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A Cluster Randomized Trial of the Impact of Education through Listening (a Novel Behavior Change Technique) on Household Water Treatment with Chlorine in Vihiga District, Kenya, 2010–2011

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Abstract. Despite multiple studies demonstrating the effectiveness of household water treatment with chlorine in disinfecting water and preventing diarrhea, social marketing of this intervention in low- and middle-income countries has resulted in only modest uptake. In a cluster randomized trial in Vihiga district, western Kenya, we compared uptake of household water treatment with chlorine among six villages served by community vendors trained in standard social marketing plus education through listening (ETL), an innovative behavior change method, and six villages served by community vendors trained in standard social marketing only. Water treatment uptake, water quality, and childhood diarrhea were measured over 6 months and compared between the two groups of villages. During the 6-month period, we found no association between ETL exposure and reported and confirmed household water treatment with chlorine. In both groups (ETL and comparison), reported use of water treatment was low and did not change during our 6-month follow-up. However, persons confirmed to have chlorinated water had improved bacteriologic water quality. Study findings suggest that ETL implementation was suboptimal, which, along with unexpected changes in the supply and price of chlorine, may have prevented an accurate assessment of the potential impact of ETL on water treatment behavior. Taken together, these observations exemplify the complexities of habits, practices, attitudes, and external factors that can create challenging conditions for implementing behavioral interventions. As a consequence, in this trial, ETL had no measurable impact on water treatment behavior.

INTRODUCTION

More than 2 billion people lack access to safely managed drinking water at home.[1] Recent evidence suggests that even improved water supplies may not be safe to drink.[2] Lack of access to safe water and sanitation may account for more than 800,000 deaths and close to 50 million disability-adjusted life years annually.[3] The burden often falls heavily on children younger than 5 years, with an estimated 5% of all global deaths attributed to water, sanitation, and hygiene deficiencies.[3] The lack of access disproportionately burdens children in developing countries, especially in sub-Saharan Africa where approximately 40% of the population are still without access to basic water supply.[1,4] More than one-third of the population in Kenya lacks access to basic water services, and diarrhea remains a leading cause of disease in children younger than 5 years in Kenya.[5–9]

Household drinking water treatment (HWT) at the point of use provides an opportunity to improve and maintain the quality of drinking water during storage and consumption in the home. Multiple systematic reviews suggest average diarrheal disease reductions of 33–45% by a variety of HWT technologies.[10–13] Building on the evidence surrounding HWT interventions, the parameters of sustainability, cost-effectiveness, and scalability are key questions as researchers, policy-makers, and implementers attempt to expand prevention efforts.[14,15] However, little rigorous evidence exists on the sustainability of HWT as measured by continued and consistent use, or by its ability to provide consistent water quality improvement and sustained health impact in the absence of intervention.[13,14,16]

Several studies have suggested that use and impact of HWT often attenuate over time, which may reflect the difficulty of changing human behavior.[16–19] A systematic review of behavior change research used in studies on HWT found only 26 articles (out of more than 1,500) that mentioned behavior change theory in the research.[20] Of these 26, only seven had used interventions grounded in behavioral theory.[20] As this evidence suggests, research into behavioral interventions that motivate adoption and sustained use of HWT technologies is an underdeveloped area of inquiry.

In western Kenya, a non-governmental organization called Safe Water and AIDS project (SWAP) has promoted HWT with chlorine products for 15 years. SWAP engages HIV support groups and self-help groups to promote and sell water treatment and other health products as an income generating activity that also benefits the wider community. SWAP field officers recruit existing community groups and introduce SWAP and its health products with the purpose of encouraging positive health promotion and risk reduction behaviors. SWAP utilizes community mobilization to promote the purchase and use of a variety of health products.[21]

In evaluations of SWAP social marketing programs in western Kenya, households in villages in the SWAP catchment area were more likely to have been visited by a SWAP vendor and to have purchased and used water treatment products, with 14–20% of households reported purchasing and/or using chlorine to treat their water.[22,23] The products used for disinfection with chlorine at the household level include WaterGuard, Aquatabs, and Pur. Although these evaluations suggest that the SWAP program has increased access to water treatment products, they also highlight that there is still room for improvement. As a result, SWAP continues to

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examine new implementation methods to increase uptake of HWT behavior in communities in western Kenya. Despite over 100 years of data documenting the effectiveness of chlorine for water treatment[24] and, more recently, the successful introduction of community mobilization around HWT behaviors, adoption of HWT with chlorine remains modest.[25] For this technically promising approach to reach its potential, novel behavior change methods are needed to motivate and enhance the adoption of these practices. Education through listening (ETL) is an innovative behavior change method that was derived from motivational interviewing,[26] stages of change,[27] and social learning theory.[28] It is an engagement technique that is a person-centered way of communicating and giving feedback to promote behavior change. This technique is based on a participatory dialogue for increasing a person's inner motivation to change by exploring and helping them resolve any mixed feelings, ambivalence, or suffering they have about adopting a new positive behavior. This can be accomplished at an individual or group level in a community.

ETL training emphasizes the basic concepts of Prochaska and DiClemente's transtheoretical stages of change model to determine a person's readiness to change.[29,30] Motivational interviewing principles counter the typical scolding often used to convince people to change by engaging them in a personal dialogue around the desired change. This promotes an understanding of the barriers to change and allows for a discussion of benefits to change. Social learning theory addresses how the person along with their environment influences change. Behavioral and social science theories provide insights into how and why people change a behavior and what gets in the way of them changing. A similar behavior change approach that used motivational interviewing and stages of change theory was shown to increase use of HWT in Zambia.[31,32]

The purpose of the study was to compare the impact of combined ETL behavior change technique plus standard SWAP social marketing training with standard SWAP social marketing training alone on HWT uptake in Vihiga district, Western Province, Kenya. ETL had previously been implemented in a study about modified cook stoves in western Kenya[33] but had not been used for HWT. Vihiga district in Western Province was selected because there had been limited research activity compared with other western Kenya districts.

In July 2010, we initiated a quantitative outcome evaluation of ETL in western Kenya with the following objectives:

1. Compare uptake of HWT with chlorine between groups of communities whose vendors received combined SWAP social marketing training plus ETL versus communities whose vendors received standard SWAP training only.
2. Evaluate the health and microbiological impacts of HWT with chlorine during a 6-month surveillance period.

MATERIALS AND METHODS

Study design. A cluster randomized controlled trial was conducted to measure the effect of combined standard SWAP social marketing training plus ETL (ETL group) versus standard SWAP social marketing training only (comparison group) on adoption of HWT with chlorine. A convenience sample of 12 villages in Vihiga district was recruited in July 2010 during which time we performed a baseline survey of all households. We randomly allocated each village to receive either the standard SWAP social marketing training only or SWAP training plus ETL using a 1:1 allocation ratio. We then followed up all households in the villages for 6 months with biweekly household interviews and monthly water samples (see Figure 1).

Sample size determination. Each village comprised a census enumeration area (EA). We included all households with children younger than 2 years in evaluation EAs; therefore, sampling was not necessary. We estimated that approximately 8% of the Kenyan population are younger than 2 years. Assuming an average population of about 500/EA, we estimated there would be approximately 40 children/EA, for a total of about 240 children in the ETL intervention group and 240 in the comparison group. Our sample size was designed to measure a diarrheal disease reduction of $\geq 20\%$ during the 6-month time period based on previous work in the region.

Standard SWAP training. To engage with the community, SWAP uses existing community organizations to implement social marketing trainings and promote products.[21,34] This includes presentations at community meetings and gatherings such as churches and local community administration meetings. During these activities, active community groups are identified and an assortment of products are offered to them wholesale. SWAP team members mentor the community groups to sell the products via a variety of approaches including door-to-door sales, vending via kiosks, community gatherings, and even via pharmacies.

Education through listening implementation. In this study, all community vendor groups were provided with the standard SWAP social marketing and product training[21] (referred to as "comparison" group). In addition, we implemented a 1-week ETL training in August 2010 to the vendor groups recruited from villages selected to receive the ETL intervention (referred to as "ETL intervention group") in addition to standard training. The training was delivered by two trainers: one member of the SWAP program and one senior behavioral scientist from the Centers for Disease Control and Prevention (CDC). The training was delivered in English with translation to the local language (either Kiswahili or Luyha).

The implementation approach to ETL included five additional days of training. During the training, participatory partner and group activities were used to demonstrate the stages of behavior change within the local cultural context and identify critical behavior change principles. Through interactive exercises, participants established a base of knowledge on the behavior change process, what motivates people to change, and what gets in the way of people changing. Distinctions were drawn between traditional health education and promotion, and ETL. Participants engaged in role plays and participatory exercises to enhance skills related to implementing ETL with an individual and with small community groups.

Data collection. *Recruitment and baseline survey.* All survey data were collected from the primary caretaker on personal digital assistants using Microsoft Access (Microsoft Corp., Redmond, WA). The eligibility criteria included having a child younger than 2 years in the household and willingness to participate. If a house had more than one child eligible, one child was chosen randomly to be included in the study. All

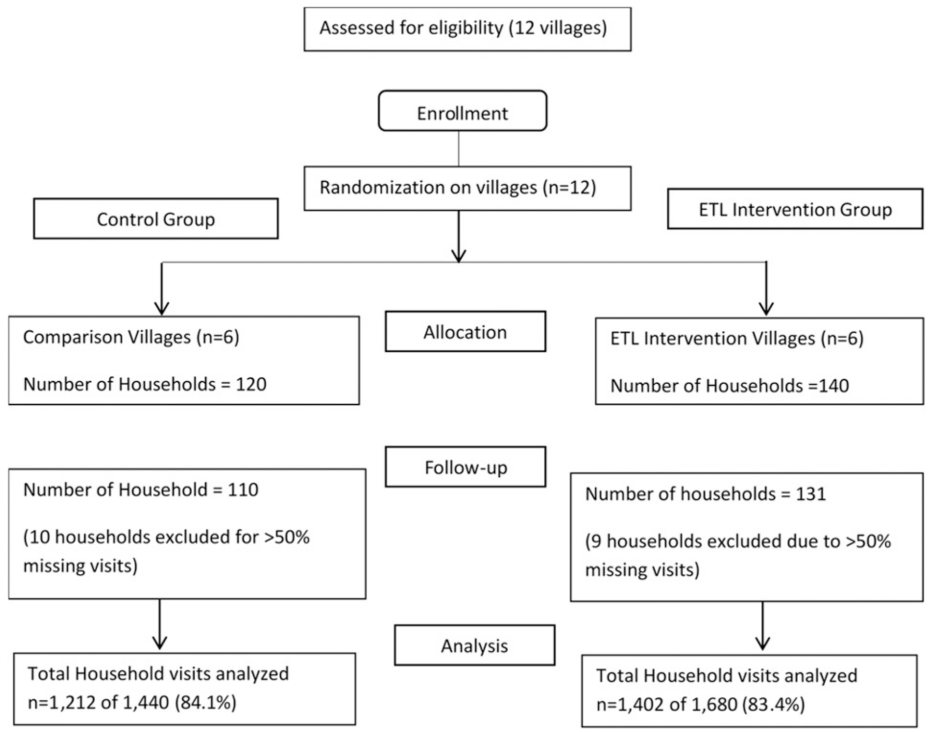

FIGURE 1. Flow diagram of participation.

households meeting the eligibility criteria were enrolled. A baseline questionnaire included demographic and socioeconomic characteristics and reported HWT practices.

Intervention follow-up. To examine the quantitative impact of the ETL training on water treatment behavior and health, we made visits every 2 weeks to each study household in the 12 villages from September 2010 to February 2011 to obtain data on self-reported diarrheal disease for children younger than 2 years. We also asked the respondent whether or not the household was visited by anyone who discussed water treatment. In addition, SWAP records regarding sales of a range of household water treatment products sold to community groups in the Vihiga district were also reviewed, and we administered a one-time survey regarding household priorities during the 6-month follow-up period.

Water quality measures. At each visit, free chlorine residual (FCR), an indicator confirming HWT, was measured in a sample of drinking water stored in the household using the N, N-diethyl-phenylenediamine method (La Motte, Chestertown, MD). The detection limit of this assay was 0.2 mg/L. Turbidity was measured at baseline and at 1-month intervals with a Hach turbidimeter. Household drinking water quality was analyzed for *Escherichia coli* and total coliforms using an IDEXX Colilert Quanti-Tray/2000™ (IDEXX, Westbrook, ME) at baseline and at 1-month intervals.

Statistical methods. Quantitative data were analyzed using Stata 10 (StataCorp LLC, College Station, TX) and SAS software version 9.4 (SAS Institute Inc., Cary, NC). Descriptive statistics were used to summarize all study variables and explore groups by time effects. Data were analyzed to assess three dichotomous main outcomes: reported HWT behavior, detection of chlorine in household drinking water, and reported diarrheal disease in the participating children younger than 2 years. To examine the impact of ETL, we assessed treatment effects for reported use of chlorination of drinking water, levels of chlorine in drinking water, microbiological quality of drinking water, and diarrheal disease in children. Statistical modeling with specification of a three-level marginal model with a binomial distribution and logit link function and visit nested within household nested within village was used to quantify water treatment effects. Generalized estimating equations (GEEs) were applied to estimate marginal model parameters. Clustering of visits within households within villages was specified in the marginal model, assuming a nested exchangeable working correlation structure, and visit was included as a fixed effect to quantify the time effect on each outcome. To account for potential confounding, we considered the following baseline characteristics in the marginal models: gender and age of the child, reported breastfeeding, marital status of the primary respondent, reported water treatment at baseline, use of unimproved water source, and presence of a latrine and soap at baseline. In addition to assessment of treatment effects, a separate analysis using a similar three-level marginal model to account for clustering of visits within households within villages was used to quantify associations with reported water treatment chlorine and household water quality as a function of presence/absence of *E. coli* in 100 mL of sampled drinking water.

Research ethics. The study protocol was reviewed and approved by the Kenyan Medical Research Institute's Ethical Review Committee (no. 1784), the Georgia State University's Institutional Review Board (no. H10227), and the CDC's Institutional Review Board (no. 5890).

RESULTS

SWAP and ETL training with community groups. A total of 24 active community groups were trained during August 2010. The community groups represented organizations focused on a variety of community concerns such as youth, women, or self-help groups. Ten groups participated from the comparison group villages, and 14 groups participated from the ETL intervention group villages. Each village had one to three active community groups that participated in the trainings. At the end of the training sessions, community groups purchased products from SWAP for sale in the community.

Study participation. A total of 260 eligible households were identified in 12 participating villages with 140 households in the six ETL intervention group villages and 120 households in the six comparison group villages. Ten households in the comparison group and nine in the ETL intervention group completed less than half of home visits and were excluded from the analysis. A total of 1,212 (84.1%) of 1,440 possible visits were completed for the comparison group and 1,402 (83.4%) of 1,680 possible for the ETL intervention group (Figure 1).

Baseline descriptive statistics. Most demographic and socioeconomic characteristics were similar at baseline in the ETL intervention and comparison groups (Table 1). The median age of respondents was 27 years in the comparison (range, 18–70 years) and ETL intervention (range, 18–59) groups, and the median age of the selected child was 6 months. More than 80% of primary respondents in both groups reported (at baseline) that the participating child was still breastfeeding. A higher percentage of respondents in the comparison group completed a primary education (69% versus 53%). Most household assets were similar in the two groups; only radio ownership was different in comparison and ETL intervention households (80% versus 69%). At baseline, a similar proportion of comparison and ETL intervention households reported using an improved drinking water source (90% versus 85%), having a latrine (98% versus 93%), storing water in clay pots (68% versus 63%), treating water at home (23% versus 24%), and treating with chlorine (8% versus 4%). A higher percentage of ETL intervention than comparison households had soap in their home (95% versus 88%).

Intervention phase data. As displayed in Table 2, the aggregate percentages of household visits with reported water treatment during the 6-month follow-up period were similar between comparison and ETL intervention groups (18% versus 16%, respectively). The percentage of household visits in which respondents reported treating water with any chlorine product was similar between the comparison and ETL intervention groups (11% versus 14%). Similar results were observed with WaterGuard (11 versus 13%) and with detectable FCR in stored water (4% versus 8%). Overall, households in both groups reported infrequent community vendor visits to discuss household water treatment (< 2% of the households reported this occurring in the prior week). The percentages of ETL intervention and comparison group respondents who reported diarrhea in children were similar (3.7% versus 4.0%). Bacteriologic water quality was similar between groups during the intervention, with 79% of samples positive for *E. coli* in both groups. Turbidity was slightly higher in the

Table 1

Baseline characteristics for comparison and ETL groups in Vihiga district, western Kenya, 2010 (n = 260 households)

Variable	Standard (120 households) count (%)	ETL (140 households) count (%)
Primary respondent completed primary education	83 (69)	74 (53)
Married	98 (82)	125 (89)
Participating child is male	68 (57)	65 (46)
Primary respondent is child's biological mother	108 (90)	128 (91)
Child is currently breastfeeding	99 (84)	109 (82)
No electricity	113 (94)	133 (95)
Own radio	96 (80)	97 (69)
Own bicycle	34 (28)	28 (20)
Own cell phone	72 (60)	78 (56)
Farm the land	112 (93)	127 (91)
Own land	55 (49)	77 (61)
Own home	114 (95)	126 (90)
Improved water source	108 (90)	119 (85)
Water storage container		
Ordinary clay pot	73 (61)	83 (59)
Plastic jerrican	22 (18)	36 (27)
Other	12 (< 1)	14 (< 1)
Reported water treatment at home	28 (23)	33 (24)
Reported boiling	9 (7.5)	13 (9.3)
Reported treatment with WaterGuard	9 (7.5)	5 (3.6)
Heard of WaterGuard	112 (93)	125 (89)
Do not use WaterGuard because of expense	39 (33)	32 (23)
Free chlorine residual present	1 (< 1)	4 (2.5)
Have latrine	118 (98)	130 (93)
Have soap	105 (88)	133 (95)
Respondent age (years): median (range)	27 (18–59)	27 (18–70)
Age of participating child (months): median (range)	6 (< 1, 24)	6 (< 1, 24)
Number of household members, median (IQR)	6 (3)	5 (2)
Number of rooms in household, median (IQR)	2 (1)	2 (1)

ETL = education through listening.

Table 2

Aggregate percentage of household visits with reported and confirmed water treatment and reported diarrheal disease compared for comparison and ETL intervention groups during follow-up home visits from September 2010 to February 2011 in Vihiga district, western Kenya*

Water treatment	Standard (%)	ETL (%)	Total (%)
Any reported water treatment	18	16	17
Reported boiling	5.3	1.2	3.1
Reported treatment with any chlorine product	11	14	13
Reported treatment with WaterGuard	11	13	12
Free chlorine residual detected	3.7	7.8	5.9
WHO definition for diarrheal disease met	4.0	3.7	3.9
Presence of *Escherichia coli* (100 mL)	79	79	79
Turbidity (> 1 NTU)	41	37	39

ETL = education through listening.
* Total number of 2,539–2,614 observations (out of possible 3,120 = 260 households × 12 visits).

comparison group with more households found to have stored water samples with turbidities above one nephelometric turbidity units (NTU) (41% compared with 37%); however, mean turbidity was low across both groups.

Table 3 shows the results of the bivariate marginal model of treatment by time effect for each outcome of interest. After adjusting for covariates, there were no difference in reported or confirmed water treatment, *E. coli* contamination, or reported diarrheal disease between households that were in the comparison villages compared with the ETL intervention villages. Aggregated percentages of water samples with detectable *E. coli* in stored water and each study outcome are displayed in Table 4. Compared with stored water samples from households with no reported or confirmed water treatment, a higher percentage of stored water samples from households that reported any water treatment (47 versus 53%), water treatment with any chlorine product (36% versus 64%), water treatment with WaterGuard (34% versus 66%), or water treatment confirmed by the presence of FCR (7.6% versus 92%) had no detectable *E. coli* (< 1 *E. coli*/100 mL). There was no difference between the presence of *E. coli* in stored water and reported diarrhea in study participants < 2 years. In the multivariable adjusted model shown in Table 5, the odds of detecting > 1 *E. coli*/100 mL in water samples with confirmed chlorine was decreased (odds ratio [OR] = 0.07; 95% CI = 0.037–0.14) compared with water samples without confirmed chlorine. In addition, the odds of detection of *E. coli* in water that had turbidity > 1 NTU was increased (OR = 1.63; 95% CI = 1.12–2.38).

Table 3

Odds ratios comparing the comparison and education through listening (ETL) intervention groups in reported or confirmed water treatment, child diarrhea, or *E. coli* presence by time effect, Vihiga district, Kenya, 2010–2011*†‡

Outcome	Adjusted odds ratio	95% CI Lower	95% CI Upper
Any reported water treatment	0.95	0.89	1.02
Any chlorine product	0.96	0.89	1.04
Treatment with WaterGuard	0.97	0.90	1.05
Chlorine residual detected	0.96	0.85	1.09
Diarrheal disease	0.95	0.84	1.09
Presence of *E. coli*	1.03	0.95	1.11
Turbidity (> 1 NTU)	1.02	0.99	1.05

E. coli = *Escherichia coli.*
* Each model adjusted for reported baseline characteristics: gender of the child, breastfeeding, marriage status of the primary respondent, reported water treatment, presence of soap, presence of latrine at baseline.
† Three-level marginal model specified to account for clustering of visits within households within villages.
‡ Total number of observations in each model varied from 2,508 to 2,582 (out of possible 3,120 = 260 households × 12 visits).

In October 2010 (approximately halfway through the study), SWAP reported that the price of WaterGuard had nearly doubled and that stock outs had been reported by vendors. As demonstrated in Figures 2 and 3, there was substantial variability over time of both reported and measured chlorine as well as vendor purchases of WaterGuard. As shown in Figure 3, based on SWAP-reported sales to community vendors, little to no WaterGuard was purchased after September 2010.

DISCUSSION

Results of this study showed low overall reported adoption of HWT behaviors and no differences between ETL intervention and comparison groups in reported and confirmed treatment with chlorine during the 6-month evaluation. The lack of impact in this randomized trial was in contrast to modest impact found in several studies examining other behavioral interventions.[22,31]

Successful implementation of behavioral interventions is a prerequisite for understanding their impact on the behavior in question. In this study, a combination of incomplete execution of ETL, beliefs and attitudes of the study population toward water treatment, and external factors regarding product accessibility contributed to the lack of measurable impact of ETL on HWT behavior. First, vendors visited households less frequently than the recommended weekly visits, which suggested that ETL was not fully implemented and calls into question the vendors' belief in and motivation to use ETL. Second, our study was limited in its ability to adequately assess all process and implementation aspects of ETL to explain the lack of impact. Additional implementation fidelity measurements might have enhanced our understanding of study outcomes. Third, as has been observed in other studies, demand for chlorine water treatment appeared to be low from the start. Less than 10% of households reported using chlorine at baseline, and FCR was detected in only 2% of all samples at baseline. Low demand may have resulted from a perception that water treatment was not needed, which was plausible because the study population used protected springs. In addition, it could demonstrate a lack of acceptability of chlorine in this community. Other studies of HWT with chlorine have documented complaints by evaluation populations about unacceptable taste, smell, and cost of the treatment product.[22,35] Fourth, limiting available options to one water

TABLE 4

Number and percent of households with reported or confirmed water treatment and diarrhea in children, by presence of *E. coli* in stored water samples, Vihiga district, Kenya, 2010–2011*

Water treatment	< 1 *E. coli*/100 mL count (%)	≥ 1 *E. coli*/100 mL count (%)	Total count
Any reported water treatment	119 (53)	107 (47)	226
Reported boiling	3 (8.6)	32 (91)	35
Reported treatment with any chlorine product	111 (64)	63 (36)	174
Reported treatment with WaterGuard	106 (66)	55 (34)	161
Free chlorine residual detected	73 (93)	6 (7.6)	79
Diarrheal disease	7 (14)	43 (86)	50

E. coli = Escherichia coli.
* Comparison and education through listening intervention group results are combined in this table.

treatment technology may have reduced the percentage of the population that would adopt a new water treatment behavior because the technology offered may not have been acceptable to many. At least one other study has suggested that offering a menu of technologies may have improved prospects for water treatment behavior change by increasing the chance that an alternative technology would better meet consumer needs.[36] Indeed, two additional water treatment technologies were unexpectedly implemented in our study communities by other organizations after our 6-month intervention period, and we found higher self-reported use of these technologies than WaterGuard (data not shown). Fifth, the price of WaterGuard increased by nearly 100% during the study, which could have decreased use of WaterGuard; price sensitivity to a similar water treatment product was observed in a study in Zambia.[37] In an analysis of household priorities and health behaviors in western Kenya, lack of disposable income and competing needs were found to limit adoption of health products and behaviors.[38] Sixth, the supply of WaterGuard varied during the study because of stock outs in Vihiga district, which likely contributed to the fluctuations in reported and measured use. Finally, in some health clinics in Vihiga district, WaterGuard was being distributed for free to people living with HIV/AIDS as part of the national program, which may have reduced the desirability of the product.[39] In other programs, populations have been observed to reject interventions that are targeted to people living with HIV because of associated stigma, whereas others have suggested that some populations are unwilling to pay for a product that others receive gratis. Taken together, these observations highlight that complexities of habits, practices, attitudes, and external factors can create challenging conditions for implementing behavioral interventions.

Despite the apparent lack of impact of the behavioral intervention, we did find associations between confirmed water treatment and microbiological drinking water quality. The

TABLE 5

Odds ratios for detecting *Escherichia coli* in stored water, by covariate, Vihiga district, Kenya, 2010–2011*

Covariate	Adjusted odds ratio	95% CI	
		Lower	Upper
Any reported water treatment	0.85	0.38	1.88
Any chlorine product	0.34	0.080	1.45
Treatment with WaterGuard	0.68	0.19	2.47
Chlorine residual detected	0.073	0.037	0.16
Diarrheal disease	1.46	0.66	3.23
Turbidity (> 1 NTU)	1.63	1.12	2.38

* Three-level multivariable marginal model specified to account for clustering of visits within households within villages.

association between chlorination and water quality has been well established for many decades and explains the continued widespread use of the chemical in water systems. The associations found in this study raise the possibility that some households with reported, but not confirmed, chlorination might have treated their water but lacked detectable FCR because treatment took place a number of hours before the home visit, resulting in FCR decreasing because of organic material in the water.[8,40] One recent study documented that even in the absence of detectable FCR, the presence of total chlorine residual, as a measure of previous chlorination, is associated with improved microbiologic water quality.[41] Future assessments of chlorination programs would benefit from including total chlorine residual as an indicator of previous chlorination.

The lack of association between water treatment and diarrhea in children was not surprising because there was no difference between the two groups in water treatment behavior over time. The high prevalence of improved water sources and the relatively low levels of contamination by *E. coli* also reduced the risk of waterborne disease in these populations. Previous studies have suggested that diarrhea risk increases with increasing levels of microbial contamination in water.[42,43] Nevertheless, HWT and improved storage are recommended for the study population because of the well-recognized risk of water contamination that can take place during the process of collecting, transporting, and storing water in the home, even for populations with improved water sources.[11,44]

This study had several important limitations. First, the project took place in a convenience sample of villages in a single district, so results are not generalizable to other regions of Kenya. Second, the relatively small sample size of villages and households, as well as lower diarrhea prevalence in children younger than 2 years, resulted in limited statistical power to measure outcomes. With a sample of only 12 villages, estimation of GEE parameters may have been biased, resulting in an inflated type I error rate. Third, budgetary limitations had several potentially adverse impacts on the study duration and methods, including inadequate time for the intervention to influence change related to individual choices and social norms; the short follow-up period (6 months) which reduced the time available to determine whether use of the intervention, or diarrhea prevalence, or both, might have changed; and limited qualitative data collection, which reduced our capacity to obtain process indicators.

Lessons learned/recommendations. In conclusion, we found no difference between the ETL intervention and comparison groups in chlorine uptake for HWT. Our evaluation revealed several key lessons from this study that could be applied to future behavior change implementation and

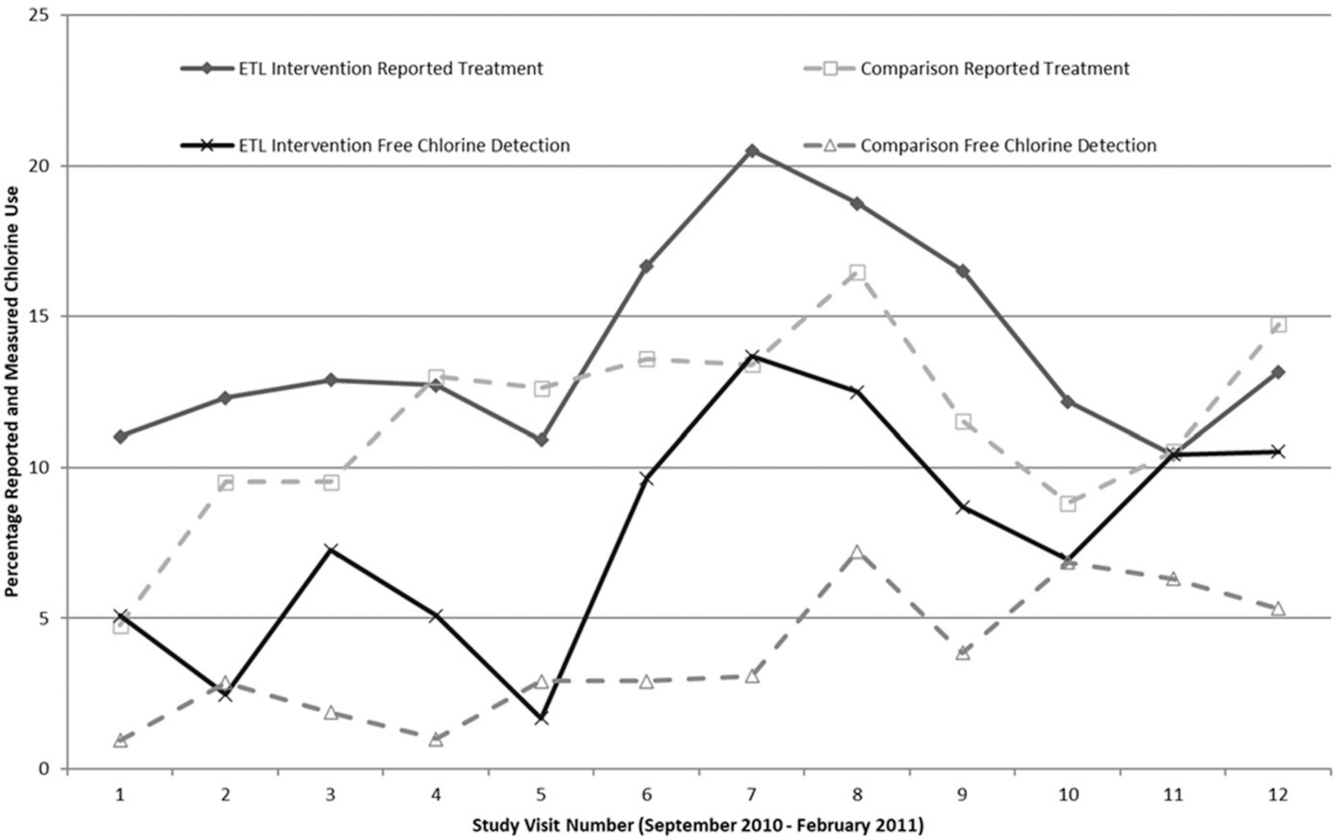

FIGURE 2. Percentage of households reporting water treatment with chlorine and percentage of households with detectable free chlorine in stored water, by treatment group and by home visit, Vihiga district, Kenya, 2010–2011.

evaluation activities. First, deficient implementation of ETL in this study implied that community vendors did not have a strong belief in the potential of ETL to enhance their sales of WaterGuard. Future trials of behavioral interventions could be improved through formative research regarding their acceptability to community vendors before implementation. Evaluations of behavior change approaches could be enhanced by the addition of qualitative research methods to explore reasons for use, or nonuse, of these interventions. Second, use of WaterGuard, a commercially available water treatment product, was low in our study population at baseline and remained low throughout the study, which indicated low demand for the product. Future efforts to increase water treatment behavior could be improved by offering a menu of potential water

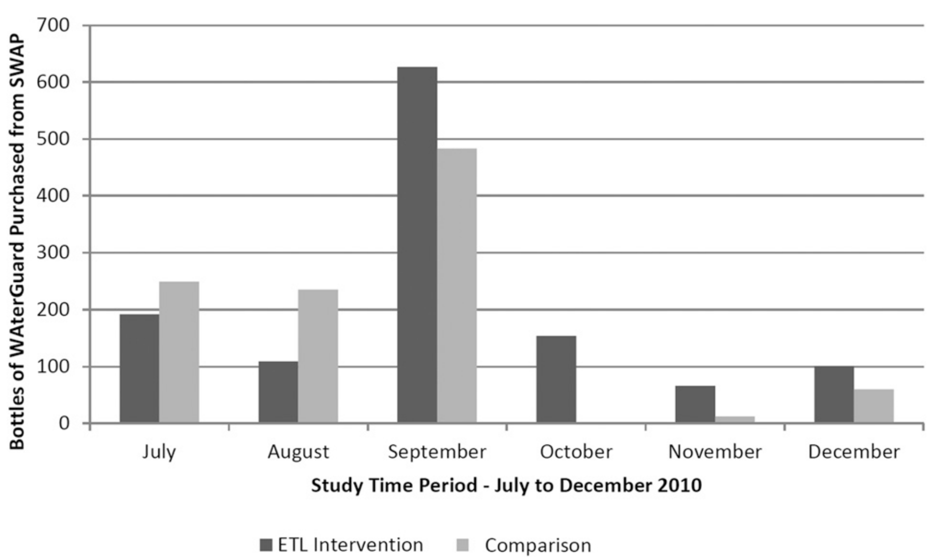

FIGURE 3. Safe Water and AIDS Project (SWAP) reported sales to vendors, by treatment group, in Vihiga district, Kenya, 2010.

treatment technologies, rather than relying on one treatment approach with the attendant risk of low acceptance. Furthermore, the addition of qualitative research methods would enhance understanding of study results involving population behaviors. Third, low levels of WaterGuard use reduced the study's statistical power to detect differences in use between the two study groups. Enrolling a larger population sample in future studies of behavioral interventions would increase the prospects of detecting associations in the event of modest increases in product use. Fourth, the increase in the price of WaterGuard and product stock outs were both unexpected external factors in this study. Although such occurrences are often unavoidable, in future evaluations of commercial products, collaborations with private sector partners should be strengthened to ensure that price and availability of the products remain consistent throughout the study. The need for behavioral interventions in water treatment remains acute, and attention to the aforementioned details could enhance future efforts to develop more effective behavior change approaches.

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