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# Iron Status, Prevalence and Risk Factors of Iron Deficiency Anemia Among 12- to 15-Year-Old Adolescent Girls from Different Socioeconomic Status in Indonesia

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## Abstract

**Background**: The aim of this study was to determine the iron status and the prevalence and risk factors of iron deficiency anemia (IDA) among adolescent girls in Central Jakarta, Indonesia. **Methods**: A cross-sectional study was conducted among 12- to 15-year-old girls studying in junior high schools that were categorized into high and low socioeconomic status (SES). Their menstrual and nutritional status, parents' education level and income, and iron intake were assessed. Tuberculin test and assessments for C-reactive protein levels and hematologic and iron parameters were also conducted. **Results**: Iron status was normal in 69.3% of 163 subjects. The prevalence of non-anemic iron deficiency was higher (17.2%; 3.1% iron depletion and 14.1% iron deficiency) than that of IDA (13.5%). The prevalence of IDA was lower among girls from the high SES than that among girls from the low SES (11.5% and 15.8%, respectively). There was no significant relationship among IDA and nutritional status, menstrual status and characteristics, SES, iron intake, and parents' education level and income; however, bioavailable iron intake in all subjects was found to be less compared to the recommended daily allowance (RDA). **Conclusions**: The higher prevalence of non-anemic iron deficiency than IDA is a potential risk factor for increasing the prevalence of IDA in the future. No significant relationship was found between IDA and its risk factors; however, iron intake was less compared to the RDA in all subjects, which requires further attention.

*Keywords: adolescent, anemia, iron deficiency, risk factors*

## Introduction

Anemia is one of the community health problems, especially in developing countries, including Indonesia.[1] Every age group is potentially affected by anemia,[2-4] including teenagers whom the World Health Organization defines as children aged 10–19 years. During this age, a growth spurt occurs, consequently increasing the requirement of various important nutrients.[1,4] However, in most of the developing countries, maternal and children health problems draw more attention, due to which the health problems of adolescents are still neglected. During adolescence, there are important changes, either psychologically or socially, that can be used as a window of opportunity to prevent various health problems later in adulthood.[1,4]

Iron deficiency anemia (IDA) is the most common type of anemia that occurs in adolescents and has several risk factors ranging from low iron intake to socioeconomic status (SES).[1,5,6] Iron deficiency has been reported to correlate with cognitive function disorders, reduction in physical work, and immune system disorders.[1,5,6] During pregnancy, IDA increases the risk of premature labor, due to which infants are born with low birth weight or suffer from anemia in the first 6 months of life. IDA in pregnancy also increases maternal mortality.[1,7] Iron supplementation administered during pregnancy is in fact too late to prevent IDA because the majority of women do not have sufficient iron store when they enter pregnancy, and their daily iron consumption alone is not sufficient to fulfill iron requirement during that period. Thus, IDA prevention should be started before pregnancy, even earlier in adolescence.[1,8] To gain more data regarding anemia in adolescents, we conducted a study to determine its prevalence as well as the iron status among 12- to 15-year-old adolescent girls, the age range that has the highest requirement of iron.[5] The risk factors of IDA in this age group were also assessed.

## Methods

This cross-sectional study was conducted from April to September 2012 in junior high schools in Central Jakarta, Indonesia. Apparently healthy 12- to 15-year-old adolescent girls were recruited. First, we classified some junior high schools in Central Jakarta into high and low SES based on their locations. The schools classified into the low SES group were located in a slum area, whereas the schools located in a better area were classified into the high SES group. Each group was then randomized so that two junior high schools were selected from each group. From these selected schools, the students aged 12–15 years were randomized targeting a total of 205 subjects.

Complete blood count and biochemical iron parameters such as serum iron, ferritin, total iron binding capacity, and transferrin saturation were evaluated. Normal iron status was defined as normal serum ferritin, transferrin saturation, and mean corpuscular volume (MCV).[9] Iron depletion was defined as a serum ferritin level that was <13 ng/mL.[9] Iron deficiency without anemia was defined based on two or three of the following criteria: serum ferritin level <13 ng/mL, transferrin saturation <15%, and MCV <78 pg plus normal hemoglobin (Hb) level.[9] IDA was defined if the Hb level was <12 g/dL, in addition to two or three of the following criteria: serum ferritin level <13 ng/mL, transferrin saturation <15%, and MCV <78 pg.[9] Subjects with an elevated C-reactive protein (CRP) level and a positive tuberculin test were excluded.

Subjects were also interviewed to collect details about other risk factors of IDA such as the nutritional status; the menstrual status and its pattern such as duration, blood loss, and frequency per month; and parents' education and income level. Nutritional status was defined by performing clinical examinations as well as measuring anthropometric parameters such as body weight and body height, than we plot subjects' body weight and body height to the 2000 Centers for Disease Control and Prevention (CDC) growth charts. For subjects who were considered as overweight or obese, the body mass index was calculated to complete the interpretation.

Menstrual blood loss was categorized as excessive and normal. Blood loss was excessive if the estimated blood loss was >80 mL (8 times changing of fully loaded diapers).[10] Parental education level was categorized as low, middle, and high. Low education level implied that the parent has already passed junior high school or equal education, middle education level implied that the parent has passed senior high school or equal education, and high education level meant that the parent has passed college or equal education. Parental income was calculated from per capita income of the father and the mother and then classified based on the World Bank classification as low if 9.128.415,00 rupiahs or under, middle-low if between 9.137.498,00 rupiahs and 36.104.925,00 rupiahs (Rp), middle-up if between 36.114.008,00 rupiahs and 111.493.825,00 rupiahs and high if 111.502.908,00 rupiahs or above.[11] Food recall was also evaluated by dietitians to assess iron intake and intake of iron enhancers such as vitamin C and heme iron and also iron inhibitors such as phytate and tea. We used nutrisurvey2007.exe to analyze the intake of these foods. We also calculated the bioavailable iron intake using the Murphy's formula.[12]

Ethical approval for this study was provided by the Ethics Committee of Health Research in Faculty of Medicine, Universitas Indonesia in Jakarta, on May 16, 2012, with the number 312/PT02.FK/ETIK/2012. Written informed consents were provided by the subjects' parents as they were interviewed and had also undergone few supporting examinations. Moreover, this study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Normally distributed data were presented as mean with standard deviation (SD), and data that were not normally distributed were presented as median with interquartile range (IQR). Mann–Whitney U test and unpaired *t*-test were used to analyze numerical data, while chi-square test, Kolmogorov–Smirnov test, and Fisher's exact test were used to analyze ordinal data. Results with $p < 0.05$ were considered to be statistically significant. Statistical analyses were performed by using the software of Statistical Package for the Social Sciences (SPSS) version 17.

## Results

A total of 205 subjects consisting of 105 girls from high SES and 100 girls from low SES participated in this study. A total of 42 subjects were excluded because of elevated CRP levels and positive results in the tuberculin test. Therefore, the final study sample consisted of 163 subjects (87 girls from high SES and 76 girls from low SES). The median (range) values of age, body weight, and body height of the subjects were 13.3 (12.0–15.6) years, 44.0 (24.5–74.2) kg, and 150.5 (125.0–166.0) cm. Distributions of age, body weight, and body height of the subjects based on SES are presented in Table 1, which showed that the mean body weight in the high SES group was significantly higher than that in the low SES group ($p = 0.009$).

Table 2 shows the nutritional status, the menstrual status and pattern, the education level, and the parents' income level. Most of the subjects were well nourished. Undernourished subjects were more in number in the low SES group. Regarding the menstrual status and pattern, excessive menstrual blood loss was significantly higher in the low SES group (p = 0.026). Parents having middle and high education level were more frequently found in the high SES group. Most of the parents (79.8%) had low income level, and none had high income level.

Low iron intake is one of the risk factors of IDA. Details regarding iron intake and intake of enhancers and inhibitors of iron absorption are described in Table 3, which show that none of the levels of iron intake and intake of enhancers and inhibitors of iron absorption

**Table 1. Distribution of Mean or Median of Age, Body Weight, and Body Height According to SES**

| Variable | Mean or median values | | *p* |
|---|---|---|---|
| | High SES (N = 87) | Low SES (N = 76) | |
| Age (year) | 13.3 (0.62)* | 13.3 (12–15.6)** | 0.572[a] |
| Body weight (kg) | 46.6 (9.8)* | 42.3 (24.5–65.1)** | **0.009[a]** |
| Body height (cm) | 151.7 (7.39)* | 150 (125.0–166.0)** | 0.085[a] |

* Mean (±SD)
** Median (IQR)
[a] Mann–Whitney U test

**Table 2. Socioeconomic, Nutritional, and Menstrual Status and Menstrual Pattern (n = 163)**

| Variable | Frequency (n (%)) | | Total | *p* |
|---|---|---|---|---|
| | High SES (N = 87) | Low SES (N = 76) | | |
| Nutritional status | | | | 0.618[b] |
| Undernourished | 8 (9.2) | 16 (21.1) | 24 (14.7) | |
| Well-nourished | 69 (79.3) | 50 (65.8) | 119 (73.0) | |
| Overweight | 7 (8.0) | 7 (9.2) | 14 (8.6) | |
| Obese | 3 (3.4) | 3 (3.9) | 6 (3.7) | |
| Menstrual status | | | | 0.646[b] |
| Not yet menstruated | 8 (9.2) | 8 (10.5) | 16 (9.8) | |
| Already menstruated | 79 (90.8) | 68 (89.5) | 147 (90.2) | |
| Duration of menstruation | | | | 0.827[b] |
| ≤7 days | 58 (66.7) | 51 (67) | 109 (74.1) | |
| >7 days | 21 (24.1) | 17 (22.4) | 38 (25.9) | |
| Menstrual blood loss | | | | 0.026[b] |
| Excessive | 19 (21.8) | 27 (35.5) | 46 (31.3) | |
| Normal | 60 (69.0) | 41 (53.9) | 101 (68.7) | |
| Menstrual frequency per month | | | | 0.094[b] |
| Once | 74 (85.1) | 58 (74) | 132 (89.8) | |
| More than once | 5 (5.7) | 10 (13.2) | 15 (10.2) | |
| Father’s education | | | | 0.004[c] |
| Low | 14 (16.1) | 31 (40.8) | 26 (16.0) | |
| Middle | 48 (55.2) | 44 (57.9) | 92 (56.4) | |
| High | 25 (28.7) | 1 (1.3) | 45 (27.6) | |
| Mother’s education | | | | 0.003[c] |
| Low | 19 (21.8) | 38 (50.0) | 21 (12.9) | |
| Middle | 49 (56.3) | 36 (47.4) | 85 (52.1) | |
| High | 19 (21.8) | 2 (2.6) | 57 (35.0) | |
| Parent’s income | | | | 0.001[c] |
| Middle-upper | 3 (3.4) | 0 (0) | 3 (1.8) | |
| Middle-lower | 27 (31.0) | 3 (3.9) | 30 (18.4) | |
| Low | 57 (65.5) | 73 (96.1) | 130 (79.8) | |

[b] Chi-square test, [c] Kolmogorov–Smirnov test

among all subjects fulfilled the recommended daily allowance (RDA) criteria. Total iron, heme iron and bioavailable iron intake levels were significantly higher ($p$ = 0.002, $p$ = 0.000, and $p$ = 0.000, respectively) in the low SES group; meanwhile, vitamin C and non-heme iron intake levels were significantly higher ($p$ = 0.000 and $p$ = 0.000, respectively) in the high SES group. The overall prevalence of anemia was 19.6%, with IDA being observed in 13.5% of the subjects. The etiology of anemia in the remaining 6.1% of the subjects could not be defined in this study. The iron status of these 6.1% of subjects was normal, so that these subjects were included as those with a normal iron status in Table 4, which shows the distribution of iron status based on SES. We also attempted to merge the subjects with iron depletion and iron deficiency in the data analyses as shown in Table 5. There were no significant differences in the prevalence of iron deficiency between the high and the low SES groups. The relationships between IDA and its risk factors, including iron intake, that were also assessed in this study are presented in Tables 6 and 7.

**Table 3. Iron Intake and Intake of Iron Absorption Enhancers and Inhibitors (n = 163)**

| Variable | Mean or median | | *p* |
|---|---|---|---|
| | High SES (N = 87) | Low SES (N = 76) | |
| Iron (mg/day) | 4.2 (1.9)** | 5.4 (2.8)** | 0.002[a] |
| Vitamin C (mg/day) | 78 (72.9)** | 22.4 (18)** | 0.000[a] |
| Heme (%) | 19.6 (22.1)** | 33 (2.2–80.4)* | 0.000[a] |
| Non-heme iron (%) | 81.3 (22.8)** | 65.6 (19.6–97.8)* | 0.000[a] |
| Phytate (g/day) | 4.3 (0.8–14.2)* | 4.4 (1.6)** | 0.969[b] |
| Tea (mL/day) | 260.8 (242.8)** | 314.6 (245.9)** | 0.163[a] |
| Bioavailable iron (mg/day) | 0.3 (0.2)** | 0.6 (0.79)* | 0.000[a] |

* Median (IQR)
** Mean (SD)
[a] Unpaired *t*-test, [b] Mann–Whitney U test

**Table 4. Iron Status (n = 163)**

| Variable | Frequency (n (%)) | | Total | *p* |
|---|---|---|---|---|
| | High SES (N = 87) | Low SES (N = 76) | | |
| Iron status | | | | 0.651* |
| Normal | 65 (74.7) | 48 (63.1) | 113 (69.3) | |
| Iron depletion | 1 (1.1) | 4 (5.2) | 5 (3.1) | |
| Iron deficiency | 11 (12.6) | 12 (15.8) | 23 (14.1) | |
| IDA | 10 (11.5) | 12 (15.8) | 22 (13.5) | |

[#] Ten subjects with anemia with undefined etiology were included in the normal iron status group
*Kolmogorov–Smirnov test

**Table 5. Distribution of Iron Status After Merging Iron Depletion and Iron Deficiency (n = 163)**

| Variable | Frequency (n (%)) | | Total | *p* |
|---|---|---|---|---|
| | High SES (N = 87) | Low SES (N = 76) | | |
| Iron status | | | | 0.275* |
| Normal | 65 (74.7) | 48 (63.1) | 113 (69.3) | |
| Iron depletion and iron deficiency | 12 (13.6) | 16 (21.0) | 28 (17.2) | |
| IDA | 10 (11.5) | 12 (15.8) | 22 (13.5) | |

[#] Ten subjects with anemia with undefined etiology were included in the normal iron status group.
*Chi-square test

**Table 6. Association Between IDA and Its Risk Factors**

| Variable | Frequency (n (%)) | | Total | *p* |
|---|---|---|---|---|
| | IDA | Non-IDA | | |
| Nutritional status | | | | 0.998[b] |
| Malnourished | 0 (0) | 0 (0) | 0 (0) | |
| Undernourished | 3 (12.5) | 21 (87.5) | 24 (14.7) | |
| Well-nourished | 18 (15.1) | 101 (84.9) | 119 (73.0) | |
| Overweight and obese | 1 (5) | 19 (95) | 20 (12.3) | |
| Menstrual status | | | | 0.699[c] |
| Not yet menstruated | 1 (6.25) | 15 (93.75) | 16 (9.8) | |
| Already menstruated | 21 (14.2) | 126 (85.8) | 147 (90.2) | |
| Duration of menstruation | | | | 0.758[a] |
| ≤7 days | 15 (13.8) | 94 (86.2) | 109 (74.1) | |
| >7 days | 6 (15.8) | 32 (84.2) | 38 (25.8) | |
| Menstrual blood loss | | | | 0.422[a] |
| Normal | 13 (12.7) | 89 (87.3) | 102 (69.3) | |
| Excessive | 8 (17.8) | 37 (82.2) | 45 (30.6) | |
| Menstrual frequency per month | | | | 0.696[c] |
| Once | 20 (15) | 112 (85) | 132 (89.7) | |
| More than once | 1 (6) | 14 (93) | 15 (10.2) | |
| Father's education | | | | 0.895[b] |
| Low | 8 (17.8) | 37 (82.2) | 45 (27.6) | |
| Middle | 13 (14) | 79 (86) | 92 (56.4) | |
| High | 1 (4) | 25 (96) | 26 (15.9) | |
| Mother's education | | | | 0.994[b] |
| Low | 9 (16) | 48 (84) | 57 (34.9) | |
| Middle | 12 (14) | 73 (86) | 85 (52.1) | |
| High | 1 (5) | 20 (95) | 21 (12.9) | |
| Parent's income | | | | 1.000[b] |
| Low | 17 (13) | 113 (87) | 130 (79.8) | |
| Middle-lower | 5 (16) | 25 (84) | 30 (18.4) | |
| Middle-upper | 0 (0) | 3 (100) | 3 (1.8) | |
| High | 0 (0) | 0 (0) | 0 (0) | |

[#]Non-IDA refers to subjects with normal iron status, iron depletion, and iron deficiency.
[#] Ten subjects with anemia with undefined etiology and normal iron status were included in the non-IDA group.
[a] Chi-square test; [b] Kolmogorov–Smirnov test; [c] Fisher's exact test

**Table 7. Association Between Iron Intake and Intake of Iron Absorption Enhancers and Inhibitors and IDA Prevalence (n = 163)**

| Variable | Mean or median | | *p* |
|---|---|---|---|
| | IDA (N = 22) | Non-IDA[#] (N = 141) | |
| Iron (mg/day) | 5.0 (1.6)* | 4.1 (1.4–15.5)** | 0.108[a] |
| Vitamin C (mg/day) | 18.8 (44–294.8)** | 29.3 (0–356.9)** | 0.585[a] |
| Heme (%) | 29.9 (19.8)* | 20.7 (0–93.7)** | 0.344[a] |
| Non-heme iron (%) | 69.6 (20.0)* | 79.4 (6.25–137.5)** | 0.281[a] |
| Phytate (g/day) | 4.2 (1.1)* | 4.1 (0.8–14.1)** | 0.948[a] |
| Tea (mL/day) | 200.0 (14.0–900.0)** | 200.0 (0–1000.0)** | 0.905[a] |
| Bioavailable iron (mg/day) | 0.4 (0.2–1.2)** | 0.3 (0.1–6.4)** | 0.073[a] |

[#]Non-IDA refers to subjects with normal iron status, iron depletion, and iron deficiency.
[#] Ten subjects with anemia with undefined etiology and normal iron status were included in the non-IDA group.
* Mean (SD); ** Median (IQR); [a] Mann–Whitney U test

## Discussion

This cross-sectional study was conducted to determine the iron status and the prevalence of IDA among 12- to 15-year-old adolescent girls in Central Jakarta, Indonesia. The median values of body weight and body height were higher in the high SES group than in the low SES group. Subjects with malnutrition were more in number in the low SES group than those in the high SES group. This finding was in agreement with the study conducted by Kurniawan *et al.* who also reported that the prevalence of malnutrition was higher in the low SES group.[13] In the present study, most of the subjects (90.8%) were found to have been already menstruated. Soekarjo *et al.* also reported that 82.5% of the subjects with a similar age group in Surabaya had already menstruated.[3]

This study stratified the subjects into two groups, the high and the low SES, based on the location of the school. Subjects' parents with a high education level were more frequent in the high SES group, while those with a low income level were more frequent in the low SES group. The distributions of parents' education level and income level were statistically significant; hence, the data supported the stratification in this study. The duration and the level of parents' education were used for stratifying SES, in studies who also determined the SES based on school category to distinguish between subjects with higher and lower SES in their studies.[3,6,7] A study also also used the criterion of whether the family had a car in distinguishing SES among their study subjects.[7]

In this study, the mean levels of iron intake and intake of enhancers and inhibitors of iron absorption among all the subjects did not fulfill the RDA criteria. Kurniawan *et al*.[13] also showed that iron intake in adolescent girls aged 10–12 years was less than two-thirds of RDA. Micronutrient deficiency, especially iron, has been frequently found in developing countries whose staple food is plant-based that contains phytate and polyphenol, iron absorbtion inhibitors. The consumption of foods containing bioavailabe iron, such as meat, poultry, and fish, was also lower in developing countries due to their expensive prices.[4] The mean bioavailable iron intake was found to be higher in the low SES group in this study. This finding could be explained by the fact that heme iron intake was higher in the low SES group; meanwhile, non-heme iron intake was higher in the high SES group, probably because subjects from the high SES group consumed more snacks or fast foods that were high in non-heme iron. Jawarkar *et al.*[14] also found that adolescent girls with anemia were consuming more junk food or ready-to-eat food in their busy life. Tea consumption in the high SES group exceeded the RDA, although it was still lower than that in the low SES group. Consuming a cup of tea along with food decreased iron absorbtion by 60%.[1]

Iron deficiency, whether it was depletion, deficiency, or IDA, was frequently found in the low SES group. This finding was consistent with the mean serum iron and ferritin levels that were significantly higher in the high SES group than in the low SES group. Keskin *et al.*[7] also found that iron deficiency and IDA were more common in the low SES group among 12- to 13-year-old adolescent girls in Turkey.

The prevalence of anemia among all the subjects was as high as 19.6%, with 13.5% of them having IDA. Tesfaye *et al.* also found that anemia was found in 19.3% of female adolescents.[15] The prevalence of IDA in this study was almost similar to the IDA prevalence in the study conducted by Keskin *et al.*, which reported a prevalence of as high as 11.2% in 508 female adolescents aged between 12 and 13 years in Turkey.[7] The prevalence of IDA in this study was lower than that observed by Kurniawan *et al.*, who reported a prevalence of 21.8%.[13] This difference might be because all the subjects in the study conducted by Kurniawan *et al.* were from low SES.[13]

The risk factors of IDA assessed in this study included iron status, menstrual status and its pattern, SES, and iron intake. Obesity and malnutrition have been believed to be the risk factors of IDA,[8,16] although this was not confirmed in this study. Subjects with a longer duration of menstruation, more excessive blood loss, and more frequent menstrual periods (more than once per month) were more common in the low SES group. This finding may probably explain why iron deficiency was more common in the low SES group, despite the lack of a significant association.

SES has been believed to be associated with IDA prevalence.[3,17,18] In the low SES group, the adequacy of iron intake was not easily obtained. Moreover, the rate of infection was also higher in the low SES group. IDA was slightly more prevalent in the low SES group, but there was no significant association between the prevalence of IDA and subjects' SES as well as parents' education and income levels. Similarly, Keskin *et al.* also found no significant association betwen IDA and SES in 508 adolescent girls aged 12–13 years.[7]

To our knowledge, this is the first study that used CRP level as well as tuberculin test simultaneously to exclude anemia from a chronic disease, i.e., tuberculosis. Some limitations exist in this sudy, such as the food recall and the interview methods to assess iron intake and the parents' data that are susceptible to recall bias.

## Conclusions

An interesting fact found in this study was that the prevalence of iron depletion and iron deficiency was higher than the IDA prevalence itself. If this problem is not overcome soon, then the subjects in the state of iron depletion and deficiency would easily go into the IDA state. Although there was no association between IDA and its risk factors, the lower-than-RDA levels of total and bioavailable iron intake in these subjects might be a risk factor that requires more attention. It is necessary to implement adequate and well-designed nutrition education, emphasizing the choice of food rich in bioavailable iron and the eating pattern that could improve the absorption of non-heme iron to increase iron intake and to overcome the problem of iron deficiency in this age group.

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## Conflict of Interest Statement

Authors declare no conflict of interest.

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