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Pattern and predictors of soil-transmitted helminth reinfection among aboriginal schoolchildren in rural Peninsular Malaysia

M. Hesham Al-Mekhlafi [a], Johari Surin [a,*], A.S. Atiya [b], W.A. Ariffin [c], A.K. Mohammed Mahdy [a], H. Che Abdullah [d]

[a] Department of Parasitology, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b] Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia
[c] Department of Pediatrics, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia
[d] Vector-Borne Diseases Control Division (VBDC), Ministry of Health, Malaysia

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ABSTRACT

Data on soil-transmitted helminth (STH) infections and reinfection among Orang Asli (aborigine) schoolchildren and their nutritional and socioeconomic status were analyzed to investigate the pattern and the possible predictors of STH reinfection. In this longitudinal study, 120 (60 males and 60 females) Orang Asli primary schoolchildren aged 7–12 years and living in remote areas in Pos Betau, Kuala Lipis, Pahang were screened for the presence of STH using modified cellophane thick smear and Harada Mori techniques. The overall prevalence of ascariasis, trichuriasis and hookworm infections were 65.8, 97.5 and 10.8%, respectively. After complete deworming with a 3-day course of 400 mg/daily of albendazole tablets, children were re-examined at 3 and 6 months from baseline. The reinfection rate, by one or more of STH species, at 3 months after deworming was high (49.5%) while 79.6% of the children were reinfected at 6 months after deworming. Logistic regression analyses showed that females, stunted children and those living in houses without toilets had significantly higher reinfection rates than others at 3 months ($P < 0.05$). At 6 months, maternal employment status emerged as another predictor where children of working mothers had significantly higher reinfection rates ($P = 0.026$). In conclusion, reinfection rate of STH is high and thus necessitates frequent and periodic deworming among children. Public health personnel need to re-look at the current control measures and identify innovative and integrated ways in order to reduce STH significantly in the rural communities.

1. Introduction

Despite many control measures and deworming programmes implemented by public and private sectors, the prevalence and reinfection rates of soil-transmitted helminth (STH) are still high among poor and rural communities especially children in developing countries. High reinfection rates with STH reveal continuous exposure to the sources of infections in these communities. Studies carried out in rural areas reported that STH reinfection can occur as early as 2 months after complete deworming (Norhayati et al., 1997a; Luoba et al., 2005). Moreover, Haswell-Elkins et al. (1988) reported that reinfection with hookworm can occur soon after treatment.

A study among Orang Asli population in Malaysia showed that by 4 months, after deworming, almost half and one-tenth of the treated population becomes reinfected with *Ascaris* and hookworm, respectively (Norhayati et al., 1997a). This study also reported that almost one third of *Ascaris*-infected people had the same pre-treatment intensity by 4 months after treatment. Similarly, studies in other parts of the world reported that by 6 months after treatment the intensity of infection of *Ascaris* and *Trichuris* reverted to the pre-treatment levels (Albonico et al., 2003; Olsen et al., 2003).

In Malaysia, the prevalence of STH among rural children is still very high (Norhayati et al., 1997b; Zulkifli et al., 2000; Al-Mekhlafi et al., 2006). However, no study looked into the pattern and predictors of reinfection. Thus, this study was undertaken to investigate the pattern and predictors of STH reinfection among Orang Asli schoolchildren in Pahang, Malaysia. It is hoped that findings of this study will assist public health officials to develop innovative and integrated control measures in order to reduce STH significantly in the rural communities.

* Corresponding author. Tel.: +603 79674747; fax: +603 79764754.
E-mail address: halmekhlafi@yahoo.com (J. Surin).

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2. Material and methods

2.1. Study area and subjects

This study was based on repeated screening on a cohort of primary schoolchildren in the National Primary School of Betau (Sekolah Kebangsaan Betau) (200 km northeast of Kuala Lumpur), Pahang, Malaysia. The schoolchildren come from 18 Orang Asli villages located around the school and these villages have homogenous nature of the populations with respect to their socio-cultural and daily economic activities.

One hundred and twenty schoolchildren (60 males and 60 females) aged between 7 and 12 years who attended the school during the visits had agreed to participate in this study. The children delivered faecal samples and then interviewed to fill in the questionnaires. Many visits to the villages were organized to avoid drop out and collect data from children who were absent during the school survey, and to observe the activities of children during daytime. Most of the children play with soil barefooted and swim or have their bath in the rivers. They also considered the rivers as the preferred sites for defecation. Besides that, their personal hygienic practices were also poor.

2.2. Data collection

A list of all the students' names and classes was obtained from the headmaster's office. Each child was coded accordingly and particulars were entered in the data sheet. Information on bio-data and socioeconomic status were collected throughout a pre-designed questionnaire. The data were collected over a period of 7 months, beginning in July 2006.

Faecal samples were collected from the children into wide mouth screw-cap 100 ml clean containers. The samples were examined by modified cellophane thick smear method as described by Martin and Beaver (1968) for the presence of *A. lumbricoides*, *T. trichiura* and hookworm eggs. Egg counts, as a measure of worm burden, were also carried out using this technique and the results were recorded as eggs per gram of stool (epg). Intensity of infections was graded as heavy, moderate or light according to the criteria proposed by WHO (2002). In order to detect the hookworm larva in light infections, Harada Mori faecal cultivation technique using test-tube was also used (Jozefzoon and Oostburg, 1994).

Albendazole tablets, produced by GlaxoSmithKline (London, UK), were used in this study as the anthelmintic treatment. Each white chewable tablet contains 400 mg albendazole as the active ingredient. In order to obtain a high curative rate, the regime used was a 3-day course of 400 mg/daily albendazole tablets. A single-dose treatment of 400 mg albendazole is found to be very effective against ascariasis and hookworm infections and conversely, low curative effect was reported with trichuriasis (Norhayati et al., 1997a; Saathoff et al., 2004). However, a study by Penggabean et al. (1998) showed that a 3-day course of 400 mg albendazole daily was very effective against trichuriasis which is the predominant STH infection in Malaysia. Children received and swallowed the tablets under direct observe therapy. Faecal samples were collected from the subjects after 10 days to check the efficacy of the treatment. Faecal samples were also collected and re-examined after 3 and 6 months of receiving the anthelmintics. All samples were examined using the same methods used for screening at baseline phase.

All children underwent anthropometric measurements as follows: children were weighed wearing school uniforms, without belts or shoes and with empty pockets using a calibrated SECA scale with 0.1 kg intervals; height was measured to the nearest 0.1 cm using the same device that has a scale and a sliding head piece. The precision of the scales was checked regularly to ensure the scale calibration. To reduce intra-individual errors, weight and height were measured twice by different persons and the mean value was used for the analysis. *Weight-for-age Z*-score was used to denote underweight as an overall indicator for malnutrition. *Height-for-age Z*-score was used as an indicator for stunting (chronic malnutrition). *Weight-for-height Z*-score was used as an indicator for wasting (acute malnutrition). For this study, children who had *Z*-score below −2 standard deviations (S.D.) of the National Center for Health Statistics (NCHS) Reference Population median values were considered to be significantly malnourished and *Z*-scores between −1 and −2S.D. were considered to be mildly malnourished. The *Z*-scores were calculated based on the median values of the National Center for Health Statistics Reference Population, United States. The *Z*-scores for *weight-for-age*, *height-for-age* and *weight-for-height* were derived using EpiNut Anthropometery (Epi Info, Version 6, 2002).

2.3. Data analysis

Statistical analysis of data was done using *Statistical Package for Social Sciences for Windows* SPSS (version 11.5, March 2002). For descriptive data, proportion was used to assess the prevalence of infections. As the egg counts of *A. lumbricoides*, *T. trichiura* and hookworm were not normally distributed, by Kolmogorov–Smirnov test, so the assessments of the variation of egg counts were done after log transformation. Reinfection rates (RR) of STH was calculated using the formula below (Olsen et al., 2003):

$$\mathrm{RR} = \frac{\%\ \text{prevalence after treatment}}{\%\ \text{prevalence before treatment}} \times 100$$

A repeated-measures ANOVA on transformed means epg was used to investigate the trend of reinfection over time. The association between STH reinfection and the possible predictors was examined by univariate analysis and multiple logistic regression model; a *P*-value of 0.20 as elimination criterion was used as suggested by Bendel and Afifi (1977). These authors showed that use of more traditional level such as 0.05 often eliminated variables that later proved to be important.

2.4. Ethical consideration

This study was approved by the Medical Ethics Committee of University of Malaya Medical Center, Malaysia. Small community meetings, before the commencement of the study, were held with the headmaster of the school, teachers, staff of the clinic, the heads of the villages, the parents, and their school-age children in order to give a clear explanation about their involvement and the objectives of the study. During the meetings, parents and their children were informed that their participation is voluntarily and therefore they can withdrawal from the study at any time without giving any reason whatsoever. Informed verbal consents were obtained from the participants themselves, their parents and from the headmaster.

3. Results

3.1. General characteristics

The schoolchildren participated in this study were from Orang Asli villages in Pos Betau, Kuala Lipis, Pahang. They comprised of one hundred and twenty children (60 males; 60 females) aged between 7 and 12 years with median age of 10 years (interquartile range 9–11). Almost 36.7% of the fathers had formal education of at least 6 years. On the other hand, only 20.8% of the mothers had similar formal education. Most of the residents of the areas work as laborers, farmers and rubber tappers. Houses of the subjects are made

Table 1
Reinfection rates and reinfection intensities of STH over a period of 6 months after deworming among Orang Asli schoolchildren in Pos Betau, Pahang ($n = 120$)

	Ascaris	*Trichuris*	Hookworm
Prevalence (%)			
Baseline	65.8	97.5	10.8
3 months	18.9	38.7	3.6
6 months	48.1	64.8	5.6
Reinfection rates (%)[a]			
3 months	28.7	39.7	33.3
6 months	73.1	66.5	51.8
Reinfection intensities[b]			
Baseline	2.58	3.30	0.28
3 months	0.68	1.16	0.07
6 months	2.10	2.37	0.12

[a] Number of infected children after deworming/number of infected children before deworming.
[b] Geometric mean counts of egg per gram faeces {log10 (epg + 1)}.

up of wood or bamboo. Most of the villages have electricity, during night time only, and piped water supply as a main source for drinking water. Water for domestic needs (bathing, washing clothes and utensils and feeding animals) is collected from the rivers located adjacent to the villages. There is no adequate or proper sanitation in these communities.

3.2. Pattern of soil-transmitted helminth reinfection

Almost all children (98.6%) were infected either by one or more of STH species. The overall prevalence of ascariasis, trichuriasis and hookworm infections were 65.8, 97.5 and 10.8%, respectively. Almost one third of the children had heavy trichuriasis, 22.3% had heavy ascariasis whereas all hookworm infections were light infections. Findings of this longitudinal investigation showed that the reinfection rates of STH were high (Table 1). In accordance with the pre-treatment infection levels, STH reinfection rate at 3 months after deworming was high (49.5%). Very close to the initial figure, 79.6% of the children were reinfected by one or more of STH species by 6 months after deworming. Individually, the reinfection rate of *A. lumbricoides* was the highest where almost three quarters (73.1%) of the children who were positive at baseline were reinfected by 6 months. Similarly, the reinfection intensity of *A. lumbricoides* infections at 6 months was close to the baseline situation. The reinfection rates of *T. trichiura* and hookworm were 66.5% and 51.8% whereas the reinfection intensities were 71.8 and 42.8% of the baseline situation, respectively.

A repeated-measures ANOVA was performed to investigate the effects of time on the intensity of STH reinfection (baseline, after 3 months and after 6 months). The intensities of STH were transformed {log10 (epg + 1)} and examined separately according to the species; the results for *Ascaris* were illustrated as an example in Fig. 1. The output of the model showed that there was a significant effect for time, Wilks' Lambda = 0.268, $F = 95.706$, $P < 0.001$ and multivariate eta squared = 0.732 (0.01 = small effect size, 0.06 = moderate effect, 0.14 = large effect). The effects of time were statistically significant for the three STH (*Ascaris*, *Trichuris* and hookworm).

3.3. Potential predictors associated with STH reinfection—univariate and multivariate analyses

The potential predictors of STH reinfection were investigated using univariate and multivariate analyses and the results are presented in Table 2. For these analyses, a child was considered to be re-infected if his/her faecal sample was found to be positive for any

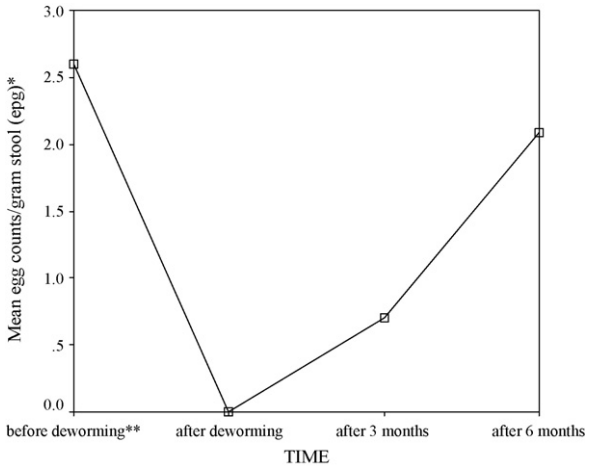

Fig. 1. Means egg counts/gram stool of *Ascaris lumbricoides* over time (repeated-measures ANOVA). *Geometric mean counts of egg per gram faeces {log10 (epg + 1)}. **Before deworming values were displayed to compare the intensity of STH infections before the distribution of anthelmintics with the intensities of reinfection over time.

Table 2
Potential predictors associated with STH reinfection among Orang Asli schoolchildren in Pos Betau, Pahang ($n = 120$)

Variables	Reinfection rates of STH	
	At 3 months *n* (%)	At 6 months *n* (%)
Age		
≤10 years	40 (46.0)	67 (79.8)
>10 years	15 (62.5)	19 (79.2)
Gender		
Male	17 (30.9)	37 (68.5)
Female	38 (67.9)[a,b]	49 (90.7)[a,b]
Fathers' educational levels		
≥6 years formal education	20 (48.8)	31 (77.5)
No formal education	35 (50.0)	55 (80.9)
Mothers' educational levels		
≥6 years formal education	11 (50.0)	19 (90.5)
No formal education	44 (49.4)	67 (77.0)
Mothers' employment status		
Working	31 (57.1)	48 (90.5)[a,b]
Not working	24 (44.9)	38 (72.7)
Low household income		
<RM450/month	38 (45.8)	63 (78.8)
≥RM450/month	17 (60.7)	23 (82.1)
Family size		
≥8 members (large)	14 (56.0)	20 (80.0)
<8 members	41 (47.7)	66 (79.5)
Toilet in house		
Yes	10 (30.3)	23 (71.9)
No	45 (57.7)[a,b]	63 (82.9)
Source of drinking water		
Piped	48 (50.0)	77 (81.1)
Others (river, rain, well)	7 (46.7)	9 (69.2)
Presence of animals in house		
Yes	9 (37.5)	18 (78.3)
No	46 (52.9)	68 (80.0)
Nutritional status		
Stunted children	30 (61.2)[a]	42 (87.5)
Non-stunted children	25 (40.3)	44 (73.3)
Underweight children	26 (50.6)	37 (86.0)
Non-underweight children	29 (42.6)	49 (75.4)

n represents the number of subjects.
[a] Significant association ($P < 0.05$).
[b] Confirmed as significant predictors by logistic regression analysis.

of the STH three species. The results of univariate analysis showed that females (X^2 = 15.153, P = 0.001), stunted children (X^2 = 4.783, P = 0.029) and those living in houses without toilets (X^2 = 6.958, P = 0.008) had significantly higher reinfection rates than others at 3 months phase. In the output of logistic regression analysis, females (OR = 6.1; 95%CI = 2.4, 17.1) and no toilet in house (OR = 4.3; 95%CI = 1.5, 12.5) were retained as significant risk factors of high reinfection rates while stunting was removed.

At 6 months, mothers' employment status joined the web of significant predictors; children of working mothers had significantly higher reinfection rates than other children (X^2 = 4.984, P = 0.026) and this was confirmed by logistic regression analysis (OR = 4.7; 95% CI = 1.3, 12.8).

4. Discussion

WHO (2006) estimated that more than two billion people are infected either by one or more of STH particularly *A. lumbricoides*, *T. trichiura* and hookworm. The prevalence is high among children in rural areas of developing countries where the 400 million school-age children who are infected are often physically and intellectually compromised by malnutrition, leading to cognitive deficits, learning disabilities and high school absenteeism.

As is common in endemic areas, the STH reinfection rate reported by this study was very high and it was about 50% of the pre-treatment situation by 3 months. At 6 months, the figure was very close to the pre-treatment situation. This may reflect the continuance of these infections in such areas as a result of the wide distribution of the infective stages of these parasites. Similarly, the intensities of infections after 6 months were very close to the initial intensities and this reflect the magnitude of the problem in this community. In Orang Asli communities the *Ascaris*, *Trichuris* and hookworm reinfection can occur as early as 2 months after treatment and by 4 months almost half and one-tenth of the population treated become reinfected with *Ascaris* and hookworm respectively (Norhayati et al., 1997a). Furthermore, studies in other part of the world reported that by 6 months the intensity of infection of *Ascaris* and *Trichuris* were similar to pre-treatment levels (Elkins et al., 1988; Albonico et al., 2003). Our findings showed a significant effect of time on the intensities of STH reinfection and this may support the explanation that reinfection rates and intensities of STH were mostly affected by the continuous exposure to the sources of infections in such communities over time (Payne et al., 2007).

With STH, the lack of sanitation plays an important role in the spread and transmission of the infections. Findings of the present study confirmed that the absence of a toilet in the house was identified as a significant predictor of STH reinfection. During the visits to the study areas, we observed that the personal hygiene of the children is poor as they swim in the rivers very closed to the defecation sites, play bare-footed, consume unwashed vegetables and fruits picked from the ground, eat without washing their hands and indulge in soil eating (geophagy). All these practices have been reported as risk factors of parasitic infections and reinfection elsewhere (Nishiura et al., 2002; Nematian et al., 2004; Saathoff et al., 2004; Quihui et al., 2006).

Findings of this study showed that females were at higher risk of reinfection than males. Responsibilities of females in chores such as cleaning and washing the ground and floors could make them more susceptible to be reinfected. Employment status of mothers (working mother) was also identified as a significant predictor of high reinfection rate and this was compatible with other studies (Quihui et al., 2006). Absence of mothers during the daytime causes the loss of many child health care and hygiene expected to be provided by the mothers and gives more opportunities for young children to play outside unsupervised resulting in more exposure to reinfection.

Malnutrition and parasitic diseases have a strikingly similar geographical distribution with the same people experiencing both insults together for much of their lives (Crompton, 1986). In this study, we found that stunted children were more prone to be reinfected by STH than children with normal anthropometric measurements. This finding was in agreement with previous studies which concluded that ascariasis and trichuriasis are more prevalent among malnourished children (Hughes et al., 2004; Ulukanligil and Seyrek, 2004; Al-Mekhlafi et al., 2005). The identified predictors of STH reinfection are related to poverty which is, in general, the root of this problem. Despite intensive efforts by government and private sectors to improve the quality of life of Orang Asli communities throughout 50 years of independence (1957), the achievement is not the size of these efforts. The main strategy was to bring Orang Asli people to the peripheral areas, close to the main town but the adherence of these people to be confined within the jungle constraining the strategy. Thus, innovative long-term interventions; such as providing job opportunities and improving quality of education; to reduce the poverty and improve the quality of life of aboriginal communities should be implemented. Coinciding with this, short-term measures; such as regular deworming and providing health education; to control STH should be also considered.

In conclusion, STH are still prevalent among rural Orang Asli children and this may contribute to a wide spectrum of health problems such as retarded growth, micronutrient deficiencies including vitamin A and iron and poor cognitive and academic performances. A long-term negative impact of these problems among children and adults may be noticed among Orang Asli population. It is also clear that the reinfection rate was very high in this community undermining the efforts of deworming programmes. Overall, long-term interventions to reduce the poverty will help significantly in reducing this continuing problem and there is no doubt that reducing of intestinal parasitic infection would have a positive impact on health, nutrition and education of these children.

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