Hymenolepis nana Impact among Children in the Highlands of Cusco, Peru: An Emerging Neglected Parasite Infection

Miguel M. Cabada,^{1,2*} Maria Luisa Morales,² Martha Lopez,² Spencer T. Reynolds,¹ Elizabeth C. Vilchez,¹ Andres G. Lescano,³ Eduardo Gotuzzo,⁴ Hector Hugo Garcia,⁵ and Clinton A. White Jr.¹

¹Infectious Diseases Division, Department of Internal Medicine, University of Texas Medical Branch, Galveston, Texas;

²Universidad Peruana Cayetano Heredia–University of Texas Medical Branch Collaborative Research Center—Cusco, Cusco, Peru;

³School of Public Health, Universidad Peruana Cayetano Heredia, Lima, Peru; ⁴Instituto de Medicina Tropical Alexander von Humboldt, Universidad Peruana Cayetano Heredia, Lima, Peru; ⁵Departamento de Microbiología, Universidad Peruana Cayetano Heredia, Lima, Peru

Abstract. *Hymenolepis nana* is the most common cestode infection in the world. However, limited information is available regarding its impact on affected populations. We studied the epidemiology and symptoms associated with hymenolepiasis among children 3–16 years old in 16 rural communities of the highlands of the Cusco region in Peru. Information on demographics, socioeconomic status, symptoms as reported by parents, and parasitological testing was obtained from the database of an ongoing *Fasciola hepatica* epidemiologic study. A total of 1,230 children were included in the study. Forty-five percent were infected with at least one pathogenic intestinal parasite. *Giardia* spp. (22.9%) was the most common, followed by *Hymenolepis* (17.4%), *Fasciola* (14.1%), *Ascaris lumbricoides* (6.1%), and *Strongyloides stercoralis* (2%). The prevalence of *Hymenolepis* infection varied by community, by other parasitic infections, and by socioeconomic status. However, only years of education of the mother, use of well water, and age less than 10 years were associated with *Hymenolepis* infection in the multivariate analysis. *Hymenolepis nana* infection was associated with diarrhea, jaundice, headaches, fever, and fatigue. Children with > 500 eggs/g of stool were more likely to have symptoms of weight loss, jaundice, diarrhea, and fever. *Hymenolepis nana* infection and age were the only factors retained in the multivariate analysis modeling diarrhea. Hymenolepiasis is a common gastrointestinal helminth in the Cusco region and is associated with significant morbidity in children in rural communities. The impact caused by the emergence of *Hymenolepis* as a prevalent intestinal parasite deserves closer scrutiny.

INTRODUCTION

Hymenolepis nana is a miniature tapeworm, which is one of the most common intestinal helminths worldwide. In areas of Asia, southern and eastern Europe, Central and South America, and Africa, the prevalence ranges between 5% and 25%.¹ However, in poor communities, the prevalence can reach up to 50%.² The infection is particularly common in children living in areas lacking sanitation and safe water.³ Several studies in developing countries have demonstrated that the burden of infection is larger in children than adults.^{4,5} A study in India among slum dwellers showed that the prevalence of *H. nana* was twice as high (12%) in subjects 1–10 years of age compared with those aged 11–50 years (6%).⁴

The parasite is transmitted from person to person mainly by the fecal–oral route without an intermediate host. The tapeworm form has a life span of 4–6 weeks. However, the parasites' eggs are infectious when shed and can reinfect the host leading to long-lasting infections.

Despite the widespread prevalence of infection, there are only limited data on the impact that *H. nana* infection imposes on children. As part of a study of the epidemiology and impact of fascioliasis on children in the Cusco area of Peru, we encountered a high frequency of *H. nana* infections. This article reports on the epidemiology and symptoms associated with *H. nana* infection among these children.

METHODS

A cross-sectional study was conducted selecting data from a cohort of children participating in a *Fasciola hepatica* epidemiologic study in rural communities of the Cusco region. This study is being performed in the Anta, Zurite, and Ancahuasi Districts of the Anta Province in the south Andes of Peru (Figure 1). The area is mainly a flat plateau at 3,350 m elevation. The climate includes a rainy season (average monthly rainfall between 77 and 152 mm) from November to March and a dry season (average monthly rainfall between 8 and 49 mm) from April to October. Most subjects live in single-room homes with latrines. Piped water is supplied from a municipal reservoir, but is not consistently available. The Ministry of Health clinics in the area provide all preschool and school children with albendazole twice a year with a coverage of over 90%.

Children aged 3–16 years were enrolled in preschools and schools from 16 communities between July 2013 and May 2015. Information regarding demographics and socioeconomic (Simple Poverty Scorecard for Peru, http://www.microfinance.com/English/Papers/Scoring_Poverty_Peru.pdf), signs and symptoms in the preceding 3 months, and diarrhea and upper respiratory infection episodes in the preceding year was collected from parents. Information regarding symptoms in the previous 3 months was also obtained from children attending secondary schools (ages 11–16 years). All children were eligible to participate regardless of the presence of symptoms at the moment of the interview. Parent interviews were conducted before laboratory results were available. Each participant was requested to provide three stool samples collected on consecutive days for *Fasciola* and intestinal helminths testing. Samples were aliquoted in to 10% formalin-containing

*Address correspondence to Miguel M. Cabada, Infectious Diseases Division, Department of Internal Medicine, University of Texas Medical Branch, 301 University Boulevard, Route 0435, Galveston, TX 77555. E-mail: micabada@utmb.edu

FIGURE 1. Map of the Cusco region. The inset shows the Anta Province and the districts where the information was collected (source Google maps 2016).

tubes and tubes without preservation solutions. Lumbreras rapid sedimentation tests were performed with formalin preserved stools.⁶ Kato-Katz tests were performed with unpreserved stools within 48 hours of collection. Internal controls were introduced with the field specimens for quality control. All positive results were confirmed by a second observer.

The statistical analysis was performed using the Statistical Package for the Social Sciences v.18.0 (IBM Corporation, NY). Frequencies, medians, and means ($\pm$ SD) were calculated to describe the study population and the prevalence of helminth infections. Odds ratios (ORs) were calculated to compare signs, symptoms, and demographic and socioeconomic characteristics between children with *H. nana* infection and uninfected children. Backward logistic regression models were used to calculate adjusted ORs for the same variables accounting for demographic and socioeconomic factors. A *P* value below 0.05 was considered to be statistically significant.

The study protocol was approved by the Institutional Ethics Committee of Universidad Peruana Cayetano Heredia (no. 60574) and by the Institutional Review Board of University of Texas Medical Branch (no. 13-080).

RESULTS

A total of 1,230 children were included in the study with a mean of 1.3 children ($\pm$ 0.65) per household. Half (51.1%) were male, the median age was 9.6 years (interquartile range [IQR]: 7–12.6), and the median years of school attendance was 3 (IQR: 2–4). The mean age and years of education for the fathers were 40.9 years ($\pm$ 8.9) and 8.2 years ($\pm$ 3.3), respectively. For the mothers, the mean age and years of education were 37.3 years ($\pm$ 8.2) and 6.7 years ($\pm$ 4.5), respec-

tively. Sixteen percent of the children lived with only one or no parent at home. The mean socioeconomic score was 36.6 ($\pm$ 9.81) out of 100 and 86.5% were enrolled in the government provided health insurance program. Nearly all (94.9%) had access to water from the municipal reservoir piped in to their homes. However, a few households also obtained drinking water from wells (2.7%) and streams (2.4%). A third (34%) eliminated excreta using public sewage, but a large percentage also eliminated excreta in latrines (25.8%), farms (22.4%), shallow holes around the home (8.3%), and septic tanks (5.6%). The median number of diarrhea episodes per year was 1 (IQR: 0–2) and the median number of respiratory infection episodes per year was 2 (IQR: 1–3).

Forty-five percent (45.8%) were infected with at least one gastrointestinal parasite. *Hymenolepis nana* (17.4%) was the second most common parasite after *Giardia* spp. (22.9%). The geometric mean concentration of *H. nana* was 134.4 eggs/g of stool with a range between 0 and 6,000 eggs/g of stool. Other common parasites were *E. hepatica* (14.1%), *Ascaris lumbricoides* (6.1%), and *Strongyloides stercoralis* (2%). The prevalence of *Trichuris trichura*, *Taenia* spp., and hookworm was $\leq$ 1%.

The prevalence of *H. nana* varied by community being highest in Tambo Real (40.6%), Markju (35.7%), and Inquilpata (31.7%) and lowest in Conchacalla (5.5%), Almeria (7.9%), and Kataniray (8.6%) (*P* < 0.01). Those with *H. nana* infection were more likely to have other parasite infections like *Giardia* and *Trichuris*, to not have the father in the household, to use well water, and to not be enrolled in the government-provided health insurance program. The mean number of years of education for the fathers and mothers and the mean socioeconomic scores were lower among children with *H. nana* infection compared with uninfected children

TABLE 1
Selected variables associated with *Hymenolepis nana* infection*

	Proportion or mean $\pm$ SD		OR (95% CI)/t test	P value
	<i>H. nana</i> (+) n (%)	<i>H. nana</i> (-) n (%)		
<i>Trichuris</i> infection	6/214 (2.8)	7/1,016 (0.6)	4.15 (1.38–12.49)	< 0.01
Using well water	14/214 (6.5)	19/1,016 (1.8)	3.67 (1.81–7.44)	< 0.01
No father in the household†	41/210 (19.5)	133/985 (13.5)	1.55 (1.05–2.28)	0.02
No access to health insurance†	37/208 (17.7)	121/964 (12.5)	1.50 (1.00–2.25)	0.04
<i>Giardia</i> infection	61/214 (28.5)	221/1,016 (21.7)	1.43 (1.02–1.99)	0.03
Eliminates excreta using public sewer	62/214 (28.9)	356/1,016 (35)	0.76 (0.54–1.04)	0.08
Age under 10 years†	100/214 (46.7)	546/1,013 (53.8)	0.75 (0.55–1.00)	0.05
Mother's years of education	5.46 $\pm$ 3.18	7.03 $\pm$ 4.71	4.13	< 0.01
Socioeconomic score	33.87 $\pm$ 9.47	37.12 $\pm$ 9.80	3.12	< 0.01
Father's years of education	7.67 $\pm$ 3.24	8.30 $\pm$ 3.38	2.09	0.03

CI = confidence interval; OR = odds ratio; SD = standard deviation.

*The infections with *Fasciola* ($P = 0.12$), *Strongyloides* ($P = 0.85$), and *Ascaris* ($P = 0.54$) were not associated with *H. nana*.

†The denominator varied due to missing data for this variable.

(Table 1). Children with *H. nana* infection were less likely to be under 10 years of age and to have public sewage to eliminate excreta than those without the infection, but the differences were not statistically significant. There was a linear association between *H. nana* prevalence and the age groups < 5 years (10.3%), 5–6 years (15.7%), 7–9 years (17.5%), 10–12 years (20.5%), and > 13 years (18.7%) ($P = 0.02$). *Hymenolepis nana* infection was not associated with sex ($P = 0.64$), absence of the mother ($P = 0.14$), other sources of drinking water ($P > 0.1$), or ways of eliminating excreta ($P > 0.1$). The covariates retained by the backward logistic regression model were years of education of the mother, using well water, age under 10 years, and community (Table 2).

The constitutional and gastrointestinal symptoms most commonly reported within the previous 3 months were headache (43%), fever (35.7%), anorexia (28.5%), right upper quadrant pain (24.5%), fatigue (22.8%), diarrhea (22.2%), and dyspepsia (21.2%). *Hymenolepis nana* infection alone compared with no infection was significantly associated with diarrhea, jaundice, and headaches in the bivariate analysis (Table 3). The infection with *H. nana* and other parasites compared with no infection showed a stronger association with diarrhea, jaundice, headaches, fatigue, fever, and dyspepsia (Table 3). In the backward logistics regression analysis modeling, the symptoms associated with *H. nana*, diarrhea, and socioeconomic score were retained by the model. (Table 4) Only *H. nana* infection and age were retained by the logistic regression analysis modeling the factors associated with diarrhea in the previous 3 months (Table 5). Among children with reported diarrhea during the previous year, those with *H. nana* infection were more likely to have $\geq$ three episodes (OR: 1.75

[1.16–2.63], $P \leq 0.01$) and have a higher mean number of episodes (1.98 [2.07 $\pm$ 1.17] versus [1.86 $\pm$ 1.20], $P = 0.04$). Children with *H. nana* infection and ≥ 500 eggs/g of stool were more likely to have reported weight loss, fever, diarrhea, and jaundice (Table 6). The age distribution varied significantly between the three groups (Kruskal–Wallis test $P = 0.002$). Sixty percent of those with ≥ 500 eggs/g of stool were under 10 years of age compared with 43.2% of those with less than 500 eggs and 53.8% of those with no *H. nana* infection (Pearson χ^2 7.5, $P = 0.023$).

DISCUSSION

Hymenolepiasis is an emerging problem in developing countries. Despite the high global prevalence of *Hymenolepis* infection, the factors associated with the infection and the morbidity caused by *H. nana* have seldom been systematically evaluated. In our study, *H. nana* infection was the most common helminth infection affecting the children in the 16 communities evaluated. The infection was associated with symptoms of diarrhea and headache in the 3 months prior to the study. Weight loss, fever, and diarrhea were more common in heavily infected children.

Single-dose mass chemotherapy with albendazole is widely used to treat soil-transmitted nematodes to prevent the anemia and poor cognitive development associated with the infection. While *H. nana* is common in the areas where albendazole mass chemotherapy is used, albendazole has little effect on *H. nana*.^{7,8} Treatment would require the expansion of mass chemotherapy programs.⁹ In our study, three times more children had *H. nana* infection compared with *Ascaris*, hookworm, or *Trichuris*. Other groups have also demonstrated a lower prevalence of soil-transmitted helminths compared with *H. nana* in Peru.¹⁰ Similarly, a study by Tefera and others in eastern Ethiopia showed that while the prevalence of STHs was less than 0.5%, the prevalence of *H. nana* was 13% in elementary school children receiving regular deworming treatment.¹¹

Hymenolepis nana has been associated with diarrhea and other gastrointestinal symptoms among children.^{12–15} In Mexico and Cuba, children with *H. nana* infection commonly had abdominal pain, anorexia, irritability, and diarrhea.^{12,13} Among refugee children in Sudan, *H. nana* infection was associated with a 9-fold higher risk of diarrhea compared with uninfected children.¹⁴ Similarly, studies in India and Australia

TABLE 2

Variables associated with *Hymenolepis nana* infection retained by the backward logistic regression model

	Adjusted OR	95% CI*	P value
Mother's years of education	1.11	1.05–1.17	< 0.01
Use well water	3.98	1.49–10.66	< 0.01
Age under 10 years	0.67	0.44–1.00	0.05
Community	1.04	0.99–1.09	0.06

*CI = confidence interval; OR = odds ratio. Variables entered in the model: age under 10 years, sex, community, *Giardia* infection, *Trichuris* infection, number of education years for the father and the mother, absence of the father, access to government provided health insurance, use of well water, and use of public sewage to eliminate excreta. Socioeconomic score was excluded due to the amount of missing values. Hosmer and Lemeshow test = 5.46, df = 6, $P = 0.48$.

TABLE 3
Symptoms associated with *Hymenolepis nana* and other parasite infections*

	No parasites†	Only <i>H. nana</i>	<i>H. nana</i> and other parasites	Only other parasites
Diarrhea	126/655	34/121 1.64 (1.05–2.55)‡	33/90 2.43 (1.51–3.89)	77/341 1.22 (0.88–1.68)
Jaundice	94/654	26/121 1.63 (1.00–2.65)	20/90 1.70 (0.98–2.92)	58/342 1.21 (0.85–1.73)
Headache	249/655	58/121 1.50 (1.01–2.21)	49/90 1.94 (1.25–3.03)	162/342 1.46 (1.12–1.91)
Fatigue	136/655	30/121 1.25 (0.79–1.98)	29/90 1.81 (1.12–2.93)	80/342 1.16 (0.85–1.59)
Dyspepsia	125/654	27/121 1.21 (0.76–1.94)	28/91 1.88 (1.15–3.05)	76/342 1.20 (0.87–1.66)
Fever	219/656	44/121 1.14 (0.76–1.70)	44/90 1.90 (1.22–2.97)	124/342 1.13 (0.86–1.49)
Nausea/vomiting	94/656	25/121 1.55 (0.95–2.54)	20/90 1.70 (0.99–2.94)	71/342 1.56 (1.11–2.20)
Anorexia	170/655	35/121 1.16 (0.75–1.78)	31/91 1.47 (0.92–2.35)	108/342 1.31 (0.98–1.75)
Right upper quadrant‡ pain	144/655	26/121 0.97 (0.60–1.55)	28/90 1.60 (0.98–2.59)	98/342 1.42 (1.05–1.92)
Weight loss	115/656	18/121 0.82 (0.47–1.41)	23/90 1.61 (0.96–2.70)	67/342 1.14 (0.82–1.60)

*The denominators vary due to missing data in the reported symptoms.

†Reference category.

‡Odds ratio (95% Confidence Interval).

have associated the infection with diarrhea. In addition, these studies suggested an association between anemia and *H. nana*.^{4,15} An Egyptian study reported high rates of malnutrition among infected children.¹⁶ The association of *H. nana* with anemia and malnutrition may be similar to the association between STH and these complications. Treatment of STH has shown benefits in weight gain and hemoglobin improvement.^{17,18} In contrast, the impact of deworming for *H. nana* has not been established. In addition, conflicting evidence has emerged on the role of *H. nana* infection in child morbidity. A case-control study in northern Peru failed to find symptoms associated with the infection among adults and children.¹⁹ Moreover, another study suggested that children with *H. nana* had better nutritional indicators and retinol levels than uninfected children or children with other parasites.²⁰ The conflicting reports are likely due to variations in study methods, limited number of cases, and failure to use control groups. In our study, *H. nana* infection and age were associated with reported diarrhea after adjusting for sex, socioeconomic status, and other parasite infections suggesting that younger individuals with *H. nana* are at higher risk for diarrhea. In developing countries, diarrhea is associated with malnutrition and long-term sequelae in younger children.

A higher *H. nana* burden was associated with reported weight loss and diarrhea in our study population. Other parasite infections like *Giardia* and *Trichuris* were more often encountered in *H. nana*-infected children. Children with *H. nana*

and other gastrointestinal parasites had a higher association with certain symptoms (i.e., diarrhea, fever, and headache) than children with only *H. nana* or only other parasites. A study by Oliveira and others in Angola reported that *H. nana* was associated with malnutrition in children aged 5–12 years. Interestingly, in that study, *Giardia* and *Ascaris* were only associated with malnutrition in subjects coinfecting with *H. nana*.²¹ Other studies showed that the infection with multiple parasites leads to worse outcomes.⁹ A recent study in southwestern China showed that infection of school children with multiple STHs was associated with malnutrition, lower working memory index, and lower processing speed ability index.²² Thus, malnutrition and its consequences in child cognitive development are potential complications of *H. nana* infection that deserve further scrutiny.

The association of *H. nana* with sanitation and unsafe water was similar to that of STHs infections.^{23,24} Interestingly, STHs seem to have a selective association with sanitation or safe water according to their mode of transmission.²³ However, in our study, *H. nana* was associated with both poor sanitation and unsafe water, which highlights the need for broader interventions. Therefore, improving access to sanitation and safe water, as well as, education on hand hygiene and food handling will not only decrease the prevalence of STHs already targeted by control programs,²⁴ but may also be effective at reducing *H. nana* infection status.

This study has some limitations. The use of a cross-sectional design limits the evaluation of the factors associated

TABLE 4

Variables retained by the logistic regression model of reported symptoms associated with *Hymenolepis nana* infection

	Adjusted OR	95% CI*	P value
Diarrhea	1.95	1.16–3.28	0.01
Socioeconomic score	0.96	0.94–0.99	< 0.01

*CI = confidence interval; OR = odds ratio. Variables entered in the model: age, sex, other parasite infections, socioeconomic score, access to health insurance, and the following reported symptoms in the previous three months: fever, headache, jaundice, weight loss, fatigue, anorexia, diarrhea, right upper quadrant pain, dyspepsia, and nausea/vomiting. Hosmer and Lemeshow test = 4.43, df = 8, *P* = 0.81.

TABLE 5

Variables associated with diarrhea retained by the backward logistic regression model

	Adjusted OR	95% CI*	P value
<i>Hymenolepis nana</i> infection	1.99	1.18–3.34	< 0.01
Age	1.09	1.03–1.15	< 0.01

*CI = confidence interval; OR = odds ratio. Variables entered in the model: age, sex, other parasite infections, socioeconomic score, and having over 500 eggs of *H. nana* in the stool. Hosmer and Lemeshow test = 7.19, df = 8, *P* = 0.51.

TABLE 6

Symptoms in those with ≥ 500 eggs/g of stool of *Hymenolepis nana* compared with < 500 eggs/g or no eggs in the stool

	≥ 500 eggs/g*	< 500 eggs/g	No. <i>H. nana</i>
Weight loss (<i>n</i>)	17/45†	24/166	180/979
		3.59 (1.71–7.54)‡	2.69 (2.44–5.03)
Fever (<i>n</i>)	26/45	62/166	336/979
		2.29 (1.17–4.48)	2.61 (1.42–4.80)
Diarrhea (<i>n</i>)	21/45	46/166	200/977
		2.28 (1.16–4.49)	3.39 (1.85–6.23)
Jaundice (<i>n</i>)	15/30	31/166	150/977
		2.17 (1.04–4.53)	2.75 (1.44–5.24)
Anorexia (<i>n</i>)	17/45	49/167	269/978
		1.46 (0.73–2.91)	1.60 (0.86–2.97)
Headache (<i>n</i>)	25/45	82/166	405/978
		1.28 (0.66–2.48)	1.76 (0.96–3.22)
RUQ§ pain (<i>n</i>)	12/45	42/166	236/978
		1.07 (0.50–2.26)	1.14 (0.58–1.24)
Nausea/vomiting (<i>n</i>)	10/45	35/166	163/979
		1.06 (0.48–2.37)	1.43 (0.69–2.94)
Fatigue (<i>n</i>)	13/45	46/166	213/978
		1.06 (0.51–2.19)	1.45 (0.75–2.82)
Dyspepsia (<i>n</i>)	11/45	44/167	198/977
		0.90 (0.42–1.93)	1.27 (0.63–2.55)

*Reference variable.

†Denominators vary because of missing data about symptoms or Kato-Katz test results.

‡Odds ratio (95% confidence interval).

§Right upper quadrant.

with *H. nana* and their causality. The missing data for some variables did not allow more exhaustive modeling of variables playing a role in the prevalence and reported symptoms of the infection. The evaluation of symptoms associated with *H. nana* relied on parental recall. The reported symptoms were likely not completely accurate even for a relatively short period (3 months). However, there is no obvious reason that inaccuracies would vary with infection status. The ongoing transmission of fascioliasis in the area and of viral hepatitis in some schools may have led us to overestimate the prevalence of symptoms like jaundice, which is associated with those illnesses. Nine percent of children with *H. nana* infection had positive stool microscopy for *Fasciola* and the prevalence increased with *Hymenolepis* egg burden. In addition, 5% of children with hymenolepiasis had positive Fas2 enzyme-linked immunosorbent assay for *Fasciola* antibodies.

In conclusion, hymenolepiasis in the Cusco region is a disease of poverty associated with gastrointestinal and constitutional symptoms. *Hymenolepis nana* is an emerging parasite gaining relevance as the prevalence of STHs is decreasing with mass chemotherapy. Further research to evaluate the impact and burden of *H. nana* infection in constrained resource settings is needed. Studies underway will further evaluate anthropometric, hematologic, and inflammatory markers in association with hymenolepiasis in Cusco, Peru.

Received March 24, 2016. Accepted for publication August 5, 2016.

Published online September 26, 2016.

Financial support: This study was funded by the National Institute for Allergy and Infectious Diseases at the National Institutes of Health Grant 1R01AI104820-01. AGL is sponsored by the training grant 2D43 TW007393 awarded by the Fogarty International Center of the US National Institutes of Health.

Disclaimer: The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the National Institute for Allergy and Infectious Diseases.

Authors' addresses: Miguel M. Cabada, Department of Internal Medicine, University of Texas Medical Branch, Galveston, TX, and Instituto de Medicina Tropical Alexander von Humboldt, Universidad Peruana Cayetano Heredia, Lima, Peru, E-mail: micabada@utmb.edu. Maria Luisa Morales and Martha Lopez, Universidad Peruana Cayetano Heredia—University of Texas Medical Branch Collaborative Research Center—Cusco, Cusco, Peru, E-mails: malu.morales.fernandez@gmail.com and martlop2000@gmail.com. Spencer T. Reynolds and Elizabeth C. Vilchez, School of Medicine, University of Texas Medical Branch at Galveston, Galveston, TX, E-mails: streynol@utmb.edu and ecvilche@utmb.edu. Andres G. Lescano, School of Public Health, Universidad Peruana Cayetano Heredia, Lima, Peru, E-mail: andres.lescano.g@upch.pe. Eduardo Gotuzzo, Instituto de Medicina Tropical Alexander Von Humboldt, Universidad Peruana Cayetano Heredia, Lima, Peru, E-mail: eduardo.gotuzzo@upch.pe. Hector Hugo Garcia, Departamento de Microbiología, Universidad Peruana Cayetano Heredia, Lima, Peru, E-mail: hgarcia1@jhu.edu. Clinton A. White Jr., Department of Internal Medicine, University of Texas Medical Branch, Galveston, TX, E-mail: acwhite@utmb.edu.

REFERENCES

1. Mega JD, Galdos-Cardenas G, Gilman RH, 2012. Tapeworm infections. Magill AS, Ryan ET, Hill DR, Solomon T, eds. *Hunter's Tropical Medicine and Emerging Infectious Diseases*, 9th edition. Liverpool, United Kingdom: Saunders Elsevier.
2. Arora HS, Ang JY, 2015. *Hymenolepiasis*. *Medscape*. Available at: <http://emedicine.medscape.com/article/998498-overview>. Accessed December 5, 2015.
3. Center for Disease Control and Prevention, 2012. *Hymenolepiasis FAQs*. Available at: <http://www.cdc.gov/parasites/hymenolepis/faqs.html>. Accessed December 5, 2015.
4. Mirdha B, 2002. *Hymenolepis nana*: a common cause of paediatric diarrhoea in urban slum dwellers in India. *J Trop Pediatr* 48: 331–334.
5. Abrar UI, Haq K, Gul NA, Hammad HM, Bibi Y, Mohsan J, 2015. Prevalence of *Giardia intestinalis* and *Hymenolepis nana* in Afghan refugee population in Mianwali District, Pakistan. *Afr Health Sci* 15: 394–400.
6. Maco-Flores V, Marcos-Raymundo L, Terashima-Iwashita A, Samalvides-Cuba F, Miranda-Sanchez E, Espinoza-Babilon J, Gotuzzo-Herencia J, 2002. Fas-2 ELISA and the rapid sedimentation technique modified by Lumberras for *Fasciola hepatica* infection diagnosis. *Rev Med Hered* 13: 49–57. Available at: <http://www.scielo.org.pe/pdf/rmh/v13n2/v13n2ao3.pdf>. Accessed November 22, 2015.
7. Jagota SC, 1986. Albendazole, a broad-spectrum anthelmintic, in the treatment of intestinal nematode and cestode infection: a multicenter study in 480 patients. *Clin Ther* 8: 226–231.
8. Horton J, 2000. Albendazole: a review of anthelmintic efficacy and safety in humans. *Parasitology* 121 (Suppl): S113–S132.
9. Soares Magalhaes RJ, Fancony C, Gamboa D, Langa AJ, Sousa-Figueiredo JC, Clements ACA, Vaz Nery S, 2013. Extending helminth control beyond STH and schistosomiasis: the case of human hymenolepiasis. *PLoS Negl Trop Dis* 7: e2321.
10. Machicado JD, Marcos LA, Tello R, Canales M, Terashima A, Gotuzzo E, 2012. Diagnosis of soil-transmitted helminthiasis in an Amazonian community of Peru using multiple diagnostic techniques. *Trans Roy Soc Trop Med* 106: 333–339.
11. Tefera E, Mohammed J, Mitiku H, 2015. Intestinal helminth infections among elementary students in Babile town, eastern Ethiopia. *Pan Afr Med J* 20: 50.
12. Romero-Cabello R, Godinez-Hana L, Gutierrez-Quiroz M, 1991. Clinical aspects of hymenolepiasis in pediatrics. *Bol Med Hosp Infant Mex* 48: 101–105 [Spanish].
13. Suarez-Hernandez M, Bonet-Couce E, Diaz-Gonzalez M, Ocampo-Ruiz I, Vidal-Garcia I, 1998. Epidemiology study on *Hymenolepis nana* infection in Ciego de Avila Province, Cuba. *Bol Chil Parasitol* 53: 31–34 [Spanish].
14. Abdel Hamid M, Eljack I, Osman M, Elaagip A, Muneer M, 2015. The prevalence of *Hymenolepis nana* among preschool children of displacement communities in Khartoum state, Sudan: a cross-sectional study. *Travel Med Infect Dis* 13: 172–177.

15. Willcocks B, Mcauliffe G, Baird R, 2015. Dwarf tapeworm (*Hymenolepis nana*): characteristics in the northern territory 2002–2013. *J Paediatr Child Health* 51: 982–987.
16. Khalil H, El Shimi S, Sarwat M, Fawzy A, El Shimi A, 1991. Recent study of *Hymenolepis nana* infection in Egyptian children. *J Egypt Soc Parasitol* 21: 293–300.
17. Stephenson LS, Latham MC, Adams EJ, Kinoti SN, Pertet A, 1993. Weight gain of Kenyan school children infected with hookworm, *Trichuris trichiura* and *Ascaris lumbricoides* is improved following once- or twice-yearly treatment with albendazole. *J Nutr* 123: 656–665.
18. Stephenson LS, Kinoti SN, Latham MC, Kurz KM, Kyobe J, 1989. Single dose metrifonate or praziquantel treatment in Kenyan children. I. Effects on *Schistosoma haematobium*, hookworm, hemoglobin levels, splenomegaly, and hepatomegaly. *Am J Trop Med Hyg* 41: 436–444.
19. Chero J, Saito M, Bustos J, Blanco E, Gonzalez G, Garcia HH, Cysticercosis Working Group Peru, 2006. *Hymenolepis nana* infection: symptoms and response to nitazoxanide in field conditions. *Trans R Soc Trop Med Hyg* 101: 203–205.
20. Muniz-Junqueira MI, Queiróz EF, 2002. Relationship between protein-energy malnutrition, vitamin A, and parasitoses in children living in Brasília. *Rev Soc Bras Med Trop* 35: 133–142.
21. Oliveira D, Ferreira FS, Atouguia J, Fortes F, Guerra A, 2015. Infections by intestinal parasites, stunting, and anemia in school-aged children in southern Angola. *PLoS One* 10: e0137327.
22. Liu C, Luo R, Yi H, Zhang L, Li S, Bai Y, Medina A, Rozelle S, Smith S, Wang G, Wang J, 2015. Soil-transmitted helminths in southwestern China: a cross-sectional study of links to cognitive ability, nutrition, and school performance among children. *PLoS Negl Trop Dis* 9: e0003877.
23. Echazú A, Bonanno D, Juarez M, Cajal SP, Heredia V, Caropresi S, Cimino RO, Caro N, Vargas PA, Paredes G, Krolewiecki AJ, 2015. Effect of poor access to water and sanitation as risk factors for soil-transmitted helminth infection: selectiveness by the infective route. *PLoS Negl Trop Dis* 9: e0004111.
24. Strunz EC, Addiss DG, Stocks ME, Ogden S, Utzinger J, Freeman MC, 2014. Water, sanitation, hygiene, and soil-transmitted helminth infection: a systematic review and meta-analysis. *PLoS Med* 11: e1001620.