INTESTINAL PARASITIC INFECTION IN THE SURUÍ INDIANS, BRAZILIAN AMAZON

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SUMMARY

This study reports the results of a cross-sectional survey carried out in 2005 to investigate the epidemiology of intestinal parasitism among the Suruí Indians, Brazilian Amazon. A total of 519 stool samples were examined by zinc-sulphate-flotation and formol-ether-sedimentation. Entamoeba histolytica/E. dispar-*positive samples were further tested by ELISA. Thirty-six percent of the subjects were positive for one more helminth species; 70.7% harbored at least one protozoan species. The most frequent helminth was* Hymenolepis nana *(29.5%). Nematodes were rare (hookworm= 3.3%;* Strongyloides stercoralis= *0.2%).* Capillaria *sp. was identified in 5.2% of the samples and one case of parasitism by* Dipylidium caninum *was detected. Prevalence of* Giardia duodenalis *and* E. histolytica/E. dispar *was 16.2% and 12.3%, respectively. Based on ELISA, the prevalence of* E. histolytica *infection was 3.2%. The overall prevalence of intestinal nematode infections depicted in this study was surprisingly low compared to what is often reported for other indigenous populations in the Brazilian Amazon. It is argued that the prevalence of helminths in the Suruí are associated with anthelminthic mass treatment schemes undertaken by the Indian health service, in the absence of other measures. The authors propose that a special program aimed at controlling intestinal parasitism in indigenous communities should step beyond the top-down distribution of medication, but rather be designed in collaboration with the target population, encompassing education, better housing, alternative sewage disposal systems and safe water supply to all villagers.*

Introduction

Intestinal parasites are important causes of morbidity among indigenous peoples of Amazonia. Most studies carried out among different ethnic groups stress a high prevalence of intestinal nematode infections (ascariasis, trichuriasis, hookworms, and strongyloidiasis), often affecting over half the village population, and moderate prevalence of cestode infections (mainly hymenolepiasis). Cases of taeniasis have been rarely reported (Coimbra and Mello, 1981). As for intestinal protozoans, prevalence rates of *Entamoeba histolytica/E. dispar* and of *Giardia duodenalis* infections are variable and may affect nearly one fourth of the population (Lawrence *et al*., 1980; Coimbra and Santos, 1991a, b; Ferrari *et al*., 1992; Kroeger *et al*., 1992; Santos *et al*., 1995; Gómez *et al*., 2004; Rivero *et al*., 2007).

Recent changes experienced by indigenous peoples from Amazonia might greatly influence the epidemiology of intestinal parasites in these communities. The curtailment of population mobility and the adoption of new housing architecture have been pointed out as major drawbacks of such changes, directly implicated in the intensification of transmission of intestinal parasites (Schwaner and Dixon, 1974; Kroeger *et al*., 1992). Against a background of inadequate sanitation and insufficient safe water supply associated with sedentarization, environmental contamination of indigenous villages with infective protozoan cysts as well as eggs and/or larvae of helminths rapidly builds up and sustains year-round transmission of intestinal parasites at high levels of endemicity in these populations (Lawrence *et al*., 1980; Coimbra and Mello, 1981; Chernela and Thatcher, 1989; Coimbra and Santos, 1991b; Fitton, 2000; Gómez *et al*., 2004). If these factors might intensify parasite transmission, the implementation of basic sanitation associated with the widespread use of antihelminthic drugs, often cheap and readily available in the health services, might help to reduce prevalence.

The present study was carried out in the context of a

KEYWORDS / Amazonia / Epidemiology / Helminth Control / Intestinal Helminths / Intestinal Protozoa / South American Indians /

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PARASITOSIS INTESTINAL EN LOS INDIOS SURUÍ, AMAZONIA BRASILERA

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RESUMEN

Se reportan los resultados de un estudio transversal llevado a cabo en 2005 sobre la epidemiología del parasitismo intestinal en indios Suruí de la amazonia brasilera. Un total de 519 muestras de heces fueron examinadas por flotación en sulfato de zinc y sedimentación en etil-éter. Muestras positivas para Entamoeba histolytica/E. dispar *fueron testeadas por ELISA. Una o más especies de helmintos estuvieron presentes en 36% de los sujetos y 70,7% presentaron al menos una especie de protozoario. El helminto más frecuente fue* Hymenolepis nana *(29,5%). Los nematodos fueron escasos (anquilostomo= 3,3%;* Strongyloides stercoralis= *0.2%). Se identificó* Capillaria *sp. en 5,2% de las muestras y se detectó un caso de parasitismo por* Dipylidium caninum. *Las prevalencias de* Giardia duodenalis *y* E. histolytica/E. dispar *fueron 16,2% y 12,3%, respectivamente. Según ELISA la prevalencia de infección por* E. histolytica *fue 3,2%. La prevalencia de infección por nematodos fue sorpresivamente baja en comparación con reportes frecuentes en otras poblaciones indígenas de la amazonia brasilera. Se argumenta que los cambios en la prevalencia de helmintiasis en los Suruí se asocian a tratamientos masivos con antihelmínticos llevados a cabo por el servicio de salud de indígenas, en ausencia de otras medidas. Se propone que un programa especial orientado a controlar el parasitismo intestinal en poblaciones indígenas debe desligarse de la distribución de medicación, sino ser diseñado en colaboración con los habitantes locales, abarcando educación, mejores viviendas y sistemas de drenaje y disposición de residuos, y suministro de agua segura a todos los pobladores.*

INFECÇÃO POR PARASITOSES INTESTINAIS ENTRE OS ÍNDIOS SURUÍ, AMAZÔNIA BRASILEIRA

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RESUMO

Este trabalho apresenta os resultados de um estudo seccional conduzido em 2005 que visou investigar o perfil epidemiológico das parasitoses intestinais entre os índios Suruí, localizados em Rondônа, Amazônia brasileira. Um total de 519 amostras fecais foi examinado pelas técnicas de flutuação com sulfato de zinco e sedimentação com formol-éter. Amostras positivas para Entamoeba histolytica/E. díspar *foram posteriormente testadas pelo método ELISA. Trinta e seis por cento dos indivíduos encontravam-se positivos para pelo menos uma espécie de helminto; 70,7% abrigavam pelo menos uma espécie de protozoário. O helminto mais freqüente foi* Hymenolepis nana *(29,5%). Nematódeos foram raros (ancilostomídeos= 3,3%;* Strongyloides stercoralis= *0,2%).* Capillaria *sp. foi identificado em 5,2% das amostras e um caso de parasitismo por* Dipylidium caninum *foi observado. As prevalências de* Giardia duodenalis *e* E. histolytica/E. dispar *foram de 16,2% e 12,3%, respectivamente. Baseada no teste ELISA, a prevalência de infecção por* E. histolytica *foi de 3,2%. A prevalência total de infecção intestinal por nematódeos demonstrada neste estudo foi surpreendentemente baixa se comparada ao que tem sido geralmente reportado para outras populações indígenas da Amazônia brasileira. Argumenta-se que a baixa prevalência de helmintos entre os Suruí está em larga medida associada a esquemas de tratamento em massa com antihelmínticos dispensados pelo serviço de saúde indígena. Os autores propõem que um programa especial destinado ao controle de parasitoses intestinais em comunidades indígenas deve ir além da distribuição de medicamentos. Preferencialmente, deve ser planejado em colaboração com a população alvo, considerando aspectos educacionais e visando a melhoria nas moradias e no sistema de esgoto e de fornecimento de água.*

rapidly changing Indian society of southwestern Brazilian Amazonia that is highly exposed to Western medical services, the Suruí. The study was designed to examine the prevalence of intestinal parasitism taking into consideration two important pieces of information: a) according to previous assessments of intestinal parasitism carried out in the Suruí, the prevalence of major parasitic helminths and protozoa was very high (Coimbra and Mello, 1981; Coimbra and Santos, 1991a); and b) in recent years the population has been receiving systematic health care by the Brazilian government, which include the implementation of basic sanitation in the villages and primary health care. As far as we are aware, the present study is the first of its kind carried out in an indigenous Amazonian society, as it provides a diachronic perspective in the interpretation of parasitological results by comparing the present-day situation among the Suruí with a previous survey. The study also aims at contributing to the understanding of the epidemiology of intestinal parasitism in indigenous populations in Amazonia in order to assist in the design of more effective and culturally-sensitive control measures.

Population and Methods

Fieldwork and setting

Fieldwork was carried out between February and March 2005 among the Suruí people of the Sete de Setembro Indian reserve, on the border between the states of Rondônia and Mato Grosso, southwestern Brazilian Amazon (~60-61ºW and 10-12ºS). The landscape is dominated by inter-fluvial tropical rain forest and is crisscrossed by small to medium-size rivers. Annual rainfall in the state of Rondônia presents a north-south gradient that varies from 2500 to 1750mm. Mean annual temperature is 24-26ºC; lower temperatures are recorded during the short dry season (June-August) when average temperature ranges between 20-22ºC (Nimer, 1979).

At the time of fieldwork the Suruí totaled 993 individuals (nearly 51% of the population was <15 years old) distributed over 11 villages. Nine villages, including the two largest ones, were surveyed by the research team, accounting for nearly 80% of the total population.

Physical examinations were carried out by one of the authors (Palhano-Silva) at a field clinic that was estab-

lished in every village. No specific sampling technique was used. An attempt was made to examine all willing individuals of both sexes, independent of age. At the time of examination, a plastic container marked with an identification number and the name of the person was handed out along with instructions about how to collect a stool sample. Samples returned next morning were split into two subsamples: one was preserved with 5% formalin for examination by light microscopy and the other frozen at -20°C for ELISA testing. A household survey aimed at characterizing Suruí housing conditions and sanitation was also carried out. Data collected included house structure (type of walls, roof, and floor), availability of sanitary facilities and sources of drinking water.

Laboratory analyses

Stool specimens were examined by zinc sulphate flotation and formol-ether sedimentation techniques. One slide was prepared from each stool sample processed by each technique. Slides were independently examined by two of the authors (Palhano-Silva and Bastos). The presence of parasites was confirmed when eggs, cysts and/or larvae were observed with any of the two techniques.

In order to estimate *E. histolytica* infection, samples kept in the freezer were defrosted at room temperature and used in a monoclonal ELISA essay for *E. histolytica* adhesin (Entamoeba histolytica II -TechLab Inc., Blacksburg, VA, USA). ELISA was performed only on those samples that tested positive for *E. histolytica/E. dispar* under the microscope.

Management of patients and ethics

Subjects diagnosed with intestinal parasites were referred to the Indian health service in Cacoal for treatment. A single dose of 400mg of Albendazole was prescribed against nematode infections, a single dose of 5-10mg/Kg Praziquantel against cestodes, and Metronidazole 500-750mg three times a day against protozoan infections by *G. duodenalis* and/or *E. histolytica/E. dispar* infections, following standard dosages.

This study is part of a broader project about the health of Suruí Indians, whose major focus is the epidemiology of tuberculosis, but which also includes the general health and nutritional assessment of the population (Basta *et al.*, 2006; Orellana *et al.*, 2006). Guidelines for research in humans determined by the Brazilian National Committee on Research Ethics (CONEP) of the Ministry of Health were followed. A research permit was also obtained from the National Indian Foundation (FUNAI). A consent form was signed by the leaders of the surveyed villages. All field procedures were undertaken in the company of a local Suruí health agent indicated by the community, who helped explain the objectives of the research plan and acted as an interpreter when necessary.

Statistical analyses

Prevalence ratios were used to assess differences in proportions between age groups and sexes for the most prevalent helminths and protozoans. P values <0.05 were considered statistically significant and 95% confidence intervals were constructed around estimates. All statistics were performed using SPSS version 11 (SPSS Inc., Chicago, IL, USA).

Results

A total of 786 Suruí individuals of all ages and both sexes (79.2% of the total population in the visited villages) were examined. There was no refusal for physical examination (individuals who were not assessed were absent from the village during our visit). Abdominal complaints (such as pain, diarrhea, nausea and/or epigastralgia) were the most common symptoms, referred by 90% of the subjects. Respiratory symptoms (mostly dry cough) and arthralgia were also common complaints. No associations between symptoms and intestinal parasitism were observed.

Approximately 98% of Suruí houses have walls made of wood boards or bricks (mixed constructions were observed). Cemented floors are present in 95.4% of the houses. Roofs are often made with simple zinc corrugated sheets (77.0%); roofing tiles were observed in 20.8% of the houses. All households referred the village well as their major source of water for domestic use. These wells were excavated by the Indian health service and usually have an electric pump in order to distribute water to one or more public faucet taps scattered throughout the village. As for sewage disposal, collective pit latrines installed by the Indian health service are the rule and can be seen in the back of almost every house (93.8%) in all villages. These are shallow holes covered with a wooden platform that has an opening in the middle, encircled by a rudimentary wall made of wood boards painted white. Very few houses (6.0%) have private indoor privies with a flushing system.

A total of 519 stool samples were processed, representing 66.0% of the subjects who underwent physical examinations. Losses were determined by insufficient stools turned in or by the person's inability to collect any specimen within the time-span given.

Table I summarizes the findings for protozoa and helminths by sex and age groups. The overall prevalence of intestinal protozoans was 70.7%. While the most affected age group by *E. histolytica/E. dispar* was that of adults >40 years old (19.7%), for *G. duodenalis* children 5-9 years were the most affected (28.8%). Helminths were detected in 36.0% of the samples examined. Overall prevalence of hymenolepiasis (i.e., *H. nana* and/or *H. diminuta*) was 30.1%, with the highest prevalence observed in children 5-9 years old (51.0%). The only nematodes detected were hookworms (3.3%) and *S. stercoralis* (0.2%). It is worth mentioning the absence of *Ascaris lumbricoides* and *Trichuris trichiura*, often reported in previous surveys of the kind. On the other hand, the finding of two helminth species not typically reported in surveys carried out in Amazonia should be highlighted. Twenty-eight subjects of various ages and both sexes presented *Capillaria* sp. eggs in the stools and the sample from one adult woman was positive to *Dipylidium caninum*. Considering the rarity of this finding, a new stool sample was collected from this person two months later and again proved positive to *D. caninum*. No association between prevalence of protozoan and/or helminth infection was discernible. Parasitism by more than one species of helminth and/or protozoa was detected in 46.2% of the samples.

For the three most frequent parasite species found (*Hymenolepis* spp., *G. duodenalis* and *E. histolytica/E. dispar*), ratios of prevalence of infection between adults and children were constructed (the ratio's numerator indicates the proportion of a given infection in adults, while the denominator indicates its relative weight in children). Prevalence ratios for hymenolepiasis and giardiasis were, respectively, 0.48 (95% confidence interval: 0.34-0.68) and 0.31 (95% confidence interval: 0.18-0.54), indicating that children <10 years old

TABLE I
PREVALENCE RATES OF INTESTINAL PROTOZOA AND HELMINTHS IN THE SURUÍ INDIANS, BY SEX AND AGE GROUPS, BRAZILIAN AMAZON (2005)

Age (years)		n	Eh/Ed	Ec	En	Ib	Gd	Bc	Bh	Hkw	Hn	Hd	Ss	Cap	Dc
0-4	Male	42	3 (7.1)	19 (45.2)	1 (2.4)	-	9 (21.4)	-	4 (9.5)	1 (2.4)	14 (33.3)	3 (7.1)	-	1 (2.4)	-
	Female	52	2 (3.8)	17 (32.7)	8 (15.4)	-	11 (21.2)	-	3 (5.8)	2 (3.8)	11 (21.2)	3 (5.8)	1 (1.9)	1 (1.9)	-
	Both	94	5 (5.3)	36 (38.3)	9 (9.6)	-	20 (21.3)	-	7 (7.4)	3 (3.2)	25 (26.6)	6 (6.4)	1 (1.1)	2 (2.1)	-
5-9	Male	64	8 (12.5)	42 (65.6)	15 (23.4)	1 (1.6)	16 (25.0)	1 (1.6)	7 (10.9)	3 (4.7)	36 (56.3)	6 (9.4)	-	2 (3.1)	-
	Female	40	5 (12.5)	23 (57.5)	8 (20.0)	1 (2.5)	14 (35.0)	-	4 (10.0)	2 (5.0)	17 (42.5)	-	-	1 (2.5)	-
	Both	104	13 (12.5)	65 (62.5)	23 (22.1)	2 (1.9)	30 (28.8)	1 (1.0)	11 (10.6)	5 (4.8)	53 (51.0)	6 (5.8)	-	3 (2.9)	-
10-19	Male	49	3 (6.1)	20 (40.8)	10 (20.4)	1 (2.0)	8 (16.3)	-	4 (8.2)	1 (2.0)	14 (28.6)	2 (4.1)	-	4 (8.2)	-
	Female	84	12 (14.3)	45 (53.6)	17 (20.2)	2 (2.4)	12 (14.3)	-	3 (3.6)	3 (3.6)	27 (32.1)	1 (1.2)	-	1 (1.2)	-
	Both	133	15 (11.3)	65 (48.9)	27 (20.3)	3 (2.3)	20 (15.0)	-	7 (5.3)	4 (3.0)	41 (30.8)	3 (2.3)	-	5 (3.8)	-
20-40	Male	55	10 (18.2)	25 (45.5)	7 (12.7)	2 (3.6)	3 (5.5)	-	7 (12.7)	4 (7.3)	9 (16.4)	3 (5.5)	-	5 (9.1)	-
	Female	67	8 (11.9)	38 (56.7)	8 (11.9)	-	7 (10.4)	-	3 (4.5)	-	14 (20.9)	2 (3.0)	-	4 (6.0)	1 (1.5)
	Both	122	18 (14.8)	63 (51.6)	15 (12.3)	2 (1.6)	10 (8.2)	-	10 (8.2)	4 (3.3)	23 (18.9)	5 (4.1)	-	9 (7.4)	1 (0.8)
>40	Male	31	7 (22.6)	18 (58.1)	6 (19.4)	1 (3.2)	2 (6.5)	-	2 (6.5)	1 (3.2)	7 (22.6)	-	-	3 (9.7)	-
	Female	35	6 (17.1)	20 (57.1)	9 (25.7)	2 (5.7)	2 (5.7)	-	3 (8.6)	-	4 (11.4)	-	-	5 (14.3)	-
	Both	66	13 (19.7)	38 (57.6)	15 (22.7)	3 (4.5)	4 (6.1)	-	5 (7.6)	1 (1.5)	11 (16.7)	-	-	8 (12.1)	-
Total	Male	241	31 (12.9)	124 (51.5)	39 (16.2)	5 (2.1)	38 (15.8)	1 (0.4)	24 (10.0)	10 (4.1)	80 (33.2)	14 (5.8)	-	15 (6.2)	-
	Female	278	33 (11.9)	143 (51.4)	50 (18.0)	5 (1.8)	46 (16.5)	-	16 (5.8)	7 (2.5)	73 (26.3)	6 (2.2)	1 (0.4)	12 (4.3)	1 (0.4)
	Both	519	64 (12.3)	267 (51.4)	89 (17.1)	10 (1.9)	84 (16.2)	1 (0.2)	40 (7.7)	17 (3.3)	153 (29.5)	20 (3.9)	1 (0.2)	27 (5.2)	1 (0.2)

Eh/Ed: *Entamoeba histolytica/ dispar*, Ec: *Entamoeba coli*, En: *Endolimax nana*, Ib: *Iodamoeba butschlii*, Gd: *Giardia duodenalis*, Bc: *Balantidium coli*, Bh: *Blastocystis hominis*, Hkw: Hookworms, Hn: *Hymenolepis nana*, Hd: *Hymenolepis diminuta*, Ss: *Strongyloides stercoralis*, Cap: *Capillaria* sp., Dc: *Dipylidium caninum*.

constitute the most affected age group for these parasitic diseases. The infection prevalence ratio for amoebiasis was 1.83 (95% confidence interval: 1.06-3.17), which shows that this infection is almost twice more frequent among adults than children.

A total of 64 *E. histolytica/E. dispar* positive samples under microscopy underwent ELISA, 17 of which tested positive for *E. histolytica*. Therefore, based on ELISA results, the prevalence of *E. histolytica* infection in the population assessed was 3.2%. These include individuals of both sexes (53% males) and all age groups.

Table II compares the prevalence of major intestinal parasites observed in 2005 with previous data collected in 1987 for Suruí children <10 years old (Coimbra and Santos, 1991a) that was analyzed by the same technique and whose sample comprised 95% of the population in this age group. There have been sharp decreases in prevalence for most nematode species; frequencies dropping from >60% to <5% for *A. lumbricoides* and hookworms. Substantial decreases were also observed in the prevalence of *S. stercoralis* and *T. trichiura*. Notwithstanding, while infection frequencies dropped for all nematode species, cestode (*Hymenolepis* spp.) prevalence increased from 19.4 to 39.4%.

TABLE II
COMPARISON OF INTESTINAL PARASITES PREVALENCE AMONG SURUÍ CHILDREN UNDER 10 YEARS OF AGE, 1987 AND 2005

Year of survey	Sample size	Eh/ Ed	Gd	Hn	Hkw	Ss	Al	Tt	Ev
1987	124	21.8	46.8	19.4	76.6	41.1	64.5	27.4	15.3
2005	198	9.1	25.2	39.4	4.0	0.5	0.0	0.0	0.0

Eh/Ed: *Entamoeba histolytica/E. dispar*, Gd: *Giardia duodenalis*, Hkw: Hookworms, Hn: *Hymenolepis nana*, Ss: *Strongyloides stercoralis*, Al: *Ascaris lumbricoides*, Tt: *Trichuris trichiura*, Ev: *Enterobius vermicularis*.

Discussion and Conclusions

The overall prevalence of intestinal nematode infections depicted in this study was surprisingly low compared to the 40-60% often reported for other indigenous populations in the Brazilian Amazon (Chernela and Thatcher, 1989; Confalonieri *et al*., 1989; Salzano, 1990; Coimbra and Santos, 1991b; Santos *et al*., 1995). Previous surveys carried out in the Suruí (Coimbra and Mello, 1981; Coimbra and Santos, 1991a) revealed a completely different picture, more similar to what most authors have found in other indigenous communities in Amazonia, i.e., high prevalence of infection by *A. lumbricoides*, *T. trichiura* and hookworms, with over 50% of the population harboring at least one helminth species. These early surveys carried out among the Suruí also showed high infection rates by *S. stercoralis* (30%), the highest so far reported for an indigenous group in Amazonia. Interestingly, when comparing data for children below age 10 in 1987 and 2005, the present study revealed a much higher prevalence of hymenolepiasis.

It is well established that environmental contamination with infective parasite forms (e.g., eggs, larvae, cysts) is critical to the epidemiology of intestinal parasitism. For this reason, housing and sanitation play a key role in control strategies. Educational interventions to promote better hygiene (e.g., food preparation, clean water storage, housekeeping) and periodic de-worming aimed at target populations (e.g., children) are considered important supplementary measures (Okun, 1988; Albonico *et al*., 1999; Scolari *et al*., 2000; Asaolu and Ofoezie, 2003; Urbani and Albonico, 2003; Sur *et al*., 2005).

Health services provided to indigenous peoples in Brazil have gone through major changes in the last decade. A new system, integrated with the national unified health system (known as SUS) was initiated in 1999 (Garnelo *et al*., 2003). Primary care is to be dispensed at the village level by Indian health agents.

Multi-professional health teams provide continuous supervision, and patients in need of further assistance are referred to Indian health clinics (*Casa de Saúde do Índio*) or general hospitals in the nearest town. Another aspect that has been emphasized is village sanitation, focusing on the construction of pit-latrines and collective wells.

Despite its many limitations (e.g., lack of personnel and uncertain budget), the current system has facilitated the access of Indian patients to health services. A greatly increased investment of resources from higher levels of the system to the local levels has produced at least one immediate result: village health posts are stocked with an unprecedented diversity of drugs. Among these are the antihelminthics. During fieldwork it was found that the Suruí had been under a mass treatment regime for at least the previous 18 months. According to the head nurse of the local Indian health clinic in the city of Cacoal, to where Suruí patients are referred, the following bi-annual regime was being applied at the time: Albendazole 400mg single dose for adults and children ≥10 years old, and Mebendazole 100mg twice daily during three days for children <10 years old. The regime was repeated after one week. The last de-worming campaign among the Suruí had been carried out at all villages in the semester previous to this survey.

Unfortunately, it appears that the ready availability of unexpensive anti-parasitic drugs in Brazil, coupled with the prevailing view among health professionals that these are relatively safe and can be administered with minimal technical supervision, has led to the adoption of unsystematic de-worming campaigns by the Indian health service. Usually, baseline surveys are not conducted, which precludes the proper evaluation of the intervention, and no clear-cut intervals between mass treatments are established. The long-term challenge, however, remains, since as it has been exhaustively demonstrated, re-infection is likely to take place rapidly. Drug mass therapy may reduce morbidity in the short run but it does not ensure sustained control of intestinal parasitism (Machado *et al*., 1996; Idris *et al*., 2001; WHO, 2001; Beltramino *et al*., 2003; Zani *et al*., 2004). This can only be achieved by significantly reducing both fecal contamination of the environment and human exposure to potentially contaminated sources. Moreover, independently of its practicality and minimal risks for human subjects, the indiscriminate distribution of antihelmintics to Indian villagers can produce at least one unwanted effect in the long run: the emergence of resistant helminth strains (Geerts and Gryssels, 2001; Albonico, 2003).

The efficacy of such unsystematic distribution of antihelmintics can also be challenged on the basis of its lack of specificity. Although this survey identified hymenolepiasis as the major helminth problem in the population, the drug regime prescribed by the Indian health service was clearly not adequate to eliminate cestodes (Amato-Neto *et al*., 1990; MeCraeken *et al*., 1992; Horton, 2000; Juan *et al*., 2000). Over 30% of the general population is infected with *H. nana/H. diminuta* and nearly 50% of the children <10 years old harbor the parasite. As noted by Mirdha and Samantray (2002), the clinical and epidemiological importance of hymenolepiasis should not be overlooked, especially in children, due to its implication in immunosuppression and flattered growth.

Various authors have highlighted that it does not necessarily follow that simply increasing the number of latrines in a community achieves a significant reduction in the rate of parasite transmission (Asaolu and Ofoezie, 2003; Corrales *et al*., 2006). As shown in this study, most Suruí families have access to pit-latrines. These are usually installed outdoors, at the back of the houses, and are intended for collective use. Through observation and informal conversations with Suruí villagers, however, one finds that these are not always used (as is revealed by the dense grasses that often encircle the little latrines), with the excuse of insufficient privacy, bad smell and the constant nuisance of flies.

This study also revealed some further unusual parasitological findings that deserve comment. The presence of *Capillaria* sp. eggs in stools has been reported in other studies carried out among indigenous peoples in the Amazon (Coimbra and Mello, 1981; Santos *et al*., 1985, 1995; Carme *et al*., 2002). This has been interpreted as resulting from transit eggs probably due to the recent ingestion of lightly cooked game liver. Among the Suruí game liver is considered a delicacy. True parasitism by *C. hepatica* does not pass eggs in stools, and human intestinal parasitism by any other species of *Capillaria* is unknown in South America (Bhattacharya *et al*., 1999). The finding of *D. caninum* is rather unusual in surveys carried out throughout Brazil and probably indicates close human-dog contact (Marinho and Neves, 1979). Suruí villages have countless free-roaming dogs, increasing the likelihood of human exposure to zoonotic helminths.

As already indicated, the changing pattern in intestinal parasitic infections (especially nematodes) among the Suruí is probably related to recent interventions undertaken by the Indian health service with a focus on mass chemotherapy. Notwithstanding, the high prevalence of intestinal protozoa infections in general clearly indicates that fecal-oral routes of transmission have not been effectively eliminated in the Suruí. Protozoa species well known for their role in determining serious gastrointestinal ailments were detected during the study, and the presence of *E. histolytica* in the population was confirmed by ELISA. Although more severe forms of amoebiasis and giardiasis are rare, both *E. histolytica* and *G. duodenalis* can cause acute and persistent diarrhea and may be implicated in nutrient malabsorption, leading to growth and development retardation (Lima and Guerrant, 1992; Farthing, 2002; Gendrel *et al*., 2003). This constitutes an issue of concern since protein-energy malnutrition affect one-fourth of Suruí children <10 years old and the prevalence of anemia in this age group is 80% (Orellana *et al*., 2006). Although the precise diagnosis of protozoal parasites by conventional microscopy presents difficulties, enzyme immunoassays and molecular techniques are not readily available in laboratory routine by the Brazilian public health service.

A sustainable program for the control of intestinal parasites in the Suruí should consider alternative ways for environmental sanitation that take into account Suruí perceptions about gastrointestinal disease, housing, personal hygiene and environmental health. Top-down approaches like those observed are unlikely to produce long-lasting results. A special consideration should be given to children, since they tend to be more susceptible to gastrointestinal infection in general. For this reason, a sanitation program should be designed in collaboration with the target population, encompassing educational measures, better housing, an alternative sewage disposable system, and safe water supply to all villagers. These measures will yield results far beyond the control of specific diseases or parasites, raising health standards more effectively.

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