Iron and vitamin A status of adolescent school girls in an urban and a rural area of Sri Lanka

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Summary

The prevalence of anaemia and iron and vitamin A deficiency were assessed in adolescent school girls of low socio-economic status in an urban (n=576) and a rural area (n=339). Their general nutritional status (anthropometry), haemoglobin concentration, iron status, (erythrocyte protoporphyrin, serum iron and total iron binding capacity and serum ferritin concentration) and vitamin A status (serum vitamin A concentration and conjunctival impression cytology) were assessed.

Twenty percent of the subjects studied had low body mass index values (<fifth percentile) for each age group. The prevalence of anaemia was 18.0%. There was no significant difference in prevalence between girls in the urban area and those in the rural area. Depleted iron stores (serum ferritin<12μg/L) were noted in 22.5% of subjects, while a further 28.7% had marginal iron stores. The urban group had a significantly lower mean percentage transferrin saturation ($p<0.05$) and mean serum ferritin concentration ($p<0.001$) than the rural group, indicating that iron deficiency was a greater problem in the urban area than in the rural area. The prevalence of vitamin A deficiency as indicated by low serum vitamin A concentration (<20μg/dL) and abormal or borderline conjunctival impression cytology (CIC) was 21.1% and 16.0% respectively. There was no significant difference in vitamin A status between urban and rural subjects, but, 12 subjects (2.5%) in the urban area and one subject (0.35%) in the rural area had very low serum vitamin A concentrations.

It is noteworthy that subjects with abnormal or borderline conjunctival impressions in the urban area had significantly lower serum vitamin A levels than those with normal impressions. Although CIC is a less sensitive indicator of vitamin A status than serum vitamin A concentration there was an association between serum vitamin A concentration and occurrence of borderline or abnormal conjunctival impressions. CIC is a useful field test to assess vitamin A status of a population, specially when HPLC facilities are not available.

Our results suggest that although the prevalence of anaemia was low in both areas, the prevalence of iron deficiency was higher in the urban area. This difference could be due to reduced access to home grown foods and unsatisfactory living conditions in the urban area. Serum ferritin levels should be estimated in population surveys, as measurement of haemoglobin alone underestimates the problem of iron deficiency.

Key words - Iron, Vitamin A, Adolescent girls, urban and rural Sri Lanka

Introduction

Iron deficiency anaemia and vitamin A deficiency are major health problems in many developing countries. Adolescence is a period of rapid growth and development and several reports suggest that adolescent girls, are at risk of multiple nutritional deficiencies (1). A high prevalence of anaemia has been noted among pregnant women in Sri Lanka (2,3), but studies on adolescent girls are limited (4). In the national survey carried out by the Ministry of Policy Planning, Ethnic Affairs and National Integration, 36% of children between 10 years and 18.9 years were anaemic. In the above survey haemoglobin levels were used to detect anaemia, while other parameters of iron status were not assessed (5). The prevalence of vitamin

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A deficiency has not been assessed previously among adolescents in Sri Lanka. It is necessary to assess their nutritional status before any intervention programme is planned and undertaken. Differences in environment and living conditions of urban and rural communities may have an impact on the nutritional status of subjects. Thus our study was undertaken to assess the nutritional status, iron and vitamin A status of an urban and a rural population of adolescent girls.

Subjects and Methods

Subjects

Five hundred and seventy six girls in the age group 13 to 19 years (mean age 15.5 ± 1.1 years) attending schools within the Colombo municipal area (urban area), and 339 girls of a similar age (mean age 15.7 ± 1.1 years) attending schools in the Kaduwella Medical Officer of Health area (rural area) were selected for study. Subjects who had not attained menarche at the time of the study were excluded. The schools selected were those in which the majority of the children were of low socio-economic status.

Methods

Data on socio-economic status and age at menarche was obtained using an interviewer - administered questionnaire. The occupation of parent/guardian was categorised according to the classification of Baker and Hall (6). Their weights and heights were measured using standardized scales to an accuracy of ± 0.1 kg and ± 0.1 cm respectively and the body mass index (BMI) calculated.

A venous blood sample (10 mL) was obtained from each subject between 8.00 and 10.00 a.m. An aliquot (3 mL) was transferred to tubes containing an anticoagulant and used for the estimation of haemoglobin, packed cell volume and erythrocyte protoporphyrin. The remainder of the blood was collected into tubes without anticoagulant, the serum separated within four hours of collection, divided into aliquots and stored at -20° C until use.

Haemoglobin concentration was determined by the cyanmethaemoglobin method (7) and packed cell volume with the use of a microhaematocrit centrifuge. Both haemoglobin and packed cell volume were estimated on the day of collection of blood. Serum iron, total iron binding capacity, erythrocyte protoporphyrin and serum ferritin were measured as indicators of iron status. Erythrocyte protoporphyrin was estimated by an extraction method (8). Serum iron (SI) and total iron binding capacity (TIBC) were determined using reagent kits obtained from Sigma Chemicals, USA (procedure No. 565) and the percentage transferrin saturation ([SI/TIBC]X100) was calculated. Ferritin concentration of the serum was determined by a sandwich ELISA technique (7). Vitamin A status was assessed by conjunctival impression cytology (9) and serum vitamin A concentration was determined by reverse phase high pressure liquid chromatography (10).

Written permission was obtained from the Ministry of Education and from principals of schools. The participants and their parents/guardians gave informed written consent. The study was approved by the Ethical Review Committee of the Faculty of Medicine, University of Colombo.

Statistical analysis

Analysis was carried out using the Epi-info version 6.0 programme. Chi-square test, student's t-test, ANOVA and Kruskal Walli's test for non parametric data and regression analysis were used to assess statistical significance.

Results

The majorty of the subjects studied belonged to families with a low socio-economic status. More than 50% of subjects in both areas had monthly incomes of less than 3000 Sri Lankan rupees per month (Table 1). There were no significant differences in socio-economic status between urban and rural subjects.

The mean age of girls in the urban area was 15.8 (SD=1.1) years and the rural girls was 15.7 (SD=1.1) years. All subjects had attained menarche

before the beginning of the study and hence had passed the peak of the adolescent growth spurt. The mean age at menarche, assessed by recall, was 13.0 (SD=1.2) years for the urban subjects and 13.1 (SD=1.1) years for the rural subjects. However, 8.1% of subjects in the urban area and 9.6% subjects in the rural area attained menarche at 15 years of age or later.

Similarities were observed in general nutritional status (Table 2) between the two groups. The mean body mass index (BMI) of subjects was 17.9 ± 2.5 kg/m^2 (urban) and 17.6 ± 2.3 kg/m^2 (rural). There was no significant difference in age between girls with BMI values less than the fifth percentile for age and those with values within the normal range. The percentage of subjects with a BMI of less than the fifth percentile for the age group, was 20.5% when both urban and rural subjects were considered and 18.5% and 23.9% respectively in subjects in urban and rural areas (Table 3). A significant positive correlation was noted between BMI and mid-upper arm circumference (urban: r^2 = 59%, F = 813, p<0.001 and rural: r^2 = 73%, F = 826, p < 0.001).

The mean haemoglobin concentrations in both the urban (130.6 ± 13.8 g/L) and the rural (130.1 ± 10.8 g/L) groups were not significantly different. The prevalence of anaemia when both groups were considered together was 18.0%. One hundred and four subjects in the urban area (18.5%) and 57 subjects in the rural area (17.3%) were anaemic (Table 4). Anaemic subjects in the urban sector had a significantly (p<0.005) lower mean haemoglobin concentration (109.1 ± 10.4 g/L) than the rural subjects (113.4 ± 6.0 g/L). A significantly higher (p<0.003) percentage in the urban group (19.4%) had low packed cell volumes than in the rural (13.6%) subjects. While 36 urban subjects (6.4%) had haemoglobin concentrations below 110 g/L, only six subjects (1.8%) in the rural group had very low values. Values below 70 g/L were noted in two subjects in the urban group but were not noted in the rural group. Although the mean haemoglobin concentration and prevalence of anaemia was not significantly different between the groups, the urban sector had a significantly (p<0.002) higher number of subjects with severe anaemia (<110g/L).

Fifty one percent of all subjects had an erythrocyte protoporphyrin concentration greater than 70 µg/dL RBC indicating iron deficient erythropoiesis.

Although there was no significant difference in mean protoporphyrin levels, the urban group had a significantly (p<0.0001) higher percentage of subjects with elevated levels of protoporphyrin (i.e. > 70 µg/dL RBC) than those in the rural area (Table 5). The same trend was noted in the ratios of protoporphyrin to haemoglobin (Table 5). The percentage of subjects in the total sample having low transferrin saturation percentages (<16%) was 12.2%. The mean percentage transferrin saturation of the urban group was significantly lower (p<0.05) than that of the rural group (Table 5). A significantly (p<0.001) higher percentage in the urban group had low transferrin saturation percentages than in the rural group. The percentage of subjects in the total sample with depleted iron stores (serum ferritin <12 µg / L) was 22.5% and with marginal iron stores (12 µg /L - 20 µg / L) was 28.7%. Mean serum ferritin concentration was significantly lower (p<0.001) in the urban than in the rural group. Although the percentage of subjects with serum ferritin levels between 12.0 µg / L and 20.0 µg / L was higher (p<0.05) in the urban group than in the rural group, the number of subjects with depleted stores (<12.0 µg / L) was not significantly different.

In order to assess the effect of menstruation on iron status, subjects in the urban area were grouped into three categories according to the time elapsed since they attained menarche until the date of blood collection: (1) upto six months (n=32). (2) six months to two years (n=326) (3) more than two years (n=164).

Subjects who had been menstruating for only six months had the highest haemoglobin concentration (136.2 ± 10.9 g/L) followed by subjects who had menstruated for six months to two years (132.4 ± 14.8 g/L). Subjects who had menstruated for a longer duration had the lowest mean haemoglobin concentration (129.4 ± 13.4 g/L). The differences were statistically significant (p<0.02). Such an association was not noted in the rural

area. An association was not observed with other laboratory parameters of iron status and menstruation.

The prevalence of vitamin A deficiency in the total group was 15.8% by conjunctival impression cytology (abnormal+borderline) and 21.1% by serum vitamin A concentration (<20 μg/dL). Vitamin A status was not significantly different between the groups, as indicated both by conjunctival impression cytology and mean serum vitamin A concentration (Table 6). Abnormal or borderline impressions were noted in 16.2% (urban) and 15.0% (rural) subjects studied. The percentage of subjects who had low vitamin A levels (<20 μg/dL) were not significantly different between the urban (22.2%) and rural (19.2%) groups. However, the percentage of subjects who had severe vitamin A deficiency (<10 ug/dL) was significantly ($p<0.05$) higher in the urban area when

Table 1
Socio-economic characteristics of adolescent school girls studied

	Percentage of subjects	
	Urban (n=576)	Rural (n=339)
Occupation of parent/guardian		
Requiring education at highest level	17.5	13.6
Requiring primary education at higher level	38.4	51.3
Requiring primary education at lower level	6.6	8.5
No formal training	9.5	8.3
Unemployed	8.2	6.5
Other*	19.8	11.8
Monthly family income		
< Rs. 1000	13.7	16.5
Rs. 1000 - 2999	56.9	56.3
Rs. 3000 - 7499	22.5	21.2
> Rs. 7500	3.5	4.1

One US $ = Sri Lankan Rs. 55.
* Pensioners or information not provided.
Information on family income was not provided by 26 subjects in the urban and 6 subjects in the rural area.

Table 2
Anthropometric data of adolescent girls

	Urban			Rural		
	n	mean	SD	n	Mean	SD
Body weight (kg)	570	41.9	6.5	319	41.9	6.4
Height (cm)	570	152.8	6.3	319	154.2	5.8
Mid upper arm circumference (cm)	569	22.3	2.4	312	21.8	2.4
Body mass index (kg/m^2)	570	17.9	2.5	319	17.6	2.3

n = number of subjects; SD = standard deviation

Table 3
Body mass index-for-age of urban and rural subjects

Age (years)	Body mass index All Subjects (kg/m²) n	Mean	SD	5th percentile (kg/m²)	Subjects below 5th Percentile (kg/m²) n	Mean	SD	%
Urban area								
13.0 - 13.9 years	42	17.6	2.2	15.36	4	14.9	0.50	0.71
14.0 - 14.9 years	137	17.1	2.1	15.67	32	14.7	0.82	5.7
15.0 - 15.9 years	213	18.1	2.7	16.01	34	15.0	0.70	6.0
16.0 - 16.9 years	112	18.1	2.3	16.37	23	15.3	0.83	4.1
17.0 - 17.9 years	46	18.9	2.7	16.59	8	15.5	0.57	1.4
≥ 18.0 years	15	18.6	2.5	16.71	4	15.6	1.12	0.71
Rural area								
13.0 - 13.9 years	14	17.1	1.7	15.36	1	14.9	-	0.31
14.0 - 14.9 years	111	17.4	2.2	15.67	25	14.8	0.89	7.9
15.0 - 15.9 years	115	17.5	2.4	16.01	26	14.8	0.89	8.2
16.0 - 16.9 years	49	17.7	2.4	16.37	18	15.3	0.81	5.7
17.0 - 17.9 years	13	18.5	1.7	16.59	2	15.8	0.53	0.63
≥ 18.0 years	16	18.9	2.2	16.71	4	15.8	0.93	1.26

n = number of subjects

Table 4
Prevalence of anaemia among adolescent girls

	Urban n	Mean	SD	%	Rural n	Mean	SD	%
Haemoglobin concentration								
All subjects (g/L)	562	130.6	13.8	-	330	130.1	10.8	-
< 120 g/L								
110 - 119g/L	68	114.9	2.9	12.1	51	115.2	2.9	15.5
< 100 g/L	36	98.0	10.5	6.4**	6	98.5	4.9	1.8
Packed cell volume								
All Subjects	563	0.40	0.03	-	330	0.39	0.02	-
< 0.38	109	0.35	0.03	19.4*	45	0.35	0.02	13.6

n = number of subjects
* Significantly higher prevalence than rural area by Chi Square (* $p < 0.05$, ** $p < 0.002$)

Table 5
Iron status of adolescent girls

	Urban				Rural			
	n	Mean	SD	%	n	Mean	SD	%
Protoporphyrin								
All subjects (µg/dL RBC)	555	39.9	27.0	-	316	26.6	10.7	-
> 70 µg/dL RBC	48	105.6	42.9$^{\#}$	8.6**	3	74.6	3.7	0.95
Protoporphyrin / Haemoglobin (Hb)								
All subjects (µg/g Hb)	554	3.20	2.77	-	315	2.06	0.86	-
> 5.5 µg/g Hb	52	9.43	5.37$^{\#\#}$	9.4**	4	5.75	0.30	1.3
Transferrin saturation [a]								
All subjects (%)	385	26.5	10.6^{+}	-	207	33.4	8.7	-
< 16 %	62	10.8	3.5	16.1**	10	12.4	2.5	4.8
Serum ferritin								
All subjects (µg/L)	533	22.5	16.2$^{\#\#\#}$	-	306	26.2	17.5	-
12.0 - 19.9 µg/L	167	16.0	2.6	31.3*	74	15.9	2.7	24.2
< 12.0 µg/L	128	7.7	2.4	24.0	61	7.1	2.6	19.9

n = number of subjects
RBC = Red blood cells
Transferrin saturation percentage = (serum iron/total iron binding capacity) X 100
* Significantly higher than rural area by chi square (* $p < 0.03$, ** $p < 0.0001$)
$^{\#}$ Significantly different to rural area by Kruskall Walli's test ($^{\#}$ $p < 0.05$, $^{\#\#}$ $p < 0.01$, $^{\#\#\#}$ $p < 0.001$)
$^{+}$ Significantly lower than rural area by student's t-test ($^{+}$ $p < 0.05$)
[a] Serum samples were insufficient for estimation of iron and TIBC in 177 urban subjects and 123 rural subjects.

Table 6
Vitamin A status of adolescent girls

	Urban				Rural			
	n	%	Mean	SD	n	%	Mean	SD
Conjunctival Impression Cytology (CIC)								
All subjects	475	-	266					
Normal	398	83.8	226	85.0				
Borderline	40	8.4	16	6.0				
Abnormal	37	7.8	24	9.0				
Serum vitamin A								
All subjects (µg/dL)	477	-	29.7	12.5	282	-	27.2	9.5
< 20 ug/dL								
10.0 - 19.9 µg/dL	94	19.7	15.9	3.0	53	18.8	15.4	2.7
< 10 µg/dL	12	2.5*	6.8	1.7	1	0.35	5.7	-
Serum vitamin A								
Subjects with normal CIC (µg/dL)	336	84.6	30.4	13.3	196	85.6	27.1	8.7
Subjects with abnormal / borderline CIC (µg/dL)	61	15.4	26.5	11.1#	33	14.4	28.5	10.6

n = Number of subjects
* Significantly higher prevalence than rural area by chi square test (* $p < 0.05$)
# Significantly lower mean serum vitamin A concentration than subjects with normal conjunctival impressions, by ANOVA (# $p < 0.05$)

compared to the rural area. Further, subjects in the urban area who had abnormal or borderline impressions had significantly ($p<0.05$) lower serum vitamin A concentrations than those who had normal impressions (Table 6) while such a difference was not noted in the rural group.

Regression analysis was carried out on pooled data to determine the association between variables. There was a significant negative association between haemoglobin concentration and erythrocyte protoporphyrin concentration (r^2=10 %, F=92.1, $p<0.001$). A significant positive association was noted between haemoglobin concentration and serum ferritin concentration (r^2=1%, F=11.1, $p<0.005$). The association between haemoglobin and serum ferritin concentration increased to (r^2=4%, F=5.5, $p<0.025$) when only the anaemic subjects were considered. Further, the mean serum ferritin concentration of anaemic subjects (20.6 ± 15.7 µg/L) was significantly lower ($p<0.005$) than among the non-anaemic subjects (24.6 ± 17.1 µg/L). The association between haemoglobin and serum vitamin A concentration was only weakly significant (r^2=1%, F=6.0, $p<0.025$). However, the mean serum vitamin A concentration of anaemic subjects (26.1 ± 10.4 µg/dL) was significantly lower ($p<0.005$) than that of the non-anaemic subjects (29.4 ± 11.8 µg/dL).

Discussion

The majority of the subjects in both areas were from families of low socio-economic status. The income distribution was similar among subjects in urban and rural areas. The adolescent age range is 10 to 19 years (11). In a cross sectional study of adolescents in this age range, the subjects would be at different stages of their growth spurt. Nutritional status is closely associated with variation in growth. In the nutritional assessment of adolescents, subjects should be followed up longitudinally to account for variation in growth, or, in the case of cross sectional studies, an assessment of the stage of pubertal growth must be made. Thus, all subjects in both areas of the present study, had attained menarche before the time of blood collection, and could be assumed to have completed their growth spurt. Age at menarche was used as an additional indicator of nutritional status and growth. Age at menarche was assessed by recall, therefore some recall bias should be expected. The mean age at menarche in both urban (13.0 ± 1.2 years) and rural (13.1 ± 1.1 years) groups was lower than the mean age of 13.54 years reported by Balasooriya and co-workers (12) for Sri Lanka. However, some variation in mean age at menarche was noted between the 17 districts, and a low value of 12.97 years was reported for the Colombo district. The population used in all districts was of mixed socio-economic status. In contrast, our urban study population consisted mostly of subjects of low socio-economic status, in the Colombo municipal area, and the mean age at menarche was higher than the heterogeneous population of Balasooriya et al (12). In both urban and rural areas, 8.7% of girls attained menarche at 15 years or later.

Genetic variability may play a role in the delayed onset of menarche (11). However, a delay caused by prolonged malnutrition leading to slower growth is a definite possibility at least in some of these subjects.

The general nutritional status of girls in the urban area and rural area was similar. Body mass index-for-age of subjects in the urban area was higher than that of girls in the Kadawatha area, reported by Amarasinghe and Wikramnayake (13). In both groups an age difference was not noted between those who were below the cut off point for body mass index (BMI) and those with normal values. BMI values less than the fifth percentile for each age group, were used as the cut-off value for BMI indicating chronic energy protein deficiency (11). Thus subjects with low values for BMI are likely to have an impaired general nutritional status. These results indicate that while the mean values for height, weight and BMI are acceptable, a significant proportion of our population have a general nutritional status which is less than acceptable for this age range. Kandiah and Wikramanayake (14) observed that, Sri Lankan adolescent girls of higher socio-economic status achieved heights-for-age comparable to the National Centre for Health Statistics of the USA (NCHS) reference population, while weight-for-age was not achieved. Hence, the use of western cut off values for BMI may overestimate the prevalence of poor nutritional status, and a need exists for cut off values specific to South Asian subjects. Mid upper arm circumference (MUAC) was used in this study as an additional measure of nutritional status as it is more practical for use in field settings than height and weight.

The strong positive correlation observed in both groups suggests that MUAC is an effective measure of nutritional status and can be used where measurement of height and weight may not be possible.

The prevalence of anaemia in our study population (18.0%) was lower than that (36%) reported in the National Survey (5). However the National survey included younger children (10 - 18.9 years) as well which may account for the higher prevalence. The present study included only girls who were past their adolescent growth spurt and had attained menarche. The prevalence data therefore is not representative of the entire adolescent age range. The aim of this study however was to find whether anaemia was a significant problem in this population in an urban and a rural context. It would also indirectly reflect the prevalence of anaemia among young women of child bearing age. Although differences may be seen in other areas, these results further strengthen the find-

ings of the national survey, in that anaemia was a significant problem in this age and sex group.

Mean haemoglobin concentrations and percentage prevalence of anaemia were similar in both groups. However, when the severity of anaemia was considered, it was noted that the urban group had a larger number of girls with very low haemoglobin values than did the rural girls. In both groups anaemia was associated with iron deficiency as indicated by erythrocyte protoporphyrin, transferrin saturation and serum ferritin.

Iron status parameters indicate that the urban subjects have a larger number of girls with impaired iron status with regard to transport iron and erythropoiesis. Urban subjects also had significantly lower iron stores as indicated by their lower mean serum ferritin levels. In a study which compared iron status of urban and rural adolescent girls in Hyderabad (15) the findings were different, in that iron deficiency was more prevalent among the rural than the urban population. However the above study used a wider age range including subjects who had not attained menarche. In a study of 93 adolescent girls Atukorala and de Silva (4) noted that depleted iron stores were more prevalent than anaemia. Similar findings were noted among adolescent females in Islamabad (16) and in Taiwan (17). In our study population the prevalence of anaemia was 18.0% while marginal iron stores were noted in 28.7% and depleted iron stores in a further 22.5% of subjects.

Haemoglobin concentrations were lower in those who had been mentruating for a few years. In the urban area, subjects who had been menstruating only for six months prior to blood collection had a significantly higher haemoglobin concentration than those who had been menstruating for longer periods of time, indicating that their iron intake had not kept pace with the increased requirements after menarche. A significant association was not noted in the rural area, however, possibly because their haemoglobin concentration was not very low at baseline.

Haemoglobin concentration was dependent on protoporphyrin concentration of the red cell and iron stores. This indicates that in this population anaemia was due to ineffective erythropoiesis and thus iron deficiency. The association between haemoglobin concentration and iron stores was also stronger in the anaemic subjects indicating that those who are anaemic are more dependant on their iron stores for the maintenance of haemoglobin than those who are non-anaemic. A lack of a regression between serum ferritin and haemoglobin has been reported in a Swedish study in subjects who were not iron deficient (18). Hence a very strong correlation between serum ferritin and haemoglobin may not be expected in a population exhibiting a wide distribution of iron stores as in our sample. Vitamin A has a role in the mobilisation of iron stores. An association between haemoglobin concentration and vitamin A concentration has been reported previously (19). In our population anaemic subjects had significantly lower vitamin A levels than non-anaemic subjects. An association between haemoglobin concentration and vitamin A concentration was also observed, although not as strong as in the previous study.

There have been no previous reports of conjunctival impression cytology done on Sri Lankan subjects. In our study population the prevalence of vitamin A deficiency was 15.8% by conjunctival impression cytology and marginal serum vitamin A concentrations were noted in 21.1% of subjects.

There were no significant differences between the groups, in vitamin A status when assessed by conjunctival impression cytology, mean serum vitamin A levels or the percentage of subjects with marginal vitamin A levels. However more urban subjects had severe vitamin A deficiency than the rural subjects. A good correlation between conjunctival impression cytology (CIC) and serum vitamin A levels has been reported by Amedee-Manesme et al (20), although it is not yet in widespread use for the assessment of vitamin A status. Our results suggest that CIC is useful to detect the prevalence of vitamin A deficiency in a population and is best when deficiency is most severe. When deficiency is mild as in the rural area CIC may not correlate well with serum vita-

min A levels. Thus CIC is not a good indicator to predict deficiency in individuals, but is a useful, less invasive tool for large scale population surveys. CIC could be used as an alternative indicator of vitamin A status when HPLC facilities are not available.

In both areas deficiencies in general nutritional status, anaemia due to iron deficiency and low vitamin A status were noted and the prevalence was similar. However a higher percentage of urban subjects had severe anaemia and vitamin A deficiency when compared with their rural counterparts. Marginal or depleted Iron stores as indicated by low serum ferritin concentrations were much higher in both groups than was the prevalence of anaemia. This indicates that there is a hidden problem of sub-clinical iron deficiency which may not be detected by haemoglobin levels alone. Anaemia occurs when iron stores are depleted.

In our study, both groups had a similar prevalence of anaemia and a similar percentage of subjects with depleted iron stores. Howerver a larger percentage of urban subjects had marginal stores and impaired iron status (transferrin saturation and protoporphyrin) than the rural subjects. This indicates that although the prevalence of anaemia was similar the prevalence of sub-clinical iron deficiency was higher in the urban group than in the rural group. The effect of helminthic infection on nutritional status of these subjects has been previously reported by us (21). There was no significant difference in BMI and haemoglobin concentration between subjects infected with *Ascaris lumbricoides, Trichuris trichiura or Necator americanus* and those who were not infected. However, serum vitamin A concentration was significantly lower in infected subjects than in non-infected subjects.

Nutrition intervention is essential in both urban and rural settings. Whether supplementation or nutrition education or a combination of both, would be most successful needs to be established. Although the prevalence of anaemia and marginal vitamin A deficiency was similar in both settings, the urban group had a higher prevalence of iron deficiency and some of those who were anaemic and vitamin A deficient were severely deficient. Such differences must be addressed by future research. Differences in the environment such as the availability of land for cultivation must also be investigated in order to develop intervention strategies.

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