

# Prevalence of soil-transmitted helminths after mass albendazole administration in an indigenous community of the Manu jungle in Peru

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Few data are available on the epidemiology of soil-transmitted helminths (STHs) in indigenous populations of the Peruvian Amazon. While albendazole is being increasingly used in deworming campaigns, few data exist on the impact of mass drug administration in isolated populations. We studied the prevalence of STHs, anemia, and malnutrition in a Matsigenka ethnic group from the Peruvian Amazon. Participants had received two doses of albendazole on consecutive days, 3 months before and again 2 weeks before data collection. Overall, 290 subjects were included. Most were female (53.7%) and 63.9% were  $\leq 19$  years old. Half of the participants had helminth infections. *Trichiuris* (30.2%), hookworm (19.1%), *Ascaris* (17.7%), and *Strongyloides* (5.6%) were the most common helminths. Other helminth ova included *Capillaria hepatica* and *Fasciola*-like eggs. Subjects of 5–19 years (51.8%) and 20–35 years (68.6%) old had helminths more often than those under 5 years (38%) and older than 35 years (41.5%) ( $P = 0.02$ ). Anemia was detected in 41% of children and this was more common in children under 5 years than in those of 5–19 years [odds ratio (OR) = 5.68; 95% CI: 2.71–11.88]. Overall, 72.1% of children were malnourished. Stunting was common in children (70.7%), but wasting was not (2.9%). Despite repeated albendazole administration, this population continued to have a high prevalence of STHs, anemia, and malnutrition. In addition, we detected unusual organisms and organisms that do not respond to albendazole. Further studies are needed to assess the rationale and efficacy of mass chemotherapy for STHs in the Amazon.

**Keywords:** Soil-transmitted helminths, Strongyloides, Mass drug administration, Manu jungle, Amazon, Peru, Albendazole

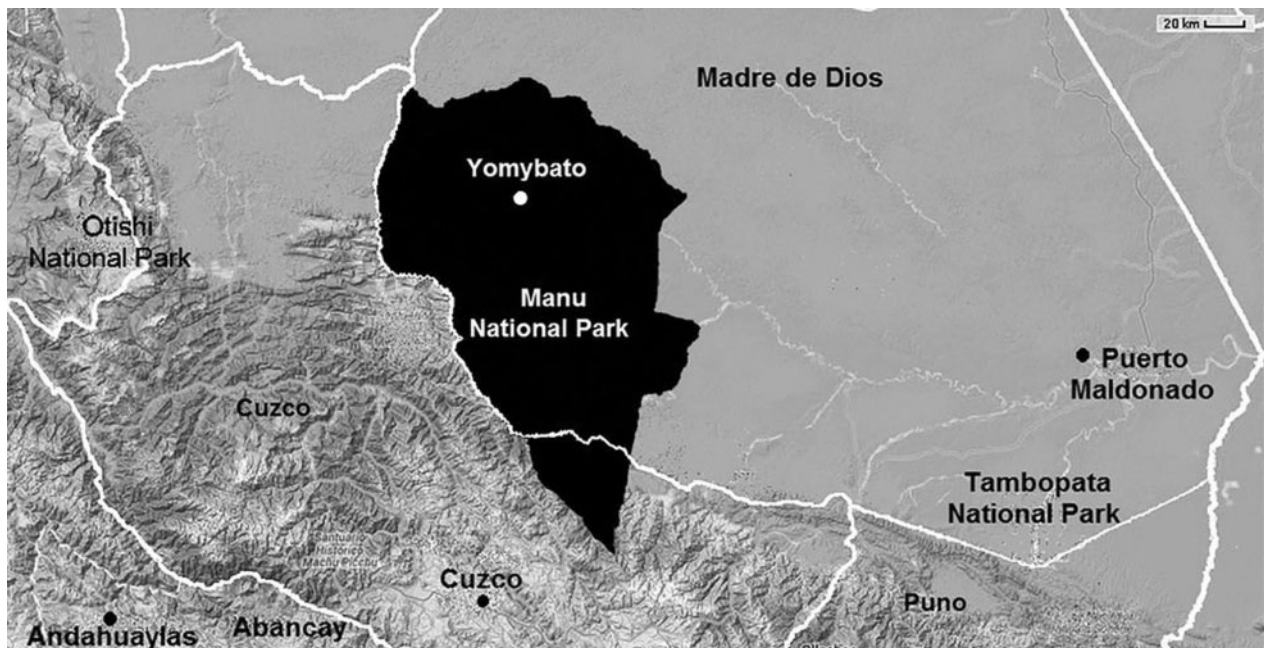
## Background

Soil-transmitted helminths (STHs) are a major health problem in resource-poor countries.<sup>1</sup> The number of *Ascaris lumbricoides*, *Trichuris trichuria*, and hookworm infections worldwide were estimated to be over 1.7 billion in 2010.<sup>2</sup> In Peru, the prevalence of STHs in school-aged children is quite variable (ranging between 1.6% and 78.9%).<sup>3</sup> Larocque *et al.* reported a prevalence of *A. lumbricoides*, *T. trichuria*, and hookworm of 64%, 82%, and 47%, respectively, in pregnant women from Iquitos in the northern Amazon basin of Peru.<sup>4</sup> In contrast, Machicado *et al.* reported a markedly lower prevalence of *A. lumbricoides* (5%), *T. trichiura* (5%), and hookworm (14%) in Shipibo-Conibo indigenous groups from the southern Peruvian Amazon jungle.<sup>5</sup> Briones-Chavez *et al.* reported

significantly higher risk for STHs in settlers than in the indigenous population in a remote region of the Peruvian Amazon.<sup>6</sup> Similar variations are evident in other regions of the Amazon.<sup>7–9</sup> Prevalence reports of STH infections among indigenous populations of the Brazilian Amazon vary between 38% and 80%.<sup>10–13</sup> These findings suggest that infection prevalence may vary significantly depending on groups tested and geographic area. In addition, they highlight the lack of information on factors associated with STHs and their impact in remote Amazon communities. Mass deworming campaigns are being performed in these communities. However, there are limited data on which to assess the rationale or impact of these efforts.

Pre-school and school-aged children are prone to have high worm burdens making them more vulnerable to short and long term sequelae. These include malnutrition, anemia, and impaired cognitive development.<sup>1</sup> In order to tackle this problem; the World Health

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**Figure 1** Geographic location of Yomybato within Manu National Park (adapted from Google maps).

Organization (WHO) recommends periodic administration of anthelmintic drugs.<sup>14</sup> In Peru, it is estimated that three million children between 1 and 15 years of age are in need of STHs mass chemotherapy.<sup>15</sup> However, only 11.2% of Peruvian school-aged children at risk received treatment in 2010.<sup>15</sup> Furthermore, some studies have demonstrated low efficacy of single-dose benzimidazole therapy in hookworm and *Trichuris* infections, suggesting either emergence of drug resistance or rapid re-infection after treatment. Either of these possibilities would compromise the efficacy of mass drug administration.<sup>1,16–18</sup>

An integrated approach including health education, sanitation, and antihelminthics has controlled STHs in some highly endemic regions.<sup>1,18,19</sup> An important obstacle to the success of these efforts is the lack of accurate epidemiological descriptions of STH infections in different geographical and ecological regions.<sup>20</sup> The prevalence of STHs and effectiveness of current WHO control recommendations in remote communities in the Peruvian Amazon have largely been ignored. To generate preliminary data on the rationale and impact of mass drug treatment, we assessed the prevalence of STHs in a Matsigenka community in the Manu area of the Peruvian Amazon after mass administration of albendazole.

## Methods

We performed a cross-sectional study during a health intervention in Yomybato community (S: 11.76085, W: 71.87385) in the Madre de Dios region of Peru (Fig. 1). This community is inside the Manu National Park in a remote area of the Southern Peruvian rainforest only accessible by boat. The population targeted consisted of subjects living in Yomybato community

( $n = 225$ ) and surrounding family clans. They belong almost exclusively to the Matsigenka ethnic group living in voluntary isolation with no commercial exchange with outside communities. Houses were made of wood and palm leaves with dirt floors and no sewage or treated water. Children and women walked bare feet. Female and male subjects from all ages were included in the health intervention organized by 'House of the Children' non-profit organization in November 2012. The non-profit organization personnel were healthcare workers familiar with the area and trained extensively for data collection. Anthropometric measurements, capillary blood, and stool samples were collected from participants by these personnel. These data were used to assess the prevalence of malnutrition, anemia, and STH infections. Health authorities had unexpectedly administered mass chemotherapy to the entire population approximately 3 months and again 2 weeks before specimen collection using two doses of albendazole 400 mg given on consecutive days. No baseline STH prevalence data are available from before mass chemotherapy.

Information on age, sex, weight, and height was used to evaluate the nutritional status of children. The WHO open access Anthroplus software was used to calculate the  $z$ -scores for weight for age, height for age, and Body Mass Index for age as appropriate for each age group. Undernutrition and stunting were defined using the 2007 WHO growth references standards.<sup>21</sup> HemoCue® Hemoglobin tests (HemoCue AB, Ängelholm, Sweden) were used on site to assess the presence of anemia. WHO age- and sex-adjusted hemoglobin cutoff values were used for comparison.<sup>22</sup> One stool sample per subject was collected and immediately preserved in 10% formalin for transport to

Cusco, where they were processed. Owing to the logistic difficulties of working in these highly isolated areas, obtaining additional specimens was not feasible. All stool samples were tested using direct and rapid sedimentation for the detection of intestinal parasites. A modified Kato–Katz test using formalin preserved stools was performed. The quantitative results from this test were excluded since the Kato–Katz is not standardized for preserved stools. All positive tests were confirmed by a second observer.

The data on demographics, anthropometry, and hemoglobin levels were extracted from the non-profit organization records using standardized forms. Data on stool test results were obtained from our laboratory records. The Statistical Package for the Social Science version 18.0 was used for data analysis (SPSS, Inc., Chicago, IL, USA). The prevalence of malnutrition, anemia, and STH infections were calculated. Means ( $\pm$ SD) were calculated for continuous variables and compared using *t*-tests. The Chi square test and Odds ratios were used to evaluate categorical variables. A  $P \leq 0.05$  was considered statistically significant.

The Universidad Peruana Cayetano Heredia Institutional Review Board approved the use of de-identified subjects' information for this study.

## Results

Two hundred and ninety subjects from 52 family clans were included in the study. The mean number of subjects per family was 5.5 ( $\pm 2.6$  subjects). Two hundred and fifteen (74.1%) subjects provided a stool sample and 225 (77.5%) provided a blood sample for hemoglobin testing. Table 1 shows the demographic characteristics of the population. Most (63.2%, 136/215) participants had at least one parasite other than *B. hominis* and 49.7% (107/215) were infected by at least one helminth parasite. Table 2 shows the total and age-stratified prevalence of intestinal parasites in the population studied.

Subjects aged 5–19 years (43/83, 51.8%) and 20–35 years (24/35, 68.6%) had helminths more often than those under 5 years (19/31, 38%) or older than 35 years (14/34, 41.2%) ( $P = 0.03$ ). When comparing all age groups significant differences were found in

the prevalence of hookworm ( $P = 0.01$ ), but not in the prevalence of *Trichuris* ( $P = 0.05$ ), *Ascaris* ( $P = 0.2$ ), or *Strongyloides* ( $P = 0.7$ ) (Table 2). Of the children 19 years old and younger who provided a stool sample for testing, 46% (61/132) were infected with at least one helminth. Those under 5 years were less likely than children of 5–19 years old to have *T. trichura* [odds ratio (OR) = 0.4; 95% CI: 0.17–0.94]. Among children with complete anthropometric data, underweight was encountered in 28.7% (27/94) of children of 0–10 years old, stunting in 70.7% (99/140) of children, and wasting in 2.9% (4/140). Overall, 72.1% (101/140) of children had some kind of malnutrition. Malnutrition was associated with family clan ( $P < 0.01$ ), but not with sex ( $P = 0.5$ ), age group ( $P = 0.1$ ), or helminth infections ( $P = 0.2$ ).

Of those children that provided a blood sample, 41% (60/146) had anemia. Anemia was more commonly diagnosed in children under 5 years old than in children of 5–19 years (67.3% versus 26.6%, OR = 5.68; 95% CI: 2.71–11.88). Children that were underweight had anemia more often than children without it (OR = 2.87; 95% CI: 0.99–8.45). Anemia was not associated with helminths infection ( $P = 0.7$ ) or with any specific species. Anemia did not vary with sex ( $P = 0.1$ ) or family clan ( $P = 0.1$ ).

## Discussion

In this study, we documented the prevalence of STHs in an isolated indigenous population of the southern Peruvian Amazon after mass chemotherapy. Owing to logistical difficulties, we were only able to test a single stool sample and did not use optimal methods for the diagnosis of *Strongyloides* or *Enterobius* infections, which were likely under diagnosed. Nevertheless, half of those studied had documented helminth infections, despite recent albendazole treatment. We documented anemia and malnutrition as important health problems in the area. In other studies, helminth infection is a major risk factor for both anemia and malnutrition.<sup>4,23</sup>

This study was designed to assess baseline prevalence of infection with STHs before chemotherapy. However, the ministry of health independently performed two rounds of mass drug administration prior

**Table 1** Demographic characteristics of the participants

Characteristic		% (n)	Median (interquartile range)
Sex (n = 287)	Female	53.7 (154)	...
	Male	46.3 (133)	...
Age groups (n = 280)	<5 years	22.1 (62)	...
	5–19 years	41.8 (117)	13.9 years (5.9–27.5 years)
	20–35 years	19.3 (54)	...
	>35 years	16.8 (47)	...
Women of reproductive age (n = 280)	Si	36.1 (101)	...
	No	63.9 (179)	...
Number of subjects per clan (n = 290)		...	5 subjects (3–7.25)

to data collection. The post-treatment prevalences of *Ascaris* (18%), *Trichuris* (30%), and hookworm (20%) found in our study are difficult to evaluate as no pre-treatment data were collected. A study in the Northern Peruvian Amazon used single-dose albendazole for deworming children and assessed the prevalence of STHs 2 weeks after treatment. This study documented a post-treatment prevalence of 2% for *Ascaris*, 67% for *Trichuris*, and 6% for hookworm which sharply contrast with the higher prevalence of *Ascaris* and hookworm found in Yomybato.<sup>24</sup> Pre-treatment studies including indigenous populations in the Amazon show a wide variation in prevalence.<sup>7–13</sup> A study of the Achuars in the northern Peruvian Amazon found a prevalence of *Ascaris* and *Trichuris* of 92% and 96%, respectively.<sup>25</sup> Markedly different pre-treatment results were reported in a study of the Shipibo-Conibo in the Madre de Dios region of Peru. The latter showed a prevalence of STHs lower than our post-treatment results (5% for *Ascaris* and *Trichuris* and 15% for hookworm).<sup>5</sup> Studies in Brazil among untreated indigenous groups from Para and Mato Grosso states reported the prevalence of *Ascaris* ranging from 25% to 35% and of hookworm ranging from 19% to 33%. Of note, *Trichuris* prevalence was very low ranging from 0.6% to 1.1%.<sup>10,12,13</sup> Interestingly, the pre-treatment prevalence of STHs in indigenous groups from Brazil was comparable to the post-treatment prevalence in Yomybato.<sup>10,13</sup> The STHs prevalence found in our study 2 weeks after treatment with two doses of albendazole suggests a high pre-treatment prevalence and/or infection intensity of STHs in Yomybato.

The prevalence of *Ascaris* in our population was almost 18% after repeated albendazole treatment before stool sample collection. Other studies have documented reductions in *Ascaris* prevalence of >90% after a single dose of albendazole.<sup>24,26,27</sup> Steinmann

*et al.* documented a reduction of *Ascaris* prevalence of 96% after a single dose of albendazole.<sup>27</sup> The prevalence of *Ascaris* decreased from 70% to 2% 2 weeks after treatment with single dose albendazole in another part of the Peruvian Amazon.<sup>24</sup> We do not believe that the observed prevalence of *Ascaris* was due to re-infection because the last dose of albendazole was given to subjects 2 weeks before collection of stools. In addition, repeated doses (four in a 3-month period) should have been effective even with rapid reinfection and with the limited albendazole activity in juvenile parasite forms.<sup>28–30</sup> Cure rates with albendazole are influenced by the tests used to diagnose the infection, the pre-treatment intensity of infection, and undernutrition.<sup>16,30</sup> The single-stool samples tests used in our study are not particularly sensitive to detect STHs. Thus, from our data, we can only ascertain that undernutrition was common and might have affected the cure rates. It is important to note that cure rates are not the best parameter to assess the efficacy of albendazole based programs.<sup>30</sup> The goal of these programs is not to achieve cure, but rather to limited the morbidity associated with high intensity infections. From our data, we cannot draw conclusions about egg reduction rates or albendazole efficacy. However, the high prevalence of infection detected with insensitive techniques suggests that the current regimen may be suboptimal in this population. Clearly, further research on the effects of mass albendazole in highly vulnerable isolated populations from the Amazon is warranted.

There was a high prevalence of helminths other than *Ascaris*, hookworm, and *Trichuris*. *Strongyloides stercoralis* infection was demonstrated in 6% of individuals. This is almost certainly an underestimation since the methods used are not sensitive enough to reliably detect *Strongyloides* larvae.<sup>31</sup> Similar high prevalence rates of strongyloidiasis have been noted

**Table 2** Age stratified prevalence of intestinal parasites in Yomybato

	Prevalence, % (n)				
	<5 years (n = 50)	5–19 years (n = 83)	20–35 years (n = 35)	>35 years (n = 34)	Total* (n = 215)
Helminths					
<i>Ascaris lumbricoides</i>	12 (6)	16.9 (14)	28.6 (10)	20.6 (7)	17.7 (38)
<i>Trichuris trichura</i>	20 (10)	34.9 (29)	40 (14)	17.6 (6)	30.2 (65)
Hookworm	10 (5)	16.9 (14)	37.1 (13)	20.6 (7)	19.1 (41)
<i>Strongyloides stercoralis</i>	6 (3)	4.8 (4)	2.9 (1)	8.8 (3)	5.6 (12)
<i>Hymenolepis nana</i>	0 (0)	2.4 (2)	2.9 (1)	0 (0)	1.4 (3)
<i>Enterobius vermicularis</i>	6 (3)	1.2 (1)	8.6 (3)	5.9 (2)	4.2 (9)
<i>Capillaria hepatica</i>	0 (0)	1.2 (1)	2.9 (1)	5.9 (2)	2.3 (5)
Fasciola-like eggs	0 (0)	3.6 (3)	5.7 (2)	0 (0)	2.3 (5)
Any helminth infection	38 (19)	51.8 (43)	68.6 (24)	41.5 (14)	49.7 (107)
Protozoa					
<i>Giardia intestinalis</i>	34 (17)	38.8 (33)	17.1 (6)	8.8 (3)	28.4 (61)
<i>Blastocystis hominis</i>	34 (17)	53.7 (44)	51.4 (18)	41.2 (14)	46.3 (99)

Note: \*Numbers in the rows do not sum the total because information about age was missing in 13 subjects.  $P < 0.05$  for *G. intestinalis*, hookworm, and any helminth infection.

elsewhere in the Peruvian Amazon.<sup>32</sup> The health impact and consequences of the infection with *Strongyloides* have largely been ignored in STHs control programs.<sup>23,33</sup> For example, one or two doses of albendazole monotherapy, as used here, have limited impact on *Strongyloides* prevalence or worm burden. Despite the likelihood of significant morbidity and mortality caused by *Strongyloides*, albendazole mass chemotherapy programs continue to be widely used.<sup>33</sup>

Five individuals had *Capillaria hepatica* eggs detected in their stool. Eggs of this parasite are only rarely found in human stool samples. The parasite infects the liver parenchyma, mainly of animals. Subjects passing *C. hepatica* eggs in the stool often have eaten animal liver harboring eggs that are then just passed in the feces. These eggs are not infectious as they require several days in the environment to embryonate.<sup>34</sup> Similar prevalence rates of *Capillaria* have been reported in indigenous groups from Brazil.<sup>10</sup> We also documented eggs that resembled *Fasciola hepatica*. Autochthonous fascioliasis has not been described from the Amazon in Peru. Neither the snail intermediate hosts nor the typical mammalian definitive hosts are reported in the area. Thus, additional studies are needed to confirm the exact identity of these parasites, and molecular studies are in process.

In our study, there was a high prevalence of malnutrition and anemia in children compared to studies among indigenous populations in the Ecuadorian and Bolivian Amazon,<sup>7–9</sup> but comparable to those described in Brazil.<sup>35</sup> While STHs were not significantly associated with anemia and malnutrition in our population, our study design, the small sample size, and the administration of albendazole before our study may have masked a real association. There are clear associations of high burdens of helminths with malnutrition, anemia, and cognitive impairment in other settings, but the health benefits of mass chemotherapy have been difficult to demonstrate. A recent Cochrane review noted better evidence for treatment of infected individuals than for mass chemotherapy.<sup>36</sup> For example, a massive cluster-randomized trial in India failed to demonstrate any clinical benefit of mass chemotherapy.<sup>37</sup> In the current population, albendazole use for mass chemotherapy is further complicated by the presence of helminths that would not be expected to respond to the current regimen (e.g. *Strongyloides* and *Fasciola*). Thus, there is a need to obtain more data on the efficacy of this approach in the Amazon.

In summary, we have documented a high post-treatment prevalence of helminth infections in an isolated indigenous population of the Peruvian Amazon. This population suffers from a high prevalence of

anemia and malnutrition, suggesting a heavy impact of helminths on the population's health. The prevalence of STHs was high despite previous rounds of chemotherapy, suggesting a need to study the factors influencing the response to mass chemotherapy among high-risk isolated populations with limited access to health care in the Amazon.

## Disclaimer Statements

**Contributors** MMC wrote the project, collected the data, analyzed the data, and wrote the manuscript. ML and EA assisted in drafting the project, performed the laboratory work, revised and approved the manuscript. ACW assisted in writing the project and analyzing the data, revised and approved the manuscript.

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**Conflicts of interest** The authors have no conflicts of interest to declare.

**Ethics approval** The Universidad Peruana Cayetano Heredia Institutional Review Board approved the use of de-identify subjects' information for this study.

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