

Associations between quantity and quality of dietary intake with haemoglobin concentration among female adolescents in Tasikmalaya, West Java, Indonesia

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ABSTRACT

Introduction: An imbalance in diet can lead to anaemia in young women, which can impact not only themselves, but also the next generation. This study aimed to determine associations between quantity and quality of dietary intake with haemoglobin (Hb) concentration among female adolescents in Tasikmalaya, West Java, Indonesia. **Methods:** A cross-sectional study was conducted on 347 young women aged 12-18 years from ten districts in Tasikmalaya City, selected by simple random sampling. Quantity and quality of dietary intake were measured by 2-repeated 24-hour dietary recalls, while portable haemoglobinometer (HemoCue® Hb 201+) was used to measure Hb concentration. Linear regression model predicted associations between quantity and quality of dietary intake with Hb concentration in female adolescents. **Results:** The proportion of subjects suffering from anaemia were 47.3%. Average intake of dietary iron was 6.7±3.0 mg and average dietary quality score was 32.6%. Dietary quality score and days of menstrual bleeding contributed as much as 12.7% to the variation in Hb concentration among female adolescents. **Conclusion:** Anaemia in female adolescents in Tasikmalaya, West Java, Indonesia is a serious public health problem. Diet quality score was associated with female adolescents' Hb concentration; therefore, improving the quality of diet is important to reduce anaemia.

Keywords: anaemia, dietary quality, dietary quantity, female adolescents, haemoglobin

INTRODUCTION

In the human life cycle, adolescents are those between the ages of 10-19 years old. There are around 1.2 billion adolescents worldwide and 90% live in low and middle-income countries (LMICs) (Shinde *et al.*, 2023). Anaemia is more common in female adolescents, especially those living in LMICs (Kundu *et al.*, 2023). Among female adolescents,

their current nutritional status is not only important for their current health status, but also for their future. Female adolescents who are anaemic are at risk of suffering from anaemia during pregnancy and pregnant mothers who are anaemic are more likely to have babies who are also anaemic (UNICEF, 2021). If this condition is not resolved, it will cause an intergenerational cycle of malnutrition.

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An imbalance of dietary intake is one of the causes of anaemia in female adolescents (Li *et al.*, 2022). Micronutrient deficiencies in adolescents are often caused by insufficient food consumption to meet the needs of rapid growth during adolescence (Cusick & Kuch, 2012). Rapid growth in adolescents results in an increased need for iron to form haemoglobin in red blood cells (Shaka & Wondimagegne, 2018). In adolescents, increased iron needs require increased consumption of iron-rich foods. Iron adequacy among adolescents is determined by the quantity and quality of their dietary intake (Hunt, 2010). The quantity and quality of iron are determined by the main meals or snacks consumed by adolescents (Hidayanti *et al.*, 2023).

Iron with good bioavailability is found in animal-source foods (ASF) (Zhang, Goldsmith & Winter-Nelson, 2016). However, ASF consumption remains low in LMICs (Adesogan *et al.*, 2020). As a country in the LMICs group, consumption patterns of Indonesians are still dominated by plant-based foods (Suryana, Martianto & Baliwati, 2019). Vegetable foods, such as leafy green vegetables and nuts, are high in iron content, but they also contain phytic acid, which can inhibit iron absorption (Bhatnagar & Padilla-Zakour, 2021). However, consumption of ascorbic acid found in fruits can overcome iron absorption barriers caused by phytic acid (Piskin *et al.*, 2022). Therefore, a quality diet is needed to prevent deficiencies of macro- and micronutrients, one of which is anaemia in adolescents (Worku, Hailemichael & Wondmu, 2017).

Tasikmalaya is located in West Java, which is home to the indigenous Sundanese people. The Sundanese are a tribe known to like all kinds of plant foods such as vegetables and fruits (Darmayanti, 2016). In a study by Rahfiludin *et al.* (2021), the prevalence

of anaemia among Sundanese is 32.4%, which is a moderate public health problem (Rahfiludin *et al.*, 2021). This study aimed to comprehensively explore the diet of female adolescents, including the quantity and quality of their dietary intake associated with haemoglobin concentration as an indicator of anaemia in this population.

MATERIALS AND METHODS

The research design used was an observational method with cross-sectional approach as the variables studied were measured simultaneously. The participants included were female adolescents aged 12-18 years who have menstruated. This research was conducted in 10 districts in Tasikmalaya City. The minimum sample size was 323 female adolescents. Calculation was based on the prevalence data for anaemia at 32.4% among female adolescents in Tasikmalaya, West Java, Indonesia (Rahfiludin *et al.*, 2021), with a 95% confidence level. The formula below was used to calculate the minimum sample size (Charan & Biswas, 2013):

$$n = \frac{Z\alpha^2 P(1 - P)}{d^2}$$

Considering non-response bias, the sample was increased by 5% and it became 354. A total of 354 out of 5841 female adolescents who lived in Islamic Boarding Schools in Tasikmalaya were selected by simple random sampling. However, three students were unwilling to participate and thus excluded from this study. Four students did not complete the 2-repeated 24-hour dietary recall assessments and their data were excluded. In total, 347 female adolescent students were included in this study. Before the study, the research objectives were explained to subjects who met the inclusion criteria. Explanation was given to the subject, as well as their

legal guardian. If the subjects agreed to participate in this research, they would sign an informed assent and their legal guardian would sign an informed consent. The study was approved by the Research Ethics Commission of Mataram Health Polytecnic, Indonesia, with protocol number LB.01.03/6/8542/22.

The dependent variable was Hb concentration, measured using capillary blood with a portable haemoglobinometer (HemoCue® Hb 201+). Haemoglobin concentration was grouped according to the World Health Organization (WHO) cut-offs into anaemia (<12 g/dL) and normal (\geq 12 g/dL). Further, anaemia was grouped into mild anaemia (11–11.9 g/dL), moderate anaemia (8–10.9 g/dL), and severe anaemia (<8 g/dL) (WHO, 2011). Measurement of Hb concentration was carried out by three competent medical personnels from local universities.

The independent variables were quantity and quality of dietary intake. Quantity of dietary intake included the consumption of energy (kcal), protein (g), iron (including haem and non-haem) (mg), vitamin C (mg), calcium (mg), and phytic acid (mg), which were measured using the 2-repeated 24-hour dietary recall method. Haem iron is obtained from animal-source foods and non-haem iron is obtained from plant-source foods. Dietary intake was taken in household portions (spoon, plate, bowl, cup, etc.), then converted into grams. The open-source NutriSurvey (SEAMEO-TROPED RCCN-University of Indonesia) was used to analyse all nutritional intake data (except phytic acid). Phytic acid was analysed using the Nutrisoft (Ministry of Health Republic of Indonesia). Quality of dietary intake was measured using the Dietary Quality Index for Adolescents (DQI-A) score instrument, which was the sum of the scores of dietary accessed (DA), dietary diversity (DD), and dietary equilibrium

(DE). Data were measured using a 2x24-hour non-consecutive recall method. Furthermore, the data were grouped into nine groups, namely 1) water, 2) bread and cereal, 3) potato and grains, 4) vegetables, 5) fruits, 6) dairy products, 7) cheese, 8) protein-source foods, and 9) oil and fat (Cuenca-garcı *et al.*, 2013). Eight nutrition students from local universities conducted the diet recalls. They had previously received training before conducting the recalls.

Demographic variables measured in this study included age and education of the subjects. Age in years was measured based on the number of years since the subject was born until the time this research was conducted. Education was the level of education received by the subject. Education was grouped into junior high school and senior high school.

This study also measured other variables that are related to Hb concentration. These variables were menstrual history (menarche, days of bleeding per menses, and menstruation during Hb examination), illness, and habit of drinking tea and coffee. Menarche was measured based on the subject's age in years when she first got her period. Days of bleeding per menses was the average number of days the subject has menstruation each month. The data on menstruation during Hb examination was measured by asking subjects whether they were menstruating during the Hb examination. The answer was "yes" if the subject was menstruating during the Hb examination, and "no" if the subject was not menstruating during the Hb examination. Illness was measured by asking the subject whether they had any illnesses such as flu, diarrhoea, etc. in the past month. The answer was "yes" if the subject had been sick in the last month, and "no" if the subject had not been sick in the last month. Data on tea and coffee drinking

habits were obtained from the results of the 2-repeated 24-hour dietary recalls. Subjects were categorised as “yes” if they drank tea or coffee within 2 days of the recall, and “no” if they did not drink tea or coffee during the recall.

Data were analysed using the IBM SPSS Statistics for Windows version 26.0 (IBM Corp., Armonk, NY, USA). Categorical data were presented in a frequency distribution table, while

continuous data were presented in mean±standard deviation (SD). Spearman’s rank was used to analyse the correlations between data on menstrual history (menarche and bleeding days per menstruation), quantity of dietary intake (consumption of energy, protein, iron, vitamin C, calcium, and phytic acid), and quality of dietary intake with Hb concentration. Independent *t*-test was used to analyse

Table 1. Characteristics of subjects

<i>Variable</i>	<i>n (%)</i>	<i>Mean±SD</i>	<i>p-value</i>
Demographic			
Age (years)		15.2±1.9	0.544 ^a
Education level			
Junior high school	146 (42.1)		0.737 ^c
Senior high school	201 (57.9)		
Menstrual history			
Menarche (years)		12.0±0.8	0.419 ^a
Days of menstrual bleeding (days)		7.1±1.2	0.072 ^{a*}
Menstruating during haemoglobin examination			
Yes	57 (16.4)		0.016 ^{b**}
No	290 (83.6)		
If yes, how many days has it been (<i>n</i> =57)			
< 4 th day	22 (38.6)		
≥ 4 th day	35 (61.4)		
Illness			
Yes	116 (33.4)		0.812 ^c
No	231 (66.6)		
A habit of drinking tea			
Yes	175 (50.4)		0.236 ^{b*}
No	172 (49.6)		
A habit of drinking coffee			
Yes	81 (23.3)		0.841 ^c
No	266 (76.7)		
Haemoglobin concentration (g/dL)			
		11.9±1.3	
Anaemia status (<i>n</i> =347)			
Normal	183 (52.7)		
Anaemia	164 (47.3)		
Anaemia grouping (<i>n</i> =165)			
Mild anaemia	90 (53.9)		
Moderate anaemia	77 (46.1)		

^aderived from Spearman’s rank, ^bderived from Mann-Whitney U test, ^cderived from independent *t*-test

*significant at *p*<0.25, **significant at *p*<0.05

Table 2. Quantity and quality of dietary intake among subjects

Variable	Mean±SD	p-value
Quantity of dietary intake		
Energy (kcal)	1431±613	0.134*
Protein (g)	31.5±13.1	0.030**
Iron (mg)	6.7±3.0	0.015**
Haem iron (mg)	1.1±1.1	0.091*
Non-haem iron (mg)	5.6±2.9	0.036**
Vitamin C (mg)	7.5±12.9	0.018**
Calcium (mg)	347.4±212.3	0.728
Phytic acid (mg)	593.3±257.2	0.702
Quality of dietary intake (DQI-A score)		
Dietary quality	27.4± 8.4	-
Dietary diversity	48.3±8.6	-
Dietary equilibrium	25.8±8.3	-
DQI-A score	33.8±5.6	<0.001**

*significant at $p<0.25$, **significant at $p<0.05$

differences in Hb concentration based on education level, illness, and habit of drinking coffee, because the data were normally distributed. Meanwhile, Mann-Whitney U test was used to analyse differences in Hb concentration based on menstruation during examination and habit of drinking tea because the data were not normally distributed. Data were considered statistically significant with a $p<0.05$. Furthermore, variables with a $p<0.25$ in the bivariate analysis were included in the linear regression analysis model.

RESULTS

Subjects who had complete data at the end of the study were 347 people (97.5%). The average age of the 347 subjects was 15 years and more than half had a senior high school education. The average age of the subject's first menstruation was 12 years old, with an average of seven bleeding days per menstruation. There were 16.4% of subjects who were menstruating when Hb concentration was checked and 33.4% of subjects who were sick in the last month. The percentage of subjects who had a habit

of consuming tea (50.4%) was almost the same as those who did not. Meanwhile, the percentage of subjects who had the habit of consuming coffee was only 23.3% (Table 1).

The average Hb concentration was 11.9 g/dL with 164 subjects (47.3%) who suffered from anaemia (Hb <12 g/dL). Of the subjects with anaemia, 90 subjects (53.9%) had mild anaemia, 77 subjects (46.1%) had moderate anaemia, and none had severe anaemia (Table 1).

Age ($p=0.544$) and education ($p=0.737$) as demographic variables were not related to Hb concentration. As for menstrual history, age of menarche ($p=0.419$) and days of bleeding per menses ($p=0.072$) were not related to Hb concentration, while Hb concentration differed based on menstrual status during Hb examination ($p<0.05$). Haemoglobin concentration did not differ based on the incidence of illness in the last month ($p=0.812$) and the habit of drinking tea ($p=0.236$) and coffee ($p=0.841$) (Table 1).

The results showed that the average dietary intakes of energy, haem iron, and iron inhibitors (calcium and phytic acid)

Table 3. Final linear regression model to predict the independent variables associated with haemoglobin concentration

Variable	β	Standardised coeff β	p-value	R	R ²
Menstruating during haemoglobin examination	0.362	0.107	0.035	0.367	0.135
Quality of the dietary intake	0.062	0.290	<0.001		

were not related to Hb concentration. However, the dietary intakes of protein, total iron, non-haem iron, and iron enhancers (vitamin C) were related to Hb concentration. The results also showed that DQA-I score was related to Hb concentration (Table 2).

At the start of linear regression modelling to predict variables related to Hb concentration, ten variables with a $p < 0.25$ were entered into the model. These variables were days of bleeding per menses, menstruation during Hb examination, habits of drinking tea, energy intake, protein intake, iron intake, haem iron intake, non-haem intake, dietary vitamin C intake, and dietary quality. At the end of the modelling, there were only two variables related to Hb concentration, namely menstruation during Hb examination ($p = 0.035$) and quality of dietary intake ($p < 0.001$) (Table 3).

DISCUSSION

This study showed that anaemia among adolescent girls in Tasikmalaya was 47.3%, which is considered a severe public health problem. This result was close to the screening results conducted by Roche *et al.* (2018), which showed that more than 50% of young women in West Java suffer from anaemia. Research by Agustina *et al.* (2020) stated that in West Java, 45% of young women experience anaemia. This result was also in line with researches in Bangladesh (Kundu *et al.*, 2023) and India (Scott *et al.*, 2022), which stated that the prevalence of anaemia in adolescents were 46.7% and 40%, respectively.

In this study, the consumption of energy, protein, iron, and vitamin C was still below the nutritional adequacy rate in Indonesia. Protein deficiency can cause several clinical syndromes, one of which is anaemia. Low protein consumption causes growth failure and worsens deficiencies of other nutrients, including iron. Protein functions as a carrier of iron to the bone marrow, which is the place for producing red blood cells (Wu, 2016). Small amounts of protein cause less iron to be carried to the bone marrow, causing a decrease in the size and colour of the red blood cells produced. This condition is characterised by low haemoglobin concentration and is known as anaemia (Ford, 2013). Low Hb concentration also occurs due to insufficient iron consumption and iron absorption (Silverberg, 2012).

Globally, most anaemia is caused by iron deficiency. Therefore, anaemia and iron deficiency anaemia are often considered synonyms. In general, an estimated 50% of the incidence of anaemia is iron deficiency anaemia (IDA). IDA occurs when the balance between iron consumption, the presence of iron stores in the body, and iron loss is insufficient for forming red blood cells or erythrocytes (Miller, 2013). A community-based survey conducted in several countries showed a specific contribution from iron deficiency in causing a high prevalence of anaemia (CDC & WHO, 2005).

In this study, dietary quality scores were correlated with Hb concentration. Research in Jambi Province, Indonesia also stated that there was a relationship

between dietary quality and Hb concentration in female adolescents (Merita *et al.*, 2019). Agustina *et al.* (2020) stated that an increase in DQI-A score was associated with a higher Hb concentration. Another factor related to anaemia in this study was menstruation during Hb examination. Menstrual bleeding is a major contributor to anaemia, therefore it should not be ignored in controlling anaemia (Nieblas-Bedolla, 2021).

This study had several limitations. Firstly, our study could not draw a causal relationship due to the cross-sectional nature of our data. Secondly, we used the recall method, which may lead to potential memory bias. The strength of this study was that we measured all components of the diet, including quantity and quality of dietary intake. In addition, we also measured other variables that might affect Hb concentration (menstrual history, illness, habit of drinking tea and coffee, calcium intake, and phytic acid intake).

CONCLUSION

Anaemia among female adolescents in Tasikmalaya, West Java, Indonesia, is a serious public health problem. Bleeding days per menstruation and dietary quality were observed to be related to Hb concentration ($p < 0.05$). Quality of dietary intake needs to be improved to prevent anaemia.

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Authors contributions

Hidayanti L, head researcher, conceptualised and designed the study, led the data collection and data analysis, wrote the manuscript; Saraswati D, supervised data collection, assisted in data analysis and interpretation, reviewed the manuscript; Aisyah ES, supervised data collection and reviewed the manuscript.

Conflict of interest

We declare no conflict of interest in this study.

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