

Published in final edited form as:

Int J Parasitol. 2009 July 15; 39(9): 1037–1043. doi:10.1016/j.ijpara.2009.01.013.

The effectiveness of 4 monthly albendazole for the reduction of soil-transmitted helminth infections in women of reproductive age in Viet Nam

Seema Miharshahi^a, Gerard J. Casey^a, Antonio Montresor^b, Tran Q. Phuc^c, Dang Thi Cam Thach^c, Nong T. Tien^c, and Beverley-Ann Biggs^{a,d,*}

^aDepartment of Medicine (RMH/WH), The University of Melbourne, The Royal Melbourne Hospital, Parkville Victoria 3050, Australia

^bWorld Health Organization, Hanoi, Viet Nam

^cNational Institute of Malariology, Parasitology and Entomology (NIMPE), Hanoi, Viet Nam

^dCentre of Clinical Research Excellence in Infectious Diseases (CCREID), The Royal Melbourne Hospital, Parkville Victoria 3050, Australia

Abstract

Soil-transmitted helminth (STH) infections are endemic in northern Viet Nam where the climate and agricultural practices, such as the use of human excreta as fertiliser and the use of wastewater for irrigation, favour transmission. An intervention was conducted in Yen Bai Province, north-west Viet Nam, to measure the effectiveness of single dose albendazole (400 mg) administered every 4 months for reducing the prevalence of STH infections in women of reproductive age. Stool samples were collected from women before the intervention and 3 and 12 months post intervention. Information on a range of demographic and socio-economic variables was also collected to measure the major risk factors for high STH burden in this area. The prevalence of hookworm, *Ascaris lumbricoides*, and *Trichuris trichiura* infection in the baseline sample of 366 women were 76.2%, 19.2% and 29.1% respectively. In the women who were surveyed at baseline and again at 3 and 12 months after the intervention (N=118) cure rates were 71.3% for hookworm, 87.0% for *A. lumbricoides* and 81.4% for *T. trichiura* by the end of the 12 month study period (i.e. with 3 doses of albendazole). The main risk factor for hookworm infection was if a women worked outside [OR =3.2 (95% CI 1.6-6.2), p=0.001] and the major risk factor for *A. lumbricoides* and *T. trichiura* infection was a lack of education. Low educational attainment was also the strongest risk factor for co-infection with all three species of STH [OR= 7.5 (95% CI 3.4-16.4), p<0.001]. The high rates of hookworm infection in this area of Viet Nam and the high cure rates for all three species of STH with four monthly albendazole suggest that this program should be expanded to all endemic areas in Viet Nam. The study also highlights the important contribution of education to women's health.

*Corresponding Author: Beverley-Ann Biggs, Department of Medicine, University of Melbourne, 4th Floor Clinical Sciences Building, The Royal Melbourne Hospital, Parkville Victoria 3050, Australia, Tel: + 61 3 83443257, Fax: + 61 3 93471863, babiggs@unimelb.edu.au.

Keywords

albendazole; *Ascaris lumbricoides*; helminths; hookworm; *Trichuris trichiura*

1 Introduction

It is estimated that 4.5 billion of the world's population are at risk of infection with soil-transmitted helminths (STH) (Keiser and Utzinger, 2008). STH infections have been identified as major contributing factors to nutritional deficiencies (Stephenson et al., 2000; Crompton and Nesheim, 2002; Casapia et al., 2006; Jardim-Botelho et al., 2008) and impaired physical and cognitive development in children (Levav et al., 1995; Oberhelman et al., 1998; Sakti et al., 1999). STH infections are a major contributory factor in iron deficiency anaemia, especially among women of reproductive age (Stoltzfus et al., 1997a; Zimmermann and Hurrell, 2007) and STH infections can also affect pregnancy outcomes. Studies conducted in Sri Lanka and Nepal have demonstrated that administration of antihelminthic drugs to women during pregnancy is associated with significantly higher birth weight and improved survival in their infants (de Silva et al., 1999; Christian et al., 2004).

The main parasites that cause STH infection are the hookworms (*Ancylostoma duodenale* and *Necator americanus*), *Ascaris lumbricoides* and *Trichuris trichiura*. *A. lumbricoides* and *T. trichiura* infections are most common amongst school aged children and the prevalence usually decreases with age (Needham et al., 1998). Heavy hookworm infections can also occur in childhood, but frequency and intensity is usually higher in adulthood and is very common among older populations (Needham et al., 1998; Galvani, 2005). A recent systematic review shows that single dose albendazole has high cure rates for hookworm and *A. lumbricoides* infections. However, single dose albendazole was found to be less efficacious in the treatment of *T. trichiura* infection (Keiser and Utzinger, 2008).

STH infections are endemic in Viet Nam where the local climate and agricultural practices such as the use of human excreta as fertiliser and the use of wastewater for irrigation favour the transmission of infections (Do et al., 2007). It is estimated that 33.9 million people in Vietnam are infected with *A. lumbricoides*, 17.6 million with *T. trichiura* and 21.8 million with hookworm (van der Hoek et al., 2003). A recent randomised trial in Viet Nam showed that single dose albendazole in adults resulted in a 75% reduction in mean hookworm eggs per gram (epg) relative to placebo, whereas triple dose albendazole resulted in an 88% reduction (Flohr et al., 2007). To date, most population based anti helminth programmes in Viet Nam have been targeted at school aged children or pregnant women in their second or third trimester of pregnancy (Olsen et al., 2006).

In 2005, the National Institute for Malariology, Parasitology and Entomology (NIMPE) in Viet Nam initiated a demonstration public health program that integrated universal anaemia prevention and deworming into the existing health service structure in two districts of the northern mountainous province of Yen Bai. A baseline assessment for this program has been previously published (Pasricha et al., 2008). In this paper, we report the impact of this program on the prevalence of STH infections in women of reproductive age, and identify the major risk factors for high STH burden among women in this area of Viet Nam.

2 Materials and methods

2.1 Subjects and Setting

A one-year demonstration anaemia and hookworm control intervention of weekly iron-folate supplementation (WIFS) with 4 monthly deworming (single dose treatment with albendazole given every 4 months) was introduced in two districts of Yen Bai province (Tran Yen and Yen Binh districts) in northwest Viet Nam from May 2006 to May 2007. The target population was all women of reproductive age (16 - 45 years) living in the two districts, approximately 52,000 women. Prior to the introduction of the intervention a baseline survey was conducted (Pasricha et al., 2008).

2.2 Intervention

The intervention commenced in May 2006 and involved deworming with single dose Albendazole (400 mg, UNICEF, Copenhagen) every 4 months in addition to weekly supplementation with ferrous sulphate-folic acid tablets (60mg/0.4mg, UNICEF, Copenhagen). Albendazole tablets were administered under direct supervision of village health workers or commune health staff.

2.3 Data collection and testing

A baseline survey was conducted in November 2005 using random population proportional to size sampling (Byass, 2003). A stratified multi-stage cluster sampling design was used. Primary sampling units (villages) were chosen using a 'probability proportional to size' random sampling method separately within each district, with half the target sample of villages taken from each district. Secondary sampling units (individual women) were selected randomly from each village using provincial lists. Women were located and invited to attend the mobile clinics, which were set up at the nearest commune health station. All women approached agreed to participate in the baseline survey.

Follow-up surveys were conducted three and 12 months after commencement of the intervention. All women in the baseline survey were invited to return for follow-up surveys, and additional women were recruited using the same multistage cluster sampling design. Random sampling of new individuals in each survey was included to assess the results of the intervention on a population level, without the possibility of bias that may have been introduced through contact with the women in previous surveys. That is, we were concerned that interactions with the study team on one or several occasions may motivate the women to higher compliance with the program. One hundred and eighteen women attended all three surveys. Surveys were conducted by the same team at each survey and included trained stool preparation and analysis technicians, phlebotomists, a demographic recorder and a supervisor.

At the surveys stool and blood samples were collected from each participant. Socio-demographic data including age, ethnicity, marital status, education, occupation, number of children, meat consumption, hand washing and type of sanitary facilities were collected using a questionnaire.

The stool specimens were assessed at the field site using standard Kato Katz methodology (Ash et al., 2004) and the intensity of each STH infection was expressed as eggs per gram of faeces (epg). Intensity of infections were classified according to WHO guidelines: hookworm infection was categorised as hookworm free (0 epg), light intensity infection (1-1999 epg) or moderate-heavy intensity infection (≥ 2000 epg); *A. lumbricoides* infection was categorised as *A. lumbricoides* free (0 epg), light intensity infection (1-4999 epg) or moderate-heavy intensity infection (≥ 5000 epg); *T. trichiura* infection was categorised as *T. trichiura* free (0 epg), light intensity infection (1-999 epg) or moderate-heavy intensity infection (≥ 1000 epg) (Montresor et al., 1998).

2.4 Statistical analysis

The data were entered into spreadsheets using Microsoft Excel (Microsoft Corporation, 2000). The Excel spreadsheets were then imported into SPSS for data cleaning and checking and coding and finally into Stata 10 (Intercooled Stata 10 for Windows, StataCorp LP, Texas USA) for analysis.

The study sample was defined in two ways: (i) to assess the overall impact of the intervention we included data on all subjects tested irrespective of whether they were included in the baseline survey. (ii) When assessing the mean within-subject change in prevalence of STH, the sample was restricted to 118 subjects who provided baseline, three and 12 month data. Village was used as a cluster variable in all analyses because of the nature of the sampling frame.

STH data (epg) were skewed to the right, with a considerable number of zero values, and so results were expressed as follows: the prevalence of hookworm, *A. lumbricoides* and *T. trichiura* infections with varying fecal egg count cut-offs were calculated using the cut-offs defined above for light and moderate-heavy intensity, and the data were dichotomized as STH positive (i.e. any eggs) or negative (i.e. no eggs). As well, for the women who were sampled at all three surveys, the number of women who were STH free at each follow-up survey (complete cure) was expressed as a percentage of the number who were STH positive at baseline. The main outcome was the reduction in prevalence of hookworm, *A. lumbricoides* and *T. trichiura* infection categorised as light or moderate/heavy intensity of infection.

Multiple logistic regression was used to determine associations between socioeconomic and demographic variables and hookworm, *A. lumbricoides* and *T. trichiura* positive at baseline as well as co-infection with multiple STH. Where possible, demographic data were dichotomized, however age was analysed both as a continuous variable and categorised into age between 15-29 or ≥30. Variables included in the regression model were age, education status, work (inside/outside), number of children, meat intake, whether shoes were worn, latrine type, socio-economic status (assessed by inclusion in the 'Free Health Card for the Poor scheme'), hand washing (with or without soap). Results of the logistic regression analysis are expressed as adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

2.5 Ethics

Extensive consultation was undertaken between the project team and community leaders, as well as liaison with village, district and provincial health staff prior to implementation. The survey team assisted the village health workers where participants expressed concerns or uncertainty relating to any aspect of their participation. Verbal informed consent was obtained at the time of enrolment. The project was approved by the Human Research Ethics Committee of the National Institute of Malariology, Parasitology and Entomology (Hanoi, Viet Nam), the Walter and Eliza Hall Institute of Medical Research (Melbourne, Australia) and Melbourne Health (Melbourne, Australia).

2.6 Role of the funding source

The sponsors of this study had no role in the study design, data collection, analysis or interpretation of the results or the decision to submit this paper for publication. The corresponding author had full access to all the data in the study and the final responsibility for the decision to submit for publication.

3 Results

In the study a total of 366 women had stool microscopy performed at baseline, 433 women at 3 months, and 467 women at 12 months. Of the 366 women tested at baseline, 118 also had stool microscopy data for both the 3 month and 12 month surveys. Table 1 shows a comparison of demographic variables for the 248 women who were only in the baseline survey, and the 118 women who attended all three surveys. There were some differences between these groups. Women who attended all three surveys were more likely to be married with children, illiterate, to work outside and to live in a house without a sanitary latrine system. There were also some differences in ethnic groups between the populations. Importantly, the prevalence of hookworm, *A. lumbricoides* and *T. trichiura* positive were similar at baseline between these groups.

Prevalence of STH infection in all women tested

Table 2 shows the prevalence of infection with each STH at each survey, using the data for all women tested at each time point. The prevalence of hookworm infection in the population sample was 76% at baseline, reduced to 56.6% at 3 months and further to 25.1% at 12 months. The prevalence of *A. lumbricoides* infection was 19.2% at baseline, and reduced to 5.6% at 3 months and to 3.9% by 12 months. The prevalence of *T. trichiura* infection was 29.1% at baseline, and reduced to 20.1% at 3 months and to 10.7% by 12 months.

Prevalence of STH infection among women who attended all three surveys (N=118)

Figure 1a shows the change in prevalence of no infection, light intensity and moderate-heavy intensity hookworm infection at baseline and 3 and 12 months among the 118 women who attended all three surveys. In this sample, 94 (79.7% of total) were positive for hookworm infection at baseline, of these women 36 (38.3%) had a complete cure (i.e. no hookworm eggs) by 3 months and 67 (71.3%) had a complete cure by 12 months.

Figure 1b shows the change in prevalence of no infection, light and moderate-heavy infection with *A. lumbricoides* at baseline and 3 and 12 months. In this sample 23 (19.5% of total) were positive for *A. lumbricoides* infection at baseline, of these women 17 (73.9%) had a complete cure (i.e. no *A. lumbricoides* eggs) by 3 months and 20 (87.0%) had a complete cure by 12 months.

Figure 1c shows the change in prevalence of no infection, light and moderate-heavy infection with *T. trichiura* at baseline and 3 and 12 months. In this sample 43 (36.4% of total) were positive for *T. trichiura* infection at baseline, of these women 20 (46.5%) had a complete cure (i.e. no *T. trichiura* eggs) by 3 months and 35 (81.4%) had a complete cure by 12 months.

Predictors of STH burden at baseline

In the baseline survey there were 60 (16.9%) women with no STH. The two strongest predictors of no infection were working inside adjusted OR 3.2 (95% CI 1.6-6.2) $p=0.001$ and eating meat more than 2 times a week adjusted OR= 2.6 (1.2-5.6) $p=0.014$.

Table 3 shows the main predictors of each of the infections (of any intensity) at the baseline survey. The only significant predictor of hookworm infection at baseline was whether the women worked outside. A lower level of education and no history of prior deworming treatment were significant predictors of *A. lumbricoides* infection at baseline, while a lower level of education and socioeconomic status were significant predictors of *T. trichiura* infection.

There were 28 (7.9%) women in the baseline sample who were infected with all three species of STH, 267 (75.2%) had one or two species and 60 (16.9%) had none. The strongest predictor of co-infection with all three species of STH at baseline was a lack of education [OR 7.4 (95% CI 2.7-20.5)] and Figure 2 shows that there was a linear relationship between the women's education level and the prevalence of co-infection with all three species of STH ($p=0.001$).

The effect of education was also tested in the sample of 118 women who attended all three surveys. At each survey level of education had a significant effect on whether a women was positive for *A. lumbricoides* and *T. trichiura* but had no effect on hookworm. There were only 11 women with no STH infection at any survey. All of these women had some form of education and 10 had an educational attainment at or above secondary level.

4 Discussion

This study confirms the high prevalence of STH infection, particularly hookworm infection, among women of reproductive age in north-west Viet Nam and shows a significant reduction in both the prevalence and intensity of STH infection with single dose albendazole (400mg) given every four months over a 12 month period. Cure rates were 71% for hookworm, 87% for *A. lumbricoides* and 81% for *T. trichiura* in women who participated in all three surveys during the study period. The study also highlights that the strongest risk factor for hookworm and any STH infection was working outdoors. The findings suggest that a higher

education level may have a protective effect against *A. lumbricoides*, *T. trichiura* and co-infection with all three species of STH.

A review of prevalence studies conducted in Viet Nam indicate that there is a large variation in the prevalence and distribution of STH species depending on the region and the characteristics of the population being studied (e.g. children, adults, pregnant women or women of reproductive age). Generally, studies in northern Viet Nam have found that *A. lumbricoides* and *T. trichiura* infections are more common in school children than adults (Verle et al, 2003) and women have a higher hookworm burden than men (Needham et al., 1998). We also found a very high prevalence of hookworm infections (76.2% at baseline) compared to *A. lumbricoides* (19.2%) and *T. trichiura* (29.1%) in women of reproductive age in Yen Bai province. However, in a prevalence study conducted in Ha Nam province in rural north Viet Nam (south east of Yen Bai) only 59% of the survey sample (males and females aged 1-88 years) were infected with hookworm whereas 83% were infected with *A. lumbricoides* and 94% of individuals were infected with *T. trichiura* (Needham et al., 1998). The results of a survey of adults in Hoa Binh, a mountainous area south of Yen Bai, show 52.4% were infected with hookworm, 45.4% with *A. lumbricoides* and 49.6% with *T. trichiura* (Verle et al., 2003). In a cross sectional study of mostly male fish farmers in Nghe An province on the central west coast, infection prevalences were 51.3% for hookworm, 34.8% for *A. lumbricoides*, 50.7% for *T. trichiura* and 81.8% were infected with at least one of the three STH's (Olsen et al., 2006). As well as host characteristics, climatic conditions, soil types, socioeconomic status, sanitation facilities, hygiene practices, eating habits and crop selections are important factors that may explain the large variations in the prevalence and distribution of STH among the regions of north Viet Nam.

The baseline prevalence of hookworm infection in women of reproductive age in this region is above WHO's 50% threshold prevalence for priority control with mass deworming treatment (Brooker et al., 2003; de Silva et al., 2003). The reason for this high prevalence could be that Vietnamese women generally do most of the daily fieldwork in agriculture such as weeding, fertilizer application and irrigation. The use of human waste as fertilizer makes them especially vulnerable to STH infection and the application in the fields is often carried out using bare hands or with shovels with little use of protective clothing such as gloves and boots (Humphries et al., 1997). The hazardous nature of this work is confirmed by the finding that the main risk factor for hookworm infection was working outdoors.

Our results show that the intervention was successful implying high compliance amongst the target group. Importantly, there was also a reduction in the intensity of infection, with moderate and heavy infections with all three species of STH almost at zero prevalence by the end of the study. A study conducted in adults in Khanh Hoa province in central Viet Nam showed 91% of adults (both men and women over 16 years) were hookworm positive at baseline (Flohr et al., 2007) and 3 doses of albendazole taken over 3 days achieved a 91% reduction in eggs. For mass treatment programs the most important measure for success of a program is a reduction in intensity of infection (Flohr et al., 2007). As mentioned previously because the environmental, climatic conditions and farming practices in Viet Nam (especially the use of human faeces as fertilizer) and the eating of fresh vegetables, favour transmission, repeated treatment is required to control reinfections.

Most of the work regarding predictors of STH infection has been done in Africa (Kenya and Uganda). A study from Kenya identified that the absence of latrines and number of inhabitants in the household were significant predictors of hookworm and that households that did not use soap had a higher risk of being infected with *A. lumbricoides* (Olsen et al., 2001). In this sample only 2.5 % of homes did not have a latrine and the type of latrine or use of soap for hand washing had no effect on the prevalence of STH in multivariate analyses. The socioeconomic status of a household was a risk factor for *T. trichiura* infection. Additional findings suggest that a woman's education is an important protective factor against STH infection (especially *A. lumbricoides* and *T. trichiura*) and that working outside is a major risk factor. Because this is a risk factor that cannot be easily modified, control programs should incorporate protective clothing and footwear for women who work outdoors as direct contact with fertilizer is the most likely source of infection. We also found that women who ate meat more than twice a week were less likely to be infected with STH. In this case meat intake could be associated with socioeconomic status.

A limitation of this study is that the 118 baseline women who reattended for later surveys were significantly different in some aspects (eg education and occupation) to the overall baseline group. Therefore some of the conclusions drawn from the analysis may be biased. For example, the 118 women who reattended were more likely to belong to the Dao ethnic group, be illiterate, work outside, and were less likely have a sanitary system. They may therefore have been living in an environment with greater soil contamination, and had a greater risk of reinfection during the 12-month intervention period.

Our results show a high prevalence of STH among women of reproductive age and high cure rates after single dose albendazole (400 mg) administered every four months during a 12 month period. The success of the intervention as a whole has resulted in the scaling up of the program to include all women of reproductive age in the province, an estimated total of 250,000 women. Our results also provide evidence to suggest that the World Health Assembly resolution which advocates for the periodic deworming of all schoolchildren and pregnant women at risk for STH infections be expanded to include women of reproductive age in high prevalence areas. In addition, the results suggest that two of the major elements to be considered in the design of long term STH control among women of reproductive age in endemic areas of Viet Nam are the use of protective clothing for women working outdoors and improving the educational attainment of women.

Acknowledgments

The authors acknowledge the support of Yen Bai People's Committee, district and commune health staff, and village health workers. We are grateful to the Yen Bai Malaria Control Program staff that were the local implementing agency, to Dr. Cavalli-Sforza who provided valuable suggestions and Pham Thi Xuyen, Beth Hilton-Thorp and Christalla Hajisava for invaluable contributions. Most importantly, we thank the women of Tran Yen and Yen Binh who participated in these surveys. Atlantic Philanthropy Incorporated kindly funded the project.

References

- Anonymous. Thinking beyond deworming. *Lancet*. 2004; 364:1993–1994. [PubMed: 15582039]
- Ash, LR., Orihel, TC., Savioli, L., Sin, MA., Montresor, A., Renganathan, E. Training manual on diagnosis of intestinal parasites - tutor's guide. World Health Organization; 2004. posting date Available at: http://www.who.int/wormcontrol/documents/benchaid/training_manual/en/

- Bethony J, Brooker S, Albonico M, Geiger SM, Loukas A, Diemert D, Hotez PJ. Soiltransmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet*. 2006; 367:1521–1532. [PubMed: 16679166]
- Brooker S, Singhasivanon P, Waikagul J, Supavej S, Kojima S, Takeuchi T, Luong TV, Looareesuwan S. Mapping soil-transmitted helminthes in Southeast Asia and implications for parasite control. *Southeast Asian J Trop Med Public Health*. 2003; 34:24–36.
- Byass P. Empirical modeling of population sampling: lessons for designing sentinel surveillance. *Public Health*. 2003; 117(1):36–42. [PubMed: 12802903]
- Casapia M, Joseph SA, Nunez C, Rahme E, Gyorkos TW. Parasite risk factors for stunting in grade 5 students in a community of extreme poverty in Peru. *Int J Parasitol*. 2006; 36:741–747. [PubMed: 16650426]
- Christian P, Khatri SK, West KP Jr. Antenatal anthelmintic treatment, birth weight, and infant survival in rural Nepal. *Lancet*. 2004; 364:981–983. [PubMed: 15364190]
- Crompton DW, Nesheim MC. Nutritional impact of intestinal helminthiasis during the human life cycle. *Annu Rev Nutr*. 2002; 22:35–59. [PubMed: 12055337]
- de Silva NR, Sirisena JL, Gunasekera DP, Ismail MM, de Silva HJ. Effect of mebendazole therapy during pregnancy on birth outcome. *Lancet*. 1999; 353:1145–1149. [PubMed: 10209979]
- de Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L. Soil-transmitted helminth infections: updating the global picture. *Trends Parasitol*. 2003; 19:547–551. [PubMed: 14642761]
- Do TT, Molbak K, Phung DC, Dalsgaard A. Helminth infections among people using wastewater and human excreta in peri-urban agriculture and aquaculture in Hanoi, Vietnam. *Trop Med Int Health*. 2007; 12(Suppl 2):82–90. [PubMed: 18005319]
- Flohr C, Tuyen LN, Lewis S, Minh TT, Campbell J, Britton J, Williams H, Hien TT, Farrar J, Quinnell RJ. Low efficacy of mebendazole against hookworm in Vietnam: two randomized controlled trials. *Am J Trop Med Hyg*. 2007; 76:732–736. [PubMed: 17426180]
- Galvani AP. Age-dependent epidemiological patterns and strain diversity in helminth parasites. *J Parasitol*. 2005; 91:24–30. [PubMed: 15856867]
- Humphries DL, Stephenson LS, Pearce EJ, The PH, Dan HT, Khanh LT. The use of human faeces for fertilizer is associated with increased intensity of hookworm infection in Vietnamese women. *Trans R Soc Trop Med Hyg*. 1997; 91:518–520. [PubMed: 9463654]
- Jardim-Botelho A, Brooker S, Geiger SM, Fleming F, Souza Lopes AC, Diemert DJ, Correa-Oliveira R, Bethony JM. Age patterns in undernutrition and helminth infection in a rural area of Brazil: associations with ascariasis and hookworm. *Trop Med Int Health*. 2008; 13:458–467. [PubMed: 18312476]
- Keiser J, Utzinger J. Efficacy of current drugs against soil-transmitted helminth infections: systematic review and meta-analysis. *JAMA*. 2008; 299:1937–1948. [PubMed: 18430913]
- Le HT, Brouwer ID, Verhoef H, Nguyen KC, Kok FJ. Anemia and intestinal parasite infection in school children in rural Vietnam. *Asia Pac J Clin Nutr*. 2007; 16:716–723. [PubMed: 18042534]
- Levav M, Mirsky AF, Schantz PM, Castro S, Cruz ME. Parasitic infection in malnourished school children: effects on behaviour and EEG. *Parasitol*. 1995; 110(Pt 1):103–111.
- Montresor, A., Crompton, DWT., Hall, A., Bundy, DAP., Savioli, L. Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level. World Health Organisation; Geneva, Switzerland: 1998. p. 1-48.
- Navitsky RC, Dreyfuss ML, Shrestha J, Khatri SK, Stoltzfus RJ, Albonico M. *Ancylostoma duodenale* is responsible for hookworm infections among pregnant women in the rural plains of Nepal. *J Parasitol*. 1998; 84:647–651. [PubMed: 9645880]
- Needham C, Thi Kim H, Viet Hoa N, Dinh Cong L, Michael E, Drake L, Hall A, Bundy DAP. Epidemiology of soil-transmitted nematode infections in Ha Nam Province, Vietnam. *Trop Med Int Health*. 1998; 3:904–912. [PubMed: 9855404]
- Oberhelman RA, Guerrero ES, Fernandez ML, Sillio M, Mercado D, Comiskey N, Ihenacho G, Mera R. Correlations between intestinal parasitosis, physical growth, and psychomotor development among infants and children from rural Nicaragua. *Am J Trop Med Hyg*. 1998; 58:470–475. [PubMed: 9574794]

- Olsen A, Samuelsen H, Onyango-Ouma W. A study of risk factors for intestinal helminth infections using epidemiological and anthropological approaches. *J Biosocial Sc.* 2001; 33:569–584.
- Olsen A, Thuan le K, Murrell KD, Dalsgaard A, Johansen MV, De NV. Cross-sectional parasitological survey for helminth infections among fish farmers in Nghe An province, Vietnam. *Acta Trop.* 2006; 100:199–204. [PubMed: 17141724]
- Pasricha SR, Caruana SR, Phuc TQ, Casey GJ, Jolley D, Kingsland S, Tien NT, MacGregor L, Montresor A, Biggs BA. Anemia, iron deficiency, meat consumption, and hookworm infection in women of reproductive age in northwest Vietnam. *Am J Trop Med Hyg.* 2008; 78(3):375–81. [PubMed: 18337329]
- Sakti H, Nokes C, Hertanto WS, Hendratno S, Hall A, Bundy DA, Satoto. Evidence for an association between hookworm infection and cognitive function in Indonesian school children. *Trop Med Int Health.* 1999; 4:322–334. [PubMed: 10402967]
- Stephenson LS, Latham MC, Ottesen EA. Malnutrition and parasitic helminth infections. *Parasitol.* 2000; 121(Suppl):S23–38.
- Stoltzfus RJ, Chwaya HM, Tielsch JM, Schulze KJ, Albonico M, Savioli L. Epidemiology of iron deficiency anemia in Zanzibari schoolchildren: the importance of hookworms. *Am J Clin Nutr.* 1997a; 65:153–9. [PubMed: 8988928]
- Stoltzfus RJ, Dreyfuss ML, Chwaya HM, Albonico M. Hookworm control as a strategy to prevent iron deficiency. *Nutr Rev.* 1997; 55:223–232. [PubMed: 9279058]
- UNICEF. Effective Information, Education and Communication in Viet Nam. UNICEF; HaNoi: 2001.
- van der Hoek W, De NV, Konradsen F, Cam PD, Hoa NT, Toan ND, Cong le D. Current status of soil-transmitted helminthes in Vietnam. *Southeast Asian J Trop Med Public Health.* 2003; 34(Suppl 1): 1–11.
- Verle P, Kongs A, De NV, Thieu NQ, Depraetere K, Kim HT, Dorny P. Prevalence of intestinal parasitic infections in northern Vietnam. *Trop Med Int Health.* 2003; 8:961–964. [PubMed: 14516309]
- Zimmermann MB, Hurrell RF. Nutritional iron deficiency. *Lancet.* 2007; 370:511–520. [PubMed: 17693180]

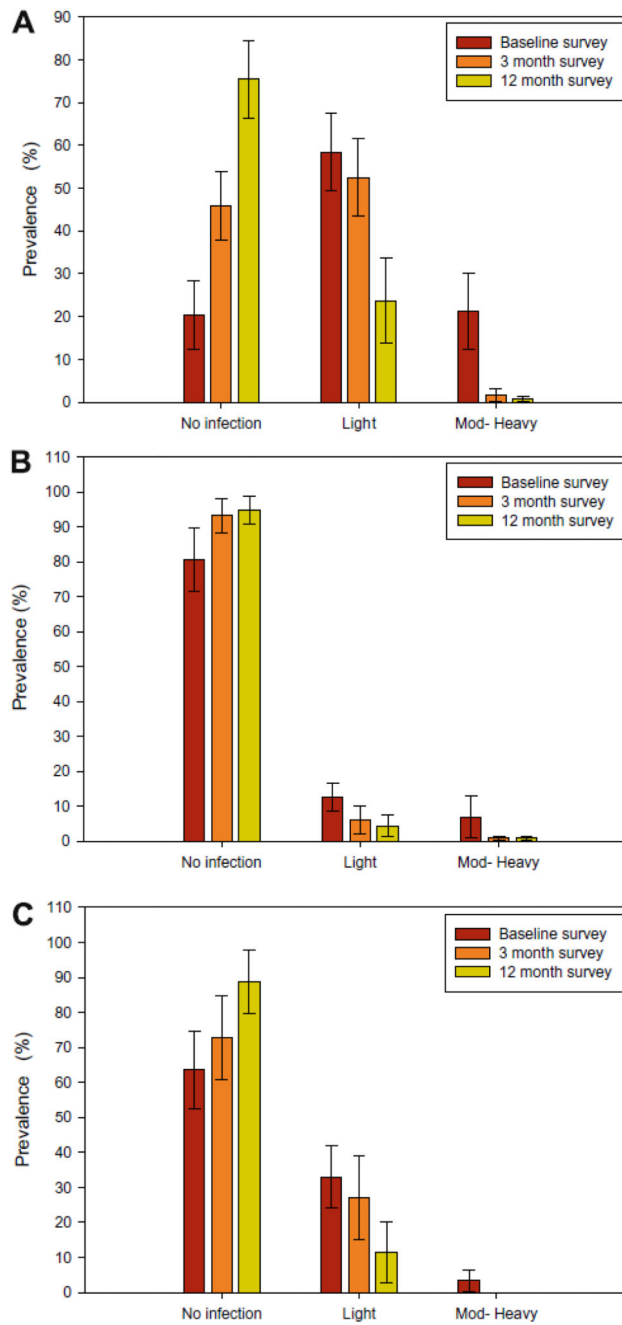


Fig. 1. Prevalence of infection before intervention and 3 months and 12 months post-intervention ($n = 118$) for hookworm (A), *Ascaris lumbricoides* (B) and *Trichuris trichiura* (C).

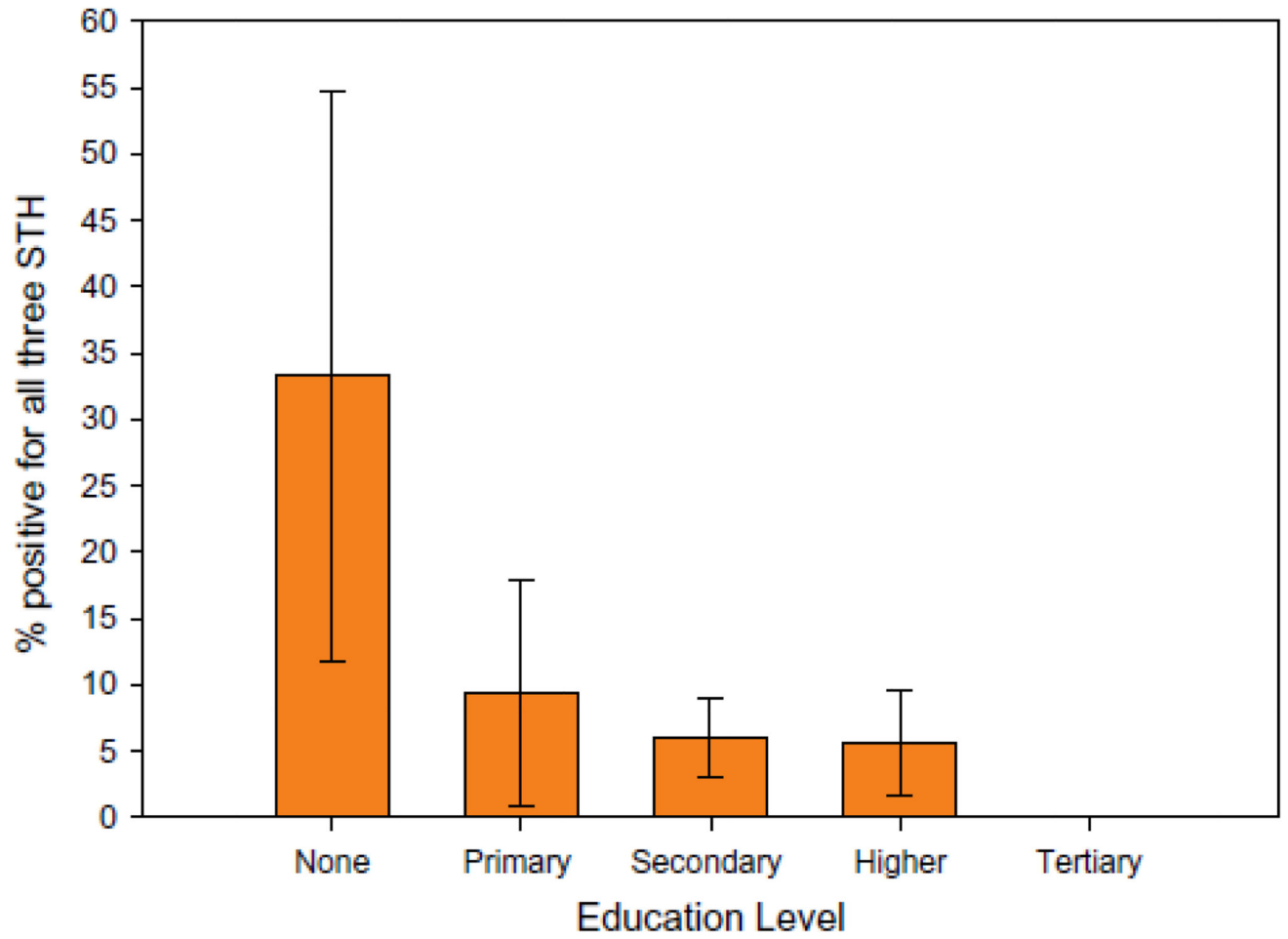


Fig. 2. Relationship between co-infection with all three species of soil-transmitted helminths (hookworm, *Ascaris lumbricoides* and *Trichuris trichiura*) and level of education in the baseline sample ($n = 356$).

Table 1

Comparison of demographic and socio economic data at enrollment for women that attended all three surveys and women that only attended the baseline survey

Variable	Baseline survey only <i>n</i> = 248	All three surveys <i>n</i> = 118	All women <i>n</i> = 366	
Mean age (\pm SD)	29.72 (8.08)	31.17 (7.49)	3020 (7.77)	
Marital status	Married ^a	196 (79.0%)	106 (89.8%)	302 (82.5%)
	Not married	42 (16.9%)	10 (8.5%)	52 (25.4%)
	Other (divorced/widowed)	2 (0.8%)	1 (0.8%)	3(1.6%)
	Missing	8 (3.2%)	1 (0.8%)	9 (2.5%)
Number of children	No children ^a	46 (18.5%)	10 (8.5%)	56 (15.3%)
	1-2 children	156 (62.9%)	80 (67.8%)	136 (37.2%)
	>3 children	37 (14.9%)	25 (21.2%)	62 (16.9%)
	Missing	9 (3.6%)	3 (2.5%)	12 (3.3%)
Ethnicity	Kinh	167 (67.3%)	71 (60.2%)	238 (65.0%)
	Tay	29 (11.7%)	14 (11.8%)	43 (11.7%)
	Cao Lan	20 (8.1%)	8 (6.8%)	28 (7.6%)
	Dao ^a	20 (8.1%)	23 (19.5%)	43 (11.7%)
	Nung	2 (0.8%)	1 (0.8%)	3 (1.6%)
	Other	1 (0.4%)	0 (0%)	1 (0.4%)
	Missing	9 (3.6%)	1 (0.8%)	10 (2.7%)
Education level	Illiterate ^a	7 (2.8%)	14 (12.0%)	21 (5.7%)
	To Grade 5	34 (13.7%)	20 (17.0%)	54 (14.7%)
	Grade 6–9	138 (55.6%)	61 (51.7%)	199 (54.4%)
	Grade 10–12	50 (20.2%)	22 (18.6%)	72 (19.7%)
	Higher	10 (4.0%)	1 (0.8%)	11 (3.0%)
	Missing	9 (3.6%)	0 (0%)	9(2.6%)
Job	Work outside ^a	192 (77.4%)	109 (92.4%)	301 (82.2%)
	Work inside	46 (18.5%)	8 (6.8%)	54 (14.8%)
	Missing	10 (4.0%)	1 (0.8%)	11 (3.0%)
Latrine	None	4 (1.6%)	5 (4.2%)	9 (2.5%)
	Squat	103 (41.5%)	52 (44.1%)	155 (42.3%)
	One stool box	79 (31.9%)	47 (39.8%)	126(34.4%)
	Two stool box	18 (7.3%)	7 (5.9%)	25 (6.8%)
	Sanitary system ^a	35 (14.1%)	7 (5.9%)	42 (11.5%)
	Missing	9 (3.6%)	0 (0%)	9 (2.5%)
Shoes	No	25 (10.1%)	18 (15.2%)	43 (11.7%)
	Yes	212 (85.5%)	100 (84.7%)	312 (85.3%)
	Missing	11 (4.4%)	0 (0%)	11 (3.0%)
Hookworm	No	63 (25.4%)	24 (20.3%)	87 (23.8%)
	Yes	185 (74.6%)	94 (79.7%)	279(76.3%)
	Missing	0	0	0

Variable		Baseline survey only <i>n</i> = 248	All three surveys <i>n</i> = 118	All women <i>n</i> = 366
<i>Ascaris lumbricoides</i>	No	199 (80.2%)	95 (80.5%)	294 (80.3%)
	Yes	47(19.0%)	23 (19.5%)	70 (19.1%)
	Missing	2 (0.8%)	0	2 (0.5%)
<i>Trichuris trichiura</i>	No	183 (73.8%)	75 (63.6%)	258 (70.5%)
	Yes	63 (25.4%)	43 (36.4%)	106 (29.0%)
	Missing	2 (0.8%)	0	2 (0.5%)

^a*P* value (chi squared for difference between proportions in baseline survey only versus all three surveys) <0.05.

Table 2

Prevalence of hookworms, *A.lumbricoides* and *T. trichiura* at baseline, 3 months and 12 months survey in all women surveyed.

Parasite	Intensity	Prevalence of infection (95% confidence interval)		
		Baseline <i>n</i> = 366	3 months <i>n</i> = 433	12 months <i>n</i> = 467
Hookworm	No infection	23.8 (16.2–31.4)	43.4 (37.3–49.6)	74.9 (70.1–79.8)
	Light	60.1 (53.7–66.5)	53.6 (47.6–59.6)	23.6 (18.9–28.3)
	Moderate-heavy	16.1 (11.0–21.2)	3.0 (1.4–4.6)	1.5 (0.5–2.5)
<i>A. lumbricoides</i>	No infection	80.8 (74.1–87.4)	94.5 (91.5–97.5)	96.1 (94.0–98.2)
	Light	11.8 (8.0–15.6)	4.6 (1.8–7.4)	3.0 (1.4–4.5)
	Moderate-heavy	7.4 (3.3–11.5)	0.9 (0.02–1.8)	0.9 (0.01–1.7)
<i>T. trichiura</i>	No infection	70.9 (64.8–76.9)	79.9 (74.3–85.5)	89.3 (85.7–93.0)
	Light	26.9 (21.1–32.8)	19.6 (14.1–25.2)	10.6 (6.9–14.3)
	Moderate-heavy	22 (0.1–4.3)	0.5 (–0.18–1.1)	0

Table 3

Predictors of Soil transmitted infection in the baseline sample of women.

	Predictor	Odds ratio (95% CI)	P value	Adjusted OR (95% CI)	Adjusted P value
No infection	Work inside	3.8 (2.0–7.3)	0.001	3.2 (1.6–6.2)	0.001
	Meat intake >twice/week	3.3 (1.6–7.0)	0.001	2.6 (1.2–5.7)	0.014
	Previous deworming	4.3 (1.0–18.5)	0.03	2.0 (0.4–9.3)	0.37
	Sanitary latrine system	3.9 (1.9–7.9)	0.001	2.1 (0.9–5.3)	0.08
Hookworm	Working outside	4.6 (2.5–8.5)	0.001	4.6 (2.1–9.9)	<0.001
	Meat ≤twice/week	1.6 (1.1–3.3)	0.04	1.2 (0.7–2.3)	0.47
	No sanitary latrine system	3.3 (1.6–10.0)	0.001	1.8 (0.8–4.1)	0.13
<i>Ascaris lumbricoides</i>	Lack of education	9.0 (3.6–22.7)	0.001	4.6 (1.5–14.2)	0.013
	No previous deworming	3.1 (1.4–6.6)	0.003	2.7 (1.2–5.9)	0.009
	Meat ≤twice/week	2.2 (1.3–3.9)	0.003	1.2 (0.6–2.6)	0.57
	No shoes worn	2.3 (1.1–4.8)	0.018	1.4 (0.4–3.7)	0.71
<i>Trichuris trichiura</i>	Lack of education	3.7 (1.5–9.1)	0.002	6.5 (2.1–19.6)	0.001
	Low SES ^a	3.0 (1.1–8.9)	0.03	5.7 (1.6–20.2)	0.006
All three STH	Lack of education	7.5 (3.4–16.4)	<0.001	7.5 (3.4–16.4)	<0.001

STH, soil-transmitted helminths; OR, odds ratio; CI, confidence interval.

^aSES, socio-economic status.