CURE AND REINFECTION PATTERNS OF GEOHELMINTHIC INFECTIONS AFTER TREATMENT IN COMMUNITIES INHABITING THE TROPICAL RAINFOREST OF ASSAM, INDIA

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Abstract. Mass de-worming targeted at socio-economically poor communities can be considered as an option for communities living in the tropical forests of Assam who do not have access to safe drinking water and proper sanitation, and consequently have a higher risk of suffering from geohelminthic infection and associated morbidity. A random sample of 265 subjects was included in this study (134 males and 131 females). The chemotherapeutic regimen followed was a single dose of albendazole 400 mg. Stools samples were collected in 10% formol-saline for detection of infection before treatment. Post-treatment stool samples were collected 10 to 14 days after treatment to determine the cure rate. Stool samples were again collected 3 to 6 months post- treatment to study the rate of reinfection. Multiple logistic regression was used to find possible associations between age, sex and treatment failure. The chi-square test was used wherever appropriate. The cure rates for *Ascaris lumbricoides, Trichuris trichiura* and hookworms were 70.8%, 68.7% and 93.0%, respectively. Logistic regression revealed that age was associated with treatment failure in *A. lumbricoides* infection. Re-infection rates after 3 months of successful treatment were 19.6% for *A. lumbricoides*, 30.9% for *T. trichiura* and 11.3% for hookworms. Six months post- treatment, the prevalence of re-infection was highest with *T. trichiura* (43.6%); followed by *A. lumbricoides* (35.3%). The rate of reinfection with hookworms was lower (11.3%) six months post-treatment. The rates of re-infection with *A. lumbricoides* and *T. trichiura* was higher in children below 15 years of age, compared with adults. Hookworm reinfection was higher in the adult age group (15 to 39 years). The rates of new infection in previously uninfected subjects were lower compared with the rates for re-infection.

INTRODUCTION

The soil-transmitted helminths *Ascaris lumbricoides, Trichuris trichiura*, and hookworms occur worldwide and are major cause of morbidity in developing countries (Savioli *et al*, 1992; Montresor *et al*, 1998). Recently, there has been renewed interest in the study of intestinal worms as current evidence shows that worm infections can affect the epidemiological patterns of other diseases (Bundy *et al*, 2000). Helminth infections cause polarization of the immune response towards the T-helper type 2 (Th2) cells. The immune response to HIV and *Mycobacterium tuberculosis* is possibly decreased when the Th2 cells are dominant (Fincham and Markus, 2001). It has been suggested that mass de-worming might help to control the progression of HIV/AIDS and tuberculosis (Bentwich *et al*, 1999). Proper sanitation and health education are important factors for the control of geohelminth infection in a community, but such activities require time and are dependent on local economic development. Mass de-worming, targeted at socio-economically poor communities, can be considered as an option for communities living in the tropical forests of Assam who do not have access to safe drinking water and proper sanitation and consequently have a higher risk for geohelminthic infection. Geohelminthic infections can be controlled cost-effectively using anthelminthics (World Bank, 1993). Albendazole has been found to be most appropriate for mass chemotherapy (Pene *et al*, 1981), however its efficacy against different geohelminths has been variable (Ismail *et al*, 1991; Albonico *et al*, 1994). Helminth reinfec-

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tion rates vary from place to place and appear to be depend on environmental, socio-economic and immunological factors, which together play important roles in the dynamic process of reinfection (Henry, 1988). The attempt to control geohelminth infections in a community requires an understanding of the rate of reinfection of the different geohelminths. To design appropriate chemotherapeutic control strategies, it is important to know the rate of reinfection with these geohelminths. We have carried out a community based study to determine the cure rates for *Ascaris, Trichuris* and hookworms using albendazole 400 mg single dose treatment, and to find the rate of reinfection with these helminths after proven successful treatment.

MATERIALS AND METHODS

Study villages

This study was conducted in two villages located in the tropical rainforest of upper Assam between 95º10′ and 95º37′ E longitude and between 27º15′ and 27º29′N latitude. The mean daily maximum temperature varies between 20º and 35ºC and the mean minimum temperature varies between 8º and 20ºC. The relative humidity varies between 80 and 95%. The average annual rainfall is 350 cm with about 260 rainy days per year.

The two study villages are socioeconomically underdeveloped with a census of about 1,800 people. Most people live in mud-plastered bamboo houses with kaccha flooring. Open field defecation is a common practice and people do not have access to sanitary latrines or safe drinking water. People drink water from the kaccha well. A random sample of 265 subjects was performed for this study (134 males and 131 females). Pregnant and lactating women and children below 2 years of age were excluded from the study. The chemotherapeutic regimen followed was a single dose of albendazole 400 mg (Zentel®, GlaxoSmithkline, India) administered under supervision.

Stools samples were collected in 10% formol-saline for detection of infection before treatment. Post- treatment stool samples were collected 8 to 12 days after treatment to determine cure rates. Stool samples were again collected 3 to 6 months of post-treatment to study the rates of reinfection. Two consecutive stool samples were examined on each occasion using the formol-ether concentration method.

Data entry and statistical analysis

Data analysis was performed using SPSS™ 11.0 (Chicago, IL) and Epi-Info™ 6 (Public Health Domain Software, CDC, Atlanta, Georgia, USA). Logistic regression was used to find possible associations between age, sex and treatment failure. The chi-square test was used where ever appropriate.

RESULTS

Prevalence of geohelminthic infections

Table 1 gives the gender and age-group prevalence of geohelminth infections in the study subjects. The prevalence of geohelminth infection before treatment was 56.5%, 58.8%, and 44.3% for *Ascaris*, *Trichuris*, and hookworms, respectively in males and 53.7%, 59.7%, and 46.3% for *Ascaris*, *Trichuris*, and hookworms, respectively in females. Of these, 79.2% (n=265) were infected with at least one species. Polyparasitic infections were widely prevalent. A significant association was found between *Ascaris* and *Trichuris* ($\chi^2 = 21.6$, $p < 0.0001$), between *Ascaris* and hookworms ($\chi^2 = 17.5$, $p < 0.0001$) and between *Trichuris* and hookworms infections ($\chi^2 = 27.5$, $p < 0.0001$). There was no statistically significant gender specific difference in the prevalence of infection. An age-specific difference in the prevalence of infection was noted only for hookworm infection (29.8% in <15 years of age *versus* 63.0% in person 40 years and above). There was also no difference in the prevalence between Soraipung and Borajan villages.

Cure rates

The efficacy results for albendazole treatment are given in Table 2. A single dose of albendazole 400 mg was very effective in eliminating hookworm infection with a cure-rate of 93.0% (n=71). On the other hand cure-rates for *Ascaris* and *Trichuris* infections were only 70.8% (n=89) and 68.7% (n=99), respectively. There was a significant association between age and treatment outcome with *Ascaris* infection. In children

Table 1
Gender and age-group prevalence of geohelminth infections in the study community living in the tropical rainforests of Assam.

Age-group (in years)	Sex	No. of samples	No. of persons infected (%)			No. of persons with polyparasitic infections (%)			
			Ascaris	*Trichurus*	Hookworms	*As* + *Tri*	*As* + Hook	*Tri* + Hook	*As* + *Tri* + Hook
2-14	M	45	24 (53.3)	25 (55.6)	13 (28.9)	16 (35.6)	8 (17.8)	10 (22.2)	6 (13.3)
	F	49	26 (53.1)	24 (49.0)	15 (30.6)	17 (34.7)	13 (26.5)	12 (24.5)	11 (22.4)
15-39	M	58	37 (63.8)	33 (56.9)	29 (50.0)	27 (46.6)	23 (39.7)	20 (34.5)	19 (32.8)
	F	67	34 (50.7)	43 (64.2)	34 (50.7)	25 (36.2)	20 (29.0)	25 (36.2)	14 (20.3)
≥40	M	28	13 (46.4)	19 (67.9)	16 (57.1)	11 (39.3)	10 (35.7)	15 (53.6)	10 (35.7)
	F	18	12 (66.7)	13 (72.2)	13 (72.2)	9 (50.0)	9 (50.0)	10 (55.6)	7 (38.9)
All ages	M	131	74 (56.5)	77 (58.8)	58 (44.3)	54 (41.2)	41 (31.3)	45 (34.4)	35 (26.7)
	F	134	72 (53.7)	80 (59.7)	62 (46.3)	51 (38.1)	42 (31.3)	47 (35.1)	32 (23.9)

AS=Ascaris; Tri=Trichuris; Hook=Hookworms

Table 2
Cure rates for geohelminths after treatment with albendazole 400 mg single dose in the study community living in the tropical rainforests of Assam.

	No. excreting *Ascaris* eggs		Cure rate (%)	No. excreting *Trichuris* eggs		Cure rate (%)	No. excreting hookworm eggs		Cure rate (%)
	Before treatment	10 - 14 days after treatment		Before treatment	10 - 14 days after treatment		Before treatment	10 - 14 days after treatment	
Age-group (in years)									
2-14	32	6	81.3	29	11	62.1	16	1	93.8
15-39	42	12	71.4	49	13	73.5	35	1	97.1
≥40	15	8	46.7	21	7	66.7	20	3	85.0
All ages	89	26	70.8	99	31	68.7	71	5	93.0
Gender									
Male	48	13	72.9	50	10	80.0	34	2	94.1
Female	41	13	68.3	49	21	57.1	37	3	91.9

Table 3
Multiple logistic regression analysis showing effect of age and gender on treatment failure in geohelminth infected subjects dwelling in the rain forests of Assam.

Helminth	N[a]	Independent variable	Odds ratio	95 % confidence interval of odds ratio	p-value
Ascaris lumbricoides	89	Age-group			
		2-14	1 (Reference)		
		15-39	1.77	0.58 - 5.41	0.317
		≥40	4.94	1.28 - 19.03	0.02[b]
		Gender			
		Male	1 (Reference)		
		Female	1.23	0.47 - 3.19	0.670
Trichuris trichiura	99	Age-group			
		2-14	1 (Reference)		
		15-39	0.52	0.18 - 1.44	0.206
		≥40	0.78	0.23 - 2.65	0.688
		Gender			
		Male	1 (Reference)		
		Female	3.20	1.29 - 7.95	0.012[b]
Hookworms	71	Age-group			
		2-14	1 (Reference)		
		15-39	0.45	0.03 - 7.62	0.576
		≥40	2.8	0.26 - 30.57	0.395
		Gender			
		Male	1 (Reference)		
		Female	1.65	0.25 - 11.12	0.607

[a] = Number of subjects included in the analysis; [b] = Statistically significant result

below 15 years of age, the cure rate for *Ascaris* infection was 81.3%, *versus* 46.7 % in persons 40 years of age and above. There were no gender specific differences in the cure rates for *Ascaris* and hookworm infections. The cure rate for *Trichuris* infection in males was 80% (n=50) compared with females (57.1%, n=49; p=0.016). Multiple logistic regression analysis (Table 3) revealed that age was a risk factor for treatment failure in *Ascaris lumbricoides* infection (odds ratio = 4.94, p = 0.02; Table 3) whereas females had a higher risk of treatment failure in *Trichuris trichiura* infection (odds ratio = 3.20, p = 0.012).

Rate of re-infection

The rate of re-infection after successful treatment was highest in *Trichuris* (30.9%; n = 55) followed by *Ascaris* (19.6%; n = 32) and hookworms (11.3%; n = 53). There was an inverse association between age and rates of reinfection (Table 4). Children had a higher rate of reinfection with *Ascaris* and *Trichuris* three months after treatment. Hookworm reinfection was highest in the adult age group (15 to 39 years; 14.3%) compared with children < 15 years of age (8.3%). No gender specific differences were noted in the rates of re-infection with *Ascaris*, *Trichuris* or hookworm infection. The rate of acquiring new infection in previously uninfected persons was 15.4% (n = 39) for *Ascaris*, 32.1% for *Trichuris* (n = 28), and 9.5% (n = 63) for hookworms.

DISCUSSION

Effective control of geohelminth infections in a community requires information about the efficacy of the treatment regimen and the rate of reinfection after successful cure. The efficacy of albendazole was determined by collecting and re-examining stool samples from treated subjects

Table 4
Geohelminth reinfection pattern three months post-treatment with albendazole 400 mg single dose in the study community living in the tropical rainforests of Assam.

	Ascaris		*Trichuris*		Hookworms	
	N	% reinfected	N	% reinfected	N	% reinfected
Age-group (in years)						
2-14	21	23.8	15	46.7	12	8.3
15-39	23	17.4	29	27.6	28	14.3
≥40	7	14.3	11	18.2	13	7.7
All ages	51	19.6	55	30.9	53	11.3
Gender						
Male	27	14.8	32	31.3	26	19.2
Female	24	25.0	23	30.4	27	3.7

after a period of 10 to 14 days. This period is considered to be long enough to detect treatment failure yet short enough to avoid reinfection (Hall and Nahar, 1993). A single dose of albendazole 400 mg was found to be the most appropriate regimen for mass chemotherapy (Pene *et al*, 1981). It is considered to be a broad spectrum anthelmintic, with efficacy against *Ascaris, Trichuris,* and hookworm infections (WHO, 1987). A single dose regimen of albendazole is preferred because such treatment is effective in controlling helminth infections and easier to implement (Sacko *et al*, 1999). Our study confirms the findings of previous studies (Sinnah *et al*, 1990; Albonico *et al*, 1994) that albendazole 400-mg single dose is effective against hookworm infection (cure rate 93%). However, albendazole at the above dose was less effective in curing *Trichuris* (cure rate 68.7%) and *Ascaris* (cure rate 70.8%) infections. There was an inverse relationship between age and cure rates for *Ascaris* infection, with the highest efficacy in the younger age group (81.5%) compared to the older age group (46.7% cure rate). Hall and Nahar (1994) pointed out that the efficacy of a single dose of albendazole against *Trichuris trichiura* needs to be evaluated locally because of regional differences in the susceptibility of *T. trichiura* to albendazole. More comprehensive studies are required to study the efficacy of different albendazole regimens against *Trichuris* and *Ascaris* infections in this region.

Assam is highly endemic for soil-transmitted helminths and our study revealed a high level of re-infection after chemotherapy. The six month post-treatment re-infection rate for hookworm was lower (11.3%). The six month post-treatment re-infection rate was highest with *Trichuris trichiura* (43.6%) followed by *Ascaris lumbricoides* (35.3%). In spite of attempts to reduce the prevalence of geohelminths they have the ability to maintain a stable population in their hosts (Anderson and May, 1982; Anderson and Medley, 1985). These findings imply that to enhance the impact of chemotherapy, improvement in sanitation and hygiene must also be considered. Our results suggest drug treatment should be given every 6 months in children since this group has higher rates of *Trichuris* and *Ascaris* re-infection compared to adults. Further studies are needed in adults to determine the appropriate albendazole regimen and re-treatment intervals.

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