Diarrheal Diseases in Children from a Water Reclamation Site in Mexico City

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This study was conducted to assess the risk of enteric diseases among children living in a water reclamation area in Mexico City. A geographic information system was used to define eligible wells and surrounding households. Sixty-five water samples from five wells were tested for fecal coliform bacteria per 100 mL (FC/100 mL) during visits to 750 eligible households; caretakers only in those dwellings with children under 5 years old were interviewed throughout repeated cross-sectional surveys, conducted during 1999–2000. Data on diarrheal diseases were obtained from 761 children during the rainy season and 732 children during the dry season; their guardians also provided information on drinking water supply, sanitation, and socioeconomic variables. The presence of indicator organisms in groundwater samples pointed to fecal pollution; bacterial indicators, however, did not predict the health risk. The rates of diarrhea were 10.7% in the dry season and 11.8% in the rainy season. Children 1 year old showed the highest rate of diarrhea during the dry season (odds ratio (OR) = 2.1 with 95% confidence interval (CI), 0.99–4.71), particularly those from households perceiving unpleasant taste of tap water (OR, 1.7; 95% CI, 0.97–2.92) and consuming vegetables washed only with water (OR, 2.2; 95% CI, 1.10–4.39). Lower risk was observed in individuals enjoying full-day water supply (OR, 0.5; 95% CI, 0.27–0.86) and a flushing toilet (OR, 0.3; 95% CI, 0.16–0.67), as well as those storing water in covered receptacles (OR, 3.9; 95% CI, 0.15–1.80). Rainy season data suggested that children from households perceiving a color to their water had a higher rate of diarrhea than did those without such complaint (OR, 1.8; 95% CI, 0.93–3.67); recent consumption of food sold by street vendors was also a significant risk factor (OR, 1.6; 95% CI, 0.98–2.87). Groundwater is at risk of contamination, as indicated by the presence of FC/100 mL. The endemic pattern of diarrhea, however, reflects mostly inadequate housing, sanitation, and water-related practices. Health protection policy must be discussed.

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Water and sanitation deficiencies represent a growing environmental health challenge in several regions around the globe. Unsafe sewage disposal and fecal–oral transmission of pathogens are responsible for otherwise preventable enteric diseases and 3.2 million premature deaths every year (1). In less developed countries, the disease burden falls heavily on the poor (2). This gap is perpetuated by the fact that environmental interventions have neglected sanitary needs and focused on the development of drinking water supplies instead (1,3). Yet the more dramatic “life-saving” oral rehydration salts therapy (an ethical imperative in primary health care) has shifted the attention from the actual role of prevention to cost-effective “solutions” (4). Exposure to fecal pollution is growing as a result of economic driving forces, overcrowded slums, and weak institutions.

The current population of the Mexico City metropolitan area (MCMA) is 18 million and is forecast to be 23.5 million by the year 2015 (5). Up to 75% of its water supply depends on groundwater reserves (6). Overextraction of water has led to soil subsidence and cracking of underground pipes, which may facilitate the mixture of drinking water supplies and sewage, as well as the downward migration of pollutants (7). Earlier investigations indicated high rates of groundwater positive microbiological tests (8); despite growing concern, public health data are limited and official reports provide scarcely credible information (9). Additional gaps reflect the limitations of microbial indicators currently used to assess drinking water quality (10); therefore, the basis for “safety” criteria stipulated by national regulations is increasingly debatable (11,12).

A water reuse program, consisting of wastewater treatment and effluent reclamation (e.g., irrigation of fodder and green belts) is being developed in MCMA (13). A series of investigations is being conducted to assess the risk of enteric disease and provide some basis for future environmental interventions. This study addressed the following research questions: Is groundwater microbiological pollution a health risk? What are the risk factors for enteric diseases? And which further questions should be addressed?

Methods

The boundaries of Mexico City were first framed within basic geostatistical areas, which in turn were characterized according to demographic variables, as provided by the national census tracks (5). Earlier investigations described the environmental indicators linked to enteric diseases, from which a “high-risk” communities approach was further developed (14). Our present case study was a second-step approach, resulting from an earlier investigation (14).

The research area is located in Xochimilco, on the outskirts of the city, where a water reclamation project is being developed. This project consists of a series of wastewater treatment plants, the effluents of which flow through a network of canals to be reused for agricultural irrigation, all of which contributes to the recharge of groundwater reserves, for subsequent extraction (i.e., pumping wells). Eligible study units were homesteads within 500 m of selected wells (Figures 1 and 2). The development of a geographic information system (GIS) allowed for the overlapping of layers containing different data, whereas site visits allowed for the detection of nonresidential units (e.g., farming plots), which were excluded from further consideration. A trained technician gathered a total of 65 water samples from five wells (35 samples during the rainy season and 30 in the dry season). Water samples were collected at a point before chlorination and distribution processing, kept on ice at 4°C, and transported to the laboratory (15). Water samples were incubated 24 hr, and the development of specific color changes (fluorescence) indicated the presence of fecal coliform bacteria (FC/100 mL), which was tested by using the Colilert method (presence/absence), as described by Edberg et al. (16) and approved by the U.S. Environmental Protection Agency. Contaminated wells were defined as those showing positive results in 95% of their water samples, whereas controls were defined as those wells consistently showing negative tests.

Only households having children under 5 years old were numbered and spatially located via GIS. A random sampling technique was used (17), and upon previous informed consent, 750 eligible households were included.
in two repeated cross-sectional studies. A total of 732 children participated in the dry season study (November through May, 1999–2000) and 761 in the rainy season (June through October 2000). Trained field workers used structured questionnaires to gather data on episodes of diarrhea, and the recall period was the preceding week, as recommended by the World Health Organization (18). The guardian (i.e., mother) also provided information on housing characteristics (e.g., water supply, sanitation, hygiene, and socioeconomic-related variables).

Data management and analysis. Both environmental and population data were entered twice and error corrected. IBM-compatible computers (486 processors) were used. For population data, the unit of analysis was the individual. Each child was allocated to one water quality category, which remained constant throughout the analysis; children exposed to different wells were allocated to the highest exposure. An episode of diarrhea (health outcome) was defined as three or more loose stools in 24 hr. Potential confounding factors were included in the analysis; crowding (proxy of low socioeconomic strata) was incorporated as a continuous variable (three to six individuals per bedroom), and the odds ratio was interpreted as the excess of disease among children living in crowded dwellings, when compared with children without this factor (i.e., < 3 individuals). Special attention was paid to seasonal differences (19), and every independent variable showing significant association (Pearson chi-squared test) with diarrheal diseases was included in the final model. Statistical analysis was performed by using multiple logistic regression techniques (20).

Results
Table 1 illustrates the characteristics of the population. The prevalence rates of diarrhea were 10.7% in the dry season and 11.8% in the rainy season. Crowding conditions were detected in more than half of the dwellings visited. Three-quarters of the children came from households with piped water supply inside their dwelling; for more than 60% of these, however, water supply failures (> 12 hr/day) were a common experience. Data showed that drinking water was usually stored in unprotected tanks and buckets (29–33%). When respondents were questioned about perceived characteristics of tap water, a third of them reported unpleasant taste; a similar proportion reported purchasing commercially bottled water, particularly during the dry season.

Water quality and spatial location of children are shown in Figures 1 and 2. Wells N1 and N3 showed the presence of bacterial indicator (FC/100 mL), whereas wells N2, N6, and SL19 showed consistently negative results (i.e., absence of bacteria).

Bivariate analysis (Table 2) showed no statistical association between the presence of bacterial indicators (FC/100 mL) in water...
samples and risk of enteric diseases (OR = 0.7 in the dry season and OR = 1.1 in the rainy season). As data illustrate, longer episodes of diarrhea were detected in the dry season than during the rainy season (OR = 3.7; 95% CI, 1.39–10.08), particularly among individuals between their first and second birthday (22.6%; OR, 2.1; 95% CI, 1.03–4.50). The lowest prevalence of diarrhea was detected in older children (7.7% and 9.5%), although this observation was statistically significant only in the wet season study (OR, 0.5; 95% CI, 0.26–0.94). The prevalence of diarrhea was higher among children from households without piped water than among children in households with it (18.5% and 8.1%, respectively), and this association was detected only in the dry season (OR, 2.5; 95% CI, 1.58–4.18). Children from households complaining of unpleasant taste of water had a higher risk than did children from households without such complaint (OR, 1.7; 95% CI, 1.04–2.70 in the dry season; OR, 1.5; 95% CI, 0.95–2.33 in the rainy season), whereas perceived color of water was statistically significant only in the rainy season (OR, 1.9; 95% CI, 0.97–3.74) and not in the dry season, when a 2-fold risk was observed among children from dwellings without water for flushing the toilet (OR, 2.1; 95% CI, 1.32–3.41), as well as from dwellings where water was stored in unprotected buckets or cisterns (OR, 1.9; 95% CI, 1.04–3.42) and with no hand-washing habits (OR, 1.7; 95% CI, 0.95–3.13). Children from households whose members held cultural explanations of diarrhea had a higher risk of diarrhea than did children in households with beliefs regarding food and water pollution or hygiene (OR, 1.9; 95% CI, 1.05–3.70). Children who had recently consumed food sold by street vendors had a higher rate of diarrhea than did those who did not, although this association was found only during the wet season (OR, 1.7; 95% CI, 0.99–2.92). A health risk was also detected in children living in crowded dwellings (OR, 1.2; 95% CI, 1.03–1.50), although this association was observed only during the dry season.

Logistic regression analysis (Tables 3 and 4) confirmed a lack of statistical association between the presence of fecal coliform bacteria in groundwater samples and health risk. The final analyses showed that the highest prevalence of diarrhea affected children 1–2 years old, whereas a decreasing risk was observed in older children; in the younger children, the difference was statistically significant in the dry season (OR, 2.1; 95% CI, 0.99–4.71), whereas the lower risk in older children was observed only during the wet season (OR, 0.5; 95% CI, 0.26–0.95).

Dry season data (Table 3) showed that children from households perceiving unpleasant taste of water had a higher risk than did children in households without such complaint (OR, 1.7; 95% CI, 0.97–2.92). In addition, a 2-fold risk was observed in children from households in which vegetables are usually washed only with tap water before consumption, compared with households using chlorine for disinfection or soap (OR, 2.2; 95% CI, 1.10–4.39). In contrast, protective associations were observed among children...
Table 1. General characteristics of the study population.

| Characteristics                        | Dry season (n = 732) | Rainy season (n = 761) |
|----------------------------------------|----------------------|------------------------|
|                                        | No. | Percent | No. | Percent |
| Prevalence of acute diarrhea (last week) | 78  | 10.7    | 90  | 11.8    |
| Piped water supply inside the dwelling | No  | 178     | 24.3| 178     | 23.4    |
|                                        | Yes | 554     | 75.7| 583     | 76.6    |
| Full-day water supply                  | No  | 488     | 66.7| 486     | 63.9    |
|                                        | Yes | 244     | 33.3| 275     | 36.1    |
| Taste of water                         | No  | 492     | 67.2| 487     | 64.0    |
|                                        | Yes | 240     | 32.8| 274     | 36.0    |
| Storage of drinking water              | Commercially bottled | 200 | 27.4| 159     | 20.9    |
|                                        | Covered jar          | 224 | 30.6| 235     | 30.9    |
|                                        | Unprotected cistern, bucket | 217 | 29.6| 251     | 33.0    |
|                                        | Protected cistern, bucket | 91  | 12.4| 116     | 15.2    |
| Availability of water for toilet flushing | No  | 488     | 63.8| 440     | 59.4    |
|                                        | Yes | 244     | 36.2| 301     | 40.6    |
| Crowding (> 2 persons/bedroom)         | No  | 332     | 45.4| 289     | 38.0    |
|                                        | Yes | 400     | 54.6| 472     | 62.0    |

Table 2. Bivariate analysis: risk factors for diarrheal diseases in children.

| Risk factors                                      | Dry season | Rainy season |
|---------------------------------------------------|------------|--------------|
|                                                   | N | Percent | n | 95% CI | p-Value | N | Percent | n | 95% CI | p-Value |
| Well water quality (FC/100 mL)                    | 428 | 11.6 | 50 | 1 | 0.47–1.25 | 0.28 | 178 | 12.8 | 24 | 1.1 | 0.69–1.87 | 0.62 |
| Clean                                             | 304 | 9.2 | 29 | 0.7 | 1.03–4.50 | 0.04 | 115 | 18.4 | 23 | 1.0 | 0.51–2.12 | 0.07 |
| Contaminated                                       | 101 | 11.8 | 12 | 1 | 0.31–1.23 | 0.17 | 516 | 9.5 | 53 | 0.5 | 0.26–0.94 | 0.03 |
| Age of children ≤ 1 year                          | 80  | 17.5 | 22 | 1 | 1.32–3.41 | 0.00 | 178 | 23.4 | 40 | 1.3 | 0.79–2.13 | 0.29 |
| 1–2 years                                         | 27  | 81.4 | 22 | 1 | 1.32–3.41 | 0.00 | 178 | 23.4 | 40 | 1.3 | 0.79–2.13 | 0.29 |
| > 2 years                                         | 90  | 71.1 | 64 | 0.5 | 0.19–1.63 | 0.29 |
| Duration of diarrheal episode                     | 679 | 10.1 | 69 | 1 | 1.04–2.70 | 0.03 | 240 | 14.1 | 40 | 1.5 | 0.95–2.33 | 0.07 |
| Piped water inside the dwelling                   | 554 | 8.1 | 45 | 1 | 0.94–3.86 | 0.12 | 178 | 18.5 | 33 | 2.5 | 0.79–2.13 | 0.29 |
| Hand washing                                       | 631 | 9.8 | 62 | 1 | 0.95–3.13 | 0.07 | 240 | 14.1 | 34 | 1.7 | 0.42–1.34 | 0.34 |
| No                                                 | 101 | 18.5 | 16 | 1.7 | 0.95–3.13 | 0.07 | 651 | 11.3 | 74 | 0.7 | 0.42–1.34 | 0.34 |
| Taste of water                                     | 492 | 8.9 | 44 | 1 | 1.04–2.70 | 0.03 | 487 | 10.2 | 50 | 1 | 0.95–2.33 | 0.07 |
| Yes                                                | 240 | 14.1 | 34 | 1.7 | 1.04–2.70 | 0.03 | 274 | 14.5 | 40 | 1.5 | 0.95–2.33 | 0.07 |
| Color of water                                     | 679 | 10.1 | 69 | 1 | 0.94–3.86 | 0.12 | 240 | 14.1 | 34 | 1.7 | 1.04–2.70 | 0.03 |
| No                                                 | 53  | 16.9 | 9  | 1.8 | 0.94–3.86 | 0.12 | 62  | 19.3 | 12 | 1.9 | 0.97–3.74 | 0.05 |
| Yes                                                | 467 | 7.9 | 37 | 1 | 1.32–3.41 | 0.02 | 301 | 17.6 | 21 | 1.2 | 0.58–1.46 | 0.75 |
| Availability of water for toilet flushing          | 265 | 15.4 | 41 | 2.1 | 0.90–2.77 | 0.11 | 533 | 13.3 | 77 | 1.7 | 0.99–2.87 | 0.05 |
| Storage of drinking water                         | 200 | 9.5 | 19 | 1 | 0.25–1.14 | 0.10 | 159 | 10.6 | 17 | 1 | 0.70–2.46 | 0.38 |
| Commercially bottled                               | 224 | 5.3 | 12 | 0.5 | 0.25–1.14 | 0.10 | 235 | 13.6 | 32 | 1.3 | 0.62–2.20 | 0.61 |
| Covered jar                                        | 217 | 16.5 | 36 | 1.9 | 1.04–4.32 | 0.03 | 251 | 12.3 | 31 | 1.1 | 0.62–2.20 | 0.61 |
| Unprotected cistern or bucket                      | 91  | 12.0 | 11 | 1.3 | 0.59–2.88 | 0.50 | 116 | 8.6 | 10 | 0.8 | 0.34–1.79 | 0.56 |
| Protected cistern or bucket                        | 217 | 7.8 | 17 | 1 | 0.90–2.77 | 0.11 | 228 | 8.3 | 19 | 1 | 0.99–2.87 | 0.05 |
| Consumption of fast food/ street-vendor products   | 515 | 11.8 | 61 | 1.6 | 0.69–2.31 | 0.43 | 312 | 9.9 | 31 | 0.7 | 0.46–1.30 | 0.32 |
| Perceived "cause" of diarrhea                       | 222 | 8.1 | 18 | 1 | 0.69–2.31 | 0.43 | 272 | 12.5 | 34 | 1 | 0.66–2.00 | 0.61 |
| Poor hygiene                                       | 328 | 10.0 | 33 | 1.2 | 0.69–2.31 | 0.43 | 312 | 9.9 | 31 | 0.7 | 0.46–1.30 | 0.32 |
| Cultural syndromes (e.g., evil eye)                | 182 | 14.8 | 27 | 1.9 | 1.05–3.70 | 0.03 | 177 | 14.1 | 25 | 1.1 | 0.66–2.00 | 0.61 |
| Crowding (> 2 persons/bedroom)*                    | 400 | 12.0 | 48 | 1.2 | 1.03–1.50 | 0.03 | 476 | 11.1 | 462 | 11.9 | 0.91–1.29 | 0.41 |

Abbreviations: N, total number of children in category; n, number of infected children (positive test). *Continuous variable.
important, perhaps, the water quality indicators used did not predict the health risk. It is necessary to emphasize, however, that groundwater is in jeopardy, and this could be the actual meaning of the presence of bacteria in water samples. Despite the lack of statistical association between groundwater quality and health risk, it is worth emphasizing that fecal pollution is finding its way to underground water sources. This observation may be different from official reports.

As expected, the rate of enteric disease was slightly higher in the wet season; more risk factors, however, were detected during the driest time of the year. These observations are not new, but reinforce the following points: The high prevalence of diarrhea detected in children within the first months after birth (rainy season) and a 2-fold risk in older children (dry season) may be suggesting different enteric syndromes with possible seasonal influences. The whole picture simply confirmed that housing deficiencies, hygiene-related behavior (including food), water storage practices, and risk perceptions were all at play (25–27).

Interestingly, children from households complaining of unpleasant attributes of water (e.g., taste, color), as well as those stating culturally influenced beliefs in disease etiology (e.g., evil eye), had a higher risk of diarrhea than did those without complaints and giving hygiene-related answers to questions regarding beliefs. Similar observations were reported by Whiteford (28) studying the ethnocology of water-based diseases in the Caribbean; our work reinforces the relevance of perception data in environmental research.

### Table 3. Logistic regression analysis: risk factors for diarrheal diseases, dry season.

| Variables                        | N     | Percent | n    | OR    | 95% CI       | p-Value |
|----------------------------------|-------|---------|------|-------|--------------|---------|
| Well water quality               |       |         |      |       |              |         |
| Clean                            | 428   | 11.7    | 50   | 1     |              |         |
| Contaminated                     | 304   | 9.2     | 28   | 1.0   | 0.58–1.75    | 0.96    |
| Age of children                  |       |         |      |       |              |         |
| < 1 year                         | 101   | 11.9    | 12   | 1     |              |         |
| 1–2 years                        | 115   | 22.6    | 26   | 2.1   | 0.99–4.71    | 0.05    |
| > 2 years                        | 516   | 7.8     | 40   | 0.6   | 0.29–1.22    | 0.15    |
| Full-day water supply            |       |         |      |       |              |         |
| No                               | 488   | 11.9    | 58   | 1     |              |         |
| Yes                              | 244   | 8.2     | 20   | 0.5   | 0.27–0.86    | 0.01    |
| Taste of water                   |       |         |      |       |              |         |
| No                               | 492   | 8.9     | 44   | 1     |              |         |
| Yes                              | 240   | 14.2    | 34   | 1.7   | 0.97–2.92    | 0.06    |
| Place for bathing                |       |         |      |       |              |         |
| Tap, yard outside                | 432   | 9.5     | 41   | 1     |              |         |
| Shower, bathroom                 | 300   | 12.3    | 37   | 0.4   | 0.23–0.96    | 0.03    |
| Storage of drinking water        |       |         |      |       |              |         |
| Commercial bottle                | 200   | 9.5     | 19   | 1     |              |         |
| Covered jar                      | 224   | 5.4     | 12   | 0.3   | 0.15–0.90    | 0.01    |
| Unprotected cistern or bucket    | 217   | 16.6    | 36   | 1.3   | 0.63–2.76    | 0.45    |
| Protected cistern or bucket      | 91    | 12.1    | 11   | 0.9   | 0.38–2.19    | 0.84    |
| Availability of water for toilet flushing | | | | | | |
| No                               | 265   | 15.5    | 41   | 1     |              |         |
| Yes                              | 467   | 7.9     | 37   | 0.3   | 0.16–0.67    | 0.002   |
| Vegetable hygiene                |       |         |      |       |              |         |
| Disinfection, chlorine           | 216   | 6.5     | 14   | 1     |              |         |
| Water and soap                   | 267   | 11.2    | 30   | 1.7   | 0.85–3.43    | 0.13    |
| Only water                       | 249   | 13.7    | 34   | 2.2   | 1.10–4.39    | 0.02    |

Abbreviations: N, total number of children in category; n, number of infected children (positive test).

### Table 4. Logistic regression analysis: risk factors for diarrheal diseases, rainy season.

| Variables                                      | N     | Percent | n    | OR    | 95% CI       | p-Value |
|------------------------------------------------|-------|---------|------|-------|--------------|---------|
| Well water quality (FC/100 mL)                 |       |         |      |       |              |         |
| Clean                                          | 574   | 11.5    | 66   | 1     |              |         |
| Contaminated                                   | 187   | 12.8    | 24   | 1.1   | 0.69–1.75    | 0.68    |
| Age of children                                |       |         |      |       |              |         |
| < 1 year                                       | 80    | 17.5    | 14   | 1     |              |         |
| 1–2 years                                      | 125   | 18.4    | 23   | 1.0   | 0.50–2.21    | 0.88    |
| > 2 years                                      | 556   | 9.5     | 53   | 0.5   | 0.26–0.95    | 0.03    |
| Color of water                                 |       |         |      |       |              |         |
| No                                             | 699   | 11.2    | 78   | 1     |              |         |
| Yes                                            | 62    | 19.4    | 12   | 1.8   | 0.93–3.67    | 0.08    |
| Consumption of fast food/street-vendor products |       |         |      |       |              |         |
| No                                             | 228   | 8.3     | 19   | 1     |              |         |
| Yes                                            | 533   | 13.3    | 71   | 1.6   | 0.98–2.87    | 0.06    |

Abbreviations: N, total number of children in category; n, number of infected children (positive test).
REFERENCES AND NOTES

1. WHO. World Health Report: Bridging the Gaps. Geneva: World Health Organization, 1995.
2. Bern C, Martinez J, Zeya I, Glass R. The magnitude of the global problem of diarrheal disease: a 10 year update. Bull WHO 70(6):705–712 (1992).
3. Bartone C. Urban sanitation, sewerage and wastewater management: responding to growing household and community demand. In: Proceedings of the Environmentally Sustainable Development Conference. Washington, DC: World Bank, 1994;136–144.
4. Okun D. The value of water supply and sanitation in development; an assessment. Am J Public Health 78(11):1463–1466 (1988).
5. INEGI. Información Estadística y Geográfica Municipal, Vol 6. México City: Instituto Nacional de Geografía e Informática, 2000.
6. National Research Council. Mexico City Water Supply. Washington DC: National Academy Press, 1995.
7. Ezcurra E, Mazari M. Are megacities viable? A cautionary tale from Mexico City. Environ 38(1):6–35 (1996).
8. Mazari M, Cifuentes E, Venczel L, Hurtado J. Panorama of acute diarrheal diseases in Mexico. Health Place 5:247–255 (1999).
9. Pipes WO. Microbiological methods and monitoring of drinking water. In: Drinking Water Microbiology (Feters MC, ed). New York: Springer-Verlag, 1999;428–445.
10. DDF. Salud Ambiental: Agua Para Uso y Consumo Humano. Límites Permisibles de Calidad, Tratamiento y Potabilización. Norma oficial Mexicana NOM 127-SSA 1-1994. México City: Diario Oficial de la Federación, 1996.
11. OECD. Microbiological Testing of Drinking Water. Working Group Document. Paris: Organisation for Economic Cooperation and Development, 2001.
12. WHO. Guidelines for a Sample Survey of Diarrheal Disease Morbidity, Mortality and Treatment Rates. Diarrhea Control Program. World Health Organization. Geneva: World Health Organization, 1994.
13. Blum D, Feachem R. Measuring the impact of water supply and sanitation investments on diarrheal diseases: problems of methodology. Int J Epidemiol 12(3):357–365 (1983).
14. Hosmer D, Lemeshow S. Applied Logistic Regression. New York: John Wiley & Sons, 1989.
15. STATA. Statistical Data Analysis: A User’s Perspective. Version 5.0. College Station, TX: Stata Co., 1997.
16. SPSS Version 9.0.1 Statistical Program. Chicago, IL: SPSS, 1999.
17. MapInfo Professional Version 4.0. New York: MapInfo Corporation, 1995.
18. ENSA. Enfermedades Diarreicas Agudas por Estados y Municipios (EDA). México City: Encuesta Nacional de Salud, 2000.
19. Esrey S. Water, waste and well being; a multicountry study. Am J Public Health 143(8):608–612 (1996).
20. VanDerslice J, Briscoe J. Environmental interventions in developing countries. Interactions and their implications. Am J Public Health 141(12):135–144 (1995).
21. Leslie JM, Lucette M, Buvicin M. Weathering the economic crises: the crucial role of women in health. In: Health, Nutrition, and Economic Crisis: Policy in the Third World (Bell DE, Reich M, eds). Dover, MA: Auburn House Publishing, 1989; 113–122.
22. Whiteford LM. Caribbean colonial history and its contemporary health care consequences; the case of the Dominican Republic. Soc Sci Med 50(10):1211–1217 (1995).