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Direct observation of hygiene in a Peruvian shantytown: not enough handwashing and too little water

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Summary

OBJECTIVE—To document frequency of hygiene practices of mothers and children in a shantytown in Lima, Peru.

METHODS—Continuous monitoring over three 12-h sessions in households without in-house water connections to measure: (i) water and soap use of 32 mothers; (ii) frequency of interrupting faecal-hand contamination by washing; and (iii) the time until faecal-hand contamination became a possible transmission event.

RESULTS—During 1008 h of observation, 55% (65/119) of mothers' and 69% (37/54) of children's faecal-hand contamination events were not followed within 15 min by handwashing or bathing. Nearly 40% (67/173) of faecal-hand contamination events became possible faecal-oral transmission events. There was no difference in the time-until-transmission between mothers and children ($P = 0.43$). Potential transmission of faecal material to food or mouth occurred in 64% of cases within 1 h of hand contamination. Mean water usage (6.5 l) was low compared to international disaster relief standards.

CONCLUSIONS—We observed low volumes of water usage, inadequate handwashing, and frequent opportunities for faecal contamination and possible transmission in this water-scarce community.

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Keywords

handwashing; water supply; hygiene; Peru

Introduction

In developing countries, diarrhoeal diseases are estimated to cause approximately two million excess deaths among children under 5 years of age each year (Kosek *et al*. 2003). These deaths are entirely preventable; indeed, it has been estimated that the universal adoption of handwashing with soap would save more than a million of these lives per year (Curtis & Cairncross 2003).

The frequency of handwashing in the shantytowns, or *pueblos jovenes*, located in the coastal desert surrounding Peru's capital city Lima is related to the amount of water used by the household (Gilman *et al*. 1993). Water is a scarce and expensive resource in these communities (Adrianzen & Graham 1974). Despite increases in the proportion of the urban population of Peru with in-home water connections, approximately 10% of Lima's population still rely on sources such as shared standpipes or *aguateros*, tanker trucks that sell water by the barrel. Both these sources suffer from interruptions in service and provide water of questionable quality (PAHO 2001, WHO/UNICEF 2006). In circumstances where the lack of adequate and convenient water supplies requires intervention in the public domain, disease prevention efforts in the domestic domain, such as handwashing promotion, may not succeed (Feachem 1978).

Differentiating between the domestic and public domains, Curtis *et al*. emphasized the importance of changes in domestic hygiene behaviour, as the home is the child's principal environment and the site of most disease transmission (Cairncross *et al*. 1996; Curtis *et al*. 2000). Hands become contaminated through contact with faecal material, usually during anal cleansing of adults and children (Aung Myo *et al*. 1986). Enteric pathogens are then transmitted from hands to mouths through the handling of household surfaces and objects, food, and stored water. Handwashing is an effective means of interrupting faecal-oral transmission and preventing the spread of diarrhoeal disease pathogens that originate from faeces (Steere & Mallison 1975; Feachem 1984). A recent review found that interventions promoting handwashing could reduce diarrhoeal morbidity by about 30% (Ejemot *et al*. 2008).

For either infrastructural or behaviour-related interventions, a characterization of hygiene practices is crucial for program design and evaluation. There is a paucity, however, of studies in water-scarce conditions documenting the frequency and nature of handwashing, faecal-contamination, and possible transmission events. We employed direct observation through continuous monitoring to determine household water usage and handwashing practices of mothers and the youngest child in a community without at-home water connections. This cross-sectional study is part of a larger longitudinal study seeking to describe the changes in community hygiene practices that accompany the installation of at-home water connections and a community-based participatory hygiene education campaign.

Methods

Study site

The study was conducted between November 2004 and January 2005, late spring to summer, in Manuel Scorza, a *pueblo joven* of approximately 450 households that comprises part of Las Pampas de San Juan de Miraflores, a peri-urban area of Lima, Peru described in previous publications (Checkley *et al*. 2002, 2004; Harvey *et al*. 2003; Johnson *et al*. 2004; Hernandez *et al*. 2006; Oswald *et al*. 2007). At the time of the study, the 62 households of three adjacent sections of the pueblo joven lacked formal and completed at-home water and sewage connections, unlike their neighbours in surrounding sections.

Study population

Households were included in the study if its youngest child was 10 years old or younger and cared for by the mother. The housing characteristics of the study population (ownership of property; housing materials; water source; toilet type; number of rooms, bedrooms, and windows) were compared with those of other households from Las Pampas which lacked at-home water and sewer connections to evaluate their representativeness. This comparison used the statistical methods described below and data collected by a previous study.

Continuous monitoring of events

Observation days were scheduled according to the family's availability. Eight fieldworkers used continuous monitoring techniques for a maximum of 12 h on three separate visits. From 7:00 am to 7:00 pm, one fieldworker continuously monitored the youngest child in the house and their mother, recording any occurrence, the start time, and duration of the following events: handling of food; placing something in a mouth; urination; defecation; diaper-changing; handling faeces; anal-cleaning; handwashing; washing utensils; washing food; washing clothes; personal hygiene (bathing, washing hair); teeth-cleaning; cooking; house-cleaning; flushing/rinsing toilet; boiling water; irrigating garden; watering animals; and rinsing-out water containers. Fieldworkers differentiated between defecation and urination events when possible, or recorded the event as toilet usage, which was subsequently classified during analysis as urination if it was 1 min or less in duration or as defecation if it was more than 1 min in duration. Fieldworkers recorded all events in which hands or cutlery manipulated food and whether the food handled was to be cooked, washed, or placed directly onto the plate or into the mouth. Eating events, such as eating a single piece of food, feeding a child, or eating an entire meal were coded as single hand-mouth events, despite possibly constituting various hand-mouth contacts. For water use events, the volume of water and use of soap were recorded. Fieldworkers interacted with residents but avoided discussing hygiene issues.

Total household water and soap usage and availability

Fieldworkers were trained to identify the types of containers used in the community and their volumes, utilizing a visual reference guide. At the beginning of each visit, fieldworkers recorded for each water storage container in use: container type, capacity, and the approximate quantity of water present. If containers were filled during the observation

period, the total volume added was recorded. At the end of the visit, fieldworkers again noted the approximate quantity of water left in each container. Total household water usage was calculated as the difference in volumes of water stored between the start and end of the visit, plus any volume of water added during the observation. Nighttime consumption was considered to be an additional 25% of that used during the visit, as residents would be awake for approximately 3 h after the end of the observation and would use some water during this period (Gilman *et al*. 1993). Total household water availability was calculated from the initial amount of water stored in the household plus the volume of water collected during the visit.

To distract attention from the weighing of soap products (bath soap, laundry soap, detergent, shampoo), fieldworkers also weighed six other consumables (toothpaste, cooking oil, salt, sugar, potatoes, rice) at the beginning and end of each visit.

Household information and ethics approval

A structured questionnaire was administered in Spanish on the first day of observation to collect socio-demographic information. Household income information had been previously obtained by another study. Informed consent was obtained from participants prior to the start of the study, explaining that the mother and the youngest child would be observed for water storage practices, activities in the kitchen and the bathroom, and personal hygiene. The Ethics Committee of the Peruvian non-governmental organization, Asociación Benéfica PRISMA, and the Johns Hopkins Bloomberg School of Public Health Institutional Review Board approved the data collection protocol.

Event categorization

Defecation, diaper-changing, handling excreta and anal cleaning of children were all categorized as faecal-hand contamination events. Food-handling or placing something in the mouth were categorized as one of four hand-mouth events: (i) preparing/handling food ready for consumption; (ii) eating; (iii) breastfeeding; and (iv) putting hands/fingers in a mouth. A program was developed with Microsoft Visual Foxpro 6.0 to identify handwashing at two critical moments: (i) after each faecal-hand contamination event, the time until the first subsequent hand-mouth event or handwashing/bathing event and (ii) prior to each hand-mouth event, the time retrospectively from each hand-mouth event until the first prior handwashing/bathing event (Microsoft Corporation, Redmond, WA, USA).

Statistical analysis

The main outcome was the occurrence of handwashing or bathing within 15 min after each faecal-hand contamination event. Handwashing within 15 min of a faecal contamination event was considered to be a purposeful interruption for comparability with a previous study (Gilman *et al*. 1993). Generalized Estimating Equations (GEE) with robust errors to account for clustering within households and an exchangeable correlation structure were fitted for mothers and children separately, calculating odds ratios for potentially predictive factors of handwashing. Covariates analysed for both mothers and children included: total household water availability; average daytime temperature; reported household monthly income; water source; and monthly water payment. To evaluate reactivity to the observer, the number (1–3)

of the visit was assessed. Also, an indicator variable was generated for a household's inclusion during piloting. For mothers, age and education were covariates. The mother's rate of water use (l/h) was included to examine the relation between water usage and hygiene. The influence of water-related activities was examined by indicator variables for whether the mother washed clothing, dishes, food, water-storage containers, or cleaned on the day of observation. For children, age and gender were examined as covariates in addition to a dichotomous variable based on their mother's frequency of handwashing after faecal-hand contamination. The rate of water usage, water availability, temperature, age, household income, and water payment were categorized in tertiles, and contiguous tertiles were aggregated *post hoc* if they had comparable frequencies of hand-washing.

To complement the assessment of the main outcome, a survival time curve was generated based on the length of time after each faecal-hand contamination until a hand-mouth event occurred, considering the end of the observation period as a censoring. In other analyses, Chi-squared tests were used to evaluate the association between categorical variables. The Hadi method was used to identify short ‘outlier’ observation lengths. The Mann–Whitney test was used to compare the distribution of numeric variables across two or more groups, and Pearson's correlation coefficients were used to evaluate associations between numeric variables. All analyses were performed with Stata/SE 9.2 (StataCorp LP, College Station, TX, USA).

Results

Study population

Of the 62 households, six families declined to participate in study activities. Two households were excluded; one because it belonged to a PRISMA nurse who lived in the community, and the second because it had an informal water connection constructed from a neighbouring house in an adjacent community. An additional 22 households did not meet the inclusion criteria. The housing characteristics of included households were not significantly different compared to others in Las Pampas. Observation data is presented here from 32 households.

Data on the hygiene practices and household water usage is presented from a total of 1008 h of observation with 11 h on average per visit, though this ranged from 4 to 12 h. Some observations were terminated prematurely due to scheduling conflicts. The demographics of observed mothers and children are presented in Table 1. Although there was no lower age limit, we did not observe any children younger than 7 months.

Handwashing after contamination events and prior to transmission events

Handwashing either after faecal-hand contamination events or prior to hand-mouth events was not frequently practiced by mothers and children (Table 2). A total of 119 faecal-hand contamination events of mothers were observed, of which 54 (45%) were followed by handwashing or bathing within 15 min. Children washed their hands within 15 min after 31% of faecal-hand contamination events (17/54). Hand-mouth events occurred frequently, but hands were washed within 15 min prior to these possible transmission events only 10% and 16% of times by mothers (54/546) and children (79/507), respectively.

The occurrence of handwashing by mothers and children depended on whether the event was faecal-hand or hand-mouth. Both mothers and children were more likely to wash their hands or bathe within 15 min after a faecal-hand event than before a hand-mouth event (Mothers: 54/119 = 45% *vs*. 54/546 = 10%, $P < 0.01$; Children: 17/54 = 31% vs. 79/507 = 16%, $P < 0.01$). For mothers, the type of faecal-hand event and the type of hand-mouth event were not associated with the occurrence of hand-washing ($P = 0.19$ and $P = 0.78$, respectively). Children's handwashing was not associated with the type of faecal-hand event but was weakly associated with the type of hand-mouth event ($P = 0.94$ and $P = 0.07$, respectively). Mothers were no more likely to use soap after a faecal-hand event than before a hand-mouth event (17/53 = 32% *vs*. 17/53 = 32%, $P = 1.00$). Children used soap more frequently after a faecal-hand event than before a hand-mouth event with marginal significance (10/16 = 62% *vs*. 30/77 = 39%, $P = 0.08$).

If a faecal-hand event was not followed or a hand-mouth event was not preceded by handwashing or bathing, faecal contamination was assumed to be present on hands, indicating possible transmission of enteric pathogens (Figure 1). As a result, 43 of 119 mothers' faecal-hand events (36%) and almost half of children's faecal-hand events (44%, 24/54) became possible transmission events. There was evidence that children experience transmission events before mothers, though this was not statistically significant (Log-rank test, $P = 0.43$). Of all 67 possible transmission events, two-thirds (64%) occurred within an hour of initial faecal-hand contamination.

Predicting factors for handwashing after faecal-hand contamination

Based on the results of GEE logistic regressions used to examine predictors for handwashing within 15 min of a faecal-hand event, mothers who were observed to wash clothing that day were approximately 50% less likely to wash their hands after faecal-hand contamination than if they had not washed clothing (OR 0.47, 95% CI 0.21–1.05), but this was only marginally significant ($P = 0.07$). Children on the third day of observation were more likely to wash their hands after faecal-hand contamination, but the number of the visit was not a significant predictor ($P = 0.10$). No other variables analysed were significant predictors of handwashing for mothers or children, and these results are not shown.

Water and soap usage for hygiene

The mean total volume of water used by the mother was low (Table 3). Mothers washed their hands twice a day on average, while children washed them once a day. For both handwashing and bathing, mothers used a mean of 4.1 l of water a day and children used 3.2 l. Children were bathed at least once on 68% of days ($n = 91$). Soap was used more frequently when bathing than when hand-washing (95/172 = 62% *vs*. 59/248 = 38%, $P < 0.01$).

Total household water and soap usage

Families used approximately 89 l of water during the observation periods (Table 3). Assuming that an additional 25% of the total water used during the day is used at night, about 112 l of water are used per day per family or a mean of 23 l per person each day (95%CI, 19.7–26.8). Seventeen short observation sessions were identified as outliers by the

Hadi method. No significant difference was found between estimates including or removing the short observations for total household water usage or mothers' total water usages. Total household water usage was positively correlated with total household water availability ($P < 0.01$).

Water was recycled for domestic uses. An additional mean 12 l of water were re-used daily by the mother and child (95%CI 7.6–15.7). Of 209 water events involving re-used water, the most frequent were handwashing, utensil washing, and house-cleaning events (22%, 22%, 17%, respectively). While filling their containers, mothers also used additional water directly from the standpipe or a neighbour's connection to wash clothes, rinse water-storage containers, or drink from the tap; none employed this time or water for personal hygiene.

Laundry bar-soap and powder detergent were the most commonly used soaps (Table 3). No significant difference was found between estimates including or removing the short observations for the total household soap usage or usages by soap type.

Water sources and comparative costs of water

The majority of the study households (59%) collected water from the shared community standpipe during an allotted 2 h every 2 days, while the remainder bought water from nearby houses with piped water connections as needed. At least one household relied on both the standpipe and neighbours' connections. The usage fee for the standpipe was $2.60 per month, and users attended obligatory meetings of the community water committee twice a month[1]. Neighbours with piped connections charged $1.50 per cubic meter or $0.92 per *cilindro* (~200 l).

The median total amount paid for water per month by households, regardless of whether they relied on the standpipe or neighbour's connection, was $3.06 (Mann–Whitney, $P = 0.92$). Households that collected water from the standpipe had higher median reported monthly total incomes than those that bought water from neighbors, $220 compared to $147, but this difference was not statistically significant (Mann–Whitney, $P = 0.18$). There was no difference in water usage according to the source (Mann–Whitney, $P = 0.83$).

Discussion

Our study revealed that the residents of a peri-urban community were relying upon only 23 l of water per person per day, less than two flushes of a toilet, for all of their water needs. There is little published information on water usage of families living in these water-scarce peri-urban communities, but our measure is comparable to previous estimates (9–20 l) (Gilman *et al*. 1993; Huttly *et al*. 1994). The mean daily usage per person in our study, calculated from the mother's usage for hygiene, drinking and preparing family meals, is about 6.5 l. By this calculation residents are currently using below the range of the minimum international water requirement for disaster situations of 7.5–15 l per person per day for drinking, cooking and basic hygiene (Sphere 2004).

[1]Exchange rate during period of study: 1 Nuevo Sol = 0.30614 US Dollars.

Limited usage could result from high water costs. Families in this community paid about $0.91 per cubic meter based on the total usage and reported monthly payment. Families spent the same amount per month regardless of their reported source, possibly because they bought additional water from neighbours beyond what they collected from the standpipe. At the time of the study, families in San Juan de Miraflores with private metered water connections paid $0.28 monthly per cubic meter for the first 20 cubic meters.[2] A family with a piped connection would only begin to pay a comparable monthly rate as a family without a water connection on usage of over 50 cubic meters. Considering only costs and not quality or ease of use, if they had piped connections, the families in this community would receive about 2900 l more water per month for the amount that they currently pay, which equates to almost 20 l more water per day per person, thereby surpassing the minimum water requirement for hygiene.

We assessed the representativeness of our findings on water usage and hygiene behaviours from a sample of 32 households by comparing socioeconomic status of the study households to other households in the area without water connections and found no important differences across several indicators. Increased frequency of hand-washing in children on the third day of observation may indicate reactivity, as people may behave differently in the presence of an observer. However, recent studies suggest that reactivity is not a great threat to validity when focusing on very specific behaviours (Harvey *et al*. 2008). Additionally, only children washed more frequently and not their mothers, and handwashing did not increase on the second day of observation. The observed increase could be a spurious result of random variation and small sample size. The possibility that participants were trying to act ‘correctly’ is not supported by the findings of the study. Although handwashing did occur during the day, we found that it is not frequently practiced after defecation by mothers or children and much less frequently prior to food-handling. As a result, more than a third of all contamination events could have resulted in the transmission of enteropathogens to others in the household.

Mothers and children in our study washed their hands more frequently after defecation or handling excreta than before handling food, breastfeeding, or eating, despite the perception of mothers in Peru that it is most necessary prior to eating (PRISMA 2004). Studies in Peru and elsewhere have suggested that factors such as personal appearance may motivate hygiene behaviours rather than disease prevention (Zeitlyn & Islam 1991; Huttly *et al*. 1994). We observed that the largest expenditure of water was for washing clothing, a burden that may limit water used for hygiene. Our results indicate the possibility that mothers were less likely to wash their hands after a faecal-hand event on days when they washed laundry. This behaviour would be consistent with perceptions held by mothers in rural Tumbes, Peru, who consider themselves to be in frequent and sufficient contact with soap and water when they wash clothes, dishes, and food (Elli Leontsini, personal communication, September 2007).

[2]Domestic usage rates at the time of the study in USD per cubic meter of water plus a fixed monthly charge ($1.29): 0–20 m^3, $0.28; 21–30 m^3, $0.39; 31–50 m^3, $0.55; 51–80 m^3, $0.75; >80 m^3, $1.06 (Source: SEDAPAL, October 2004).

The general perception of mothers in Peru that water alone is sufficient for handwashing is illustrated by the finding that soap was rarely used for handwashing despite being available in some form in almost all households (PRISMA 2004). Mothers, particularly in rural areas, believe that water and soap resources are limited, which could influence the allotment of water for household usages in our study population, the majority of whom were born in the more rural, highland regions (PRISMA 2004). Further qualitative study is recommended to explore the motivations behind the allotment of water for household uses and handwashing in Lima and other areas where water is a scarce resource, as the ramifications of this practice could influence the impact of water supply interventions or thwart health education efforts.

Regardless of the motivation, the possible reliance on alternative washing activities for hand decontamination among mothers of peri-urban communities is dangerous, as it can result in transmission of faecal material through a variety of routes. A study in a similar community found evidence of faecal contamination on hands, in the water used for rinsing dishes, and on glasses washed in this water, indicating the hazard of reliance upon other water activities for hand decontamination instead of dedicated hand-washing or bathing (Oswald *et al*. 2007).

This study reveals that the residents of this community and other peri-urban communities in Lima, Peru continue to rely on insufficient quantities of water for their daily needs. Handwashing was not frequent enough to prevent the possible transmission of faecal material. It is unclear whether these unhygienic practices are simply the result of insufficient water in these households due to cost, an inadequate method of supplying water to the houses, or limited knowledge about the importance of handwashing. It is hoped that the installation of at-home piped water connections in this community and the resulting lower costs of water will permit these families to access sufficient water for better health and improved quality of life. Future research on the impact of interventions in both the public and domestic domains may shed light on the conditions or events necessary to improve the health and quality of life of residents of Las Pampas.

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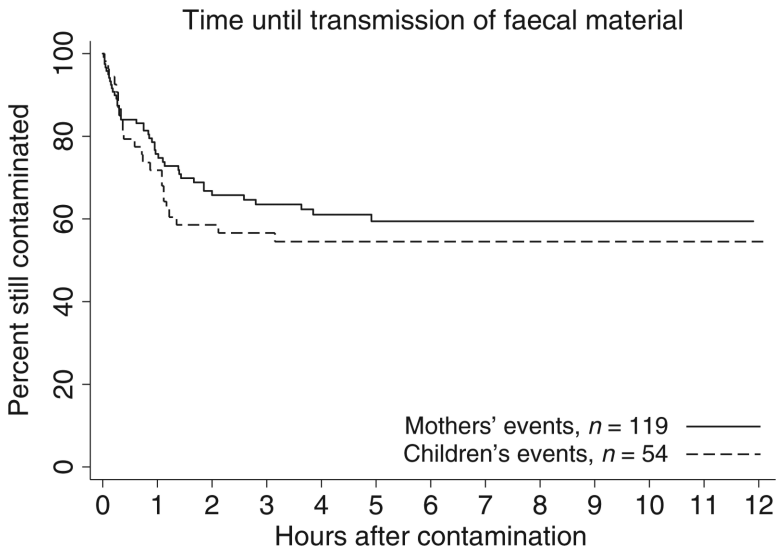

Figure 1.

No significant difference between mothers and children in the time until transmission of faecal material from hands to food or mouths after 173 faecal-hand contamination events recorded during 3 separate 12-h observation visits in a peri-urban community of Lima, Peru ($P = 0.49$).

Table 1

Demographic information of 32 mother and child pairs from a peri-urban community of Lima, Peru

	n	%
Age of mothers (years)		
<33	11	34
33–37	11	34
>37	10	32
Education of mothers		
Some primary	14	44
Completed primary	7	22
Some secondary	7	22
Secondary or higher	4	12
Relation of mothers to household head		
Head	2	6
Spouse	28	88
Daughter	2	6
Marital status of mothers		
Married	5	16
Living with partner	23	72
Separated	4	12
Birth place of mothers		
Coast	8	25
Mountain	24	75
Parity of mothers		
<3	15	47
3	11	34
>3	6	19
Age of children (years)		
<2	10	31
2–4	12	38
5–10	10	31
Gender of children		
Female	16	50

Table 2

Handwashing after faecal contamination and prior to hand-mouth events in a peri-urban community of Lima, Peru: percentage of events by family role and age*

	Mothers		Children <5 years		Children ≥5 years	
	n	%	*n*	%	*n*	%
After faecal-hand event						
Defecation**	64	100	28	100	22	100
Hands not washed	35	55	18	64	17	77
Hands washed with						
Water only	20	31	4	14	1	5
Water & soap	9	14	6	22	4	18
Changing diapers/anal cleaning	44	100	–	–	–	–
Hands not washed	27	61	–	–	–	–
Hands washed with						
Water only	10	23	–	–	–	–
Water & soap	7	16	–	–	–	–
Handling stools	10	100	1	100	2	100
Hands not washed	3	30	1	100	1	50
Hands washed with						
Water only	6	60	–	–	1	50
Water & soap	1	10	–	–	–	-
Prior to hand-mouth event						
Manipulating food	150	100	2	100	1	100
Hands not washed	133	88	2	100	1	100
Hands washed with						
Water only	13	9	–	–	–	–
Water & soap	4	3	–	–	–	–
Breastfeeding	107	100	–	–	–	–
Hands not washed	97	90	–	–	–	–
Hands washed with						
Water only	5	5	–	–	–	–
Water & soap	5	5	–	–	–	–
Eating***	288	100	296	100	103	100
Hands not washed	262	91	254	86	77	75
Hands washed with						
Water only	18	6	26	9	17	16
Water & soap	8	3	16	5	9	9
Hand in mouth	–	–	47	100	56	100
Hands not washed	–	–	40	85	54	96
Hands washed with						
Water only	–	–	3		61	2

	Mothers		Children <5 years		Children ≥5 years	
	n	%	*n*	%	*n*	%
Water & soap	–	–	4		91	2

* Based on events recorded during 3 separate 12-h observation visits.

** Soap usage was not recorded for two events.

*** Soap usage was not recorded for three events.

Table 3

Household and mother's water and soap usage in peri-urban households, Lima, Peru

	Median	Mean	SD	Range
Total household stored-water use (l)	73.0	89.4	61.7	(18.0–403.0)
Domestic water usage of mothers (l)				
Washing clothes	0.0	15.1	28.4	(0.0–155.0)
Washing raw foods	5.5	6.4	4.5	(0.0–24.8)
Cooking foods	3.0	3.2	2.7	(0.0–13.0)
Washing dishes/utensils	12.7	14.6	11.0	(0.0–52.0)
Cleaning house	0.0	1.3	3.1	(0.0–19.5)
Rinsing water containers	0.0	1.3	5.0	(0.0–37.0)
Hygiene water usage of mothers (l)				
Washing hands	1.0	1.6	2.3	(0.0–15.6)
Bathing	0.5	2.4	4.1	(0.0–18.0)
Cleaning teeth (rinsing mouth)	0.0	0.1	0.2	(0.0–2.0)
Rinsing toilet after use	0.0	2.3	5.7	(0.0–30.2)
Total water use of mothers (l)	40.5	48.5	29.7	(6.0–161.2)
Total household soap use (g)	30.0	91.5	161.2	(0.0–960.0)
Soap type (g)				
Bath soap	0.0	4.7	11.7	(0.0–100.0)
Shampoo	0.0	3.7	9.2	(0.0–50.0)
Laundry soap	0.0	17.5	49.3	(0.0–255.0)
Detergent	10.0	65.4	148.0	(0.0–960.0)