 5 to 18 years is applied for categorization (Permenkes, 2020) :

A. Severe thinness;
B. Thinness;
C. Normal nutritional status;
D. Overweight; and
E. Obesity.

Panel Iron Analysis (TIBC, Serum Iron, Iron Saturation)

Based on laboratory examinations, iron deficiency anemia can be measured through hemoglobin levels, red cell indices, MCV, MCHC, MCH, serum iron, TIBC, serum ferritin, erythrocyte protoporphyrin, serum transferrin receptor, and bone marrow. To establish a diagnosis of iron deficiency anemia, three steps can be taken: determining the presence of anemia by measuring hemoglobin or hematocrit levels, confirming the presence of iron deficiency, and identifying the cause of iron deficiency.

In this study, an iron panel analysis was carried out which included TIBC levels, serum iron levels, and iron saturation levels. Sample examination was carried out by a laboratory assistant from the SIMA laboratory. This research has passed the ethics review at the Ethics Committee of dr. Soebandi University with No.034/KEPK/UDS/III/2023.

RESULT

The following will present research data related to the early detection of anemia through nutritional status examination and iron panel analysis in female adolescents at SMK Baitul Hikmah. The results of nutritional status examination and iron panel are presented in the form of frequency distribution tables and bar diagrams as described in the following explanation :

Table 1. Nutritional Status Overview of Female Adolescents at SMK Baitul Hikmah Based on Body Mass Index (BMI).

Nutritional Status	Quantity	Frequency%
Severely thinness (<-3 SD)	1	4.8
Thinness (- 3 SD sd <- 2 SD)	9	42.9
Normal (-2 SD sd +1 SD)	10	47.6
Overweight (+ 1 SD sd +2 SD)	1	4.7
Obese (> + 2 SD)	0	0
Total	21	100

Source: Primary Data (Questionnaire)

From Table 1, we can see that the majority of female students at SMK Baitul Hikmah have a good (normal) nutritional status, accounting for 10 students (47.6%). However, there are several students with undernutrition (42.9%) and severe undernutrition (4.8%).

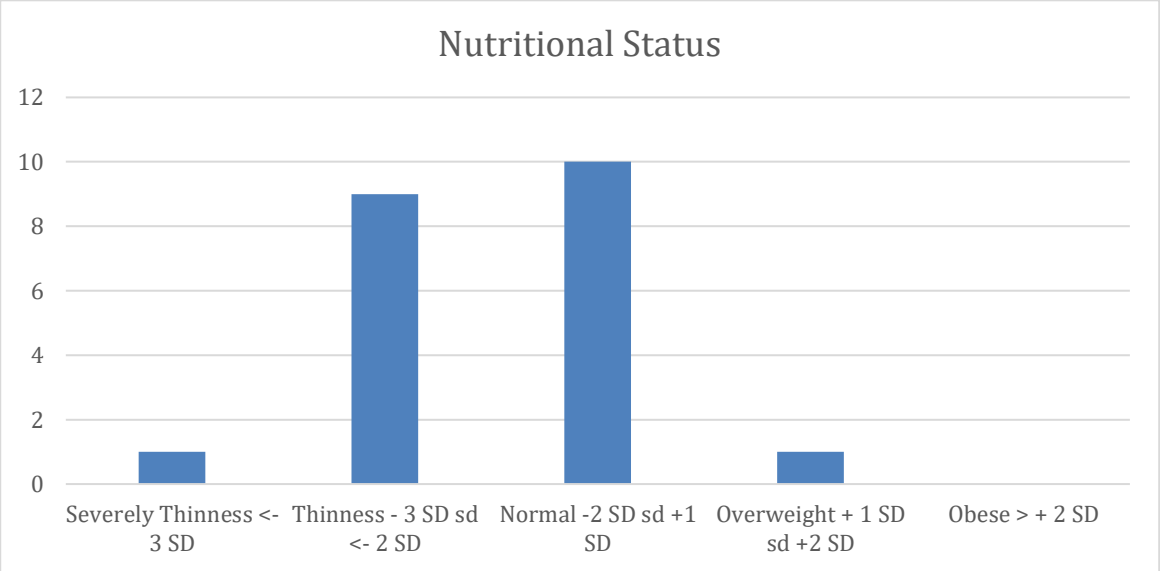


Chart. 1 Nutritional Status Overview of Female Adolescents Based on Body Mass Index

From chart 1, we can see that the majority of female students at SMK Baitul Hikmah have a good (normal) nutritional status (2 SD sd +1 SD). However, there are several students with thinness (- 3 SD sd <- 2 SD) and severe thinness (<-3 SD).

Table 2. Overview of the Nutritional Status of Female Adolescents at SMK Baitul Hikmah Based on Upper Arm Circumference (LILA)

Nutritional Status	Quantity	Frequency %
Normal (>23,5 cm)	3	14.3
Chronic Energy Deficiency (<23,5 cm)	18	85.7
Total	21	100

Source: Primary Data (Questionnaire)

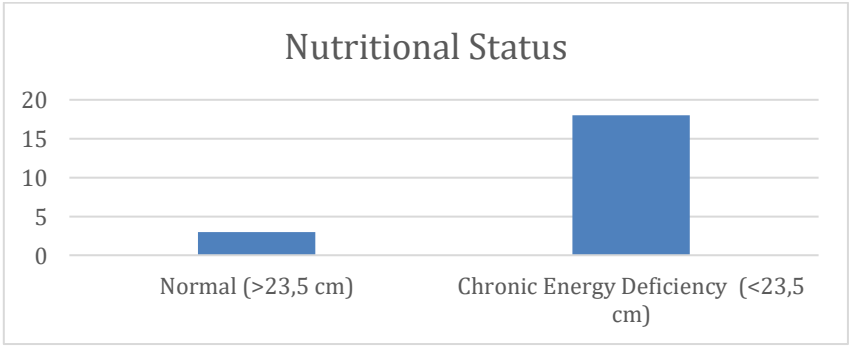


Chart. 2 Overview of the Nutritional Status of Female Adolescents Based on Upper Arm Circumference (LILA)

From Table 2 and chart 2, it's evident that the majority of female students at SMK Baitul Hikmah have an abnormal arm circumference (85.7%), leading to the conclusion that these students are at risk of chronic energy deficiency (KEK).

Table 3. Iron Panel Analysis of Female Adolescents at SMK Baitul Hikmah

Panel Iron	Quantity	Frequency %
Serum Iron (60 – 150 µg/dL)		
Normal	11	52.4
Abnormal	10	47.6
TIBC (300-360 µg/dL)		
Normal	20	95.2
Abnormal	1	4.8
Transferin Saturation (15-50%)		
Normal	15	71.4
Abnormal	6	28.6
TOTAL	21	100

Source: Primary Data (Questionnaire)

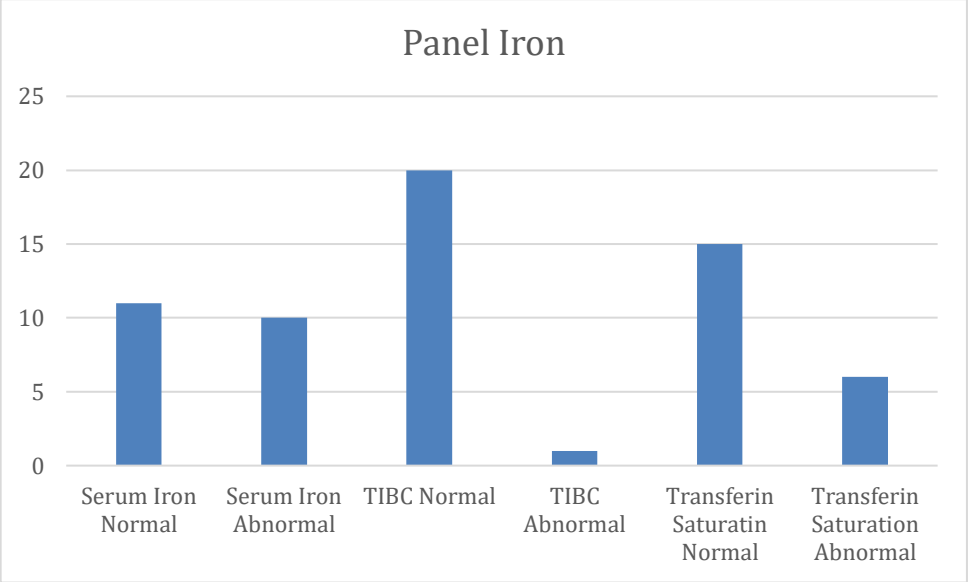


Chart. 3 Iron Panel Analysis of Female Adolescents

From Table 3 and chart 3, we observe that most female students at SMK Baitul Hikmah have normal serum iron levels, with 11 students (52.4%), yet there are 10 students (47.6%) with abnormal serum iron levels. The majority of respondents, 20 students (95.2%), have normal TIBC levels. Regarding transferrin saturation, 15 students (71.4%) have normal levels, but there are six students (28.6%) with abnormal transferrin saturation levels.

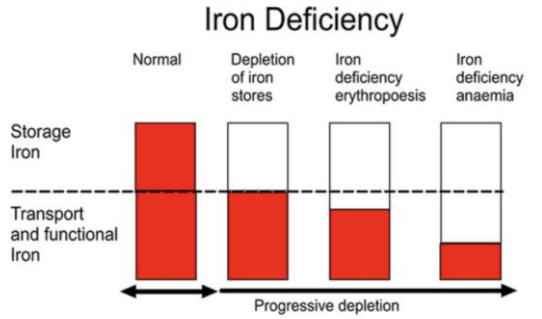
DISCUSSION

Iron deficiency refers to a reduction in the overall quantity of iron within the body. A severe iron deficiency in the body can disrupt the erythropoiesis process, causing symptoms of anemia (Widiada, 2020). Iron deficiency stands out as the

prevailing nutritional issue on a global scale that can affect the growth and development of women and children. Iron deficiency begins with mild deficiency (iron reserves are slightly reduced), Subsequently, it advances to a marginal deficiency where the production of iron-dependent proteins is hindered despite normal hemoglobin levels, and eventually culminates in iron deficiency anemia characterized by reduced hemoglobin synthesis and impaired oxygen transport to tissues (Coad and Pedley, 2014).

According to Odzemir (2015), the stages of iron deficiency include : (1) Normal : with good iron stores. (2) Iron depletion or store iron deficiency : marked by a reduction or absence of iron stores. Hemoglobin and other iron protein functions remain normal. In this stage, there is an increase in non-heme iron absorption. Serum ferritin decreases, while other tests for iron deficiency remain normal. (3) Iron-deficient erythropoietin or iron-limited erythropoiesis : insufficient iron supply to support erythropoiesis. The laboratory findings reveal a decline in serum iron and transferrin saturation, an upswing in total iron-binding capacity (TIBC), and an elevation in free erythrocyte porphyrin (FEP). (4) Iron deficiency anemia occurs when there is insufficient iron reaching the bone marrow for erythropoiesis, leading to a decrease in Hb levels. Blood smear analysis reveals progressive microcytosis and hypochromia. At this stage, epithelial changes, especially in the gastrointestinal tract, have occurred.

Anemia is characterized by a decrease in the quantity of red blood cells or a lowering of the hemoglobin (Hb) concentration in the blood. The primary culprit behind this condition is often iron deficiency, and its prevalence can be influenced by factors such as age, gender, and socioeconomic status (Warner and Kamran, 2023). Iron deficiency anemia poses a worldwide health challenge, particularly affecting school-aged children. This condition has the potential to hinder psychomotor development and interfere with cognitive performance (Desalegn, Mossie and Gedefaw, 2014).



Iron status	Normal	Mild deficiency	Marginal deficiency	Severe deficiency
Haemoglobin	Normal	Normal	Normal	Low
Other Fe functions	Normal	Normal/low	Low	Low
Stores (SF)	Normal	Normal/low	Low	Low

Figure 2. Stages Of Iron Deficiency (Coad and Pedley, 2014)

Children with iron-deficiency anemia can experience disturbances in growth and development, behavioral changes, and motor disturbances, thereby reducing learning abilities and decreasing academic performance in school. This situation can certainly hinder the development of the quality of human resources (Kurniati, 2020).

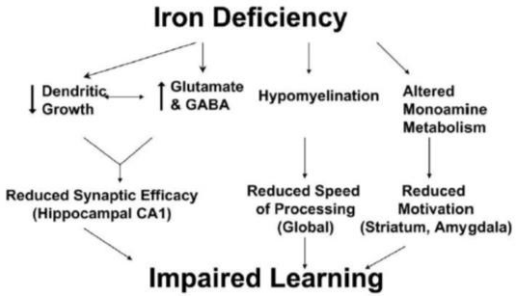


Figure 3. The Impact of Iron Deficiency on Learning Disorders

Iron deficiency can lead to disruptions in the growth, differentiation, and electrophysiology of neurons, causing changes in neurotransmitter regulation (Radlowski and Johnson, 2013). Iron is indispensable in the functioning of various enzymes crucial for neurotransmitter synthesis. This includes its involvement in

tryptophan hydroxylase, essential for serotonin production, and tyrosine hydroxylase, vital for the synthesis of norepinephrine and dopamine. The synthesis of neurotransmitters begins during embryogenesis. Dopamine plays a role in regulating cognition, emotions, movement, and hormone release. Striatal tissue with normal dopamine levels as the primary neurotransmitter is associated with higher cognitive abilities, emotional processes, motivated behavior, positive affect, and good motor function (Purnamasari, Lubis and Gurnida, 2020). Studies conducted on mice suggest that iron deficiency can lead to alterations in the density of serotonin transporter and norepinephrine transporter, indicating potential changes in neurotransmitter regulation (Radlowski and Johnson, 2013). Serotonin disorders are associated with developmental nerve disorders, such as anxiety or depression (Calabrese et al., 2013). Iron deficiency leads to a decrease in the expression of SERT, resulting in a reduction in the expression of Brain-Derived Neurotrophic Factor (BDNF). The decrease in BDNF can impact the structure and function of the hippocampus, leading to a decline in learning and memory abilities (Purnamasari, Lubis and Gurnida, 2020).

Research involving mice indicates that a deficiency in iron may bring about modifications in the density of serotonin transporter (SERT) and norepinephrine transporter. This implies the possibility of adjustments in the regulation of neurotransmitters (Fitriany, Saputri and Anemia, 2018). Early detection to prevent iron-deficiency anemia is by conducting biochemical examinations as a basis for diagnosis determination (Ningrum, Setiati and Sari, 2023). The screening results obtained by the researchers on female adolescents regarding the iron panel analysis found that 10 students (47.6%) had abnormal serum iron levels, one student (4.8%) had an abnormal TIBC, and six students (28.6%) had abnormal transferrin saturation levels. From the data above, we can conclude that, among the adolescents examined, several are experiencing iron-deficiency anemia. Iron-deficiency anemia itself is a condition of the body with low Hb levels caused by the lack of iron availability in the body, leading to insufficient iron needed for erythropoiesis. This can be characterized by a picture of hypochromic microcytic erythrocytes, a decrease in serum iron, transferrin, and iron reserves, accompanied by an increase in the total iron binding capacity (TIBC) (Kurniati, 2020).

Furthermore, an indicator of iron deficiency is a reduction in serum ferritin. Ferritin levels falling below 12 ng/mL (mcg/L) for children under 5 years old and below 15 ng/mL for children aged 5 years and older signify the presence of iron deficiency anemia. Serum ferritin levels cannot be used to diagnose if there is infection or inflammation. Hence, it is essential to conduct examinations in conjunction with C-reactive protein and/or erythrocyte sedimentation rate (WHO, 2020). In situations where the iron balance becomes negative, there is a subsequent decrease in serum iron, followed by an elevation in iron binding capacity (TIBC), leading to a reduction in transferrin saturation. Insufficient iron to bind to protoporphyrin for heme production leads to the accumulation of FEP, hindering the synthesis of hemoglobin. Consequently, blood hemoglobin levels decrease, along with a drop in MCV and average MCH, while the red cell distribution width (RDW) increases (Aksu, 2023).

Several factors, including deficiencies in micronutrients such as iron, folic acid, and vitamin B12, along with the presence of infectious diseases like malaria and worm infections, contribute to the initiation of anemia. Iron, a vital micronutrient for cell growth and differentiation, plays a crucial role in the body's metabolic processes. When the intake and absorption of iron fall short of meeting the regular turnover and loss

requirements, depleting iron reserves, an insufficient amount of iron is directed to transferrin, the circulating iron transport protein. This leads to a decrease in transferrin saturation, impacting hemoglobin synthesis and resulting in a state of iron-deficiency anemia. (Desalegn, Mossie and Gedefaw, 2014). This statement is in line with the results of research conducted by Hendra and Rahmad (2015) which states that protein and iron intake has a strong influence on increasing hemoglobin levels, that is the more protein and iron intake increases, the more hemoglobin levels increase (Hendra and Rahmad, 2015). Similar research was also conducted by Novita and Ismah (2018), where administration of Fe tablets had a significant effect on changes in hemoglobin levels in tuberculosis (TB) patients).

Iron deficiency and iron-deficiency anemia are commonly observed conditions at different phases of a woman's life. Women are especially susceptible to these conditions due to monthly bleeding, particularly for those experiencing heavy menstrual flows (menstrual cycle disorders) (Jaelani, Simanjuntak and Yuliantini, 2015). Anemia in children and teenagers can be treated by Fe tablets (Yuanti, Damayanti and Krisdianti, 2020). The iron consumed does not have to be blood-boosting tablets/Fe tablets, iron can also come from food, for example animal protein, nuts, vegetables and fruit (Hermawan, Abidin and Yanti, 2020). Early screening to establish a diagnosis of iron-deficiency anemia is still very lacking, making it impossible to provide early intervention and appropriate treatment. This condition results in serious long-term impacts that can affect all aspects of a woman's physical and emotional health and well-being (Mirza et al., 2018).

The signs of symptoms that teenagers with iron deficiency including paleness, which is the most common condition and teenagers may not be aware of until their hemoglobin level is below 7-8 g/dL. A pale condition can be seen or detected in the extremities and conjunctiva. Clinical indicators of anemia include palpitations, shortness of breath during activity, decreased cognitive function, and dizziness. In cases of severely low hemoglobin levels, additional symptoms may include reduced appetite, tachycardia, and in extreme situations (Mattiello et al., 2020).

Early screening that can be done to detect anemia in adolescents is by measuring height (TB) and weight (BB) to determine the BMI, measuring the upper arm circumference (LILA), and identifying clinical signs of anemia. Anthropometric examination is an easy and inexpensive way to determine nutritional status and detect anemia, compared to biochemical tests that are relatively more expensive. Anthropometric measurements encompass various parameters, including ; BB (weight), TB (height), LILA (upper arm circumference) (Yunieswati, 2014). A significant association is underscored between nutritional status and the prevalence of anemia. Thus, determining BMI and measuring LILA are appropriate steps that can be used for early screening of anemia (El Shara, Wahid and Semiarti, 2017).

The research results related to the nutritional status of female adolescents found that nine students (42.9%) were undernourished, and one student (4.8%) was severely malnourished. From these findings, we can infer that many female adolescents are facing nutritional issues. It is well-known that these nutritional problems in adolescent girls will continue and carry into adulthood if not promptly addressed (Muchtar et al., 2022). Meanwhile, based on the upper arm circumference (LILA) measurements, 18 students (85.7%) have abnormal arm circumference (indicative of chronic energy deficiency, KEK). Upper arm circumference measurements, along with body mass index, can be used to determine the risk of KEK. LILA measurement is a

simple and practical way to measure the risk of KEK in women of childbearing age. Rahmadi (2013) explained that the optimal value of LILA measurements for early detection of KEK has a high sensitivity (87.65%) with a LILA standard measurement of 22.7 cm . Adolescents diagnosed with KEK face a heightened risk of developing anemia (Wirawanti, 2022). KEK in adolescents can increase the risk of infectious diseases and hormonal disturbances that adversely impact health. KEK can actually be prevented by consuming a balanced nutritious diet (Ministry of Health, 2018).

According to Jaelani (2017), the occurrence of anemia among adolescent girls is influenced by several factors, including breakfast habits, nutritional status, protein intake, consumption patterns of foods that inhibit iron absorption, and menstrual duration. Nutritional issues in adolescents stem from inappropriate dietary behaviors, specifically an imbalance between actual nutritional intake and recommended guidelines. Adolescents often opt for food choices outside the home or school, selecting popular items that boost their social standing, and frequently exhibit irregular eating habits (Jaelani, Simanjuntak and Yuliantini, 2015). Rosalinna (2020) also stated that dietary patterns significantly influence hemoglobin levels in preschool children. Anemia control can be achieved by managing dietary patterns, including increasing intake, selecting food ingredients, processing, and presentation to maximize iron absorption A similar study conducted by Melyani (2019) stated that adolescent girls with thin nutritional status have a 2.565 times higher chance of experiencing anemia compared to adolescent girls with normal nutritional status.

CONCLUSIONS

Based on the findings, we can conclude that many adolescent girls, especially those in school settings, range from having undernutrition to severe malnutrition. These results correlate with the iron panel analysis, where a significant portion of adolescent girls were diagnosed with iron-deficiency anemia, characterized by decreased levels of serum iron, transferrin, and iron reserves, accompanied by an increase in the total iron binding capacity (TIBC). For future research, it is hoped to identify the nutritional status and iron panel analysis in adolescent girls, especially in school environments, with a larger sample as an anemia screening effort to enhance adolescent health status.

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