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High prevalence of soil-transmitted helminths in Southern Belize-highlighting opportunity for control interventions

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PEER REVIEW

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Comments

This is a good study in epidemiology of STH, in which authors performed a survey of STH infection for 500 children of 10 schools in Southern Belize. Result showed infection rate of STH was more than 60% in these areas. That is a pre-requisite work for successfully conducting a deworming programme in Belize.

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ABSTRACT

Objective: To assess prevalence and intensity of soil-transmitted helminths (STH) in school age children of two southern districts as baseline information prior to implement a deworming program against intestinal parasites as part of an integrated country development plan.

Methods: Children randomly selected from urban and rural schools in Southern Belize provided one stool sample each, analysed by the Kato-Katz method to assess prevalence and intensity of STH infections. Epi Info software was used for data analysis; *Chi*-square test and Fischer exact test were applied to compare group proportions; $P<0.05$ was considered of statistical significance; descriptive statistics were expressed as percentages.

Results: A total of 500 children from 10 schools participated in the study from May to December 2005. Prevalence of STH ranged between 40% and 82% among schools, with a median of 59.2%; the majority of light intensity, and with 2.2% high intensity infection. *Trichuris* and *Ascaris* infections presented similar frequency in children aged from 6 to 9 years old; hookworm infections tended to be more frequent in the older group 10 to 12 years old. Statistical significances ($P\leqslant0.01$) were found in children in rural schools infected with any species of STH, in moderate *Trichuris* infections, in hookworm infections in rural areas with strong Mayan presence and in *Ascaris* infections in children of Mayan origin.

Conclusions: High prevalence of STH in Southern Belize provided sound ground for implementing an integrated deworming control program.

KEYWORDS

Belize, Intestinal parasites, Soil-transmitted helminths, Survey

1. Introduction

Neglected tropical diseases, also known as forgotten diseases or diseases of the poor, are a group of 17 prominent chronic infections of different etiology, bacterial, viral and parasitic (helminthic and protozoan), known to prevail among poorest populations in less developed countries in the world[1-3]. One common denominator is that they not only affect people with limited resources, but also indigenous groups, women in childbearing age, small farmers in rural areas, migrant workers, prisoners, and refugee groups. For example, 56% of 1 254 African refugees had intestinal parasites, with children more likely than adults to be parasitized with helminths and protozoa[4].

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Children of migratory seasonal farm workers are a high-risk group in nutritional status, intestinal parasitic infections and psychomotor development delay[5]. The soil-transmitted helminths (STH) infections impair intellectual and physical development starting at preschool age[6], and in adult life they significantly diminish economic productivity[6], cause disabilities, and can result in stigmation and perpetuation of the poverty cycle[1-3,7].

Of the seven diseases included in the neglected tropical diseases group targeted for preventive chemotherapy by World Health Organization (WHO), *i.e.*, lymphatic filariasis, schistosomiasis, STH *Ascaris lumbricoides* (*A. lumbricoides*), *Trichuris trichiura* (*T. trichiura*) and human hookworm infections (*Necator americanus* and *Ancylostoma duodenale*), onchocercosis and blinding trachoma, STH rank highest among prevalent neglected diseases in many developing countries, afflicting mostly children in impoverished regions living in slum dwellings or rural locations in Africa, Asia and Latin America[8]. Ascariasis and trichuriasis reduce appetite and food intake, promote malabsorption and poor growth rate; iron deficiency anemia is a hallmark of human hookworm infections[9]. Such chronic afflictions in children affect mental development and learning capacity and by extending into adulthood, affect worker productivity and in pregnant women, low birth weight of the newborn and even an increase in infant and maternal morbidity[10]. Thus these parasites are of importance to maternal and child healthcare programs such as Integrated Management of Childhood Illness and nutritional programs.

In the last 20 years, safe drugs have been used for mass or selective treatment against widespread neglected diseases thanks to initiatives for free drug donations and partnerships to control or eliminate them. The Mectizan Donation Program, for example, has donated 1.8 billion ivermectin tablets reaching more than 68 million people in Africa, Latin America and Yemen to combat onchocerciasis with notable economic benefits, strengthening health systems, and generating positive health impacts in the community[11]. Several other indirect collateral benefits of this program have been noted, such as de-worming of intestinal parasites in children, increased school attendance, improvements in individual health, and increased food production[12] and reducing misery-inducing ectoparasites such as scabies and lice.

According to the WHO recommendations[13,14], ascariasis, trichuriasis and human hookworm infections can also be successfully controlled through periodic anthelmintic administration to target populations, such as school age children[14]. Highly effective drugs such as albendazole and mebendazole can be used in integrated control efforts through coordination within ministries and among partners, using and public health infrastructure to deliver health services at very low cost[12,15]. The appropriate control treatment regimen for STH is to be determined based on categories of risk infection. Two risk categories have been recently determined, including high risk schools with 50% or more helminth infection and low risk schools with infection between 20% and 49% helminth infection. These data can be determined by base line data collection during epidemiological surveys conducted through schools for particular communities, regions or even the whole country[14]. This classification also provides an indication of the need or urgency of other control measures such as improved access to basic sanitation, safe water and health and hygiene education activities. These cost-effective chemotherapy interventions contribute to achieve the Millennium Development Goals[16,17], becoming an attractive investment to donors of international health agencies, together with non-governmental organizations (NGOs) and national health authorities.

In order to plan for control interventions, reliable data on prevalence and intensity of STH infection are necessary. Under the WHO 2011 guidelines, the decision to treat all persons (mass treatment) or only school children and other high risk groups (selective treatment) once or more times a year depends on the prevalence of infection in a particular region or country[14]. In a survey conducted 40 years ago in two towns of Cayo district, West-Central Belize, the cumulative prevalence for intestinal parasites, helminths and protozoa was 74%, with high prevalence rates of *A. lumbricoides* (43%) and *T. trichiura* (40%) infections and lower human hookworm (7%) infection rates[18]. A second epidemiologic survey conducted in 1998 and published in 2004[19] in five localities of Toledo district among Mayan Ketchi and Mayan Mopan indigenous population of all ages, the cumulative prevalence of helminth infections was 67% and provided evidence of higher human hookworm infections (55%), small but significantly ($P<0.025$) more in females than that of in males, with *A. lumbricoides* (30%) and *T. trichiura* (19%) showing lower rates than 1968. These two surveys were the only records available for the country. Since the government of Belize had special interest in the southern districts of Stann Creek and Toledo, which are characterized by high poverty (60% poor, 50% indigenous), high unemployment (13%), low school attendance with no education or only primary education (78% combined), school absenteeism and hygiene and environmental sanitation issues (65% without latrine facilities, 35% no electricity, 13% with only standpipe or well for drinking water)[20], among other needs and with high population densities (70% or more) of indigenous Mayan people in Toledo district, it was decided to investigate prevalence and intensity of STH among 10 schools of both districts following WHO guidelines[14]. The implementation of a new health reform program by the government of Belize with the support of various agencies and NGOs represented in the country, offered a special opportunity to implement a deworming program aimed at school age children in impoverished areas of Southern Belize. Results of the survey conducted in 2005-2006 constitute the basis of this paper. The data obtained

are expected to facilitate the planning and implementation of STH control strategies as well as later evaluations of the program in these particular regions of Belize.

2. Materials and methods

2.1. Study area

Belize is geographically situated in Central America, bordering Mexico to the north and Guatemala to the west and south, the Caribbean Sea bounded to the east. There is a small sea link to Honduras but no direct land border (Figure 1).

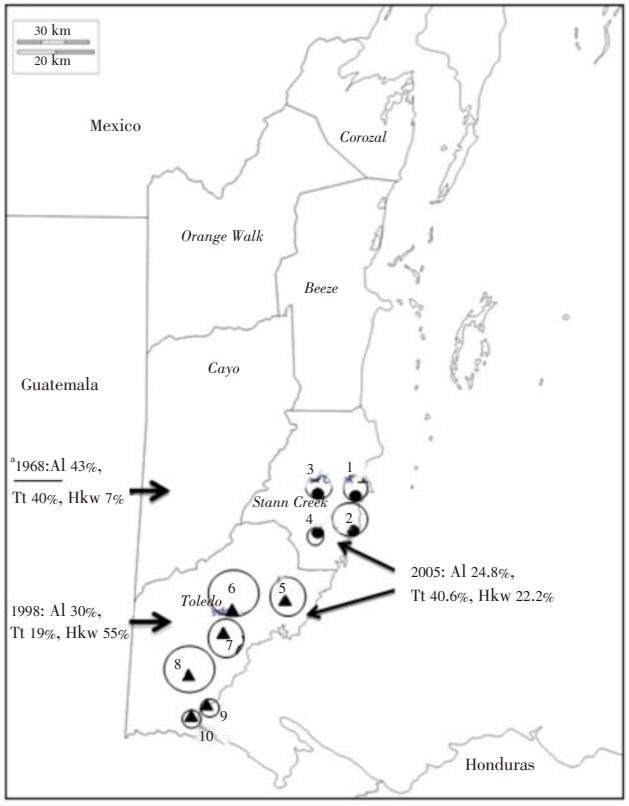

Figure 1. Geoposition of Belize marking districts and sites of previous and present surveys; school locations in southern districts, 2005-2006 survey.
[a]: Percentage of STH from previous surveys, Cayo district in 1968 and Toledo district in 1998 marked by arrows. The different size circles compare total percentage of infection with any STH by schools, 2005 survey. Stann Creek: 1=Sacred Heart 54%, 2=Holy Ghost 72%, 3=Holy Angels 52%, 4=Silk Grass 46%. Toledo district: 5=Bella Vista 68%, 6=Bladden 82%, 7=Indian Creek 68%, 8=St. Marcus 81%, 9=St. Peter Claver 40%, 10=PG Methodist 46%.

The Belize Barrier Reef consists of over 120 Cayes or islands, mostly uninhabited which are the center of tourism activity, water sports and diving. The country is divided administratively in six districts, from north to south: Corozal, the slowest growing population (1.5% per year); Orange Walk; Cayo which includes the capital Belmopan and the universities; Belize with Belize City as the largest city in the country and a commercial center and port, Stann Creek and Toledo, both in the southern part. The total country extension is 22 966 sq. km and a total population of around 330 200 inhabitants according to 2009 national data. The two districts that were targeted for the study, Stann Creek district (SCD) situated along the Caribbean coastline with a split population among Garifuna (40%) of some African descent, Mestizo and Creole, a major producer of bananas and citrus fruits in large plantations, and Toledo district (TD), further south, mainly agricultural small holdings, the center of the dominant groups of Mayan Ketchi and Mopan populations, just under 70%, dispersed over 50 small villages, many along major roads, traditionally the poorest district in the country. Both districts have the largest population of foreign-born households (24%) as well[20].

2.2. Sampling and data collection

In preparation for the survey, an intensive 18 h course on the use and performance of the egg count technique using the Kato-Katz (KK) thick smear method[21] was conducted for three laboratory technicians who were to perform the stool examinations. At the end of the course, an exam was given to test for reliability in the performance and egg counting methodology, obtaining more than 95% accuracy by each of the technicians. The total number of children for both school districts surveyed was 4 737, of which 1 857 belonged to SCD. A total of 10 schools from both urban and rural locations selected according to accessibility were identified: two urban (Holy Ghost and Sacred Heart) and two rural (Holy Angels and Silk Grass) in SCD with a total of 1 857 students enrolled and two urban (Methodist and Saint Peter Claver) and four rural (Indian Creek, Bella Vista, San Marcus and Bladden) in TD, with a total of 2 880 students enrolled. A total of 50 children aged 5 to 12 years old were selected at random from the class roll of each of those schools, for a total of 500 children. Participating children were informed by their teachers the previous day of the stool collection and the proper procedure for collection (one stool sample from each participating child, in previously provided name-tagged containers with lid, free of soil, water and urine). Samples were kept in an ice box during field work and taken to the laboratory within the next 3 h for immediate parasitological examination the same day. During sample collection at the school, four trained health staff performed interviews directly with each child, who at the same time was measured using a wooden meterstick attached to a standard bathroom weighing scale, and weighed. Children were requested to remove their shoes and any headclips or bands that would obstruct proper measuring and the meterstick was read at eye level. Weighing was done with empty pockets and without shoes. Children without parental consent were not enlisted. A questionnaire used to interview the child during the stool collection did not include any socio demographic or other type of data, except to register school name, age, sex, height, weight, and symptoms likely related to worm infections, such as presence of diarrhea, abdominal pain, nausea or vomiting or spontaneous expulsion of worms.

2.3. Parasitological stool examination

Stool (fecal) samples were collected during the morning from each designated school, usually one school a day. The stool samples were taken to Dangriga Southern Regional Laboratory for those in Stann Creek and to Punta Gorda Regional Laboratory for those in Toledo. In the laboratory samples were examined macroscopically to register consistency, presence of blood, mucus or adult worms. Each stool specimen was analyzed by the Kato-Katz thick smear method which used a template that once filled contained approximate 41.7 mg of feces[21,22]. Using a hand-held cell counter *Ascaris*, *Trichuris* and human hookworm eggs were counted according to species and recorded. Special consideration was given to examine the Kato-Katz thick smear between 5 and 15 min after preparation as soon as they cleared to avoid disappearance of human hookworm eggs[21,22]. The intensity of infection was calculated multiplying the results of the egg counts by a factor of 24 and expressed as number of eggs per gram of feces (epg). Field and laboratory supervision as well as quality control were performed by a consulting parasitologist; 20% of negative smears and all smears with high egg counts were reviewed. Since the revision was done at a later date, only *Ascaris* and *Trichuris* eggs were visible. No special methods for intestinal protozoa and *Strongyloides stercoralis* larvae detection were implemented. Due to delays in obtaining an appropriate device to read hemoglobin levels in the field, blood samples by finger pricking were collected from participating children in two schools in TD at a later date by a trained laboratory technician. Anemia was defined as hemoglobin value of less than 10 g/dL.

2.4. Ethical approval

The study was granted approval by officials in the Ministries of Health and Education. Official meetings with school personnel and with parents from potential study sites were previously carried out in order to explain the purpose and protocol of the study and to obtain a written participation consent from school officials and parents. A child questionnaire was pilot-tested in one study site in order to detect and correct problems with the questionnaire. Participating schools filled up a school form including general information about the school location, availability of water on tap in the school premises for flushing the toilet or for washing hands; availability of soap and water in the latrines; and cleanliness of the latrines. Adequacy in the number of toilets was not calculated. A separate short course on the transmission and prevention of soil transmitted helminths was offered to supervisors and teachers of participating schools who were going to administer a single dose deworming treatment to child participants. Only children with permission to participate were registered. All entries and results of the survey were kept confidential. Treatment was offered at the end of the survey for children in the first three grades consisting of a single dose of albendazole 400 mg. Later the Ministry of Health implemented a deworming program for school-age children in these two districts.

2.5. Data analysis

The data obtained from the survey were analyzed by the Epidemiologic Unit of the Ministry of Health located at the Dangriga Hospital in SCD by appropriate methods and statistical tests. Interpretation of some statistics was further reviewed and analyzed at Instituto de Enfermedades Tropicales Pedro Kouri, Havana, Cuba. Epi Info software was used; *Chi*-square test and Fischer exact test were applied to compare group proportions; $P<0.05$ was considered statistic significance; descriptive statistics were expressed as percentages. Levels of endemicity of STH and degrees of intensity of infection were categorized according to 2011 WHO recommendations[14], *i.e. A. lumbricoides* infections: 1-4 999 epg; 5 000-49 999 epg and >50 000 epg for low, moderate and high intensity respectively; *T. trichiura* infections: 1-999 epg; 1 000-9 999 epg and >10 000 epg for low, moderate and high intensity respectively; Hookworm infections with 1-1 999 epg; 2 000-3 999 epg and >4 000 epg counts for low, moderate and high intensity respectively.

3. Results

This study was a stratified non-intervention descriptive survey carried in 2005-2006 specifically on intestinal STH infections in 500 subjects from a total of 4 737 students, 50 from each of 10 schools from SCD and TD, both in the southern region of Belize. There were two urban and two rural schools in SCD and two urban and four rural in TD (Figure 1). For analysis purposes, the single child in the 5 years old group was omitted, as were four other children who presented infections other than STH (three *Hymenolepis nana* and one *Enterobious vermicularis*). Of the 495 remaining participants in the study, 220 were males (44.4%) and 275 females (55.5%); a total of 375 children were in the age categories of 6 to 9 years old group (75.0%) and 120 children (24.2%) in the ages 10 to 12 years old group, respectively (data not shown). A total of 60.1% was parasitized with one or more STH, with 16.8% mixed infections (Table 1). About 39.2% (194 subjects) were negative for STH infections (data not shown).

When stratifying STH infections by species by schools in both districts, the prevalence ranged between 4.0% to 60.0% for *A. lumbricoides*, 18.0% to 60.0% for *T. trichiura* and 0% to 66.0% for human hookworm (Table 1). The majority were low intensity infections (252, 50.4%); 43 (8.6%) were of moderate intensity; 11 (2.2%) high intensity infections were found in seven children with ascariasis, two with trichuriasis and three with human hookworm infections (Table 3). Mean

percentage of infection with any species of STH was 56.0% for children in SCD and 64.7% for TD children.

There was a degree of heterogeneity in STH distribution among schools surveyed in SCD and TD. For SCD, *T. trichiura* was the most prevalent STH, with an overall prevalence of 43.5%, followed by *A. lumbricoides* with a prevalence of 25.7% and human hookworm with a prevalence of 3.0% (Table 1). Urban schools in SCD had significant ($P\leqslant0.01$) higher prevalence of infection with any STH (63.0%) and with *T. trichiura* (51.0%) infection. In TD, the most prevalent STH was *T. trichiura* (38.0%), followed by human hookworm (34.6%) and *A. lumbricoides* (24.2%). All four rural schools in TD had significant ($P\leqslant0.01$), the highest prevalence of infection with any STH (range 68.0%-82.0%), with human hookworm infection (range 2.0%-66.0%, $P\leqslant0.003$), with *T. trichiura* (range 18.0%-60.0%, $P\leqslant0.01$) and with *A. lumbricoides* (range 14.0%-60.0%, $P\leqslant0.01$) infections (Table 1). The prevalence of human hookworm infection in TD was significant ($P\leqslant0.01$) when compared with that of in SCD (Table 1); however, no such difference was found with *T. trichiura*, *A. lumbricoides* prevalences or mixed infections (Tables 1 and 2). There were significant differences ($P\leqslant0.05$ and $P\leqslant0.01$) in frequency of infection by *Trichuris* and *Ascaris* among schools in both districts, and then among schools in TD, notable for a high presence of Mayan children compared to schools with non-indigenous children. There were significant differences in frequency of infection by *Ascaris* ($P\leqslant0.05$), human hookworm ($P\leqslant0.01$), total infected subjects ($P\leqslant0.01$) and mixed infections ($P\leqslant0.05$) between rural and urban schools in TD, but not by *Trichuris* infections. The difference of mixed infections in TD rural St. Marcus school was significant ($P=0.01$) when compared to the rest of the schools in both districts (Table 2).

There was not much difference in STH infections between boys and girls; no significant difference was found between females (56.5%) and males (43.5%) infected with at least one STH. *Trichuris* and *Ascaris* infections seemed of similar frequency in children aged 6 to 9 years old; human hookworm infections tended to be more frequent in the older group 10 to 12 years old (Table 2).

Hookworm infections were significant most prevalent in TD schools compared to SCD schools, mainly St. Marcus, Indian Creek, Bladden ($P<0.01$) and Bella Vista school ($P<0.05$) as compared to all schools in SCD as well as when compared to schools with non indigenous children such as PG Methodist and St. Peter Claver ($P<0.01$) schools in TD.

Table 3 presents the distribution of STH infections according to prevalence intensity. Seven heavy ascariasis infections (1.4%) were found among children between Sacred Heart (SCD) and Bella Vista (TD) schools; heavy trichuriasis (0.4%) was found in Holy Ghost (SCD) and St. Marcus (TD) schools (one child each); Bladden, St. Marcus and PG Methodist participants (TD) had one each heavy human hookworm infections (0.6%).

Table 1

Number and percent of STH infections in urban and rural schools of Stann Creek and Toledo districts, Belize.

Infections	Urban of Stann Creek		Rural of Stann Creek		Urban of Toledo		Rural of Toledo				Total
	HG	SH	HA	SG	Meth	SPCl	IC	BV	SM	Bl	
Enrollment	50/625	50/645	50/325	50/262	50/609	50/948	50/182	50/838	50/180	50/123	500/4737
Infected, any [a]STH (%)	36 (72.0)	27 (54.0)	26 (52.0)	23 (46.0)	23 (46.0)	20 (40.0)	34 (68.0)	34 (68.0)	42 (81.0)	41 (82.0)	306 (60.1)
P value	<0.01						<0.01	<0.01	<0.01	<0.01	
Infected by sex %males/%females	26/46	22/32	26/26	34/12	20/26	10/30.5	30/38	32/36	34/46	28/54	59.0/61.1
T. trichiura (%)	30 (60.0)	21 (42.0)	20 (40.0)	16 (32.0)	16 (32.0)	13 (26.0)	9 (18.0)	28 (56.0)	18 (36.0)	30 (60.0)	201 (40.6)
P value	<0.01							<0.01	<0.01	<0.01	
A.lumbricoides (%)	16 (32.0)	13 (26.0)	11 (22.5)	11 (22.5)	11 (22.5)	2 (4.0)	11 (22.5)	7 (14.0)	30 (60.0)	11 (22.5)	123 (24.8)
P value							<0.01		<0.01	<0.01	
Hookworms (%)	0 (0.0)	3 (6.0)	1 (2.0)	2 (4.0)	6 (12.0)	1 (2.0)	27 (54.0)	10 (20.0)	33 (66.0)	27 (54.0)	110 (22.2)
P value							<0.01		<0.003	<0.01	

HG=Holy Ghost, SH=Sacred Heart, HA=Holy Angels, SG=Silk Grass, Meth=PG Methodist, SPCl=Saint Peter Claver, BV=Bella Vista, SM=Saint Marcus, Bl=Bladden. Subtotals of STH infections by district, Stann Creek district: *Trichuris* 43.5%, *Ascaris* 25%, human hookworm infection 3%; Toledo district: *Trichuris* 38.6%, *Ascaris* 24.6%, human hookworm infection 34.6%.

Table 2

Number and percentage infections of soil-transmitted helminths by sex, age groups and mixed infections in rural and urban schools of Stann Creek and Toledo districts, Belize.

Parameters		Stann Creek district				Toledo district						Totals
		HG	SH	HA	SG	Meth	SPCl	IC	BV	SM	Bl	
Infected by sex (%)	Male/female	26/46	22/32	26/26	34/12	20/26	10/30.5	30/38	32/36	34/36	28/54	59/61
No. *T. trichiura* infections by [a]age	6-9 y	25	21	10	10	12	9	5	27	8	23	150
	10-12 y	5	0	10	6	4	4	4	1	10	7	51
No. *A. lumbricoides* infections by age	6-9 y	13	12	5	8	8	2	8	7	13	10	86
	10-12 y	3	1	6	3	3	0	3	0	17	1	37
No. hookworm infections (%) by age	6-9 y	0	2	0	2	3	1	15	10	14	19	66
	10-12 y	0	1	1	0	3	0	12	0	19	8	44
No. (%) mixed infections		10 (20%)	10 (20%)	6 (12%)	6 (12%)	7 (14%)	1 (4%)	5 (10%)	4 (8%)	25 (50%)	10 (20%)	84 (16.8%)

HG=Holy Ghost, SH=Sacred Heart, HA=Holy Angels, SG=Silk Grass, Meth=PG Methodist, SPCl=Saint Peter Claver, BV=Bella Vista, SM=Saint Marcus, Bl=Bladden. [a]: Total number of children by age category. 5 y=1 (omitted), 6 y=9, 7 y=83, 8 y=150, 9 y=135, 10 y=75, 11 y=30, 12 y= 17.

Table 3

Total number and intensity of soil-transmitted helminths by age categories, 500 school children, Stann Creek and Toledo districts, Belize.

Parasites No. (%)	Total No. infections	Intensity of infections		
		Low	Moderate	High
A. lumbricoides	123 (24.6)	73 (14.6)	43 (8.6)	7 (1.4)
T. trichiura	201 (40.2)	155 (31.0)	44 (8.8)	2 (0.4)
Hookworms	110 (22.0)	100 (20.0)	7 (1.4)	3 (0.6)
Intensity by age in years				
6-9	214 (56.6)	178 (47.1)	30 (7.9)	6 (1.6)
10-12	87 (71.3)	74 (60.7)	13 (10.7)	5 (4.1)
Totals	301 (60.2)	252 (50.4)	43 (8.6)	11 (2.2)

Prevalences of infection with any STH were high for each school, the lowest 40% and the highest 82%, with a median of 59.2% (Table 1). Figure 1 shows the percentages using circles of different sizes indicating approximate school locations. Previous survey results from Petana[18] and Aimpun[19] were indicated by an arrow according to district surveyed. In the present survey, the highest percent prevalence (64% to 82%) infections, as well as the highest intensities of parasitic infections were found in the rural schools in TD which concentrated the highest Mayan indigenous populations. Nevertheless, SCD with a high percentage of African descent population had a median of 56% helminthic infection. More important, urban schools in SCD had higher prevalences compared to rural schools in the same district. Based on the population of school age children (year 2000 census) in the age cohort of 5 to 14 years, there were estimated 7 057 and 6 285 children in SCD and TD respectively, for a total of 13 342 children, of which 8 005 (60.1%) would be expected to be infected with one or more species of STH according to these results.

None of the participating children reported recent spontaneous worm expulsion. When comparing non-specific symptoms between infected and uninfected children, more children from schools in TD and children in Holy Ghost school from SCD reported more symptoms in the infected group, but were found not statistically significant. Anthropometric measurements indicated that of the 495 children examined, 39 (7.8%) were below the third percentile for weight and 82 (16.5%) were below the third percentile for height. Three comparisons showed statistically significant differences ($P<0.01$): a) between the proportion of individuals with high intensity of infection under the third weight percentile and the proportion of uninfected individuals below the third weight percentile; b) between the proportion of individuals with high intensity of infection under the third height percentile and the proportion of uninfected individuals below the third height percentile; c) between the proportion of individuals with moderate intensity of infection under the third height percentile and the proportion of uninfected individuals below the third height percentile (data not shown). Anemia as a basic nutritional status indicator occurred in Indian Creek and Bladden communities (data not shown), with strong Mayan presence and high prevalence of human hookworm infections as well; however, only those two schools in TD were tested for hemoglobin levels at a different time and no other causes for anemia were tried to be established.

All schools had latrines, few in number; the better kept ones had a padlock at the door, which was removed by a supervisor when requested for use. Some toilets were flushed using a bucket with water; not all schools had soap to wash hands nor was hand washing performed routinely by the children in the schools. At the end of the survey, children from participating schools were treated with a single dose of albendazole.

4. Discussion

This study focused exclusively on the prevalence and intensity of STH in 500 school children in four urban and six rural schools from two southern districts of Belize, using the Kato-Katz thick smear for prevalence and intensity of infections, with no inclusion of sociodemographic data anaylisis, risk factors analysis or spatial geographic distribution of infections. The survey was completed in December 2005; hemoglobin measures and revisions were completed in 2006; the baseline data presented in this report should be of value for evaluating and monitoring any progress towards STH control accomplished so far in both Belize southern districts.

Nearly two thirds of the children tested were infected with one or more STH, with schools in the rural areas of TD having the highest percentages of infection for all three species of parasites tested. It was evident that *Trichuris* infections predominated in SCD while *Ascaris* and hookworm infections were most significant among indigenous Mayan populations of Toledo. Prevalence of infection was high, up to 82% in one rural school of TD; most of the intense infections were associated to rural schools in TD as well. It became evident that in Southern Belize high prevalence rates of STH were favored by rural poverty of indigenous populations and those communities of Mayan and African descent. Similarly, in Guatemala, one of the six countries in Latin America where 80% of indigenous populations live, 8 million individuals have been estimated to be infected with human hookworm alone, 8.6 million with *Ascaris* and 7.9 million with *Trichuris*[24]; it also has the highest prevalence of underweight children[25]. Parasitological assessment of infection in indigenous children in Philippines showed that cumulative prevalence of STH infection was significantly higher ($P=0.021$) than in non indigenous ones[26]. Children born to indigenous groups often live in areas where basic health services are scarce, with limited access to safe water and sanitary toilet or latrines, conditions that contribute to increased risks of transmission and reinfection. A study in Venezuela found that important determinants for acquiring ascariasis and trichuriasis were to live in a rural area in a vulnerable poorly constructed house with a soil floor, conditions representing more than double risk for these helminthic infections[27]. A comparative study in children of two communities in Venezuela also concluded that poor socioeconomic and sanitation conditions are conductive of higher exposure to gastrointestinal parasites and deficient nutritional status[27]. The nutritional status is compromised by excessive loss of nitrogen in stools due to the intestinal

parasitosis, conductive of malabsorption of sugars and vitamins. Furthermore, the production of IgA and IgE becomes altered, with higher levels of non-specific IgE inversely proportional to malnutrition, with the consequent less specific anti-parasite response and less resistance to reinfection[28].

Trichuris trichiura infections are mostly asymptomatic, especially in light infections. One of the early studies on trichuriasis in children found that heavy infections consistently produce diarrhea and dysentery, with a few cases of rectal prolapse[29]. A later study in Caribbean communities with endemic trichuriasis showed that chronic colitis due to this infection was associated with growth stunting and that heavy infections tended to be aggregated in predisposed individuals and age groups[30]. Observations of blood loss in moderate to heavy *Trichuris* infection in otherwise healthy children showed that in the absence of severe colitis with bleeding, blood loss was negligible[31]. Consequences of STH infections have been detailed as adversely affecting nutritional status, impairing cognitive processes, causing complications that require surgical intervention and inducing reactions in tissues[14,29,32]. It would be important to evaluate such parameters in school age children in both districts of Southern Belize after deworming and measure differences as a result of the interventions. Most investigators believe that the impact of trichuriasis in children in endemic areas has not been properly assessed. In the present study, 44 children had moderate trichuriasis and two children had severe infections according to results of the egg counts. None of the children interviewed during this survey reported passing blood and mucus in stool; however, there were significant differences in the anthropometric measures ($P<0.01$) associated with moderate or heavy infections with any of the three intestinal parasites.

Ascariasis in children is an important cause of nutritional impairment, especially when protein intake is low[9]. Adult worms often cause abdominal emergencies due to their tendency to migrate out of the intestine or congregate in packed masses that obstruct the intestine or block the biliary and pancreatic duct. A literature search that explored three different epidemiological aspects of ascariasis complications from countries such as Brazil, Myanmar, South Africa and India, concluded that intestinal obstruction represented a mean of 72% of all complications, and that the proportion and number of cases per year were significantly related to the local prevalence of ascariasis[33]. The mean case fatality rate was 5.7% and the age of the patients was below the age of 10. In Honduras, a country that did not meet the goal of 75% deworming of school age children by 2010, about 90 documented cases of ascariasis included intestinal, biliary, hepatic abscess, pancreatic and pleural complications, mainly in children less than 10 years of age[34]. No official reports or publications of surgical emergencies caused by *A. lumbricoides* were identified from Belize, but they are known to occur.

Human hookworm infection is one of the most prevalent helminthic parasitosis of man in warm climates, known to be a major cause of anemia in children[35] and adverse pregnancy outcomes in women. The continuous propagation of human hookworm infection is largely due to constant human soil pollution in the domestic or peridomestic surroundings, where women and children have more opportunity of exposure to the larvae in the soil[19]. In Viet Nam, however, hookworm prevalence risk factor (76% of 366 women) depended on women working outside the house and on lack of education[36]). A study in two communities in Mexican rural school children found that lower status, lower education level of mothers and defecation in open air were significant factors to acquire this infection[37].

Anemia as a basic nutritional status indicator occurred in Indian Creek and Bladden communities (data not shown), with strong Mayan presence and high prevalence of human hookworm infections as well; however, only two schools in TD were tested for hemoglobin levels at a different time and no other causes for anemia were tried to be established. Anemia is an important nutritional deficiency worldwide and helminths, particularly the human hookworm, are well established contributors to the morbidity associated to it in chronic infections due to the pervasive blood loss caused by the adult human hookworm in the intestine. In a recent study that explored the significance of low intensity multiple concurrent helminth infections to anemia, it was found that polyparasitized children, even with one or two helminth species at a low intensity, were at high odds of having anemia, independently of nutritional status, sex or place of residence[38]. The importance of this observation relates to the possibility that globally, several million children could be multiparasitized at low intensity, excluding them from beneficial health interventions when resources are limited.

A previous study[19] also found that more women than men were infected with human hookworm. Their assumption was that since 94% of the women worked at home and 72% wore no shoes, the exposure to contaminated areas was greater than for men. It is also an indication that this infection is a serious problem extending beyond childhood and potentially affecting women of child bearing age and pregnant women who in general are more susceptible to develop anemia, affecting their work capacity and health[39]. Anemia is an important contributor to maternal and infant morbidity and mortality in women of childbearing age in many countries[10,40].

These results clearly illustrate the need to implement large scale preventive chemotherapy interventions based on an action following WHO recommendations[14]. In localities with >50% or more infection prevalence, the recommendation is to treat all school aged children, whether enrolled or not, twice a year providing availability of resources. School age children in Belize can be safely treated district wide with mebendazole or albendazole in a single dose in an integrated cost effective approach that can latter become nationwide. Several other interventions such as improving education, sanitation and hygiene, socioeconomic development, use of sanitary latrines and wearing shoes may also contribute to the reduction of intestinal parasitoses. These infections are the results of interrelated cultural, social, economic, educational and other factors, known today as part of the social determinants of health, that could to some extent

be reversed when control programs concurrently include deworming and health promotion through education and training of lower income families, as well as improved access to basic sanitation and safe water in schools and at home[41].

Since the completion of the study in 2006, Belize has been one of four countries in the region that reached 75% anthelminthic treatment coverage rate in school age children against STH after implementing a preventive chemotherapy program starting in 2006 (in partnership with an international NGO, Vitamin Angels) which will soon complete its first monitoring and evaluation; results will be published at a later date.

Conflict of interest statement

We declare that we have no conflict of interest.

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Comments

Background

Neglected tropical parasitic diseases cause serious problems of public health in developing countries, such as in Belize. The integrated epidemiological data are prerequisite for successfully performing control programme. Therefore, it's necessary that a survey of infection condition was carried out before conducting national control plan in Southern Belize.

Research frontiers

The study was performed to determine the infection rate and intensity of helminthes in school children, Southern Belize. And this was the latest and most comprehensive survey data about helminthes infection in school children in Belize.

Related reports

In history, there were only two times of surveys about helminths infection in Belize, in 1968 and 1998, respectively. And in the two surveys, it just included one district, Cayo and Toledo.

Innovations and breakthroughs

In this study, for implementing a deworming program organized by government, a selective survey was performed among 500 school children in two districts, Stann Creek and Toledo, targeted on *Trichuris*, *Ascaris* and hookworm. And the results showed that more than 60% of children were infected by one or more STH. This is the latest epidemiological data of STH infection in Belize.

Applications

The result of epidemiological survey can be used in a selective deworming programme as background data in Southern Belize. It's useful for performing STH control strategies and evaluating results of the programme.

Peer review

This is a good study in epidemiology of STH, in which authors performed a survey of STH infection for 500 children of 10 schools in Southern Belize. Result showed infection rate of STH was more than 60% in these areas. That is a pre-requisite work for successfully conducting a deworming programme in Belize.

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