# Water Cost and Availability: Key Determinants of Family Hygiene in a Peruvian Shantytown


## ABSTRACT

*Objectives.* This study was conducted to determine whether poor hygiene practices are owing to difficulty in getting enough water and/or to ignorance of sanitary principles.

*Methods.* In a water-scarce shantytown in Lima, Peru, we observed in 12-hour periods over 3 consecutive days the amount of water and soap used for personal and domestic activities in 53 families and the frequency with which direct fecal contamination of hands was interrupted by washing. We also surveyed women in a similar shantytown concerning their knowledge of hygiene to ascertain whether noncompliance was owing to ignorance.

*Results.* Three hundred fecal contamination events were registered, of which only 38 (13%) were interrupted by hand washing within 15 minutes. The mean 12-hour per capita amount of water and soap used by the families was low. More than 80% of the water stored by these families had fecal coliforms. Yet the level of knowledge concerning the importance of hand washing and other hygienic practices was high.

*Conclusions.* In water-scarce areas, sanitary education programs probably will not change hygiene practices. In these areas, an adequate supply of water is essential for good hygiene. (*Am J Public Health.* 1993; 83:1554–1558)



*Robert H. Gilman, MD, Grace S. Marquis, MS, Gladys Ventura, BS, Miguel Campos, MD, William Spira, PhD, and Fernando Diaz, MD*


## Introduction

Hand washing is an effective means of interrupting fecal-oral transmission and decreasing the intrafamiliar spread of diarrheal disease pathogens such as shigella.[1–4] Poor hygiene practices may be due to ignorance of sanitary principles, high cost, scarcity of clean water, or distance from it.[5–8] When water is plentiful, programs that emphasize hygiene education increase personal sanitation practices and result in decreased rates of diarrhea.[9,10] However, educational messages may not succeed if adequate and convenient water supplies are not available.[11]

Water is a scarce resource in Lima shantytowns called *pueblo jovenes.*[12,13] To describe the effect of water scarcity on sanitary behavior, we used direct observation to determine hygienic practices in such a town.

## Methods

### Study Sites

The study was carried out in 1987, prior to the cholera epidemic, in two well-described periurban *pueblo jovenes* of Lima, Peru: Huáscar, Canto Grande, and Las Pampas de San Juan de Miraflores.[13,14]

### Family Selection

Our study population consisted of families living in Canto Grande who were previously selected at random to participate in a longitudinal diarrhea study.[13,14] Fifty-three of these families, all with at least one child less than 3 years of age, were chosen for the current study. Although all families were impoverished, a skilled field-worker classified them into three ascending grades of wealth.

Differences in income (based on family expenditure data) in a *pueblo joven* are small, varying by less than $1500 per year between families. Seventeen families were selected with equal numbers in each wealth category to determine if that small difference in income affected water and soap consumption. No difference was found, and the remaining 36 families were selected from the randomly generated list without further stratification for wealth. There was no difference between the two groups in their mean socioeconomic status, family size, or water and soap use; therefore, both data sets were pooled and analyzed together.

### Detailed In-House Methodology

*Hygiene activities.* Three consecutive days of 12-hour (7 AM to 7 PM) in-house observation were scheduled with mothers. During the observation period, the field-worker noted the activities of each family member, including preparation and consumption of food and water, defecation, handling of children's feces, and bathing and washing of hands. The field-workers engaged in small talk and avoided all comments concerning soap and water use. Children were asked


Robert H. Gilman and William Spira are with The Johns Hopkins School of Hygiene in Baltimore, Md. Drs Gilman and Spira and Miguel Campos and Fernando Diaz are with the Universidad Peruana de Cayetano Heredia, Lima, Peru. Grace S. Marquis and Gladys Ventura are with the Instituto de Investigacion Nutricional in Lima, Peru. Dr Diaz is also with A. B. PRISMA, Lima.

Requests for reprints should be sent to Robert H. Gilman, MD, Department of International Health, The Johns Hopkins School of Hygiene and Public Health, 615 N Wolfe St, Baltimore, MD 21205.



This paper was accepted April 29, 1993.

whether they had defecated when they used the household borehole latrine or the nearby hillside. However, because adults were not similarly questioned about these activities, the defecations that were recorded were limited to those spontaneously mentioned by the adults or their children. Adult fecal contamination events are therefore probably underestimated. The type of water (fresh or reused) and soap (face, clothes, shampoo, or detergent) used by each family member was documented. The field-worker noted how often the mother observed her children drinking water that had not been boiled and permitted them to do so.

A contamination event was defined as a family member having just defecated or handled fecally contaminated material such as diapers. An interruption event was defined as the family member hand washing with water or with water and soap within 12 hours of the contamination event.

*Total water and soap use.* The field-worker observed whether water obtained from the storage tank was boiled before it was drunk. She also noted how much water was used for washing dishes, food, and laundry, and for cleaning house. To facilitate the measurement of water, mothers were provided with a 1-L graduated pitcher. The field-worker weighed all soap at the beginning and end of each 12-hour observation period and noted the type of soap (but not the number of grams) used for each activity. Other household staples were weighed at the same time in order not to call attention to the measurement of the soap.

*Water bacteriology.* Quality of water stored outside the house was tested in 44 of the 53 Canto Grande families. Samples of 100 mL in sterile bottles were taken from the household cement tank (n = 35) or metal cylinder (n = 9). Fecal contamination of the water was determined by the presence of presumptive coliforms, heterotrophic plate counts,[15] and viable counts of *Aeromonas* and *Vibrio cholerae* sero group non-01. Counts of *Aeromonas* and *Vibrio* species were performed as previously described.[16–19]

*Water attitudes and beliefs survey.* We also surveyed 107 randomly selected families living in Las Pampas de San Juan to document their knowledge regarding the use of water, hand washing, and bathing. This *pueblo joven,* although different from Canto Grande, is socioeconomically similar.[13] The survey identified the mothers' perceptions of the health risks of not washing hands after fecal contamination and of drinking water that had not been boiled. Mothers were also asked whether water should be stored covered and, if so, why, and whether they drank water that was not boiled. They were also asked at what age and how often babies should be bathed.

**TABLE 1—Water and Soap Usage after Fecal Contamination: Percentage of Events,[a] by Family Role and Age**

| | Age, y | | | | |
|---|---|---|---|---|---|
| After Contamination Events | 0–2.0 | 2.1–5.0 | 5.1–10.0 | >10.0[b] | Mothers |
| Defecation | (n = 74) | (n = 79) | (n = 42) | (n = 21) | (n = 9) |
| Hands not washed | 88 | 99 | 90 | 71 | 89 |
| Hands washed with | | | | | |
| Fresh water only | 4 | | 2.5 | | |
| Fresh water & soap | 5 | 1 | | 10 | |
| Used water only | 3 | | 5 | 19 | 11 |
| Used water & soap | | | 2.5 | | |
| Touching stools | (n = 1) | (n = 3) | (n = 7) | (n = 10) | (n = 54) |
| Hands not washed | 100 | 33 | 100 | 80 | 76 |
| Hands washed with | | | | | |
| Fresh water only | | | | 10 | 7 |
| Fresh water & soap | | | | 10 | 2 |
| Used water only | | 67 | | | 15 |
| Used water & soap | | | | | |

[a]Based on events reported during 3 days of 12-hour observation periods.
[b]>10-year-old group does not include mothers.

## *Statistical Analysis*

Activities were analyzed by age and sex and presented in frequency tables. We followed contamination events over time, using survival curves to determine rates and time intervals of the interruption of fecal-hand contamination. Life tables were used to examine, first, the duration between contamination and hand washing and, second, the duration between uninterrupted contamination and an episode of transmission. These curves were based on the following assumptions: (1) fecal contamination persisted if uninterrupted for at least a 12-hour period; and (2) handwashing, whether with soap or with water alone, stopped fecal transmission.[1] Handwashing that occurred within 15 minutes of a fecal contamination event was considered to be a purposeful interruption. Interruption after this time was defined as unintentional.

Mean daily soap and water consumption was tabulated, and the variances for each day were compared for homogeneity using Bartlett's test.[20] Pearson's correlation coefficients and linear stepwise regressions for the per capita amounts of water and soap used over 3 days were performed with the following variables: the field-worker's socioeconomic evaluation of the families, a housing quality scale (the concordance between the field-worker's scale and a previously described housing quality scale was good, McNemar test),[20] and the mother's and father's education. We also examined the correlation between the percentage of uninterrupted fecal contamination events by each mother and the above variables, as well as the total amount of water and soap used.

Plate counts, fecal coliforms, and individual and combined *Aeromonas* and *Vibrio* counts were tabulated, and linear regressions were run with the socioeconomic and total water and soap usage variables described above.

# *Results*

## *Contamination and Transmission Events*

Family hygienic practices were observed in 53 Canto Grande families for a total of 1872 hours. There were 300 fecal contamination events registered, of which only 38 (13%) were interrupted by hand washing within 15 minutes (Table 1). There were significantly fewer contamination events interrupted in children under 10 years of age than in family members over 10 years of age (odds ratio [OR] = 0.275, 95% confidence interval [CI] = 0.13, 0.588). Soap was used in less than one half (10/38) of the intentionally interrupted events in both age groups. No socioeconomic or demographic characteristics identified which individuals interrupted fecal transmission (using a step-

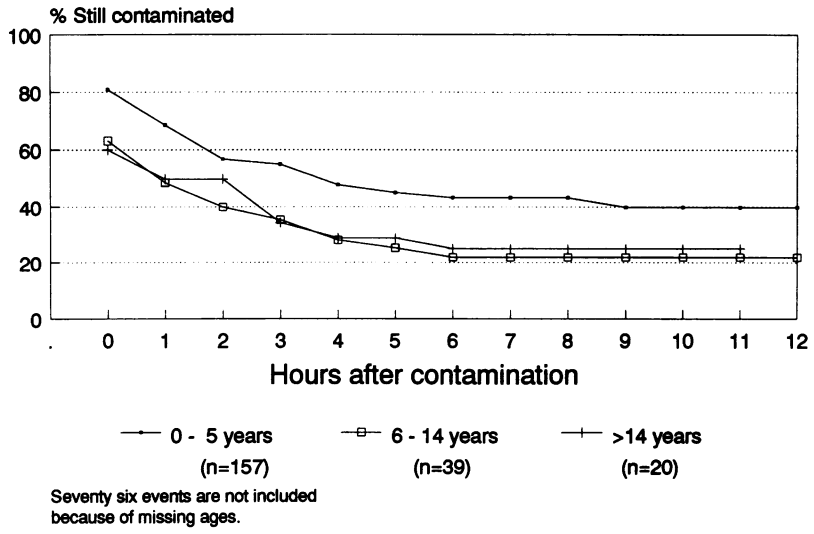


**FIGURE 1—Interruption of fecal contamination by hand washing in 216 events.**

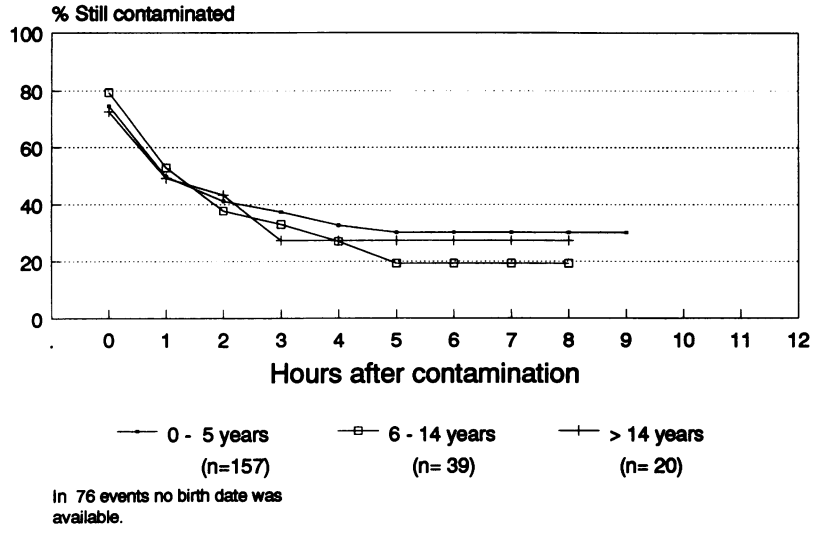


**FIGURE 2—Transmission of fecal material from hands to food or water in 216 events.**

wise regression model). However, the percentage of mothers' events that were interrupted after fecal contamination had occurred was significantly associated with the total amount of water used by the family ($r = .42$; $P < .05$). Also, the percentage of times that mothers washed their hands prior to eating or preparing food was associated with the total grams of soap used ($r = .42$; $P < .01$) and the fieldworker's economic evaluation of the family ($r = .57$; $P < .001$).

There were 3593 eating, preparing, and serving events observed, of which only 834 (23%) were preceded by hand washing within 15 minutes. The younger age group showed a significantly lower number of these events preceded by hand washing than did individuals over 10 years old (OR = 0.41, 95% CI = 0.34, 0.48). Soap was used significantly less often with hand washing before eating or handling food than after defecating (OR = 0.15, 95% CI = 0.07, 0.31). Soap use was not noted in 12 events.

Survival curves showed that most of the contamination episodes were uninterrupted during the first several hours of observation (Figure 1). Within an hour, more than 20% of individuals with contaminated fingers handled food, thus permitting the potential transfer of enteropathogens to other individuals (Figure 2). More than 25% of all contamination events were not interrupted. Moreover, 70% of contamination events became a transmission event.

### *Water and Soap Usage Patterns*

The amount of water, as well as of soap, used by the family during the three 12-hour periods of observation did not vary significantly over the 3 days. The mean 12-hour per capita amount of water and soap used in the 53 families (mean family size was 5) was extremely low (8.8 +/− 3.8 L of water and 8.6 +/− 6.0 g of soap). About half of the water and nearly all of the soap (in the form of either detergent or laundry soap) was used for washing clothes (Table 2). Less than 15% of the total water was used for bathing and hand washing. Fewer than half (16/39) of the children 0 to 2 years of age and one fourth (12/48) of the 2- to 5-year-olds were bathed at least once during the 3 days of observation.

Most (87%) of the drinking water was consumed after boiling (normally as teas). Not only was more unboiled water drunk by older children but mothers permitted older children to consume such water and observed them doing so significantly more often ($\chi^2 = 11.6$; $P = .003$) than they did younger children (see Table 3).

Hand washing infrequently occurred with face soap, laundry soap, or detergent (Table 1). During the 3-day observation period, four families did not have any type of soap available for 1 of 3 days.

*Socioeconomic factors and water usage.* There was a weak but statistically significant association between total water used and mothers' education ($r = .3$; $P < .05$). Socioeconomic variables were not associated with total soap use. However, there was a significant association between the amount of total soap and total water used ($r = .66$; $P < .001$).

*Water bacteriology.* Ninety-five percent (42/44) of the houses sampled had a heterotrophic plate count of more than 500 colony-forming units (CFU)/mL, the standard for acceptable potable water.[15] More than three quarters of the 44 water samples had presumptive fecal coliforms present (Table 4).

In addition, half the families had *Aeromonas* species and almost one third had non-01 *Vibrio cholerae* isolated from their water. *V. cholerae* and *Aeromonas* species counts did not correlate with fecal coliforms counts.

There was no association between the fecal coliform count and either socioeconomic characteristics or quantity of water and soap used during the 12-hour observation period.

*Comparative water supply and costs.* Families used an average of 58 L of water

**TABLE 2—Mean 12-Hour Water and Soap Use in Canto Grande Families (n = 53)**

| | Mean | Standard Deviation |
|---|---|---|
| Water use, L | | |
| Personal hygiene | 7.7 | 7.3 |
| Washing clothes | 21.4 | 28.7 |
| Washing raw foods | 5.0 | 5.0 |
| Cooking foods | 6.9 | 4.0 |
| Washing dishes/ utensils | 10.3 | 16.3 |
| Cleaning house | 0.9 | 1.9 |
| Boiling water to drink | 3.9 | 2.6 |
| Drinking unboiled water | 0.6 | 0.9 |
| Total | 58.2 | 36.5 |
| Soap type, g | | |
| Face soap | 2.0 | 3.4 |
| Shampoo | 2.7 | 5.8 |
| Clothes bar soap | 20.7 | 37.9 |
| Detergent | 29.8 | 48.9 |
| Total | 53.6 | 55.3 |

per 12 daylight hours. Assuming that an additional 25% of the total water used during the day is used at night, about 75 L a day of water are used per day per family, 10 times less than the amount used by the average Peruvian family with in-house water connections (1134 L) (Webb S. Waterborne disease in Peru. World Bank; August 1992, unpublished working paper).

In Canto Grande, water costs about $0.38 per 378 L. This price is nearly five times what it costs a family with in-house connections ($0.08 per 378 L). Both the *pueblo joven* and the middle-class families spend approximately 2% of their monthly income on water ($2.22/$120.00 and $7.2/$500.00, respectively). However, whereas *pueblo joven* families receive small quantities of poor quality water, middle-class families enjoy large quantities of relatively good quality water.

*Mothers' attitudes and behavior on hygienic issues.* Nearly all the 107 mothers surveyed in Las Pampas de San Juan were aware that hand washing and boiling of water were important methods of blocking the transmission of infection (Table 5). However, this knowledge did not affect the type of water that mothers reported drinking. Thirty-seven (35%) mothers said that a portion of the water they consumed was not boiled. Yet these mothers knew that boiling water killed germs as often as did the mothers who drank only boiled water. About 90% of mothers knew that contamination of hands with feces produced disease.

**TABLE 3—Consumption of Unboiled Water (%), by Age of Child, y**

| | 0–2.0 (n = 26) | 2.1–5.0 (n = 64) | 5.1–10 (n = 94) |
|---|---|---|---|
| Mother saw child drink unboiled water | 38 | 44 | 67 |
| Mother did not see child drink unboiled water | 62 | 56 | 33 |

**TABLE 4—Enteropathogenic Contamination of Water Stored in Cisterns or Cylinders in Canto Grande Families (n = 44)**

| | Total Houses No. | % |
|---|---|---|
| Presumptive fecal coliform count[a] | | |
| 0 | 9 | 20 |
| 1 | 17 | 39 |
| 2 | 18 | 41 |
| *Aeromonas* sp.[b] | | |
| 0 | 22 | 50 |
| 1 | 16 | 36 |
| 2 | 6 | 14 |
| Non-01-*Vibrio cholera*[b] | | |
| 0 | 31 | 70 |
| 1 | 10 | 23 |
| 2 | 3 | 7 |

*Note.* CFU = colony-forming units.
[a]0 = negative; 1 = <3 log CFU/100 mL; 2 = >3 log CFU/100 mL.
[b]0 = negative; 1 = <3 log CFU/mL; 2 = >3 log CFU/mL. Presumptive fecal coliforms per 100 mL.

**TABLE 5—Mothers' Knowledge and Attitudes about Water Use in San Juan de Miraflores (n = 107)**

| | No. | % |
|---|---|---|
| Does contamination of hands with feces produce illness? | | |
| No | 12 | 11 |
| Yes: intestinal infections | 54 | 51 |
| skin infections | 13 | 12 |
| no specific reason given | 20 | 19 |
| No response/don't know | 8 | 7 |
| Does bathing a child produce illness? | | |
| No | 86 | 80 |
| Yes, respiratory infections | 17 | 16 |
| Don't know | 4 | 4 |
| Do you drink unboiled water? | | |
| No | 70 | 65 |
| Yes: prefers the taste | 22 | 21 |
| when in a hurry | 12 | 11 |
| Don't know, no response | 3 | 3 |
| Is boiled water better than unboiled water? | | |
| No: vitamins are lost | 1 | 1 |
| unboiled tastes better | 1 | 1 |
| Yes | 105 | 98 |
| Why is it better to drink boiled water? | | |
| Protects from germs | 98 | 93 |
| Taste or don't know | 7 | 7 |
| Is it better to have water covered? | | |
| No, it is the same as uncovered | 3 | 3 |
| Yes | 103 | 96 |
| Don't know | 1 | 1 |

## *Discussion*

This study used direct observation because it is the most accurate method for documenting family hygienic behavior.[13,21] The duration between fecal contamination events and their interruption by hand washing was analyzed using survival curves to analyze hygienic behaviors that are censored at varying times.

Water quantity has been considered an important factor in diarrheal disease prevention.[8] We found that families that used more total water interrupted fecal contamination by hand washing more often. Interruption of fecal contamination was not influenced by mother's education or by family socioeconomic characteristics.

In Bangladesh, where water is plentiful, sanitary education was effective in reducing the number of diarrheal episodes.[9,10] In Lima, where per capita levels of water are among the lowest reported,[22] the majority of *pueblo joven* mothers knew that fecally contaminated hands transmitted disease, yet few washed their hands after obvious fecal contamination. Although knowledge about sanitation practices was adequate, hygienic practices were poor, presumably because water is scarce.

In addition to being insufficient in quantity, the water is also lacking in quality since it is stored in easily contaminated uncovered or partially covered tanks or cylinders. The effect of contamination is somewhat mitigated since more than 85% of water is boiled before consumption.

However, based on the speed with which cholera spread through the *pueblo jovenes*, it would appear that the remaining 15% contamination is enough to effectively transmit disease.

In 1992, because of drought, water was more expensive and scarcer than it was in 1987 (personal communication, Dr Carmen Marin, AB PRISMA, Lima, Peru, July 10, 1993). During the 1992 cholera epidemic, there were widespread media messages about boiling water and washing hands. Yet in a 1992 study of water practices, the percentage of water not boiled before drinking and the number of episodes of fecal contamination not purposely interrupted were similar or slightly worse than what was found in our 1987 precholera study.

The detection of fecal coliforms is the standard routinely used to determine water quality.[15,22] Our data and others[17,22] suggest that counts of *Aeromonas* and *Vibrio* species may also be useful for monitoring the purity of drinking water. We and others found no association between coliform and *Aeromonas/Vibrio* counts.[17]

Lima's *pueblo jovenes* have one of the highest diarrheal rates reported: 10 episodes per year.[23] Our results suggest that providing increased information concerning hygiene without providing increased water probably will not result in better sanitation practices. In water-scarce communities, personal hygiene and possibly the number of diarrheal episodes would be improved by providing convenient, cheap, in-house water. For the same cost as they are paying now, in-house connections to a *pueblo joven* household would provide four to five times the volume of high-quality water as they are currently receiving. The money saved by reducing diarrheal episodes would eventually cover some or all of the installation costs. Costs can also be reduced if the community provides free labor and perhaps designs less orthodox and lower-cost systems.[24] In-house water connections would measurably improve the quality of life in the periurban marginal communities of Peru. □

## Acknowledgments

Financial support for this research was provided by the RG-ER fund, Smith Kline French Co, and the US Agency for International Development, PSTC grant #7234. We thank Drs M. Bateman and J. Briscoe for their helpful comments concerning the manuscript; M. Rau Rau for able field support; and J. B. Phu, D. Sara, and M. Manuco for assistance. We also thank the communities of Huáscar, Bayovar, and Las Pampas de San Juan for their collaboration.

## References

1. Steere AC, Mallison G. Handwashing practices for the prevention of nosocomial infections. *Ann Intern Med.* 1975;83:683–690.
2. Khan MU. Interruption of shigellosis by handwashing. *Trans R Soc Trop Med Hyg.* 1982;76:164–168.
3. Aung MH, Hlaing T. Prevention of diarrhoea and dysentery by handwashing. *Trans R Soc Trop Med Hyg.* 1989;83:128–131.
4. Black RE, Dykes AC, Anderson KE. Handwashing to prevent diarrhea in day care centers. *Am J Epidemiol.* 1981;113:445–451.
5. Gilman RH, Skillicorn P. Boiling of drinking water: can a fuel-scarce community afford it? *Bull WHO.* 1985;63:157–163.
6. Feachem RG, Burns E, Cairncross S, et al. *Water, Health and Development: An Interdisciplinary Evaluation.* London, England: Tri Med Books; 1978:106.
7. White GF, Bradley DJ, White A. *Drawers of Water, Domestic Water Use in East Africa.* Chicago, Ill: University of Chicago Press; 1972:129.
8. Esrey SA, Shiff C, Roberts L, Potash JB. *Health Benefits from Improvements in Water Supply and Sanitation: Survey and Analysis of the Literature on Selected Diseases.* Arlington, Va: US Agency for International Development; 1990. Water and Sanitation for Health Project Technical Report no. 66. Project 936–5942.
9. Stanton BF, Clemens JD. An educational intervention for altering water sanitation behaviors to reduce childhood diarrhea in urban Bangladesh: II. a randomized trial to assess the impact of the intervention on hygienic behaviors and rates of diarrhea. *Am J Epidemiol.* 1987;125:292–301.
10. Alam N, Wojtyniak B, Henry FJ, Rahaman M. Mothers personal and domestic hygiene and diarrhoea incidence in young children in rural Bangladesh. *Int J Epidemiol.* 1989;18:242–247.
11. Feachem R. Domestic water supplies: health and poverty. *Water Supply Manage.* 1978;2:357–362.
12. Adrianzen TB, Graham GG. The high cost of being poor: water. *Arch Environ Health.* 1974;28:312–315.
13. Marquis GS, Ventura G, Gilman RH, et al. Fecal contamination of shanty town toddlers in households with non-corralled poultry, Lima, Peru. *Am J Public Health.* 1990;80:146–149.
14. Lanata CF, Black RE, Gilman RH, Lazo F, Del Aguila, R. Epidemiologic, clinical and laboratory characteristics of acute vs. persistent diarrhea in periurban Lima, Peru. *J Pediatr Gastroenterol Nutr.* 1991;12:82–88.
15. Greenberg AE, Clesceri LS, Eaton AD, eds. *Standard Methods for the Examination of Water and Waste Water.* 15th ed. Washington, DC: American Public Health Association, American Water Works Association, and Water Pollution Control Federation; 1985.
16. Gracey M, Burke V, Robinson J. *Aeromonas*-associated gastroenteritis. *Lancet.* 1982;2:1304.
17. Burke V, Robinson J, Gracey M, Peterson D, Partridge K. Isolation of *Aeromonas hydrophilia* from a metropolitan water supply: seasonal correlation with clinical isolates. *Appl Environ Microbiol.* 1984;48:361–366.
18. Kaper J, Seidler RJ, Lockman H, Colwell RR. Medium for the presumptive identification of *Aeromonas hydrophila* and *Enterobacteriaceae. Appl Environ Microbiol.* 1979;38:1023–1026.
19. Farmer JJ, Hickman-Brenner FW, Kelly M. *Vibrio.* In: Lennette EW, Balows A, Hausler WJ, Shadomy JH, eds. *Manual of Clinical Microbiology.* 4th ed. Washington, DC: American Society for Microbiology; 1985:282–301.
20. Norusis MJ. *SPSS-SPSS/PC +V.2.0 Base Manual.* Chicago, Ill: SPSS Inc; 1988:B-157, B190.
21. Stanton BF, Clemens JD, Aziz KMA, Rahman M. Twenty-four-hour recall, knowledge-attitude-practice questionnaires, a comparative study. *Bull WHO.* 1987;65:217–222.
22. Feachem R, Bradley D, Garelick H, Duncan D. *Sanitation and Disease. Health Aspects of Excreta and Wastewater Management.* Washington, DC: The World Bank; 1983:303.
23. Black RE, Lopez de Romaña G, Brown KH, Bravo N, Grados O, Creed H. Incidence and etiology of infantile diarrhea and major routes of transmission in Huascar, Peru. *Am J Epidemiol.* 1989;129:785–799.
24. Briscoe J. The role of water supply in improving health in poor countries (with special reference to Bangla Desh). *Am J Clin Nutr.* 1978;31:2100–2112.