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Iron deficiency and anemia among adolescent girls in Banten, Indonesia: a cross -sectional study

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Abstract

Anemia is diagnosed when the hemoglobin level is below the World Health Organization's (WHO) normal value based on age and gender. Adequate hemoglobin can be synthesized if the iron supply is sufficient. Studying iron status (hemoglobin and ferritin), thus, in adolescent girls, the next age group that will possibly experience pregnancy, is necessary to be performed. A cross-sectional study was performed in Banten, Indonesia. A total of one hundred fifty-eight girls were recruited and joined the study. Blood was drawn, and iron status (ferritin and hemoglobin) was analyzed. In addition, respondents' characteristic was obtained through direct interviews. Weight and height were determined to calculate the Z-scores of BMI-for-age using WHO AnthroPlus software. A total of one hundred fifty-two respondents were analyzed, excluding 6 respondents due to an infection condition, resulting in an average age of 16.04±1.00 years old and an average z-score BMI-for-age of -0.32. The study revealed that anemia prevalence was 44.7%, 55.4% of whom had iron deficiency. Another result showed that the prevalence of iron deficiency was 36.8% among all respondents. In addition, chi-square analysis showed a relationship between anemia and iron deficiency status with an OR ratio of 4.083 (2.029-8.217, p = 0.000). Correlation analysis unveiled that a medium coefficient between hemoglobin and ferritin levels was observed (r = 0.497, p = 0.000). Iron deficiency in adolescent girls enhances the risk of progressing anemia. Thus, increasing iron consumption through food and supplementation might tackle iron deficiency and anemia.

1. Introduction

Anemia is diagnosed when hemoglobin (Hb) level is below the World Health Organisation's (WHO) normal value based on age and gender (World Health Organization, 2001). The classical symptoms of anemia are fatigue, skin pallor, shortness of breath, light-headedness, dizziness, or a fast heartbeat. Anemia can be caused by several contributors, including low nutrition intakes such as iron, folic acid, vitamin A, B2 (riboflavin), B6 (pyridoxine), B12 (cobalamin), C, D, and E, malabsorption, bleeding, infection, and genetical blood disorders (Lopez *et al.*, 2016). Nearly 2.3 billion people worldwide experience anemia dominantly in women and children, making anemia a major health focus (Kassebaum *et al.*, 2014). Specifically, in Indonesia, the study showed that the prevalence of anemia in pregnant women reached 45% (Indonesian Ministry of Health, 2018) and in adolescents was 44% (Agustina *et al.*, 2021). Anemia would decrease work productivity in adults and harm intellectual and behavioural maturity in children (Chaparro and Suchdev, 2019). In addition, anemia in pregnancy has been associated with a higher risk of having low baby weight, preterm delivery, maternal mortality, and newborn and children mortality (Figueiredo *et al.*, 2018). An anemia study in adolescent girls is necessary to tackle the higher prevalence in pregnant women because this generation may be the next age group to undergo pregnancy. Thus, a study in adolescent girls measuring Hb and ferritin to investigate the prevalence of iron and anemia status and explore the link between Hb and ferritin must be performed.

Anemia mostly occurs due to iron deficiency (ID)

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(Camaschella, 2015). Iron is a prominent source for several body processes, supplying essential microminerals for blood synthesis (erythropoiesis), and other body functions such as enzyme creation, energy fabrication, and immune function (Muckenthaler *et al.*, 2017). Iron is the main component to create Hb, which can help distribute oxygen and nutrients to all body parts. Lack of iron in the body could contribute to ID and iron deficiency anemia (IDA) (Camaschella, 2015, 2019). ID is not similar to IDA. Iron deficiency is a state in which physiologic function runs normally, although it is insufficient in iron concentration (Umbreit, 2005; Camaschella, 2019). This problem might be caused by a lack of iron in the diet and high blood loss due to bleeding and other diseases (López and Martos, 2004; Lopez *et al.*, 2016). ID can sometimes be with or without anemia, and ID and low Hb levels are named IDA (Camaschella, 2015). This can be explained that IDA goes through the stages of 1) low iron reserves, 2) impaired red blood cell formation due to ID, 3) decreased Hb and haematocrit levels (World Health Organization, 2001; Umbreit, 2005; Killip *et al.*, 2007; Camaschella, 2015; Lopez *et al.*, 2016; Camaschella, 2019). Thus, studying to relate iron stores and Hb is very crucial.

ID was found in 50% of the cases of anemia in the world. ID and anemia can be observed from blood parameters, especially Hb and ferritin levels. Hb is a blood protein with heme and globin components. Heme, particularly, is a porphyrin whose core is iron (Fe) (Guyton and Hall, 2007). While ferritin is a protein store of iron in the body, which is not influenced by recent iron intake (Guyton and Hall, 2007). Therefore, it is very important to examine ferritin as another analysis of Hb level to detect whether there is ID. Studies showed that analysing both parameters can measure the risk ID to cause anemia (Ahmad *et al.*, 2014). Literature noted that the odd ratio (OR) risk when babies had ID to gain anemia was 5.8 (Ahmad *et al.*, 2014). This means that people with ID have a higher risk of anemia around 5.8 times. A study in India found that adolescent girls had an anemia prevalence of around 97% and an iron deficiency prevalence of around 75% (Goyle and Prakash, 2009). In Indonesia, a recent study reported that anemia prevalence in adolescent girls was 44% (Agustina *et al.*, 2021). In particular, 57% of reproductive women in Banten were also anemic (Prihatini *et al.*, 2009). However, this study did not study the ferritin value and was not conducted in adolescent girls. Thus, research on anemia, iron deficiency, and OR calculation in Banten, Indonesia, among adolescent girls has not been fully studied.

Hence, in this study, Hb and ferritin were measured to calculate the percentage of adolescents, a next-generation likely to have a pregnancy, with anemia and ID. In addition, an OR value would be generated, relating anemia status to ID status.

2. Materials and methods

2.1 Study design

A cross-sectional design was used in this study with a descriptive-analytical approach. From October to December 2018, Banten Province was chosen as the research location, selecting Pandeglang and Lebak Regencies as the research sites by focusing on the stunting locus from Indonesia's Government (Tim Nasional Percepatan Penanggulangan Kemiskinan (TNP2K), 2017). In the Pandeglang district, the research was conducted in Panimbang and Cigeulis districts. Meanwhile, in Lebak Regency, Malimping, Wanasalam, and Cijaku districts were chosen as the locations. Before obtaining a blood sample, an interview with a closed structure was done to observe the respondent's characteristics, food habits, physical activity, and disease history. Respondents' recruitment was performed consecutively and inclusion criteria used were 1) adolescent girls aged 15-18 years, 2) active students in the selected districts, and 3) currently not on a diet program either for increasing or lowering body weight. In addition, exclusion criteria were 1) having an infectious disease and 2) consuming regularly (one time per day) high-phenol drinks such as tea, coffee, cocoa, and soft drinks. Ethical clearance was obtained from the Research Ethics Commission of the Faculty of Medicine, University of Indonesia, Indonesia.

2.2 Research variables

In this study, the observed iron status variables were Hb and ferritin levels. A Phlebotomist took blood from the median cubital vein, which was then divided into two tubes with EDTA for Hb analysis and non-EDTA for ferritin analysis. Hb levels were measured using the cyanmethemoglobin method, known as the standard for quantitative Hb calculation, and were categorized as anemia if the blood Hb level was <12 g/dL (World Health Organization, 2001). Meanwhile, the research variable ferritin was analysed using the Enzyme-Linked Immunoassay (ELISA) method, where the criteria for ID were ferritin value <15 ng/L (World Health Organization, 2001). C-reactive protein (CRP) was also calculated using an ELISA kit to observe whether respondents had an infection (positive) or not (negative). In addition, the characteristics of respondents were obtained by conducting interviews using a structured questionnaire. In addition, this study also carried out weight and height measurements to see the respondents' nutritional status. Body weight was measured using a

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digital scale with an accuracy of 0.1 kg (Omron HN-289, China). Height was observed using a stadiometer with an accuracy of 0.1 cm (Onemed, Indonesia). Then, the z-score of body mass index for age was calculated using the WHO AnthroPlus software, plotting to growth reference for 5 – 19 years (World Health Organization, 2007).

2.3 Statistical analysis

The statistical analysis was carried out using SPSS 13. Six respondents were excluded from the analysis because of a positive result of CRP, indicating an infection condition. Descriptive analysis was performed for univariate data such as age, BMI-for-age, Hb, and ferritin levels. Hb and ferritin were also presented in frequency for each category. Bivariate analysis was performed using chi-square to explore the relationship between both iron parameters. The OR between Hb and ferritin status, in addition, was calculated. Furthermore, Pearson correlation analysis was performed to analyze the connection between Hb and ferritin levels. The P value of 0.05 indicates a significant result.

3. Results

A total of 158 respondents were recruited and enrolled in the study and signed the informed consent. However, 152 respondents were analyzed, excluding six respondents with positive CRP Status. The average age of the respondent was 16.04±1.00 ranging from 14 to 18 years old (Table 1). Next, this study observed that the average Hb level was 11.86±1.56 g/dL; the lowest Hb level was 4.5 g/dL and the highest level was 14.2 g/dL (Table 1). Ferritin level, another iron status, was observed at 41.23±37.85 ng/dL on average, varying from 1.5 to 174 ng/dL (Table 1). An average of -0.32 was observed for the z-score of BMI-for-age with a minimum value of -3.10 and a maximum value of 1.84 (Table 1).

The anemia prevalence of adolescent girls in this study was 45.57% (72 girls) (Table 2). Of that number, 56% was caused by ID (40 girls). Examining the details of anemia status showed that most respondents were in the mild category, while 2.94% and 19.12 % of the participants were in severe and moderate levels, respectively. In addition, 59 girls (37.34%) (Table 2) were observed to have an ID (ferritin level below 15 ng/mL).

Connecting the relationship between anemia and ID status, this study found that both parameters were related with an OR value of 4.083 (2.029-8.217, p = 0.000) (Table 3). In addition, further analysis using Pearson's correlation test showed that the coefficient was 0.497 between Hb and ferritin levels (p = 0.000), a medium coefficient.

Table 1. Respondent characteristics, including age, hemoglobin, ferritin, and z-score BMI-for-age.

	N	Mean	SD	Minimum	Maximum
Age	152	16.04	1	14	18
Hb	152	11.86	1.56	4.5	14.2
Ferritin	152	41.23	37.85	1.5	174
z-score BMI-for-age	152	-3.1	0.95	-3.1	1.84

Table 2. Frequency of anemia status, iron deficiency status, and anemia with iron deficiency in the study.

Parameters	Category	n	%
Anemia status*	Anemia (<12 g/dL)	68	44.7
	- Severe (<7.00 g/dL)	2	2.94
	- Moderate (7.00-9.99 g/dL)	13	19.12
	- Mild (10.00-11.99 g/dL)	53	77.94
	Normal (≥12 g/dL)	84	55.3
Iron deficiency status*	Iron deficiency (<15 ng/mL)	56	36.8
	Normal (≥15 ng/mL)	96	63.2
Anemia with iron deficiency	Iron Deficiency + Anemia	37	54.4
	Anemia + Normal feritin	31	45.6

*Anemia and iron deficiency status were categorized according to the World Health Organization (2001).

Table 3. Association between anemia and iron deficiency status.

Iron deficiency status	Iron deficiency		Normal		p-value*
	n	%	n	%	
Anemia	37	24.3	31	20.4	0
Normal	19	12.5	65	42.8	OR 4,083 (2.029-8.217)

*The Chi-square test was applied to analyze the relationship between anemia and iron deficiency status

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4. Discussion

This study found that the prevalence of anemia was 45.6%, showing more than half of it was iron deficient. ID contributes to anemia; here, it strongly suggests that if adolescent girls with ID, it would enhance the risk by 4 times. In addition, to support the risk analysis, Pearson's analysis showed a positive-moderate correlation between Hb and ferritin values.

Anemia is defined by WHO when the Hb value is below 12 g/dL for adolescent girls. The result showed an average of Hb 11.86±1.56 g/dL, contributing to anemia of around 45.6% among adolescent girls. Anemia prevalence was similar to previous reports on pregnant women (Indonesian Ministry of Health, 2018) and adolescent girls (Agustina *et al.*, 2021). Another research in Banten Province found a higher prevalence, showing that 57% of reproductive women were anemic (Prihatini *et al.*, 2009). Moreover, compared to other developing countries in the region of Southeast Asia, percentages of anemia prevalence were 51.7%, 40.9, and 41.8% for Cambodia, Laos, and the Philippines, respectively, which were closely comparable to Indonesia (Petry *et al.*, 2016). In contrast, anemia prevalence in developed countries showed lower prevalence, which was 3.2%, 5%, and 4.1% for Germany (Eisele *et al.*, 2013), The United States of America (Cusick *et al.*, 2008), The United Kingdom (Tong *et al.*, 2019), respectively. This prevalence gap between developed and developing countries might happen due to better consumption of iron regarding its quantity and quality.

Since the anemia problem is still counted as a major health problem and according to the Global Burden of Disease Study, it is the foremost reason that might contribute to women's life burden (James *et al.*, 2018). Here, anemia prevalence in adolescent girls was a national health problem with a prevalence of more than 40% (World Health Organization, 2001). Anemia in this study is possibly caused by low intake and quality of iron. In Pandeglang district-Banten, adolescent girls ingested iron lower than the recommended dietary intake, showing only 8 mg/ day of iron consumption, which was predominantly from vegetables with lower bioavailability scores (Aji *et al.*, 2021). Consuming iron from animal sources also decreased anemia, showing a prevalence risk of 0.59 (Knijff *et al.*, 2021). In addition, anemia in adolescent girls was related to the score of a dietary quality index for adolescents (DQI-A), which showed a lower score in anemic girls and presented a positive relationship, increasing the score of DQIA by 1% magnifies the Hb level by 3.967 g/dL (Agustina *et al.*, 2020). Another potential explanation is possibly due to iron-folic acid (IFA) tablet consumption. Riskesdas 2018 explained, moreover, that the Banten IFA supplementation program for adolescent girls (10-19 years) was only accepted by 69.6% of targeted girls, which was lower than the national percentage (76.2%) (Indonesian Ministry of Health, 2018). In addition, a study highlighted that anemia in adolescent girls was less connected to knowledge such as education level, and gained knowledge of anemia from education and health workers, showing a p-value less than 0.1 (Agustina *et al.*, 2021). A study reported that anemia was also caused by other inadequate nutritional intake such as vitamin A, folic acid, vitamin B2, calcium, and vitamin C, as well as protein and energy (Laily *et al.*, 2023). Moreover, infectious diseases such as helminth infection and malaria also cause anemia (van Zutphen *et al.*, 2021).

Another laboratory test to study iron was ferritin level, which depicts iron storage condition. Results showed that the average ferritin level was 41.23±37.85, varying from 1.5 to 174 ng/dL. ID is a condition where iron storage (ferritin) in the circulation is lower than normal value, but an asymptomatic condition occurs. Grouping ID and non-ID, 36.8% of respondents were found as iron deficient since their ferritin value was below 15 ng/mL as WHO defined. Literature noted that ID could be with or without anemia. Connecting ID to anemia, the result observed that 37 of 68 (54.4%) respondents were categorized as iron deficient. WHO explained that around 50% of people with anemia were ID (Kassebaum *et al.*, 2014). A reviewed paper focusing on Indonesia highlighted a similar number ranging from 53% to 58% of anemia could be justified by ID (van Zutphen *et al.*, 2021). This might happen since people are diagnosed with anemia if only their Hb level is below normal value for age and sex, without contributing ferritin as a factor for anemia (Camaschella, 2015; Lopez *et al.*, 2016). Furthermore, anemia happens as the final consequence of ID. This phenomenon was supported when this study analysed the odd ratio between anemia and ID status, showing OR 4.083 (2.029-8.217, p = 0,000), which implies that ID girls would have a greater risk of around 4 times to have anemia compared with non-ID girls. In addition, this study also suggests that this connection was strengthened when correlating between Hb and ferritin levels, displaying a moderate correlation r = 0.497 (p = 0.000).

To tackle the ID and anemia problems, the Indonesian government campaigns to consume a balanced diet (Indonesian Ministry of Health, 2014) and provides iron supplementation in adolescent girls as a community health program (Indonesian Ministry of Health, 2016).

4. Conclusion

This study found that the prevalence of anemia was

44.7%, 54.4% of whom had iron deficiency. In addition, Iron deficiency in adolescent girls enhances the risk of progressing anemia. Therefore, increasing iron consumption through foods and supplementation might tackle anemia and iron deficiency problems.

Conflict of interest

The authors declare no conflict of interest.

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