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Increasing Equity of Access to Point-of-Use Water Treatment Products Through Social Marketing and Entrepreneurship: A Case Study in Western Kenya

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Abstract

Point-of-use water chlorination reduces diarrhoea risk by 25–85%. Social marketing has expanded access to inexpensive sodium hypochlorite for water treatment, at a cost of less than US$0.01 per day, in Kenya. To increase product access, women's groups in western Kenya were trained to educate neighbours and sell health products to generate income. We evaluated this programme's impact on equity of access to water treatment products in a cross-sectional survey. We surveyed 487 randomly selected households in eight communities served by the women's groups. Overall, 20% (range 5–39%) of households in eight communities purchased and used chlorine, as confirmed by residual chlorine observed in stored water. Multivariate models using illiteracy and the poorest socioeconomic status as a referent showed that persons with at least some primary education (OR 2.5, 95% CI 1.8, 3.5) or secondary education (OR 5.4, 95% CI 1.6, 17.5) and persons in the four wealthiest quintiles (OR 2.5, 95% CI 1.0, 6.0) were more likely to chlorinate stored water. While this implementation model was associated with good product penetration and use, barriers to access to inexpensive water treatment remained among the very poor and less educated.

INTRODUCTION

Over 1 billion people worldwide lack access to improved water sources and hundreds of millions more rely on improved water sources that are not safe to drink (WHO *et al.* 2000). Disease attributable to contaminated water and inadequate sanitation is a leading cause of childhood mortality (WHO 2002), accounting for an estimated 2 million deaths per year (Parashar *et al.* 2003). To address this problem, the United Nations established the Millennium Development Goal (MDG) for water, which aims to reduce by half the proportion of people living without sustainable access to safe drinking water by 2015 (WHO *et al.* 2000). Although the MDG target is safe water, the metric used to assess achievement of the MDGs is access to improved water sources such as boreholes and piped water supplies that may not completely remove the risk of waterborne disease (Rheingans *et al.* 2006). Even if the MDG target is reached, the need for safe water will extend far into the future, and will require the development and dissemination of inexpensive, innovative, alternative technologies to improve water quality and protect health (Mintz *et al.* 2001).

One promising strategy for improving water quality in resource poor settings is the Safe Water System (SWS). Developed by the Centers for Disease Control and Prevention (CDC) and the Pan American Health Organization/ World Health Organization, the SWS is a simple, inexpensive, point-of-use (POU) household water quality

intervention using: 1) locally produced sodium hypochlorite solution for water treatment; 2) safe storage with containers with a narrow mouth, tight fitting lid and tap (Wright *et al.* 2004); and 3) behaviour change communications (CDC 2000). Field trials have shown that the SWS improves water quality (Quick *et al.* 1996; Sobel *et al.* 1998; Luby *et al.* 2001) and reduces the risk of diarrhoeal disease by 25 to 85% (Semenza *et al.* 1998; Quick *et al.* 1999, 2002; Luby *et al.* 2004; Lule *et al.* 2005; Clasen *et al.* 2007).

In 2000, CARE Kenya implemented the SWS in 72 rural villages in southern Nyanza Province, Kenya, an impoverished region with poor coverage of improved water supply, high diarrhoea rates, and high prevalence of HIV infection (Makutsa *et al.* 2001). To expand the reach of this programme, in 2002 CARE Kenya began training other non-governmental organizations (NGO) and community-based organizations (CBO) to incorporate the SWS into their activities. One of these organizations, the Safe Water and AIDS Project (SWAP, formerly known as the Society for Women and AIDS in Kenya), an NGO that serves as an umbrella organization for local HIV self-help groups, employed a 'social entrepreneurship' model of SWS dissemination as an income generating activity, targeting poor families in rural or peri-urban communities with little disposable income and poor access to health services. In this model, SWAP group members purchased water treatment products at wholesale prices, sold them at retail prices to neighbours, and kept the difference as an incentive. Previous research suggests that community mobilization or interpersonal interventions appear to achieve higher SWS adoption rates than social marketing (Thevos *et al.* 2000; Dunston *et al.* 2001), but little is known about their ability to overcome economic or behavioural barriers to SWS access. To determine whether the social entrepreneurship programme achieved equal access to SWS products among families in different socioeconomic strata, we conducted an evaluation of this project in June and July 2004.

METHODS

Point-of-use water quality interventions

SWAP group members, primarily women and young adults, received training on diarrhoea prevention and proper water treatment practices, and were given the opportunity to buy three water treatment products wholesale and sell them at retail prices. These were:

- Klorin, a local 1.0% commercial sodium hypochlorite product packaged in a 500 ml bottle sufficient to treat 2,500 litres of water at a wholesale cost of 20 KSh (US$0.27) and a retail cost of 25 KSh (US$0.33 [US$0.013 per 100 litres treated]);
- PuR™ (Procter & Gamble Co., Cincinnati, Ohio), a combined flocculant and chlorine disinfectant product packaged in a sachet that treats 10 litres of water and costs 3 KSh (US$0.04) wholesale and 5KSh (US$0.07) retail (US$0.70 per 100 litres treated);
- WaterGuard, a disinfectant solution identical to Klorin that was socially marketed by Population Services International (PSI) through the commercial sector at a price of 28 KSh (US$0.37) wholesale and 35 KSh (US$0.47) retail (US$0.019 per 100 litres treated).

At the time of this evaluation, a number of HIV self-help groups were actively selling PuR™ and Klorin and had begun to promote WaterGuard but were not selling it directly, since it had only recently entered the market.

Evaluation design

To ensure that the evaluation population included households exposed to self-help group entrepreneurial activities, we selected the eight SWAP groups that had sold the greatest volume of the products from more than 50 registered SWAP groups in Nyanza Province. Six groups were located in rural areas and two in peri-urban slums of Kisumu. The evaluation took place in communities where the eight self-help groups engaged in outreach and product sales activities.

To determine the sample size, we assumed a Klorin utilization rate of 14%, based on an estimate of Klorin use from an evaluation in 2003 (S. Bratton, unpublished data, 2003), an error of ± 9%, and a confidence level of 95%. From these assumptions, we calculated that we would need to survey approximately 60 households in each area.

In each of the eight evaluation areas, households were selected using systematic random sampling. To calculate the sampling interval for each target area, we first obtained

the number of households in each community through discussions with local leaders. To obtain the inverse of the sampling proportion (P) for each community, we divided the number of households by the proposed sample size (60). The field team then chose a random number (R) between 1 and P for each community. Kenyan fieldworkers began at the edge of the sampling area for each community and counted off houses until they arrived at house number R, where they conducted the first interview. Fieldworkers then walked through the community and selected one every P households and interviewed the female head of household using a questionnaire that included demographic and socioeconomic variables; water sources and storage practices; knowledge, attitudes and practices regarding water treatment with Klorin, WaterGuard, PuR™ and other methods; and sanitation and hygiene practices. If respondents indicated that they had treated their current stored water with one of the three chlorine-containing products, their water was tested for residual chlorine using the orthotolidine (OTO) method (www.aquachem.com).

Data analysis

Household data were analysed using EpiInfo v. 3.2.2 (CDC), SAS v.9.2 (SAS Institute) and SUDAAN (Research Triangle Institute). Although we selected a convenience sample of SWAP groups in our first sampling stage, results were analysed as a two-stage cluster sample. We conducted a bivariate analysis to determine predictors of awareness of Klorin, and history of use and confirmed use of any of the three products, using a chi-square test. WaterGuard had recently entered the market and was promoted through social marketing channels other than SWAP; households with awareness of WaterGuard but not Klorin were not included in the multivariate analysis assessing product awareness. Those aware of PuR™ were nearly exclusively also aware of Klorin. Multivariate models were constructed from variables found to be statistically significant in bivariate analysis.

To classify respondents by socioeconomic status, we used two different methods to construct quintiles. The first methods used weights calculated by the World Bank, using asset scores derived from the Kenya Demographic and Health Survey (Gwatkin et al. 2007). This set of quintiles

was used to compare our study population with the Kenyan population as a whole. The second set of quintiles was developed using principal component analysis (PCA) using household assets derived from our study population such as housing materials, water sources, sanitary facilities and household goods (Filmer & Pritchett 2001). This second set of quintiles was used to assess awareness, reported and confirmed use of POU water treatment between different socioeconomic groups.

Ethical review

The evaluation protocol was approved by the Institutional Review Board (IRB) at the Rollins School of Public Health at Emory University. Based on a consideration of the study protocol, the IRB at CDC determined that, because this work consisted of programme evaluation of a proven public health practice, IRB regulations did not apply. Informed consent was obtained from all survey participants and all survey materials were kept confidential.

RESULTS

A total of 487 persons were interviewed, but two questionnaires were incomplete and excluded from analysis. Of 485 survey respondents from the eight groups, 430 (90%) were female, with a median age of 32 years. Overall, 384 (79%) respondents had attended school and were able to read, with school attendance ranging from 63 to 97% in the eight groups; 103 (21%) respondents had attended at least some secondary school (Table 1). Using the quintiles derived from the World Bank analysis, our analysis revealed that 62% of evaluation households fell into the poorest socioeconomic quintile of the Kenyan population.

Water source, storage and treatment

Overall, 72% of households used water from an unprotected source while 8% had a protected water source (Table 1). None of the households used a municipal water supply and none of the water sources was chlorinated. Drinking water was stored in the home by over 99% of respondents.

Of the 485 respondents, 372 (77%) had heard of Klorin (Table 2). When we constructed five equal-sized

Table 1 | Demographic, household, water, sanitation and hygiene characteristics in eight communities in Nyanza Province, Kenya 2004 ($n = 485$)

	No. (%)	Median (range for eight communities)
Median age of respondent (years)	-	32 (18–85)
Female respondent	435 (90)	88 (85–100)
Reported literacy	384 (79)	82 (63–97)
Attended any secondary school	103 (21)	18 (8–48)
Household lighting method		
Unimproved (tin & wick lighting)	252 (52)	48 (33–80)
Improved (hurricane lamps)	205 (43)	49 (20–54)
Improved (electricity)	15 (4)	0 (0–17)
Improved roofing*	334 (69)	66 (45–94)
Improved floor†	163 (34)	23 (13–74)
Improved walls‡	146 (30)	22 (5–72)
Current source		
Protected source§	78 (16)	8 (0–80)
Rain water catchment	44 (9)	4 (0–27)
Surface water and unprotected source¶	281 (58)	72 (5–91)
Piped water‖	82 (17)	2 (0–93)
Store water	482 (99)	100 (98–100)
Store water in narrow-mouth container (jerrycan/plastic bottle/narrow mouth clay pot)	46 (10)	11 (3–16)
Presence of soap	467 (96)	98 (83–100)
Observed presence of latrine in compound	358 (74)	75 (53–95)
Observed presence of faeces in compound	77 (16)	16 (5–30)

*Improved roofing includes metal sheets or tile. Unimproved roofing includes thatch/natural materials.
†Improved floor includes cement or tile. Unimproved includes mud/dung.
‡Improved walls include wood, cement/plaster, or bricks/block/stone. Unimproved walls include mud/dung and natural material.
§Protected sources include protected hand dug wells, protected springs and boreholes.
¶Unprotected sources and surface waters include open wells, open springs, lakes, ponds, rivers and dams.
‖Piped water includes public standpipes and in-home taps.

socioeconomic quintiles (each with 97 households) from the evaluation sample, 65% of households in the poorest quintile had heard of Klorin, as opposed to 79% in the other quintiles (range of 72 to 90%) (Figure 1). Of the 485 respondents, 159 (33%) had ever used Klorin, with a range of 15 to 58% in the eight different areas (Table 2). Across the five socioeconomic quintiles constructed for our

evaluation sample, the (%) of respondents who reported having ever used either Klorin, WaterGuard or PuR™ ranged from 15% in the poorest quintile to 44% in quintile 4 (Figure 1). Detectable chlorine residuals attributable to Klorin were found in 83 stored water samples, 17.1% of the total evaluation population (Table 2).

Overall, 270 (56%) of the 485 respondents had heard of WaterGuard, and 42 (9%) had ever used it; over 30% of reported users were from one peri-urban area. Residual chlorine attributable to WaterGuard was found in 12 samples, 2.5% of the total population (Table 2).

Of the 485 respondents, 120 (25%) had heard of PuR™, and 48 (10%) had ever used it (range 0–28%). Only 3 (<1%) respondents had heard of PuR™ but not Klorin. Only four water samples, 0.8% of the total population, had detectable chlorine residuals attributable to PuR™ (Table 2).

Of the 179 (37%) respondents who had ever used Klorin or WaterGuard, 98 (20% of the total) reported that they had made repeat purchases and 48 (10%) said they had not replenished their supply because they were still using the first bottle. Forty-eight (10%) respondents had ever used PuR™; 24 (5%) reported that they had used more than one sachet and 7 (1%) said they had used more than 10 sachets.

Of the 326 respondents who had never used Klorin, 113 (23%) said they were not aware of it, 77 (16%) reported that it was too expensive, 70 (14%) indicated they did not know where to purchase it, 49 (10%) said it had a bad taste or smell, and 44 (9%) felt they did not need it. Of the 443 respondents who had never used WaterGuard, 213 (44%) said they had never heard of it, 131 (27%) indicated that they did not know where to buy it, 56 (12%) reported that it was too expensive, and 25 (5%) felt they did not need it. Of the 437 who had never used PuR™, 362 (75%) said they had never heard of it, 27 (5%) reported that it was too expensive, 11 (2%) said their water source was safe, and 10 (2%) indicated that they were too busy.

Detectable chlorine residuals attributable to Klorin, WaterGuard or PuR™ were found in the stored water of 99 (20%) out of 485 respondents. In the second to fifth socioeconomic quintiles, the (%) of respondent households with detectable chlorine residuals in stored water were similar; the range was only 8% in the first (poorest) quintile, 15% in the next poorest quintile and between 25 and 28% in the three least poor quintiles (Figure 1).

Table 2 | Awareness, ever use, and confirmed use of three water treatment products among the population served by AIDS self-help groups in eight communities in Nyanza Province, Kenya, 2004 ($n = 485$)

	Klorin	WaterGuard	PuR™
Heard of product, No. (%)	372 (77)	270 (56)	120 (25)
Median % for eight communities (range)	78 (55–95)	55 (40–80)	22 (0–57)
Ever used product, No. (%)	159 (33)	42 (9)	48 (10)
Median % for eight communities (range)	35 (15–58)	7 (0–20)	7 (0–28)
Confirmed use of product (detectable chlorine residual in stored water), No. (%)	83 (17.1)	12 (2.5)	4 (0.8)
Median % for eight communities (range)	17 (3–36)	2 (0–12)	0 (0–3)

Multivariate analysis

Logistic regression models were constructed to evaluate predictors of awareness of Klorin, the most commonly used water treatment product, and chlorination of stored water with any water treatment product, confirmed by the presence of residual chlorine. The models combined data from the eight communities and included two predictor variables: educational level and socioeconomic quintile. Using illiterate persons and persons in the poorest socioeconomic quintiles as referents, there was an independent association between awareness of Klorin with at least some primary education (odds ratio [OR] 2.3, 95% confidence interval [CI] 1.7, 3.1), at least some secondary education (OR 5.7, 95% CI 3.2, 10.2), and persons in the second highest socioeconomic quintiles (OR 4.0, 95% CI 1.2, 12.9) (Table 3). There was an independent association between use of a POU water treatment product and persons completing at least some primary education (OR 2.8, 95% CI 1.7, 4.8), at least some secondary education (OR 4.8, 95% CI 2.8, 8.4) compared with those who were illiterate; those in the upper four socioeconomic quintiles had a significantly greater odds of having ever used one of the products compared with those in the poorest quintile (Table 3). Educational level was a significant predictor of having detectable chlorine residual in stored household water; compared with the poorest households, households in the upper four quintiles were more likely to have detectable levels of chlorine in their stored water (Table 3).

DISCUSSION

This evaluation demonstrated that impoverished populations at high risk of waterborne illness in rural western Kenya exhibited high levels of awareness and trial purchase, and lower levels of current use of water treatment products. These populations, while poorer than the overall population of Kenya, were principally exposed to these products through members of AIDS self-help groups whose motivation was community service and a small financial incentive. The level of current, confirmed use of water treatment products was, at 20%, noteworthy compared with findings among similar populations in the same province (5.9%, R. Rheingans, unpublished data, 2007), for it represented the proportion of the population in these evaluation communities willing to purchase and use a preventive public health intervention.

Despite the promising findings of this evaluation, economic barriers to access to these products were evident. The most utilized product, Klorin, was also the least expensive, costing US$0.01 per 100 litres treated. WaterGuard, which was commercially launched by PSI less than one year before the evaluation, at US$0.02 per 100 litres, was more expensive than Klorin and had a lower level of use. PuR™, at US$0.70 per 100 litres, was used by the lowest (%) of respondents. Although awareness of Klorin was high across wealth quintiles, initial purchase and sustained use
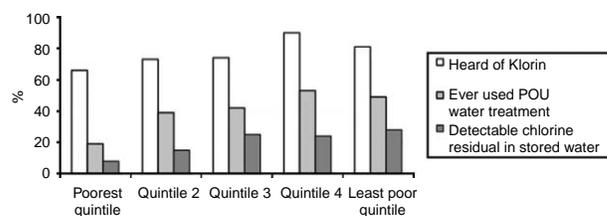

Figure 1 | Percentage of respondents with awareness of Klorin, ever used any POU water treatment product, and with detectable chlorine residuals in stored water (attributable to any water treatment product), by socioeconomic quintile in populations in eight communities served by AIDS self-help groups (N = 485), Nyanza Province, Kenya 2004.

Table 3 | Awareness of Klorin, use of POU treatment products and presence of detectable chlorine residual in stored water (attributable to any water treatment product), by educational level and socioeconomic status, determined by multivariate logistic regression model

Predictor	Ever heard of Klorin		Ever used any POU product		Detectable chlorine residual in stored water	
	OR	95% CI	OR	95% CI	OR	95% CI
Educational level[†]						
Completed at least some primary school	2.3[§]	1.7, 3.1	2.8[¶]	1.7, 4.8	2.8[¶]	1.3, 5.9
Completed at least some secondary school	5.7[§]	3.2, 10.2	4.8[¶]	2.7, 8.4	5.4[¶]	1.6, 17.5
Socioeconomic status[‡]						
Quintile 2	1.3	0.7, 2.3	2.7[¶]	2.1, 3.4	1.8	0.7, 4.9
Quintile 3	1.2	0.5, 2.7	2.6[¶]	1.7, 4.0	3.1[*]	1.2, 7.9
Quintile 4	4.0[§]	1.2, 12.9	4.0[¶]	1.9, 8.3	2.7[§]	1.0, 7.8
Least poor quintile	1.1	0.4, 3.0	2.3[¶]	1.5, 3.6	2.3[*]	0.9, 6.1

[*]significant at $\alpha < 0.1$ level.
[†]referent is illiterate status.
[‡]referent is the lowest (poorest) quintile.
[§]significant at $\alpha < 0.05$ level.
[¶]significant at $\alpha < 0.01$ level.
Note: OR = odds ratio; CI = confidence interval.

was limited in the lower population quintiles and among those least educated. Nearly a quarter of respondents who had never used Klorin said that the product was too expensive. These results suggest that many of those at greatest risk of diarrhoeal diseases did not purchase Klorin because they had little or no disposable income (Onwujekwe *et al.* 2004). Social entrepreneurship and reliance on market forces therefore may not be sufficient to reach the poorest households (Thevos *et al.* 2000; Black *et al.* 2003). This economic barrier points to the possible need to create incentives, such as targeted subsidies to better reach the poor and stimulate increased product uptake (Onwujekwe *et al.* 2003, 2004).

A significant barrier to product awareness and use was illiteracy. Though it is possible that educational level represents another dimension of socio-economic status (SES), thus reinforcing the disparity between wealth quintiles, education may represent an additional independent barrier to awareness and adoption of POU water treatment products. As there were low numbers of wealthy illiterate respondents, interaction between SES and education could not be assessed. The correlation between lack of education and low product adoption is likely to reflect a poor understanding of the relationship between diarrhoea and unsafe water. Such knowledge is particularly important in these communities because of the high risk of diarrhoea

that results from unsanitary environmental conditions, high rates of immunodeficiency caused by HIV infection, and widespread belief that rain water is sacred and requires no treatment.

Respondents who had never used Klorin provided additional clues to important barriers to use of the product. For the 21% who did not know where to find Klorin, product distribution may have been an important barrier. For 15%, taste was an important behavioural barrier. For 13%, a belief that their water did not need to be treated was an obstacle to product use. Misconceptions about the safety of the drinking water source may have arisen from a belief by some that the water their family had used for generations was not contaminated, or that clear water was safe to drink. These barriers could possibly be overcome with additional education and clearer messaging about the health benefits of safe water, particularly if the messages come from a trusted source such as a community group, rather than through mass media (Montazeri 1997), and are targeted to groups at highest risk.

This evaluation had two important limitations. First, because no baseline data were obtained, we were not able to demonstrate the comparative impact of different implementation approaches, such as social marketing and social entrepreneurship on product use. However, the only implementation approach for Klorin and PuR™ involved

the SWAP groups, so utilization of both products was probably attributable to their efforts. Second, because the first stage of sampling involved a convenience sample of the most active SWAP groups, the population surveyed was not representative of the population in Nyanza Province and, consequently, survey results were not generalizable to all SWAP groups.

CONCLUSIONS

The findings of this evaluation suggest that an entrepreneurial product promotion and sales approach employing local residents as vendors and agents of behaviour change may be an effective method of increasing access to health products in populations with relatively low exposure to radio and print advertisements and limited access to retail stores and pharmacies. As such, this approach complements social marketing and commercial distribution. Despite the potential of this combined approach, overcoming persistent barriers to product access for the poorest and least educated households will require additional interventions, such as provision of subsidies or alternative motivational strategies (Onwujekwe *et al.* 2003). A more complete understanding of motivations for uptake and use of water treatment technologies is needed. Future evaluations of this programme, which is expanding in Kenya, are planned to test the effectiveness of additional intervention approaches in lowering barriers to access to water treatment products, and to measure their health impact.

ACKNOWLEDGEMENTS

REFERENCES

Black, R. E., Morris, S. S. & Bryce, J. 2003 Where and why are 10 million children dying every year? *Lancet* **361**, 2226–2234.

CDC 2000 *Safe Water Systems for the Developing World: A Handbook for Implementing Household-Based Water Treatment and Safe Storage Projects (SWS)*. Centers for Disease Control and Prevention, Atlanta. Available at: http://www.cdc.gov/safewater/manual/sws_manual.pdf (accessed 12 December 2007).

Clasen, T., Schmidt, W. P., Rabie, T., Roberts, I. & Cairncross, S. 2007 Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. *Brit. Med. J.* **334**, 782.

Dunston, C., McAfee, D., Kaiser, R., Rakotoarison, D., Rambeloson, L., Hoang, A. T. & Quick, R. E. 2001 Collaboration, cholera, and cyclones: a project to improve point-of-use water quality in Madagascar. *Am. J. Public Health* **91**, 1574–1576.

Filmer, D. & Pritchett, L. H. 2001 Estimating wealth effects without expenditure data–or tears: an application to educational enrollments in states of India. *Demography* **38**, 115–132.

Gwatkin, D. R., Rustein, S., Johnson, K., Pande, R., Wagstaff, A. & Amouzou, A. 2007 *Socio Economic Differences in Health, Nutrition, and Population in Kenya*. World Bank, Washington, DC. Available at: www.worldbank.org/povertyandhealth/countrydata (accessed 2 December 2008).

Luby, S. P., Agboatwalla, M., Raza, A., Sobel, J., Mintz, E. D., Baier, K., Hoekstra, R. M., Rahbar, M. H., Hassan, R., Qureshi, S. M. & Gangarosa, E. J. 2001 A low-cost intervention for cleaner drinking water in Karachi, Pakistan. *Int. J. Infect. Dis.* **5**, 144–150.

Luby, S. P., Agboatwalla, M., Hoekstra, R. M., Rahbar, M. H., Billhimer, W. & Keswick, B. H. 2004 Delayed effectiveness of home-based interventions in reducing childhood diarrhea, Karachi, Pakistan. *Am. J. Trop. Med. Hyg.* **71**, 420–427.

Lule, J. R., Mermin, J., Ekwaru, J. P., Malamba, S., Downing, R., Ransom, R., Nakanajako, D., Wafula, W., Hughes, P., Bunnell, R., Kaharuza, F., Coutinho, A., Kigozi, A. & Quick, R. 2005 Effect of home-based water chlorination and safe storage on diarrhea among persons with human immunodeficiency virus in Uganda. *Am. J. Trop. Med. Hyg.* **73**, 926–933.

Makutsa, P., Nzaku, K., Ogutu, P., Barasa, P., Ombeki, S., Mwaki, A. & Quick, R. E. 2001 Challenges in implementing a point-of-use water quality intervention in rural Kenya. *Am. J. Public Health* **91**, 1571–1573.

Mintz, E. D., Bartram, J., Lochery, P. & Wegelin, M. 2001 Not just a drop in the bucket: expanding access to point-of-use water treatment systems. *Am. J. Public Health* **91**(10), 1565–1573.

Montazeri, A. 1997 Social marketing: a tool not a solution. *J. Roy. Soc. Health* **117**, 115–118.

Onwujekwe, O., Hanson, K. & Fox-Rushby, J. A. 2003 Who buys insecticide-treated nets? Implications for increasing coverage in Nigeria. *Health Policy Plann.* **18**, 279–289.

Onwujekwe, O., Hanson, K. & Fox-Rushby, J. 2004 Inequalities in purchase of mosquito nets and willingness to pay for insecticide-treated nets in Nigeria: challenges for malaria control interventions. *Malaria J.* **3**, 6.

Parashar, U. D., Bresee, J. S. & Glass, R. I. 2003 The global burden of diarrhoeal disease in children. *Bull. World Health Organ.* **81**, 236.

Quick, R. E., Venczel, L. V., Gonzalez, O., Venczel, L. V., Gonzalez, O., Mintz, E. D., Highsmith, A. K., Espada, A., Damani, E., Bean, N. H., De Hannover, E. H. & Tauxe, R. V. 1996 Narrow-mouthed water storage vessels and in situ chlorination in a Bolivian community: a simple method to improve drinking water quality. *Am. J. Trop. Med. Hyg.* **54**, 511–516.

Quick, R. E., Venczel, L. V., Mintz, E. D., Soleto, L., Aparicio, J., Gironaz, M., Hutwagner, L., Greene, K., Bopp, C., Malonry, K., Chavez, D., Sobsey, M. & Tauxe, R. V. 1999 Diarrhoea prevention in Bolivia through point-of use water treatment and safe storage: a promising new strategy. *Epidemiol. Infect.* **122**, 83–90.

Quick, R. E., Kimura, A., Thevos, A., Tembo, M., Shamputa, I., Hutwager, L. & Mintz, E. 2002 Diarrhea prevention through household-level water disinfection and safe storage in Zambia. *Am. J. Trop. Med. Hyg.* **66**, 584–589.

Rheingans, R., Dreibelbis, R. & Freeman, M. C. 2006 Beyond the millennium development goals: public health challenges in water and sanitation. *Global Public Health* **1**, 31–48.

Semenza, J. C., Roberts, L., Henderson, A., Bogan, J. & Rubin, C. H. 1998 Water distribution system and diarrheal disease transmission: a case study in Uzbekistan. *Am. J. Trop. Med. Hyg.* **59**, 941–946.

Sobel, J., Mahon, B., Mendoza, C. E., Passaro, D., Cano, F., Baier, K., Francesca, R., Hutwagner, L. & Mintz, E. 1998 Reduction of fecal contamination of street-vended beverages in Guatemala by a simple system for water purification and storage, handwashing, and beverage storage. *Am. J. Trop. Med. Hyg.* **59**, 380–387.

Thevos, A. K., Kaona, F. A. D., Siajunza, M. T. & Quick, R. E. 2000 Adoption of safe water behaviours in Zambia: comparing educational and motivational approaches. *Educ. Health* **13**, 366–376.

WHO 2002 *World Health Report 2002: Reducing Risks, Promoting Healthy Life*. World Health Organization, Geneva.

WHO, UNICEF (United Nations Children's Fund), Water Supply and Sanitation Council 2000 *Global Water Supply and Sanitation Assessment 2000 Report*. UNICEF, New York.

Wright, J., Gundry, S. & Conroy, R. 2004 Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. Int. Health* **9**, 106–117.