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Dietary patterns and haemoglobin levels in female adolescents living in boarding schools in Tasikmalaya city, Indonesia

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ABSTRACT

Introduction: Anaemia is prevalent among female adolescents with low dietary intake of iron-rich foods, which is considered a significant risk factor. This study investigated the contribution of main meals and snacks to the total dietary intake and haemoglobin (Hb) levels in female adolescents attending Islamic boarding schools. **Methods:** This cross-sectional study involved 323 female adolescents residing full-time in eight Islamic boarding schools in Tasikmalaya City, West Java, Indonesia. Data collected included dietary intake (total dietary intake, main meals, and snacks) and Hb levels. **Results:** The average Hb level was 11.9 g/dL, with 49.2% subjects being anaemic. The average total dietary iron intake in subjects with anaemia (6.7 mg) was lower than those without anaemia (7.5 mg). Anaemic subjects with dietary iron intake <80% Recommended Dietary Allowances (RDA) (50.5%) were more prevalent than those with dietary iron intake ≥ 80% RDA (39.8%). In anaemic subjects, the majority of dietary iron intake came from snacks (55.1%), whereas in non-anaemic it predominantly came from main meals (53.7%). A significant correlation exists between total dietary iron intake and Hb levels (p=0.011), underscoring the importance of adequate dietary iron intake. **Conclusion:** The finding indicates that total dietary iron intake contributes to increased Hb levels, therefore it is important to provide awareness regarding iron adequacy in female adolescents.

Keywords: anaemia, dietary intake, female adolescents, iron, snacks

INTRODUCTION

A haemoglobin (Hb) level below 12 g/dL defines anaemia in female adolescents (WHO, 2024). The presence of anaemia in this demographic is crucial as it influences the health status of future generations (UNICEF, 2019). Anaemia can impair immunity in young women, heightening their susceptibility to infectious diseases (Abuga *et al.*, 2023), lead to decreased learning ability (Nguyen *et al.*, 2022), and reduced work productivity (Mitchell *et al.*, 2020). As these adolescents transition into adulthood, many will become pregnant and anaemia often persists into pregnancy. Anaemia during

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pregnancy is associated with increased risks of maternal mortality and adverse pregnancy outcomes (Edelson *et al.*, 2023).

Adolescence is a period of rapid growth in the human life cycle, necessitating increased nutritional intake, including iron. These heightened nutritional requirements are essential to support this accelerated growth (WHO, 2014). Additionally, menstruation in female adolescents further elevates their iron needs (Endale *et al.*, 2022). Despite these increased requirements, female adolescents often restrict their dietary intake to avoid weight gain, making meeting their Recommended Dietary Allowances (RDA) challenging (Cohen & Powers, 2024).

Many adolescents' diets are deficient in macro- and micronutrients, including iron (Zimmerman *et al.*, 2023). Adolescents' eating habits often involve snacking on energy-dense foods and drinks, skipping meals, and adhering to various diets (Girma Sisay *et al.*, 2024). A low frequency of main meals intake and the habit of skipping breakfast can increase the risk of anaemia in female adolescents (Agustina *et al.*, 2020). Those residing in boarding schools typically consume two to three main meals per day on a fixed schedule and often supplement their diet with snacks outside boarding school (Nicholaus *et al.*, 2020).

In 2019, the World Health Organization (WHO) estimated that 30% (539 million) of non-pregnant women worldwide suffered from anaemia. The most significant burden of anaemia is borne by low- and middle-income countries (LMICs), particularly among populations in rural areas with low economic status and limited education. In Indonesia, an LMIC, the prevalence of anaemia among adolescent girls remains at 30%. Indonesia has a population of 128.1 million women, with 17.5% female adolescents (22.4 million), of which 2.2 million (9.9%) have dropped out of school. In 2018, one in nine young Indonesian women aged 20-24 were married before the age of 18 (UNICEF & PUSKAPA, 2020).

The majority of Indonesia's population is Muslim and the country has a significant number of Islamic boarding schools. Students often reside in these schools to study both Islamic and general knowledge. Tasikmalaya City, located in West Java Province, is Indonesia's most populous province and hosts the highest number of Islamic boarding schools. This study investigates the contribution of dietary patterns, specifically the dominance of main meals and snacks, to Hb levels in female adolescents residing in Islamic boarding schools. Additionally, it examines the impact of other factors on these adolescents' Hb levels.

METHODOLOGY

This research was done at Islamic boarding schools known as "*pondok pesantren*" in Tasikmalaya City, West Java, Indonesia. In Tasikmalaya City, there are Islamic boarding schools that provide two main meals a day and there are also those that provide three main meals a day. We purposely select boarding schools that provide two main meals per day to represent students with low economic status. The inclusion criteria for this study are students who lived and ate twice a day at a boarding school. Meanwhile, the exclusion criteria are boarding schools that refused to be involved in this study. Eight boarding schools met the inclusion criteria and were willing to participate in this research.

The population in this study are female adolescents known as "*santriwati*", aged 12 to 18, menstruating, and registered at Islamic boarding schools.

The minimum sample size is determined at a 95% confidence interval level based on the prevalence of anaemia in female adolescent students in Tasikmalaya City, as reported by Rahfiludin *et al.*, which was 32.4% (Rahfiludin *et al.*, 2021). After accounting for a 10% anticipated non-response rate, the required sample size is established at 356. Thirty-three (33) participants are excluded from the study because 11 had incomplete recall results, 10 left the boarding school, and 13 did not complete the questionnaire.

This research has received permission from the Tasikmalaya government. After providing a detailed explanation of the study, each boarding school principal and female student who met the inclusion criteria and expressed willingness to participate in the study signed a consent form. Parents or legal guardians also signed a consent form. The Research Ethics Commission of the Faculty of Public Health, Universitas Diponegoro, Indonesia approved this research (Protocol Number: 39/EA/KEPK-FKM/2020).

This study was observational, with baseline data collected to design a specific intervention study. We used a cross-sectional as all variables were measured once. The dependent variable was Hb level. Haemoglobin levels (g/dL) were measured using capillary blood samples drawn from the fingertip by a competent local health worker. The HemoCue™ Hb 201+ portable device was used as it has been shown to be adequate for Hb assessment in the general population (Levy *et al.*, 2017). The test was performed between 7:00 and 11:00 AM. Haemoglobin levels were categorised as non-anaemic (≥12 g/dL) and anaemic (<12 g/dL). Anaemia was further categorised as mild anaemia (11.0-11.9 g/dL), moderate anaemia (8.0-10.9 g/dL), and severe anaemia (<8 g/dL) (WHO, 2024).

The independent variable in this study was dietary intake, including main meals provided by the Islamic boarding school and snacks purchased from outside the school. Subjects received two main meals daily, one in the morning and one in the evening. In the morning, the main meal was served between 7:00 and 10:00 AM and in the evening, the main meal was served at 5:00 PM. Dietary intake was obtained from the average of 3x24-hour non-consecutive dietary recall methods, which included energy (kcal), protein (g), fat (g), carbohydrate (g), and iron (mg). After that, the percentage of dietary intake was calculated based on the Indonesian RDA, and grouped into <80% and ≥80% RDA. Food photo books were used to determine household portion sizes to improve the accuracy of dietary intake measurements. To ensure the accuracy of snack consumption data, we purchased and weighed local snacks. For commercially packaged snacks, we used the weight and nutritional information listed on the packaging. The open-source software NutriSurvey (http://www.fao.org/infoods/infoods/software-tools/en/) was used to analyse dietary intake data. The food database in NutriSurvey includes the 2017 Indonesian Food Composition Table published by the Ministry of Health of the Republic of Indonesia.

During the study, the nutritional content of local snacks was determined based on the raw materials used, while for commercially packaged snacks, the nutritional content was obtained from the nutritional information available on the packaging. Dietary intake (energy, protein, fat, carbohydrate, and iron) was assessed as the total intake from snacks and main meals. After that, it was classified according to the dominant nutrient source, whether from snacks or main meals. If the nutrient intake (energy, protein, fat, carbohydrate, and

iron) from the main meals exceeded the intake from snacks, it was categorised as a main meal-dominant intake. Conversely, if the intake from snacks exceeded the main meals, it was categorised as a snack-dominant intake.

This study also collected data on confounding variables, including subject characteristics (age, education level, pocket money, and health status), menstrual characteristics (menstrual status at the time of Hb examination, menstrual duration, age of menarche, and time interval since menarche), daily activities (sleep duration and physical activity), and parental characteristics (parental education and employment status). Age was measured in years from birth to the time of the study, categorised as 12–15 years and 16–18 years. Education referred to the highest level of formal education achieved by the subjects at the time of the study, categorised as elementary school, junior high school, or senior high school. Subjects reported the average daily pocket money received from their parents, which was divided into two categories: <IDR 20000 per day and ≥IDR 20000 per day. In addition, subjects were asked whether they had experienced any illness in the past month, with answers categorized as "yes" or "no."

When Hb levels were assessed, subjects were inquired about their menstruation status, categorised into menstruating and not menstruating. The duration of menstruation was recorded as the number of days from the first day to the last of bleeding. It was further classified into < 8 days and ≥ 8 days. The age of menarche refers to the time when a woman experiences her first menstruation. The interval since menarche was defined as the number of years from the start of menstruation to the time of the study, divided into two categories: ≤ 2 years and > 2 years (Wang *et al.*, 2024). Sleep duration was measured in hours, starting from the time the subject went to bed until waking up, categorised as ≤ 5 hours per day and > 5 hours per day. Physical activity was assessed based on the frequency of sports activities undertaken by the subject in a week, grouped into < 3 times per week and ≥ 3 times per week.

Mothers' and fathers' education levels were classified as non-formal, elementary school, junior high school, senior high school, and university. Mother's employment status was categorised as unemployed or employed, while father's employment status was categorised as informal or formal.

All data are presented based on anaemia status (anaemic and non-anaemic). Categorical data are presented as frequencies and percentages, while continuous data are presented as means ± standard deviations (SD). An independent *t*-test was used to test for differences in independent and confounding variables based on anaemia status when all variables followed a normal distribution. Conversely, the Mann-Whitney test was used if the variables did not meet this assumption. The Kolmogorov-Smirnov test was performed to assess the normality of data distribution, with a significance threshold set at $p \geq 0.050$. Categorical data were analysed using the chi-square test. Variables with a $p < 0.250$ were considered for inclusion in linear regression modelling. Statistical significance was defined as a $p < 0.050$.

RESULTS

The average Hb level recorded was 11.8 g/dL, with 49.2% of subjects classified as anaemic, while the remaining 50.8% were classified as non-anaemic. Among those classified as anaemic, 48.4% were mildly anaemic, 50.9% were moderately anaemic, and 0.6% were severely anaemic (see Table 1). Table 2 presents a description of demographic

Table 1. Haemoglobin status of female adolescents in Islamic boarding schools in Tasikmalaya, Indonesia

Haemoglobin (n=323)	*n (%)*	*Mean±SD*
Haemoglobin level (g/dL)		11.8±1.4
Anaemia status		
Anaemia	159 (49.2)	
Non-anaemia	164 (50.8)	
Anaemia grouping (*n*=159)		
Mild	77 (48.4)	
Moderate	81 (50.9)	
Severe	1 (0.6)	

factors according to anaemia status. In the anaemia categories, the average age of subjects was 14 years, while in the non-anaemia categories it was 15 years. More than half of the subjects in the anaemia categories had a junior high school education, while those in the non-anaemia categories had an elementary school education. In the anaemia categories, the education of the subjects' mothers and fathers was almost the same between elementary school-junior high school and high school-university. Likewise, the employment status of mothers in the anaemia group was almost the same between those unemployed and those employed (see Table 2).

In the anaemia categories, 57.5% of subjects reported experiencing menstruation at the time of the Hb examination, whereas this figure was 42.4% in the non-anaemia categories. Subjects in the anaemia categories had an average menstrual duration of seven days, a menarche age of 11 years and an interval from menarche to Hb examination of three years. Additionally, subjects suffering from anaemia (4.9 hours per day) had shorter sleep duration than those who did not suffer from non-anaemia (5 hours per day). Both groups reported engaging in physical activity less than three times a week (see Table 2).

In addition, subjects' education, parents' education, and parents' occupation did not differ significantly between subjects who suffered from anaemia or not. Daily activities, including sleep duration and levels of physical activity, were also comparable between the categories. Similarly, aspects such as the age of menarche, menstrual length, and the interval from menarche to the Hb examination showed no significant differences between the anaemia and non-anaemia groups (see Table 2).

Table 3 presents the dietary intake from main meals and snacks among subjects with differing anaemia statuses. Both the anaemic and non-anaemic groups exhibited higher energy, fat, and carbohydrate intake from snacks compared to main meals; however, protein and iron intakes from snacks was lower than that from main meals. Within the anaemic group, snacks provided the highest amounts of energy, protein, carbohydrates, and iron, while main meals were the primary source of fat intake. Conversely, in the non-anaemic group, snacks were the leading source of fat, whereas the majority of energy, protein, carbohydrates, and iron came from main meals (see Table 3).

Total daily iron intake was found to differ between the anaemic and non-anaemic groups ($p<0.050$), whereas total energy, protein, fat, and

Table 2. Demographic factors according to the anaemia status of female adolescents in boarding schools in Tasikmalaya City, Indonesia

Demographic factors	*Anaemia (n=154)*		*Non-anaemia (n=169)*		*p*	*Crude odds ratio cOR (95% CI)*
	n (%)	*Mean±SD*	*n (%)*	*Mean±SD*		
Subject's characteristic						
Age (years)[b]		14.9±1.9		15.2±1.9	0.191	
12-15[c]	88 (52.1)		81 (47.9)		0.337	1.270 (0.820-1.967)
16-18	71 (46.1)		83 (53.9)			
Education level						
Elementary school	21 (42.0)		29 (58.0)			
Junior high school	82 (51.6)		77 (48.4)			
Senior high school	56 (49.1)		58 (41.6)			
Education level[c]						
Elementary, junior high school	102 (49.3)		106 (50.7)		1.000	1.006 (0.638-1.589)
Senior high school	56 (49.1)		58 (50.9)			
Pocket money (IDR per day)[b]		287798.7±114491.9		285091.5±114129.7	0.755	
< IDR 20000[c]	91 (50.3)		94 (49.7)		0.741	1.105 (0.710-1.721)
≥ IDR 20000	64 (47.8)		70 (52.2)			
Illness[c]						
Yes	17 (45.9)		20 (54.1)		0.803	0.862 (0.434-1.713)
No	142 (49.7)		144 (50.3)			
Subject's menstruation characteristic						
Menstruation during haemoglobin test[c]						
Yes	34 (57.6)		25 (42.4)		0.199	1.512 (0.855-2.674)
No	125 (47.3)		139 (52.7)			
Menstrual duration (days)[b]		7.0±1.3		7.1±1.3	0.235	
< 8[c]	116 (52.5)		105 (47.5)		0.108	1.516 (0.944-2.434)
≥ 8	43 (50.2)		59 (57.8)			
Age of Menarche (years)[b]		11.8±0.8		11.9±0.9	0.111	
The time interval from menarche (years)[c]		3.0±1.9		3.2±1.5	0.392	
≤ 2	66 (53.2)		58 (46.8)		0.307	1.297 (0.827-2.033)
> 2	93 (46.7)		106 (53.3)			

to be continued...

Table 2. Demographic factors according to the anaemia status of female adolescents in boarding schools in Tasikmalaya City, Indonesia (continued)

Demographic factors	*Anaemia (n=154)*		*Non-anaemia (n=169)*		*p*	*Crude odds ratio cOR (95% CI)*
	n (%)	*Mean±SD*	*n (%)*	*Mean±SD*		
Subject's daily activities						
Sleep duration (hours per day)[b]		4.9±0.8		5.0±0.8	0.206	
≤ 5[c]	136 (52.3)		124 (47.7)		0.024*	1.907 (1.081-3.365)
> 5	23 (36.5)		40 (63.5)			
Physical activity (times per week)[b]		1.5±1.5		1.5±1.4	0.931	
< 3[c]	125 (48.6)		132 (51.4)		0.677	0.891 (0.519-1.531)
≥ 3	34 (51.5)		32 (48.5)			
Parental characteristic						
Mother's education level						
Elementary school	99 (46.7)		113 (51.3)			
Junior high school	35 (57.4)		26 (42.6)			
Senior high school	19 (47.5)		21 (52.5)			
University	6 (60.0)		4 (40.0)			
Mother's education level[c]						
Elementary, junior high school	134 (49.1)		139 (50.9)		1.000	0.964 (0.527-1.762)
Senior high school, university	25 (50.0)		25 (50.0)			
Father's education level						
Elementary school	110 (49.8)		111 (50.2)			
Junior high school	21 (47.7)		23 (52.3)			
Senior high school	24 (49.0)		25 (51.0)			
University	4 (49.2)		5 (51.8)			
Father's education level[c]						
Elementary, junior high school	131 (49.4)		134 (50.6)		0.988	1.047 (0.593-1.849)
Senior high school, university	28 (48.3)		30 (51.7)			
Mother's employment status[c]						
Unemployed	139 (49.3)		143 (50.7)		1.000	1.021 (0.530-1.966)
Employed	20 (48.8)		21 (51.2)			
Father's employment status[c]						
Informal sector	149 (48.9)		156 (51.1)		0.756	0.764 (0.294-1.988)
Formal sector	10 (55.6)		8 (44.4)			

[a] derived from the independent *t*-test; [b] derived from Mann Whitney; [c] derived from Chi-square

* significant at $p<0.050$

Table 3. Dietary intake according to the anaemia status of female adolescents in Islamic boarding schools in Tasikmalaya City, Indonesia (*n*=323)

Dietary intake	*Anaemia (n=154)*		*Non-anaemia (n=164)*		*p*	*Crude odds ratio cOR (95% CI)*
	n (%)	*Mean±SD*	*n (%)*	*Mean±SD*		
Energy						
Total energy intake (kcal)[b]		1439±475			0.360	
< 80%RDA[c]	108 (48.6)		114 (51.4)		0.851	0.929 (0.580-1.487)
≥ 80% RDA	51 (50.5)		50 (49.5)			
Energy intake from snacks (kcal)[b]		779±195			0.925	
Energy intake from main meals (kcal)[a]		659±195		714±445	0.012*	
Domination of energy Intake						
Snack-predominant energy intake	82 (50.9)		79 (49.1)		0.541	1.146 (0.741-1.773)
Main meal-predominant energy intake	77 (47.5)		85 (52.5)			
Protein						
Total protein intake (g)[b]		30.9±9.8		33.9±12.8	0.069	
< 80%RDA[c]	152 (51.0)		146 (49.0)		0.045*	2.677 (1.086-6.598)
≥ 80% RDA	7 (28.0)		18 (72.0)			
Protein intake from snacks (g)[b]		13.1±7.9		13.6±8.6	0.721	
Protein intake from main-meals (g)[b]		17.8±7.8		20.4±8.7	0.002*	
Domination of protein intake						
Snack-predominant protein intake	52 (55.9)		41 (44.1)		0.160	1.458 (0.898-2.367)
Main-meal-predominant protein intake	107 (46.5)		123 (53.5)			
Fat						
Total fat intake (g)[b]		42.9±20.0		43.7±20.2	0.584	
< 80%RDA[c]	121 (48.6)		128 (51.4)		0.776	0.896 (0.533-1.506)
≥ 80% RDA	38 (51.4)		36 (48.6)			
Fat intake from snacks (g)[b]		28.9±19.9		27.8±18.5		
Fat intake from main meals (g)[b]		13.9±7.1		15.8±7.8	0.024*	
Domination of fat intake					0.797	
Snack-predominant fat intake	114 (48.9)		119 (51.1)		0.961	0.958 (0.589-1.558)
Main-meal-predominant fat intake	45 (50.0)		45 (50.0)			

to be continued...

Table 3. Dietary intake according to the anaemia status of female adolescents in Islamic boarding schools in Tasikmalaya City, Indonesia (*n*=323) (continued)

Dietary intake	*Anaemia (n=154)*		*Non-anaemia (n=164)*		*p*	*Crude odds ratio cOR (95% CI)*
	n (%)	*Mean±SD*	*n (%)*	*Mean±SD*		
Carbohydrate						
Total carbohydrate intake (g)[b]		245.7±84.5		249.9±84.7	0.694	
< 80% RDA[c]	83 (50.0)		76 (48.4)		0.861	1.066 (0.689-1.649)
≥ 80% RDA	83 (50.0)		81 (51.6)			
Carbohydrate intake from snacks (g)[b]		132.2±84.5		130.7±81.4	0.906	
Carbohydrate intake from main meals (g)[a]		113.4±33.6		119.2±30.9	0.108	
Domination of carbohydrate intake						
Snack-predominant carbohydrate intake	82 (50.9)		79 (49.1)		0.617	1.146 (0.741-1.773)
Main-meal-predominant carbohydrate intake	77 (47.5)		85 (52.5)			
Iron						
Total iron intake (mg)[b]		6.7±2.0		7.5±2.8	0.036*	
< 80% RDA[c]	145 (50.5)		142 (49.5)		0.255	1.605 (0.790-3.260)
≥ 80% RDA	14 (38.9)		22 (61.1)			
Iron intake from snacks (mg)[b]		3.0±1.3		3.1±2.1	0.915	
Iron intake from main meals (mg)[b]		3.7±1.8		4.4±1.9	0.001**	
Domination of iron intake						
Snacks-predominant iron intake	59 (55.1)		48 (49.9)		0.168	1.426 (0.895-2.271)
Main-meals-predominant iron intake	100 (46.3)		116 (53.7)			

RDA: Recommended Dietary Allowances
[a]derived from independent *t*-test; [b]derived from Mann Whitney; [c]derived from Chi-square
*significant at $p<0.050$; **significant at $p<0.001$

Table 4. Final model for dietary intake on haemoglobin levels of female adolescents in Islamic boarding schools in Tasikmalaya City, Indonesia

Variables	*Beta*	*Standardised coefficient beta*	*p-value*	*R*	R^2
Age of menarche	0.182	0.110	0.047*	0.171	0.029
Total iron intake	0.083	0.142	0.011*		

*Significant at $p<0.050$

carbohydrate intake did not show significant differences between the two groups. The consumption of nutrients (energy, protein, fat, carbohydrate, and iron) from snacks also did not vary between the anaemic and non-anaemic subjects. However, when examining main meals, only carbohydrate intake was similar between the two groups, while energy, protein, fat, and iron intake were significantly different ($p<0.050$). The predominance of energy, protein, fat, carbohydrate, and iron intake from snacks did not increase the risk of anaemia among female adolescents (see Table 3).

In the first model, six variables (age, period length, menarche, sleep duration, total protein intake, and total iron intake) had $p<0.250$ and were included in the model. In the linear regression analysis, modelling was carried out four times by removing one by one the variables that had a $p\geq0.050$. In the final modelling, the two remaining variables associated with Hb levels ($p<0.050$) were total iron intake and age of menarche (see Table 4).

DISCUSSION

This study represents the first investigation into female adolescents living in Islamic boarding schools (*santriwati*), who consume two main meals a day. It aims to provide insights into the relationship between dietary intake and Hb levels. Furthermore, the research explores how individual characteristics, daily activities, and parental influences affect anaemia status. This research was conducted in Tasikmalaya, a city known as the "*Santri* City" (city of Islamic boarding schools), located in West Java province. West Java province has the largest number of Islamic boarding schools (*pondok pesantren*) in Indonesia. The province has 8,343 Islamic boarding schools with approximately 148,987 resident students (*santri mukim*) (Fuaddah & Agung, 2023).

Our finding of anaemia incidence at 49.2% was higher than the 45% reported by Agustina *et al.* in 2016, which examined 326 junior and senior high school students aged 12 to 19 years across three districts in West Java (Agustina *et al.*, 2020). In their study, respondents lived in their own homes and had a varied diet. In contrast, our subjects were female adolescent students (*santriwati*), who resided full-time in boarding schools that offered two meals a day. All participants consumed the main meals provided by their boarding school, resulting in a less varied diet. Although the boarding school offered different menus for breakfast and dinner, rice was consistently served at both meals.

In addition to main meals, nutritional intake is significantly influenced by snack consumption (Enriquez & Gollub, 2023). This study revealed that iron (Fe) intake predominantly comes from main meals rather than snacks in both anaemic and non-anaemic groups. Traditional snacks, particularly street foods, are commonly consumed in developing

countries. Most of these foods are made from flour and are typically fried, resulting in a high content carbohydrate and fat but low levels of protein and iron (Hidayanti *et al.*, 2023). Snacking has developed into a regular eating habit among adolescents, with most of them engaging in this behaviour daily, both at school and home (Hidayanti *et al.*, 2022a). As a result, it is crucial to enhance nutritional knowledge among adolescents. This can empower them to make healthier snack choices, ultimately increasing their overall nutrient intake, including iron (Hidayanti *et al.*, 2022b).

Total dietary iron intake is closely tied to an individual's Hb level. A meta-analysis indicated that dietary intakes are linked to the prevalence of anaemia (Wiafe, Ayenu & Eli-Cophie, 2023). The dietary intake of iron, particularly heme iron, is associated with Hb levels in female adolescents (Rahfiludin *et al.*, 2021). Iron is a crucial element in the synthesis of Hb and plays an essential role in oxygen transport, serving as a significant component of oxygen carriers (Dutt, Hamza & Bartnikas, 2023).

In this study, the age of menarche was also found to correlate with Hb levels in female adolescents. Supporting this, the data from National Health and Nutrition Examination Survey (NHNES) reported similar findings, noting that the number of menstrual years was related to the incidence of anaemia (Sekhar *et al.,* 2017). Research conducted on female adolescents in India further demonstrated the connection between menarche and the prevalence of anaemia (Kavthekar *et al.*, 2016). Menarche, the initial occurrence of menstruation in women, varies across individuals. Routine menstrual bleeding can lead to iron loss, contributing to anaemia (Munro *et al.*, 2023).

To overcome anaemia, the Indonesian government has launched an iron supplementation programme for female adolescents aged 10-19 who have menstruated, including adolescents in Islamic boarding schools (Ministry of Health Republic Indonesia, 2018). However, based on the 2018 Indonesia Basic Health Research, only 76.2% of female adolescents have received iron supplementation in the last 12 months; and only 1.4% of female adolescents are obedient in consuming iron supplementation of at least ≥ 52 pills in a year (Ministry of Health Republic Indonesia, 2019). In Islamic boarding schools, education about anaemia for school managers and female students has been shown to increase iron intake from main meals (Hidayanti *et al.*, 2022b).

The primary limitation of this research lies in data collection method for the independent variables, which relies on interviews. This could raise potential memory bias and subjectivity in responses. To mitigate these biases, we opted for face-to-face interviews. Nevertheless, this study has also taken into account other factors that may influence Hb levels beyond dietary intake.

CONCLUSION

This study enhances existing national data regarding the incidence of anaemia among female adolescents aged 12 to 18, particularly within Islamic boarding schools, where the reported figures remain alarmingly high. Our findings indicate that increased dietary iron intake correlates with higher Hb levels in these girls. These results can serve as a foundation for interventions aimed at improving the anaemia status of female adolescents in Islamic Boarding Schools by improving awareness of the nutritional quality of main meals and snacks to meet iron requirements.

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Conflict of interest

We declare no conflict of interest in this study.

Authors' contributions

Hidayanti L, head researcher, conceptualised and designed the study, lead the data collection, data analysis, and write the manuscript; Murwani R, supervision on data collection, data interpretation, and manuscript proofread.

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