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by Nur Alam Fajar

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SERUM IRON LEVELS OF PRIMARY SCHOOL CHILDREN IN MALARIA-ENDEMIC REGIONS IN SELUMA REGENCY, BENGKULU PROVINCE

R Flora[1*], M Zulkarnain[2], N A Fajar[1], A F Faisya[3], Nurlaily[4], Ikhsan[4], S Slamet[4]

[1]Public Health Science Study Program, Faculty of Health Science, Sriwijaya University
[2]Public Health Science Study Program, Faculty of Medicine, Sriwijaya University
[3]Environmental Health Study Program, Faculty of Health Science, Sriwijaya University
[4]Diploma III in Nursing Science, Faculty of Mathematics and Natural Sciences, Bengkulu University
***corresponding author: rostikaflora@gmail.com**

Abstract

Children living in malaria-endemic regions are at risk of developing anemia particularly iron deficiency anemia (IDA). Iron is a very essential mineral needed by the body to help make hemoglobin, process cell division, stimulate brain cell growth, build muscle cells, and strengthen the immune system. Iron deficiency in primary school children has a significant impact on their immune system, cognitive skills, and learning achievement. The objective of this study was to analyze serum iron levels of primary school children in malaria-endemic regions in Seluma Regency, Bengkulu Province. The research design was a cross-sectional study. The research population was primary school children aged 9-11 years old in Seluma Regency Bengkulu Province collected from five sub-districts. The sample size was seventy-nine children collected by using a simple random sampling technique. The research data of this study were obtained from questionnaires (data for characteristics of parents and children), blood tests (data for hemoglobin, TIBC, saturated transferrin, and malaria), and fecal examinations (data for helminthiasis). The data were then analyzed in univariate and bivariate using SPSS. The hematology tests showed that the mean level of hemoglobin was 13.41 ± 2.21 g/dL, serum iron was 43.42 ± 19.88 μg/dL, TIBC was 301.65 ± 65.02 μg/dL, and saturated transferrin was 15.185 ± 8.15%. Based on these laboratory findings, 15.18% of the children were suffering from iron-deficiency anemia, 12.65% were anemia, 49.39% were iron deficiency, and 22.78% were in a normal range. The minimum level of serum iron was found in children with iron deficiency (34.19 ± 10.46 μg/dL). The results of statistical analysis using ANOVA indicated that there was a significant difference ($p < 0.05$) in the mean level of serum iron among children with iron deficiency anemia, iron deficiency, anemia, and normal range. The blood smears for malaria parasites showed that all children (100%) were not infected with helminthiasis. On the other hand, from the fecal examination, it was shown that twenty-six children (32.9%) were positive with helminthiasis. There was no significant correlation ($p > 0.05$) between hemoglobin level and helminthiasis. Almost half of the primary school children living in malaria-endemic regions of Seluma Regency, Bengkulu Province are suffering from iron deficiency. Infection of malaria parasites and helminthiasis do not contribute to iron deficiency in primary school children living in malaria-endemic regions of Seluma Regency, Bengkulu Province.

Key words: iron serum, iron deficiency, iron deficiency anemia, primary school children, malaria-endemic areas

1. INTRODUCTION

Malaria continues to remain the leading cause of morbidity and mortality particularly in children in developing countries [1,2]. Malaria plays a key role in the incidence of anemia in endemic regions. Anemia is caused by the destruction of red blood cells containing parasites (hemolysis), increased clearance of red blood cells by the lien, cytokine-induced diserythropoiesis (production of abnormal red blood cells), and iron absorption disorder [3,4,5].

Children living in malaria-endemic regions are highly vulnerable to suffer from anemia. If anemia occurs in a long period, the children will tend to be more prone to some diseases. Their body development is inhibited as well. The most common anemia in children is iron deficiency anemia (IDA). Iron is an important mineral needed by the body to produce hemoglobin. Besides, iron is also required for cell division, growth of brain cells, muscle development, and the immune system [6]. In children, IDA develops slowly and causes several acute symptoms. When this anemia becomes chronic, children will look pale, be easily tired, feel weak, and lose appetite and weight. These symptoms will have an impact on children's cognitive abilities and learning outcomes.

It is estimated that nearly 750 million children worldwide and 30-40% of children in industrialized countries experience IDA. According to WHO, the prevalence of IDA in primary school-aged children is 25.4%, and 305 million school-aged children worldwide suffer from anemia. Globally, the prevalence of anemia in school-aged children shows a fairly high rate of 37% [7]. The results of the 2013 Basic Health Research (Riskesdas) stated that IDA is still a public health problem in Indonesia with a prevalence of 29% in children aged 5 - 12 years [8].

In malaria-endemic regions, the presence of malaria infection will aggravate the occurrence of iron deficiency anemia. One of the areas in Indonesia that are endemic with malaria is Seluma Regency, Bengkulu Province. In addition to malaria-endemic regions, Seluma Regency is also categorized under one of the underdeveloped regencies [9]. The presence of parasitic infections, lack of nutrient intake, and low socio-economic status can lead to iron deficiency in children which has an impact on the incidence of IDA [10]. Therefore, this study is aimed at determining iron levels and IDA incidence rates in elementary school children in Seluma District as one of the malaria-endemic areas in Indonesia.

2. MATERIALS AND METHODS

This was a cross-sectional study. The population of this study was elementary school children aged 9-11 years collected from five sub-districts in Seluma District, Bengkulu Province. The names of sub-district are Talo, Seluma Utara, Seluma Barat, Seluma Timur, and Lubuk Sandi. The sample of this study was 79 students taken by simple random sampling technique.

The data of this study were collected using questionnaires, blood tests, and stool examinations. The questionnaires were used to collect the data on the characteristic of children and parents such as gender, parental education, work of parents, medical history of parasite infections (malaria and helminthiasis), and nutritional status. The blood samples were taken for the examinations of hemoglobin levels, malaria parasites, serum iron levels, TIBC levels, and transferrin saturation. The examination of hemoglobin was done digitally using *Easy Touch*, the examination of iron levels was carried out by using the spectrophotometric method, and the examination of TIBC levels and transferrin saturation was carried out by ELISA method. The examination of malaria was carried out using the slide method i.e thick smear and thin smear. Stool examination is performed to examine helminthiasis infection using qualitative methods (positive or negative). This research was approved by the Ethics Commission of the Faculty of Public Health, Sriwijaya University No. 46/UN9.1.10/KKE/2019.

3. RESULTS AND DISCUSSIONS

Based on the characteristic distribution data (Table 1), it was found that 39.2% of respondents were 10 years old and most of them (53.2%) were female. The results of the hemoglobin level examination showed that 27.8% of children had hemoglobin levels <12 mg/dL and most children (81%) had an iron deficiency. The measurements of nutritional status showed 64.4% of children were in normal nutritional status. Based on the history of parasitic infection it revealed that 25.3% of children had been infected with malaria, and 27.8% had been infected with helminthiasis. These pieces of evidence indicate that the children living in malaria-endemic regions do not only have a history of malaria infection but also have been infected with worms.

Table 1. Frequency Distribution of Respondents' Characteristics

Frequency Distribution	n	%
1. Age		
a. 9 years old	20	25.3
b. 10 years old	31	39.2
c. 11 years old	28	35.4
2. Sex		
a. Male	37	46.8
b. Female	42	53.2
3. Medical History of Malaria		
a. Yes	20	25.3
b. No	59	74.7
4. Medical History of Helminthiasis		
a. Yes	22	27.8
b. No	57	72.2
5. Hemoglobin Level		
a. < 12 g/dl	22	27.8
b. ≥ 12 g/dl	57	72.2
6. Nutritional Status		
a. Thin	14	17.7
b. Normal	51	64.6
c. Overweight	8	10.1
d. Obese	6	7.6
7. Worm Infection		
a. Positive	26	32.9
b. Negative	53	67.1
8. Malaria Infection		
a. Positive	0	0
b. Negative	79	100
9. Serum Iron		
a. Defisiency	64	81

b. Normal	15	19
10. Anemia Status		
a. Anemia	10	12.6
b. Iron Deficiency	39	49.4
c. Iron Deficiency Anemia	12	15.2
d. Normal	18	22.8

Table 2. Frequency Distribution of Parents' Characteristics

1. Father's Education		
a. Elementary School (not finished)	5	6.3
b. Elementary School	23	29.1
c. Junior High School	24	30.4
d. Senior High School	25	31.6
e. College	2	2.5
2. Mother's Education		
a. Elementary School (not finished)	6	7.6
b. Elementary School	24	30.4
c. Junior High School	27	34.2
d. Senior High School	18	22.8
e. College	4	5.1
3. Father's Job		
a. Farmer/Laborer	54	68.4
b. Civil Servant/Army/Police	6	7.6
c. Self-employee	19	24.1
4. Mother's Job		
a. Housewife	48	60.8
b. Farmer/Laborer	24	30.4
c. Civil Servant/Army/Police	5	6.3
d. Self-employee	2	2.5

According to Ozasuwa [11], children are highly susceptible to being infected with parasites because of their low immune responses. Besides poor hygiene and sanitation. environmental conditions that are suitable for the development of parasites also support the occurrence of parasitic infections in children. In malaria-endemic areas. the presence of malaria and helminthiasis infections increases morbidity in children and also affects iron deficiency in children. Iron deficiency in malaria sufferers is caused by several mechanisms including the destruction of red blood cells containing parasites. shortening the life span of non-parasitic red blood cells. and decreasing red blood cell production in the bone marrow [12,13]. In helminthiasis. iron deficiency occurs because worms directly suck blood and damage the structure of the intestinal mucosa to absorb micronutrients. As a result. the absorption of iron in the intestine is decreased [14,15].

Table 3. Results of Hematology Lab Tests

No.	Variable	N	Mean ± SD	Minimum	Maximum
1.	TIBC	79	301.65 ± 65.02µg/dL	188.06	553.71
2.	Serum iron	79	43.42 ± 19.88µg/dL	20.45	83.58
3.	Transferrin Saturation	79	15.18 ± 8.15 %	5.69	39.71
4.	Hemoglobin	79	13.41 ± 2.21 g/dL	8.90	18.80

Table 3. Mean of Serum Iron Levels in Iron Deficiency Anemia

No.	Variable	n	%	Mean ± SD (µg/dL)	Minimum	Maximum
1.	Normal	18	22.8	71.23 ± 12.06	188.06	553.71
2.	Iron Deficiency	39	49.4	34.19 ± 10.46	20.45	83.58
3.	Iron Deficiency Anemia	12	15.2	35.15 ± 17.01	5.69	39.71
4.	Anemia	10	22.8	39.19 ± 17.43	8.90	18.80

Table 3 shows that the mean level of hemoglobin is 13.41 ± 2.21 g/dL. the mean level of serum iron is 43.42 ± 19.88 µg/dL. the mean level of TIBC is 301.65 ± 65.02 µg/dL. the mean level of transferrin saturation is 15.185 ± 8.15%. Based on these results. it was found that 15.18% of children had iron deficiency anemia. 12.65% had anemia. 49.39% had iron deficiency. and 22.78% were normal. The lowest level of serum iron was found in the group of children who had iron deficiency (34.19 ± 10.46 µg / dL) (Table 4). Iron deficiency occurs in three stages. In the first stage. iron depletion is indicated by serum ferritin <12 µg/l. in the second stage there is a decrease in serum iron (ID) and transferrin saturation (<16%). in the third stage there is iron deficiency anemia which is characterized with a decrease in hemoglobin level (IDA) [16]. Based on the stages of iron deficiency. elementary school children in this study are in the second and third stages. The results of the ANOVA test showed that there were significant differences (p <0.05) on serum iron levels among the groups of children who had iron deficiency anemia. iron deficiency. anemia. and normal (Table 5).

Table 5. Mean Levels of Serum Iron

No.	Variable	Mean ± SD (µg/dL)	Minimum	Maximum	*p *value*
1.	Normal	71.23 ± 12.06	188.06	553.71	0.00
2.	Iron Deficiency	34.19 ± 10.46	20.45	83.58	
3.	Iron Deficiency Anemia	35.15 ± 17.01	5.69	39.71	
4.	Anemia	39.19 ± 17.43	8.90	18.80	

*ANOVA Test

Iron is very necessary for DNA formation. electron transport. and myelin formation and neurotransmitter functions [17]. IDA has an impact on the poor development of a nervous system. growth delay. and impaired immune response [18,19,20]. Many studies reported that these adverse effects cannot be restored. A longitudinal study conducted on 191 children aged 12-23 months who experienced IDA in Costa Rica revealed that at the age of 5. 11 to 14 years the scores of motoric. cognitive. and behavioral performance are found low compared to non-anemic controls although they have been given iron therapy at an early age[21,22].

Table 6. Correlation between Serum Iron Levels and Helminthiasis

Helminthiasis (CI 95%)					**Total**		***p** ***value*** **PR**	
Serum Iron Level	**Negative**		**Positive**					
	n	**f(%)**	**n**	**f (%)**	**n**	**f(%)**		
Normal	12	70.6	5	29.4	17	100	0.729	1.229
Deficiency	41	66.1	21	33.9	62	100	(0.382-3.954)	
Total	53	67.0	26	33.0	63	100		

*p Chi-square test

The prevalence of iron deficiency and iron-deficiency anemia can be affected by the presence or absence of infectious diseases. Infectious diseases that often cause iron deficiency and iron deficiency anemia are malaria and helminthiasis. Therefore. in this study. we also examined malaria infections and worms. The results of the malaria parasite examination showed that all children (100%) were not positively infected with malaria. whereas the results of the helminthiasis examination showed that 26 children (32.9%) were positively infected with worms. Children with iron deficiency 33.9% are positively infected with helminthiasis.

The children with iron deficiency are 33.9% positively infected with helminthiasis. However. the results of statistical tests (Table 6) show that there is no significant relationship (p> 0.05) between the mean level of serum iron and worms. According to Lee & Osazuwa [23,24], iron deficiency and iron deficiency anemia besides being caused by parasitic infections (such as malaria and helminthiasis)can also be caused by micronutrient deficiencies such as iron. folic acid. vitamin B12. and low economic problems. In this study. there was no assessment of nutrient intake. but based on the frequency distribution of the characteristics of parents of children. it was known that most parents were low educated and worked as laborers. This certainly will greatly affect children's nutritional intake.

4. CONCLUSION

Almost half (49.39%) of the elementary school children living in malaria-endemic areas experience iron deficiency. It is assumed that a low intake of iron plays a role in the high number of iron deficiency cases in elementary school children in malaria-endemic areas of Seluma Regency. Bengkulu Province.

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