Risk of Giardia intestinalis Infection in Children From an Artificially Recharged Groundwater Area in Mexico City

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Abstract. The objective of this study was to assess the risk of infection with Giardia intestinalis in children living in an area with artificial groundwater recharge and potable water reuse in Mexico City. Eligible wells and surrounding homesteads were defined by using a geographic information system. Five wells were tested for G. intestinalis cysts per 400 liters of water. A total of 750 eligible households were visited during two cross-sectional surveys. Stool samples were provided by 986 children in the rainy season study and 928 children during the dry season survey for parasitologic tests. Their guardians provided information on water, sanitation, hygiene, and socioeconomic variables. The prevalence rates of G. intestinalis infection were 9.4% in the rainy season and 4.4% in the dry season. Higher rates of infection were observed in older individuals (9.5% and 10.6%) and girls had a lower risk of infection than boys (odds ratio [OR] = 0.55, 95% confidence interval [CI] = 0.34, 0.88 in the rainy season and OR = 0.47, 95% CI = 0.25, 0.90 in the dry season). During the wet season survey, a health risk was detected among those storing water in unprotected receptacles (OR = 4.00, 4.69, and 5.34 for those using uncovered jars, cisterns or tanks, and buckets, respectively), and bathing outside the dwelling, i.e., using a tap (OR = 1.93, 95% CI = 1.10, 3.39). A health risk was also detected among children from households with unsafe food hygiene practices (OR = 2.41, 95% CI = 1.10, 5.30) and those with no hand-washing habits (OR = 2.27, 95% CI = 1.00, 5.20). Groundwater reserves are at risk of fecal pollution, as indicated by the presence of G. intestinalis cysts. However, the endemic pattern of intestinal infection reflects low standards of personal hygiene and unsafe drinking water storage and food-related practices at household level. Prevention activities must address health education and environmental protection policies.

Introduction
Excreta disposal practices and water pollution are leading causes of disease worldwide. Even in industrialized societies, which already have sophisticated water treatment technology in place, an increasing number of waterborne outbreaks have fueled the debate concerning public health protection measures. In less developed countries, the excess burden of diarrhea is likely to reflect multiple modes of transmission of pathogens. Global exposure to fecal pollution is on the increase as a result of population growth, economic driving forces, and weak institutions. The population of the Mexico City Metropolitan Area (MCMA) is 18 million individuals, for whom water is obtained mainly (70%) from underground reserves. Water extracting rates during the last five decades have resulted in soil subsidence, cracking of pipes, and downward migration of pollutants. Pilot water reclamation projects are being evaluated in the MCMA, some of which will rely on a series of advanced wastewater treatment plants; the effluents may be reused for artificial recharge of groundwater or cropland irrigation. Given the water quality indicators currently used, chlorination is included as an additional protection measure. However, both the indicators and the rationale for such a policy is increasingly questioned on the grounds of actual health risk and preventive actions needed. This may be the case of protozoan infections (e.g., Giardia intestinalis), the cysts of which resist common water disinfection practices, and remain viable for several weeks in the environment. The purpose of this investigation was to evaluate the risk of groundwater pollution with G. intestinalis, as well as the risk of infection with G. intestinalis, in children living in an area with artificial groundwater recharge and potable water reuse in Mexico City.

Population and Methods
The study area was located on the southern boundaries of Mexico City (i.e., Xochimilco). The water reclamation project currently in place consists of a series of advanced wastewater treatment plants. The effluent of these plants flows through a network of canals and is subsequently reused for cropland irrigation and greenbelts and for recharging of groundwater reserves for subsequent extraction (i.e., pumping wells). Eligible study units were defined by using a geographic information system that allowed for the overlapping of layers containing hydrologic and demographic data. Site visits facilitated the detection of non-residential units (e.g., farming plots), which were excluded from further consideration (Figures 1 and 2). Only households with children less than six years of age were numbered, spatially located and included in the census. A random sampling technique was used, and after informed consent was obtained, 750 eligible households were included in two cross-sectional surveys. The dry season study was conducted November–May 2000–2001, whereas the rainy season survey was conducted June–October 2001. Households thus acted as the sampling units, whereas the unit of analysis was the individual; siblings were involved if complying with the required criteria. The study was reviewed and approved by the Ethics Committee of the National Institute of Public Health.

Trained field workers used structured questionnaires to gather data on the drinking water supply, sanitation, and hygiene-related variables. At the end of the interview, barcode-labeled flasks containing 25 mL of 2.5% potassium dichromate in phosphate buffer were delivered to the guardian, who received face-to-face explanations and written instructions for the collection of stool samples from each child. Approxi-
approximately two grams of these fecal samples were gathered the following day, bar coded (i.e., identification, age, location), and immediately transported to the laboratory at the Center of Infectious Diseases in Cuernavaca, Mexico. After vortexing, 500 μL of stool dichromate buffer mixture were centrifuged at 12,000 × g for five minutes, decanted, washed with ethyl acetate, and resuspended in 100 μL of phosphate buffer. One drop of sediment was spread into the wells of glass slides,

![Figure 1](image1.png)

**Figure 1.** Frequency of *Giardia* species in groundwater samples and giardiasis in children during the rainy season in Xochimilco, Mexico City, 2000–2001. N = well; SL = San Luis.

![Figure 2](image2.png)

**Figure 2.** Frequency of *Giardia* species in groundwater samples and giardiasis in children during the dry season in Xochimilco, Mexico City, 2000–2001. N = well; SL = San Luis.
air-dried, and fixed with methanol before staining with the MERIFLUOR direct immunofluorescence detection kit (Meridian Diagnostics, Inc., Cincinnati, OH); positive and negative controls were stained simultaneously. Each well was scanned at a magnification of ×100 under a fluorescence microscope, while confirmation was performed at ×400, using an epifluorescence microscope (excitation filter = 450–490 nm, mirror = 510 nm, barrier filter = 520 nm; Carl Zeiss, Inc., Thornwood, NY).

A trained technician collected 30 water samples from five wells (i.e., three replicates from each well, and 15 in each season), which were tested for *G. intestinalis* cysts. Briefly, 400 liters of water from each well were filtered through 1.0-μm porosity, wound polypropylene yarn cartridge filters (A-01508-77; Cole-Parmer, Vernon Hills, IL), kept on ice at 4°C, and transported to the laboratory for immediate analysis. Cartridge filters were cut down to the plastic core and rinsed with 4 liters of deionized water. *Giardia intestinalis* cysts were recovered following elution and centrifugation procedures. Samples were then concentrated by centrifugation in a Percoll-sucrose gradient and placed on a nitrocellulose filter, stained with fluorescein isothiocyanate−conjugated monoclonal antibody against *G. intestinalis* cysts (Aqua-Glo; Waterborne, Inc., New Orleans, LA) for microscopic observation.

**Data management and analysis.** Both population and environmental data were entered twice and corrected for error using IBM 486 (International Business Machines, Yorktown Heights, NY) compatible processors. Case children were defined on the basis of presence of *G. intestinalis* oval cysts (diameter = 10–14 μm; fluorescence = 2+ to 3+) in stool smears. Contaminated wells were defined as those showing positive results for *G. intestinalis* cysts. Those consistently showing negative results were included as “clean” wells. Every child was allocated to one well water quality category, and this exposure remained constant throughout the analysis. Multiple logistic regression was used for bivariate analyses, and since person-to-person transmission was not excluded, an intrafamily correlation structure was examined as a source of bias. Generalized estimation equations were developed to account for autocorrelation within the data, while allowing for the use of time-dependent covariates. Potentially confounding factors (e.g., sex, age) were controlled for, and after adjusting for the effect of water quality, the final model included only statistically significant associations. Measurements used included prevalence rates, odds ratios (ORs), 95% confidence intervals (CIs), and *P* values, all of which were obtained by the use of STATA and SPSS. The interpretation of the regression coefficients followed the usual conventions. The use of a geographic information system (MapInfo software) allowed for the overlapping of both health and environmental data.

**RESULTS**

The rates of *G. intestinalis* infection were 9.4% in the rainy season and 4.4% in the dry season. As shown in Table 1, more than 70% of the children came from households with piped water supplies; however, one-third of these households reported water supply interruptions (12 or more hours a day), and 8% reported water from taps with an unpleasant taste and some color. Half of the interviews provided positive answers on water treatment before ingestion, while 20–25% reported purchasing commercially bottled water, particularly during the driest time of the year. Nearly all of the dwellings had excreta disposal facilities; however, 15% were discharging waste into rudimentary tanks into the backyard soil. Wells N1, N2, and N3 showed positive results for the presence of *G. intestinalis* cysts, whereas wells N6 and SL19 showed consistently negative results (Figures 1 and 2). Bivariate analysis (Table 2) showed no statistical association between the presence of *G. intestinalis* cysts in water samples and *G. intestinalis* infection in these children (OR = 1.77 in the dry season and 0.73 in the rainy season). Data from the wet season shown that older children had higher rates of infection than infants (OR = 6.83, 95% CI = 0.92, 50.52 and OR = 7.58, 95% CI = 1.11, 51.82, respectively). Girls had a lower prevalence of

**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dry season (n = 985)</th>
<th>Rainy season (n = 928)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. %</td>
<td>No. %</td>
</tr>
<tr>
<td>Prevalence of <em>Giardia intestinalis</em> infection</td>
<td>43 4.4</td>
<td>87 9.4</td>
</tr>
<tr>
<td>Piped water supply inside the dwelling</td>
<td>Yes</td>
<td>715 72.5</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>271 27.5</td>
</tr>
<tr>
<td>Water availability days/week</td>
<td>4 or less</td>
<td>76 7.7</td>
</tr>
<tr>
<td></td>
<td>5 or more</td>
<td>910 92.3</td>
</tr>
<tr>
<td>Full day water supply</td>
<td>Yes</td>
<td>675 68.5</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>311 31.5</td>
</tr>
<tr>
<td>Taste in the water</td>
<td>Yes</td>
<td>340 34.5</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>646 65.5</td>
</tr>
<tr>
<td>Color in the water</td>
<td>Yes</td>
<td>78 7.9</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>908 92.1</td>
</tr>
<tr>
<td>Drinking water treatment</td>
<td>Yes</td>
<td>528 53.5</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>458 46.5</td>
</tr>
<tr>
<td>Drinking water storage</td>
<td>Commercially bottled</td>
<td>239 24.2</td>
</tr>
<tr>
<td></td>
<td>Jar</td>
<td>308 31.2</td>
</tr>
<tr>
<td></td>
<td>Cistern or tank</td>
<td>302 30.6</td>
</tr>
<tr>
<td></td>
<td>Bucket</td>
<td>137 13.9</td>
</tr>
<tr>
<td>Place for bathing</td>
<td>Shower, bathroom</td>
<td>549 55.7</td>
</tr>
<tr>
<td></td>
<td>Tap, yard outside</td>
<td>437 44.3</td>
</tr>
<tr>
<td>Hard-washing habits</td>
<td>Yes</td>
<td>835 84.7</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>151 15.3</td>
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<tr>
<td>Excreta disposal facilities</td>
<td>Yes</td>
<td>977 99.1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>9 0.9</td>
</tr>
<tr>
<td>Sewage</td>
<td>Public system</td>
<td>832 85.2</td>
</tr>
<tr>
<td></td>
<td>Septic tank</td>
<td>105 10.7</td>
</tr>
<tr>
<td></td>
<td>On soil</td>
<td>40 4.1</td>
</tr>
<tr>
<td>Vegetables hygiene practices</td>
<td>Disinfection, chlorine for 5 minutes</td>
<td>286 29.0</td>
</tr>
<tr>
<td></td>
<td>Water and soap</td>
<td>335 34.0</td>
</tr>
<tr>
<td></td>
<td>Only water</td>
<td>365 37.0</td>
</tr>
<tr>
<td>Animal pets</td>
<td>Yes</td>
<td>631 64.0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>355 36.0</td>
</tr>
<tr>
<td>Number of families per dwelling</td>
<td>&gt;2</td>
<td>471 47.8</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>515 52.2</td>
</tr>
</tbody>
</table>
infection than boys (OR = 0.47, 95% CI = 0.25, 0.89 in the dry season and OR = 0.55, 95% CI = 0.34, 0.86 in the rainy season). The health risk was higher in individuals from households without piped water than those with piped water (OR = 2.08, 95% CI = 1.25, 3.48), and individuals from households storing water in jars, cisterns or tanks, and buckets had higher rates of infection than those purchasing commercially bottled water (OR = 5.44, 95% CI = 1.60, 18.52, OR = 7.49, 95% CI = 2.25, 24.85, and OR = 7.51, 95% CI = 2.12, 26.57, respectively). Children from households complaining of an unpleasant taste in the water had a higher risk of infection than those without this complaints (OR = 4.07, 95% CI = 1.51, 10.99). Individuals using water for feces disposal (i.e., flush toilet) had a higher risk of infection than those who did not (OR = 1.97, 95% CI = 1.18, 3.29). Increasing rates of infection were also observed if sewage was disposed in a septic tank or directly on the soil when compared with sewage that was disposed into the public drainage system (OR = 2.05, 95% CI = 1.10, 3.83 and OR = 3.12, 95% CI = 1.23, 7.91). A health risk was also observed among children bathing outside the dwelling (e.g., tap, backyard), instead of inside in a bathroom (OR = 2.64, 95% CI = 1.53, 4.57). Individuals with higher rates of infection were more likely to live in crowded dwellings (two or more families per home; OR = 1.84, 95% CI = 1.08, 3.13), and a two-fold higher risk was detected in children from dwellings with corrugated roofs (OR = 2.34, 95% CI = 1.40, 3.94). A risk was observed in children from households with low standards of food hygiene i.e., washing vegetables only with soap or water, compared with those who used chlorine for more than five minutes (OR = 2.73, 95% CI = 1.27, 5.89 and OR = 2.57, 95% CI = 1.20, 5.56, respectively). In the dry season study, a two-fold higher risk of infection was found among those with no hand washing habits (OR = 2.18, 95% CI = 0.97, 4.91).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Bivariate analysis of <em>Giardia intestinalis</em> infection in children in Xochimilco, Mexico City*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater quality (<em>Giardia intestinalis</em>)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>345 3.2 11 1</td>
</tr>
<tr>
<td>Contaminated</td>
<td>641 5.0 32 1.77 0.77, 4.07 0.18 462 8.4 39 0.73 0.44, 1.21 0.21</td>
</tr>
<tr>
<td>Sex of children</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>510 5.1 26 1 484 11.6 56 1 444 7.0 31 0.55 0.35, 0.86 0.009</td>
</tr>
<tr>
<td>Female</td>
<td>476 3.6 17 0.47 0.25, 0.89 0.02 386 10.6 41 7.58 1.11, 51.82 0.03</td>
</tr>
<tr>
<td>Age of children (years)</td>
<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>98 1.0 1 1 69 1.4 1 1 69 1.4 1 1</td>
</tr>
<tr>
<td>1–4</td>
<td>496 4.6 23 0.66, 20.03 0.13 473 9.5 45 6.83 0.92, 50.52 0.06 386 10.6 41 7.58 1.11, 51.82 0.03</td>
</tr>
<tr>
<td>≥ 5</td>
<td>392 4.8 19 0.61, 19.64 0.16 386 10.6 41 7.58 1.11, 51.82 0.03</td>
</tr>
<tr>
<td>Piped water inside the dwelling</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>715 3.5 25 1 686 7.6 52 1</td>
</tr>
<tr>
<td>No</td>
<td>271 6.6 18 1.01 0.25, 0.89 0.02 242 14.4 35 2.08 1.25, 3.48 0.005</td>
</tr>
<tr>
<td>Drinking water storage</td>
<td></td>
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<tr>
<td>Commercially bottled</td>
<td>239 4.2 10 1 188 1.6 3 1</td>
</tr>
<tr>
<td>Jar</td>
<td>308 4.5 14 0.41, 2.65 0.94 274 9.1 25 5.44 1.60, 18.52 0.007</td>
</tr>
<tr>
<td>Cistern or tank</td>
<td>302 4.3 13 0.31, 2.22 0.70 315 12.4 39 7.49 2.25, 24.85 0.001</td>
</tr>
<tr>
<td>Bucket</td>
<td>137 4.4 6 0.33, 3.38 0.93 151 13.2 20 7.51 2.12, 26.57 0.002</td>
</tr>
<tr>
<td>Taste in drinking water</td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>312 4.2 13 0.43, 12.96 0.32 333 9.0 30 1</td>
</tr>
<tr>
<td>Unpleasant</td>
<td>28 7.1 2 0.63, 20.03 0.13 31 29.0 9 4.07 1.51, 10.99 0.006</td>
</tr>
<tr>
<td>Place for bathing</td>
<td></td>
</tr>
<tr>
<td>Shower, bathroom</td>
<td>549 3.8 21 1 440 5.2 23 1</td>
</tr>
<tr>
<td>Tap, backyard</td>
<td>437 5.0 22 1.28 0.63, 2.60 0.49 488 13.1 64 2.64 1.53, 4.57 0.000</td>
</tr>
<tr>
<td>Availability of water/flushing toilet</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>595 3.7 22 1 485 6.4 31 1</td>
</tr>
<tr>
<td>Yes</td>
<td>381 5.0 19 1.37 0.67, 2.81 0.39 423 12.8 54 1.97 1.18, 3.29 0.01</td>
</tr>
<tr>
<td>Sewage</td>
<td></td>
</tr>
<tr>
<td>Public drainage</td>
<td>832 3.7 3 1 749 8.1 1 1</td>
</tr>
<tr>
<td>Septic tank</td>
<td>98 6.1 6 0.58, 4.46 0.36 128 14.8 19 2.05 1.10, 3.83 0.02</td>
</tr>
<tr>
<td>Soil (backyard)</td>
<td>40 5.0 2 1.10 0.18, 6.81 0.91 35 20.0 7 3.12 1.23, 7.91 0.01</td>
</tr>
<tr>
<td>Hand washing</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>835 3.7 31 1 778 8.7 68 1</td>
</tr>
<tr>
<td>No</td>
<td>151 7.9 12 2.18 0.97, 4.91 0.06 150 12.7 19 0.86, 2.90 0.14</td>
</tr>
<tr>
<td>Vegetables hygiene practices</td>
<td></td>
</tr>
<tr>
<td>Disinfection, chlorine for 5 minutes</td>
<td>286 4.5 13 1 246 4.5 11 1</td>
</tr>
<tr>
<td>Water and soap</td>
<td>335 3.9 13 0.37, 2.18 0.81 317 11.7 37 2.73 1.27, 5.89 0.01</td>
</tr>
<tr>
<td>Only water</td>
<td>365 4.7 17 0.96 0.40, 2.31 0.93 365 10.7 39 2.57 1.20, 5.56 0.01</td>
</tr>
<tr>
<td>Number of families per dwelling</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>515 3.7 19 1 403 6.5 26 1</td>
</tr>
<tr>
<td>2</td>
<td>471 5.1 24 1.22 0.60, 2.49 0.57 525 11.6 61 1.84 1.08, 3.13 0.02</td>
</tr>
<tr>
<td>Housing/roof</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>702 3.6 25 1 639 7.2 46 1</td>
</tr>
<tr>
<td>Corrugated</td>
<td>250 6.4 16 1.74 0.83, 3.65 0.14 264 14.4 38 2.34 1.40, 3.94 0.001</td>
</tr>
</tbody>
</table>

*OR = odds ratio; CI = confidence interval.*
Logistic regression analysis is summarized in Tables 3 and 4. No statistical association was detected between the presence of *G. intestinalis* cysts in groundwater samples and the risk of *G. intestinalis* infection in these children. The wet season data show a health risk among children from households storing water in jars, cistern or tanks, and buckets (OR = 4.00, 95% CI = 1.14, 14.03, OR = 4.69, 95% CI = 1.35, 16.28, and OR = 5.34, 95% CI = 1.46, 19.58). In addition, children bathing outside the dwelling (i.e., backyard) had a higher risk of infection than those taking a shower inside their home (OR = 1.93, 95% CI = 1.10, 3.39). Finally, a two-fold higher risk was observed in children from households in which vegetables were usually washed solely with tap water or water and soap before consumption (OR = 2.41, 95% CI = 1.10, 5.30 and OR = 2.15, 95% CI = 0.98, 4.71, respectively).

Older children had an increased risk of infection (OR = 7.04, 95% CI = 1.10, 46.16 in the 1–4-year-old group and OR = 8.48, 95% CI = 1.31, 54.96 in the oldest children). However, in both surveys, girls showed a lower health risk than boys (OR = 0.55, 95% CI = 0.34, 0.88 in the wet season and OR = 0.47, 95% CI = 0.25, 0.90 in the dry season). Dry season data confirmed that children with no hand washing habits had a two-fold higher risk of infection (OR = 2.27, 95% CI = 1.00, 5.20).

**DISCUSSION**

This investigation suggested an endemic pattern of *G. intestinalis* infection, rather than a waterborne outbreak because the rates of infection were not substantially different from the ones recently reported for Mexico as a whole.20,21 Despite the lack of statistical associations between groundwater quality and health risk, it is worth emphasizing that fecal pollution is finding its way into underground water sources; this is the actual meaning of the presence of highly resistant protozoa cysts in groundwater samples.22 However, following our methods, closer socio-cultural risk factors were observed: unsafe water and food-related practices, as well as poor standards of personal hygiene (i.e., behavior); seasonal differences may explain different risk factors.23–25 The health risk detected in the oldest children, and the lower risk observed in girls when compared with boys, reinforce the potential role of behavior and recreational exposure.26 Again, this epidemiologic picture may be different from waterborne disease outbreaks reported in communities in North America outside Mexico.1,2

Our data provides original information on the risk of *G. intestinalis* infection in children from an artificially recharged groundwater project in Mexico City. However, several limi-

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**Table 3**

Logistic regression analysis of *Giardia intestinalis* infection in children in Xochimilco, Mexico City during the rainy season, 2001*

<table>
<thead>
<tr>
<th>Variables</th>
<th>No.</th>
<th>%</th>
<th>n</th>
<th>OR†</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater quality (<em>Giardia intestinalis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>466</td>
<td>10.3</td>
<td>48</td>
<td>1</td>
<td>0.57, 1.62</td>
<td>0.888</td>
</tr>
<tr>
<td>Contaminated</td>
<td>462</td>
<td>8.4</td>
<td>39</td>
<td>0.96</td>
<td>0.34, 0.88</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>484</td>
<td>11.6</td>
<td>56</td>
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</tr>
<tr>
<td>Female</td>
<td>444</td>
<td>7.0</td>
<td>31</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of children (years)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>69</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>1–4</td>
<td>473</td>
<td>9.5</td>
<td>45</td>
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<tr>
<td>≥ 5</td>
<td>386</td>
<td>10.6</td>
<td>41</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage of drinking water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercially bottled</td>
<td>188</td>
<td>1.6</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jar</td>
<td>274</td>
<td>9.1</td>
<td>25</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cistern or tank</td>
<td>315</td>
<td>12.4</td>
<td>39</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket</td>
<td>151</td>
<td>13.3</td>
<td>20</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place for bathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shower, bathroom</td>
<td>440</td>
<td>5.2</td>
<td>23</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap, backyard</td>
<td>488</td>
<td>13.1</td>
<td>64</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable hygiene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disinfection, chlorine for 5 minutes</td>
<td>246</td>
<td>4.5</td>
<td>11</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water and soap</td>
<td>317</td>
<td>11.7</td>
<td>37</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only water</td>
<td>365</td>
<td>10.7</td>
<td>39</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*OR = odds ratio; CI = confidence interval.
† Adjusted for all variables in the table.

**Table 4**

Logistic regression analysis of *Giardia intestinalis* infection in children in Xochimilco, Mexico City during the dry season, 2000–2001*

<table>
<thead>
<tr>
<th>Variables</th>
<th>No.</th>
<th>%</th>
<th>n</th>
<th>OR†</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater quality (<em>Giardia intestinalis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>345</td>
<td>3.2</td>
<td>11</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminated</td>
<td>641</td>
<td>5.0</td>
<td>32</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>510</td>
<td>5.1</td>
<td>26</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>476</td>
<td>3.5</td>
<td>17</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-washing habits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>835</td>
<td>3.7</td>
<td>31</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>151</td>
<td>8.0</td>
<td>12</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*OR = odds ratio; CI = confidence interval.
† Adjusted for all variables in the table.
Construccio
tical parasitologic procedures were used for both the exposed
that reduced the chance of bias. It is worth noting that iden-
come (i.e., cysts passing) to interviewers and respondents,
the blinding of both water quality data and the health out-
within the same compound). The inclusion of a control group,
from the study design, which does not prove cause and effect.
However, it is important to note that more than 70% of the
individuals involved in this investigation were repeatedly
rated during two seasons (the rest were replacements
within the same compound). The inclusion of a control group,
the binding of both water quality data and the health out-
come (i.e., cysts passing) to interviewers and respondents,
along with the procedures used for controlling potentially
confounding factors during the analysis, were all strategies
that reduced the chance of bias. It is worth noting that iden-
tical parasitologic procedures were used for both the exposed
and control groups to reduce bias.

Finally, both public health and groundwater reserves ur-
gently require broader protection policies, and this may be, in
our view, a central issue in groundwater recharge programs in
Mexico City; a cautious approach resulted from technical
gaps that have limited our ability to make baseline health
recommendations. Clearly, further research is needed, but
safe water reclamation projects must always include a code of
safe practices and evidence-based research. This study pro-
vided original data from which we may suggest basic and
― novel ― interventions: households and individuals should as-
sume empowerment self care and common sense activities,
community health promotion including use of narrow-mouth
flasks (i.e., drinking water), safer food related practices, hand
washing, and ecologic sanitation toilets. This may be the core
of behavior ― simple ― and cost-effective interventions.

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