Original Article

Serum iron status in Orang Asli children living in endemic areas of soil-transmitted helminths

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We conducted a cross sectional study to examine the association of intestinal parasitic infections and protein energy malnutrition (PEM) with iron-status indicators and anaemia among Orang Asli children in Selangor, Malaysia. A total of 281 children aged 2 - 15 years were studied. The data were collected using structured questionnaires, anthropometric measurements and laboratory analysis for blood and faecal samples. All children were infected either by *A. lumbricoides*, *T. trichiura* or hookworm and almost 19%, 26% and 3% of the children had severe infection of ascariasis, trichuriasis and hookworm infection respectively. The prevalence of giardiasis among them was 24.9%. Overall, 41.5% of the children were anaemic (haemoglobin < 11.0 g/dL). Of these 61.0% of the children had iron deficiency and 36.5% had iron deficiency anaemia (IDA), which accounted for 88.0% of anaemia in this population. Severe trichuriasis had the most significant correlation with anaemia and iron deficiency in this population. It contributed to low concentrations of haemoglobin, serum iron and serum ferritin and high total iron binding capacity (TIBC). Significant underweight and stunting were associated with low concentrations of haemoglobin and serum iron while significant wasting was significantly associated with low concentration of serum ferritin. Logistic regression analysis confirmed that severe trichuriasis was a strong predictor of IDA. It also confirmed that children who were significantly underweight and whose mother was working were independent predictors of IDA in this population.

Key Words: iron deficiency anaemia, soil-transmitted helminthiases, protein-energy malnutrition, Orang Asli children, Malaysia

INTRODUCTION

Iron deficiency anaemia (IDA) affects 20% to 50% of the world's population[1]. It is common in young children and prevalence has been reported to be as high as 22% among East-Asian school children and 60% among children less than 5 years of age.[2-4] In developing countries, hookworm infections account for most cases of IDA whereas in developed countries, pregnancy and chronic blood loss are the most common causes. In children IDA develops slowly and causes few acute symptoms. As it becomes chronic, the affected children become pale and weak, eat less and gain weight poorly. They are also susceptible to respiratory and intestinal infections.

In Malaysia, a survey by the Ministry of Health supported by UNICEF reported that 18.3% and 20.8% of girls and boys below 5 years had haemoglobin concentration less than 11g/dL.[5] Thus, the most common cause of anaemia in Malaysia is IDA. A nutritional study carried out in rural villages reported that children aged 1-7 years had inadequate dietary intake of iron, energy and niacin according to Recommended Daily Intake (RDI).[6] Among the low-income groups beside poor dietary intake, soil-transmitted helminth infection also contributes to the high anaemia rates in children. Ascariasis, trichuriasis, hookworm infection, giardiasis and amebiasis are the most common intestinal parasitic infections, and are of health significance in Malaysia. The prevalence is worse in the very low-income groups that include aboriginal groups and communities from rural poor Malay villages, estates and squatter areas.[7,8]

Severe trichuriasis and hookworm infection can lead to IDA. Trichuriasis causes colitis leading to dysentery and chronic faecal blood loss. Hookworm infection causes intestinal bleeding at the site of attachment resulting in chronic intestinal bleeding. In the severe form, these infections also contribute to malnutrition and hypoalbuminaemia in children. A study on 658 primary school children in Panama reported that haemoglobin concentrations were significantly lower in children with severe trichuriasis.[9] A study in

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Jamaica reported that the prevalence of anaemia in children with severe trichuriasis was significantly higher than in those non-infected[10]. This study also suggested that IDA is associated with severe trichuriasis where there are more than 10000 eggs per gram (EPG) of stool. Although the iron losses were observed to be less than in hookworm infection, they were considered sufficient to cause IDA.[11]

A recent study in highly endemic areas of hookworm infestation in Nepal reported that the prevalence of anaemia with low serum ferritin increased with the severity of infection.[12] That study showed that hookworm infection was strongly associated with depleted iron stores. Similar observations were seen in a study among an Aboriginal community in northwest Australia[13] and among school children in Zanzibar.[14] It was reported that anaemia was found more frequently among children infected with intestinal parasites including giardiasis.[15] This study was carried out to see the association between haemoglobin, serum iron and serum ferritin concentrations and total iron binding capacity (TIBC) in Orang Asli children living in endemic areas of intestinal parasitic infections in Malaysia.

METHODS

This was a cross-sectional study conducted in Orang Asli children (aborigines), aged 2-15 years old, living in eight villages in Selangor, Malaysia. The villages have homogenous nature of the populations with respect to their socio-cultural and daily economic activities. Most of the residents work as labourers, farmers or rubber tappers or do odd jobs, such as selling forest products. Most of the houses have electricity and piped water supply. Most of the children play with soil without wearing shoes or slippers. Some of them play and swim in the river near their villages after school and in their leisure time. In addition, their personal hygienic practices were poor. All children who agreed voluntarily through their parents to participate were included in this study (universal sampling). Of the 368 children recruited, blood samples were collected from 282 children and only 281 children delivered stool specimens for examination. The study included both males and females.

The data were collected over a period of two months, (November 2003-Jan 2004) during many visits. The parents were read an Informed Consent Form and permission was obtained from parents whose children participated in this study. Each child was given an identity code accordingly and particulars were entered in the data sheet. The parents were interviewed directly on the personal particulars of the children, as well as socio-economic status, using a standardized questionnaire. Date of birth and birth weight were obtained from birth certificates while immunization status was obtained from each child's health record.

Fresh stool samples were collected into wide mouth screw-cap 100 ml clean containers. The faeces were examined for the presence of soil-transmitted helminthes by the Kato-Katz technique and worm burden.[16] Infections with soil-transmitted helminthes were recorded according to species. The intensity of infection was recorded as eggs per gram (epg) of faeces according to the relevant formula and it was graded according to criteria proposed by the World Health Organization.[17] Approximately, 10 gm of faeces was mixed thoroughly and fixed in polyvinyl alcohol (PVA) for the detection of *Giardia duodenalis* using trichrome stain technique. *G. duodenalis* infection was recorded positive by the presence of cysts and/or trophozoites in the faeces.

About 3-4 mls of venous blood was collected into plain tubes for biochemisry analysis. Haemoglobin concentrations were measured directly after blood withdrawal using HemoCue hemoglobinometer (HemoCue, AB, Angelhom, Sweden). Haemoglobin concentration was recorded, as g per dL Children of age ≤ 6 years with haemoglobin concentration less than 11 g/dL and children of age > 6 years with haemoglobin concentration less than 12 g/dL were considered as being anaemic. After clot formation the tubes were centrifuged at 3000 rpm for 10 minutes to obtain the serum. Serum ferritin concentrations were analyzed by microparticle enzyme immunoassay (MEIA) method on the AxSYM, Abbott Diagnostics using AxSYM Ferritin Reagent Pack, (No. 7A58-20). Serum iron and TIBC were determined colorimetrically using Guanidine/Ferro Zine method on the COBAS INTEGRA 800 analyser. Children with normal haemoglobin levels and low serum ferritin levels were considered to have iron deficiency while anaemic children with low serum iron level (less than 10.6 μmol/L) and high TIBC (more than 75 μmol/L) and/or serum ferritin (less than 10 μg/L) were considered to have IDA.[14,18] A portion of the serum was kept at -20C^{o} and used in determination of serum retinol level using High Performance Liquid Chromatography (HPLC), LC-10AD (Shimadzu, Kyoto, Japan), as described by Tee and Swan-Choo[19] with suitable modifications. Children with concentrations of retinol less than 20 μg/dL were considered to have VAD.

All children underwent anthropometrics measurement as follows: children were measured without shoes using SECA scale which had intervals of 0.5 kg; height was measured to the nearest 0.1 cm using calibrated scale consisting of a wooden platform with a scale and a sliding head piece. To reduce intra-individual error, weight and height were measured twice and the mean value was used for analysis. *Weight-for-age* Z-score was used to denote underweight as an overall indicator for malnutrition. *Height-for-age* Z-score was used as an indicator for stunting (chronic malnutrition). *Weight-for-height* Z-score was used as an indicator for wasting (acute malnutrition). The Z-scores were calculated based on the median values of the National Center for Health Statistics (NCHS) Reference Population, United States. For this study, children who had Z-score below –2 standard deviations (SD) of the *NCHS* Reference Population median were considered to be significantly malnourished and Z-scores between –1 and –2 SD were mildly malnourished. The Z-scores for *weight-for-age*, *height-for-age* and *weight-for-height* were derived using EpiNut Anthropometery (Epi Info, Version 6, 2002).[20]

Statistical analysis of data was performed using SPSS (version 11.5, March 2002). Univariate and multivariable analysis were used for the determination of risk factors.

Table 1. Iron-status indicators, prevalence of anaemia and IDA among Orang Asli children according to age and gender

Age/Gender	Haemoglobin Mean (SD)	Serum iron Mean (SD)	Serum ferritin Mean (SD)	TIBC Mean (SD)	Anaemia[a] %	Severe Anaemia[b] %	IDA[c] %
Age (Years)							
2-4 (n=49)	10.9 ± 1.9	9.5 ± 5.1	19.1 ± 17.0	69.2 ± 10.7	38.8	14.3	34.7
5-7 (n=93)	11.3 ± 1.9	10.4 ± 4.8	21.6 ± 17.5	68.9 ± 10.8	45.2	12.9	39.8
8-10 (n=82)	11.8 ± 1.8	12.1 ± 5.8	22.4 ± 15.2	68.4 ± 10.5	40.2	11.0	34.1
11-13 (n=46)	11.9 ± 1.8	11.2 ± 5.4	22.7 ± 20.3	72.3 ± 10.2	43.5	6.5	41.3
>13 (n=12)	12.5 ± 1.8	11.9 ± 7.9	16.0 ± 8.8	76.1 ± 12.3	25.0	8.3	16.7
Gender							
Males (n=142)	11.6 ± 1.8	11.1 ± 5.5	21.2 ± 16.2	68.0 ± 9.5	40.8	10.6	35.9
Females (n=140)	11.5 ± 2.0	10.8 ± 5.4	21.6 ± 17.8	71.3 ± 11.7	42.1	12.1	37.1
Total (n=282)	11.5 ± 1.9	10.9 ± 5.4	21.4 ± 16.9	69.7 ± 10.7	41.5	11.3	36.5

n represents the number of subjects; [a] Haemoglobin concentration < 11 g/dL. in children of age ≤ 6 years and < 12 g/dL in children of age > 6 years; [b] Haemoglobin concentration < 8 g/dL; [c] Anaemia with low serum iron, high TIBC and /or low serum

Table 2. Odds ratios for anaemia, serum iron, serum ferritin and TIBC associated with hookworm infection, trichuriasis, ascariasis, giardiasis, underweight, stunting and wasting

Risk factors	Haemoglobin < 11g/dL	Serum iron <11μmol/L	Serum ferritin <10μg/L	TIBC >68μmol/L
Severe hookworm infection (n=5)	*	*	4.4 (0.72-16.9)	*
Severe trichuriasis (n=66)	2.9 (1.54-5.45) [a]	1.9 (1.01-3.63) [a]	2.7 (1.4-5.12) [a]	1.9 (1.0-3.7) [a]
Severe ascariasis (n=53)	1.6 (0.82-3.2)	1.3 (0.66-2.62)	1.4 (0.66-2.91)	1.5 (0.73-2.86)
Positive giardiasis (n=82)	0.7 (0.34-1.8)	0.6 (0.33-1.13)	0.9 (0.46-1.84)	0.7 (0.38-1.3)
Significant underweight (n=190)	1.8 (1.1-2.9) [a]	2.2 (1.33-3.52) [a]	1.7 (0.96-2.83)	0.84 (0.52-1.36)
Significant stunting (n=206)	1.7 (0.94-2.8) [a]	1.7 (1.0-2.7) [a]	1.6 (0.95-2.92)	1.4 (0.83-1.83)
Significant wasting (n=41)	1.6 (0.67-3.85)	2.5 (0.94-6.6)	2.6 (1.1-6.4) [a]	1.0 (0.43-2.43)

n represents the number of subjects; [a] Significant (p<0.05); * Cornfield 95% confidence interval for adds ratio is not accurate due to small numbers.

Odds ratios (OR) were calculated by logistic regression models. Association of malnutrition and the Z-scores for *weight-for-age*, *height-for-age* and *weight-for-height* were derived using EpiNut Anthropometery.[20] This study was approved by the Research and Ethical Committee, Faculty of Medicine, Universiti Kebangsaan Malaysia, Malaysia.

RESULTS

Three hundred and sixty eight children (178 males; 190 females) aged between 2-15 years with median age of 7.0 years participated in this study and underwent physical examination including anthropometry. 281 of the children delivered stool for examination and all of them were infected with at least one of these soil-transmitted helminthes, *A. lumbricoides* (61.9%), *T. trichiuara* (98.2%) and hookworm (37.0%). Of these children 19%, 26% and 3% had severe infection of ascariasis, trichuriasis and hookworm infection respectively. The prevalence of giardiasis was 24.9%. The overall prevalence of mild and significant underweight was 32.1% and 56.5% respectively. The prevalence of mild stunting was 25.6%, while another 61.3% had significant stunting. The overall prevalence of mild and significant wasting was 39.0% and 15.1%.

Serum iron status

Blood samples were collected from 282 children. The prevalence of anaemia and iron-status indicators among Orang Asli children according to age and gender are shown in Table 1. Overall 41.5% of the children were anaemic (haemoglobin < 11.0 g/dL). Of these 61.0% of the children had iron deficiency and 36.5% had IDA, which accounted for 88.0% of anaemia in this population. The mean haemoglobin, serum iron and serum ferritin concentrations were 11.5 ± 1.9 g/dL, 10.9 ± 5.4 μmol/L and 21.4 ± 16.9 μg/L respectively. The mean total iron binding capacity (TIBC) was 69.7 ± 10.7 μmol/L. The percentage of children with low serum iron and low serum ferritin concentrations was 55.3% and 28.4% respectively and high TIBC was found in 51.1% of the children. There was no significant difference in the prevalence of IDA according to age (X^2 = 3.13, p=0.526) and gender (X^2 = 0.046; p= 0.831).

Potential factors associated with anaemia, iron deficiency and iron deficiency anaemia

Odd ratios for anaemia, serum iron, serum ferritin and TIBC associated with intestinal parasitic infections and malnutrition are shown in Table 2. Analyses showed that severe trichuriasis was the most significant contributor to anaemia and iron deficiency in this population. It contributed to low concentrations of haemoglobin, serum iron and serum ferritin and high TIBC. In addition underweight wasting was significantly associated with low concentration of serum ferritin. None of the other infections studied (severe ascariasis, severe hookworm infestation and giardiasis) showed significant association with iron status indicators.

Potential associated factors with IDA were analyzed

using univariate and multivariate analyses and the findings are presented in Table 3. The results showed that non-educated mother, severe trichuriasis, low serum retinol concentration, mixed infection with worm score of ≥ 7, underweight, stunting and working mother were the significant risk factors of IDA. Logistic regression analysis confirmed that severe trichuriasis was the main predictor of IDA in this population (OR=3.1; 95% CI=1.7-5.8). It also confirmed that significant underweight (OR=2.2; 95% CI=1.3-3.6) and working mother (OR=2.2; 95% CI=1.1-4.1) were the risk factors of IDA.

DISCUSSION

Iron deficiency anaemia (IDA) and STH infections coexist among low-income population. Their associations are complex and superinfection between various groups of organisms is commonly seen in this population.

We studied the prevalence of anaemia and IDA among children from endemic areas of intestinal parasitic infections with poor socioeconomic background. The association of anaemia and IDA with severe infection of STH, giardiasis and protein-energy malnutrition (PEM) was also examined. This study demonstrated high prevalence of anaemia and IDA among Orang Asli children. Although the mean concentrations of haemoglobin, serum iron and serum ferritin were at the lower limits of normal, the prevalence of children with low concentrations of these indicators were high as compared to figures from recent study in Malaysia.[5]

In this study, 88.0% of the study population was found to have iron deficiency and it appeared to be the dominant cause of anaemia. In Malaysia, a survey by the Ministry of Health reported that 20% of children less than 5 years old had low haemoglobin concentrations, a prevalence that is one third of the figure obtained in this study[5]. An earlier study among Orang Asli children reported that the prevalence of anaemia ranges from 26.5% in adolescents to 44% in the preschoolers.[21] Janabhai et al. observed that 16.5% and 28.1% of school-aged children in South Africa had low concentrations of haemoglobin and ferritin respectively.[22] In contrast, it was reported that 62.3% school children in Zanzibar were anaemic and 82.7% was due to IDA.[14]

Although the mean concentration of haemoglobin observed in this study increased with age the prevalence of anaemia and IDA according to age groups and genders was not statistically significant. In general, females are known to be more anaemic than males especially in the reproductive age due to physiological variations. However, a study among Kenyan preschool children reported that the prevalence of anaemia and IDA was significantly higher in males than females and the prevalence decreased steadily with increasing age.[23] A similar observation was also reported among Zanzibar schoolchildren.[14] In Malaysia, Khor reported that the prevalence of anaemia was significantly decreased with age, which is contrary to the present finding.[21]

In this present study the mean concentration of serum ferritin, which reflects the iron body store, was in the lower limits of the normal range with 28.4% of the children having depleted iron stores, Depleted iron store and low serum iron level increases TIBC as were reflected in our findings. IDA is a multifactorial problem and it may result from interactions of many factors that coexist in this population such as poor dietary intake, increased demands (growth), recurrent infections, socio-economic causes and genetic factors (thalassaemia). Parasitic infections resulting in bleeding (e.g. hookworm infection and schistosomiasis) or in dysentery (e.g. trichuriasis and amebiasis) are known to be predictors for IDA. In this study population, severe trichuriasis was identified as one of the important contributors to IDA. The association

Table 3. Multivariate analysis of potential risk factors with IDA among Orang Asli children

Variables	Prevalence of IDA			
	Normal	Anaemic	OR (95% CI)	*p*
Non-educated father	28.2	24.3	0.81(0.47-1.40)	0.469
Non-educated mother	63.5	44.7	0.46(0.28-0.76)	0.002[a]
Working mother	11.7	22.3	2.20(1.10-4.10)	0.018[a,b]
Low family income	72.6	68.3	0.82(0.48-1.40)	0.453
Family size ≥8 members	38.5	43.7	1.20(0.76-2.00)	0.397
Incomplete immunization	5.0	9.7	2.00(0.80-5.20)	0.131
Breastfeeding ≤ 4 months	19.6	17.5	0.87(0.47-1.60)	0.667
Prolonged breastfeeding > 2 years	24.6	22.3	0.88(0.50-1.60)	0.669
Birth weight <2.5 kg	24.2	38.4	2.00(1.10-3.50)	0.210
Age group 2-6 years	37.4	37.9	1.00(0.62-1.70)	0.942
Female	49.2	50.5	1.10(0.65-1.70)	0.831
Severe ascariasis	25.6	35.0	1.60(0.75-3.30)	0.233
Severe trichuriasis	16.4	38.0	3.10(1.70-5.80)	0.000[a,b]
Severe hookworm infection	0	14.3	*	0.014 (Fisher's)
Mixed infection worm score ≥7	3.6	12.6	3.90(1.30-11.5)	0.010[a]
Giardiasis	27.5	26.1	0.70(0.36-1.30)	0.247
Low serum retinal	21.2	32.0	1.70(1.00-3.00)	0.044 [a]
Significant underweight	48.0	67.0	2.20(1.30-3.60)	0.003 [a,b]
Significant stunting	57.1	72.9	2.10(1.20-3.50)	0.010 [a]
Significant wasting	9.7	13.3	1.40(1.60-3.40)	0.421

[a] Significant by univariate analysis ($p<0.05$); [b] Confirmed as significant predictors by logistic regression analysis; * Cornfield 95% confidence interval for odds ratio is not accurate due to small numbers

between trichuriasis and IDA has been shown clearly by several studies.[9,10] It was also suggested that IDA is associated with *Trichuris* infection of over 10000 eggs per gram (epg) stool.[10]

Our findings were in contrast with other studies that examined the association of hookworm infection and IDA. Studies which were carried out in populations with high prevalence of hookworm infection found that hookworm infection was a strong predictor of IDA and anaemia in school-age children.[13,23-25] A large-scale school-based study in Tanzania suggested that hookworm was responsible for 6% of anaemia cases in the population.[26] A low overall prevalence of severe hookworm infection in that study population may be the possible reason to explain this. Mixed infections with worm score ≥7 were observed as a predictor of IDA. This may be due to the synergistic effect of the three species of STH in this population. A similar observation was found in a study among schoolchildren in South India.[27]

In this study, an association was also observed between significant underweight and low concentrations of haemoglobin and serum iron. Similar association was also seen between significant stunting and low concentrations of haemoglobin and serum iron and between significant wasting and low concentration of serum ferritin. A study among various age groups in Philippines concluded that there was an interaction between anaemia and PEM.[28] Smith et al. reported that mild to moderate anaemia was always present in cases of severe malnutrition due to deficiency of iron and folic acid, chronic malaria, dysentery and worm infestation.[29] A study among schoolchildren in Zanzibar showed that stunting was associated significantly with anaemia and IDA.[14] It has also been observed that there is presence of multiple mineral and vitamin deficiencies in severe malnutrition.[30] A recent study carried out among lactating women in Ethiopia reported that the prevalence of malnutrition had positive correlation with the serum ferritin concentration.[31] This present study has highlighted and strengthened previous observations that significant underweight, stunting and wasting is correlated with IDA.

It is interesting to note the association between Vitamin A deficiency (VAD) and IDA in this study population. This study observed that VAD was a significant risk factor for IDA. A possible association between iron and vitamin A was suggested in many studies and serious attention has been given to this relationship.[12,32-34] In a randomized trial to examine the effect of vitamin A supplementation on iron status in children found that vitamin A supplements was found to directly improve iron status.[32] Furthermore, two months of daily vitamin A supplementation has been reported to significantly increase the haemoglobin concentration and reduced the prevalence of anaemia by 23%; thus anaemia was almost completely eliminated in those who received both vitamin A and iron supplements.[34] A possible mechanism to explain this association is that the lack of vitamin A decreases the level of transferrin and consequently diminishes the transport of iron.[33]

This study also observed that socio-economic factors such as mothers' education and employment status had association with IDA. Mothers' education especially nutritional education is known to be critical for the children's health and nutritional status. However, when all the significant variables were considered jointly in multivariate model, severe trichuriasis, working mothers and significant underweight remained the strongest predictors for IDA in this study population. This study did not measure factors such as malaria infection and daily iron intake. Earlier studies had shown that daily iron intake by Orang Asli children was low, about 29% to 49% of the RDI.[6,21] Previous studies on interactions among micronutrient deficiencies and undernutrition concluded that there was apparent association between anaemia and vitamin A deficiency and PEM.[28,35]

CONCLUSION

Our findings provide a population-based picture of iron status among Orang Asli children living in conditions of poor socio-economic background, high prevalence of chronic malnutrition and high prevalence of trichuriasis and other intestinal parasitic infections. The prevalence of anaemia and IDA among Orang Asli children was high. About 42% of the children were anaemic while 36.5% had IDA. The prevalence of anaemia and IDA was not significantly dependent on age or gender. Severe trichuriasis, significant undernutrition, stunting and wasting were other contributory factors of anaemia and IDA in this population. In addition, our data also suggested that iron deficiency appeared to be the dominant cause of anaemia in this population and deworming programmes should be included in public health strategies for the control and prevention of protein-energy malnutrition and anaemia particularly IDA in this population.

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AUTHOR DISCLOSURES

U Nor Aini, MS Hesham Al-Mekhlafi, M Azlin, A Shaik, A Sa'iah, MS Fatmah, MG Ismail, MS Ahmad Firdaus, MY Aisah, AR Rozlida and M Norhayati, no conflicts of interest.

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Original Article

Serum iron status in Orang Asli children living in endemic areas of soil-transmitted helminths

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土壤傳染蛔蟲病疫區 Orang Asli 孩童之血清鐵狀態

我們進行一個橫斷性研究，以鐵狀態指標和貧血來調查馬來西亞 Selangor 的 Orang Asli 孩童的寄生腸傳染病及蛋白質熱量營養不良症。共有 281 名 2-15 歲孩童納入研究。資料收集包括：結構式問卷、人體測量及實驗室血液及糞便檢體分析。所有的孩童都感染到蛔蟲、鞭蟲或鉤蟲，而受蛔蟲、鞭蟲和鉤蟲嚴重感染的孩童分別佔 19%、26%及 3%。梨形蟲病的盛行率為 24%。整體而言，41.5%的孩童為貧血（血紅素< 11.0 g/dL）。其中，61.0%有鐵缺乏，36.5%有缺鐵性貧血(IDA)，佔這個族群貧血人口的 88.0%。在這個族群嚴重的鞭蟲症與貧血和鐵缺乏相關最為顯著。它影響到低的血紅素濃度、血清鐵、血清鐵蛋白和高的總鐵結合能力（TIBC）。嚴重的體重不足和發育遲緩與低的血紅素濃度和血清鐵有關，而嚴重的肌肉消失與低血鐵蛋白有顯著相關。羅吉斯迴歸分析確定嚴重的鞭蟲症是 IDA 的一個重要的預測因子。也確定在這個族群，嚴重體重不足及孩童母親有工作兩項為 IDA 的獨立預測因子。

關鍵字：缺鐵性貧血、土壤傳染蛔蟲病、蛋白熱量營養不良、Orang Asli 孩童、馬來西亞。