

# Intestinal parasites in paper money circulating in the city of Diamantina (Minas Gerais, Brazil)

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**Background:** Banknotes are objects of great turnover and diffusion among the population, and can be efficient mechanisms in the dissemination of several intestinal parasites. This study investigated the presence of biological forms of intestinal parasites present in circulating cash banknotes in the city of Diamantina, Minas Gerais, Brazil, aiming to propose interventions aimed at improving local public health.

**Materials and methods:** Between February and April 2017, samples of banknotes collected in five commercial establishments of the city were analyzed, namely: 1) gas station, 2) supermarket, 3) butchery, 4) pharmacy and 5) free fair. Ten circulating banknotes of each value (R\$2.00, R\$5.00, R\$10.00, R\$20.00, R\$50.00 and R\$100.00) were exchanged for new banknotes, washed with Tween 80 and, after spontaneous sedimentation, analyzed under an optical microscope with a magnification of 10× and 40×.

**Results:** Cysts of *Entamoeba coli* (74.60%), cysts of *Endolimax nana* (16.94%), *Giardia lamblia* cysts (4.44%), unidentified nematode larvae (2.02%), *Hymenolepis* sp. (0.81%), *Taenia* sp. (0.81%) and Ancylostomidae larvae (0.40%) were found.

**Conclusions:** The results revealed the need for improvements in basic sanitation, health and education activities that emphasized the importance of proper hand hygiene.

**Keywords:** intestinal parasites, banknotes, Diamantina

## Introduction

Intestinal infections caused by helminths and protozoa affect about 2 billion people worldwide, ~150 countries, constituting a serious public health problem in several regions, including in Brazil.<sup>1,2</sup> They can cause different clinical manifestations in the infected persons among which we can mention malnutrition, anemia, cognitive delay, irritability and diarrhea as well as greater susceptibility to other infections.<sup>3,4</sup>

The absence of basic sanitation and the inadequate practice of personal and domestic hygiene are the main facilitating factors for the dissemination of intestinal parasites.<sup>5</sup> The creation and maintenance of endemic foci are directly related to the spread of infectious forms, which have resistance to several environmental factors.<sup>6,7</sup>

Eggs and larvae of helminths and protozoan cysts released into the environment can be disseminated by humans through several mechanisms already described.<sup>8,9</sup> Banknotes, being objects of great turnover and diffusion among the population, may be efficient mechanisms in the dissemination of various intestinal parasites.<sup>7,10</sup>

Therefore, the present study aimed to investigate the biological forms of intestinal parasites in circulating banknotes in the city of Diamantina, in order to evaluate the current situation and propose interventions aimed at improving the local public health.

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## Materials and methods

### Study area

Diamantina (latitude 18°14'58" S – longitude 43°36'01" W) is a mining municipality located in the Jequitinhonha River Valley with an estimated population of 48,095 inhabitants and a Human Development Index of 0.716. Considered a polo city, Diamantina through the Superintendência Regional de Saúde serves the 33 municipalities of the macro-region, developing specific activities through two intermunicipal health consortia: the Consórcio Intermunicipal de Saúde do Alto do Jequitinhonha and the Consórcio Intermunicipal de Saúde do Médio Jequitinhonha. The characteristics of the urban infrastructure services of the city of Diamantina show that ~95% of the population have garbage collection in their home, 93.7% have water supply through the general network and 76% have sanitary sewage. Only 50% have sewage treated and the other 50% flow directly into the Rio Grande.<sup>11</sup>

### Collection and processing of samples

Between February and April 2017, samples of cash banknotes were collected from five commercial establishments in the city of Diamantina, namely: 1) gas station, 2) supermarket, 3) butchery, 4) pharmacy and 5) free fair. Ten circulating banknotes of each amount (R\$2.00, R\$5.00, R\$10.00, R\$20.00, R\$50.00 and R\$100.00) were exchanged for new notes. The collected banknotes were packed in transparent plastic bags according to their value and transported to the Laboratory of Parasitic Diseases of the Federal University of the Jequitinhonha and Mucuri Valleys.

To the samples, already distributed and conditioned in sacks, 100 mL of diluted Tween 80 in distilled water in the ratio 1:1000 were added. Then, each bag was shaken 100 times for detachment of the biological forms from the banknotes. The resulting liquid from each wash was transferred to a spontaneous settling cup where it remained for 24 h, using the method of Hoffman et al,<sup>12</sup> modified. Posteriorly, the banknotes were placed in a plastic tray containing distilled water for the removal of Tween 80 residues. After 24 h, with the aid of the Pasteur pipette, the pellet was aspirated, placed on a slide in triplicate and taken for analysis under an optical microscope, with a magnitude of 10× and 40×.

### Statistical analysis

For the analysis of continuous variables, analysis of variance or the Kruskal–Wallis test was used; in this way, 1) the number of parasites in relation to the type of note (independent of the commercial establishment) was tested and 2) the number

**Table 1** Frequency of biological forms of intestinal parasites found by banknote and commercial establishment in the city of Diamantina, Minas Gerais, Brazil in the period between February and April 2017

Species	Gas station						Supermarket						Butchery						Pharmacy						Free fair						Total (%)
	\$2	\$5	\$10	\$20	\$50	\$100	\$2	\$5	\$10	\$20	\$50	\$100	\$2	\$5	\$10	\$20	\$50	\$100	\$2	\$5	\$10	\$20	\$50	\$100	\$2	\$5	\$10	\$20	\$50	\$100	
<i>Endolimax nana</i>	7	4	6	5	3	2	2	2	3	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	42 (17)
<i>Entamoeba coli</i>	5	11	10	4	4	4	20	12	7	11	1	1	21	12	4	9	3	4	2	1	1	20	2	2	3	4	5	4	3	3	185 (74.5)
<i>Giardia lamblia</i>	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	11 (4.5)
<i>Hymenolepis</i> sp.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2 (0.8)
<i>Taenia</i> sp.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2 (0.8)
Ancylostomidae	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 (0.4)
Nematoda (ni)	12	17	17	9	7	6	20	14	10	13	1	5	24	14	8	11	3	5	0	7	0	20	0	2	5	1	4	6	4	3	5 (2.0)
Total (N)	4.9	6.9	6.9	3.6	2.8	2.5	8.0	5.7	4.0	5.2	0.4	2.0	9.7	5.7	3.2	4.4	1.2	2.0	0	2.8	0	8.0	0	0.8	2.0	0.4	1.6	2.5	1.6	1.2	248 (100)
% Total	27.6						25.3						26.2						11.6						9.3						

Note: Banknote values in R\$.

Abbreviation: ni, not identified.

of parasites in relation to the commercial establishment (regardless of the note) was tested. A  $p$ -value of  $<0.05$  was considered significant. The statistical package Stata, version 11.0 (StataCorp LP, College Station, TX, USA), was used for the analysis.

## Results

Two hundred forty-eight biological forms of intestinal parasites were detected, with *Entamoeba coli* cysts being the most frequent (74.6%) of the samples, followed by *Endolimax nana* cysts (16.9%), *Giardia lamblia* cysts (4.4%), unidentified nematode larvae (2.0%), eggs of *Hymenolepis* sp. (0.8%), *Taenia* sp. (0.8%) and Ancylostomidae larvae (0.4%) (Table 1).

Among the commercial establishments studied, the gas station was the place where a greater number of biological forms were verified in the money notes with a total of 27.6%. This was followed by banknotes collected at the butcher's shop (26.2%), supermarket (25.3%), pharmacy (11.6%) and free fair (9.3%). The mean of biological forms per banknote was 0.8% (+SD 6.6). Figure 1 shows the mean of the biological forms of intestinal parasites found by banknote in the city of Diamantina, Minas Gerais.

The analysis of the number of intestinal parasites in relation to the value of the banknote (independent of the commercial establishments) did not present statistical significance ( $\chi^2 = 9.19$ ,  $p = 0.1044$ ), which means that the value of the banknote (R\$2.00, R\$5.00, R\$10.00, R\$20.00, R\$50.00, and R\$100.00) was not a factor that interferes with the amount of parasite found in them. On the other hand, the number of intestinal parasites in different establishments presents a borderline statistical relationship ( $\chi^2 = 9.411$ ,  $p = 0.0516$ ). This means that the establishment may be a factor that inter-

feres with the amount of intestinal parasites regardless of the value of the certificate.

## Discussion

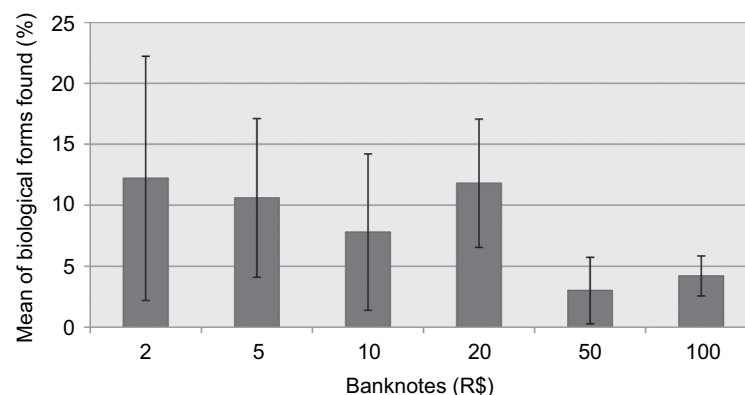
In Brazil, a pioneering study by Levai et al<sup>10</sup> investigated the presence of protozoan cysts and helminth eggs in cash and circulating currencies at various locations in the city of São Paulo, SP. In this survey, the authors demonstrated cysts of *Entamoeba histolytica* and eggs of *Ascaris lumbricoides* and *Taenia* sp. Sudré et al,<sup>13</sup> in a similar study, identified the presence of nematode and arthropod larvae in circulating banknotes in the city of Niterói, RJ.

In this work, a higher frequency of cysts of *E. coli* and *E. nana* was identified as evidenced by Aguiar and Lamounier.<sup>7</sup> The presence of these organisms, even considered nonpathogenic, indicates fecal contamination of banknotes potentiating the spread of these pathogenic forms and protozoa.

The intestinal parasites *G. lamblia*, *Taenia* sp., *Hymenolepis* sp. and unidentified nematode larvae were also recorded in this study. These findings revealed the absence of adequate hand hygiene by the population, which facilitates the maintenance of transmission of these diseases.

Piccolo and Gagliani<sup>14</sup> found a predominance of helminth eggs and protozoan cysts in the R\$1.00 and R\$2.00 banknotes. Although the present study verified the same for the R\$2.00 bills, our results were not statistically significant. We expected a higher frequency of biological forms in the lower value tickets because they presented a greater circulation in relation to the others. We believe that the use of magnetic cards by the population may have influenced this result.

In a general way, the detection of biological forms in the banknotes reveals the absence of hand hygiene on the part of the people who manipulate them, which may facilitate the



**Figure 1** Mean biological forms of intestinal parasites found by money bill in the city of Diamantina, Minas Gerais, Brazil in the period between February and April 2017.

transmission of pathogens to humans.<sup>15</sup> At the same time, it is assumed that the high frequency of intestinal parasites found in the banknotes may be related to the basic sanitation services of the city of Diamantina. These do not cover the entire population, and thus may be contributing to the maintenance of these parasites in the population.

Previous studies conducted in the city of Diamantina have shown that the same intestinal parasites are also circulating in schools and buses.<sup>16,17</sup> It is noticed that the biological forms of these parasites are circulating in the most diverse environments and so it is necessary to establish public health policies and to encourage healthy habits. Thus, avoiding the transmission of these agents.<sup>13</sup>

## Conclusion

There is a need for population-based control measures through improvements in basic sanitation and education and health activities that emphasize the importance of hand hygiene so that the cycle of transmission of these and other biological forms ends.

## Author contributions

All authors contributed toward data analysis, drafting and revising the paper and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest in this work.

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