Anthrop. Közl. *43;* 95–104. (2002)

THE RELATIONSHIP BETWEEN NUTRITIONAL STATUS, GROWTH AND INTESTINAL PARASITES IN BANGLADESH

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Abstract: *Four groups of Bangladesh children aged between 2 and 8 years took part in a 18 months randomised trial to study the effects of chemotherapy and health education on growth, nutritional status and prevalence and intensity of intestinal parasites. Approximately 500 children from each rural area participated in the trial, each area receiving a different intervention. One area received chemotherapy at baseline and at 6, 12, and 18 months; another received health education only; a third area received both chemotherapy (at baseline, 6, 12 and 18 months) and health education, and the fourth area was a control. All children and their families were given a single dose of albendazole (400mg) at the beginning and end of the study. Children had their height, weight and mid-upper arm circumference measured at baseline, 6, 12, and 18 months. Stool samples were taken prior to chemotherapy at baseline and again at 6,12, and 18 months and the eggs/g of round worm, whip worm and hook worm were counted.*

Overall there was evidence of wasting (17%) and stunting (31%) at baseline while at the end of the study there was little change in wasting (16%) but the percentage stunted had increased to over 40%. There was little consistent evidence suggestion a relationship between anthropometric status and worm infestation; regular de-worming was not associated with consistent growth gains. Cost-effective analysis showed that annual de-worming treatment was the most cost effective means of reducing the prevalence and intensity of worm infestations.

Keywords: *Growth; Nutritional status; Intestinal parasites; Ascaris lumbricoides; Trichuris trichiura; Bangladesh.*

Introduction

Intestinal worm infections are among the most common infections in the World and roundworm (*Ascaris lumbricoides*) and hookworm infections rank below only tuberculosis and diarrhoeal disease in prevalence in Asia, Africa and Latin America (Pawlowski 1984). Of the nematodes (roundworms) Ascaris is the most common and it is estimated by The World Health Organisation that about one quarter of the world's population is infected with *Ascaris lumbricoides* (roundworm), about one-eighth with Trichuris trichiura (whipworm) and one-fifth with hookworm (either *Ancylostoma duodenale* or *Necator americanus*). The world's population harbours ten thousand million Ascaris worms, a total burden of about 1 million kilogrammes. Every day about 100,000 kg of Ascaris eggs are released into the environment.

Helminths pass through three stages, egg, larva and adult, in their life. The life cycle of the hookworm begins with eggs from an infected person passing out of the body in faeces. Under favourable environmental conditions the eggs hatch and larvae emerge. When the larvae come into contact with skin, they penetrate it, and burrow rapidly. They migrate through the blood stream to the lungs and then climb the windpipe. They are coughed up and swallowed and enter the gut where maturation to adults occurs. The spread of hookworm infection is encouraged by the use of faecal material as a fertiliser and by walking barefoot.

Ascaris and Trichuris have similar life cycles. Eggs pass out of the body in faeces, and, on average a female roundworm will produce 240,000 eggs/day. The eggs are not immediately infective but become so in two or three weeks in suitable environmental conditions. The developing eggs enter the body in food contaminated with infected soil. In the stomach the eggs hatch and the larvae burrow through the gut wall into the blood vessles through which they travel to the liver and then the lungs. There they feed, grow, and develop into young adults. The worms migrate to the trachea where they are coughed up and swallowed and return to the intestine. About 2 months after the initial ingestion of eggs, the female adult roundworm begins releasing eggs.

The intensity and prevalence of helminthic parasites in humans are related to a variety of ecological, behavioural, immunological and demographic determinants (Bundy and Medley 1992). Worm transmission is enhanced by poor socio-economic conditions, deficiencies in sanitary facilities, improper disposal of human faeces, insufficient supplies of potable water, poor personal hygiene, substandard housing, and lack of health education (Holland et al. 1988). These factors correlate with poverty and underdevelopment, and in that sense intestinal parasitoses can be labelled "diseases of poverty" (Cooper 1991).

Parasitic infection constitutes a significant health and social problem (WHO 1987). Infection can lead to (a) significant morbidity and mortality (b) poor physical development, reduced physical activity and reduced capacity for productive work and infection is associated with impaired mental development and unsatisfactory performance of children at school (Nokes and Bundy 1994, Morrow 1984).

The clinical signs and symptoms of infection vary according to the infective organism and the extent of infection. Ascaris can cause cough and intestinal obstruction, Trichuris abdominal pain and diarrhoea, and hookworm abdominal pain, diarrhoea and iron deficiency anaemia. Blood loss in hookworm infection has been estimated as 0.2 ml per worm per day in *A. duodenale* and 0.04 ml per worm per day in *N. americanus*. Even small hookworm loads may cause anaemia over time and a blood loss of 1 ml per day (equivalent to a worm load of about 5 for *A. duodenale* and 25 for *N. americanus*) would cause the loss of 250mg of iron in two years, the equivalent of the total iron stores of a 50kg women. Ascaris infection is associated with reduced weight-for-age, impaired lactose digestion, decreased food consumption, lower plasma Vitamin A levels and short intestinal transit time. Heavy Trichuris infection is associated with the loss in weight in adults and failure to grow in children (Holland 1991, Stephenson 1994). Worm infections are part of a vicious "disease-malnutrition-growth-productivity" cycle.

The magnitude of the problem of soil and water transmitted intestinal parasites has not yet been rigorously investigated in Bangladesh through a nation-wide study, but it is generally accepted that people living in rural areas and in urban slums will be particularly at risk because of poor sanitation, unclean water, and lack of personal hygiene. Surveys conducted over the last 30 yr on rural samples, hospital patients, students, urban slum dwellers and tea garden workers suggest prevalences of roundworm in the range 70–95%, whipworm between 38–79% and hookworm from 2–71% (Muttalib et al. 1976, Hall et al. 1992). However, much less information is available on intensities of infection (as measured by eggs/g in stool samples), and the few studies conducted do not suggest high levels of infection.

The results described in this paper relating nutritional status, growth and intestinal parasites in rural Bangladeshi children were part of a wider study that examined the cost-effectiveness of different interventions on reductions in prevalence and intensity of gut infection (Mascie-Taylor et al. 1999).

Materials and Methods

A randomised intervention survey involving 4 discrete geographical areas, all located within a radius of about 80 km from Dhaka, the capital of Bangladesh was conducted over 18 months. No ethical clearance was required as the main interventions of health education and chemotherapy are part of accepted government policy. Four discrete areas were chosen because the health education programme involved the whole community (see below). Each area was randomly assigned to a different regimen. Area 1, Palash, received albendazole chemotherapy at the beginning of the 18 months study period (baseline) as well as health education; area 2, Bhaluka received albendazole chemotherapy at baseline and again at 6 and 12 months; area 3, Mirzapur, received both albendazole chemotherapy at 0, 6, and 12 months and health education and area 4, Kaliganj where albendazole chemotherapy was given at 0 months only and no health intervention was carried out. In all 4 areas the index child and all the other household members received albendazole chemotherapy at the commencement of the study. In Bhaluka and Mirzapur, only the index child from each house was treated at 6 and 12 months.

A total of 550 children between 2 and 8 years in each of the 4 areas were randomly selected on a household basis to participate in the study. Before the initial albendazole treatment, each child provided a faecal sample so that prevalence and intensity of infection (eggs/g in faecal samples, using the Kato-Katz method) for the 3 worms (round, whip and hookworm) could be determined. At the end of the study the index child as well as the family members received anthelminthic treatment. All children in the 4 areas had their height, weight and mid-upper arm circumference (MUAC) measured at 6 monthly intervals commencing at the baseline survey. Height-for-age, weight-for-age and weight-for-height Z scores were computed using the NCHS reference values. Children also provided a faecal sample at 6, 12, and 18 months for determination of egg counts. Basic socio-demographic and household data were collected by questionnaire at the beginning of the study and a knowledge, attitude and awareness (KAP) questionnaire was administered at the beginning and end of the study to monitor changes in attitudes, awareness, and changes in practices over the 18 months fieldwork period.

Health education was organized in each of the 2 relevant areas through a team of 6 health assistants and a supervisor. The educational package comprised home visits once a month, focus group discussions, and visits to schools. The aim of the project was to increase the awareness of worm transmission and the disabilities caused by intestinal helminths; to improve personal hygiene by hand washing before food preparation, consumption, and after defecation, and regular nail trimming, and to promote routine wearing of shoes, use of a latrine, and use of clean water in cooking and washing of utensils. It is understood that the findings of the study that relate to the health education intervention are applicable only to the specific package of health education provided and that alternative health education interventions may have brought about different sets of results.

A subset of children (10%) provided a second stool sample 6 wk after receiving anthelminthic treatment for ascertaining cure rates of each worm. The results confirmed the findings of previous such studies in showing high cure rates using albendazole for *Ascaris lumbricoides* of 93% and lower rates for hookworm (85%) and *Trichuris trichiura* (72%). The reliability of egg counts was also assessed, and paired t-tests confirmed that there were no significant inter-observer differences between the egg counts for any of the 3 worms.

Here the growth of the children over the 18-month period is examined in relation to prevalence and intensity of the three worms as well as background socio-demographic variables.

Results

At the beginning of the study nearly 31% of children aged 2–8 years were free of all three intestinal parasites. Nearly half the children had Ascaris, a third Trichuris and 40% hookworm; 14% had all three worms. At the end of the 18 months study, children free of worm infestation increased to nearly 56%, and prevalences fell to 33% for Ascaris and Trichuris and 10% for hookworm; only 4% had all three worms (Table 1). Based on WHO classification intensities of mean worm infestation were low for all three worms (Table 2) at the beginning of the study and even lower at the end of the study period.

Table 1. Prevalence of gut parasites at the beginning and end of the study.

Worm	Baseline	18 months
None	30.7	55.7
Ascaris only	14.6	16.8
Trichuris only	5.4	5.0
Hookworm only	10.8	2.4
Ascaris + Trichuris	10.0	12.0
Ascaris + Hookworm	9.3	1.6
Trichuris + Hookworm	5.0	2.2
All three	14.2	4.3

Table 2. Intensities (eggs/g) of gut parasites at the beginning and end of the study.

	Baseline		18 months	
	Mean	SD	Mean	SD
Ascaris	769	2156	400	1364
Trichuris	121	590	67	237
Hookworm	105	375	25	172

Associations between worm prevalence and intensity of infection with socio-economic, education and cleanliness variables did not show consistent and significant relationships for all three worms. Children from poorer households tended to have higher prevalences of Trichuris and hookworm but few variables associated with Ascaris.

There was clear evidence of acute and chronic malnutrition: mean weight-for-height Z-score was –1.21 and height-for-age –1.47 at the beginning of the study and declined to –1.24 and –1.68 respectively at the end of the study (Table 3). The percentage of children below –2 Z scores improved slightly for weight-for-height by the end of the study but worsened for weight-for-age and height-for-age (Table 4).

Table 3. Anthropometric Means at baseline and 18 months.

Variable	Baseline	18 months
Height	104.3	111.7
Weight	15.4	17.5
MUAC	148.1	154.4
Weight-for-height	-1.21	-1.24
Weight-for-age	-1.76	-1.88
Height-for-age	-1.47	-1.68

Table 4. Percentage below cut-off of –2 SDs.

Variable	Baseline	18 months
Weight-for-height	16.4	14.0
Weight-for-age	44.1	49.0
Height-for-age	36.9	42.1

Children from poorer households and living in less clean environments were more likely, on average, to have lower heights, weights and mid upper arm circumferences and reduced Z scores at baseline.

The relationship between prevalence of gut parasites and height, weight and mid-upper arm circumference (after removing the effects of age and sex) indicated that children without Trichuriasis were taller on average and had greater arm circumference than children with whipworm infestation (Table 5). In addition there was a highly significant relationship between Polyparasitism and mid-upper arm circumference with children without any gut infestation having a higher mean value. There was a negative relationship between Trichuris infection and height and height-for-age (Table 6); higher levels of Trichuris infestation were associated with reduced height and height-for-age. However the opposite trends were found with Trichuris prevalence and intensity with weight-for-height.

Longitudinal analysis showed that on average children fell further behind the NCHS reference values over the 18-month study period. Weight-for-age fell by –0.13, height-for-age by –0.22 and weight-for-height by –0.04 (Table 7).

Table 5. Associations between anthropometric variables and prevalence and intensity of worm infestation at baseline.

	Height (cm)	Weight (kg)	MUAC (mm)
Prevalence			
Ascaris	NS	NS	NS
Trichuris	-ve +1.19 p=0.013	NS	-ve +2.59 p=0.005*
Hookworm	NS	NS	NS
Polyparasitism			P=0.005
0	NS	NS	+3.60
1			+3.12
2			+2.43
3			0
Intensity			
Ascaris	NS	NS	NS
Trichuris	-0.0007 p = 0.002	NS	NS
Hookworm	NS	NS	NS

* after removing the effects of ownership, education, occupation and cleanliness variables the association remains significant +1.93 p=0.003

Table 6. Associations between Z scores and prevalence and intensity of worm infestation at Baseline.

	Weight-for-age	Height-for-age	Weight-for-height
Prevalence			
Ascaris	NS	NS	NS
Trichuris	NS	-ve + 0.26 p=0.012	-ve –0.06 p=0.005
Hookworm	NS	NS	NS
Polyparasitism	NS	NS	NS
Intensity			
Ascaris	NS	NS	NS
Trichuris	NS	-0.0002 p = 0.032	+0.00014 p=0.003
Hookworm	NS	NS	NS

Table 7. Changes in anthropometric variables and Z-scores over the 18 months intervention.

Variable	Mean	SD
Height (cm)	+7.50	1.95
Weight (kg)	+2.11	1.24
MUAC (mm)	+6.73	6.75
Weight-for-age	-0.13	0.50
Height-for-age	-0.22	0.51
Weight-for-height	-0.04	0.71

In order to try and examine the longer term impact of gut infestation children were classified on a scale of 0 to 4 depending on whether there had been not infected (0) on all four occasions (baseline, 6, 12 and 18 months), infected once (1), twice (2) three times (3) or on all 4 occasions (4). The results (Table 8) indicate although one quarter of children were free of Ascaris throughout the study period, over 30% of children were probably infected for most of the study period. For Trichuris and hookworm nearly 50% of the children remained free of infection but nearly 20% for Trichuris and 4% for hookworm were infected for most of the investigation. Because of the small number of children infected with hookworm on all four occasions, categories 3 and 4 were combined in subsequent analyses.

Table 8. History of worm infestation: Percentage of children with worm infestation at baseline, 6, 12 and 18 months.

Worm Infestation	Ascaris	Trichuris	Hookworm
None	24.3	45.3	46.4
Once	21.1	16.6	35.4
Twice	23.7	18.1	14.3
Three	19.2	14.1	3.5
All four surveys	11.7	5.0	0.4

There was a general trend of decreasing stature with increasing frequency of infection. Children free of Trichuris and hookworm throughout the study had significantly higher mean heights than those infected on all four surveys after removing the effects of age and sex (Table 9) but no significant associations were found with Z-scores.

Table 9. Relationship between worm infestation history and height.

Trichuris	Height	Hookworm	Height
None	+0.72	None	+1.038
Once	+0.43	Once	+0.760
Twice	-0.18	Twice	+0.619
Three	+0.42	Three or four surveys	0
All four surveys	0		
	P <0.001		P <0.006

Mean intensities of infection were also computed based on the eggs counts at baseline, 6, 12 and 18 months (Table 10) and higher mean intensities of Trichuris infection over the 4 surveys were associated with lower weight, weight-for-age and weight-for-height (Table 11) again after removing the effects of age and sex.

Table 10. Mean intensity of infection of the four surveys.

Worm	Mean	SD	Minimum	Maximum
Ascaris	693.7	1173.7	0	9562
Trichuris	106.0	316.0	0	6395
Hookworm	41.1	91.6	0	1281

Table 11. Associations between mean Trichuris intensity, anthropometric variables and Z-scores.

	Regression Coefficient	P
Weight	-0.00033	0.011
Weight-for age	-0.00016	0.002
Weight-for-height	-0.00018	0.016

Although the regression coefficients are small, it is worth noting that a child with 6000 eggs/g. over the 18-month period, would, on average weigh nearly 2 kg less than a child free of Trichuris. Likewise Z scores were reduced by about 1 between a child with 6000 eggs/g and one without infestation (Table 12).

Table 12. Relationship between egg count and anthropometric variables computed using the regression equation.

Trichuris Egg Count	Weight (kg)	Weight-for-age (Z score)	Weight-for-height (Z score)
2000	-0.67	-0.32	-0.36
4000	-1.32	-0.64	-0.72
6000	-1.98	-0.96	-1.08

Subsequent analyses which removed the effects of age, sex and Ascaris and Hookworm mean intensities before testing for the relationship between Trichuris mean worm intensity, anthropometric variables and Z-scores showed that the earlier relationships remained significant.

Table 13. Associations between Trichuris mean worm intensity, anthropometric variables and Z-scores.

	Regression Coefficient	P
Weight	-0.00036	0.008
Weight-for-age	-0.00018	0.001
Weight-for-height	-0.00022	0.004

Discussion

A large number of studies have examined the relationship between helminth infection and child malnutrition (see review by Stephenson 1994) and the majority of clinical trials using drug/placebo models report improvements in nutritional status and growth as a result of deworming. However not all studies have found an association (e.g. Reddy et al. 1986) and there is still a debate on the extent to which helminth infection interferes with the digestion and absorption of nutrient, thereby contributing to malnutrition. In Bangladesh an 18-month study on pre-school children also failed to significant improvements in growth of treated compared with untreated children (Rousham and Mascie-Taylor 1994).

The present study adds to the growing body of data in showing that regular anthelminthic treatment results in significant reductions in prevalence and intensity of infection of all three worms. Furthermore children who are free of gut parasites, especially Trichuris, for a longer period of time are likely to show better growth and nutritional status.

References

Bundy, D.A.P., Medley, G.F. (1992): Immuno-epidemiology of human geohelminthiasis: ecological and immunological determinants of worm burden. *Parasitology, 104:* 105–119.

Cooper, E.S. (1991): Intestinal parasitoses and the modern description of diseases of poverty. *Transactions of the Royal society of Tropical Medicine, 85:* 168–170.

Hall, A., Anwar, K.S., Tompkins, A.M. (1992): Intensity of reinfection with Ascaris lumbricoides and its implications for parasite control. *Lancet, 339:* 1253–1257.

Holland, C.V. (1991): Helminth infections, impact on human nutrition. *Encyclopedia of Human Biology, 4:* 113–122.

Holland, C.V., Taren, D.L., Crompton, D.W.T., Nesheim, M.C., Sanjur, D., Barbeau, I., Tucker, K., Tiffany, J., Rivera, G. (1988) Intestinal helminthiases in relation to socio-economic environment of Panamanian children. *Social Science and Medicine, 26:* 209–213.

Holland, C.R., O'Shea, E., Asaolu, S.O., Turley, O., Crompton, D.W.T. (1996): A cost-effectiveness analysis of anthelminthic intervention for community control of soil-transmitted helminth infection: levamisole and Ascaris lumbricoides. *Journal of Parasitology, 82:* 527–530.

Mascie-Taylor, C.G.N., Alam, M., Montanari, R.M., Karim, R., Ahmed, T., Karim, E., Akhtar, S. (1999) A study of the cost effectiveness of selective health interventions for the control of intestinal parasites in rural Bangladesh. *Journal of Parasitology, 85:* 6–11.

Morrow, R.H. (1984): The application of a quantitative approach to the assessment of the relative importance of vector and soil transmitted diseases in Ghana. *Social Science and Medicine, 19:* 1039–1049.

Muttalib, M.A., Islam, N., Islam, S. (1976): Prevalence of intestinal parasites in rural children of Bangladesh. *Bangladesh Medical Journal, 5:* 4–11.

Nokes, C., Bundy, D.A.P. (1994) Does helminth infection affect mental processing and educational achievement? *Parasitology Today, 10:* 10–14.

Pawlowski, Z.S. (1984) Implications of parasite-nutrition interactions from a world perspective. *Federation Proceedings, 43:* 256–260.

Reddy, V., Vijayaraghavan, K., Mathur, K.K. (1986): Effect of deworming and Vitamin A administration on serum vitamin A levels in preschool children. *Journal of Tropical Paediatrics, 32:* 196–199.

Rousham, E.K., Mascie-Taylor, C.G.N. (1994): An 18-month study of the effect of periodic anthelminthic treatment on the growth and nutritional status of pre-school children in Bangladesh. *Annals of Human Biology, 21:* 315–324.

Stephenson, L.S. (1994): Helminth parasites, a major factor in malnutrition. *World Health Forum, 15:* 169–172.

World Health Organisation (1987): *Prevention and control of intestinal parasitic infections.* Report of a WHO expert Committee, Geneva, WHO Technical Report Number 749.

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