

## Nutritional status and productivity of Sri Lankan tea pluckers

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(Index words: Anaemia, chronic energy deficiency, hookworm infection; iron deficiency, labour productivity)

### Abstract

**Objective** To assess the impact of nutritional status on productivity of tea pluckers.

**Design** Cross-sectional, analytical.

**Setting and participants of study** All tea pluckers in five divisions of a tea estate in Hatton.

**Measurements** A dietary survey was conducted using the 24 h dietary recall method. Nutritional status was assessed by measurement of body mass index (BMI) and haemoglobin (Hb) levels, and faeces were examined for helminth ova. The daily weight of tea leaves plucked and the number of days worked by each woman during the preceding month were noted from production records.

**Results** Three hundred and four women (mean age 37.8 years, SD 8.4) were examined. The majority (59.9%) had evidence of chronic energy deficiency (BMI<18.5). Almost all (94.4%) were anaemic (Hb<13.3 g/dl, altitude adjusted cutoff). Mean daily iron intake was 8.7 mg (SD 2.3 mg), 45.9% of the national recommended dietary allowance. Only 10.1% had hookworm infection, all of light intensity. Multivariate regression analysis showed that dietary iron intake, the number of children and the number of children below 5 years, but not hookworm infection, were independently associated with Hb ( $p<0.05$ ). There was a strong positive correlation between monthly productivity and Hb, but not with BMI. Variation in Hb levels accounted for 65% of variation in productivity (adjusted  $R^2=0.651$ ).

**Conclusions** Most of the study population had chronic energy deficiency and anaemia. Dietary inadequacy of iron is a much more important causative factor than hookworm infection. Productivity was strongly associated with the degree of anaemia but not with BMI.

### Introduction

Tea is the principal agricultural export commodity of Sri Lanka, earning the country US\$ 600 to 700 million each year, and employing a labour force of several hundred thousands. The tea pluckers are almost exclusively women. Despite efforts to improve living conditions, many plantation workers still have to contend with poor housing, inadequate sanitary facilities and limited access to safe drinking water. Undernutrition and anaemia remain problems. In a study of anaemia in pregnancy

conducted in the plantation sector it was found that 58.3% of the subjects were anaemic [1], mainly due to iron deficiency [2]. Soil transmitted helminth infections are also widespread in the estate communities [3] and hookworm infection is well known to cause iron deficiency anaemia.

Iron deficiency anaemia is known to reduce physical capacity and work performance [4–6]. The potential impact of anaemia on working women in the plantation sector is high since the take home pay is linked to the weight of tea leaves plucked. Worker productivity is also important from a management perspective, since tea pluckers with a higher capacity would increase the productivity.

The main objectives of this study were to assess the nutritional status of women tea pluckers in the selected study area, the impact of chronic energy deficiency and anaemia on their productivity, and to ascertain the main causes of anaemia.

### Methods

The study was conducted on a tea estate located at 2500 m above sea level in the Nuwara Eliya District of the Central Province, during the period November 2001 to February 2002. The study population consisted of women tea pluckers in 5 randomly selected divisions from 11 divisions in the estate. All women who had worked as tea pluckers during the immediately preceding month, excluding those who were pregnant, were recruited.

The women were visited at home and interviewed after obtaining informed consent. Details recorded at interview were entered on a pre-tested questionnaire. The 24 h dietary recall method was used for dietary assessment. A food record sheet was filled in by a Tamil-speaking, trained research assistant, and nutrient contents calculated from the Sri Lankan Food Composition Table [7]. Weight was measured in kilograms to the nearest decimal point, using a spring balance. Height was measured in centimetres to the nearest decimal point, using a measuring tape fixed to a wall. The body mass index (BMI) was calculated as weight in kg / height in  $m^2$ . The BMI classification used to classify the energy status is given in reference 8.

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Blood was drawn using a sterile disposable lancet, and 20 µL transferred onto Whatman's No. 1 blotting paper using a micropipette. The filter papers were dried at room temperature and brought for analysis in the University laboratories. Haemoglobin concentration was measured within a week of sample collection. Haemoglobin was extracted into Drabkin's solution (from Randox®), by allowing 30 min for elution. Haemoglobin concentration was estimated using the cyanmethaemoglobin method [9]. A standard curve was prepared by plotting the absorption values of the diluted haemoglobin standard solution at concentrations of 4.0, 6.0, 8.0, 10.0 and 12.0 g/dL. Faecal samples were examined in the University laboratories for intestinal nematode ova using the modified Kato-Katz technique [10] with kits from Vestergaard-Frandzen, India.

Data on productivity were obtained from cards maintained by the estate management. These provide a record of the days on which the tea plucker reported to work and the weight (in kilograms) of tea leaves plucked each day. The total weight of tea leaves plucked over the month immediately before recruitment to the study was used to calculate the mean daily weight of leaves plucked.

Data entry and analysis was done using EpiInfo Version 6 and SPSS Version 10. The factors determining haemoglobin concentration and productivity were identified by carrying out two separate multiple regression analyses. Age, number of children, number of children under 5 years, dietary iron adequacy, evidence of hookworm infection, economic status (number of wage earners in the family and monthly income) were the variables taken into account as predictors of anaemia. Haemoglobin concentration, BMI, number of children under 5 years were the variables taken into account as predictors of productivity. Both analyses were adjusted for estate division as both outcome variables and many of the predictor variables were significantly associated with the estate division.

Approval for this study was obtained from the Ethics Committee of the Faculty of Medicine, University of Kelaniya. Informed consent was obtained from participants

before recruitment to the study. Because of the frequency of hookworm infection, all participants were offered a single dose of anthelmintic (mebendazole 500 mg) free of charge. All women with Hb < 12.0 g/dL were referred for treatment of anaemia.

## Results

A total of 304 tea pluckers were recruited to the study; the number from each division is shown in Table 1. The mean age was 37.8 years (SD 8.36, range 19–58 years). They had a median of five children (interquartile range 3–6 children). Most (71.4%) had just the first year of schooling; only 11.5% had gone beyond primary school. Almost half the women (47.4%) lived in households with two wage earners, but a significant number (38.2%) were the sole wage earners. About half (53.6%) said that they had a total household monthly income less than Rs 2000 (approximately 95 SLR = 1 US\$ at the time of study). Only 9.5% said that they had a monthly household income above Rs 5000. At the time of the study, tea pluckers were paid at the hourly rate of Rs 15 with a minimum monthly wage of Rs 1060. They were expected to pluck a minimum of 14 kg tea leaves during an 8 h day (with a daily pay of Rs 120), and if plucked less, they were paid for 6 h work. Those who plucked more than 14 kg a day were paid extra (Rs 3.75 for each additional kg).

### Anthropometry

The mean height of the women was 1.48 m (SD 0.056, range 1.34–1.65 m); mean weight was 40.3 kg (SD 5.5, range 30–66 kg). Their BMIs ranged from 13.7 to 28.9 with a mean of 18.3 (SD 2.5). Only 39.4% (123/304) had a BMI above 18.5, the recommended cutoff point for diagnosis of chronic energy deficiency (CED). Among those with CED, 73 (40%) had BMIs indicative of mild CED, while 59 (33%) women had moderate CED, and 49 (27%) had severe CED.

As calculated from the 24 h dietary recall survey, the mean dietary calorie and protein intake in the study

Table 1. Mean haemoglobin levels and monthly productivity by division

<i>Estate division</i>	<i>Mean haemoglobin in g/dl (SD, range)</i>	<i>Mean productivity in kg/month (SD, range)</i>
Y (n = 53)	10.3 (1.2, 6.9–13.3)	206.9 (108.9, 65.9–561.2)
G (n = 50)	10.5 (1.3, 7.7–14.2)	257.8 (135.2, 61.7–664.8)
NV (n = 50)	10.8 (1.8, 6.8–14.1)	267.6 (136.9, 75.8–575.8)
FH (n = 76)	11.4 (1.3, 6.9–15.4)	289.4 (111.2, 37.6–562.8)
S (n = 75)	11.7 (1.4, 8.9–15.4)	325.6 (138.9, 29.5–641.8)
<b>Overall (n = 304)</b>	<b>11.2 (1.5, 6.8–15.4)</b>	<b>275.5 (131.7, 29.5–664.8)</b>

population were 1169 kcal and 25 g respectively. According to the recommended dietary allowances for Sri Lankans, formulated in 1998 by the Department of Nutrition of the Medical Research Institute, Colombo, this converts to mean adequacies of 52.5% and 56.4% respectively. Mean calorie and protein adequacy levels among the 181 women with CED were 47.9% and 52.5%, significantly less than those of women with a normal BMI, who had mean calorie and protein adequacies of 58.3% and 62.1% respectively ( $p < 0.0001$  for both, Student *t*-test). Calorie adequacy (but not protein adequacy) showed a tendency to increase with monthly household income, the number of wage earners in the household, and the years of schooling, but these were not statistically significant.

### Anaemia

The mean haemoglobin level of the women was 11.2 g/dL (SD 15, range 6.8–15.4 g/dL). Using an altitude adjusted cutoff point of 13.3 g/dL for the diagnosis of anaemia [11], we found that 94.4% of the women were anaemic. Table 2 shows the relationship between haemoglobin levels and several factors that may contribute to anaemia. Multivariate regression analysis of the variables found to be associated with Hb levels on bivariate analysis, showed that dietary iron adequacy, the number of children and the number of children below 5 years, but not hookworm infection, had an independent significant association with Hb.

The dietary survey indicated a mean daily iron intake of 8.7 mg (SD 2.3, range 3.8–14.2 mg), which is only 45.9% of the Sri Lankan recommended dietary allowance.

The dietary inadequacy was clearly reflected in food consumption patterns: 89.1% of the subjects consumed fish or meat only rarely. Consumption of green leafy vegetables, an important and affordable source of dietary iron for Sri Lankans, was also minimal: 99% said they consumed this item only occasionally. Many of the workers consumed tea with their main meals; the tannin in tea is known to inhibit absorption of dietary iron and reduce its bioavailability [12].

Faecal samples were provided by 248 women (82% compliance). Only 25 of these (10.1%) were positive for hookworm ova; all infections were of light intensity ( $< 2000$  epg faeces). Roundworm eggs were found in 79 (31.8%) and whipworm eggs in 27 samples (10.9%).

### Productivity

The women worked for a monthly average of 18.7 days (SD 5.1, range 4–29) during the study period, and plucked a daily average of 14.0 kg of tea leaves (SD 3.7, range 3.7–27.7). The average monthly productivity, measured as the total weight of tea leaves plucked, was 275.5 kg (SD 131.72, range 29.5–664.8).

Figures 1 and 2 show the relationship between each tea plucker's productivity, as indicated by the total weight of tea leaves plucked for the month, and BMI and haemoglobin levels. There was a positive linear association between haemoglobin and productivity (Fig. 2), whereas there was almost no association between BMI and productivity (Fig. 1). Table 1 shows the mean haemoglobin levels and monthly productivity by division. Since these were significantly different, the data was stratified by division

Table 2. Factors associated with haemoglobin concentration

Factor	Overall n=304	Hb>12.0 g/dL n=73	Hb 10.0–11.9 g/dL, n=152	Hb<100 g/dL n=79
Age in years: mean $\pm$ SD (range)	37.7 $\pm$ 8.4 (19–58)	37.0 $\pm$ 8.0 (20–58)	37.7 $\pm$ 8.5 (19–58)	38.6 $\pm$ 8.5 (21–56)
Median number of children (interquartile range)*	5 (3–6)	5 (3–8)	5 (3–6)	5 (3–6)
Proportion with children <5 years of age*	72.4%	61.6%	73%	81%
Proportion with household income <Rs 2000 per month	53.6%	31.5%	50%	81.0%
Proportion with single wage earner in household	38.2%	31.2%	33.6%	53.2%
Proportion with only 1 year of schooling	71.4%	69.9%	69.1%	77.2%
Dietary iron adequacy** Mean $\pm$ SD (range)*	45.9 $\pm$ 12.2% (20.2–74.9)	56.3 $\pm$ 11.2% (21.0–74.9)	47.2 $\pm$ 8.4% (32.9–67.8)	33.6 $\pm$ 7.8% (20.2–61.3)
Prevalence of hookworm	25/248 (10.1%)	3/58 (5.2%)	7/119 (5.9%)	15/71 (21.1%)

\* independent significant association with Hb on multivariate regression analysis ( $p < 0.05$ )

\*\* as a percentage of recommended dietary allowance for Sri Lanka

and the relationship between anaemia and productivity re-examined. A similar relationship was seen in all divisions.

Different regression models were then applied to the data to predict the monthly weight of tea leaves plucked in kilograms. The simplest model using haemoglobin as the only predictor variable revealed that variation in haemoglobin level accounted for 65% of variation in productivity (adjusted  $R^2 = 0.651$ ). An increase in haemoglobin of 1g/dL was associated with an increase in monthly productivity of 73 kg, which is 26% of the average weight plucked by a worker. The only other variable that could be entered to the model in addition to haemoglobin was the estate division, but even this could improve the model only slightly. The adjusted  $R^2$  for the model with haemoglobin, division and their interaction term as predictors was 0.674.

## Discussion

Over 90% of our study population were anaemic and 60% had evidence of CED. These results are similar

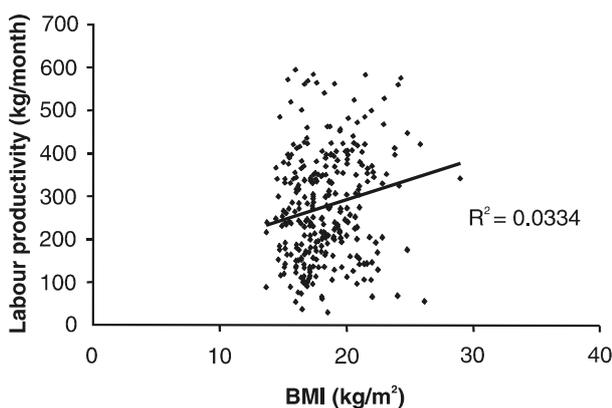


Figure 1. Scatter plot showing relationship between body mass index and monthly productivity

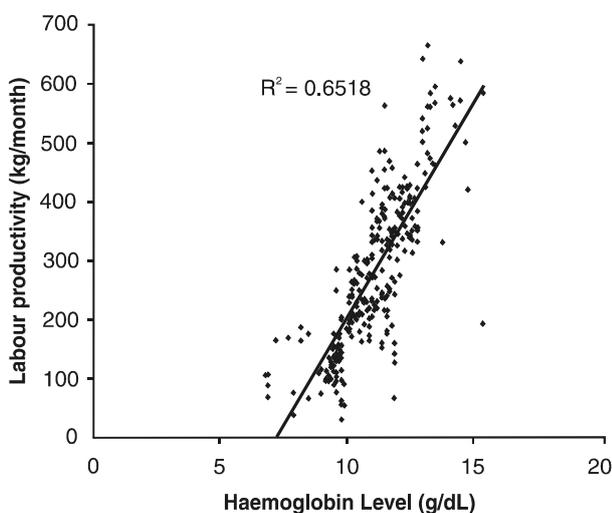


Figure 2. Scatter plot showing relationship between haemoglobin level and monthly productivity

to those of previous surveys in the plantation sector. The Fourth National Nutrition and Health Survey conducted in 1995 found that 58.6% of 198 non-pregnant mothers (with children below 6 years) in the estate sector had a BMI less than 18.5 [13]. The same national survey also found a mean Hb of 11.2 g/dL, among 482 non-pregnant women from the estate sector [14]. In another study it was found that 58.2% of 309 pregnant women (10–26 weeks of gestation) working on 5 plantations were anaemic, but these were all women on iron-folate supplements, received free of charge from antenatal clinics [2].

We found a strong association between anaemia and productivity. It seems likely that this contributes to a vicious cycle that maintains poverty. Anaemia results in low productivity, which in turn results in low take home pay and inability to purchase food. Although the 24 h dietary recall technique has its shortcomings as a way of assessing dietary adequacy, the correlation between calorie and protein adequacy and BMI, as well as iron adequacy and haemoglobin levels, indicates that the data obtained by the dietary survey is of good quality. The low Hb levels appear to be mainly due to dietary inadequacy of iron, consequent to poverty and ignorance. The inability to purchase animal protein (with high quality sources of iron) is compounded by bad dietary habits, which exclude the regular consumption of cheap sources of iron and inhibit absorption of the little available iron. Lack of education, even to primary school level (71% had only 1 year of schooling), probably adds to the problem, as do repeated pregnancies (50% had five or more children).

Hookworm infection does not appear to be a significant causative factor of anaemia in this study population, since the prevalence of infection was low and all the infections were light. However, in a population with a low dietary iron intake, even this level of hookworm infection may result in worsening of iron deficiency.

Mean haemoglobin levels and daily productivity described in a study conducted on a tea estate in the Kandy area of the Central Province in the 1970s were similar to those found by us [15]. However, this study did not investigate the factors that could lead to iron deficiency anaemia in the study population, particularly hookworm infection. It is likely that a large proportion of the population in the earlier study had hookworm infection since very high prevalence rates were found subsequently in plantations in the same area [16, 3]. A study conducted among women tea pluckers in Bangladesh reported a much higher daily productivity (mean of 29.8 kg per tea plucker) than in Sri Lanka, and that lower Hb values are associated with lower labour productivity, but with no association between BMI and productivity [17].

The nutritional status of tea pluckers in Sri Lanka has apparently not improved much over the last 30 years. This is despite knowledge of the extent of the problem of anaemia and malnutrition in this community, and its impact on labour productivity. Breaking the cycle of poverty, malnutrition and low productivity would require

a multi-faceted approach involving both short and long term strategies. Interventions that could be tried include weekly oral iron supplementation as a short term strategy, and long-term measures that encourage young girls to stay on in school, as well as health education regarding nutrition and the need for family planning. Better productivity related wage incentives may be necessary to see the full impact of improved health on labour productivity.

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### References

1. Atukorala TMS, de Silva LDR, Dechering HJCW, Dassenaieke TSdeC, Perera RS. Evaluation of effectiveness of iron-folate supplementation and anthelmintic therapy against anaemia in pregnant women: a study in the plantation sector of Sri Lanka. *American Journal of Clinical Nutrition* 1994; **60**: 286–92.
2. De Silva LDR, Atukorala TMS. Micronutrient status of plantation workers in Sri Lanka during pregnancy and postpartum. *Journal of Obstetrics and Gynaecology Research* 1996; **22**: 239–46.
3. Sorensen E, Ismail M, Amarasinghe DKC, Hettiarachchi I, Dassenaieke TSdeC. The prevalence and control of soil-transmitted nematode infections among children and women in the plantation in Sri Lanka. *Ceylon Medical Journal* 1996; **41**: 37–41.
4. Spurr GB, Barac M, Maskud MG. Childhood under nutrition: Implications for adult work capacity and productivity. In: Folinsbee LJ, ed. *Environmental Stress: Individual Human Adaptations*. New York: Academic Press, 1978: 165–81.
5. Viteri FE, Toun B. Anaemia and physical work capacity. *Clinics in Hematology* 1974; **3**: 609–26.
6. Husaini MA, Djojoseobagio S, Karyadi D. *Socioeconomic and Dietary correlates of Iron Deficiency on an Indonesian Tea Plantation*. In: Hallberg L, Scrimshaw NS, eds. *Proceedings of the Eighth Annual INACG Meeting*; 1984: Bali, Indonesia, International Nutritional Anaemia Consultative Group (INACG).
7. Wickramanayake TW. *Food and Nutrition*. Colombo, Hector Kobbekaduwa Agrarian Research and Training Institution; 1998, 365–8.
8. James WPJ, Ferro-Luizzi A, Waterlow JC. Definition of chronic energy deficiency in adults. Report of working party of the intervention dietary energy consultation group. *American Journal of Clinical Nutrition* 1998; **42**: 969–81.
9. Lewis SM, Sudarshini K. Guidelines on standard operating procedures for haematology. New Delhi: WHO Regional Office for South East Asia, 2000: 23–5.
10. Pawloski ZS, Schad GA, Stott GJ. Hookworm and anaemia: approaches to prevention and control. Geneva: World Health Organization, 1991: 64–7.
11. WHO. *Iron Deficiency Anaemia: Assessment, Prevention and Control*. Geneva: World Health Organization, 2001: 99.
12. Brune M, Rossander HL, Hallberg L. Iron absorption and phenolic compounds: importance of different phenolic structures. *European Journal of Clinical Nutrition* 1989; **43**: 547–58.
13. Ramanujam P, Nestel P. Preliminary report on the fourth national nutrition and health survey. *Ceylon Journal of Medical Science* 1997; **40**: 13–24.
14. Mudalige M, Nestel P. Prevalence of anaemia in Sri Lanka. *Ceylon Journal of Medical Science* 1996; **39**: 9–16.
15. Edgerton VR, Gardner GW, Ohira Y, Gunawardena KA, Senewiratne B. Iron-deficiency anaemia and its effect on worker productivity and activity patterns. *British Medical Journal* 1979; **15**: 1546–9.
16. Balasuriya S, Edirisinghe JS, Rajudeen NMM. Effectiveness of mass treatment with mebendazole in the control of soil-transmitted helminths in Sri Lanka. *Ceylon Medical Journal* 1990; **35**: 15–20.
17. Gilgen D, Mascie-Taylor CGN, Rosetta L. Intestinal helminths infections, anaemia and labour productivity of female tea pluckers in Bangladesh. *Tropical Medicine and International Health* 2001; **6**: 449–57.