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Iron Profile in Adolescent Scavengers Living in Slum Areas

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Abstract

Background: Iron deficiency anemia (IDA) is one of the major health issues in the world, especially in developing countries. During adolescence, iron deficiency can be caused by a growth spurt, inadequate nutritional intake, parasite infection, and heavy blood loss during menstruation. Regarding the importance of this issue, we aimed to assess the iron profile in adolescent scavengers living in slum areas.

Materials and Methods: This was a cross-sectional study conducted in October 2016 at an alternative school for adolescents working as scavengers in Bekasi, Indonesia. Data on menstrual status, weight and height measurements, and blood samples were collected to define iron status (iron depletion, iron deficiency, and IDA).

Results: In this study, 96 adolescents aged 10–18 years were recruited. The prevalence of anemia was 13.6%, and half was caused by iron deficiency. The iron profiles of subjects were iron depletion (2.1%), iron deficiency (18.8%), and IDA (7.3%). Hemoglobin, ferritin, and transferrin saturation were significantly lower in females (P<0.01, P=0.01, P<0.01 respectively).

Conclusion: Anemia, iron depletion, iron deficiency, and IDA are more prevalent among adolescent girls. Special attention is needed to improve the iron status of girls, especially by giving iron supplementation for IDA prevention. Moreover, achieving the optimal iron reserve is imperative to enter a safe and healthy pregnancy by reducing delivery complications due to inadequate iron storage of both mother and fetus.

Keywords: Adolescents, Iron deficiency anemia, Scavengers

Introduction

Anemia is defined as a low blood hemoglobin concentration that has significant health consequences as well as adverse impacts on social and economic development (1). It is estimated that more than half of anemia cases are caused by iron deficiency anemia (IDA),(2) with a lack of sufficient iron to form normal red blood cells (3). Iron is an essential component of hemoglobin and myoglobin, and an important element in enzymatic processes, DNA synthesis, and mitochondrial energy generation (2,4). Adolescence is a transitional period from childhood to adulthood marked by rapid pubertal growth and development that places a high demand on nutritional and micronutrient requirements (5,6).

Adolescents are at high risk of iron deficiency because of their increased requirement for iron, poor dietary intake of iron, high rate of infection and worm infestation, and menorrhagia in female adolescents (4,7). Negative impacts of iron deficiency in adolescents include decreased physical capacity and work performance, and increased morbidity from infections. IDA in infants can cause developmental delays, but the relationship between iron status and cognitive achievement in older children is less clear. Lower cognitive test scores were found among iron-deficient anemic school-age girls (8). In Indonesia, there has not been a national study of the prevalence of IDA in adolescents, but one study in East Borneo found that 15.2% of children aged 12–18

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years had IDA (9), while another study found a 13.5% prevalence (10). A study among children living in a slum area in Bangladesh showed poor iron intake below the World Health Organization (WHO) recommended daily allowance (11). Adolescents under low-socioeconomic status had lower iron intake thus more susceptible to iron deficiency (12). However, study on iron deficiency and IDA in adolescents moreover in low-socioeconomic status are still limited in Indonesia. Therefore, this study was aimed to determine the prevalence of anemia and iron status of adolescents among scavenger population who had low-socioeconomic status.

Materials and Methods

A cross-sectional study was conducted in "*Sekolah Kami*," Bantar Gebang, Bekasi, West Java, Indonesia which is an area for final garbage dumping. "*Sekolah Kami*" is an informal school that is dedicated to adolescents and young adults who work as scavengers in a surrounding neighborhood. Written consent was obtained from the subject or the subject's parent or legal guardian. Further treatment of adolescents with anemia was conducted in primary health care. Data collected in October 2016 included information regarding menstruation status (menarche age, duration, menstruation volume), body weight, height, and blood samples for complete blood count, serum iron (SI), transferrin iron binding capacity (TIBC), reticulocyte hemoglobin content (CHr), ferritin, transferrin saturation (TS), and C-reactive protein (CRP). Subjects with a history of iron supplementation or fever were excluded from the study. Drop-out criteria were subjects who did not complete physical and laboratory examinations. Laboratory analysis was conducted at the Laboratory of Clinical Pathology, Dharmais Hospital, West Jakarta using the kit Sysmex XN-2000. Iron status was defined based on hemoglobin (Hb) level, ferritin, CHr, and TS (13–15). The diagnosis of anemia was according to WHO criteria with Hb level based on sex and age (13). Subjects were considered microcytic if the mean corpuscular volume (MCV) was <80 fl. The following are the detailed definitions of iron status presented in Table I (13–15):

Nutritional status was measured using body mass index (BMI) for age; (1) Obesity if BMI is $\geq 95^{th}$ percentile, (2) Overweight if BMI is between $\geq 85^{th}$ and $<95^{th}$ percentile, and (3) Underweight if BMI is $<5^{th}$ percentile (16). Menstruation status was described by whether the patient had their menarche, menstruation duration (< or >7 days), and menstruation volume (< or ≥8 pad changes per day) on average.

Ethical Consideration

This study was approved by the Ethical Committee, Faculty of Medicine, Universitas Indonesia (No: 850/UN2.F1/ETIK/2016). The research methods complied with the 1975 Helsinki Declaration, All human-related research techniques were executed in accordance with the ethical principles established by the responsible committee that supervised human experimentation at both the institutional and national levels.

Statistical Analysis

Statistical analysis was performed using IBM SPSS version 22 (IBM Corp., USA). Numerical data were described by mean and standard deviation if the data distribution was normal; otherwise, median and range were used. Normality tests were done using Kolmogorov–Smirnov and Shapiro–Wilk. The chi-square test was used to analyze iron status differences according to sex. Comparison of hematological parameters according to sex was analyzed using an independent *t*-test and Mann-Whitney U. A *p*-value<0.05 was considered statistically significant.

Results

A total of 96 subjects were recruited using consecutive sampling with male and

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female ratios of 53 and 43, respectively. The overall mean age was 13,5 years. Thirteen subjects (13/96, 13.6%) suffered from anemia, with iron deficiency as the primary underlying etiology (7/13, 53.9%). Of the remaining six subjects (46.1%), three subjects had microcytic anemia and three subjects had normocytic anemia. Iron status disorders were prevalent in around a third of study participants, with 2% having iron depletion, 18.8% had iron deficiency without anemia, and 7.3% IDA. Of subjects who suffered from an iron status disorder, 70.4% were females. Table II shows the result of the iron profile in adolescents according to sex.

There was a higher prevalence of anemia among female than male subjects (23.2% *versus* 5.6%). All subjects who had IDA were female adolescents. Iron depletion and iron deficiency were also more prevalent in females compared to males, where two females were iron depleted (100%) and 10 females had iron deficiency (55.6%). An analytic test showed that female subjects were more prevalent to iron depletion, iron deficiency, and IDA compared to male subjects ($P < 0.01$).

No significant differences were found between nutritional status and iron profile ($P>0.05$). However, this study found that both obese subjects had IDA or iron deficiency. There were 26/43 (60.4%) female subjects who had their menstruation period. All subjects who have a history of changing pads >8 times/day experienced IDA, iron deficiency, and iron depletion, although not statistically significant. Characteristics of subjects regarding nutritional status and menstruation status are displayed in Table III.

Hematological parameters in both sexes are listed in Table IV. Hb, ferritin, TS, and CHr levels in female subjects were lower than in male subjects. The analysis showed that there were significant differences in Hb, ferritin, and TS levels between the two groups. Hematological parameters according to iron status classification are displayed in Table V.

Table I: Iron status classification.

	Hb g/dL		**CHR pg**	**Ferritin µg/l**	**TS %**
	Male	Female			
Normal	≥13	≥12	≥29	≥15	≥30
Iron depletion	≥13	≥12	≥29	<15	<30
Iron deficiency	≥13	≥12	<29	<15	<20
IDA	<13	<12	<29	<15	<10

Hb=hemoglobin; CHR=reticulocyte hemoglobin content; TS=transferrin saturation; IDA=iron deficiency anemia

Table II: Iron profile in adolescents according to gender.

Stage	**Females, n (%) (n = 43)**	**Males, n (%) (n = 53)**	**Total, n (%) (n = 96)**	***p***
Normal	21 (33.3)	42 (66.7)	63 (65.5)	**0.001***
Iron depleted	2 (100.0)	0 (0.0)	2 (2.1)	
Iron deficiency	10 (55.6)	8 (44.4)	18 (18.8)	
IDA	7 (100.0)	0 (0.0)	7 (7.3)	
Anemia non-IDA	3 (50.0)	3 (50.0)	6 (6.3)	

IDA=iron deficiency anemia, *Fisher Exact test

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Table III: Nutritional status and menstrual status among iron deficiency anemia, iron deficiency, iron depletion, and normal subjects.

Variable	IDA, iron deficiency/ depletion	Normal/ Anemia non-IDA	Total	p
Nutritional status (n=96)				
Normal	15 (25.0)	45 (75.0)	60 (62.5)	0.24*
Underweight	3 (27.3)	8 (72.7)	11 (11.5)	
Overweight	7 (30.4)	16 (69.6)	23 (23.9)	
Obesity	2 (100.0)	0 (0)	2 (2.1)	
Female subject with Menstruation (n=43)	12 (46.1)	14 (53.8)	26 (60.4)	0.35#
Menstruation duration (n=26)				
≤7 days	8 (38.1)	13 (61.9)	21 (80.7)	0.15*
>7 days	4 (80.0)	1 (20.0)	5 (19.3)	
Menstrual pads change (n=26)				
≤8 times/day	9 (39.1)	14 (60.9)	23 (88.4)	0.08*
>8 times/day	3 (100.0)	0(0)	3 (11.6)	

*Fisher exact test, #Chi-square test, IDA=iron deficiency anemia, Anemia Non-IDA is anemia by other causes than IDA.

Table IV: Hematological parameters according to gender.

Parameter	Female (n = 43)		Male (n = 53)		*p*
	Median/Mean	95% CI	Median/Mean	95% CI	
Hb (g/dl)	13 (1.1)	12.7–13.4	14.1 (1.3)	13.8–14.5	**<0.01***
MCV (fl)	80.6 (58.5–90.5)	77.3–81.6	81.1 (57.5–277.3)	75.9–90.8	0.37*
Ferritin (μg/l)	28.5 (4.6–106.3)	27.2–42.1	45.4 (5.7–131.1)	46.1–60	**0.01**†
TS (%)	18.2 (8.3)	15.7–20.8	26.3 (9.5)	23.7–28.8	**<0.01***
CHr (pg)	28.9 (17.5–31.3)	26.5–28.7	29.1 (19.3–32.1)	28–29.5	0.12*

Mean (SD), Median (min-max), CI=confidence interval; Hb=hemoglobin; SD=standard deviation; MCV=mean corpuscular volume; TS=transferrin saturation; CHr=reticulocyte hemoglobin content, *Independent sample *t*-test, †Mann–Whitney test

Table V: Hematological parameters according to iron status classification.

Parameter	Normal (n = 63)	Iron depleted (n = 2)	Iron deficiency (n = 18)	IDA (n = 7)
Hb (g/dl)	14 (1.2)	13.5 (0.1)	13.3 (0.9)	11.3 (0.5)
MCV (fl)	82.1 (59.5–277.3)	83.3 (81.3–85.4)	77.6 (65.7–82)	74.3 (58.5–80.2)
Ferritin (μg/l)	43.2 (17.9–131.1)	12.6 (11.4–13.8)	21 (5.7–87)	12.5 (4.6–106.3)
TS (%)	26.52 (7.4)	17.9 (2.6)	11.2 (2.9)	8.9 (4.1)
CHr (pg)	29.9 (19.6–31.9)	29.5 (29.2–29.7)	27 (21.9–28.9)	22.7 (19.4–25.2)

Mean (SD), Median (min-max), IDA=iron deficiency anemia; Hb=hemoglobin; SD=standard deviation; MCV=mean corpuscular volume; TS=transferrin saturation; CHr=reticulocyte hemoglobin content

Discussion

The overall prevalence of anemia in this study was 13.6%, which is similar to that in the Indonesian national health survey in 2013 (18.4%) among adolescents and young adults aged 15–24 years) (17). In this study, IDA was the most common cause of anemia among adolescents working as scavengers in a refuse dump site on the outskirts of Jakarta. This result is consistent with other studies that showed IDA as the main etiology of anemia in children and adolescents. The prevalence of iron depletion, iron

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deficiency without anemia, and IDA in this study were 2.1%, 18.8%, and 7.3%, respectively. This finding is similar to a previous study among adolescent girls in Indonesia which reported the prevalence of iron depletion, iron deficiency, and IDA to be 3.1%, 14.1%, and 13.5%, respectively (10). Another study in Indonesia showed that the prevalence of iron depletion, iron deficiency, and IDA were 4.3%, 18.4%, and 5.8% (18). A study on Korean females also found a prevalence of IDA of 4.2% (19). This finding can be similar due to the subjects' background of having low-socioeconomic status. All subjects with IDA were females. Hemoglobin, ferritin, and transferrin levels were significantly reduced among females compared with males. In Nigeria, a study with a similar subject's background showed that ferritin and transferrin levels had sex-related significant differences with males having higher mean values of iron status. Females also tend to have a higher prevalence of anemia, iron depletion, iron deficiency, and IDA (20–22). In another study, although Hb, ferritin, and transferrin had no significant differences between sex, iron depletion, and iron deficiency were more prevalent in females (21). Higher IDA rates in female subjects in this study may be explained by an increased daily iron requirement in adolescent girls due to increased blood loss during menstruation. This study showed that all IDA subjects have had their menstrual cycle. It is reported that a mean menstrual blood loss of 84 ml/period and assuming a mean Hb of 13.3 g/dl, provides an estimate that 0.56 mg of additional iron is needed per day (23). Ferritin concentration is relatively low in females until menopause as a result of menstruation, affecting females' iron storage (20). The overall iron requirement increases from approximately 0.7–0.9 iron per day to 1.40–3.27 in adolescent girls (23). The iron status parameter in this study showed that ferritin in iron-depleted, iron deficiency, and IDA were dropped below the normal range. Ferritin is a reliable indicator of iron status while its concentration may be elevated in an acute infection state. Therefore, CRP was added to rationalize the ferritin level. The combination between ferritin and other measurements of iron status can increase accuracy in detecting iron deficiency (20). In iron-deficient subjects, the mean of CHr was 27 meanwhile in IDA, it dropped to 22.7 pg. CHr has recently been known as a good alternative screening parameter for iron deficiency and IDA. A study in 6–18 years old children showed that CHr of 28.9 pg and 27 pg as a cut-off value is optimal to identify iron deficiency and IDA (24). The subjects in this study mostly came from low-socioeconomic status. They had to do part-time work as scavengers and were forced to live in unsanitary and unhygienic conditions. A study on Korean adolescent girls also found that lower socioeconomic status is associated with the prevalence of anemia and IDA (19). The prevalence of IDA in low-socioeconomic status is due to lower consumption of iron and vitamins. In contrast, an Indonesian study showed that it may be because all subjects had not fulfilled the recommended dietary allowance of iron intake (10). However, this study did not compare subjects with those of higher socioeconomic status and nutritional assessment was not undertaken to understand iron intake. In addition to low-socioeconomic status, the subjects' occupation as scavengers might predispose them to certain parasitic diseases known to be associated with anemia and IDA, such as ascariasis or hookworm infection. Hookworms in humans can cause anemia mainly through intestinal blood loss from gut mucosal penetration by adult worms, the increased tendency of bleeding at the site of attachment due to parasite-derived anticoagulants, and to a lesser degree active feeding by the parasites. Chronic blood loss that exceeds the host's iron intake and reserves can result in IDA. In Ibadan, Nigeria, dumpsites were found to have a higher degree of contamination

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with intestinal parasites such as *Ascaris* species, hookworms, *Strongyloides* species, and *Schistosoma* species. In Ethiopia, a study showed that nearly 60% of adolescents had a parasite in their stool examination. In this study, 6 subjects with anemia of non-IDA had normocytic anemia or microcytic anemia. However, this study did not further assess anemia causes whether it could be tropical parasitic disease or hemoglobinopathies such as thalassemia or HbE. The bioavailability of iron intake can also be worsened by parasitic infections causing chronic blood loss (12,25). This study found that all IDA groups had normal to obese nutritional status. The relationship between nutritional status and iron status is still conflicting. One study among children and adolescents showed that overweight children had double the risk of iron deficiency,(26) while another study in adolescent females showed that undernourished adolescents who had BMI<18.5 kg/m^2 were 2.54 times more likely to have anemia (6). A study by Sumarlan et al.(10) among adolescent girls in Indonesia found no association between IDA and nutritional status, iron intake, or parents' educational level. Mild to moderate iron deficiency without anemia has adverse consequences in adolescence, such as reduced physical capacity and work performance,(27) reduced immune status leading to more frequent viral infection, increased morbidity from diseases,(5) and reduced cognitive performance (2). Girls of reproductive age that enter pregnancy with suboptimal iron reserves can also increase the risk of adverse maternal and neonatal outcomes (16). Therefore, the Indonesian Pediatric Society currently recommends giving iron supplementation to adolescents two times a week for three consecutive months every year (28). Special attention and strategies may be needed to improve iron status and intake for adolescent girls. A meta-analysis showed that iron supplementation can increase attention and concentration in adolescents and women (29). The limitation of this study was that nutrition diaries to track iron intake in the scavenger population were not undertaken. In conclusion, IDA was more prevalent in female adolescents, suggesting the need for health interventions such as iron supplementation for IDA prevention. Moreover, achieving the optimal iron reserve is imperative to enter a safe and healthy pregnancy by reducing delivery complications due to inadequate iron storage of both mother and fetus.

Conclusion

Adolescent girls are more likely to experience anemia, iron depletion, iron deficiency, and IDA. To improve their iron levels, it is important to focus on providing iron supplements for IDA prevention. Additionally, adolescent girls must achieve the appropriate iron reserve to have a safe and healthy pregnancy, as insufficient iron storage in both the mother and fetus can lead to delivery complications.

Conflict of interest

The authors declare no conflict of interest.

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