

## **Giardia duodenalis infection: risk factors for children living in sub-standard settlements in Brazil**

Infecção por *Giardia duodenalis*: fatores de risco para crianças residentes em áreas de assentamento subnormal no Brasil

Júlio César Teixeira <sup>1</sup>  
Léo Heller <sup>2</sup>  
Mauricio L. Barreto <sup>3</sup>

### **Abstract**

*The objective of the present study was to characterize Giardia duodenalis infection among children living in sub-standard settlement areas in the municipality of Juiz de Fora, Minas Gerais State, Brazil. The cross-sectional epidemiological study included 590 children from 1 to 5 years of age. Data were collected from one child per selected family through home interviews with the parent or guardian and parasitological examination of stool samples. Thirty-one putative risk factors concerning family structure, socioeconomic status, and environmental factors were analyzed by multivariate logistic regression. Prevalence of G. duodenalis infection was 18% (106 children). Four potential risk factors were heavily associated with G. duodenalis infection: number of under-five children in the same household, index child's birth order, existence of a bathroom in the home, and drinking water source.*

*Giardia; Environmental Health; Water; Sewage; Hygiene*

### **Introduction**

Infection by *Giardia duodenalis*, a parasitic protozoan that attacks the small intestine and especially the duodenum, occurs frequently in Brazil and is particularly common among preschool-aged children. Most infections are asymptomatic, although infected individuals eliminate cysts through the feces for up to six months. Since the oval-shaped cysts, measuring some 8 to 12µm in length and 7 to 9µm in width, are highly characteristic, the presence of this disease is readily established through parasitological examination of the feces <sup>1</sup>.

Estimated prevalence of the disease in developed countries varies from 2 to 5%, while in less developed countries it can reach 20 to 30% <sup>2</sup>. Among the many factors for such high prevalence rates of parasitic diseases in underdeveloped countries, the most important are lack of basic sanitation and inadequate peridomiliary conditions <sup>3</sup>. Transmission of *G. duodenalis* can occur via contaminated water, food contaminated with cysts, and direct personal contact <sup>1</sup>. The cysts are highly resistant, remaining viable for up to two months. Water treatment using chlorination and heating to 60°C have proven ineffective for inactivating the cysts <sup>4</sup>.

The present study aimed to characterize *G. duodenalis* infection in children living in sub-standard settlement areas in the municipality (county) of Juiz de Fora, Minas Gerais State,

<sup>1</sup> Departamento de Hidráulica e Saneamento, Universidade Federal de Juiz de Fora, Juiz de Fora, Brasil.

<sup>2</sup> Departamento de Engenharia Sanitária e Ambiental, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.

<sup>3</sup> Instituto de Saúde Coletiva, Universidade Federal da Bahia, Salvador, Brasil.

#### **Correspondence**

J. C. Teixeira  
Departamento de Hidráulica e Saneamento, Universidade Federal de Juiz de Fora.  
Rua Antônio Marinho Saraiva 115, apto. 202,  
Juiz de Fora, MG  
36025-555, Brasil.  
juliotei@terra.com.br

Brazil. To identify the associated risk factors, the relationship between *G. duodenalis* infection and the intra- and peridomiciliary environment and sanitation conditions were investigated.

## Material and methods

The study was conducted in the city of Juiz de Fora, located in the Zona da Mata in Southeast Brazil. Juiz de Fora has some 500,000 inhabitants, with an infant mortality rate of 16.4 per thousand live births, life expectancy 78.9 years, and a 4.4% illiteracy rate <sup>5</sup>. Twenty-nine slum settlements with approximately 2,700 households and an estimated population of 12,000 inhabitants were selected for the study.

A cross-sectional design was used to compare different exposure patterns. The sample size was determined using Epi Info 6.0 (Centers for Disease Control and Prevention, Atlanta, USA), framed by a preliminary study in which several variables had been analyzed <sup>6</sup>, resulting in an initial group of 650 children in the 1-to-5 year age range. The study thus covered 650 households from the 29 settlements. One child within the specified age range was selected by a simple draw from each of the homes visited. A specially trained team that had worked in Juiz de Fora during the national census confirmed each child's gender and age and conducted the interviews with parents or guardians. Fecal samples were provided by the children and delivered immediately by the interviewer to an ISO 9002-certified medical laboratory. The Hoffmann-Pons-Janer method <sup>7</sup> was used to identify *G. duodenalis* cysts, besides other protozoa and helminths not included in this paper. Presence of cysts characterized the group of infected children, while absence of cysts characterized the uninfected children.

The initially selected study variables were divided into eight sub-groups as follows: (i) *family structure* (eight variables); (ii) *socioeconomic status* (six); (iii) *hygiene* (four); (iv) *water supply* (two); (v) *sanitation* (three); (vi) *solid waste disposal* (four); (vii) *surface water drainage* (one); and (viii) *presence of parasite vectors* (three). The collected data were analyzed using SPSS software, version 10.0 (SPSS Inc., Chicago, USA). A backward stepwise method adapted from Hosmer & Lemeshow <sup>8</sup> was used to progressively discard the variables not associated with *Giardia* infection. This process involved the following sequence: (i) preliminary selection by univariate analysis of variables with  $p < 0.25$ ; (ii) logistic regression analysis of the pre-selected variables, eliminating variables with  $p > 0.15$ ; and (iii) construction of the final logistic regression model, including

all variables with  $p < 0.05$  from each of the eight sub-groups. Final statistical significance was 5%, and the test's statistical power was 99.9%.

The project was approved by the Research Ethics Committee of the Federal University in Minas Gerais according to Ruling 196/96 of the Brazilian National Health Council. Written informed consent was obtained from parents or legal guardians of all participants.

## Results

A total of 590 children from the 29 settlements were selected to participate in the study, after excluding those whose parents did not agree to take part in the research program and those who did not provide stool samples. Table 1 shows the distribution of children according to prevalence of *G. duodenalis* infection, gender, and age. The high prevalence of *G. duodenalis* infection (18%) among the children is particularly relevant (Table 1). Among the initial selection of 31 variables, only four presented statistically significant ( $p < 0.05$ ) associations with *G. duodenalis* infection in the multivariate model (Table 2).

## Discussion and conclusions

Some limitations should be pointed out while analyzing the results. The use of a single stool sample for diagnosing *G. duodenalis* can lead to underestimation of prevalence, due to intermittent fecal elimination of cysts. However, there is no evidence that this biased the results, due to the standard procedure adopted in collecting and examining stool samples.

Despite the above, the 18% infection prevalence for *G. duodenalis* among children in sub-standard settlements in Juiz de Fora was somewhat higher than typically reported in other urban areas of Brazil. In Salvador, prevalence of infection in children 2 to 45 months of age was 13.7% <sup>9</sup>, while in Fortaleza prevalence amongst children up to 48 months of age was much lower, only 8.8% <sup>10</sup>. The high infection rate in our study can be explained by the population's characteristics. While in the present study the children lived in destitute squatter settlements, those participating in the studies in Salvador and Fortaleza were preschoolers from probabilistic samples, not necessarily from poor areas.

Considering the variables "number of children" and "birth order", one can conclude that risk of *G. duodenalis* transmission is greater in families with large numbers of children (OR = 1.40) and for children who spend long periods

Table 1

Characteristics of the sample of 590 children living in 29 sub-standard settlements in Juiz de Fora, Minas Gerais State, Brazil.

Characteristics	n	%
Infected with <i>Giardia duodenalis</i>		
Yes	106	18.0
No	484	82.0
Gender		
Male	308	52.2
Female	282	47.8
Age (years)		
1 > 2	146	24.7
2 > 3	142	24.1
3 > 4	132	22.4
4 > 5	170	28.8

Table 2

Correlation between selected risk factors and *Giardia duodenalis* infection in a population of children living in sub-standard settlements in Juiz de Fora, Minas Gerais State, Brazil.

Risk factors	Categories	OR (95%CI)
Number of children	Continuous variable	1.40 (1.03-1.89)
Birth order *	2 <sup>nd</sup> pregnancy	2.05 (1.04-4.05)
	4 <sup>th</sup> pregnancy or greater	3.51 (1.84-6.68)
Presence of bathroom **	No	2.56 (1.23-5.06)
Water source ***	Wells	2.07 (1.07-4.02)
	Springs	2.80 (1.50-5.24)

\* In relation to first pregnancy;

\*\* Compared to yes;

\*\*\* Compared to water from public water system.

of time in contact with siblings. This result corroborates the hypothesis of interpersonal transmission<sup>9,11</sup>.

The absence of a bathroom in the home was heavily associated (OR = 2.56) with *G. duodenalis* infection. In homes without bathrooms, children and adults defecate on the floor or ground (both inside and outside) where young children later walk and play. Since *G. duodenalis* cysts are highly resistant and can remain viable in the environment for up to two months, the presence of a single infected individual disseminates the parasite in the environment, from which there are several routes for children's contamination, mainly by oral contact with soiled hands. It has been demonstrated that installing bathrooms in camps set up for homeless people in Colombia

significantly reduced *G. duodenalis* infection<sup>12</sup>, and a similar effect was observed in a Brazilian urban area<sup>9</sup>.

With respect to the source of water used by children, evidence suggests that the supply of water from public treatment plants is a key protective factor against infection. However, some researchers<sup>13,14</sup> have demonstrated that even these sources of water can become contaminated. Bastos et al.<sup>13</sup> and Heller et al.<sup>14</sup> emphasized the possibility of contamination of water treatment plants with cysts of *G. duodenalis* and *Cryptosporidium parvum* due to technical problems involving coagulation, filtration, or disinfection. Although treated water supplied by public services may not be 100% contamination-free, the expected protective effect against *G. duodenalis*

was verified in the present study in comparison with the use of water obtained from wells or natural springs.

Wells are particularly vulnerable to contamination, especially when adequate care has not been taken in their design and construction and/or where water is collected inappropriately. All these factors help explain the contamination of well water and the risk it poses for transmission of *G. duodenalis* infection (OR = 2.07). Omar et al.<sup>15</sup> found a similar strong association between *G. duodenalis* infection and contaminated well water compared to treated water (OR = 2.15).

Most of the springs in Juiz de Fora are contaminated, according to the municipal water and sewage utility company. In addition, transport and storage of water from these sources typically involves the use of inadequate recipients. These factors explain the strong association between the use of such water and *G. duodenalis* infection (OR = 2.80). A strong association between infection and spring water, as compared to water from public treatment plants, was also reported

by Omar et al.<sup>15</sup> (OR = 2.97) and Hoque et al.<sup>11</sup> (OR = 4.70).

The high prevalence (18%) of *G. duodenalis* infection in squatter settlements in Juiz de Fora compared to other Brazilian cities is mainly a consequence of contamination and insufficient availability of water; inadequate personal hygiene, especially among children; and lack of domestic bathrooms. The parasite is also transmitted directly between residents in crowded dwellings, particular among children, the most vulnerable group.

Based on the results of this research, overcoming *G. duodenalis* infection in sub-standard settlements in Brazil clearly bears crucial links to the water cycle in these areas. Thus, in terms of public environmental health policies, the research highlights the need to prioritize interventions associated with: (i) adequate water supply, with internal running water facilities in households; (ii) housing improvement, with appropriate bathrooms; and (iii) educational measures to improve personal hygiene.

## Resumo

*Um estudo epidemiológico transversal com 590 crianças, com idade entre um ano completo e cinco anos incompletos, residentes em 29 áreas de invasão urbana em Juiz de Fora, Minas Gerais, Brasil, foi desenvolvido com o objetivo de identificar fatores de risco para a infecção por Giardia duodenalis. O critério de inclusão na amostra foi de uma criança por família, por sorteio. A coleta de dados foi feita mediante entrevistas domiciliares. Da amostra, 106 crianças (18%) apresentaram G. duodenalis no exame parasitológico de fezes. No estudo, foram avaliadas 31 variáveis associadas à estrutura familiar, em nível sócio-econômico da família e a fatores ambientais. Após análise multivariada, usando-se modelos de regressão logística, quatro fatores de risco significativos foram encontrados: (a) número de crianças menores de cinco anos residentes na moradia; (b) ordem de nascimento das crianças; (c) existência de banheiro; (d) origem da água de consumo.*

Giardia; Saúde Ambiental; Água; Águas Residuárias; Higiene

## Contributors

All the authors participated in the article's conceptualization. J. C. Teixeira supervised the data collection and analysis. J. C. Teixeira and L. Heller wrote the first draft, which was reviewed and received original contributions from the other author (M. L. Barreto). All three authors reviewed and approved the final version.

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