Soil-Transmitted Helminth Infections and Sri Lankan Children

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Introduction

Many millions of people in tropical and subtropical regions are infected by parasitic worms, including *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Ancylostoma duodenale* and *Necator americanus* (hookworms) and *Schistosoma* species. As a rule, children carry the heaviest worm and egg burdens, and because of their defaecation practices, are the principal disseminators of infection[1]. Helminth infections cause malnutrition, anaemia and growth retardation as well as impose a higher susceptibility to other infections[2].

Impact on physical health and growth

Undernutrition is one of the commonest consequences of infection with intestinal helminths[3]. In Kenya, treatment for hookworm, *T. trichiura* and *A. lumbricoides* in undernourished schoolboys improved physical fitness only seven weeks after treatment despite continual exposure to re-infection and some incomplete cures[4]. In another study, which was conducted in Kenya, physical activity, growth and appetite of a group of undernourished Kenyan primary school children with hookworm (93% prevalence), *T. trichiura* (84% prevalence) and *A. lumbricoides* (29% prevalence) infections improved significantly following random treatment with albendazole, when compared with the group which received a placebo[5].

Roundworm infection or ascariasis is estimated to be present in up to 90% of children in some areas of the tropics[2]. This parasite also has important nutritional effects; treatment can improve food intake and growth in infected children. The utilisation of protein declines in *Ascaris* infected children, an important phenomenon where there is severe protein energy malnutrition or in children on low protein diets. The parasite can decrease the absorption of fat in hosts and exacerbate protein energy malnutrition and vitamin A deficiency. Lactose activity in the small intestine is reduced and milk intoleranee develops in children[6].

T. trichiura has been associated with undernutrition, growth stunting and iron deficiency anaemia in intense infections, and treatment of infected children has been shown to increase the haematocrit, improve growth rates and anthropometric indices, increase serum albumin, decrease diarrhoea and reduce bacterial and protozoan infections in the gut[7].

The hookworms cause loss of blood and protein, which often results in anaemia, especially in girls and pregnant women. Nutritional status is altered through a decline in food intake and/or an increase in nutrient wastage through blood loss, vomiting or diarrhoea. These effects can lead to or aggravate protein energy malnutrition, anaemia and other manifestations of nutrient deficiency[3]. A well known association exists between hookworm infection and anaemia, and the growth stunting potential of hookworm has long been known[8]. Anaemia in children causes retarded physical and mental development, decreased resistance to infection and increased morbidity, especially in those below school-age. Fatigue and a decreased capacity for work may stem from anaemia in older children and adults, and substantial socioeconomic development is unlikely to be achieved if the prevalence of this condition is not reduced[1].

The public health impact of ascariasis, trichuriasis and hookworm infections has been reviewed comprehensively in several recent publications [9-13].

Impact on learning abilities

Helminth infections are believed to have adverse effects on the development of children and on the efficiency of their cognitive functions. Almost a century ago, Strong found that infected children tended to be smaller and their performance on a mix of tests judged educationally relevant, was generally poorer than the performance of uninfected children[14]. Following treatment, infected children gained weight and their test performance improved. Around the same time, Waite & Neilson reported links between the intensity of hookworm disease and scores on Binet intelligence scales and a maze learning task[15]. Since then, several studies have shown an association between parasitic helminth infection rates in children and poor cognitive performance and absenteeism from school; an improvement in educational achievement of infected children has been observed following anthelminthic and supportive treatment, indicating that the infection per se, rather than associated sociological factors were responsible for impaired learning [16,17].

Nokes *et al.* found a relationship between school performance and infection with *T. trichiura*, the prevalence and intensity of infection being greater among academically less able children[18]. Callender *et al.* tested and followed children diagnosed with the Trichuris Dysentery Syndrome[19]. These children were found to be stunted, showed deficits on the Griffiths test, and were more anaemic than the control group matched for age, sex and socio-economic status. These children also came from less stimulating homes.

It has been shown that performance on tests of reaction time is associated with *A. lumbricoides* infection[20]. Levav and others found that infection with *A. lumbricoides* was associated with poor performance on tests of verbal ability[21]. Another group of researchers have demonstrated that a group of primary school children from Jakarta treated with mebendazole showed a significant improvement in their learning ability, concentration and eye-hand coordination after five months of receiving the intervention[22].

The adverse effect of helminth infection on cognition suggests that helminths may have even greater developmental consequences than was previously thought, since the most intense infections with *T. trichiura* and *A. lumbricoides* occur at an age when children are receiving what may be the only education they will ever receive. Further studies are required to determine whether the effect of infection has long-term implications for school achievement.

Recent prevalence data from Sri Lanka

There are no nationally representative data on the prevalence of soil-transmitted helminth infections in Sri Lanka, except for hookworm surveys done in the 1920's when prevalence rates were extremely high[23]. Similar prevalence rates were seen in many communities well into the 1970's and 1980's [24-27]. Since the 1980's however, prevalence rates have changed in many areas owing to improvements in sanitation and the widespread use of mebendazole and albendazole, both of which are highly effective anthelmintics. In order to focus on the current situation, this review concentrates on the more recent studies. Most of these have been in the plantation sector and in urban slums, where overcrowding, poor sanitation, and a favourable climate combine to provide the conditions necessary for high transmission.

A comprehensive survey, spanning 14 tea and rubber plantations in the Central, Sabaragamuwa, Southern, Western and Uva provinces, was carried out in 1992[28]. This survey found that 90% of the 1614 children (aged 3 12 years) examined were infected with one or more helminths. The overall prevalence rates for ascariasis, trichuriasis and hookworm infection were 77%, 69.4% and 23.2% respectively. While ascariasis and trichuriasis prevalence rates were very high in almost all plantations, hookworm prevalence rates were much more heterogeneous. In general, hookworm prevalence was low in the plantations of the Central and Uva provinces, which are at a much higher elevation, and therefore colder, than those in the Southern and Sabaragamuwa Provinces[29]. Subsequent to this survey, a biannual mass treatment programme with 500mg mebendazole, targetting school aged children was implemented in the plantation sector. Since implementation of this programme in 1994, surveys have been carried out regularly to monitor its effectiveness. These data indicate a general decline in the prevalence of all three infections[30]. For example, among 537 children surveyed from five plantations in 2000, the prevalence of ascariasis was 53.4%, trichuriasis was 24.8% and hookworm 6.9%. These five plantations included one each in the Western, Southern and Sabaragamuwa provinces and two in the Central Province.

Four studies have surveyed the prevalence of STH infections among children in rural areas, living in villages outside the plantation sector (see Table 1). Two of these have been done in primary schools in the Uva Province in 1999. One study involved 349 children attending 5 schools in the Buttala and Kataragama DS divisions in the Monaragala District[31], and the other, 145 children in 2 schools in the Mahiyangana DS division of Badulla District[32]. The geographical areas covered by these studies are among the remotest in Sri Lanka. The villages served by these schools are very poor, with wholly inadequate facilities for water and sanitation. Nevertheless transmission of ascariasis and trichuriasis seemed virtually non-existent. Hookworm was the most frequent infection, but at a fairly low level of transmission.

In the single study carried out in the Western Province during the period under review, 231 adolescent girls (aged 14 18 years) from rural schools in the Kaduwela area of Colombo district were examined[33]. The prevalence of each of the 3 helminths was <5.0% and all infections were of mild intensity except for a single hookworm infection. The most recent of the rural surveys was carried out in the villages of Mathotagama, Hamugewatta and Walgama in the Southern Province (Mirani Weerasooriya, personal communication). The prevalence of STH among children of the 5 18 year age group in these communities was less than 15%.

The five studies carried out in urban / semi-urban areas cover communities in Kandy, Colombo, Matara, Wattala and Ragama (see Table 1). The study in Colombo involved 383 adolescent girls attending several schools within the Colombo Municipal Council limits[33]. All these schools served low-income communities. Trichuriasis was the most common helminth infection (46.2%) while 16.7% had ascariasis and only 4.8% had hookworm. Only 2.1% of those with ascariasis and 2.9% of those with trichuriasis had infections of moderate or heavy intensity (=5000 *Ascaris eggs* per gram faeces, or =1000 *Trichuris* epg faeces)

The study in Kandy was a community-based survey of 307 pre-school children living in a slum area in the heart of the City[M]. Despite environmental conditions and behavioural practices that would greatly favour transmission, only 23.8% of these children has ascariasis, 7.2% had trichuriasis and 1.6% had hookworm.

Another community-based survey, done in 1996 in a slum area in Matara Town in the Southern Province involved 74 children aged 6 12 years[35]. Hookworm was the most common infection in this community, infecting 39.2% of the children examined; trichuriasis was next, (32.4%), while the prevalence of ascariasis was 24.3%.

Two studies report on prevalence rates in the Gampaha District. The first was a survey carried out in a semi-urban slum community in Wattala, which found prevalence rates of <10% among 111 children aged 1 10 years[36]. The other study, a survey of 252 primary school children attending 6 schools in the Ragama MOH area, found prevalence rates that were even lower[37].

Understanding the epidemiology of STH infections in Sri Lanka

The prevalence rates of STH infections are known to be influenced, perhaps even determined, by environmental factors. Classically, Sri Lanka is divided into 3 ecological zones (wet, dry and intermediate), based on the sequential rainfall pattern for the year, and the 75% expectancy value of annual rainfall. A second subdivision takes into account altitude and temperature, giving a Low Country (<300 m), Mid Country (300 900 m), and Up Country (>900 m)[38]. The Dry Zone falls wholly within the low country, while the wet and intermediate zones fall within all three subdivisions.

For purposes of understanding the epidemiology of STH infections, a simple categorization into the 'Hill Country' (which covers all terrain above 900 m); the 'Wet Zone' (areas with 75% expectancy of annual rainfall >1250 mm, and altitude <900 mm) and the 'Dry Zone' (which includes the Dry and Intermediate Zones in terrain <900 m), is suggested.

The data reviewed here indicates that high transmission of STH infections, with prevalence rates of >50% is now largely confined to the plantation sector, which lies within the 'Wet Zone' and the 'Hill Country'. In the 'Hill Country', hookworm prevalence rates are low, probably due to the cooler temperatures.

Empirical data on prevalence rates outside the plantation sector are scarce, but even in the poorer urban areas of the 'Wet Zone', where conditions for transmission would seem ideal, prevalence rates seem to be only moderately high. This is marked contrast to rates described in studies carried out in all parts of the country, until the 1980s. This change is most probably due to the widespread use of broad-spectrum anthelmintics (especially generic mebendazole), since availability and use of sanitation and water supplies have not changed much during the period in question. Anthelmintics have been given to school children throughout the country during School Medical Inspections; parents also often buy anthelmintics over the counter for regular treatment of their children, since it is easily affordable: a single dose of 500mg mebendazole produced by the State Pharmaceutical Manufacturing Corporation costs only ab 3.00.

With regard to the 'Dry Zone', empirical data are available from the period under review for only 2 of the 17 districts that lie within this area. Three other relatively recent studies also provide useful information. The first was a study carried out in 1986 among 200 pre-school children living in an under-privileged sector of the Jaffna Municipal Council[39]. The prevalence of ascariasis, trichuriasis and hookworm was 22.5%, 27% and 10% respectively. The second study is also from Jaffna, reporting on prevalence among 187 children admitted to the University Paediatric Ward in Jaffna General Hospital in 1989[40]. 15% of these children had ascariasis, 13.4% had trichuriasis and 17.6% had hookworm. The third study reports on 496 children attending 3 schools in Dehiattakandiya DS division in Ampara District during the period 1986 89[41]. The prevalence of STH infections was very low throughout the 3 years, with overall prevalence rates of <5.0%. It is likely that transmission of STH infections in the Dry Zone is low because of unfavourable climatic conditions and the low population density. However, such broad generalization needs to be done very cautiously since very little empirical data is available.

In the meantime, declining prevalence rates also appear to have resulted in declining awareness of these infections and lack of basic diagnostic skills. For example, a case was reported recently, of a 2-year-old child who presented with melaena and severe anaemia[42]. The diagnosis of hookworm infection was only made when numerous adult worms were seen in the duodenum on endoscopy, since an initial stools examination had been reported as negative for helminth ova. The child was from a very poor family that did not have access to latrine facilities. This case report serves as a timely reminder that focii of intestinal nematode infections still remain in parts of Sri Lanka where socio-economic conditions are poor and latrines are absent. It also emphasizes the fact that personnel in Sri Lankan hospital laboratories should be better trained to carry out the simple, inexpensive laboratory tests involved in stools examination for intestinal nematode ova.

Table 1. Surveys of soil-transmitted helminth infections outside the plantation sector of Sri Lanka, 1992 2001

Population	Year of survey	Location	Number examined	Prevalence rates			Reference
				Ascariasis	Triehuriasis	Hookworm	
Pre-school children (1 – 6 yrs)	1992	Mahaiyyawa, Kandy	307	23.8%	7.2%	1.6%	34
Schoolgirls (14 – 18 yrs)	1996	Kaduwela	231	2.2%	4.3%	4.8%	33
		Colombo	383	16.7%	46.2%	5.7%	
Children (6 – 12 yrs)	1996	Matara town	74	24.3%	32.4%	39.2%	35
Children (1 – 10 yrs)	1998	Enderamulla, Wattala	111	9.9%	5.4%	1.8%	36
School children (6 – 15 yrs)	1999	Dambana, Badulla	145	0	0	17.2%	32
School children (6 – 13 yrs)	1999	Monaragala	349	0.3%	0	1.7%	31
Children (5 – 18 yrs)	2001	Walgama, Matara	239	4.2%	12.6%	8.4%	M. Weerasooriya pers. comm
School children (8 – 9 yrs)	2002	Ragama	252	0.4%	1.6%	0	37

References:

1. Evans AC & Stephenson LS (1995). Not by drugs alone: the fight against parasitic helminths. *World Health Forum* 16; 258-261.

2. WHO (1995). Improving health through schools. *World Health* 48th Year, No.2, March-April.

3. Stephenson LS (1994). Helminth parasites, a major factor in malnutrition. *World Health Forum* 15(2); 169-72.

4. Stephenson LS, Latham MC, Kinoti SN, Kurz KM & Brigham H (1990). Improvements in physical fitness of Kenyan school boys infected with hookworm, *Trichuris trichiura* and *Ascaris luinbricoides* following a single dose of albendazole. *Royal Society of Tropical Medicine and Hygiene 84;* 277-282.

5. Adams EJ, Stephenson LS, Latham MC & Kinoti SN (1994). Physical activity and growth of Kenyan school children with hookworms, *Trichuris trichiura* and *Ascaris lumbricoides* infections after treatment with albendazole. *Journal of Nutrition* 124; 1199-1206.

6. Mahmoud AAF (1995). In: Mandell GL, Bennett JE & Dolin R (Eds) Principles and Practice of Infectious diseases, 4th edition. New York: Churchill Livingstone, pp 2526-2531.

7. Cooper ES, Bundy DAP, MacDonald TT & Golden MHN (1990). Growth suppression in the Trichuris dysentery syndrome. *European Journal of Clinical Nutrition* 44; 138-147.

8. Pawlowski ZS, Schad GA & Stott GJ (1991). Hookworm Infection and Anaemia. Geneva: World Health Organization.

9. Stephenson LS, Latham MC, Ottesen EA (2000). Malnutrition and parasitic helminth infections. *Parasitology* 121: S23 S38.

10. O'Lorcain P & Holland CV (2000). The public health importance of *Ascaris lumbricoides*. *Parasitology* 121: S51 S71.

11. Crompton DWT (2000). The public health significance of hookworm disease. *Parasitology* 121: S39 S50.

12. Crompton DWT & Nesheim MC (2002). Nutritional impact of intestinal helminthiasis during the human life cycle. *Annual Review of Nutrition* 22: 35 59.

13. De Silva NR (2003). Impact of mass chemotherapy on the morbidity due to soil-transmitted nematodes. *Acta Tropica 86* (2-3): 197 214.

14. Strong EK (1916). Effects of hookworm disease on the mental and physical development of children. International Health Commission, Publication 3. New York: Rockefeller Foundation.

15. Waite JH & Neilson L (1919). A study of the effects of hookworm infection upon the mental development of North Queensland school children. *Medical Journal of Australia* 1: 1-7.

16. Kvalsvig JD, Cooppan RM & Connolly KJ (1991). The effects of parasite infections on cognitive processes in children. *Annals of Tropical Medicine and Parasitology* 85; 551-568.

17. Nokes C & Bundy DAP (1994). Does helminth infection affect mental processing and educational achievement? *Parasitology Today* **10**(1); 14-18.

18. Nokes C, Cooper ES, Robinson BA & Bundy DAP (1991). Geohelminth infection and academic assessment in Jamaican children. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **85**; 272-272.

19. Callender JEM, Grantham-McGregor SM, Walker S & Cooper ES (1992). *Trichuris* infection and mental development in children. *Lancet* **339**; 181.

20. Watkins WE. & Pollitt E (1997). "Stupidity or worms": do intestinal worms impair mental performance? *Psychological Bulletin* **121**; 171-191.

21. Levav M, Mirsky AF, Schantz PM, Castro S & Cruz ME (1995). Parasitic infection in malnourished school children: effects on behaviour and EEG. *Parasitology* 110; 103-11.

22. Hadidjaja P, Bonang E, Suyardi MA, Abidin SA, Ismid IS & Margono SS (1998). The effects of intervention methods on nutritional status and cognitive function of primary school children infected with *Ascaris lumbricoides*. *American Journal of Tropical Medicine and Hygiene* **59**; 791-795.

23. Chellappah SF (1938). Public health aspects of anchylostomiasis. *Journal of the Ceylon Branch of the British Medical Association* **35**: 419 45.

24. Fernando MA & Balasuriya S (1976). Prevalence of soil-transmitted helminths in the Hindagala Community Health Project area. *Ceylon Medical Journal* **22**: 177 183.

25. De Silva DGH, Jayatilleka SMD (1981). The prevalence and severity of soil transmitted helminths in an urban slum community in Colombo. *Ceylon Medical Journal* **26**: 160 164.

26. Balasuriya S, Edirisinghe JS, Rajudeen NMM. (1990). Effectiveness of mass treatment with mebendazole in the control of soil transmitted helminths in Sri Lanka. *Ceylon Medical Journal* **35**: 15 20.

27. Ismail MM, Premaratne UN, Suraweera MGW. (1991). Comparative efficacy of single dose anthelmintics in relation to intensity of geohelminth infections. *Ceylon Medical Journal* **36**: 162 167.

28. Sorensen E, Ismail M, Amarasinghe DKC, Hettiarachchi I, Dassenaieke TSdeC (1996). The prevalence and control of soil-transmitted nematode infections among children and women in the plantations in Sri Lanka. *Ceylon Medical Journal* **41**: 37 41.

29. Sorensen E, Ismail M, Amarasinghe DKC, Hettiarachchi I, Dassenaieke TSdeC (1994). The effect of the availability of latrines on the soil-transmitted nematode infections in the plantation sector in Sri Lanka. *American Journal of Tropical Medicine & Hygiene* **51**: 36 39.

30. Ismail MM, Naotunne T, Hettiarachchi I (2001). Effectiveness of a bi-annual deworming programme in the plantations in Sri Lanka: an evaluation after 4 years. In: Hayashi S (ed) *Collected Papers on the Control of Soil-Transmitted Helminthiases Vol VII.* Tokyo APCO, pp 185 194.

31. Fernando SD, Goonethilleke H, Weerasena KH, Kuruppuarachchi ND, Tilakaratne D, de Silva D, Wickremasinghe AR (2001). Geo-helminth infections in a rural area of Sri Lanka. *Southeast Asian Journal of Tropical Medicine & Public Health* **32**(1) 23 25.

32. Chandrasena TGAN, Morel RP, de Alwis C, Sudusinghe HP, de Silva NR (2000). Intestinal parasitic infections in primary school children in Mahiyangana. *Annual Scientific Sessions of the Sri*

33. **Atukorala TMS & Lanerolle** P *(1999)*. Soil-transmitted helminthic infection and **its effect on** nutritional status of adolescent schoolgirls of low socio-economic status in Sri Lanka. *Journal of Tropical Paediatrics 45: 18 22.*

34. De Silva NR, de Silva HJ & Jayapani VPP (1 *994)* Intestinal parasitoses in the Kandy area, Sri Lanka. *Southeast Asian Journal of Tropical Medicine & Public Health 25 (3) 469 473.*

35. **Amarasinghe Y &** Weerasooriya MV *(1999)*. Prevalence of intestinal parasites in **an** urban **slum** community in **Matara.** *Galle Medical Journal 11 (4) 1 6.*

36. Udayani WI, Uduwevidane IK, Uvais AL, Wanniarachchi SL, Warnakulasuriya SN, de Silva NR *(1999)*. Intestinal helminth infections among children in a slum community in **Enderamulla.** *Ceylon Medical Journal 44: 187 188.*

37. De Silva NR, Pathmeswaran **A,** Fernando SD, Weerasinghe **CR, Selvaratnam** RR, Padmasiri EA, Montresor A. Impact of mass chemotherapy **filariasis** control programme on soil-transmitted helminth infections in Sri **Lanka** *Annals* **d** *Tropical Medicine & Parasitology* (in press).

38. **Panabokke** CR (1 *996)*. ***Soils** and agro-ecological environments of **Sri Lanka.*** Colombo, Natural Resources, Energy & Science Authority, Natural Resources **Series No** 2.

39. **Nageswaran** C **& Sivarajah** N *(1986)* Intestinal parasitic infestations in children living in the underprivileged sector **of Jaffna** Municipality. *Jaffna Medical Journal* **21** (1) *23 28.*

40. **Ramadas** G **& Ramadas** D *(1 989)* Pattern of parasites in a paediatric ward in the General Hospital (Teaching), Jaffna. *Ceylon Journal of Child Health 18: 29 33.*

41. **Wijesundera MdeS,** de Silva NR, Ariyaratne CA *(1993)*. Prevalence patterns of **intestinal** parasitoses in schoolchildren in Mahaweli System C, a new settlement in Sri Lanka. *Kandy Medical Journal 2 (1) 5 9.*

42. Lamabadusuriya S **& Perera** S. An unusual cause of melaena in a child. *Ceylon Medical Journal* **2003;48**:27 *8.*