Reduction of fecal contamination of street-vended beverages in Guatemala by a simple system for water purification and storage, handwashing, and beverage storage

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Abstract. Street-vended foods and beverages, an integral part of urban economics in the developing world, have been implicated in cholera transmission in Latin America. To improve the microbiologic quality of market-vended beverages in Guatemala, we tested a simple system consisting of dilute bleach (4.95% free available chlorine) for water purification, narrow-mouth plastic vessels with spigots for disinfecting and storing water and for preparing and storing beverages, handwashing soap, and education in using the system. We conducted a randomized controlled intervention trial among 41 vendors who received the intervention and 42 control vendors, comparing total and fecal coliform bacteria and *Escherichia coli* contamination of market-vended beverages, stored water, and vendors' hands. Samples were obtained at baseline and at each of six weekly follow-up visits. At baseline, fecal coliform bacteria were found in 40 (48%) market-vended beverages and *E. coli* in 14 (17%). When compared with samples from control vendors, a significant decrease in total coliform ($P < 0.001$) and fecal coliform ($P < 0.001$) bacteria in samples of stored water and beverages sold by intervention vendors was observed over the course of the study. The vessel system was well accepted by vendors. This simple inexpensive system consisting of hypochlorite disinfectant, plastic vessels, soap, and education can significantly reduce fecal contamination of market-vended beverages.

The cholera epidemic that began in Peru in 1991 and swept across Latin America has produced more than 1,365,000 reported cases and 11,500 deaths.[1] Underlying this explosive spread are water quality and sanitation deficiencies.[2-6] Foods and beverages prepared and sold by street vendors have contributed to transmission of cholera and other enteric diseases in Latin America. Cholera transmission was associated with consumption of street-vended beverages in Peru,[2] Ecuador,[4] and Guatemala,[7] and a study in Guatemala revealed heavy fecal contamination of street-vended beverages (Mahon B, Centers for Disease Control and Prevention [CDC], unpublished data).

Consumption of street-vended foods and beverages is common in metropolitan centers of the developing world; street vendors are often the only affordable source of ready-made meals for urban workers near their place of employment.[8] Street vendors typically do not have a continuous supply of potable, running water for drinking, cleaning, cooking, and preparing beverages. They are obliged to store water, often using for this purpose wide-mouth storage vessels that permit the introduction of hands and consequent contamination of stored water (Venczet L, CDC, unpublished data).[9-11] Facilities for handwashing before and during food preparation or after defecation are often not available. Under these circumstances, street-vended beverages may become contaminated with feces by several routes. They may be made with contaminated stored water or ice, be prepared on contaminated surfaces, or come in contact with contaminated hands during preparation, storage, and serving. Simple inexpensive means for water purification and storage, handwashing, and beverage storage are urgently needed.

A simple, inexpensive system for water purification and storage developed by the CDC[12] reduced the incidence of dianheal disease by 44% in a controlled trial in Bolivian homes (Quick R, CDC, 1996, unpublished data). We adapted this system to include handwashing with soap and beverage storage, and tested it among food vendors in municipal marketplaces in Guatemala City, Guatemala in the summer of 1996. The system, called the vessel system, consisted of 4.95% free available chlorine solution and three vessels: a five-gallon narrow-mouth, lidded, plastic vessel for water purification and storage, an identical vessel with a soap dish and soap for handwashing, and a third vessel for beverage storage and dispensing (Figure 1). Education in use of the system was also part of the intervention.

BACKGROUND

Guatemala City is a rapidly growing city whose population has increased by more than a million in the past 10 years. The increase is due largely to migration from rural areas to periurban zones by persons of lower socioeconomic status. There is considerable strain on the municipal water supply; piped water is highly chlorinated but is usually available only a few hours per day. Street vendors of food and beverages, including those who operate outdoors and those in covered municipal markets, store municipal water in wide-mouth vessels. Beverages made by these vendors at the point of sale are a popular item, commonly included in the price of a meal.

FIGURE 1. The vessel system. Left to right: a five-gallon plastic vessel with a narrow 6-cm mouth and durable faucet for water purification and storage, an identical vessel with detachable soap dish mounted on top, a 2.5 gallon vessel with a 1.5-cm mouth and faucet for storing and dispensing beverages. chlorine, and soap. Pictorial instructions are affixed to the vessel walls.

MATERIALS AND METHODS

Study design. We conducted a randomized, clustered, repeated measure intervention study. We randomly selected eight of the 23 municipal markets in Guatemala City and randomly divided them into four intervention and four control sites. A vendor was defined as a seller of non-commercially produced beverages operating within the market or in a fixed structure located on either side of the streets surrounding the market. All vendors in the selected markets were asked to participate, except in one two-story control market, where only vendors working on the upper level were enrolled.

Informed consent was obtained from all participants prior to enrollment in the study. The study was reviewed and approved by the Institutional Review Board of CDC.

We conducted a baseline survey of demographic and workplace characteristics, and water and food-handling practices. Intervention market vendors were given the vessel system, and control market vendors were invited to participate in exchange for receiving the vessel system upon completion ot the study. Vendors were then followed weekly for six weeks. At baseline and at each of the six follow-up visits, samples of stored water, beverages, and hand-rinses were obtained from all vendors for microbiological studies; intervention vendors also responded to a brief questionnaire about vessel system use. During follow-up week 2, intervention vendors were given colanders to rinse ice before placing it in beverages. During follow-up week 4, they were given funnels to pour beverages into the beverage storage vessel. Instructions on proper use of the vessel system were reviewed with intervention vendors during follow-up weeks 4, 5, and 6. Beginning two months after the study, both groups of vendors (all now possessing the vessel system) were visited monthly for four months. At each monthly visit, samples of stored water were obtained for chlorine level measurements, and vendors responded to a brief questionnaire.

Soap and hypochlorite. A bar of Safeguard Antibacterial Soap™ and a 125-ml bottle of Magia Blanca™ bleach (4.95% free available chlorine) provided by the Procter and Gamble Company (Cincinnati, OH) were given to intervention vendors after the baseline survey and at each weekly follow-up visit. Vendors were instructed to add 1/2 capful (about 2.5 ml) of bleach to the full 20-liter water storage and hand-washing vessels to obtain a final concentration > 0.5 ppm average CI; and wait 30 mm before using the water. They were asked to use only treated water for beverage preparation, drinking, cooking, and handwashing, and to clean the vessels periodically by swirling a small volume of diluted bleach. Vendors were instructed to wash their hands with soap before preparing foods and beverages, after handling raw animal materials and after using the toilet.

Laboratory measurements. Samples of source water from the municipal taps, stored water, beverages, hand-rinses, and ice were collected from all vendors at baseline. Follow-up samples of stored water (from the vessel supplied to intervention vendors or the habitually used vessel for control vendors), beverages, and hand-rinses were collected from all vendors dunng the next six weeks. All samples were transported from the field to the laboratory in coolers with icepacks. The day of the week and time of day of sample collection at each market varied so that the timing of visits could not be anticipated by vendors. To determine the rate of recontamination after handwashing, the hands of 13 vendors were cultured immediately after handwashing with soap and water and again 1 hr later.

Table 1: Baseline characteristics of intervention and control vendors, Guatemala City, 1996*

	Intervention Group		Control Group		
Demographics	Proportion	(%)	Proportion	(%)	P†
Female	41/41	(100)	40/42	(95)	NS
Median age (range)	44	(17-70)	39	(17-68)	NS
Speak Spanish only‡	40/41	(98)	39/42	(93)	NS
Illiterate	4/41	(10)	7/41	(17)	NS
Vending characteristics					
Median years vending (range)	15	(0-48)	12	(0-49)	NS
Median days worked per week (range)	6	(5-7)	6	(5-7)	NS
Median hours worked per day (range)	9	(4-13)	10	(6-13)	NS
Median vending locations in previous 12 months (range)	1	(1-2)	1	(1-2)	NS
Median glasses of beverage sold per day (range)	30	(10-100)	30	(5-180)	NS
Water access and water handling practices					
Have own water tap	37/41	(90)	33/42	(79)	NS
Have access to running water all day	3/41	(7)	11/42	(26)	NS
Store water at vending site	38/40	(95)	38/42	(91)	NS
Use stored water to make beverage	21/39	(54)	26/38	(68)	NS

* Values represent number (%) with chanctehttic except where indicated
† NS = not significant.
‡ Interviews were conducted in Spanish. Sixty percent of Guatemalans are Maya Indians who may speak one of the Mayan languages as their native tongue.

Chlorine content determination. Water and ice samples were collected in 120-ml Whirl-Pack™ bags (Nasco, Fort Atkinson, WI). Total and free chlorine levels were measured within 3 hr of collection using a digital chlorimeter (Hach Co., Loveland, CO).

Water and ice bacterial cultures. One hundred milliliters of source and stored water and ice samples were collected in 100-ml Whirl-Pack™ bags containing three 10-mg sodium thiosulfate tablets for chlorine inactivation. Total and thermotolerant (fecal) coliform colony counts were determined by the membrane filtration method using three different volumes of sample (50, 10, and 1 ml). All typical and atypical coliform colonies were read as positive. Coliform counts were adjusted and reported per 100 ml of sample.[13] If confluent growth was obtained in the least filtered volume (1 ml), the results were reported as too numerous to count (TNTC). For computational purposes, a reading of TNTC was defined as 155,000 colonies. This represents a lowest estimate because the filtration membrane contains 155 squares, and counts cannot be accurate for equal to or greater than 10 colonies/square. *Escherichia coli* was confirmed by biochemical tests: cytochrome oxidase, ß-glucuronidase, urease, and indole, methyl red, Voges-Proskauer, and citrate (IMViC).[14]

Determination of pH and bacterial cultures of beverages. Beverage samples were placed in 100-ml Whirl-Pack™ bags using the vendors usual beverage serving method, e.g., ladled or scooped with a cup. Total and fecal coliform and *E. coli* colony counts were determined by the most probable number method.[15] The pH was determined using an aliquot of the beverage sample within 3 tor of sample collection using S/P™ pH Indicator Strips (Baxter Diagnostics, Dcerfield, DL).

Hand-rinse cultures. Vendors rinsed each hand for 5 sec in 100 ml of 0.1% peptone broth with neutralizers: 0.5% Tween 80, 0.07% soy lecithin[15] and 1% sodium sulfate.[16] Fecal coliform and *E. coli* counts were determined by the membrane filtration method as described for water, using MFC medium[13] and biochemical tests for identification of *E.coli* as described above.[14] In a separate study of the risk of recontammation after handwashing, additional hand-rinse samples were obtained from a convenience sample of 13 vendors, 3-4 from each intervention market; the vendors were then asked to wash their hands with soap, and a second hand-rinse sample was obtained immediately after washing. A third, unannounced hand-rinse sample was obtained 1 hr later.

Statistical analysis. Microbiologic contamination was analyzed as the geometric mean of colony forming units of total and fecal coliform bacteria and *E. coli.* and also dichotomized as the presence or complete absence of indicator bacterial organisms (referred to as positive or negative samples). To control for effects of clustering of vendors within markets at baseline, generalized estimating equations (GEE1) were used to compare vendors in intervention and control markets.[17]

Longitudinal analysis was conducted for the entire study period. Mixed models were used to analyze the association between use of the vessel system and coliform counts.[18] Generalized estimating equations (GEE2), based on odds ratios, were used to determine the association between use of the vessel system and proportion of positive samples.[19] Mixed models and GEE2 were used in the analysis of the weekly measurements for the entire study period to control for effects of clustering of vendors markets.

RESULTS

Baseline survey. Forty-one intervention and 42 control vendors completed the study; five vendors declined to participate and one intervention vendor was dropped from the study on week 3 because she stopped selling beverages.

Vendors in intervention and control markets were similar with respect to demographic and workplace characteristics. Vendors in both groups were predominantly Spanish-speaking, literate adult women who had worked at least five full days per week at a single location during the past year (Table 1).

Water handling and storage practices were similar for intervention and control groups (Table 1). Most vendors (84%)

TABLE 2 Baseline microbiologic measurements in samples obtained from intervention and control vendors. Guatemala City, 1996

	Samples Positive (%)				Geometric mean count		
Sample	Intervention	Control		*P*†	Intervention	Control	*P*†
Source water							
Total coliform	3 (12)	0	(0)	NS	2.0	0	NS
Fecal coliform	0 (0)	0	(0)	NS	0	0	NS
Stored water							
Total coliform	17 (47)	10	(39)	NS	54.1	53.0	NS
Fecal coliform	11 (31)	4	(15)	<0.05	7.2	4.8	NS
Hand-rinse							
Fecal coliform	24 (59)	30	(71)	NS	79.4	158.5	NS
Escherichia coli	2(5)	5	(12)	NS	1.5	2.6	NS
Beverage							
Total coliform	27 (66)	23	(55)	NS	25.7	27.5	NS
Fecal coliform	18 (44)	22	(52)	NS	5.5	16.7	0.001
E. coli	6 (15)	8	(19)	NS	1.7	2.5	NS
Ice							
Total coliform	14 (67)	13	(77)	NS	981	6205	NS
Fecal coliform	14 (66)	11	(65)	NS	37.7	71.1	NS
E. coli	14 (67)	10	(77)	NS	1.4	2.2	NS

* Values are the number (%)
† NS = not significant.

had a tap within their establishment; those that did not obtained their water from a tap a median of 6.5 meters away (range = 1-100). Twenty-six percent of control vendors and 7% of intervention vendors had access to running water throughout the day. Intervention vendors had access to running water for a median of 3.5 hr per day (range = 0-12) and control vendors for a median of 4.3 hr per day (range = 1-12).

Almost all vendors stored tap water for assorted uses, including beverage preparation. By interviewer observation, the median volume of water stored by intervention vendors was six gallons (range = 1-164) and by control vendors seven gallons (range = 1-60). Ninety-two (94%) water storage vessels used by intervention vendors and 97 (96%) water storage vessels used by control vendors had a mouth equal to or greater than 10 cm in diameter, large enough to permit entry of a hand, ladle, or cup.

Both groups used similar vessels for beverage storage. The median volume of beverage storage vessels used by both groups of vendors was three gallons. Forty (98%) beverage storage vessels used by intervention vendors and 42 (100%)

beverage storage vessels used by control vendors had mouths equal to or greater than 10 cm in diameter. To serve beverages, 31 (73%) of 41 intervention vendors and 31 (76%) of 40 control vendors used a ladle that usually required them to put their hand into the storage vessel to serve the beverage. Eight (20%) of 40 intervention vendors and eight (20%) of 41 control vendors served beverages by scooping with a glass or a cup from the storage vessel. Nearly all intervention (93%) and control vendors (95%) used ice in their beverages and manipulated the ice with their hands.

Beverages most commonly made by vendors included tamarindo, a tamarind-based drink; horchata, a sweet cereal-based drink; juices made from water and fresh fruit; various drinks made from concentrates and powders; and rosa de Jamaica, a drink made from water, sugar, and hibiscus flowers.

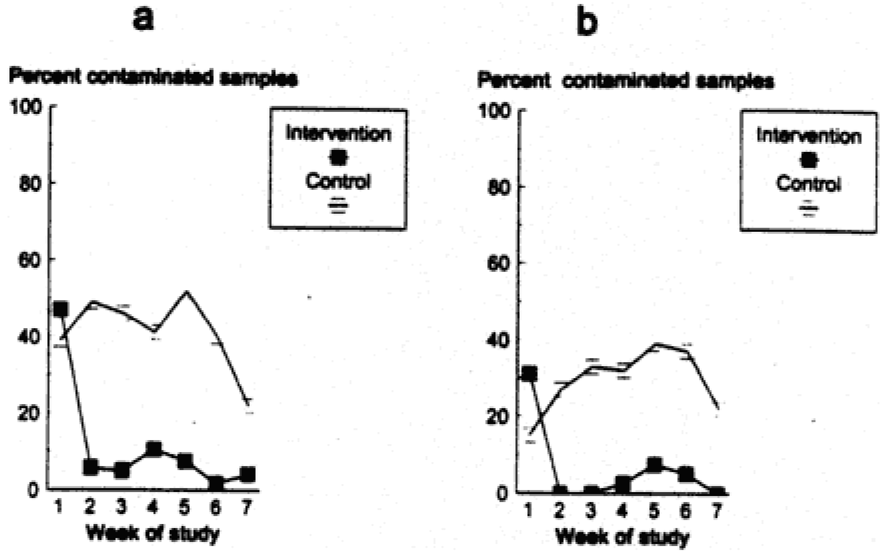
Beverages were made with tap water by 37 (97%) of 38 intervention vendors and by 40 (98%) of 41 control vendors; the test used bottled water. Of the vendors who used tap water to make beverages, 24 (65%) of 37 intervention vendors and 17 (43%) of 40 control vendors thought that municipal water was always potable. Eighteen (48%) of 41 intervention vendors and 26 (62%) of 42 control vendors reported treating municipal water before making beverages, 38 (84%) by chlorination, and seven (16%) by boiling.

Intervention and control vendors were similar in their acceptance of chlorination for water purification. Thirty-seven (90%) intervention vendors and 39 (93%) control vendors thought chlorination was a good way to purify water; however, 12 (30%) intervention vendors and 15 (36%) control vendors thought chlorine had unpleasant consequences. ranging from disagreeable smell and taste to serious health effects.

Intervention and control vendors reported having received similar food-handling training, usually a single 3-4 hour course given by a municipal worker. Intervention and control vendors employed a median of one additional person.

Baseline laboratory data. The minimum bactericidal concentration of chlorine in drinking water is 0.5 ppm. Samples of source water, stored water, and ice collected from intervention ami control venters at baseline did not differ significantly in total and free chlorine (respectively, source water median total chlorine, 1.2 ppm versus 0.8 ppm; source water median free chlorine, 0.94 ppm versus 0.68 ppm; stored water median total chlorine, 0.22 ppm versus 0.26 ppm; stored water median free chlorine, 0.16 ppm versus 0.17 ppm; ice median total chlorine, 0.09 ppm versus 0.10 ppm; ice median free chlorine. 0.09 ppm versus 0.07 ppm). At baseline, similar proportions of intervention and control vendors had source water, stored water, or beverage samples that were contaminated with total coliform, fecal coliform, or *E. coli* bacteria, and similar proportions of hand rinse samples were contaminated with fecal coliform bacteria or *E. coli* (**Table 2**). Source water, i.e., municipal piped water, contained no detectable fecal coliform bacteria, while 15-31% of stored water samples were contaminated with fecal coliforms. The geometric mean total and fecal coliform counts in source water and stored water, fecal coliform and *E. coli* counts in hand-rinse cultures, and total coliform and *E. coli* counts in beverages were similar for intervention and control vendors. However, the geometric mean fecal coliform count was lower in beverage samples from intervention vendors than in those from control vendors (5.5 versus 16.7; $P < 0.001$) (**Table 2**).

FIGURE 2. Contamination of stored water by total and fecal coliform bacteria, intervention versus control vendors. **a.** percent samples contaminated with total coliform bacteria, **b.** percent samples contaminated with fecal coliform bacteria.



Intervention study laboratory results. By longitudinal analysis, the proportions of intervention vendors stored water samples contaminated with total and fecal coliform bacteria decreased markedly over the course of the study, and were significantly lower than the proportions from control vendors ($P < 0.00001$ and $P < 0.00001$, respectively) (Figure 2). Similarly, the proportions of intervention vendors beverage samples contaminated with total and fecal coliform bacteria decreased during the study, and were significantly lower that the proportions from control vendors ($P < 0.001$ and $P < 0.001$, respectively) (Figure 3). The proportion of beverage samples contaminated with E. *coli* was also significantly lower among intervention vendors ($P < 0.05$). The concentration of chlorine in the water stored by the intervention vendors in the water-storage vessel was consistently > 0.5 ppm, the level required to eliminate enteric bacteria (Figure 4).

Using univariate analysis for the intervention period alone, geometric mean coliform bacteria counts were significantly lower in stored water samples (total coliforms. 2.9 versus 75; $P < 0.0001$; fecal coliforms. 1.5 versus 9.0; $P < 0.0001$) and beverage samples (total coliforms. 12.0 versus 28.6; $P < 0.005$; fecal coliforms, 4.2 versus 9.2: $P < 0.02$) collected from intervention vendors compared with those from control vendors. This reduction was largely due to the decrease in the proportion of contaminated samples. When cohform counts in only those samples that tested positive for bacterial contamination were compared, a significant reduction was noted only for total coliform bacteria counts in stored water (P < 0.01).

FIGURE 3. Contamination of beverages by total and fecal coliform bacteria, intervention versus control vendors, **a.** percent samples contaminated with total

coliform bacteria, **b.** percent samples contaminated with fecal coliform bacteria.

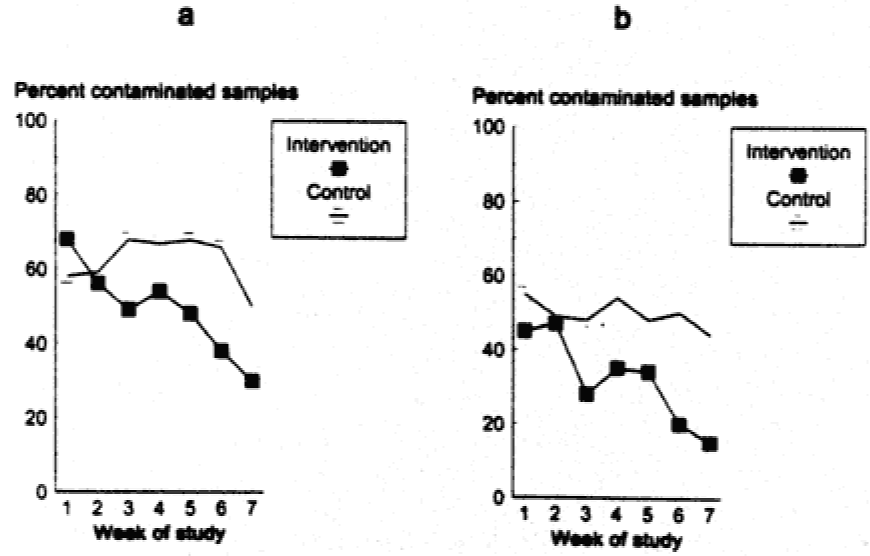


FIGURE 4. Chlorine concentration in stored water samples, intervention versus control vendors. 0.5 ppm is recommended level to kill enteric bacteria.

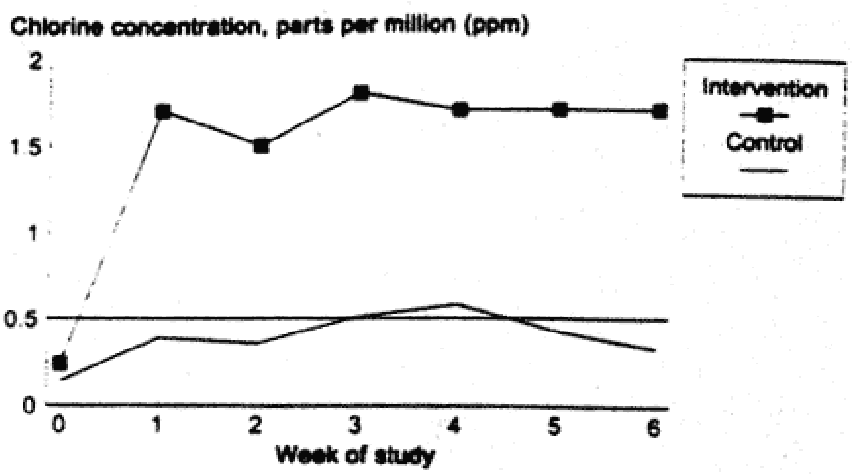
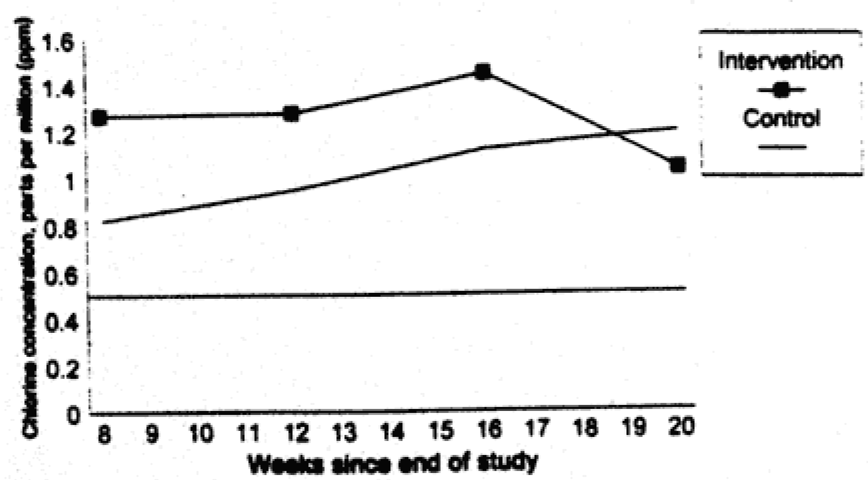


FIGURE 5. Chlorine concentration in stored water samples, former intervention versus former control vendors, five month post-study follow-up. All control vendors were

given the vessel system at the end of the study.



A beverage pH of 4.5 or lower was independently associated with a lower percentage of contaminated beverages and lower coliform counts. Within the intervention group, using the smaller beverage storage vessel was significantly associated with a lower proportion of contaminated beverages and with decreased coliform counts, independent of beverage pH.

Hand rinse samples and hand recontamination study. No difference was observed in fecal coliform or *E. coli* contamination of hand-rinse samples from the intervention and control groups. In the hand recontamination study, immediately after handwashing, hand-rinse samples from only one (8%) of 13 vendors contained detectable fecal coUform bacteria and *E. coli.* However, 1 hr later, fecal coliform bacteria were detected in hand-rinse samples from six (46%) vendors, and *E. coli* was detected in hand-rinse samples from three (23%) vendors.

Acceptability of intervention. Acceptability of the system was not measured quantitatively, but all vendors stated they felt that the system helped their sales because customers perceived the beverages to be safer. Vendors in markets not enrolled in the study sought to buy the vessels, saying they thought having the vessels would increase their sales. The vessels cost approximately US $3.50 each, and last a minimum of three years with daily use. At this price, with low-cost locally produced quality soap and chlorine, the vessel system is readily affordable to Guatemala City beverage vendors.

Long-term follow up after the study. During the five months following the study, median free chlorine levels were consistently > 0.5 ppm in stored water from both groups of vendors (all now possessing the vessel system) at each of the four monthly visits (Figure 5). No significant difference in free chlorine levels was noted between the two groups. During this period, most vendors continued using the vessel system for water storage and purification and handwashing; however, few intervention or control vendors were using one of the vessels to store beverages.

DISCUSSION

Consumption of street-vended foods and drinks is a documented risk factor for cholera in Guatemala.[7] In this study, we demonstrated that a simple, inexpensive system for water disinfection and storage, handwashing, and beverage storage can reduce bacterial contamination of street-vended beverages. Reduced contamination, in turn, likely reduces the likelihood of transmission of cholera and other bacterial enteric illnesses.

The dramatic improvement in microbiologic quality of stored water in the intervention group mirrors the results of earlier studies in Bolivian homes,[9] which demonstrated highly significant, sustained improvements in the quality of water disinfected and stored in the water-storage vessel. This study demonstrates that these improvements can be extended, through the vessel system, to beverages prepared by marketplace vendors.

The vessel system addresses the principal barriers to safer street-vended beverages. First, because the vessels have a standard volume, a vessel of water can be reliably disinfected with a standard volume of fixed-concentration chlorine solution. Second, the vessel's narrow mouth impedes reconiamination by introduction of hands. Third, the spigot makes serving easy, again, without introducing hands into the vessel. Fourth, the soap dish and soap mounted on one vessel enable vendors to effectively wash their hands at any time. Fifth, the beverage storage vessel enhances safe storage and dispensing of beverages. Several possibly helpful adaptations were made to the vessel system during the study. After finding fecal coliform bacteria in ice samples, we gave vendors a strainer for rinsing ice with treated water from the water storage vessel, and later, at the vendors' request, we gave them funnels to use when pouring beverages into the beverage storage vessel.

Longitudinal analysis was conducted for the entire study period (baseline and follow-up) to give a measure of continuous change over time, as opposed to a dichotomized comparison between baseline and a single mean value obtained during the follow-up period. Such continuous change might be expected when increasing familiarity with a system has a cumulative effect on behavior.

Samples were categorized as positive or negative based on presence or absence of indicator organisms. This categorization simplifies interpretation because a negative sample is considered safe for consumption. However, it may not distinguish between clinically significant and insignificant reductions in contamination; reduction from near-zero levels of indicator organisms to zero are given the same weight as reductions from TNTC to zero. Therefore, changes in levels of contamination were also evaluated by comparing geometric mean coliform counts. For most microbiologic indicators measured in the study, both geometric mean coliform counts and the categorical presence/absence variable followed the same trend.

Although the microbiologic quality of beverages improved, we cannot quantify the contribution of handwashing to this outcome. No improvement in hand-rinse samples from intervention vendors occurred during the study. This lack of improvement is probably due to recontamination after washing; after effective handwashing with soap, we found that vendors' hands quickly became recontaminated with fecal coliform bacteria and *E. coli* Moreover, a single weekly hand-rinse sample would be unlikely to show an effect of handwashing on beverage quality since it may not reflect the benefits of handwashing before beverage preparation. Since handwashing, especially after defecation and before food preparation, is fundamental to food hygiene, stressing these strategic times for handwashing may have enhanced the efficacy of the intervention.

Vendors' ice was highly contaminated with E. *coli,* but we do not know whether this was surface contamination incurred during transport and handling or whether the ice was made from contaminated water. Contaminated ice has been implicated in transmission of cholera through street-vended beverages and other settings.3 We tried to reduce surface contamination by providing the vendors with colanders for rinsing ice placed in the beverages. Enforcement of chlorination at ice factories, education of vendors about chlorinating water used to make ice at home, and recognition of the need to keep ice clean will reduce the risk of enteric disease transmission by this vehicle.

This study had several limitations. During the study, contamination levels decreased in stored water and beverages for both intervention and control groups (Figures 2 and 3), suggesting that the weekly interviews and sampling may have motivated all vendors to improve their practices, the Hawthorne effect.[20] However, despite any observation-induced changes in behavior, the intervention was independently effective. Although the presence of the vessels made it impossible to blind field workers to intervention and control groups, it is unlikely lack of blinding biased the study results because chlorine levels were measured with digital readouts requiring no interpretation, and samples collected for culture were coded so that laboratory workers were blinded to the intervention status of the vendors.

It is important to note that subjects in this study were marketplace vendors operating in formal structures with access to well-chlorinated municipal water several hours per day. Since chlorination of source water is one component of the vessel system, the system is likely to have an even greater impact on the safety of beverages sold by street vendors with more limited access to potable water, as is the norm in others areas of Guatemala and other countries.

Long-term follow-up showed that vendors from both groups continued to use the vessel system for water purification and storage and handwashing five months after the study. Water stored in the vessels was consistently chlorinated > 0.5 ppm in both groups of vendors. However, fewer control vendors than intervention vendors were using the vessel system, and fewer control vendors recalled the correct amount of chlorine or the time required for chlorine to purify stored water. Few vendors in either group were using the vessels to store beverages. These findings suggest that the vendors value the system for water purification and storage and handwashing, and that repeated instruction produces longer-term proper use; additionally, repeated instruction, enforcement, or modification of the system will be necessary to induce the vendors to continue using the system to store and dispense beverages

This study demonstrates the ability of a simple, inexpensive system to reduce fecal contamination of beverages prepared and sold in Guatemala City marketplaces under optimal conditions. The vessel system may be considered for widespread implementation as a public health measure aimed at reducing the risk of transmitting enteric infections. including cholera, from street-vended beverages. Provision of universally and continuously available treated piped water and sewage disposal is the long-term, definitive solution to the transmission of waterborne pathogens. However, until the necessary infrastructure is created in the developing world, appropriate technology for point-of-use water disinfection and storage, handwashing, and beverage preparation and storage, combined with education of vendors in proper use can provide a sustainable means of reducing the risks of enteric disease transmission, including cholera, from street-vended beverages. As urban populations increase in developing countries, and the consumption of street-vended foods increases, the urgent need for a readily available and effective intervention continues to grow.

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