SOIL-TRANSMITTED HELMINTHIASIS IN RURAL SOUTH-WEST CHINA: PREVALENCE, INTENSITY AND RISK FACTOR ANALYSIS

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Abstract. Only few studies in rural China have explored the epidemiology of intestinal helminth infections and identified risk factors for transmission. The study was carried out in Simao and Mengla counties, where single fecal samples were collected from 317 school-aged children and from 94 inhabitants of a single village. Fecal specimens were examined with the Kato-Katz thick smear method and examined for helminth eggs. Data regarding socio-demographic and behavioral risk factors were collected using questionnaires. In Simao County the overall soil-transmitted helminthes (STH) prevalence was 40.2% (2.7, 5.4 and 35.7% for ascariasis, trichuriasis and hookworm infection, respectively). The STH infection rates were significantly higher in Mengla County, with an overall prevalence of 68.3% (19.0, 34.6 and 47.3% for ascariasis, trichuriasis and hookworm infection, respectively). Females were less likely to be infected with *Trichuris trichiura* (OR 0.29; 95% CI 0.15-0.56) and with hookworms (OR 0.55; 95% CI 0.33-0.93) than males. Hookworm infections were more prevalent among those 12 years of age or older (OR 2.9; 95% CI 1.2-7.1). Children of mothers with educational attainment of secondary school or higher had a protective effect against *T. trichiura* (OR 0.18; 95% CI 0.06-0.54) and hookworm (OR 0.21; 95% CI 0.09-0.51) infections. In the village survey, hookworm was the most prevalent species (62.8%) with infection seen in those 50 years of age and older. Based on recommended intervention strategies by the World Health Organization, Simao County should opt for school-based deworming once each year, while Mengla County should implement a similar strategy biannually, but should include the elderly population.

Keywords: soil-transmitted helminthiasis, prevalence, intensity, risk factor, China

INTRODUCTION

Soil-transmitted helminth (STH) infections, particularly *Ascaris lumbricoides*, hookworm (*Ancylostoma duodenale*, *Necator americanus*) and *Trichuris trichiura*, are globally endemic and cause an immense disease burden. Intestinal helminths predominantly occur in rural areas in which social and environmental conditions, such as poor hygiene and sanitation, are ideal for parasite infection and transmission (Hotez *et al*, 2006). STH have been

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described as a main cause of morbidity in school-aged children (5-14 years) in the developing world (World Bank, 1993), having negative impacts on children's physical and cognitive development (Chen *et al*, 2008).

Global STH distribution studies indicate China is one of the most active regions for infection (de Silva *et al*, 2003). In order to assess the current helminth situation in China, two nationwide surveys were conducted under the guidance of the Chinese Ministry of Health in 1990 and 2003 (Xu, 2000; Coordinating Office of the National Survey on the Important Human Parasitic Diseases, 2005; cited in Chen *et al*, 2008). Results from the 1990 survey found the STH prevalence rate standardized by age and sex was 53.2%, but this had declined to 19.3% by 2003 (Chen *et al*, 2008). This reduction occurred as a result of school-based chemotherapy interventions carried out for 10 consecutive years in all provinces, and universal treatment strategies in rural areas (Chen *et al*, 2008). The provision of adequate water supplies and latrines was implemented in rural areas. In both surveys, the total prevalence rates of STH in females were higher than those in males, with *A. lumbricoides* infection being most common. Both surveys had a similar age-prevalence, with hookworm infection peaking in older ages (50+ years), and *A. lumbricoides* and *T. trichiura* reaching a maximum prevalence between 5-14 years. High risk groups generally remained the same between the two studies, with vegetable farmers, schoolchildren and fisherman being at the highest risk for hookworm infection, ascariasis and trichuriasis, respectively. Pre-schoolers were at second highest risk for *A. lumbricoides*, as were school-aged children for *T. trichiura*.

Intestinal helminths were found to be particularly aggregated in agricultural regions of the Yangtze River Valley provinces, including Yunnan Province (Hotez *et al*, 1997). The 1990 nationwide survey found Yunnan to be highly endemic for STH, with prevalence rates *of A. lumbricoides, T. trichiura*, and hookworm infections of 59.6, 27.3, 19.3%, respectively (Lili *et al*, 2000). The second national parasitological survey in 2003 reported a mean STH prevalence of 21.7% in Yunnan Province (Ministry of Health, 2005; cited in Steinmann *et al*, 2007). However, a study conducted in two rural villages of Simao and Lushui Counties, in Yunnan found prevalences greater than 70% (Lili *et al*, 2000). Steinmann *et al* (2007) found a low prevalence of *T. trichiura* (1.7%) and hookworm (0.3%) among children and adults in Eryuan County, Yunnan. The authors concluded possible reasons for the observed figures were recent economic advances, such as improved access to clean water, sanitation and anthelminthic medication.

Although control strategies against STH infections are promoted at the national level, efforts remain weak in Yunnan Province, especially in rural areas. There has been a scarcity of studies assessing the current prevalence of STH infections and underlying risk factors in different regions of rural China, including Yunnan.

The purpose of this study was to assess the current prevalence and intensity of STH infections in Simao County and, for the first time, in Mengla County located in the extreme south of Yunnan. The study investigated sociodemographic, behavioral and environmental risk factors for infection. Rural school-aged children and rural village inhabitants of Yunnan Province were focused on in order to assess the need for implementation of school-based deworming programs and to acquire a deeper understanding of

transmission patterns in the region.

MATERIALS AND METHODS

Study area

The study took place in two autonomous prefectures in Yunnan Province, China. The first location, Simao County, Pu'er Prefecture, lies at 100°58 E, 22°46 N with an elevation of approximately 1,070 m. Simao Prefecture consists of 60% ethnic minorities. The area is generally poor, with the economy governed by the surrounding tea plantations. The second location, Mengla County, Xishuangbanna Prefecture is located at the extreme southern tip of Yunnan Province, bordering Lao PDR at 101°39 E, 21°16 N with an average elevation of 870 m. Approximately 13 ethnic minorities inhabit Xishuangbanna, accounting for 75% of the total population. Farming of rice, corn, vegetables and tea is common in both areas. At the village level, animal husbandry is also an important source of income.

Preliminary study

A preliminary survey in Simao County was conducted in July/August 2007 in order to obtain baseline data regarding the range, prevalence and intensity of intestinal helminth infections in rural and urban areas of Yunnan Province. Two schools, one rural and one urban, were selected for sampling in Simao County, Pu'er Prefecture. Based on the findings of this pilot study, an expanded follow-up study was undertaken in 2008 in Simao and extended to Mengla, focusing on rural schools as described below.

Population survey, informed consent and treatment

Six schools, two in Simao County and four in Mengla County, were selected for sampling on the basis they were accessible to laboratory facilities, had prior communication with Simao/Mengla Center for Disease Control (CDC) and were located in ecologically diverse areas where the prevalence of STH was likely to differ.

Upon completion of the school survey, a village helminth survey was conducted across the age ranges in Xikong Village, Mengla County in order to determine the age-prevalence of STH in this population. This village was selected for sampling due to its close proximity to the township hospital and the large population size (38 households).

The study was approved by the Research Ethics Committee of the London School of Hygiene and Tropical Medicine (London, UK) and the CDC in both Simao and Mengla counties. Yunnan Institute of Parasitic Diseases (YIPD) staff and Simao/Mengla CDC officials contacted the headmasters of the participating schools and the leader of Xikong Village to explain the aims and procedures of the study and received verbal consent. In the case of the village survey, written informed consent was obtained from the heads of participating households. Upon completion of the study and in accordance with local treatment policies, a single dose of albendazole (400 mg) was provided free of charge to those children and adults testing positive for STH infection.

Field procedures and questionnaires

The fieldwork was carried out between July and August 2008. In each school, five classes were randomly selected for sampling with hopes of obtaining 50 samples from each. In order to obtain a variety of ages, at least 15 students were sampled from each class. Questionnaires were administered to participants by classroom teachers in the school survey and by YIPD officials in the village survey.

The questionnaire was used to obtain sociodemographic (age, sex, parental education and occupation), behavioral (access to anthelminthic drugs), and environmental (type of water source, latrine ownership) data.

In parallel, 15 ml wax-coated cardboard containers were distributed to each participant along with instructions on obtaining a thumb-size fecal specimen. A unique identification number was generated for each participant and clearly labelled on both the questionnaire and the stool sample container. All containers and questionnaires were collected the following day and within two hours of collecting stool samples were stored at 4˚C pending analysis.

Laboratory analysis

Diagnosis of STH infection was performed by stool analysis using the Kato Katz (KK) method (Katz *et al*, 1972). All fecal specimens were processed within 4 days of collection. Slides were examined by microscope within one hour of preparation. Slides were scanned for helminth eggs under 10x magnification, and detected eggs were examined under 40x magnification to confirm morphological features. Stools considered to be too watery or dry were excluded from examination. As recommended by the World Health Organization (Montresor *et al*, 1998), a subsample of 10% of the slides were re-examined by a head laboratory technician, without knowledge of the previous result. In only 3 slides from the whole study was there a discrepancy greater than 10% and in these cases the results were discussed by the two readers and further slides were prepared and examined. Egg counts were multiplied by 24 to obtain the number of eggs per gram of feces. Intensity of infection with *A. lumbricoides*, *T. trichiura* and hookworm were calculated for each subject based on the recorded KK method egg counts and infection intensity calculated according to World Health Organization guidelines (WHO, 2002).

Data management and statistical analysis

Questionnaire and parasitological data were double-entered and validated in EpiData version 3.1 (EpiData Association, Odense, Denmark). All further analyses were conducted with STATA version 10 (StataCorp LP; College Station, USA). Only participants with complete data records were considered for the final analysis.

For all analyses, strong evidence of an association between variables was considered at $p<0.05$, and suggestive evidence of an association at $0.05<p<0.10$. Bivariate logistic regression analysis was carried out to obtain crude odds ratios (OR) for the association between infection prevalence and categorical risk factor variables. Likelihood ratio tests were used to assess the overall effect of variables with more than two subgroups on STH prevalence. Subsequently, multiple logistic regression models for each helminth infection were produced to assess the relationship between risk factors and infection prevalence, in the presence of other factors. Age group and sex were used as a base for each model, and remaining variables found to be significant on bivariate analysis ($p<0.10$) were added in stepwise fashion.

The geometric mean of infection intensity was calculated for each risk factor subgroup due to the positively skewed shape of intensity distributions. With dichotomous risk factor variables, *t*-tests were used to indicate differences across infection intensity means. An Analysis of Variance (ANOVA) was used to compare

Table 1
Prevalence of STH infections diagnosed with the KK technique in 2 schools in Simao County, Yunnan Province, China. Data are stratified by school location.

Helminth	Overall prevalence		Urban (n=136)		Rural (n=198)		p-value [a]
	No.	%	No.	%	No.	%	
A. lumbricoides	39	11.7	3	2.2	36	18.2	<0.001
T. trichiura	63	18.9	5	3.7	58	29.3	<0.001
Hookworm	75	22.5	1	0.7	74	37.4	<0.001
Any STH infection	130	38.9	10	7.4	120	60.6	<0.001

[a] p-value from χ^2 test

the means of infection intensities across risk factor variables with more than two subgroups. Multiple linear regression models were used to quantify the association between infection intensity and risk factors, while controlling for confounders, in the same stepwise manner described above. For the village survey, only associations between infection prevalence and intensity with age and sex were assessed.

RESULTS

Preliminary study

The preliminary study consisted of 334 samples from both urban (40.7%) and rural (59.3%) Simao County. The overall prevalence of STH was 38.9%, of which the prevalences of *A. lumbricoides*, *T. trichiura* and hookworm were 11.7, 18.9 and 22.5%, respectively. As shown in Table 1, large differences in STH prevalences were observed between urban and rural school locations.

Both *Ascaris* and hookworm infection were associated with sex; males were 2.5 times more likely to have *Ascaris* infection (p=0.04) and 1.8 times more likely to have hookworm infection (p=0.04). The high prevalence of STH infections (60.6%) in rural Simao warrants further study.

Follow-up school survey

Study cohort, demographic and socioeconomic profile. Completed questionnaire data and stool samples were available for 317 children, with an overall compliance rate of 80.2%. All participants were inhabitants of rural areas. Demographic characteristics for each school are shown in Table 2. The sex distribution within the primary schools was homogenous but age distribution was not. Participants in the study cohort had a mean age of 10.8 years, and 56.1% were males. Han and Yi ethnic groups made up the majority of the sample (62.5%). Of the children included in the study, 20.5% had illiterate mothers, and 56% had mothers who had only attained a primary school education. Approximately 36% of children had mothers who were rice farmers, followed by general farmers (32%). General farming is defined as engagement in more than one type of income-generating farming practice (*eg*, rice, tea, coffee, rubber), with or without vegetable farming. Paternal occupation followed a similar pattern. Approximately 87% of households had running tap water and 64.3% of households had toilet facilities in their compound.

Helminth infections. The overall prevalence of STH was 58.4%, of which the

Table 2
Demographic characteristics of the study population by school, age and sex.

Demographic characteristic	Schools[a]						*p*-value[c]
	Simao County		Mengla County				
	Manxieba	Zhengdong	Xiang Ming-Primary	Xiang Ming-Secondary	Song Shan Ling	Mansai	
Children[b]	59	53	66	48	58	33	
Sex							0.384
Male	30 (50.9)	26 (49.1)	37 (56.1)	33 (68.8)	31 (53.5)	20 (60.6)	
Female	29 (49.2)	27 (50.9)	29 (43.9)	15 (31.3)	27 (46.6)	13 (39.4)	
Age (years)							<0.001[d]
6-8	8 (13.6)	14 (26.4)	10 (15.2)	0	20 (34.5)	1 (3.0)	
9-11	36 (61.0)	35 (66.0)	34 (51.5)	0	35 (60.3)	19 (57.6)	
12-14	15 (25.4)	4 (7.6)	21 (31.8)	28 (58.3)	3 (5.2)	13 (39.4)	
≥15	0	0	1 (1.5)	20 (41.7)	0	0	

[a]Manxieba and Zhengdong schools were located in Simao County and the remaining four schools were located in Mengla County.
[b]The number of children participating in the study by school.
[c]*p*-value from the χ^2 test.
[d]*p*-value calculated using regrouped age variable (6-8, 9-11, ≥12years) for primary schools only.

prevalences of *A. lumbricoides*, *T. trichiura* and hookworm were 13.3, 24.3 and 43.2%, respectively. As shown in Table 3, large differences in STH prevalences were observed between counties.

The overall prevalence of STH infections in Simao County was 40.2%, corresponding to 2.3, 5.4 and 35.7%, for ascariasis, trichuriasis and hookworm infections, respectively. Mengla County had a higher prevalence of all three STH infections, with an overall prevalence of STH infections of 68.3%, and prevalences of ascariasis, trichuriasis and hookworm infection being 19.0, 34.6 and 47.3%, respectively. Among participants with eggs detected in their stools, 68.7% were infected by a single species, whereas dual (24.3%) and triple infections (7.0%) were less common. *Enterobius vermicularis* was detected in two samples (0.6%) and *Trichostrongylus orientalis* in one sample (0.3%).

The degree of infection intensity was categorized into light, moderate and heavy infection using World Health Organization standard grading guidelines as shown in Table 4. The majority of infections were light in nature but 6.6% of hookworm infections were heavy. Among *Ascaris* and *Trichuris* infections, only one heavy infection was seen in each (Table 4). Geometric means were relatively low for all three infections, with *Ascaris* infection having the largest mean value (926.86 epg).

Reported risk factors associated with STH infection prevalence. The results of bivariate logistic regression analyses are presented in Table 5. A statistical difference in STH infection prevalence

Table 3
Prevalence of STH infections diagnosed by KK technique in 6 rural schools in Simao and Mengla counties, Yunnan Province, China. Data are stratified by school location.

Helminth	County						
	Overall prevalence		Simao (*n*=112)		Mengla (*n*=205)		*p*-value[a]
	No.	%	No.	%	No.	%	
A. lumbricoides	42	13.3	3	2.7	39	19.0	<0.001
T. trichiura	77	24.3	6	5.4	71	34.6	<0.001
Hookworm	137	43.2	40	35.7	97	47.3	0.046
Any STH infection	185	58.4	45	40.2	140	68.3	<0.001

[a]*p*-value from χ^2 test

Table 4
Degree of infection intensity and geometric mean egg counts (epg) per STH species for all positive cases (*n*=185) among school-aged children.

Parasite[a]	Degree of infection intensity[b]			Geometric mean (epg) (95% CI)
	Light (%)	Moderate (%)	Heavy (%)	
A. lumbricoides	33 (78.6)	8 (19.1)	1 (2.4)	926.9 (487.6-1,761.9)
T. trichiura	64 (83.1)	12 (15.6)	1 (1.3)	197.1 (140.1-277.5)
Hookworm	111 (81.0)	17 (12.4)	9 (6.6)	437.7 (335.3-571.4)

[a]Individuals may appear more than once in the table due to dual and triple infections.
[b]Intensity thresholds calculated according to WHO guidelines.

between males and females was observed for *Trichuris* (*p*=0.0013) and hookworm infections (*p*=0.0516). Age group was not associated with infection prevalence for any helminth species. The risk of infection with all three STH species was higher in schools in Mengla County than those in Simao County. Ethnic group was associated with all three infections. Lack of toilet facilities in household compounds was associated with increased risk for *Ascaris* (*p*=0.0960) and hookworm infections (*p*=0.0056).

Significant differences in prevalence by maternal education level were apparent for all three STH infections, whereas paternal education level was only associated with hookworm prevalence (*p*=0.0093). Maternal occupation was not associated with hookworm infection (*p*=0.4052), but both maternal and paternal occupation were associated with all other STH infections. The use of anthelminthic drugs during the past year was associated with reduced *Ascaris* (*p*=0.0572) and hookworm infections (*p*=0.042).

Table 6 presents the stepwise multiple logistic regression models for all three helminth species. After adjusting for other factors, females had a protective effect against both *Trichuris* (OR 0.3; 95% CI 0.2-0.6) and hookworm infection

Table 5
Bivariate logistic regression analyses of the relationship between prevalence of STH infection among children 6-19 years old (n=317) and socioeconomic, behavioral and environmental variables.

Variables	*A. lumbricoides* infection		*T. trichiura* infection		Hookworm infection	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value[a]	OR (95% CI)	*p*-value[a]
Sex		0.8805		0.0013		0.0516
Male	1.00		1.00		1.00	
Female	1.05 (0.55-2.02)		0.41 (0.56-2.56)		0.64 (0.41-1.01)	
Age (years)		0.8928		0.7039		0.1607
6-8	1.00		1.00		1.00	
9-11	1.26 (0.48-3.29)		1.20 (0.56-2.56)		1.42 (0.74-2.71)	
≥12	1.20 (0.43-3.34)		1.38 (0.63-3.01)		1.90 (0.96-3.79)	
Location		<0.0001		<0.0001		0.0452
Simao County	1.00		1.00		1.00	
Mengla County	8.54 (2.57-28.31)		9.36 (3.92-22.37)		1.62 (1.00-2.60)	
Ethnic Group		0.0294		<0.0001		<0.0001
Han	1.00		1.00		1.00	
Hani	4.95 (1.45-16.92)		9.50 (3.47-26.02)		1.43 (0.58-3.48)	
Dai	1.10 (0.12-9.79)		7.39 (2.26-24.13)		0.33 (0.07-1.52)	
Yi	3.17 (1.18-8.56)		2.94 (1.31-6.61)		2.14 (1.20-3.83)	
Yao	4.95 (1.63-15.03)		3.28 (1.24-8.64)		5.80 (2.58-13.08)	
Jinuo	3.88 (0.99-15.21)		10.45 (3.56-30.65)		2.51 (0.97-6.50)	
Other	1.03 (0.12-9.14)		2.92 (0.80-10.69)		2.57 (0.91-7.25)	
Toilet in household		0.0960		0.1506		0.0056
Yes	1.00		1.00		1.00	
No	1.75 (0.91-3.36)		1.47 (0.87-2.49)		1.92 (1.21-3.06)	
Maternal education level		0.0808		0.0287		0.0001
Illiterate	1.00		1.00		1.00	
Primary school	0.46 (0.23-0.98)		0.58 (0.31-1.09)		0.67 (0.37-1.19)	
Secondary school or above	0.38 (0.14-1.00)		0.34 (0.15-0.77)		0.23 (0.11-0.48)	
Paternal education level		0.1237		0.1305		0.0093
Illiterate	1.00		1.00		1.00	
Primary school	0.34 (0.13-0.92)		0.79 (0.32-1.97)		0.77 (0.33-1.79)	
Secondary school or above	0.36 (0.13-1.01)		0.47 (0.18-1.23)		0.39 (0.16-0.93)	
Maternal occupation		0.0092		<0.0001		0.4052
Rice farmer	1.00		1.00		1.00	
Rubber farmer	3.65 (0.84-15.78)		2.02 (0.57-7.12)		0.67 (0.21-2.13)	
General farmer[b]	3.72 (1.58- 8.80)		3.60 (1.91-6.76)		0.73 (0.42-1.26)	
Other	1.56 (0.58-4.23)		0.82 (0.37-1.79)		1.15 (0.66-2.02)	
Paternal occupation		0.0260		<0.0001		0.0060
Rice farmer	1.00		1.00		1.00	
Rubber farmer	2.22 (0.56-8.81)		1.71 (0.55-5.31)		0.54 (0.18-1.64)	
General farmer[b]	2.62 (1.24-5.54)		2.70 (1.52-4.80)		0.75 (0.45-1.28)	
Other	0.80 (0.27-2.35)		0.12 (0.02-0.52)		1.08 (0.60-1.96)	
Use of anthelminthic drugs in past year		0.0572		0.0784		0.0242
Yes	1.00		1.00		1.00	
No	0.41 (0.179-0.98)		0.49 (0.23-1.06)		2.48 (1.08-5.71)	

[a]*p*-value from likelihood ratio test.
[b]General farmer implies more than 2 different farming practices (*ie*, tea, rice) with or without vegetable farming.

Table 6
Stepwise multiple logistic regression to assess associations between risk factors and parasite infection status in school-aged children.

Risk factors	*A. lumbricoides* infection		*T. trichiura* infection		Hookworm infection	
	OR (95% CI)	*p*-value[a]	OR (95% CI)	*p*-value[a]	OR (95% CI)	*p*-value[a]
Sex		0.5007		0.0001		0.0237
Male	1.00		1.00		1.00	
Female	1.27 (0.63-2.56)		0.29 (0.15-0.56)		0.55 (0.33-0.93)	
Age (years)		0.5688		0.2395		0.0537
6-8	1.00		1.00		1.00	
9-11	1.46 (0.50-4.25)		2.21 (0.80-6.08)		2.25 (0.99-5.13)	
≥12	1.00 (0.30-3.33)		1.57 (0.52-4.69)		2.92 (1.19-7.14)	
Ethnic group		0.0399		0.0018		0.0005
Han	1.00		1.00		1.00	
Hani	3.13 (0.85-11.57)		7.47 (2.12-26.23)		0.89 (0.30-2.60)	
Dai	0.84 (0.09-8.22)		7.46 (1.78-31.27)		0.47 (0.09-2.40)	
Yi	2.21 (0.72-6.76)		2.66 (0.96-7.39)		2.84 (1.40-5.76)	
Yao	6.76 (2.08-21.99)		1.96 (0.63-6.10)		3.91 (1.56-9.79)	
Jinuo	2.40 (0.54-10.77)		10.71 (2.78-41.28)		4.64 (1.50-14.30)	
Other	0.90 (0.10-8.34)		3.37 (0.71-16.09)		2.08 (0.69-6.31)	
Maternal education level	[b]			0.0048		0.0003
Illiterate	[b]		1.00		1.00	
Primary school	[b]		0.59 (0.27-1.31)		0.70 (0.35-1.42)	
Secondary school or above	[b]		0.18 (0.06-0.54)		0.21 (0.09-0.51)	
Maternal occupation		0.0112	[b]			0.0571
Rice farmer	1		[b]		1.00	
Rubber farmer	4.84 (0.91-25.69)		[b]		0.78 (0.13-4.68)	
General farmer	4.55 (1.65-12.50)		[b]		0.46 (0.23-0.92)	
Other	1.65 (0.56-4.85)		[b]		1.25 (0.65-2.42)	
Paternal occupation	[b]			<0.0001	[b]	
Rice farmer	[b]		1.00		[b]	
Rubber farmer	[b]		3.01 (0.59-15.36)		[b]	
General farmer	[b]		1.7 (0.80-3.63)		[b]	
Other	[b]		0.09 (0.02-0.47)		[b]	

[a]*p*-value from likelihood ratio test.
[b]Variable not included in final model.

(OR 0.6; 95% CI 0.3-0.9). Adding ethnicity into the model revealed significant associations with each prevalence outcome. Jinuo ethnicity is the most prevalent in Mengla County and had the highest risk for *Trichuris* (OR 10.7; 95% CI 2.8-41.3) and hookworm (OR 4.6; 95% CI 1.5-14.3) when compared to the Han ethnic group.

After controlling for other factors, age group was associated with increased risk of hookworm infection in those 12 years of age and older (OR 2.9; 95% CI 1.2-7.1). Children of mothers with an education level of secondary school or higher had a

protective effect against *Trichuris* (OR 0.2; 95% CI 0.1-0.5) and hookworm (OR 0.2; 95% CI 0.1-0.5). Children whose mothers were general farmers had 4.6 (95% CI 1.7-12.5) times the risk of *Ascaris* infection, but a reduced risk of hookworm infection (OR 0.5; 95% CI 0.2-0.9), compared to those of rice farmers. Conversely, paternal occupation was only associated with *Trichuris* infection, in which "other" farming practices had a protective effect (OR 0.1; 95% CI 0.02-0.5).

Risk factors associated with infection intensity. Maternal education (p=0.0252) and school location (p=0.0170) were associated with intensity of *Ascaris* infection. There were no other significant differences in intensity means across remaining risk factor variables for any STH infections. Multiple linear regression models showed no linear association between risk factor variables and infection intensity (p>0.10).

Village survey

In total, 94 individuals from Xikong village were included in the survey, giving a compliance rate of 63.9%. Participants ranged in age from 5 months to 79 years, with a mean age of 31.8 years. Forty-nine percent of the village population were males. The highest STH prevalence was hookworm (62.8%), but the prevalences of *Ascaris* (4.3%) and *Trichuris* (3.2%) infections were low. Two samples were positive for *Paragonimus westermani* (2.1%).

Due to low rates of *Ascaris* and *Trichuris* infection, only data on hookworm infection was used for further analyses. Fig 1 shows the age-prevalence curve for hookworm infection. The graph shows a gradual rise in prevalence in early childhood until 20-29 years, where the curve plateaus, dips at 40-49 years, and then continues to increase in those over 50 years old. Age group was found to have a significant association with hookworm (p=0.0005) when controlling for sex. No differences in intensity means across age groups or sex were found using ANOVA (p>0.10).

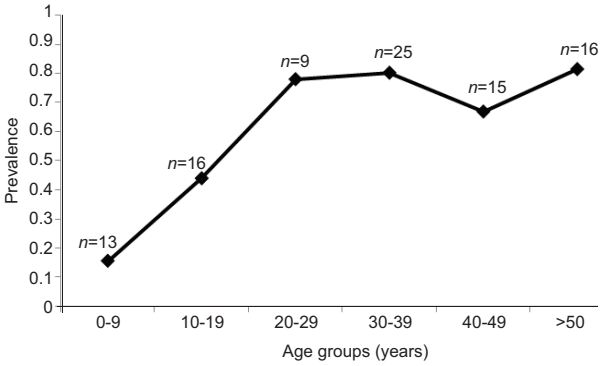

Fig 1–Prevalence of hookworm infection across different age groups. Numbers above data points indicate sample size in each age group.

DISCUSSION

This study provides data regarding the prevalence of STH in Mengla County, adding to earlier studies from Lushui County in the western part of the province and from Simao County (Lili *et al*, 2000) and Menghai County in the northwestern part of Mengla (Steinmann *et al*, 2008). Based on tested schoolchildren, the observed prevalences in Mengla (68.2, 47.3, 34.6 and 19.0% for STH, hookworm, *Ascaris* and *Trichuris*, respectively) were similar to those from Lushui (72.0, 48.0, 43.4 and 15.8%, respectively). The various studies from Simao have reported moderate (40.2%, follow-up school survey) to high (60.6%, preliminary rural study and 77.3%; Lili *et al*, 2000) STH prevalences. A study from Menghai County reported prevalances of greater than 85% for each of the three STH (Steinnmann *et al*, 2008);

it is clear the prevalences of STH remain high in large regions of Yunnan Province.

A particularly striking difference in the prevalence of *Ascaris* and *Trichuris* was observed between the results from Simao County in the school survey and the results from our preliminary study, and the results from Simao County by Lili *et al* (2000). Although hookworm prevalences were similar in the three studies, 35.7, 37.4 and 39.9%, respectively. The prevalences of *Ascaris* and *Trichuris* (2.7 and 5.4%, respectively) were lower in the follow-up school survey compared to the preliminary study (18.2 and 29.3%) and very much lower compared to the Linger village study (60.2 and 35.7%) (Lili *et al*, 2000), This may reflect variation in ecology and ethnicity of the communities studied, although a larger sample size study would need to be carried out to confirm this.

The current study's findings of higher hookworm and *Trichuris* prevalences among males are similar to previous studies (Bradley *et al*, 1992; Glickman *et al*, 1999; Keiser *et al*, 2002). Other studies have shown no association between gender and STH prevalences for both adults and children (Annan *et al*, 1986; Traub *et al*, 2004). Gender differences in STH prevalences and intensities may be explained by differences in gender roles (Traub *et al*, 2004). However, this is may not be the case in young age groups. The present study found children > 12 years old had a higher risk of hookworm infection. This finding is plausible, since hookworm infection is associated with agricultural practices (Hotez *et al*, 2006) and children in this age group are likely to have commenced working in the fields. Although it is well established that heavy worm infection frequently peaks in childhood for *Ascaris* and *Trichuris* infections (Chongsuvivatwong *et al*, 1996; Steinmann *et al*, 2007; Alaofé *et al*, 2008), the present study did not find such an association; the low number of detected cases, especially for *Ascaris* infection, could have compromised findings.

Ethnicity was found to be a significant risk factor for infection with all three STH. Differences in prevalences of helminths across ethnic groups have been previously observed (Prata, 1992). Results from rural Yunnan Province (Steinmann *et al*, 2007) found Schistosomiasis japonicum was more prevalent among the Han minority than the Bai, however no association was observed with *Ascaris*, *Trichuris* or hookworm infections. Differences in ethnicity are commonly the result of confounding by variations in environmental and socio-economic conditions (Cooper *et al*, 1993). However, controlling for ethnicity in the present study still resulted in significant associations between infection, maternal education and parental occupation. Children of illiterate mothers were at increased risk for *Trichuris* and hookworm infections. Other studies have found maternal education to be one of the most important risk factors for intestinal helminth infections (Toma *et al*, 1999; Phiri *et al*, 2000). A study in rural China found higher education and socio-economic status were positive predictors for hand washing, which in turn had a protective effect on *A. lumbricoides* and *T. trichiura* seropositivity (Steinmann *et al*, 2007).

The prevalence of *Ascaris* was higher in those children whose mothers engaged in general farming practices compared to rice farmers, whereas the risk of hookworm infection was lower. The reason for these associations is unknown. Previous studies have found that maternal, but not parental, occupation was inversely correlated with risk of STH infection in children (Saathoff *et al*, 2005; Alaofé *et al*, 2008).

Analysis of stool samples from the village survey gave a high hookworm prevalence (62.8%) and low *Ascaris* (4.3%) and *Trichuris* (3.2%) prevalence. Age group was associated with hookworm infection status, but neither age group nor sex were significant risk factors for infection intensity. The observed age-prevalence profile for hookworm (Fig 1), with a peak prevalence in the elderly population (>50 years) is similar to those found in other studies from China (Changhua *et al*, 1999; Lili *et al*, 2000; Gandhi *et al*, 2001; Bethony *et al*, 2002) and Southeast Asia (Humphries *et al*, 1997). A study conducted in Menghai County, Yunnan Province found the prevalence of hookworm in those ≥40 years old was 83.9% (Steinmann *et al*, 2008), compared to 74.2% found in the present study. A possible explanation for the peak prevalence among the older population could be due to longer exposure among the elderly in Asia (Brooker *et al*, 2004). The association between older age and higher prevalence of hookworm infection uncovers an important public health issue, since the elderly are not generally viewed as a high risk group for hookworm infection, their poor nutritional status and background health makes them more vulnerable to morbidity associated with heavy hookworm infection (Bethony *et al*, 2002).

In general, this study found the intensities of STH infections were low in both Simao and Mengla Counties. Previously, only schools in urban areas of Simao County implemented mass anthelminthic drug administration to school-aged children; no deworming strategies took place in the rural areas studied. Although anthelminthic drugs are available at local hospitals, rural families may not be able to afford the cost. It is unlikely the intensities of infection observed in our study were influenced by previous deworming interventions since the village and schools sampled are located in semi-rural and rural areas.

The present study characterizes the prevalence, intensity and risk factors for STH infections among children and adults in rural Yunnan Province, China. Future research in rural Yunnan Province should link stool sample analysis and questionnaire data with clinical features of infection (*eg*, anemia) in order to provide a better understanding of morbidity caused by STH infections in this area. A longitudinal cohort study design, similar to that employed by Mukhopadhyay *et al* (2008) in Nepal, would be ideal in acquiring a better understanding of risk factors for STH infections in this area, as well as providing greater evidence for causality.

Based on World Health Organization guidelines for treatment strategies (WHO, 2006), the two schools sampled from Simao County are regarded as being low-risk and thus recommended treatment strategies include treatment of all enrolled and non-enrolled school-aged children once each year, in addition to other high-risk groups. Conversely, Mengla County falls into the high-risk category, and should be targeted for treatment of school-aged children biannually. If resources are available, Mengla County may opt to include a third round of drug treatment, with deworming activities occurring every four months. In Mengla County, the elderly population should also be regarded as a high risk group and included in targeted treatment strategies. Further studies in Yunnan Province would be valuable to determine if the observed prevalence differences between Simao and Mengla counties are typical of the region. Investigation of the prevalence of STH infection in adjacent areas is also

important, so as to delineate the regions recommended for chemotherapy-based deworming programs. Public health efforts should focus on improving sanitation, promoting personal hygiene and increasing awareness of STH infections and available anthelminthic treatment using integrated control strategies.

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