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Prevalence, Age Profile, and Associated Risk Factors for *Hymenolepis nana* Infection in a Large Population-Based Study in Northern Peru

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Abstract. *Hymenolepis nana*, the dwarf tapeworm, is a common intestinal infection of children worldwide. We evaluated infection and risk factor data that were previously collected from 14,761 children aged 2–15 years during a large-scale program in northern Peru. We found that 1,124 of 14,761 children (7.61%) had *H. nana* infection, a likely underestimate given that only a single stool sample was examined by microscopy for diagnosis. The strongest association with infection was lack of adequate water (adjusted prevalence ratio [aPR] 2.22, 95% confidence interval [CI] 1.82–2.48) and sanitation infrastructure in the house (aPR 1.94, 95% CI 1.64–2.29). One quarter of those tested did not have a bathroom or latrine at home, which doubled their likelihood of infection. Similarly, one quarter did not have piped public water to the house, which also increased the likelihood of infection. Continued efforts to improve access to basic water and sanitation services will likely reduce the burden of infection in children for this and other intestinal infections.

INTRODUCTION

Hymenolepis nana, the dwarf tapeworm, is one of the most prevalent parasitic diseases worldwide, mainly affecting children.[1] The reported prevalence varies by region, including Europe (0.5–5%),[2,3] Asia (0.2–28.4%),[4,5] Africa (1.8–2.9%),[6,7] and the Americas (0.9–23%).[8,9] The adult egg-laying tapeworm resides in the small intestine and releases eggs excreted in the stool. Others become infected via fecal–oral transmission when they ingest *H. nana* eggs excreted in fecal contamination, or via consumption of infected arthropods. The parasite therefore primarily affects populations with limited basic sanitation services.[10,11] Although most infections are asymptomatic, clinical presentations can range from mild nonspecific symptoms[1,12] to rare but severe disease.[13] In spite of the increased basic service availability in Peru (59% at the 2007 national census), there is still a large segment of the population without basic services that are exposed.[14] Prior studies in Peru have reported prevalence as high as 37.5% in studies conducted in school children.[8,9] The goal of this study was to describe the prevalence of and risk factors for *H. nana* infection in children aged 2–15 years in a large population-based sample in northern Peru.

MATERIALS AND METHODS

We conducted a cross-sectional secondary analysis of data collected during a large-scale elimination demonstration program for cysticercosis in Tumbes, Peru, which included 107 peri-urban and rural communities between 2009 and 2010.[15] Tumbes is a northern coastal region in Peru with a land area of 4,669 km^2 and elevation ranging from 5 to 380 m above sea level. Residents are mostly of "mestizo" heritage ("a mix of Spanish and Amerindian") who subsists primarily through small-scale agricultural and fishing. During the elimination program, field teams visited each household in the 107 villages to apply a demographic survey to the head of household, followed by treatment with niclosamide for taeniasis for all consenting household members over the age of 2 years, and collection of a single posttreatment stool sample.

Whole stool samples were collected by field personnel trained in biosafety. Aliquots of 10 g of feces were placed in 40 mL of 5% phosphate-buffered saline formal for preservation and stored upright in falcon tubes. Samples were allowed to settle by gravity for a period of 24 hours before the fecal sediment was analyzed by light microscopy for the presence of parasites. The spontaneous settlement technique was used given its high sensitivity for parasitological diagnosis.[16] Testing was performed at the Center for Global Health in Tumbes, quality control of all positive samples, as well as of the samples immediately before and after the positive, was performed at the Universidad Peruana Cayetano Heredia (UPCH) Infectious Disease Laboratory in Lima.

Statistical analyses were conducted using Stata V14.0 (College Station, TX). We used binomial family generalized lineal models with logarithmic link function to estimate the prevalence ratio of selected variables while controlling for other factors including age and sex of the participant, as well as urban city, water supply, and basic hygienic services at the home. Robust sandwich-type standard errors were used to account for household clustering. The log likelihood ratio was used to evaluate each variable for inclusion in the final model. We report 95% confidence intervals (CIs) and set statistical significance at $P < 0.05$. This study was approved by the UPCH Ethical Review Committee (SIDISI 60361). Children were provided the opportunity to assent; however, written informed consent by the parent or guardian was required for participation of minors.

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TABLE 1
Demographic characteristics of children who did and did not provide a stool sample for this study, Tumbes, Peru, 2009

	Non participants (*N* = 5,488)		Participants (*N* = 14,761)	
	n	%	*n*	%
Sex				
Female	2,576	46.9	7,388	50.1
Male	2,912	53.1	7,373	49.9
Age (years)				
Mean ± standard deviation	8.0	4.6	8.4	3.8
Location of homes				
Urban	2,784	50.7	8,171	55.4
Rural	2,704	49.3	6,590	44.6
Housing material				
Brick and concrete	1,607	29.3	4,080	27.6
Locally available	3,881	70.7	10,681	72.4
Water supply				
Public network	4,141	75.4	11,284	76.4
Surface water	904	16.5	2,084	14.1
Cistern trucks	443	8.1	1,393	9.5
Basic hygienic services				
Bathroom	1,984	36.2	5,165	34.9
Latrine	1,988	36.2	5,442	36.9
Neither	1,516	27.6	4,154	28.2
Electricity				
Public service	4,695	85.5	12,431	84.2
No public service	793	14.5	2,330	15.8

Participants also provided written permission to use samples and data for future studies.

RESULTS

A total of 20,249 children between 2 and 15 years of age were included in the elimination program; 14,761 (72.90%) provided a fecal sample and were therefore included in this secondary analysis. Girls and residents of peri-urban villages were slightly more likely to participate than their counterparts (Table 1). The mean age of participants was 8 years (± 3.8). Just over half of samples were collected from children in peri-urban villages. Lack of basic sanitation infrastructure in the household was common, with over one quarter living in homes that lacked a bathroom or latrine, and a similar proportion with no public water source to their homes (Table 1).

Microscopy showed that 1,124 of 14,761 children (7.61%; 95% CI 7.19–8.04%) had *H. nana* infection. Polyparasitism was common (6,718/14,761; 45.51%) as was infection with any pathogenic parasite (5,132/14,761; 34.77%). In the multiple variable analysis, the prevalence was 38% lower among residents of rural areas compared with peri-urban areas, increased 8% per year of age and was 30% higher among boys than girls (Table 2). The difference by gender appeared to be primarily driven by higher prevalence among boys aged 10–12 years compared with their female counterparts (Figure 1). The prevalence was nearly double in children whose homes lacked a bathroom or latrine, and was also higher among those whose homes

TABLE 2
Risk factors for *Hymenolepis nana* infection in children aged 2–15 years, Tumbes, Peru

	Without *Hymenolepis*		With *Hymenolepis*				
	N = 13,637		*N* = 1,124				
	n	%	*n*	%	PR*	*P* value	aPR*
Sex							
Female	6,897	93.4	491	6.6	Reference		Reference
Male	6,740	91.4	633	8.6	1.29	< 0.001	1.30 (1.16–1.45)
Age (years)							
Mean ± standard deviation	8.3	3.8	9.4	3.4	1.08	< 0.001	1.08 (1.07–1.10)
Urbanity							
Peri-urban	7,467	91.4	704	8.6	Reference		Reference
Rural	6,170	93.6	420	6.4	0.74	< 0.001	0.62 (0.54–0.72)
Water supply							
Public network	10,546	93.5	738	6.5	Reference		Reference
Surface water	1,927	92.5	157	7.5	1.15	= 0.10	1.26 (1.02–1.55)
Cistern tanks	1,164	83.6	229	16.4	2.51	< 0.001	2.22 (1.82–2.48)
Basic hygienic services							
Bathroom	4,903	94.9	262	5.1	Reference		Reference
Latrine	5,003	91.9	439	8.1	1.59	< 0.001	1.68 (1.41–2.00)
Neither	3,731	89.8	423	10.2	2.01	< 0.001	1.94 (1.64–2.29)

Apr = adjusted prevalence ratio; PR = prevalence ratio.
* Unadjusted PR and aPR estimated using binomial family generalized linear models with log link function and robust standard error to control for household clustering.

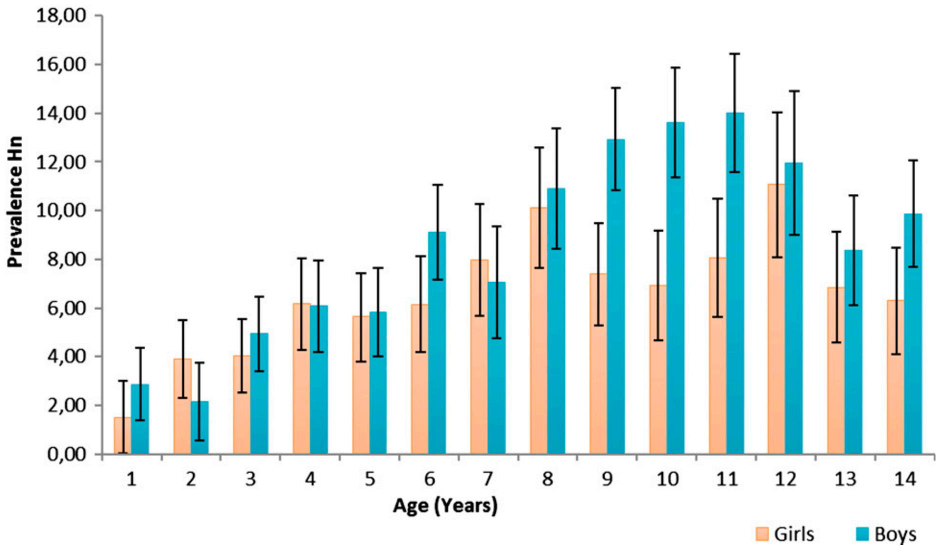

FIGURE 1. Prevalence of *Hymenolepis nana* infection by age and sex.

did not have public piped water; 26% higher for homes that collected surface water and more than double for homes that received water deliveries by truck.

DISCUSSION

Results from this large population-based study show that *H. nana* is a common infection of childhood in the Tumbes region of northern Peru. Despite the fact that diagnosis was based on analysis of a single stool sample, about one in 13 children were found to harbor this tapeworm infection. This is a likely underestimate of the true prevalence given the low sensitivity of microscopy on a single sample even with the best methods.[17] The large size of this study and the representative nature of the sample taken allow evaluation of potential risk factors with a high degree of precision.

Hymenolepis nana is transmitted through ingestion of fecal contamination. This study verifies that existence of basic sanitary services in the home, including both clean water and adequate disposal of sewage, are associated with protection against infection in children. Other large studies have had similar findings, with one study showing that three of every four children with *H. nana* in Mexico have substandard water and sanitation at the home.[18] Another study in Mexico reported that lack of basic services at the home doubled the odds of infection.[19] These household factors were much more strongly associated with infection than were individual characteristics such as sex or age.[20] Increasing efforts to provide adequate household sanitation are therefore probably important to reduce the burden of this and other diseases caused by fecal–oral transmission.

Interestingly, children who lived in homes where the primary source of water was delivery through trucks that filled onsite cisterns were more than twice as likely to be infected, compared with children living in households with water piped directly to the home. This was independent of whether a bathroom or latrine was present, or whether the family practiced outdoor defecation. Further investigation is needed to understand whether this risk is attributed to the source of the water, to fecal contamination of storage tanks, or to another factor. Because of the cross-sectional retrospective nature of this study, our analysis is limited to those data collected during the elimination program. Some important factors, such as type of water storage containers used, handwashing practices or evidence of rodent infestation in the home, could not be evaluated.

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