Research article

Soil-transmitted helminth infections, associated factors and nutritional status in an estate community in Sri Lanka

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Sri Lankan Journal of Infectious Diseases 2018 Vol.8 (2)100-114

DOI: *http://dx.doi.org/10.4038/sljid.v8i2.8226*

Abstract

Objectives: To determine the prevalence, intensity, and risk factors associated with soil transmitted helminth (STH) infections and to explore the association between STH infections and nutritional status of an estate community.

Methods: A cross-sectional study was conducted in Hanthana Tea Estate (HTE) in Kandy, Sri Lanka, from September 2013 to November 2014. Demographic data were obtained using an interviewer-administrated structured questionnaire. Haemoglobin and serum albumin concentrations were measured in children. Faecal samples were analyzed by direct smears in saline and iodine and Kato-Katz technique using single-stool samples. Anthropometric measurements were obtained to calculate weight-for-age (WAZ), height-for-age (HAZ), and body-mass-index-for-age (BAZ) to evaluate underweight, stunting and wasting, respectively.

Results: A total of 233 children (50% female, aged between 1 and 12 years, mean age 6.2±3.4) and 98 parents (93% female, aged between 20 and 52 years, mean age 33±6.2 years) participated in this study. The prevalence of STH infections in children and adults were 27.4% and 14.3% respectively. *Ascaris lumbricoides* was found in children and adult populations predominantly (26.6% and 14.3% respectively) followed by *Trichuris trichiura* (0.8% and 1%).

Of the infected group, 57.8% of children and 92.8% of adults had a light infection. Moderate infection was found in 40.6% of the children, and 7.2% of the adults. Only one child had a heavy egg count (≥ 50000). The prevalence of STH infections was significantly higher among children than adults ($p = 0.014$). Not hand washing before a meal ($p = 0.002$) and after defecation ($p < 0.001$), greater de-worming period ($p < 0.001$), use of shared latrine facilities ($p = 0.023$) and lower levels of mother`s education ($p = 0.035$) were significantly associated with STH infections. Children with and without STH infection had comparable levels of nutritional indicators. However, 17.6% (n=41) of stunted, 19.3% (n=45) of wasted and 39.5% (n=92) of underweight

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Received 7 August 2018 and revised version accepted 7 October 2018

children were identified in the present study. In addition, 20.2% (n=47) of the children had a low serum albumin level and 15.9% (n=27) had anaemia.

Conclusions: Prevalence of STH infections was notably high in both children (27.4%) and their parents (14.3%), indicating a high level of morbidity among the study population. Therefore, a coordinated control and prevention programme considering the diverse socio-demographic characteristics of estate communities is needed to eliminate STH infections in the study population.

Keywords: *Soil-transmitted helminth infections, Ascaris lumbricoides, Trichuris trichiura, Intensity, Prevalence, Anthropometric measurements*

Introduction

Soil-transmitted helminthiasis (STH) is one of the most common neglected tropical diseases (NTDs) in the world and the poorest communities are most affected.[1,2] Approximately one third of the world's population is infected with STH.[3,4,5] The current level of infection for ascariasis, trichuriasis and hookworm in South Asia is 29%, 24% and 23%, respectively.[2] STH infections still remain endemic in many parts of the world including Sri Lanka, despite several comprehensive efforts made by respective governments and non-governmental organizations, to control these neglected tropical diseases.[2] Unfortunately, STH infections have become a normal and inevitable part of one's life in low-income communities of countries where it is endemic.[6,7] However, Salam et al. (2014)[8] suggested that "community based interventions are effective in reducing the prevalence and intensity of STH".[8]

The most common STH are *A. lumbricoides*, *T. trichiura*, *Necator americanus* and *Ancylostoma duodenale*.[3,4] *A. lumbricoides* and *T. trichiura* are mainly transmitted by the ingestion of viable eggs in contaminated food and/or water.[9,10,11] The infective larval stages of hookworms are found freely in the soil and enter the human body by skin penetration.[12] Limited access to clean water, poverty, a lack of education, poor sanitary facilities and personal hygiene are major risk factors associated with the STH infections.[13] Previous studies have shown that hookworm infections are common among agricultural workers in China, Vietnam and tea estate workers in Sri Lanka, Bangladesh and India.[14,15,16,17] STH infections may contribute to social marginalization, malnutrition and economic instability in societies, particularly in developing nations, and a large number of children are more susceptible to STH infections than adults.[18,19] The most common clinical features of STH infections in children are anaemia, stunted growth, fatigue, protein-calorie malnutrition (PCM), and poor cognitive development.[6,7]

The plantation sector in Sri Lanka, with a population of 939,000, represents significantly low-income families in the country, with a high prevalence of child malnutrition and mortality in mothers.[20] According to a survey conducted in 1992, 90% of children living in these areas were at a risk of acquiring STH infections.[21] Poor household hygiene and sanitation and poor level of maternal education were identified as risk factors associated with STH infections of the plantation sector in Sri Lanka.[22,23] A mass deworming campaign commenced in 1994, which included children aged 3-18 years. The campaign continued for 11 years up to 2005. In 2011, a survey was conducted in the plantation sector communities to identify the prevalence of STH infection. It showed 29% prevalence despite the mass de-worming campaign conducted up to 2005.[23] The need for well planned control strategies to eradicate STH infection was emphasized.

A national survey conducted in school children in 2003, representing regions other than the plantation sector, identified only 6.9% of the population as having STH infections.[24] However, in our opinion, this does not reflect the actual situation in the country at large, since several other studies have shown that STH infections are still endemic, in poor, urban and plantation sector communities in Sri Lanka.[22,25,26,27]

The main focus of the present study was to determine the prevalence and intensity of STH infections in the Hanthana Tea Estate (HTE) in Kandy, Sri Lanka. In addition, the relationship between STH infections and the nutritional status of children in this estate was investigated. The findings of the present study will be helpful in implementing new strategies to control STH infections in the plantation sector in Sri Lanka.

Materials and methods

Study population

The present study was conducted from September 2013 to November 2014 in the Hanthana Tea Estate (latitude and longitude coordinates: 7º 20'-7º 29'N and 80º 61'- 80º 64'E) in Kandy, Sri Lanka. This mountainous region (1130.38 hectares) is located 600m-1100 m above sea level with an estimated population of 5511 (National Census 2012: http://www.statistics.gov.lk/). In general, the socioeconomic status of people living in this estate is very low, compared to urban communities. These families live in heavily crowded houses with limited space, resources and poor sanitary facilities. The majority of residents, including children, often go to nearby jungles for defecation due to lack of latrine facilities for the study population. Major sources of drinking water were streams and unprotected wells. Most of the residents were employed in tea estates, factories and shops as unskilled laborers.

HTE consists of 7 divisions, namely, Factory division, West division, Top division, Middle division, Urawala division, Uduwela division and Kithulmulla division. Factory and West divisions were selected using the cluster sampling method considering divisions as clusters and each division was given a number from 1 to 7. Two numbers were selected randomly using a random number generator. The sample size was determined using a formula of $n = Z^2Pd/d^2$. 5% margin of error (d) and 95% confidence interval was used for the calculation. Prevalence (P) of STH infections among children in the plantation sector in Kandy was considered as 23%.[23] The calculated sample size was 272. All children aged between 1 to 12 years (335) and their parents (140) from the selected two divisions were included in the study. Children <1 year and ≥ 13 years were excluded from the study.

Data collection

All parents/guardians of the West and Factory divisions were summoned to a common place prior to collection of samples and methods and implications of the research were explained to them with the help of estate administrators and medical authorities. The demographic and socioeconomic data (gender, age, family members, mother's education attainment, occupation, and household income), sanitary facilities, living conditions and behavioral characteristics (Floor type, latrine facilities, water source, hand washing, drinking unboiled water, sucking fingers and wearing shoes) and the history of deworming were obtained from children using an interviewer administrated and structured questionnaire. These variables/data relating to parents were not assessed. The questionnaire was prepared in their native language to enable correct understanding of the purpose of the study.

Evaluation of nutritional status

The weight and height of the children were measured using a calibrated digital electronic balance and a height pole, respectively. All measurements were recorded on a pre-prepared data sheet. Adults were not enrolled to take the anthropometric measurements. Weight and height were measured twice to minimize errors. Average values were used for the final calculation. These measurements (age, weight and height) were used to calculate the following parameters, Height-for-age Z-score (HAZ), Weight-for-age Z-score (WAZ) and Body-mass-index-for-age Z-score (BAZ) to assess stunted growth, underweight and wasting, respectively. AnthroPlus version 1.0.4 (WHO, Geneva, Switzerland) and the Epi Info software 3.5.1 (CDC, USA) were used to calculate each indicator with the international reference values given by the WHO (World Health Organization: http://www.who.int/).

Collection of stool and identification of parasites

Each participant was given a clean, wide mouthed labelled plastic container with a lid and a spoon. A single stool sample was collected from each participant. Stool samples were then transported in a cool box to the Department of Parasitology, Faculty of Medicine, University of Peradeniya, for laboratory investigation. First, direct smears were observed in saline and iodine. Then, the Kato-Katz technique was performed as recommended by WHO.[28,29] After that, the slides were observed under a light microscope, and the number of eggs were counted for each parasite. Finally, the number of eggs per gram of faeces (epg) was determined. The intensities of infection were grouped as follows into light, moderate, or heavy infections, according to WHO guidelines as follows, for "*A. lumbricoides*, 1–4,999 epg, 5,000 – 49,999 epg and ≥50,000 epg; for *T. trichiura*, 1–999 epg, 1,000–9,999 epg and ≥10,000 epg; and for hookworms, 1–1,999 epg, 2,000–3,999 epg and ≥4,000 epg", respectively.[30]

Collection of blood and measurement of albumin and haemoglobin levels

Two to three milliliters of blood was collected into labeled EDTA tubes using disposable syringes. The blood samples were stored in a cool box until transported to the laboratory for further investigation. Haemoglobin concentrations were measured in a private medical laboratory in Kandy using an Auto Hematology Analyzer. WHO recommended haemoglobin levels in different age categories were used to identify anaemia in children.[31] Serum albumin level was measured using a commercial kit (Liquicolor, Human, Germany) according to the manufacturer`s instructions. The reference value of the serum albumin level was provided by the manufacturer (3.8-5.1 g/dl or 38-51 g/l).

Statistical analyses

SPSS (Statistical Package for the Social Sciences) version 17 (SPSS, Chicago, IL, USA) was used for the statistical analysis. Descriptive data were used to explain the distinctiveness of the study population.

Firstly, all variables were analyzed using the univariate model to determine the relationship between the dependent variable (prevalence of STH), and the independent variables (socio-demographic, health hygiene behavior, deworming treatment, living and sanitary condition characteristics).

Secondly, significantly associated variables identified by the univariate model were included in a multivariate logistic regression analysis using forward step-wise elimination model to determine the risk factors of STH infections.

In addition, multiple regression analysis was done to assess the predictive effect of the factors associated with the intensity of infection. For nutritional status, differences in proportions for categorical variables (e.g., stunting, thinness, underweight, anaemia and hypoalbunaemia) were calculated using Chi square test of independence. Differences in mean values of continuous variables (e.g., HAZ, WAZ, BAZ, Hb and albumin) for infection status (negative and infected) were assessed using the student t-test. One-way ANOVA was used to analyze differences in anthropometric mean Z-scores of the study population for the intensity of infections (negative, light, moderate and heavy). The *p*-value ≤ 0.05 was considered to be statistically significant. Odds ratio (OR) and 95% confidence interval (CI) were calculated for logistic regression analysis.

Results

Characteristic of the study population and sample collection (Figure 1)

Of the 7 divisions, 2 divisions (Factory division, and West division) were selected for the study. 335 children and 140 parents were included in the study (180 children and 77 parents from the Factory division and 153 children and 63 parents from the West division). Written consent was obtained only from mothers and/or guardians. 102 children and 42 parents refused to provide faecal samples due to unknown reasons. The mean age of children was 6.2 years (SD=3.4) and 117 (50%) were females. Parent ages ranged from 20 to 52 years (mean age was 33 years (SD=6.2)), of whom 91 (93%) were females. 233 (69.55%) and 98 (70%) faecal samples were collected from children and from their parents and/or guardians, respectively. In addition, 233 blood samples (2-3 ml) were collected from children to measure the haemoglobin and serum albumin levels.

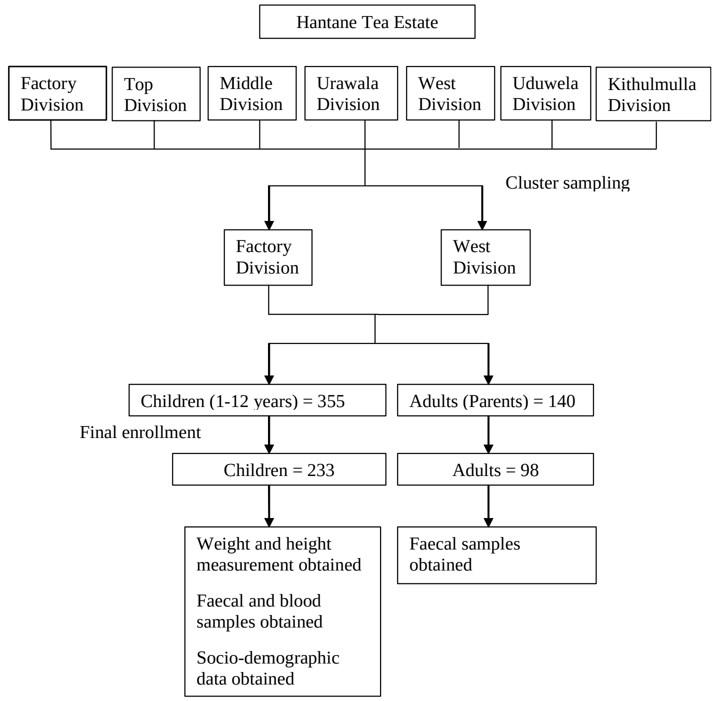

Figure 1 Flow diagram showing the participant enrollment, sampling and the data collection.

Prevalence of STH infections

Of the 233 children, 64 (27.47%) children were infected with STH. Of the STH infected children, the majority (26.6%) were infected with *A. lumbricoides* followed by *T. trichiura* (0.86%). None of the children had mixed infections. The prevalence in adults was 14.6% for *A. lumbricoides*. Mixed infection (*A. lumbricoides* and *T. trichiura)* was detected in one adult only. Among children, the highest prevalence (39.5%) was reported in the 4 to 6 year age group. In adults, 18 to 26 year age group had the highest (16.7%) prevalence. A significantly higher prevalence of STH infections was reported among children than in adults (*p*< 0.05) (Table 1).

Table 1 Prevalence of STH infections in children and parents

Parasite	**Children (n = 233)**	**Parents (n = 98)**	***p*-value**
Ascaris lumbricoides (AL)	62 (26.6%)	14 (14.3%)	-
Trichuris trichiura (TT)	2 (0.86%)	-	-
Mixed infection (AL+TT)	-	1	-
Total	64 (27.46%)	14 (14.3%)	0.01

Intensity of STH infections

Of the infected group, 57.8% (37/64) of children and 92.8% (13/14) of adults had a light infection (epg<5000). Moderate infection (epg =5000-49999) was observed in 40.6% of children (26/64) and in 7.2% (1/14) of adults. Only one child had a heavy epg count (≥ 50000) (Table 2).

Table 2 Intensity of *A. lumbricoides* infection in children and parents

Age (years) and sex	**Number of eggs per gram (epg)**		
	< 5000 (light)	5000–49999 (moderate)	≥ 50000 (heavy)
Children			
1 – 3 (n = 65)	11	9	1
4 – 6 (n = 63)	14	11	-
7 – 9 (n = 64)	6	3	-
10 – 12 (n = 41)	6	3	-
Adults			
18-26 (n = 24)	4	-	-
27-35 (n = 44)	7	-	-
36-44 (n = 23)	2	1	-
45-52 (n = 7)	-	-	-
Sex (children)			
Male	16	14	-
Female	18	15	1
Sex (adults)			
Male	-	-	-
Female	13	1	-

STH infections and associated factors in children

Table 3 shows the socio demographic, personal hygiene and other factors, which may potentially be associated with STH infections. Females had a slightly higher rate of infection than their male counterparts. Children aged between 1-6 years showed a higher prevalence (29.7%) than older children (24.7%), though not statistically significant.

Univariate analysis was used to analyze the risk factors associated with STH infections in this community (Table 3). There were five risk factors identified which included those who use shared latrine facilities (OR =2.53; 95% CI =1.36-4.70; p = 0.003), getting deworming treatment before 6 months (OR =4.39; 95% CI = 2.36-8.16; p<0.001), mothers' education level less than grade 8 (OR =3.23; 95% CI = 1.68-3.20; p<0.001), rarely washing hands with soap before a meal (OR =2.94; 95% CI = 1.31–6.62; p = 0.009) and after defecation (OR= 3.43; 95% CI = 1.86–6.33; p<0.001), although, being female (29.1%; p = 0.585), aged between 1 to 6 years (29.7%; p = 0.402), having more than 6 family members (32.4%; p = 0.266), low household income

(31.3%; *p* = 0.058), having earthen floors in households (35.3%; *p* = 0.271), using unprotected spring water (27.7%; *p* = 0.796), drinking boiled water (36.1%; *p* = 0.209), eating unwashed fruits (28.9%; *p* = 0.700), sucking fingers (35.5%; *p* = 0.057) and walking barefooted (31.2%; *p* = 0.130) were factors that also showed higher infection rates. However, none of these variables were statistically significant.

Table 3 Risk factors associated with STH infections in children (Univariate analysis, n = 233)

Variables	Categories	No. examined	No. of positives	Percentage (%)	OR (95% CI)	*p*-value
Individual characteristics						
Gender	Male	116	30	25.9	1	
	Female	117	34	29.1	1.17 (0.66-2.90)	0.585
Age	1 – 6	128	38	29.7	1	
	7 – 12	105	26	24.7	0.78 (0.44-1.40)	0.402
Number of family members	1 – 6	162	41	25.3	1	
	>6	71	23	32.4	1.41 (0.77-2.60)	0.266
Mothers educational level	> Grade 8	99	16	16.2	1	
	≤ Grade 8	134	48	35.8	3.23 (1.68-6.20)	<0.001
De-worming treatments	≤ 6 months	167	31	18.6	1	
	> 6 months	66	33	50.0	4.39 (2.36-8.16)	<0.001
Household income (Rs./month)	≤ 16000	160	50	31.3	1	
	> 16000	73	14	19.2	0.52 (0.27-1.02)	0.058
Household characteristics						
Floor type	Earthen	34	12	35.3	1	
	Cement	199	52	26.1	0.65 (0.30-1.40)	0.271
Toilet facility	Separate	171	38	22.2	1	
	Shared	62	26	41.9	2.53 (1.36-4.70)	0.003
Water source	Unprotected spring water	213	59	27.7	1	
	Wells	20	5	20.0	0.87 (0.30-2.50)	0.796
Eating and sanitation habits						
Hand washing with soap before meals	Every time	58	8	13.8	1	
	Rarely	175	56	32.0	2.94 (1.31-6.62)	0.009
Hand washing with soap after defecation	Every time	123	20	16.3	1	
	Rarely	110	44	40.0	3.43 (1.86-6.33)	<0.001
Drink unboiled water	Yes	197	51	25.9	1	
	Never	36	13	36.1	1.62 (0.76-3.43)	0.209
Eat unwashed fruits	Yes	90	26	28.9	1	
	Never	143	38	26.6	0.89 (0.50-1.60)	0.700
Sucking fingers	Yes	76	27	35.5	1	
	Never	157	37	23.6	0.56 (0.31-1.02)	0.057
Barefoot	Yes	138	43	31.2	1	
	Never	95	21	22.1	0.62 (0.34-1.15)	0.130

Multivariate analysis using forward logistic regression model revealed that shared latrine facilities were 2.5 times (95% CI = 1.13–5.32; *p* = 0.023), getting deworming treatment before 6 months had 5 times (95% CI = 2.28–11.14; *p*<0.001), mothers' education level less than grade 8 had 2.4 times (95% CI = 1.06–5.58; *p* = 0.035), rarely washing hands with soap before a meal was 5.7 times (95% CI = 2.12–15.24; p = 0.002) and after defecation was 6 times (95% CI = 2.73–13.15; p<0.001) more prone to STH infections respectively (Table 4).

Table 4 Multivariate logistic regression analysis of risk factors

Variables	Categories	OR (95% CI)	*p*-value
Toilet facility	Separate	1	
	Shared	2.45 (1.13-5.32)	0.023
De-worming treatments	≤ 6 months	1	
	> 6 months	5.04 (2.28-11.14)	<0.001
Hand washing with soap before meals	Every time	1	
	Rarely	5.68 (2.12-15.24)	0.002
Hand washing with soap after defecation	Every time	1	
	Rarely	5.99 (2.73-13.15)	<0.001
Mothers educational level	> Grade 8	1	
	≤ Grade 8	2.44 (1.06-5.58)	0.035

OR: odd ratio; CI: confidence interval

Nutritional status of children

Table 5 shows the assessments of nutritional indicators (HAZ, WAZ, BAZ, Hb and serum albumin) in our study population. Most of the children's nutritional status was within the WHO recommended level. However, 17.6% (n=41) of stunted, 19.3% (n=45) of wasted and 39.5% (n=92) of underweight children were identified in the present study. In addition, 20.2% (n=47) of children had a low serum albumin level and 15.9% (n=27) had anaemia.

Associations between STH infections and nutritional status

The relationship between STH infections and the nutritional status of children was also assessed using an independent sample t-test. It was shown that the mean values for WAZ, HAZ, BAZ, haemoglobin and serum albumin were not significantly associated with children who are either STH negative or positive (p>0.05). Therefore, we suggest that there was no significant association between nutritional status and STH infections in the study population.

Table 5 Analysis of nutritional indicators (anthropometrics, Hb and albumin levels) in children

Nutritional status	STH positive (%)	STH negative (%)	Total (%)	*p*-value
HAZ				
Normal (Z> - 2.00 SD)	51 (79.7)	141 (83.4)	192 (82.4)	
Stunted (Z<- 2.00 SD)	13 (20.3)	28 (16.6)	41 (17.6)	
Mean z-score	-1.32	-1.23	-1.25	0.576
SD	1.09	1.07	1.08	
WAZ				
Normal (Z> - 2.00 SD)	44 (68.8)	97 (57.4)	141(60.5)	
Underweight (Z<- 2.00 SD)	20 (31.2)	72 (42.6)	92 (39.5)	
Mean z-score	-1.50	-1.51	-1.51	0.915
SD	1.05	0.94	0.97	
BAZ				
Normal (Z> - 2.00 SD)	52 (81.3)	136 (78.7)	188 (80.7)	
Wasted (Z<- 2.00 SD)	12 (18.7)	33 (21.3)	45 (19.3)	
Mean z-score	-1.19	-1.51	-1.16	0.114
SD	1.32	1.18	1.22	
Hb (g/dl) *				
Normal	59 (92.2)	137 (81.1)	196 (84.1)	
Low	5 (7.8)	32 (18.9)	37 (15.9)	
Mean	12.3	12.1	12.2	0.876
SD	0.8	0.8	0.7	
Albumin(g/l)				
Normal	54 (84.4)	132 (78.1)	186 (79.8)	
Low	10 (15.6)	37 (21.9)	47 (20.2)	
Mean	41.5	42.6	42.3	0.287
SD	4.0	3.6	3.7	

SD: standard deviation; Hb: haemoglobin; Height-for-age Z-score (HAZ), Weight-for-age Z-score (WAZ), Body-mass-index-for-age Z-score (BAZ)
*Haemoglobin cut-off values (g/dl) for different age categories are as follows 6-59 months-11.0; 5-11 years-11.5; 12-14 years-12.0 (WHO, 2011 (WHO/NMH/NHD/MNM/11.1)

Discussion

Studies conducted in the 1980's and 1990's, showed a 100%, 95% and 89.7% prevalence of STH infections in urban slum communities in Colombo (1981), Galle (1989) and plantation sector (1994), respectively.[21,32,33] The results of the present study showed a much lower prevalence of STH infections compared to that of previous studies. However, in comparison with recent studies, the prevalence of STH reported in this study was higher than in the urban and rural areas, while it was lower than that in other plantation sectors in Sri Lanka.[22,2324,34,35,36] One to 6 year children showed a slightly higher prevalence (29.7%) than 7 to 12 year old children (24.7%). This difference may be due to various reasons including a lack of awareness, increased soil related activities of younger children than adults, and the prevailing poor health and personal hygiene in the plantation sector.
A. lumbricoides is the most predominant STH found in both children and adult populations. The close environment of the inhabitants of the study area may be heavily contaminated, especially by children with infected faeces, due to defecation in open areas and close to the line houses. The

eggs of *Ascaris* are more resilient and can remain infective for years in the soil.[14] Children are therefore more likely to be infected when playing on these contaminated grounds. Soil samples were not checked for the presence of parasitic eggs in the current study.

Trichuris eggs were found only in 2 children and 1 adult. Similar low prevalence was reported by Gunawardena et al. (2011) in school children in the plantation sector in Sri Lanka.[22] A low prevalence has been shown in children living in rural communities of Pakistan as well.[23,37] Eggs of *T. trichiura* are not resistant to cold, drought and direct sunlight compared to *Ascaris* eggs which may be one of the reasons for the very low prevalence of *Trichuris* infection. Further investigation using a larger sample size may be indicated.

In the current study, hookworm infection was not detected in children and adults. Similar results were reported in previous studies in the Kandy area.[23,26] Hookworm is not a common backyard infection, requiring shady, sandy and moist soil for its further development.[17] The area surrounding the study participants homes were not shady which could be a contributory factor for the low detection. Gilgen et al. (2001) have previously reported a high rate of hookworm infection among tea estate workers and among their family members.[14] Periodic deworming, improved sanitation and hygiene since 2001 may also have contributed to a decline in hookworm infection in the plantation sector.[14]

Table 3 shows the intensity of *A. lumbricoides* infection in children and adults. Both light and moderate infections were high in children. A heavy intensity was reported in one female child. Our results indicate that the intensity of *A. lumbricoides* infection gradually decreased with age. This might be due to an improvement in hygienic practices. Similar results were reported in adolescent school girls in Sri Lanka.[27]

Analysis of the factors associated with STH infection in children showed that age, gender, number of family members, socioeconomic status, type of drinking water, sucking fingers, walking barefooted, source of drinking water and eating unclean fruits were not significantly associated with STH infection. Although these variables may not have a direct relationship with STH infections, these findings should be further investigated using a larger sample size to get a clearer understanding of their role in these infections. Low maternal education, infrequent hand washing using soap before meals and after defecation, shared latrine facilities and longer periods between de-worming were significantly associated with STH infection. Several studies have shown that poor maternal education is a risk factor associated with STH infection.[38,39,40,41] Generally, a mother plays a significant role in the health education of their children. In this study, we found that the mother's awareness of STH was very poor. It may be a contributing factor to the high prevalence of STH in children. A shared poor quality latrine can also lead to STH infection among children. Previous studies carried out in Sri Lanka,[36] in Nepal,[41]and in Pakistan[37] have shown similar results.

Nutritional indicators (HAZ, WAZ, BAZ, and haemoglobin and serum albumin levels) of children were also analyzed in the present study. The findings were compared with the general data of the country and with the WHO reference values.

Nutrition and growth status of many children were within the normal ranges. However, there were many under-weight children in the study group (39.5%). The Sri Lankan National Nutrition and Micronutrient Survey conducted in 2012 showed that 13.1% children aged between 6 to 59 months were stunted, 19.6% wasted and 23.5% underweight. In addition, the same survey reported that 15.7%, 20.2% and 24.7% were stunted, wasted and underweight respectively in the Kandy district.[42] A comparison between the country and district data reported that the prevalence of stunting and underweight was significantly higher in our study population.

The prevalence of anaemia in children was 15.9%. This figure was slightly higher than the country`s average (15.1%) but lower than the district average (16.9%). A reasonably high prevalence of the thalassemia traits can be a reason for the high prevalence of anaemia, but we could not find any evidences to prove it. In addition, 20.2% of children showed hypoalbuminaemia. There was no significant relationship between nutritional status and STH infections in children. This is probably due to widespread poverty in the population living in the tea plantation areas in Sri Lanka.

The Kato-Katz method was used to determine the intensity of the infection which varied from light to moderate. Limitations of the study include nonuse of the concentration technique to detect STH and examining only one stool sample per participant, both of which could increase the detection of STH.

The nutritional status and socio-demographic features in this community was studied for the first time.

Conclusions and recommendations

The findings of this study contribute to the epidemiological data of STH infections which could be used to plan an effective control programme. Prevalence of STH infections was notably high in both children and their parents, indicating a high level of transmission. Providing single houses instead of line houses, health education and the improvement of sanitary facilities are essential for the effective control of STH infections in the study population. Therefore, coordinated control and prevention programmes considering the diverse socio-demographic characteristics of estate communities is needed to eliminate STH infections in the study population. Government and local authorities should pay more attention to improving not only the health, housing and sanitary facilities of these marginalized communities, but also, their household income as a priority.

Acknowledgements: The authors are very grateful to Mr. N.L.S. Wijesundara, Mrs. D.R.L.N. Bandara, and other technical staff of the Department of Parasitology, Faculty of Medicine, University of Peradeniya for providing technical assistance. We would like to thank the management of the estate medical authorities, welfare officers and other healthcare workers from the respective estates for their technical assistance given during the study. Furthermore, the authors would like to express our deepest gratitude to all the children and their parents/guardians who have voluntarily participated in this study.

Funding: Financial assistance given by the Faculty of Medicine Research Grant (RG/EF/2013/11) is acknowledged.

Competing interests: The authors declare that they have no competing interests.

Ethics approval: Ethical approval was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Peradeniya, Sri Lanka. Written informed consent was obtained from parents and/or legal guardians of children before collecting data, blood and faecal samples. In addition, written permission was obtained from the estate authorities. All data were kept strictly confidential.

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