

Epidemiology of Hookworm Infection in Itagua, Paraguay: a Cross Sectional Study

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*A cross-sectional study in Itagua, Paraguay tested 192 people for the presence, intensity and species of hookworm infection. Fifty-nine percent of these individuals were found to be infected. Intensity of infection was determined on 92% of infected individuals by quantitative egg counts. The high intensity hookworm infections, which cause the greatest morbidity, were clustered between the ages of five and 14 years. No differences were seen between genders. The species of hookworm was determined for parasites reared from 72% of infected individuals. Both *Necator americanus* and *Ancylostoma duodenale* were identified, although the former species predominated. We conclude that hookworm infection continues to be a public health problem in Paraguay, particularly among children and adolescents who suffer from high intensity infections. *A. duodenale* continues to persist in the Western Hemisphere and has not been completely displaced by *N. americanus*.*

Key words: *Necator americanus* - *Ancylostoma duodenale* - hookworm - Paraguay - epidemiology

Human hookworm infection is a world wide public health threat affecting up to one billion people in the underdeveloped nations of the tropics and sub-tropics (Gilles 1985). Adult hookworms cause chronic blood loss by rupturing the mucosal lining of the intestine. Heavily infected individuals suffer a large blood loss that leads to chronic hookworm anemia. In children, hookworm anemia leads to profound alterations in intellectual, cognitive, and physical growth. Hookworm infection continues to be a problem in South America. In 1987, 72 million people were estimated to be infected with hookworm (Apt 1987). Most infections in Latin America were associated with the species *Necator americanus* ("American killer"), while *Ancylostoma duodenale* infections were considered rare.

Hookworm was first identified as an important pathogen in Paraguay in the 1920's when Soper detected an overall prevalence of 98%. Of interest was the finding that *A. duodenale* was the predominating species among isolated indigenous groups west of the Paraguay River, whereas *N. americanus* predominated on the east. Soper speculated that *A. duodenale* was the indigenous hookworm, but was gradually displaced by *N. americanus* when it was introduced east of the Paraguay River by Brazilian troops during the War of the Triple Alliance (1865-1870) (Soper 1927). Hookworm continues to be present in areas of Brazil. Recently a study in córrego do Bernardo in Minas Gerais, Brazil found hookworm prevalence to be 57% (Webster et al. 1997). Interestingly, *A. duodenale* has also been found in Brazil. In a study of Grande São Paulo, Brazil, 40% of those found to be infected harbored *A. duodenale* (Correa et al. 1979).

Presence of *A. duodenale* is significant because it differs in modes of infection and virulence. Although both *N. americanus* and *A. duodenale* are transmitted through skin penetration, *A. duodenale* differs from *N. americanus* in that it is also transmitted through the oral route and is hypothesized to infect through maternal breast milk. In addition, *A. duodenale* causes a greater blood loss making it more virulent (Hotez 1989). This study examines the prevalence, intensity and predominant

Supported by the Wilbur G. Downs International Travel Fellowship and the Yale University Medical School Research Fund.

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Received 13 October 1998

Accepted 12 May 1999

ing species of hookworm infection among the people living in Itagua, a semi rural region 30 km from Asuncion.

MATERIALS AND METHODS

Fieldwork was conducted in Itagua, Paraguay from July to late August, 1996. Itagua lies on the coordinates S 57° 04' and W 26° 09', approximately 30 km from Asuncion. The population of Itagua is approximately 38,000 people, of which 60% are classified as rural. The population density is between 200 to 399 habitants/km². Adult males generally work in Asuncion while women often work selling meat from local slaughterhouses. The main spoken language of the area is Guaraní, an indigenous language, although Spanish is generally understood.

Two isolated areas of Itagua, separated by approximately 3.5 km, were chosen. All families living in the two selected areas were asked to participate. A 120 ml volume plastic container was provided for each member of the family, with instructions to fill at least one-half of the container with feces. Each container was assigned a number, corresponding to the individual's name, age, sex and residence. Informed consent was obtained from the mother of the family, who, in turn provided family members with the numbered containers for fecal samples. All infected individuals were offered specific anthelmithic chemotherapy with either mebendazole or albendazole as per the preference of local physicians (HIC # 8785).

Fecal samples were collected the following afternoon and processed the following morning at the Universidad Nacional de Asuncion. Samples were processed for identification of parasites using direct observation of fecal smears after concentration. Negative samples were re-examined by flotation with saturated NaCl solution. Quantitative egg counts were determined using the McMaster method. In order to identify hookworm species, third stage larvae were isolated by the method of Harada and Mori (1951) and then examined by light microscopy.

RESULTS

A total of 192 people from 35 families was included in the study. The compliance rate of individuals asked to participate in the study was 88%. The ages of the study population ranged from 5 months to 81 years, with a mean and median age of 18 years and 10 years respectively. The age and sex distribution of the study population is shown in Fig. 1.

The overall hookworm prevalence was 59%. The hookworm prevalence of males (64%) was higher than that of females (54%), although the

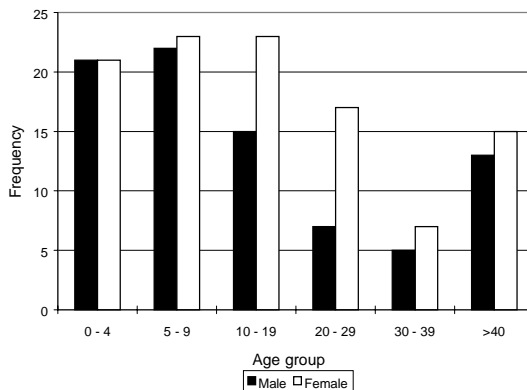


Fig. 1: age and sex distribution of the study population in Itagua, Paraguay.

difference was not statistically significant (p -value: 0.318). Age specific prevalence ranged from 43% (>40 age group) to 79% (19-29 age group). The difference between the lowest and highest age specific prevalence was significant at a $p < 0.05$ level (Pearson Chi Square=7.08, p -value: 0.008). Hookworm prevalence increased with age, peaking in the 19-29 age group (Fig. 2).

Quantitative egg counts were performed on 103 of the 112 infected individuals (92% of the infected population). Intensity of infection ranged from 0 to 8,200 EPG. Worm burden was over-dispersed within the infected population (Fig. 3). Sixty percent of the infected population had less than 1,000 EPG, and only 9% of the population had more than 3,000 EPG. Eighty-eight percent of high intensity infections (>3,000 EPG) occurred between the ages of 5 and 14 (Fig. 4). A five-year-old boy had the highest quantitative egg count in the study (8,200 EPG). Intensity of hookworm infection did not differ by sex. Egg counts were performed on 49 and 54 males and females, respectively. The mean hookworm intensity for males was 1,139 EPG, while that of females was 1,089 EPG.

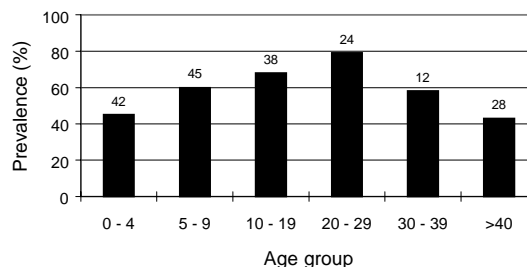


Fig. 2: age specific prevalence of hookworm infection. Numbers above bars are the total number of people in the category.

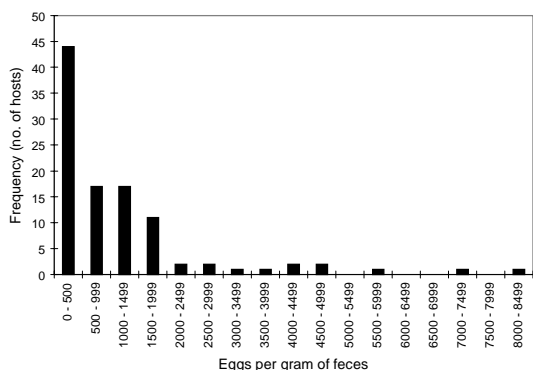


Fig. 3: distribution of hookworm burden, measured as eggs per gram among people in Itagua, Paraguay.

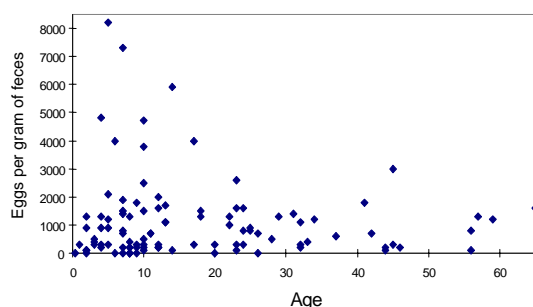


Fig. 4: relationship between age and intensity of infection.

Morphological identification of the third stage larva was used to determine the species of hookworm-infection. Species of hookworm were identified in 81 of the 112 hookworm-infected individuals (72% of infected population). Of those infected with hookworm 73% were infected with *N. americanus*, 15% with *A. duodenale* and 12% with both *A. duodenale* and *N. americanus* (mixed infection). Eleven out of the 12 *A. duodenale* infections occurred in children less than 15 years of age. Infections with *Ascaris lumbricoides* and *Hymenolepis nana* were also observed, occurring in 8% and 7% of the population respectively.

DISCUSSION

Anthelmintic chemotherapy, education and aggressive sanitation, including the construction of latrines, resulted in the reduction of hookworm prevalence from 98% in 1924 to 47% four years later. Yet these measures have failed to eradicate hookworm from Paraguay. This study found a prevalence rate of 59% in the communities sampled. Accordingly, a study of over 10,000 individuals conducted between the years 1963 to 1975 in nine different areas of Paraguay, found an overall prevalence rate of 59% (Canese 1992). The study population was not a random sample, rather

studied everyone in two isolated areas of Itagua. Due to the high level of participation within the two areas, it is not believed that selection bias affected the results of this study. This study found that hookworm prevalence was related to age of host, but not to gender. Hookworm prevalence increased with age, reached a maximum of 79% in the 20-29 age group, then decreased.

The severity of hookworm pathology is directly related to the number of worms harbored by an individual. We found that intensity of hookworm infection exhibited an over-dispersed distribution. Although a majority of the population was infected, only 9% harbored infections greater than 3,000 EPG, putting them at greatest risk for hookworm-related anemia. Similar patterns have been reported in other hookworm endemic areas such as Papua New Guinea (Pritchard et al. 1990), West Bengal (Nawalinski et al. 1978), and Zimbabwe (Bradley et al. 1993). Intensity of infection was determined using quantitative fecal egg counts, a commonly used indirect measure of worm burden. A weakness of this method is that very heavy infections can display a partial density dependent depression of fecundity: that is, egg output per individual worm declines as parasite burden rises (Anderson & Schad 1985). However, a recent study of Zanzabari schoolchildren found that hookworm egg counts do reflect worm burden, and indeed, were strongly and linearly related to anemia and iron deficiency anemia (Stolzfus et al. 1997).

Different age distributions of heavy infections have been reported from various study sites. Most commonly, hookworm intensity either plateaus or continues to rise through adulthood (Behnke 1987, Bundy 1989). Our study found a different pattern of worm burden. Intensity of infection increased with age through adolescents then declined in adulthood, with highest intensity infections occurring between the ages of 5 and 14. Age-intensity relationships similar to that found in our study were reported in Nigeria, where hookworm intensity peaked in the 15-19 age group then declined rapidly (Udonski 1980), and in females of West Bengal, India (Schad et al. 1975). Such an age-intensity pattern is more commonly seen in other nematode infections such as *Trichuris trichura* and *A. lumbricoides* (Bundy et al. 1987), but is rare in the case of hookworm. Differences in the age-intensity patterns of hookworm may be due to differences in the relative abundance of *N. americanus* and *A. duodenale*, perhaps because of differences in transmission dynamics of mixed infections (Behnke 1987).

Our study found continued presence of *A. duodenale* in Paraguay which is contrary to the belief that *A. duodenale* is an "old world hook-

worm". It is interesting to note that *A. duodenale* occurred predominantly in children less than 15 years of age, especially when considering its additional modes of transmission and greater blood loss. High rates of *Ancylostoma* in Paraguay were first noted in the 1920s, concentrated west of the Paraguay River (the Chaco). This area was considered unusual for its high ratio of *A. duodenale*-to-*N. americanus* infection (Soper 1927). Our study found that 27% of hookworm-infected individuals were infected with *A. duodenale* (15% *A. duodenale* alone and 12% mixed infection). These results may under-represent of mixed infections, as in some cases only a few larvae were recovered from patients with very low egg counts.

Hookworm infection continues to be highly prevalent in Paraguay. Further studies are needed to determine why children and adolescents suffer high intensity infections relative to other populations in this region. It remains to be determined why *A. duodenale* infections persist in this region and has not been entirely displaced by *N. americanus*.

ACKNOWLEDGEMENTS

To Passionaria Ramos, Dirma Mesquita-Rolo and Cristian Noldin for field help. Additional support was provided through grants to Peter Hotez from the American Heart Association, the March of Dimes, Thrasher Research Fund, and the National Institute of Health (AI - 32726).

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