Original Article

Anaemia and iron deficiency anaemia among young adolescent girls from peri urban coastal area of Indonesia

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Anaemia due to iron deficiency is still a widespread problem. Among adolescent girls, it will bring negative consequences on growth, school performance, morbidity and reproductive performance. This cross sectional study aimed to identify the different nutritional and iron status characteristics of young adolescent girls 10 – 12 years old with iron deficiency anaemia and anaemia without iron deficiency in the rural coastal area of Indonesia. Anaemic girls ($N = 133$) were recruited out of 1358 girls from 34 elementary schools. Haemoglobin, serum ferritin, serum transferrin receptor and zinc protophorphyrin were determined for iron status, whilst weight and height were measured for their nutritional status. General characteristics and dietary intake were assessed through interview. Out of 133 anaemic subjects, 29 (21.8%) suffered from iron deficiency anaemia, which was not significantly related to age and menarche. About 50% were underweight and stunted indicating the presence of acute and chronic malnutrition. The proportion of thinness was significantly higher ($P <0.05$) among subjects who suffered from iron deficiency anaemia (51.7% vs. 29.8%). Furthermore, thin subjects had a 5 fold higher risk of suffering from iron deficiency anaemia ($P < 0.05$) than non-thin subjects (OR: 5.1; 95%CI 1.34 -19.00). Further study was recommended to explore other factors associated with anaemia and iron deficiency anaemia, such as the thalassemia trait and vitamin A deficiency. The current iron-folate supplementation program for pregnant women should be expanded to adolescent girls.

Key Words: iron, deficiency, anaemia, adolescent, girls, urban, Indonesia.

Introduction

Despite more than 30 years of iron supplementation program, anaemia is still a widespread problem among pregnant women and under-five children in Indonesia. Intervention through iron supplementation during pregnancy might be too late for improving pregnancy outcomes as many women are already anaemic or iron deficient when they enter pregnancy. Many adolescent girls from rural areas usually drop out from school and enter marriage during adolescent period or at around 17 years.[1] Therefore, anaemia prevention has to start prior to pregnancy, or even earlier, during adolescence period, considering that anaemia among adolescent girls will bring negative consequences on growth, school performances[2-4], morbidity status[5] and future reproductive performance.[6,7]

The definition for anaemia refers to an abnormally low haemoglobin level due to pathological conditions related to nutritional and non-nutritional factors. Iron deficiency is one of the most common causes of nutritional anaemia.[8] Iron deficiency anaemia (IDA) is a condition in which severe iron deficiency causes anaemia. Some functional consequences such as cognitive impairment, decreased physical activity and reduced immunity are commonly associated with iron deficiency anaemia. Iron is needed for haemoglobin formation. Approximately 73 percent of the body's iron is normally incorporated into haemoglobin, 12 percent in the storage complexes of ferritin and hemosiderin, and 15 percent is incorporated into other iron–containing compounds such as enzymes. When iron intake does not meet the requirement for normal iron turn over, iron stores can become exhausted.[10,11] Low dietary iron intake (below 2/3 of RDA[9]), is the major cause of anaemia in Indonesia. In addition, iron in a rice-based diet has poor bioavailability, which leads to poor iron absorption. Other nutrition factors causing anaemia are deficiencies of protein, folic acid, vitamin B12, vitamin A and copper.[7,10,11] Non-nutritional causes of anaemia include chronic infections such as malaria, worm infestation and hereditary haemoglobinophathies such as thalassemia and sickle cell diseases.[7,10]

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The Indonesian National Household Health Survey in 2001 showed that 30% of adolescent girls (10-19 yrs) were anaemic (haemoglobin level <120 g/l).[12] This figure is similar to findings from other smaller studies showing an anaemia prevalence between 22% and 44%[13-15], indicating that anaemia is a public health problem in Indonesia. According to WHO guidelines, anaemia is considered a public health problem when the prevalence is higher than 15%.[10]

This cross sectional study was carried out to show the characteristics of adolescent girls 10–12 years old suffering from iron deficiency anaemia compared to those who suffered from anaemia without iron deficiency. This study was the first stage of a larger study on the effects of iron-zinc supplementation on iron-zinc status and morbidity status amongst anaemic adolescent girls.

Material and methods

Subjects

School girls from 34 elementary schools in two sub-districts of the coastal area of Teluk Naga and Kosambi were studied. Sub-districts, Tangerang District, Banten Province, Indonesia were recruited. Initially, 1358 girls aged 10-12 years old were screened for haemoglobin using Hemocue from finger prick. Those who had haemoglobin concentration <115 g/L ($N = 238$) were given antihelminthic drug (a single dose of 500 mg mebendazole). One week after deworming, a second blood drawing (at this time venous blood) was carried out and those who had haemoglobin concentration <120 g/L ($N = 133$) were enrolled in the study.

Study area

The study area was located around 30 km west of Jakarta. The total population of two sub-districts was 113.000, of which 23.000 (11.5%) were aged 10-14 years old. The illiteracy rate was 16% which was higher than the national level (10.2%). The income per capita was 4 millions rupiah/ year in Teluk Naga and 2 millions rupiah/ year in Kosambi, which were lower than the national income per capita (7.1 millions rupiah/year; 1 US$= 9.220 rupiah as of February 7th, 2005).[16] These data indicate that both areas can be categorized as poor areas.

Laboratory measurement

Venous blood drawing was performed by an experienced nurse during 8.00–10.00. Haemoglobin concentration was determined using cyanmethaemoglobin method (Cell Dyn 1700). Serum ferritin concentration and serum transferrin receptor concentration were assessed using ELISA method with equipment of Labsystems (Multiskan Ascent). Zinc protophorphyrin was measured using portable hematofluorometer of the Helena ProtoFluor® Reagent System. Anaemia[6] was defined when haemoglobin (Hb) concentration was <120 g/L, whilst subjects were categorized as having iron deficiency anaemia if haemoglobin (Hb) concentration was <120g/L[17], serum ferritin (SF) concentration <12µg/L[18], serum transferin receptor (TfR) concentration >8.5mg/L[19] and zinc protophorphyrin (ZPP) value >40 µmol/mol heme.[20]

Anthropometric measurement

Measurement of body weight and height was conducted by a trained nutritionist using standardized procedures.[21] Body weight was measured using the platform weighing Scale (770 alpha; SECA, Hamburg, Germany) to the nearest 0.1 kg and body height with Microtoise tape (Microtoa Type Height Measure; CHASMORS LIMITED) to the nearest 0.1 cm.

Nutritional status was defined on the basis of Z-scores of weight-for-age (WAZ) and height-for-age (HAZ) according to WHO-NCHS, 1983.[22] In this study, 10 (7.5%) subjects had heights >145.0cm, therefore, the BMI-for-Age (BMI/A) according to the NHANES reference values, 2002[23] was used to assess thinness.

Subjects were categorized to have normal nutritional status when their BMI for age lay between ≥2 SD and <+2 SD, whereas underweight was defined when WAZ <- 2SD, stunting when HAZ <- 2SD, and thinness when BMI-for-Age < - 2SD.

Food and nutrient intakes

Dietary intake was assessed using 1 x 24 hour recall and food frequency questionnaire. Food models and household measurements were used to assist subjects in defining portion size. Fifteen mothers were interviewed to verify their daughter's answers, particularly to ascertain the ingredients in foods/dishes. Energy and nutrient intakes was calculated using software of NutriSurvey and World Food program on the basis of the Indonesian Food Composition Tables (MOH-RI, 1979,1995,2001)[24-26] and compared to the Indonesian RDAs.[27] Data from the 24-hour Food Recall and FFQ were also used to estimate the bioavailability of iron consumed. The available iron intake was calculated by taking into account the iron content of foods/meals along with the presence of iron enhancers (heme-iron and vitamin C promote iron absorption) and inhibitors (phytate and tea inhibit iron absorption) (method adopted from Gibson and Fergusson in 1999[28]). The formula to calculate the available iron is: "Available iron intake (mg/day) = {(bioavailability of iron (%) x non heme iron intake (mg/d)} + heme iron intake". Age and menarche were obtained from interview.

Statistical analysis

All statistical analyses were performed by using the program Statistical Package for Social Sciences (SPSS) for windows version 11.5. Data were checked for normal distribution by the Kolmogorov-Smirnov test of normality. The descriptive statistics of mean, standard deviation (SD) and the proportion (%) of numeric values were calculated. Relationships between menarche, nutritional status, iron dietary intake and status of anaemia were analyzed using Chi-Square test. Multivariate ANOVA was performed to determine the characteristics of age, menarche, nutritional and iron status among subjects who suffered from iron deficiency anaemia.

Ethical approval

Parents were informed about the procedures and purpose of the study. Subjects were enrolled in the study after written informed consent was obtained from the mothers

or fathers. The protocol was approved by the Ethical Committee of the Faculty of Medicine, University of Indonesia and the Local Government of Tangerang District.

Results

Profile of the adolescent girls

In general, the hygiene and sanitation condition of this population was poor, as reflected by 30.1% of subjects still had a habit to defecate in the river, sea or garden. Only 11 (8.3%) girls had menarche and the average age of menarche was 11 years old. Table 1 shows the characteristics of subjects with iron deficiency anaemia compared to non-iron deficiency anaemia subjects in terms of

Table 1. Characteristics of subjects, weight, height, Body Mass Index and iron status.

Variable :	Non-IDA[†] (N = 104)	IDA[‡] (N = 29)	P value
Menarche (n, %):	9 (8.7)	2 (6.9)	0.763
Age (yrs)[1]	10.5 ± 0,5	10.5 ± 0.6	0.723
Weight (kg)[1]	26.7 ± 5.6	26.1 ± 4.1	0.508
WAZ[1]	- 1.72 ± 0.69	- 1.64 ± 0.83	0.601
Height (cm)[1]	132.2 ± 8.7	132.8 ± 6.0	0.666
HAZ[1]	- 1.71 ± 1.00	- 1.78 ± 1.16	0.756
BMI (kg/m^2)[1]	15.1 ± 1.6	14.8 ± 1.7	0.278
BMI/A[1]	- 1.63 ± 1.01	- 1.38 ± 0.92	0.238
Iron status:			
Hb conc. (g/L)[1]	111.5 ± 6.3	105.5 ± 9.2	0.002**
SF conc. (μg/L)[1]	32.8 ± 18.4	7.1 ± 2.6	0.000
TfR conc. (mg/L)[1]	8.1 ± 3.8	15.4 ± 5.8	0.000*
ZPP value (μmol/ mol heme)[1]	56.8 ± 19.7	79.8 ± 35.5	0.002**

[†]Non-IDA=anaemia: Hb conc <120 g/L. [‡]IDA: Hb conc <120 g/L, SF conc <12 μg/L, TfR conc >8.5 mg/L and ZPP value >40 μmol/mol heme. Significant differences at*) (P <0.001) and ** (P < 0.01) (Independent T-test) ; [1]Mean ± SD
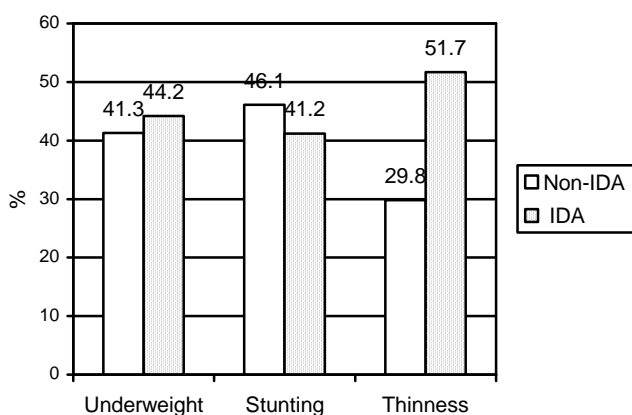
Underweight; weight for age < - 2SD, stunting; height for age < - 2SD, thinness; BMI for age < - 2SD. *Significant different at (P < 0.05) (Pearson's Chi-Square)

Figure 1. The proportion of underweight, stunting and thinness among anaemia non iron deficient and iron deficiency anaemia subjects.

age, menarche, nutritional status and iron status. The average age, weight, height and BMI were comparable among the 2 groups. The variables of nutritional and iron status were normally distributed (P<0.05; the Kolmogorov-Smirnov test).

The mean of WAZ, HAZ and BMI/A was negative, indicating that growth and length development was impaired in these girls based on WHO-NCHS, 1983 and NHANES reference value, 2002.[20] The prevalence of undernutrition was high; 42.1% were underweight, 45.1% stunting and 34.6% thinness (Table 1). The proportion of thinness was significantly higher (P<0.05) among subjects who suffered from iron deficiency anaemia (Fig. 1); thinness was associated with 5 fold risk of iron deficiency anemia (OR: 5.1; 95% CI 1.34 -19.00), (Table 2).

Table 2. Nutritional status of anaemic subjects and those with iron deficiency anaemia

Nutritional status	Non-IDA[†] (N = 104)		IDA[‡] (N = 29)		OR	95% CI
	N	(%)	N	(%)		
-Underweight: WAZ < -2 SD	43	41.3	13	44.8	0.4	0.09 – 1.78
-Stunting: WAZ < -2 SD	48	46.1	12	41.2	0.9	0.32 – 2.57
-Thinness: BMI/A < -2 SD	31	29.8	15	51.7	5.1	1.34 – 19.00*

[†]Non-IDA=anaemia: Hb conc <120 g/L. [‡]IDA : Hb conc <120 g/L, SF conc <12 μg/L; TfR conc > 8.5 mg/L and ZPP value >40 μmol/mol heme; *Significant difference at (P<0.05) (Logistic regression)

Iron status

Among 133 anaemic subjects, 27.3% had serum ferritin concentration <12 μg/L, 51.1% had serum transferrin receptor concentration >8.5 mg/L and 81.2% had zinc protoporphyrin value >40 μmol/mol heme (Fig. 2). These findings suggested that the major cause of anaemia amongst young adolescent girls in this study was insufficient iron in red blood cells rather than iron storage insufficiency. Serum ferritin concentration reflects iron stores,[18] whilst serum transferrin receptor concentration indicates concentration of iron being transported[19] and the zinc protophorphyrin value indicates the iron supply for erythrocyte formation.[20]
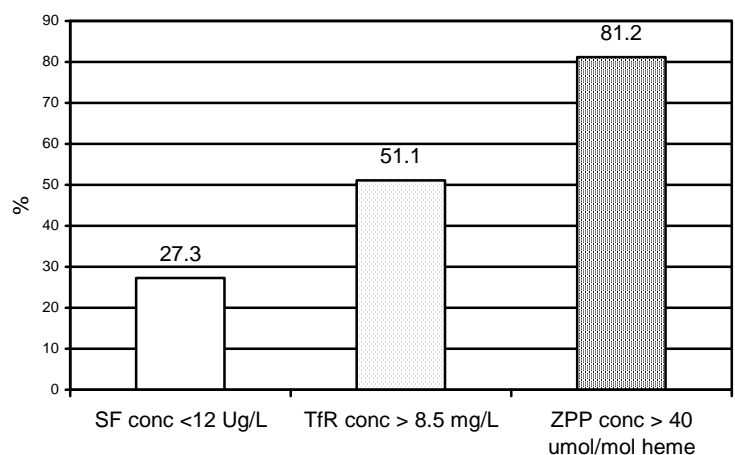
Figure 2. Indicators of iron status among anaemic subjects

Table 3a. Energy and nutrients intake.

Energy & nutrients :	RDA	Non-IDA[†] (N = 104)	IDA[‡] (N = 29)	P value
Energy (Kcal/d)[1]	1900	1122.2 ± 114.7	1126.5 ± 143.2	0.880
Protein (g/d)[1]	54	43.8 ± 6.6	45.3 ± 6.3	0.270
Iron (mg/d)[1]	14	6.9 ± 2.2	8.3 ± 2.6	0.011[*]
Vitamin C (mg/d)[1]	50	33.0 ± 49.4	55.6 ± 111.0	0.278

[†]Non-IDA=anaemia: Hb conc <120 g/L. [‡]IDA : Hb conc <120 g/L, SF conc <12 μg/L, TfR conc > 8.5 mg/L and ZPP value >40 μmol/mol heme. [*]Significant difference at (P < 0.05) (Independent T-test); [1]Mean ± SD

As expected, Table 1 showed that the mean haemoglobin and serum ferritin concentrations were significantly lower (P<0.05 and P<0.001), whilst serum transferrin receptor concentration and zinc protophorphyrin values were significantly higher (P<0.001, P<0.05) among subjects with iron deficiency anaemia as compared to anaemic subjects. However, in general, all subjects were in poor iron status.

Energy and nutrient intakes
In general, the subjects consumed insufficient energy and nutrients (Fig. 3). The average consumption of energy and nutrients (protein, iron, vitamin C) was below the Indonesian RDA[27] (Table 3a). The energy and nutrient intakes were not different between subjects with non-iron deficiency anaemia and those with iron deficiency anaemia, except for iron intake. The total iron intake among subjects with iron deficiency anaemia was much lower than the Indonesian RDA (2002) of 14mg.day for girls aged 10–12 years.[27] Even though subjects with iron deficiency anaemia had iron intakes significantly higher (P<0.05) than the non-iron deficient, the heme iron intake and
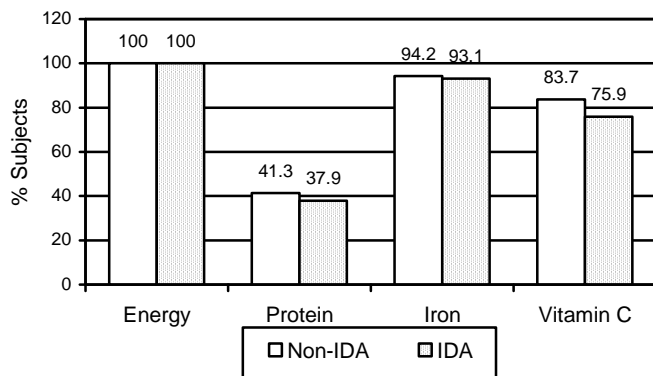

Figure 3. The proportion of subjects with energy and nutrients intake < 80% Indonesian RDA, 2002.

iron bioavailability was not significantly different between the two groups (Table 3b).

Discussion
Among all anaemic subjects, the proportion of subjects with iron deficiency anaemia was 21.8%. The prevalence of iron deficiency anaemia in the population under study was higher than in other areas of Tangerang district, in which the prevalence of iron deficiency anaemia amongst female elementary school children was only 4% of the total anaemic children (UNICEF, 2001; unpublished).[28] This latter finding was comparable to the prevalence of anaemia in primary school girls in urban areas of South Vietnam (3.7%).[29] In the current study, the prevalence of iron deficiency anaemia in the total population was 2.1% (29 out of 1,358 girls) and age and menarche were not found to be risk factors for iron deficiency anaemia. This was expected given the narrow age range of the study subjects and that most of the subjects were not menstruating.

The proportion of malnutrition in both groups using various measurements was quite high. Almost half of the subjects had either one or both measures of acute and chronic malnutrition. Subjects with iron deficiency anaemia seemed to be more vulnerable to being underweight, indicating that adolescent girls who suffered from acute malnutrition were also at risk of suffering from iron deficiency anaemia. The proportion of underweight in this study (42.1%) was higher compared to a study among urban primary school children in West Jakarta and Bogor (8-10 years), where the prevalence of underweight amongst girls was only 7.8% (WFA-Z score).[30] However, it should be noted that in this study all subjects were anaemic, which in this case the anaemic subjects had been in a poorer condition.

The nutritional status of the population in this study is in line with the nutritional status of children aged under five living in urban slum areas of Jakarta[31] which revealed

Table 3b. Estimated available iron intake intakes, its enhancers and inhibitors.

Nutrients	[+]Adequate Intake	Non-IDA[†] (N = 104)	IDA[‡] (N = 29)	P value
Heme iron (% iron)[1]	>40%	13	13	0.290
Non-heme iron (% iron)[1]	<50%	86.9%	85.5%	0.068
Phytate (g/d)[1]	< 13	13.5 ± 3.8	13.4 ± 4.7	0.987
Tea (ml with meal)[1]	< 200	50.5 ± 91.5	75.9 ± 104	0.240
Iron bioavailability (%)[1]	> 30%	6%	7%	0.386
[+]Available iron intake (mg/d)[1]	> 4.2	0.4 ± 0.3	0.6 ± 0.3	0.038[*]

[†]Non-IDA=anaemia: Hb conc < 120 g/L. [‡]IDA : Hb conc < 120 g/L, SF conc < 12 μg/L, TfR conc > 8.5 mg/L and ZPP value > 40 μmol/mol heme. [+]Available iron intake (mg/day) = {bioavailability of iron (%) x non heme iron intake (mg/d)} + heme iron intake (mg/d), (Gibson and Ferguson, 1999). [*]Significant difference at (P < 0.05) (Independent T-test); [1]Mean ± SD ;

that 27.9% of them suffered from both anaemia and stunting. It is assumed that children living in poor areas suffering from anaemia and chronic malnutrition will also be malnourished during adolescence.

It is generally assumed that anaemia was mostly caused by iron deficiency in areas where anaemia is prevalent.[10] The generalization that anaemia was mainly due to iron deficiency is derived from studies among women. As expected, this study reveals that adolescent girls (10–12 years old) who suffered from iron deficiency anaemia had lower iron status than those who did not. Although the proportion of anaemic subjects with iron deficiency was only 22%, the iron status level of anaemic adolescent girls was not optimal. About 27% of all subjects either with or without iron deficiency anaemia had low serum ferritin concentration (<12 μg/L) reflecting depleted iron stores in one third of anaemic subjects. While serum transferrin receptor concentrations were >8.5 mg/L which provides information on the severity of tissue deficiency or deficiency of iron in the circulation. Zinc protophorphyrin values >40 μmol/mol heme in the red cell indicates the low availability of iron supply for red blood cell maturation.[19,20,32] More than half of all anaemic subjects had high serum transferin receptor concentration (51%) and high zinc protophorphyrin values (81%) showing that both lack of iron stores and iron supply caused anaemia among young adolescent girls in this population.

The mean of serum ferritin concentration of all anaemic subjects was still in the normal range (27.2 μg/L). Whilst the mean of serum transferrin receptor concentrations (9.7 mg/L) and the mean of zinc protophorphyrin values (61.8 μmol/mol heme) were both higher than normal range, suggesting that the depletion of iron stores was not a major factor causing iron deficiency anaemia. In this study, the inability of iron supply on tissue function for haemoglobin formation might lead subjects to suffer from anaemia. In this condition, instead of iron store deficiencies, the possibility of abnormalities in the haemoglobin (haemoglobinopathies) should be considered as the cause of inability of erythrocytes to use iron. A study conducted among the same population of 150 female students aged 10-12 years old showed that 39.7% of them had haemoglobinopathies.[33] Findings on low intake of iron were consistent with the findings from a study in Malaysia. The prevalence of iron deficiency anaemia among adolescent girls from a rural community in Sabah, Malaysia, was 28.6%. Similarly, the study in Malaysia also showed that almost all female adolescent girls (91%) had a dietary iron intake below two-thirds of the Malaysian RDA level.[34] It is interesting to note that the consumption of iron and iron enhancers were slightly higher among subjects with iron deficiency anaemia However, considering that the iron intake was too low, any difference in iron intake will not give a significant effect. In this study, the iron intake did not fulfil the increased iron requirements during adolescence, which might explain the lower proportion of iron deficiency anaemia among stunted subjects (Table 2). During adolescence the greater demand for iron are for their growth spurt and development rather than for iron stores.[35]

The lifestyle of adolescent girls in this population was relatively homogenous. Students of elementary school usually have similar food patterns and food selection. Meal skipping and irregular eating pattern characterizes the adolescent food habits. The dietary recall in this study showed that breakfast or lunch appeared to be the most frequently skipped meals. It should be noted that the meal skipping among our subjects was not due to dieting but due to socio-economic condition. High bioavailability iron rich foods, which are usually expensive, were seldom consumed. A study of adolescent girls in East Java in 2001 supported this assumption, which showed that girls had a lower chance of being anaemic when they had a higher socio-economic status.[14]

Although the prevalence and severity of worm infestation was not investigated in this study, worm infection is likely to be an important cause of anaemia, and therefore should be considered as a component of an anaemia alleviation program. This is shown by the fact that one week after deworming tablet administration, 44.1% out of 238 anaemic children (Hb <115 g/l) became non-anaemic (data not shown). Perhaps the bad practices of personal hygiene and poor sanitary facilities at the rural coastal area have put the population at risk of infection. Data from Tangerang District showed that the proportion of respiratory infection cases among the age group of 5 – 14 years was almost half (45%) of total cases.[36] These data also showed that cases of diarrhoea, typhoid, otitis and mastoiditis, conjunctivitis, varicella, measles and TBC were still high among this group, reflecting that during pre-adolescence, children are still vulnerable for having infectious diseases.

It is concluded that anaemia and iron deficiency anaemia are problems among young adolescent girls in the rural coastal area of Tangerang District. Instead of iron store depletion, the lack of iron supply for haemoglobin formation might lead them to suffer from anaemia and inadequate intake of iron rich foods should be considered as the contributing factors. Other factors contributing to nutritional anaemia were not explored in this study, such as vitamin A deficiency and other nutrient deficiencies. Several studies have shown that poor vitamin A status is associated with low haemoglobin concentration.[37,38]

The high prevalence of anaemia amongst young adolescent school girls in rural coastal areas might lead to multiple health problems, such as impaired cognitive function, reduced school performance and poor reproductive health. These in turn would impact the future quality of human resources. The current iron-folate supplementation program for pregnant women should be expanded to non pregnant women, including adolescent girls. The school health program is a potential strategy to increase the iron status as well as improving the general health and nutritional status of school children. With regards to the possibility of haemoglobinopathies, particularly in the area where the prevalence of anaemia is considered to be high, a screening procedure is suggested before iron supplementation program is launched.

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Original Article

Anaemia and iron deficiency anaemia among young adolescent girls from peri urban coastal area of Indonesia

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印度尼西亚沿海城市周边地区青春期早期女孩的贫血和缺铁性贫血状况

缺铁性贫血仍然是一个普遍问题。它会对青春期女孩的生长发育、学习成绩、发病率及生殖能力产生负面影响。这项代表性研究的目的是搞清印度尼西亚沿海乡村地区年龄在 10－12 岁患缺铁性和非缺铁性贫血的处于青春期早期的女孩的营养状况和铁状况的差异。从来自于 34 所小学的 1358 名女孩中挑选了 133 名贫血女孩，测定了血红蛋白、血清铁蛋白、血清转铁蛋白受体和原卟啉锌来反映铁状况，同时测量了身高、体重来反映营养状况。一般特征和饮食摄入通过面谈来评估。在这 133 个贫血女孩中，有 29（21.8%）个患缺铁性贫血，这与年龄和月经无显著相关。大约 50％的女孩体重偏轻、身材矮小，这显示存在急性和慢性的营养不良。缺铁性贫血女孩中消瘦的比例显著高于非缺铁性女孩（P＜0.05，51.7% vs. 29.8%）。而且，消瘦女孩患缺铁性贫血的危险性比非消瘦女孩高 5 倍（P＜ 0.05, OR: 5.1; 95%CI 1.34 -19.00）。建议进一步探索其它和贫血及缺铁性贫血相关的因素，如地中海贫血特征和维生素 A 缺乏。目前流行的给孕妇补充铁和叶酸的措施应该应用于青春期女孩。

关键词：铁、缺乏、贫血、青春期的、女孩、城市的、印度尼西亚。