

Making Water Safe: Price, Persuasion, Peers, Promoters, or Product Design?*

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Abstract: Fewer than 10% of households in the Kenyan study area use individually-packaged dilute chlorine solution for home water purification, sold at a retail price of \$0.30 per month, despite years of social marketing. Using a series of randomized evaluations, we find that chlorine take-up is highly sensitive to price, with more than half of households using chlorine when it is delivered free to the home. More intense persuasion efforts had little impact on adoption. There is little evidence that knowing a peer who has used chlorine meaningfully increases adoption. Locally-elected chlorine promoters also boost adoption, and they are effective even when compensated at a flat rate alone rather than via performance bonuses. A new chlorine dispenser technology drastically reduces the cost of chlorination, and is designed to maximize salience, convenience and opportunities for creating social norms favoring use through installation at the source. This leads to a high rate of sustained use (60%) at low cost.

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1 Introduction

Two million children die of preventable diarrheal diseases each year and unsafe drinking water is often to blame (Bryce 2005). Randomized controlled trials have documented that point-of-use chlorination is an effective means of improving water quality and reduces self-reported diarrhea by 20-40%.¹ Yet despite vigorous social marketing campaigns in many areas, take-up remains low under distribution models that rely on households to purchase individually-packaged chlorine.

In this paper, we examine the impact of price, persuasion, peers, promoters, and product design on the take-up of a point-of-use (POU) water treatment technology using a series of randomized evaluations. Consistent with other studies, in our Kenya study region roughly three quarters of households have heard of the local point-of-use chlorine brand (called “WaterGuard”) and roughly 70% volunteer that drinking “dirty” water causes diarrhea, but only 5% of households report that their main drinking water supply is chlorinated as baseline.

We find that higher prices sharply reduce demand for dilute chlorine solution. The majority of households randomly chosen to receive a free supply of dilute chlorine used it to treat their drinking water but most households have a very low willingness to pay for the product, despite its effectiveness at improving water quality and reducing child diarrhea prevalence. We find no evidence that price is an effective screening mechanism to target households who are more likely to benefit from cleaner water. These results are consistent with the steep demand curves for other health technologies recently documented by Kremer and Miguel (2007) and Cohen and Dupas (2008).

Several different persuasion messages delivered by outsiders (similar to NGO sensitization campaigns) have little incremental effect on chlorine take-up when prices are low enough, and have only a moderate and short-lived effect at current retail prices. This is consistent with non-

¹ See Arnold and Colford 2007, Clasen *et al.* 2006, and Fewtrell *et al.* 2005 for reviews of this literature. Schmidt and Cairncross (2009) argue that reported diarrhea measures are problematic because of reporting bias and that more evidence is needed objectively on measured health outcomes.

experimental evidence from this region that several years of intensive social marketing has not generated widespread take-up of POU water products.

We explore informal social learning using exogenous variation in the proportion of a household's social network that had access to a free six-month supply of chlorine, extending the approach used in Kremer and Miguel (2007) by randomizing the number of community members who are exposed to treatment. Individuals whose social contacts received free chlorine are not more likely than others to use the POU product themselves, although there is some evidence that links to community leaders lead to somewhat higher take-up.

Some argue that it is important to charge clients at least something for health-related goods and services, asserting that a positive price is important for financial sustainability, that it will screen out those who will not use the product, or that it may actually lead consumers to place higher value on the product. Another potential rationale for charging is that it could help to address moral hazard among providers or adverse selection between donors and implementing organizations. For example, a retail distribution model might provide a method of incentivizing workers in the product supply chain or allow donors who subsidize goods and services to assess whether they are in fact valued by the target population.

There may be alternative mechanisms for targeting products towards those that need them most and keeping product use at the front of people's minds. We find that one such approach, hiring local community members to promote chlorine use among their neighbors, is effective. These results are similar to those from evaluations of education service delivery in developing countries, suggesting that locally-hired workers paid at low wages can be highly effective (for example, Banerjee *et al.* 2007, Duflo *et al.* 2007, Muralidharan and Sundararaman 2008).

We explore whether paying these workers in a way that links their compensation to chlorine use is necessary and find that incentivizing these promoters by explicitly basing their pay on take-up rates seems to provide only modest additional benefits.

Another approach to product promotion is to redesign the product to make it salient, convenient, and cheap, and to create opportunities for social learning. We developed and tested a community-level chlorine dispenser system that can be installed at water sources (see Figure 1 for a photo). Because the cost of packaging POU chlorine for household use is high relative to the cost of the chemical, we estimate that the long-run cost of supplying a community with bulk chlorine through a dispenser is only about $\frac{1}{4}$ to $\frac{1}{3}$ as much as with individually-packaged bottles. In addition, the dispenser provides a daily physical reminder to households to treat their water at the moment when it is most salient – as water is collected – and maximizes the potential for learning and social network effects by making the dispenser public. The required agitation and wait time for chlorine treated water are at least partially accomplished automatically during the walk home from the source. Overall, point-of-collection dispensers were the most promising of all the strategies we explored to increase chlorine take-up, generating high take-up at low cost. We estimate that the cost per DALY saved by a chlorine dispenser could be less than \$20, extremely cost-effective relative to other public health interventions in less-developed countries.

Ashraf, Berry, and Shapiro (2008) also evaluate the role of price in adoption of point-of-use chlorine using a two-stage randomization of product discounts that disentangles screening effects of higher prices from sunk cost effects, by differentiating the price that a household is willing to pay from the price that they eventually do pay. They find that higher prices help to target households who will actually use the product, and conclude that there is a trade-off between the number of households that will buy chlorine at a subsidized price and the amount of chlorine that will be wasted. However because the product in question is storable, it is difficult to separately identify wastage and storage.

Moreover, in their study higher prices do not effectively target households with young children, the population of most interest from a public health perspective. Direct comparisons between our results and theirs are complicated by the substantial differences in the research environments. In contrast to our rural Kenyan study site, their experiment was conducted in peri-urban Zambia, where current and prior POU usage rates are roughly twice as high as among our household sample.

However, in our study setting it appears that most households chlorinate their water intermittently rather than regularly or not at all, so that at any given point in time whether the current supply of drinking water is treated might not reflect the households' ultimate valuation for chlorine. In a dynamic context, one-time discounts (like those studied in Ashraf et al 2008) do not affect the marginal cost of an additional bottle and thus would not be expected to affect whether or not a household treats their water intermittently or regularly. Moreover, it is not clear that demand during a household sales visit (like those studied in Zambia), in which purchase decisions are under direct observation, would be representative of choices in a more natural context.

Section 2 of this paper describes the study and presents summary statistics. Section 3 discusses the proportion of households who adopt the dilute chlorine technology when it is supplied for free, and shows that valuation appears to be low but that most people use WG when free. Sections 4 and 5 present evidence on the role of persuasion messages and peer effects in the take-up decision. Section 6 documents the effectiveness of electing local promoters of the technology to implement a context-specific persuasion campaign, and shows that high take-up rates can be maintained by providing free chlorine via a dispenser at the source. Section 7 concludes.

2 Rural Water Project (RWP) overview and data

This section describes the setting, the dilute chlorine product, the interventions, the data collection procedures, and baseline characteristics. (A more detailed description of the sampling strategy and randomization into treatment groups can be found in Appendix A.)

2.1 *Setting*

Our study site is located in rural western Kenya. The daily agricultural wage in the area ranges from US\$1 - US\$2 per day depending on the task. Water is typically collected from wells or springs by women and children, who carry between 10 and 20 L of water per trip in plastic jerry-cans. Drinking water is then decanted into a wide-mouthed clay storage pot in the home, which keeps water cool. Water is retrieved from the pot using a dipper, typically a plastic cup without a handle. As a result, water is typically touched during scooping and pouring, which can lead to contamination.

In practice, few households take steps to actively manage water quality. Available methods to improve quality include boiling water prior to consumption and treatment of the water with dilute chlorine. Only one quarter of the households in our sample report boiling water and between 5-10% of sampled households report treating the drinking water currently in their home with chlorine. Half of all households with children under age two report that these young children drink unboiled water (in addition to milk or tea, for example).

2.2 *WaterGuard in Kenya*

Just as chlorine is used to disinfect municipal water supplies in developed countries, it can also be used for decentralized treatment prior to consumption. In combination with safe water storage, household chlorination is an important component of the Safe Water System developed by the U.S. Centers for Disease Control and the Pan American Health Organization over 10 years ago. Even if a

safe storage container is not available, a proper dose of chlorine will protect against recontamination for up to 24 hours.²

Population Services International (PSI), an NGO, markets, distributes, and maintains quality control for dilute chlorine (sodium hypochlorite) solutions in over 20 countries worldwide. The product was introduced in Kenya in 2003, branded as WaterGuard. Each 150 mL bottle is enough to treat 1000 L of water, or approximately a one-month supply of drinking water for a household. It has a shelf-life of 18 months. Instructions are provided on the bottle in Swahili and in pictures: add one capful of the solution to 20 L of water (the standard jerry-can size), agitate briefly, and let sit for 30 minutes before consuming.³ Immediately after treatment, water smells and tastes strongly of chlorine, though this dissipates over time; if dosed appropriately, only a faint smell and taste (similar to tap water in developed countries) remains after a few hours.⁴ Although WaterGuard is promoted as a method for treating drinking water, it can also be used to treat water for washing vegetables, dishes, or clothes or any other household chores that use bleach. WaterGuard is a dilute whereas household bleach is much cheaper per unit of chlorine, so it is unlikely that households would purchase WaterGuard for such purposes, but households who are given the product for free might not use it exclusively for drinking water. The price difference between WaterGuard and household bleach partially reflects the fact that WaterGuard is a much more precise concentration of chlorine, but is mostly due to the cost of the individual packaging.

At the time of our study, one bottle of WaterGuard sold for 20 Kenyan shillings (or US\$0.30), or about a quarter of the agricultural daily wage. This price is already subsidized, as it does not reflect the cost of PSI's extensive multi-year advertising campaign, with ads painted on

² There may be variation in this period of time depending on whether water is stored in ceramic containers or plastic, as recommended by the CDC.

³ Highly turbid water requires a double-dose. Very few households in our area rely on turbid water for drinking.

⁴ The strong odor of the product in the bottle also serves as a deterrent against over dosing, or of children accidentally ingesting WaterGuard directly. The chlorine solution is sufficiently dilute (less than one quarter the strength of household bleach, which many households also have in the home) that even direct consumption does not pose a serious health risk.

buildings and broadcast over the radio. WaterGuard is available in many local shops thanks to PSI's distribution network.

Take-up of WaterGuard is low in the study area. Only 5-10% of households report that their water was chlorinated at baseline. This is despite the fact that roughly 70% of households volunteer "dirty water" as a cause of diarrhea. Although the strong taste of chlorine is often cited as a potential deterrent to use, only around 10% of the households we surveyed volunteered taste as a reason why they chose not to use WaterGuard. According to self-reports, not knowing how to properly treat water prevented approximately as many people from using WaterGuard as taste did, but price was by far the most frequent reason given for non-use, cited by about half of the respondents. No other factors (including forgetting to treat their water, not trusting that WaterGuard was safe to use, or not finding WaterGuard in stock at the local shop, etc.) were commonly listed. PSI's social marketing campaigns have been successful at creating brand recognition: between 70-90% of the households we surveyed were familiar with the product.

2.3 The Two Phases of Project Interventions

The two phases of project interventions were designed to understand the role of prices, persuasion, peers and the product itself on the WaterGuard take-up decision.

The First Phase (2004-2007)

In the first phase of the project, a randomly selected treatment group of households was given seven 150 mL WaterGuard bottles; an improved clay drinking water storage pot with a tap; and detailed instructions on how to use the product as well as its potential benefits. In addition, a random one third of these treatment households were also given 12 coupons for a 50% discount on WaterGuard purchased at a wide range of local shops; in all 17 shops participated in the coupon program. Each coupon was valid for a single month over the following year, clearly indicated on the coupon itself,

starting two months after the initial distribution of free WaterGuard. Because most women attend markets near the specified shops at least once a month, marginal travel costs associated with redeeming coupons was minimal. We gave households wall calendars that labeled coupon expiration dates to remind them about the product.⁵ Coupon redemption was measured at shops, not homes. This data collection strategy allows us to monitor WaterGuard purchases without potentially disruptive survey visits.

Another randomly selected third of the treatment households were chosen to receive additional persuasion messages beyond the basic WaterGuard instructions. This intensive persuasion script administered by enumerators focused on the particular benefits of WaterGuard for children. These two additional interventions – the year worth of coupons, and the persuasion messages – were independently randomly assigned, so a small group of households (73) received both coupons and intensive persuasion.

To induce exogenous variation in WaterGuard exposure to estimate social network effects, the free distribution of WaterGuard was implemented as either a “low-intensity” local treatment (in which two of eight sample households in a spring community were randomly chosen to receive free WaterGuard) or a “high-intensity” local treatment (six of the eight sample households received WaterGuard). Since springs were divided equally between the two treatment intensities, in total half of the household sample received free WaterGuard.

Finally, the WaterGuard intervention was cross-cut with a randomization of spring communities into a spring protection treatment as described in Kremer *et al.* (2009a). This factorial design allows us to compare the relative cost-effectiveness of source water quality improvements

⁵ In this area of rural Kenya, there are very few decorations in people’s homes aside from the occasional poster or calendar. As such, we expect that the calendars were a very visible reminder of the coupons and would have been displayed by all who received them. Similarly, households have few important documents other than health cards, and it is very unlikely that coupons would have gotten lost among other papers in the home. We cannot rule out the possibility that households lost their coupons or forgot about them rather than actively choosing not to redeem them, but this in itself is an indication of their valuation for WaterGuard.

versus point-of-use water treatment within the same sample of households, as well as investigate whether these two technologies substitute for or complement one another. We briefly consider these relationships in this paper, but explore them in more detail in other work.

The timing of the intervention and data collection for the first phase of the research is summarized in Panel A of Figure 2. Free WaterGuard was distributed during the third survey round, and the follow-up survey round was collected between 2-7 months later. Data on coupon redemptions from shop-keepers continued to be collected until the expiry date for all coupons had passed, one year later.

The Second Phase (2007-2008)

In the second phase of the research, we compare the effect of six different treatments designed to increase WaterGuard take-up among another distinct household sample, using data from a baseline survey and two follow-up surveys as summarized in Panel B of Figure 2. The first follow-up survey was conducted approximately 3 weeks after the baseline in order to measure short-run take-up rates with the second follow-up occurring between 3-6 months after baseline (the medium-run follow-up).

The first three treatments in this second research phase were variants of a persuasion campaign in which promotional messages were delivered at either the household level or community level, or both (treatments 1A, 1B, and 1C, respectively). The marketing scripts used in this intervention were developed in extensive piloting intended to expose and document existing models of water, health, and preventive care (see Mullainathan, Schwartzstein, and Shleifer 2006). Based on this process, we developed specific messages targeted to mothers, emphasizing the importance of preventing illness and taking control over protecting one's drinking water from the many potential sources of contamination, rather than being reliant on

others to take care of a communal water source or feeling discouraged that children in the home are likely to contaminate the water. Households who were randomly chosen to be exposed to the persuasion scripts did not receive any price reductions but rather were simply encouraged to purchase WaterGuard from their local shop.⁶

The next two treatment arms extended the persuasion campaign from the one-time visit by the survey enumerators to repeated reminders delivered by a member of their own community. This local “promoter” was elected by the community to encourage neighbors to use WaterGuard. In these communities, the 20 households randomly selected to participate in the study at baseline were each given a single coupon valid for one free bottle of WaterGuard that they could redeem at a local shop. These coupons were clearly marked with the expiration date, which was three weeks after the day they were distributed. Enumerators explained what WaterGuard is and how to use it.

We experimented with two different compensation schemes for the promoters.⁷ Compensation schemes were not announced until after the community meeting when promoters were elected, so we measure the treatment, not selection, effect of different compensation schemes. Payments were framed as compensation for six month’s of effort but promoters were aware that they would not be paid again after the medium-run follow-up even if this was before the end of the 6 month period. In a random half of the promoter communities, the promoter was paid a flat fee of 450 Ksh (US\$6.43) per follow-up visit for his or her efforts (treatment 2A). In the other half of the promoter communities, payment was based on the number of positive chlorine tests at the sample households in follow-up visits (treatment 2B). These “incentivized” promoters received a flat fee of 100 Ksh (US\$1.43) per follow-up visit plus 20 Ksh (US\$0.29)

⁶ Levine and Luoto (2009) examine related issues of how marketing scripts affect POU water product take-up in a nearby area of western Kenya.

⁷

per positive chlorine test.⁸ The payment per positive test was calibrated to equate the two payment systems at a take-up rate of 70%, on the basis of pilot results. Both flat-fee and incentivized promoters were informed that all households who had been included in the baseline survey would be revisited at follow-up and that several other community members would also be surveyed at that time in order to motivate the promoters to encourage all members of the community to use WaterGuard (see below for further details). The daily agricultural wage for men in this area is between \$1 to 2, so flat-fee promoters received the equivalent of at least one day of work per month during the study, which is an arguably generous income supplement considering that promoters had all agreed to serve their communities in a volunteer capacity.

The final treatment arm (treatment 3) combined the incentivized promoter model with an unlimited supply of free WaterGuard delivered through a point-of-collection chlorine dispenser installed at the spring. At the community meeting when the dispenser was introduced to the community, all spring users were encouraged to use the dispenser (e.g., turn the knob to see how chlorine is dispensed, etc.), so in this treatment arm the price reductions were not limited to households selected for the baseline survey. The dispenser has several technical advantages relative to in-home treatment with WaterGuard, as previously described.

To summarize this phase of the research, the baseline visit for all households, including those in the comparison group, consisted of a short survey of household characteristics and a basic description of how and why to use WaterGuard for point-of-use water treatment. At all but the comparison and community-script-only households (treatments 0 and 1B), the survey enumerator also read a more extensive WaterGuard marketing script and, depending on the treatment arm, a detailed explanation of how to redeem coupons or use the dispenser.

⁸ If the target number of 25 households could not be reached on a follow-up visit, the promoter was paid on the fraction of tests with positive results, normalized to be equivalent to 25 tests.

Community meetings were held later in the same week at all but the comparison springs. At these meetings, enumerators read a marketing script for WaterGuard that was targeted at the community as a whole and, depending on the treatment arm, promoters were elected and/or use of the dispenser was demonstrated. Immediately after these meetings, an enumerator met with the promoter to collect basic demographic information, explain household-level marketing, suggest ways that the promoter could encourage households to redeem coupons or use the dispenser, and explain the payment scheme.

The first follow-up survey visit was conducted approximately three weeks after the baseline visit, so that households who had been given coupons were still likely to be using their free bottles of WaterGuard. The second follow-up (medium-run) survey visit was conducted three to six months after the baseline visit, when the free bottles of WaterGuard were expected to be exhausted.⁹ Household drinking water was sampled for chlorine residual at both follow-up visits if the household reported that their drinking water was treated. Payments to promoters in treatments 2 and 3 were disbursed by the enumerators after all chlorine tests in the community had been completed.

In addition to the households who had been sampled at baseline, during the first follow-up enumerators surveyed approximately five new households per spring community (randomly selected from the community census as described in Appendix A); these same households were also surveyed during the medium-run follow-up. These households were incorporated into the sample in order to assess the extent to which promoters were targeting their efforts more intensively to sampled households than to the community more broadly.

⁹ Due to political violence in Kenya which disrupted field activities, the elapsed time between the baseline survey and medium-run follow-up survey was approximately twice as long for the first third of sampled households than it was for the remainder of the sample. Survey wave fixed effects are included in all regressions below, and these capture overall differences due to these delays.

2.4 *Data collection procedures*

We measure chlorine use in household drinking water in two ways: 1) respondent self-reports of whether or not the drinking water supply had been treated with WaterGuard or any other chlorine product, and 2) an objective test for the level of total chlorine residual present in the water.¹⁰ The former likely overestimates the proportion of households who had actually chlorinated their water because of courtesy or social desirability bias, whereas the latter likely underestimates the proportion of households who had actually chlorinated their water because chlorine levels decline over time. As previously discussed, most people do know that there are links between drinking water and child health and have been exposed to the idea of home water treatment. Even if they are not using the chlorine treatment product, they likely understand that they “should” use it. They are probably especially likely to report use to representatives of an NGO that has previously provided this and other health technologies in their community. Social desirability bias also almost certainly varies according to the type of intervention a subject has been exposed to (e.g., free product or persuasion messages), in ways that are difficult to predict *ex ante*. Because of these concerns, our preferred measure of chlorine take-up is the actual presence of chlorine in drinking water (based on an objective field chemical test), despite some concerns that this data is subject to downward bias because of false negatives as a result of chlorine decay (see Appendix A). Taken together, the two measures can plausibly be considered upper and lower bounds on actual chlorine usage.

In the first phase of the research, an extensive household survey gathered baseline information about hygiene knowledge and behaviors (hand washing), household water collection, and socioeconomic status; source and household water samples were also tested for *E. coli*, an indicator bacteria common in fecal matter. In the second phase of the research an abbreviated household survey elicited household demographics and chlorine use patterns. In both

¹⁰ In both phases of the research, we have one more survey round of data on self-reported chlorine use than we do for positive chlorine tests.

cases, the target survey respondent was the mother of the youngest child living in the home compound (where extended families often co-reside), or another woman with childcare responsibilities if the mother of the youngest child was unavailable. In addition to the household survey data, we have data on coupon redemptions from shop-keepers' records that allow us to directly track which household redeemed coupons and in which months they did so. (Further details on the data collection protocols are provided in Appendix B.)

2.5 *Baseline descriptive statistics*

Table 1 presents baseline summary statistics for the first phase of the research using data from the first survey round for households (Panel A) and the survey round in which free WaterGuard was distributed for children under age three (Panel B). Table 2 provides the equivalent information for the sample used in the second phase of the research. In general, the randomizations in both cases created treatment groups that were for the most part statistically indistinguishable from the comparison households. Moreover, the two household samples resemble each other quite closely, as would be expected since they were geographically integrated. Average mother's education is six years, which is less than primary school completion. Water and sanitation access is fairly high compared to many other less developed countries as over 80% of households report having a latrine, and the average walking distance (one-way) to the closest local water source is approximately eight minutes. While few households in either research phase report chlorinating their drinking water, roughly a third have used WaterGuard at some point in the past and the majority of households have heard of WaterGuard.

Though there are a few statistically significant differences between treatment and comparison groups in Tables 1 and 2, there are no more than would be expected from random chance – 8 of 88

coefficient estimates in Tables 1 and 2 are significantly different than zero at over 90% confidence – and most are small in magnitude from an economic perspective (as in the case of soap in the home).¹¹

3 Impact of distributing free WaterGuard

This section discusses the estimation strategy we use throughout the rest of the analysis and presents the impacts of free WaterGuard distribution on take-up. Impacts of treatment on comparison households, as mediated by social networks, are discussed in Section 4. Thus, results presented in this section understate the effect of the treatment to the extent that comparison households were also affected. In this section we also document that the intervention was successful at significantly improving water quality. Finally, we show that households who are willing to use the POU product when it is provided for free, nonetheless have very low willingness to pay for WaterGuard.

3.1 Estimation strategy

Equation 1 illustrates an intention-to-treat (ITT) estimator using linear regression.

$$W_{it} = \alpha_t + \delta_i + \beta_1 T_{it} + (T_{it} * X_i)' \beta_2 + \varepsilon_{it} \quad (1)$$

W_{it} is the chlorine use measure for household i at time t ($t \in \{2, 3, 4\}$ for the three survey rounds in which we have self-reported chlorination or $t \in \{3, 4\}$ for the two survey rounds with chlorine tests) and T_{it} is a treatment indicator that takes on a value of one after the free WaterGuard intervention was implemented. Random assignment to treatment implies that β_1 is an unbiased estimate of the reduced-form ITT effect of WaterGuard receipt (as opposed to use). The interaction of treatment status with baseline household characteristics X_i allows for differential treatment effects as a function of these characteristics, captured in the vector β_2 . We also allow for potential complementarity or substitution patterns between POU chlorination and the source water quality

¹¹ One difference between treatment and comparison households during the first phase of the research is potentially of concern. Young children in households that received the free WaterGuard supply were significantly more likely to have diarrhea in the past week than children in comparison households (22% vs. 18%, respectively, significant at 95% confidence). We have searched for explanations for this difference and have concluded that there is no reason to believe it is due to anything other than chance. However, because of this baseline difference, we do not emphasize child diarrhea impacts of WaterGuard in this paper; details available upon request.

improvement from spring protection. Survey round fixed effects α_i are included to control for time-varying factors affecting all households. Regression disturbance terms ε_{it} are clustered at the spring level in these regressions, since households using the same spring could have correlated outcomes: they share common water sources and the local sanitation environment, and may have kinship ties.

3.2 *WaterGuard take-up*

At the unannounced follow-up household visit two to seven months following WaterGuard receipt, most households (79%) that received free WaterGuard reported that their current supply of drinking water was treated and more than half (58%) had detectable levels of chlorine in their drinking water. Factoring in baseline take-up rates and time trends, we estimate the effect of the intervention to be a 69 percentage point increase in self-reported chlorination and a 52 percentage point increase in validated chlorination in a regression (Table 3, columns 1 A and B). These are huge effects relative to baseline self-reported and validated chlorination rates of just 6% and 2%, respectively. Households who rely on unprotected springs for their water are no more likely to report using WaterGuard than those whose springs were randomly selected to be protected. We see no evidence that either measure of take-up is related to pre-intervention source water quality (column 2) or other household characteristics, aside from whether the household boiled drinking water pre-intervention (column 3). Households with more children, or more sick children, at the time of the intervention are no more likely to have detectable levels of chlorine in their water at follow-up.

Over 99% of treatment households report using at least some of the WaterGuard provided, and on average treatment households used slightly less than one bottle per month in the period since WaterGuard was distributed. Because the quantity of WaterGuard required for consistent chlorination depends on the number of household members, and whether or not chlorinated water is reserved for drinking alone or consumption by children exclusively, it is hard to say exactly how many households report having used an appropriate amount of their free WaterGuard supply. We

estimate that roughly half of the treatment households were chlorinating consistently and appropriately based on the number of bottles they report using and the elapsed time between the intervention and follow-up. This is comparable to the 58% of treatment households who have detectable levels of chlorine in the water when tested at follow-up. While our follow-up survey instrument did not explicitly ask treatment households if they had any remaining free supply of WaterGuard, it appears that most of the take-up we observe is the free WaterGuard we distributed rather than purchased WaterGuard. Few households accounted for the full supply of seven bottles when asked what they had done with them at follow-up, and the presence of chlorine in the water is not significantly higher among households whose follow-up visit occurred less than three months after the intervention or among those with more than two bottles remaining at follow-up (not shown).

However, lack of information regarding the health benefits of using WaterGuard does not seem a plausible explanation since 82% of respondents at baseline volunteered at least one valid health-related benefit of WaterGuard. Overall, households had very favorable pre-existing impressions of the product, with over 95% of respondents who were familiar WaterGuard saying that they thought a typical adult in their area would use WaterGuard if it was received as a gift and a similar percentage saying that they thought local households would use it during a cholera epidemic.¹²

3.3 Effects on water quality and water source choice

Distributing free WaterGuard drastically reduced both the fraction of households whose water did not meet U.S. EPA drinking standards and the average contamination level (Table 4). Households who

¹² One other factor that could have influenced take-up rates relates to the improved water storage containers that were distributed with the free WaterGuard. Some of these clay pots were poorly manufactured and leaked. Largely as a result of these problems, 30% of households who received pots report not using them. Because households who were given WaterGuard were specifically instructed that it would be most effective if used in the improved containers, when the new pots failed, some households may have decided not to use the WaterGuard. Indeed, both self-reported and validated take-up rates are significantly lower among households who specifically complained about their pot being broken relative to those who did not. Had this aspect of the intervention not been so problematic, perhaps take-up rates would have been even higher.

received a free supply of WaterGuard were approximately half as likely as comparison households to have water contaminated with any *E. Coli* (column 1). Using a continuous measure of *E. Coli*, the 1.37 log point reduction achieved with free distribution of WaterGuard (column 2) corresponds to a 75% reduction in fecal contamination.

While the availability of WaterGuard could presumably change the treatment households' choices of where and how much water to collect and how to store it, we see very little evidence that these behaviors are either substitutes for or complements of the WaterGuard technology (results available upon request). There is a slight and marginally significant reduction in water collection trips among free WaterGuard treatment households (roughly 10% of trips, significant at 90% confidence), but they do not switch to new water sources, nor whether or not they send children to collect water, or whether or not they drink from the spring in their community.

3.4 Willingness-to-pay for WaterGuard

Take up of point-of-use chlorine is highly sensitive to price. In Figure 3, we plot the proportion of households who use the product at the three prices faced by sample households: zero Ksh per bottle for treatment households at the follow-up survey, 10 Ksh for the subset of treatment households given the 12 months of coupons, and the 20 Ksh market price for comparison households (and treatment households prior to the intervention). As discussed above, demand is high at a price of zero using either self-reported use or positive chlorine test results, but drops off precipitously at even the low price of 10 Ksh per bottle.¹³ An increase in the price from 10 to 20 Ksh barely affects demand.

Our results from this aspect of the intervention differ from those of Ashraf *et al.* (2008) who find much higher willingness to pay for a product like WaterGuard. In a door-to-door marketing study of a dilute chlorine solution in Lusaka, Zambia, around 70% of sampled households chose to

¹³ The low coupon redemption rate among households who had just received a free supply also implies that a lack of familiarity with the product is not the only impediment to product adoption.

purchase when offered a 50% discount off the retail price.¹⁴ However, our results are consistent with Ashraf *et al.* along a different, but important, dimension: as shown in Panel B of Table 4, we find no evidence that households with young children, who stand to benefit more from the product, have a higher willingness to pay. Such households are no more likely to use the free supply, and there is suggestive evidence that higher prices might even disproportionately discourage use among these households (based on the percentage of coupons redeemed in column 2 and self-reported use in column 4A). Instead, a household's awareness about the link between contaminated water and diarrhea seems to be a more important correlate of willingness to pay, as shown in Panel C. This discrepancy between households who could benefit from WaterGuard and those who are willing to pay more suggests charging more will not help target chlorine in ways that maximize health benefit.¹⁵

Looking more closely at the details of who redeemed coupons and when, we find that less than a third of the 227 households who were given coupons redeemed any of them (recall that each household was given a set of 12 coupons, for roughly a year's supply) and on average among households who redeemed at least one coupon, only four coupons were redeemed. Overall, only 10% of the coupons distributed with free WaterGuard were redeemed. Figure 4 plots the distribution of coupon redemption over time and documents that households redeemed coupons intermittently, rather than consistently. Fewer than 15% of households redeemed the first two coupons that were valid, and several households let six months of coupons expire before redeeming their first or second coupon.¹⁶

¹⁴ In their urban setting, the presence of chlorine in the water likely overstates POU take-up since most households depend on municipal water sources that are sometimes chlorinated. For instance, only half of the Ashraf et al 2008 households with chlorine in their drinking water at baseline claimed they had personally treated it with chlorine.

¹⁵ The correlation between households who have children under age 3 and those who volunteered "dirty water" as a cause of diarrhea at baseline is below 0.05 for the free WaterGuard households and retail price households, and below 0.15 for the coupon sample.

¹⁶ While we cannot precisely separate out the effects of price versus the psychic costs of remembering to redeem a coupon, a related ongoing project run through health clinics in Kenya finds that mothers given 12 coupons for *free*

We inquired during the follow-up survey about reasons for not using the coupons, letting the respondent volunteer as many reasons as she wanted to. By far the most common explanation, given by over 80% of households who said they had not yet used a coupon, was that they still had WaterGuard from the free supply remaining, consistent with rationing and intermittent use.¹⁷ Such evidence is inconsistent with the claim of Ashraf et al. (2008) that rationing is limited because chlorine is used for other “off label” activities (e.g., toilet cleaning).

There was only a minimal increase in coupon redemptions as supplies of free WaterGuard were used up, but this was countered by generally declining redemption as time elapsed since coupons distribution, shown by the overall downward trend in Figure 4. Around half of the coupon redemptions occurred between 4 and 7 months after distribution, roughly at the same time as the follow-up survey. It is possible, though purely speculative, that the follow-up visits served as implicit reminders to households that they could redeem their coupons, but this faded from mind over time.

4 Intensive persuasion interventions

Both phases of the research featured treatments in which households received intensive persuasion efforts, though these differed on the basis of whether or not they were paired with a price discount for WaterGuard. Table 5 shows that additional persuasive messages had no effect on either measure of take-up among households who received the free supply of WaterGuard.

However, as shown in Figure 5 and Panel B of Table 6, among households who were not given any sort of price discount, intensive social marketing can boost take-up of WaterGuard purchased through the retail system, though the effect is short-lived. Relative to the comparison households in the second phase of the research, community-level promotion scripts (treatments

WaterGuard in local shops have a much higher redemption rate than we find here, with over 40% of households who were given coupons redeeming them 8 months into the program in that sample, although the redemption rate also fell during the course of that program. (see Dupas et al 2009).

¹⁷ There were almost no cases of self-reported gift-giving of coupons, in contrast to gifts of the free WaterGuard itself, which were quite common (almost half the households who were given free WaterGuard reported giving at least one bottle away). No personal identification was necessary to redeem a coupon at a shop, so in principle they were fungible, though some households may not have realized this.

1B and 1C) roughly tripled take-up rates at the three week follow-up for both measures of take-up, albeit from a low base in comparison households. Evidence on the effectiveness of a household-level script (treatment 1A) is not as strong, with no effect on take-up based on positive chlorine tests; it is quite plausible that such marketing would directly affect social desirability bias, causing over-reporting of chlorination relative to the comparison households and leading to the discrepancy between the self-reported and verified chlorine use. Yet none of the promotion scripts had any significant effect on take-up at the medium-run follow-up 3-6 months after exposure. Considering the short-run nature of the effects and the high cost of marketing during one-on-one conversations during household visits, or even through community-level meetings, such strategies do not appear to hold much promise as cost-effective means of promoting POU chlorine take-up at scale.

5 Social networks and the diffusion of WaterGuard

In this section, we document that while giving away WaterGuard led local households to engage in more discussion about the product, this did not actually translate into significant peer effects on product take-up. We collected data on a household's social ties with all seven other households surveyed in the same community, for a total of $(8 \text{ respondents}) \times (7 \text{ other households}) \times (2 \text{ directions of a social link, } i \text{ to } j \text{ and } j \text{ to } i) = 112 \text{ relationship pairs per community}$.

5.1 Characterizing social networks

The spring communities in rural western Kenya are quite ethnically homogenous, with three-quarters of all respondent pairs saying that they are members of the same tribe.¹⁸ Though different tribes have different mother tongues, communication barriers do not appear consequential – we find that conversation frequency is similar among individuals in the same versus different tribes – most likely due to widespread fluency in Swahili. The majority (59%) of respondent pairs share a family bond,

¹⁸ In our data, household i 's stated relationship to j and j 's stated relationship to i constitute two "relationship pairs".

the most common of which are mother in-law/daughter in-law (around 20% of relationships) and sisters in-law (around 25%), a reflection of the social institutions in this area that lead young women to move into their husbands' communities upon marriage, and the fact that our survey protocol interviews the mother of the youngest child in the compound or, if she was unavailable, another woman. Aside from relatives, another common relationships is "neighbors", accounting for 35% of non-family relationships.

We categorize a relationship as "close" if the respondent reports talking to their social link at least two to three times per week. These communities are quite close-knit, with another local household being "unknown" only 14% of the time, and 60% of relationships being "close" as defined above. Thus, the average household identifies roughly 4 of the 7 other local households as close contacts. There are very few households who have no close contacts among the local sample households (just 3% of households are "isolated" in this way) or who have only one close contact (10%). Pre-intervention the average household had 1.8 close connections to households that became part of the free WaterGuard treatment group, or roughly half of all close links (as expected given the randomization), and only 20% of households had no close connections to the eventual free WaterGuard treatment group.¹⁹

5.2 *Changes in conversation patterns*

Using detailed data on conversation frequency and topics collected in the second and fourth survey rounds (of the first phase of the research), we find strong evidence that the distribution of free WaterGuard promoted conversations about the product as well as about drinking water more generally and, to a lesser degree, child health (Table 7). In particular, conversations about WaterGuard were roughly three times more likely to occur if the respondent was a member a

¹⁹ Aspects of network structure could also be relevant determinants of spillover effects but we do not explicitly consider such characteristics in this paper. A related working paper explores the possibility that households discount redundant information received through dense social networks, but he fails to find robust patterns using our data and network definitions (see Casaburi 2008).

treatment household and slightly more than twice as likely if the other household in a relationship pair was in the treatment group (columns 1 and 2), with these increases occurring as both more frequent conversations as well as the probability that two households had ever had a conversation about WaterGuard.²⁰ Conversations about drinking water were also significantly more likely to be reported if either member of the conversation pair was from a treatment household (columns 3 and 4). There was a smaller but statistically significant increase in the probability that a respondent in the WaterGuard treatment group had ever spoken with other households about child health (columns 5 and 6), suggesting that these households at least partially internalized messages about the connection between water and children’s health that were delivered as part of the intervention.

We do not observe significant interactions between the respondent’s treatment status and the paired household’s status in any of these specifications, nor do we find evidence that any additional conversations led to a meaningful increase in the closeness of relationships between study households (results not shown).

5.3 Social network effects on WaterGuard take-up

Although the distribution of free WaterGuard prompted more conversations about the product, the evidence is consistent with the hypothesis of weak social network effects on actual use, with larger impacts on social desirability bias. Our estimating equation for peer effects is similar to Equation 1 from Section 3.1, with the difference being that we now introduce a second “treatment” term P_{it} which is equal to a measure of peer WaterGuard exposure after product distribution ($t=4$) and zero prior to the intervention ($t \in \{2, 3\}$). Using the same notation as before with the addition of the peer “treatment” variable P_{it} , our estimating equation for social network effects is

$$W_{it} = \alpha_i + \delta_i + \beta_1 T_{it} + \beta_2 P_{it} + \beta_3 (T_{it} * P_{it}) + \varepsilon_{it} \quad (2)$$

²⁰ Importantly, while courtesy bias could certainly be inflating the effects of being in the treatment group, since treatment households might feel compelled to tell the enumerator that they discussed the topics of the intervention with other people, the coefficient on the treatment indicator for the non-respondent in the pair is less likely to suffer from such bias.

We begin by testing whether households at high-intensity treatment springs were more likely to use WaterGuard (Table 8 column 1; P_{i4} equal to an indicator variable for whether or not household i lives at a high-intensity spring) and then test whether the proportion of treated links has any effect on take-up (column 2; P_{i4} equal to the proportion of household i 's close contacts who received free WaterGuard), always controlling for the household's own treatment status.²¹

The comparison of our two chlorine use outcome measures – self-reported versus objectively tested – indicated that the intervention appears to have affected social desirability bias more than actual chlorine use. We find statistically and economically significant effects of peer exposure on self-reported chlorination but point estimates that are much smaller and not generally statistically significant using positive chlorine tests in home drinking water. Using the self-reported measure, comparison households at high-intensity springs are over twice as likely to use WaterGuard than those at low-intensity springs (Table 8 column 1); the effect magnitude is similar if all of a comparison household's close contacts received free WaterGuard (column 2).²² Note that all of the reported social network effects are driven by comparison households; we fail to reject the null hypothesis of no effect for households that received free WaterGuard themselves (the sum of the coefficient estimates on the network variable and the interaction with one's own treatment status, $\beta_2 + \beta_3$, cannot be distinguished from zero). These estimates may in fact be upward biased if treatment households share some of their free supply.

²¹ In the proportion specification, the baseline total number of close contracts in our sample interacted with a post-intervention indicator is also included as a control variable to account for the fact that more sociable people may more readily adopt new technologies. Likewise, we also include a indicator for households who have no close contacts interacted with a post-intervention indicator to allow for the possibility that non-sociable people might be more or less likely to adopt new technologies.

²² We also tested for the effects of distant contacts (those the respondent is acquainted with, but with whom the respondent reports talking once a week or less) and second-degree contacts (close friends of the respondent's close friends, not including her own close friends). We find no effect of either of these types of contacts on the basis of either measure of take-up after controlling for close contacts.

There is some evidence that certain types of community members are particularly influential in encouraging the use of WaterGuard by their social contacts.²³ For these specifications, we modify Equation 2 to include the proportions of certain types of close contacts who received free WaterGuard in the post-intervention period, the vector Π_{it} .²⁴

$$W_{it} = \alpha_t + \delta_i + \beta_1 T_{it} + \beta_2 P_{it} + \beta_3 \Pi_{it} + \varepsilon_{it} \quad (3)$$

Relationships with households who received free WaterGuard and are members of the same tribe as the respondent appear to be especially important in the take-up decision (column 3). Since tribe determines mother-tongue, this would be consistent with conversation being an important means by which information about the product diffuses. While we do not see major differences in conversation frequency between households who are or are not members of the same tribe, it is certainly possible that the nature of these conversations differs, making it easier for information to flow between members of the same tribe.

Self-identified community leaders also play a special role (column 4), as seems natural since they have displayed a willingness to participate in community improvement in some other sphere as well.²⁵ Importantly, the social network effects do not stem from sociable people per se, but rather specifically from those who serve their community (results not shown).

6 Promoters and point-of-collection chlorine dispensers

The results discussed so far have shown that 1) most households are willing to use WaterGuard when it is provided for free but take-up is very sensitive to price increases, 2) intensive door-to-door social

²³ In addition to those described below, we also tested for the effects of relationships with households who received WaterGuard and were family members, those with whom the respondent had previously discussed WaterGuard, those who are socially well-connected (listed as a close contact by more than the median number of other households at the spring), and those who reported an outbreak of cholera occurring in their community in the past two years, but we find no additional effect from any of these social relationships.

²⁴ As in the basic proportions specifications, we include interactions of a post-intervention indicator and the total number of close contacts (both all close contacts and those of a certain type) and indicators for no close contacts (both all and of a certain type).

²⁵ Includes self-identified leaders of women's groups, farmer/agricultural groups, water group/well committee, credit/savings/insurance groups, prayer or bible study groups, burial committees, and school committees or clubs.

marketing can be effective at increasing take-up even without price discounts but these effects are moderate in magnitude and short-lived, and 3) there are small peer effects on using validated chlorine in water with individually marketed WaterGuard, although some evidence that relationships with community leaders can boost take-up. In this section, we show that locally-elected promoters can also spur WaterGuard take-up. We then show that chlorine dispensers at water sources are a promising technology for reaching high take-up rates that are plausibly sustainable at scale.

The fraction of households with residual chlorine in their water was approximately ten times as high in communities with a local promoter relative to comparison households in the short-run 3 week follow-up survey, at 40% roughly versus 4%, respectively (Figure 5, Table 6 Panel C). Although self-reported chlorination was significantly higher in communities with a dispenser, at the short-run follow-up there was no statistically significant difference in take-up based on positive chlorine tests between the promoter communities versus those with a dispenser;. Eighty-six percent of households who were given a coupon for a free bottle of WaterGuard said they had redeemed it, and 97% of these households reported using it. While take-up fell somewhat at the medium-run (3-6 month) follow-up as used up their free bottle, communities with promoters but not dispensers (treatments 2A and 2B) were nonetheless able to sustain high adoption rates between 30-35 percentage points higher than the comparison group take-up rate of 8% . In communities with dispensers (treatment 3) take-up rates increased significantly on the basis of positive chlorine tests at the second follow-up, ultimately reaching over 60% of the sampled households (53 percentage points higher than the comparison group).

Interestingly, there are no significant differences in take-up based on how promoters with coupons were compensated (flat fee versus incentivized) in communities where coupons were distributed. Most incentivized promoters were ultimately paid less than their flat fee counterparts as shown in Table 9, despite the fact that incentivized promoters received between

\$2 to 8 per follow-up, with an average payment of \$4.27, while none of the incentivized promoters earned more over the course of the study than the flat fee payment of \$12.86.

We now turn to take-up in the households who were added to the follow-up survey sample as a way to gauge whether the incentivized promoters were targeting their efforts at households whose water they knew would be tested rather than encouraging the whole community to use WaterGuard. Because these non-baseline households did not receive coupons for WaterGuard, take-up rates are clearly lower (Table 10). We also have data on whether or not the household said they had been encouraged to use WaterGuard by the promoter. Although both flat-fee and incentivized promoters in communities where coupons were distributed (treatments 2A and 2B) seem to have focused their attention on baseline households leading up to the short-run follow-up as shown in columns 2 and 5 of Table 10, the difference in encouragement rates between non-baseline and baseline households is much more pronounced for flat-fee promoters than it is for incentivized promoters. This is consistent with the possibility that incentivized promoters might have tried harder to convince everyone in the community to use WaterGuard, even if they were unable to overcome the price barrier for non-baseline households who did not have coupons for a free bottle.

Yet in communities with incentivized promoters and dispensers (treatment 3), encouragement rates are not significantly different depending on whether or not households were sampled at baseline, perhaps because the dispenser technology serves as a highly visible conversation piece even in the absence of direct promotion activities. More importantly, take-up rates (based on positive chlorine tests) are not significantly different between non-baseline and baseline households at the short-run follow-up in dispenser communities. Clearly the fact that chlorine from the dispenser is free is an important factor. Taken together, this provides

suggestive evidence that promoters are not critical to achieving high chlorine take-up through dispensers, although further work is needed to more rigorously establish this claim.

By the medium-run follow-up (3-6 months later), the gaps in both promoter encouragement rates and chlorine take-up between the non-baseline and baseline survey households were closing in communities where coupons were distributed. Incentivized promoters (treatments 2B and 3) again appear to achieve better outcomes than flat-fee promoters (treatment 2A) although statistical precision is such that we cannot draw firm conclusions. One possibility is that it took promoters longer than three weeks to reach all community members with a promotion message, but by the second follow-up few gaps remained between different groups of households. Alternatively, promoters may have targeted their efforts to the baseline non-targeted households once they were surveyed in the 3 week follow-up, suspecting (correctly, as it turned out) that they would be re-surveyed in the next follow-up. Unfortunately we cannot distinguish between these two explanations, and both could be true to some extent.²⁶

Discussion

Promoters were clearly effective at convincing other community members to use WaterGuard on a regular basis. Even if they strategically focused their promotion efforts on households they knew would be visited by the research team at follow-up, the 20-25 households to be surveyed comprised a large share of the local community (and in some cases, the entire community).

While the research design does not allow us to precisely identify the particular channels through

²⁶Positive test results on the day of a survey might not be representative of every day usage patterns, particularly when there is a financial incentive to inflate take-up rates. Follow-up survey visits were unannounced, but promoters, particularly those on the incentivized pay scheme, could have rushed to chlorinate the water supplies of as many households as possible as soon as enumerators arrived in the community. We see no evidence to support this hypothesis, however, since the levels of chlorine residual present in household water samples in promoter communities are not disproportionately high, as they would be shortly after water has been treated (not shown).

which local promoters were much more effective than one-time intensive social marketing scripts delivered by a survey enumerator, there are several reasonable possibilities, including the higher frequency of promoter messages, and the fact that promoters are community members, with greater local knowledge, trust and social influence than NGO outsiders.

Recall that the promoters were elected by their communities and initially agreed to serve without considering compensation. This may explain why the compensation system seemed to play a relatively small role in determining promoters' success at increasing take-up rates of WaterGuard. In any case, there is scope for further research on what makes local promoters effective and whether they require any compensation at all (monetary or otherwise) to assess whether this model is a viable strategy for increasing long-run take-up. If promoters are only needed long enough to establish new household habits and local social norms, even paid temporary promoters could be a worthwhile investment.

Our results on the effects of promoters are consistent with several other recent studies that have documented that household POU take-up is responsive to increased scrutiny by others, in some cases even when the extra attention is not intended to change behavior. Kremer *et al.* (2009b) find that households who were randomly selected to be surveyed about diarrhea prevalence on a bi-weekly basis were between two and three times as likely to have chlorine residual in their water relative to households who were surveyed once every six months, despite the fact that there was no explicit messaging advocating WaterGuard use during the survey visits. Not far geographically from our Kenyan study site, Garrett *et al.* (2008) were able to verify residual chlorine in the stored water of 43% of study households after an intervention in which community health workers promoted

household water treatment (but did not offer the product at a discount).²⁷ Data for that study were also conducted during weekly visits by interviewers who asked about diarrhea prevalence.

Finally, note that medium-run take-up of free WaterGuard, provided via a dispenser in the second phase of the research and as a six-month supply of individually-packaged bottles in the first phase, are remarkably similar as shown in Figure 6. Yet the comparison between take-up of the free bottles of WG in phase one and of free chlorine from a dispenser is an apples and oranges comparison, since the enumerator visit in phase one itself plausibly affects take-up and such visits are expensive. Based on current evidence we believe that the high take up with dispensers is not due solely to price, although more data will be needed to determine this. Although non-baseline households appear to have a slightly lower take-up rate at first glance, upon closer inspection the difference on the basis of positive tests is relatively small (self-reported use accounts for most of the discrepancy).²⁸ Household visits of the sort that were part of the baseline surveys in both phases of the research are expensive and cannot be part of a viable strategy to increase take-up at scale in a sustainable way. Dispensers, on the other hand, are much cheaper and equally effective (at least when combined with a local promoter, even among households who were not targeted for social marketing by a third party).

Preliminary cost estimates based on the documented health benefits of WaterGuard and our best approximation of the cost of bulk chlorine provision suggest that the cost of each dispenser system could be as low as \$0.15 per person per year, including the hardware

²⁷ Community health workers also promoted safe water storage containers like those distributed in our intervention, as well as latrines, shallow wells, and rainwater harvesting.

²⁸ The fact that the gap between self-reported use and positive chlorine tests is much larger for households in the first phase of the research and those surveyed at baseline of the second phase relative to the non-baseline households in the second phase is consistent with courtesy bias being more pronounced for households who had been engaged in a conversation with a survey enumerator about the need to treat water (non-baseline households might have heard such messages from the local promoter or the survey staff at a community meeting, but had not been in a direct conversation with an enumerator the way baseline and first-phase treatment households had).

installation cost of the dispenser (which is expected to last five years) and chlorine delivery.²⁹ The cost per DALY saved, assuming all diarrheal morbidity and mortality is in children under age three, could be under \$20, even if the system is only one-half as effective at scale as it was during the course of this initial research. This is well below the common benchmark for cost-effective health interventions in developing countries of \$100/DALY (World Bank 1993). Because we cannot be certain of the relationship between cases of diarrhea and deaths averted, we might also want approach the question from the other direction and estimate the mortality impact necessary for dispensers to meet the cost-effective benchmark of \$100 / DALY. Using this approach and regional statistics from the 2003 Kenya Demographic and Health Survey, we find that even a 0.02% reduction in mortality would be needed to meet the standard cost-effectiveness target of \$100 / DALY (calculations available upon request).

7 Conclusion

We examine the role of price, persuasion, peers, promoters, and product design in households' demand for chlorine as a point-of-use water treatment technology, using a series of randomized evaluations that generated exogenous variation in each of these factors. We find that price is extremely important for Kenyan households, whereas even intensive person-to-person persuasion campaigns have only a modest and short-lived effect. There is little evidence for large peer effects with individually packaged chlorine, although community leaders may have a moderate positive impact on take-up. Local promoters and a new chlorine dispenser technology both generate higher take-up.

The provision of a free supply of chlorine increased the households who treat their drinking water from under 5% to over 60% based on an objectively measured chlorine residual, but even a 50% discount off the retail price was not enough to convince most households to buy the product,

²⁹ The authors thank Vivian Hoffman for these cost-effectiveness estimates.

and we find no evidence that positive prices serve as an effective means of targeting those households most vulnerable to diarrhea, those with small children. Intensive social marketing by an NGO at household visits and community meetings had only a modest and short-lived effect on take-up rates and would be extremely expensive to implement on a larger scale.

Local chlorine promoters were effective at boosting take-up, even after households' free trial supplies of chlorine ran out. Basing promoters' pay on take-up rates did not make a difference in their effectiveness relative to promoters who were paid a flat fee.

The highest take-up rates were achieved in communities that were provided with an unlimited supply of chlorine via a point-of-collection dispenser (in combination with a local promoter). Take-up rates actually increased over time in these communities and were similar to the much more expensive delivery of individually-packaged free chlorine directly to households. These point-of-collection chlorine dispensers have a number of attractive features, including drastically cutting the cost of chlorine by reducing packaging, and facilitating social network effects by making the chlorine treatment decision public. The combination of high initial take-up levels and the upward trend in our data over up to six months leads us to be most optimistic about this particular strategy for increasing chlorine take-up as a sustainable alternative to the current status quo of individually-packaged point-of-use chlorine distributed through retail channels.

While the potential for chlorine dispensers appears great, important questions remain. We plan to conduct a major health study in collaboration with Professor Fabian Esamai, Dean of the School of Medicine at Moi University, that will investigate the long-term health benefits of chlorine dispensers using objective measures such as anthropometrics. In addition to quantifying health effects of chlorine dispensers, we also plan to test alternate strategies for scaling up the technology. Part of chlorine dispensers' appeal is greatly reducing the effort required to achieve home water treatment, but the trade-off is the need for a mechanism that ensures a consistent supply of chlorine over time. In the pilot study of chlorine dispensers we discuss in this paper, the dispenser

infrastructure and chlorine refills were provided free of charge by an NGO with high institutional capacity for monitoring operation. In future research, we will address the crucial question of how to design distribution chains for chlorine refills that set up the right incentives for suppliers while keeping costs low.

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Appendix A: Sample selection and randomization procedures

The current study is one component of a larger project, called the Rural Water Project (RWP), which also examines source water quality improvements and water quantity-related interventions, and which may provide guidance on priorities in the rural water sector. The first sample of households analyzed in this paper were initially identified for another aspect of the RWP, which was concerned with estimating the impacts of spring protection infrastructure. Spring protection seals off the source of a spring and reduces source water contamination from exposure to the environment. Randomization of households into the initial WaterGuard intervention was cross-cut with randomization of their communities (defined by the spring from which they collect their water) into the spring protection intervention. Panel A of Figure 2 summarizes the randomization process and the timing of survey activities for this phase of the research.

As discussed in Kremer, Miguel, Leino, and Zwane (2008), the household sample used in the first phase of the research is representative of users at each source and was constructed according to the following procedure, which we developed to address the fact that there were no administrative records in this rural area that would have identified all households that use a given spring. Instead, survey enumerators interviewed users at each spring, asking their names as well as the names of other household users. Enumerators elicited additional information on spring users from the three to four households located nearest to the spring. Households that were named at least twice among all interviewed subjects were designated as “spring users”. The number of household spring users varied from eight to 59 with a mean of 31. Seven to eight households per spring were then selected (using a computer random number generator) from this spring user list for the household sample used in this paper. In subsequent surveys, over 98% of this spring users sample was later found to actually use the spring at least sometimes, but the few baseline non-user households were nonetheless retained in the analysis.

The spring user list is representative of all households living near sample springs. In a census of all households living within roughly a 20 minute walk at nine sample springs, nearly three quarters of these nearby households were included on the original spring users lists, with even higher rates for those households located within a 10 minute walk of the sample spring. A description of the spring selection and randomization procedures is provided in Kremer *et al.* (2009).

Panel B of Figure 2 summarizes how springs and households were randomized into the various treatment arms in the second phase of the research and documents the timing of the data collection process. Springs were first randomly assigned to each of the five community-level treatments described above (using a computer random number generator). Prior to the baseline visit, an enumerator visited each spring community and asked two community leaders to compile a list of all compounds located near enough to the spring to be able to use it as a water source if they so chose. On the day of the baseline visit, enumerators began by cross-checking these two lists to identify duplicates. Once the list of compounds had been finalized, a random sample for the survey was selected in the field using schedules produced by the research team (with a computer random number generator) that picked compounds based on their position in the list (schedules were stored in sealed envelopes until the list was finalized). This same procedure was used to randomize households into the household script treatment at springs in the control and community script treatment arms.

To address concerns about seasonal variation in water quality and disease burden, all springs were stratified geographically and randomly assigned to an activity “wave,” and all project activities were conducted by wave (three waves in the first phase of the research and two waves in the second phase).

Appendix B: Measuring chlorination, diarrhea, water quality, hygiene knowledge, and social networks

Chlorination

During the second through fourth survey rounds, all households were asked whether the water in their primary drinking water storage container was treated with WaterGuard or any other chlorine products, the basis for our measure of self-reported take-up. In addition, during the third and fourth survey rounds, among respondents who reported treating the drinking water currently in their storage pot, a sample was taken to test for the presence of chlorine residual. The water was tested for total chlorine levels using Pocket Colorimeter II handheld devices, produced by Hach Company, using the following protocol: A 10 mL bottle was rinsed twice with the sample water, and re-filled. The blank was used to reset the machine to zero on the low-range measurement scale and then the contents of one DPD Total Chlorine sachet were added to the sample and agitated gently for 20 seconds. The enumerator recorded the color (clear, light pink, pink) and the sample was then loaded into the machine. After 5 minutes the numeric reading was taken. We test for total chlorine rather than free chlorine, which is the subset of total chlorine that actually disinfects the water, since the primary outcome in this study is take-up. The procedure is equivalent to USEPA Standard Method 4500-CL G for drinking water.³⁰ The test provides an instantaneous visual confirmation of whether chlorine is present in water; if a sample contains chlorine, the reagent causes the water to turn a shade of pink, with darker colors proportional to higher concentrations of chlorine. In addition, after a short delay, a numeric estimate of the mg/L of chlorine present in the water is produced by the colorimeter. Bi-monthly quality-control checks ensured consistency across the set of colorimeters and each colorimeter's internal consistency was also periodically confirmed.

Depending on the elapsed time since treatment and the characteristics of the storage container, the level of residual chlorine in the water can vary drastically. Experiments conducted in favorable controlled conditions using actual WaterGuard and clay storage containers similar to the type used by the majority of households in our study suggest that residual chlorine may no longer be detectable as few as 12 hours after treatment with WaterGuard following the manufacturer's directions. Details of these experiments are available upon request. Other studies have also noted similar problems with measurement of chlorine in such circumstances (Ogutu *et al.* 2001 and Lantagne forthcoming). Since we are interested in whether or not the water was *ever* treated with chlorine, rather than the current concentration in the water, we use a definition of take-up that is based on the lowest concentration chlorine (.1 mg/L with pink color) that could not plausibly be a false positive and acknowledge that this cut-off likely leads to false negatives in many cases, given that two-thirds of the respondents who said their water was treated had added chlorine more than 12 hours prior and were using clay storage pots.

Water quality

Water samples were collected in sterile bottles by field staff trained in aseptic sampling techniques. At springs, the protocol was as follows. The cap of a 250 ml bottle is removed aseptically. Samples are taken from the middle of standing water and the bottle is dragged through the water so the sample is taken from several locations at unprotected springs, while bottles are filled from the water outflow pipe at protected springs. About one inch of space is left at the top of full bottles. The cap is replaced aseptically. In homes, following informed consent procedures, respondents are asked to bring a sample from their main drinking water storage container (usually a clay pot). The water is poured into a sterile 250 ml bottle using a household's own dipper (often a plastic cup).

Samples were then packed in coolers with ice and transported to water testing laboratories for same-day analysis. A substantial fraction of water samples were held for longer than six hours, the recommended holding time limit of the U.S. EPA, but baseline water quality measures are balanced across treatment and comparison groups when attention is restricted to those water samples incubated within six hours of collection, yielding the most reliable estimates (results not shown). Extended holding time increases the noise in the *E. Coli* estimate, but there is no definitive direction of bias as bacteria both grow and die prior to incubation.

The labs use IDEXX Colilert, a method which provides an easy-to-use, error-resistant test for *E. Coli*, an indicator bacteria present in fecal matter. Our lab procedures were adapted from EPA Colilert Quantitray 2000 Standard Operating Procedures. A continuous quantitative measure of fecal contamination is available after 18-24 hours of incubation. *E. Coli* MPN CFU measurements provided by Colilert can take values from <1 to >2419. In the analysis, we treat values of <1 as one and values of >2419 as 2419, although in practice, there are very few censored observations. We categorize water samples with *E. Coli* CFU/100 ml ≤ 1 as “high quality” those with counts between 1 and 126 “moderate quality” those and with counts > 126 as “poor quality”. For reference, the U.S. EPA and WHO standard for clean drinking water is zero *E. Coli* CFU/100 ml, and the EPA standard for swimming/recreational water is less than 126.)

Quality control procedures used to ensure the validity of the water testing procedures included weekly positive and negative controls, and duplicate samples (blind to the analyst), as well as monthly inter-laboratory controls. There are several potential sources of measurement error. First, Colilert generates a “most probable number” of *E. Coli* Coliform forming units (CFU) per 100 ml in a given sample, with an estimated 95% confidence interval. Second, samples that are held for more than six hours prior to incubation may be vulnerable to some bacterial re-growth/death, making tested samples less representative of the original source. Third, sampling variation is an issue given the small size of the collection bottle (at 250 ml).

It is common to use *E. Coli* to quantify microbacteriological water contamination in semi-arid regions like our study site. The bacteria *E. Coli* is not itself necessarily a pathogen, but testing for specific pathogens is costly and can be difficult. Dose-response functions for *E. Coli* have been estimated for gastroenteritis following swimming in fresh water (Kay *et al.* 1994), but such functions are location-specific because fecal pathogen loads vary over space and time. In a district near our study site, a U.S. Centers for Disease Control study finds that the most common bacterial pathogens are Shigella and non-typhoidal Salmonella.

Hygiene knowledge and behaviors

A baseline “diarrhea prevention knowledge score”, was constructed based on the number of correct responses to an unprompted question on methods to prevent diarrhea; provided. The set of plausible answers include “boil drinking water”, “eat clean/protected/washed food”, “drink only clean water”, “use latrine”, “cook food fully”, “do not eat spoiled food”, “wash hands”, “have good hygiene”, “medication”, or “clean dishes/utensils”. Hygiene behavior was explored by measuring contamination of people’s hands. To measure fingertip contamination, respondents pressed their hands into KF Streptococcal media (agar plates), and the lab isolated *fecal streptococci* bacteria colonies. Fingertip contamination was measured in only one round of follow-up data collection, so the reported coefficient gives the difference between the treatment and comparison groups rather than the difference-in-difference estimate.

Social network data

In the survey round prior to the WaterGuard intervention, we collected data on each household's relationship to every other sample household living at their spring. Respondents volunteered the nature of their relationship with each of the other survey respondents (e.g. neighbors, familial relationships, community settings in which they primarily interact), as well as whether or not they share the same mother tongue, and how frequently they spoke with the other household in general and on the specific topics of children's health problems, drinking water, and WaterGuard. This social networks module of the questionnaire was repeated in the survey round following the WaterGuard intervention. For the last 40% of the follow-up surveys, additional questions asked whether or not the respondent had received a gift of WaterGuard from the other household or made a gift to them, allowing us to directly observe some of the sharing occurring within the spring community.

Figure 1: The chlorine dispenser



Notes: The dispenser is installed immediately next to a communal water source and delivers a dose of dilute chlorine sufficient to treat 10 liters of water with each turn of the knob (most households in this area use 20 liter jerrycans to transport water and thus require two turns of the knob; children sometimes use the smaller 10 liter jerrycan, however). Pictorial instructions are prominently displayed on the roof of the dispenser, which protects the chlorine storage tank inside from the elements. The dispenser holds one liter of dilute chlorine solution, enough to treat 6660 liters of drinking water or a three-week supply for a community of 80 people drinking three liters per day.

Figure 2: Study timeline

Panel A: Phase 1, Distribution of free WaterGuard and coupons, 2004-2007

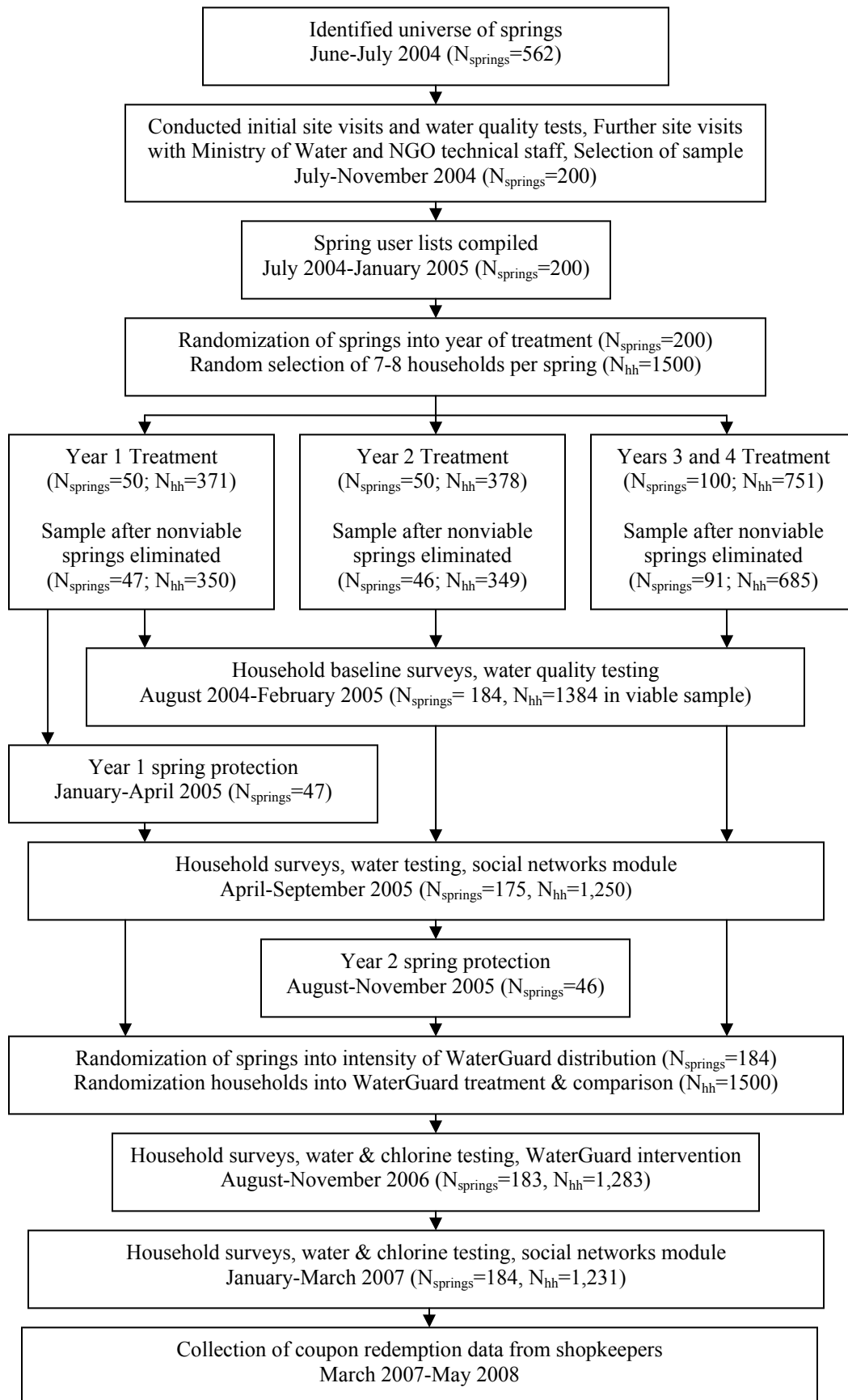


Figure 2: Study timeline
 Panel B: Phase 2, Alternative strategies to promote take-up, 2007-2008

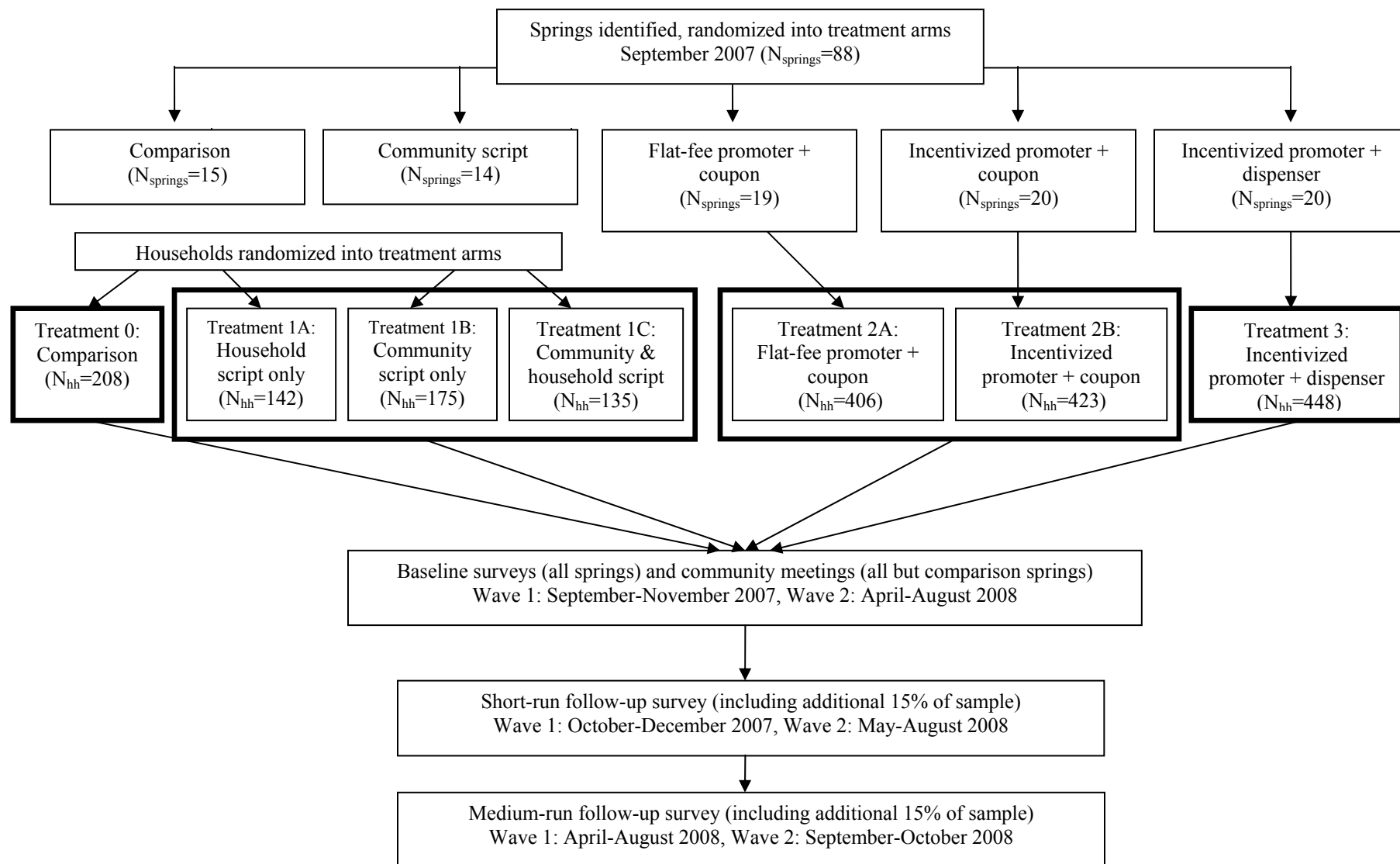
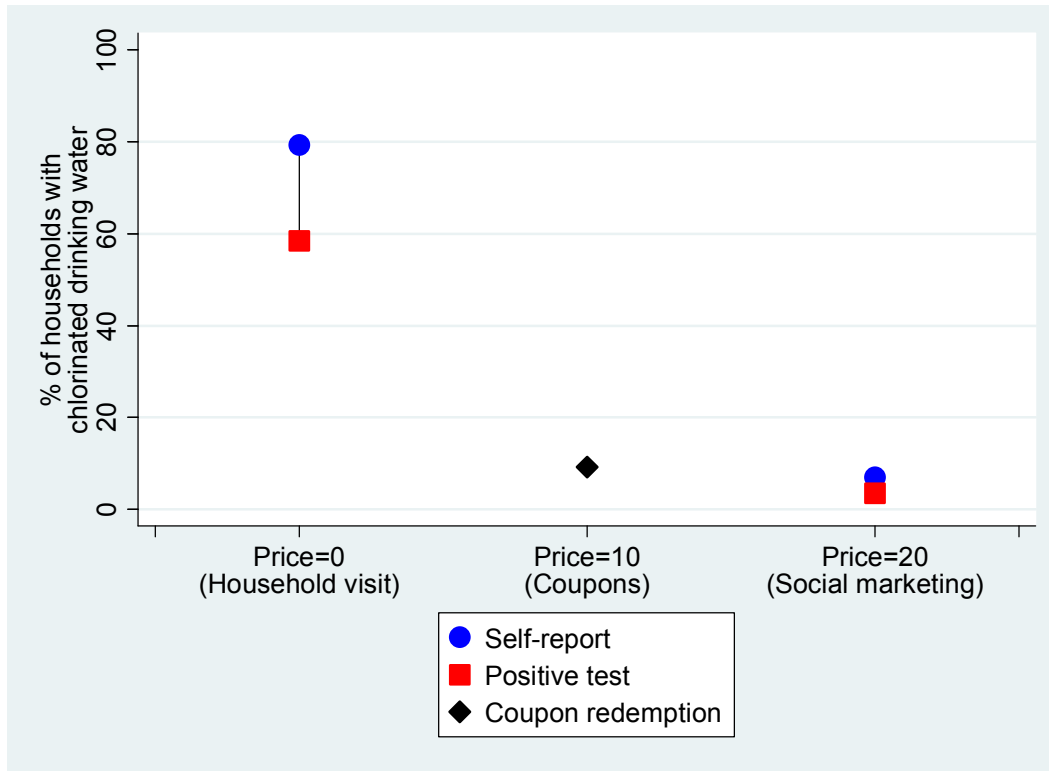
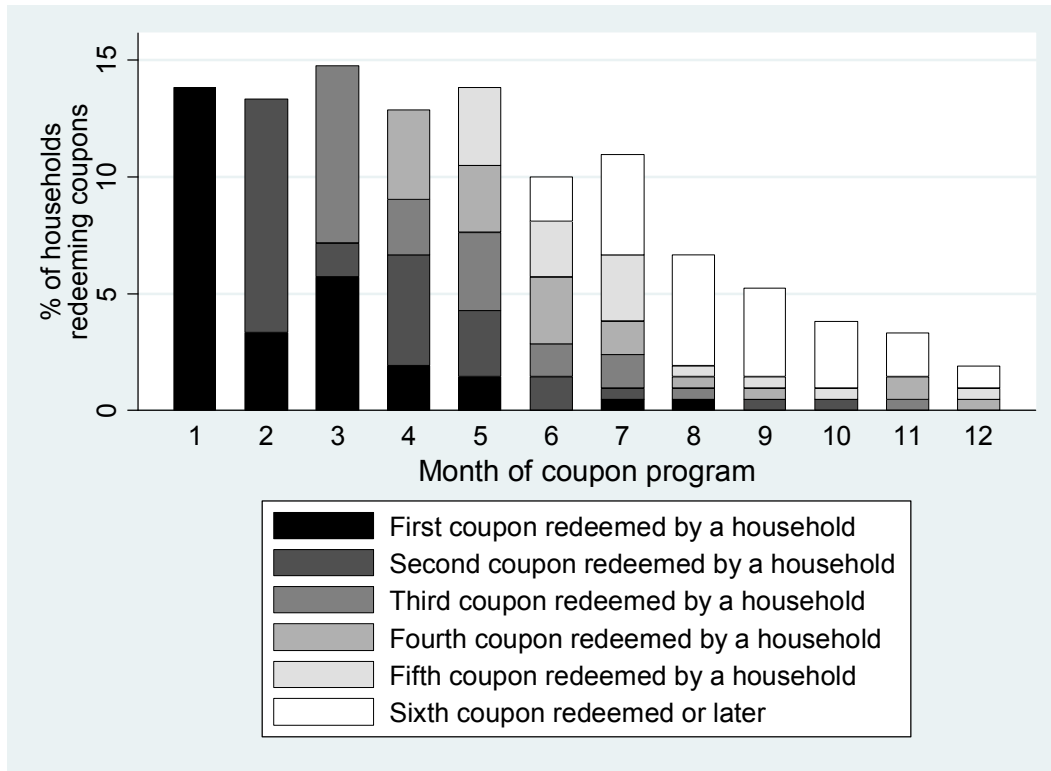


Figure 3: Demand for WaterGuard



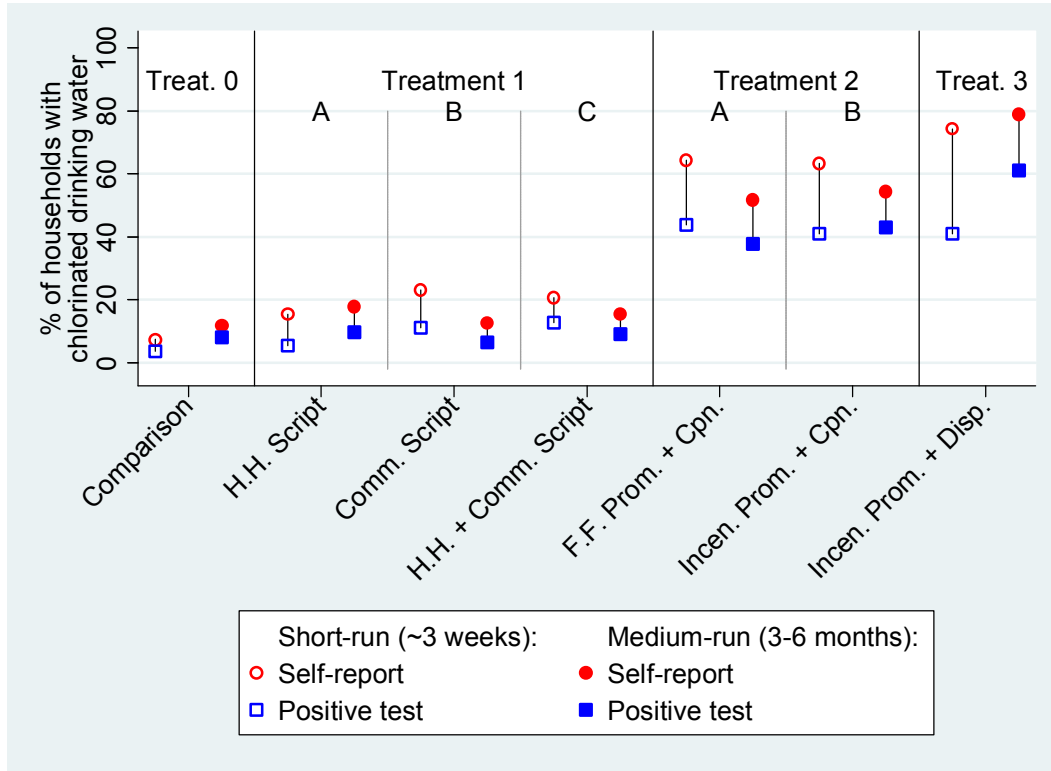
Notes: A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. Data for price = zero are from treatment households in the follow-up survey (n = 628 for self-reports and 627 for test results). Data for price = 10 are from coupons for discounted WaterGuard distributed to subset of treatment households at the time of the intervention (n = 2520; 210 households with 12 coupons each). Coupon redemption data are from shopkeepers' records. Data for price = 20 are from all households prior to the intervention and control households after the intervention (n = 3194 for self-reports and 1942 for test results).

Figure 4: Coupon redemption rates over time



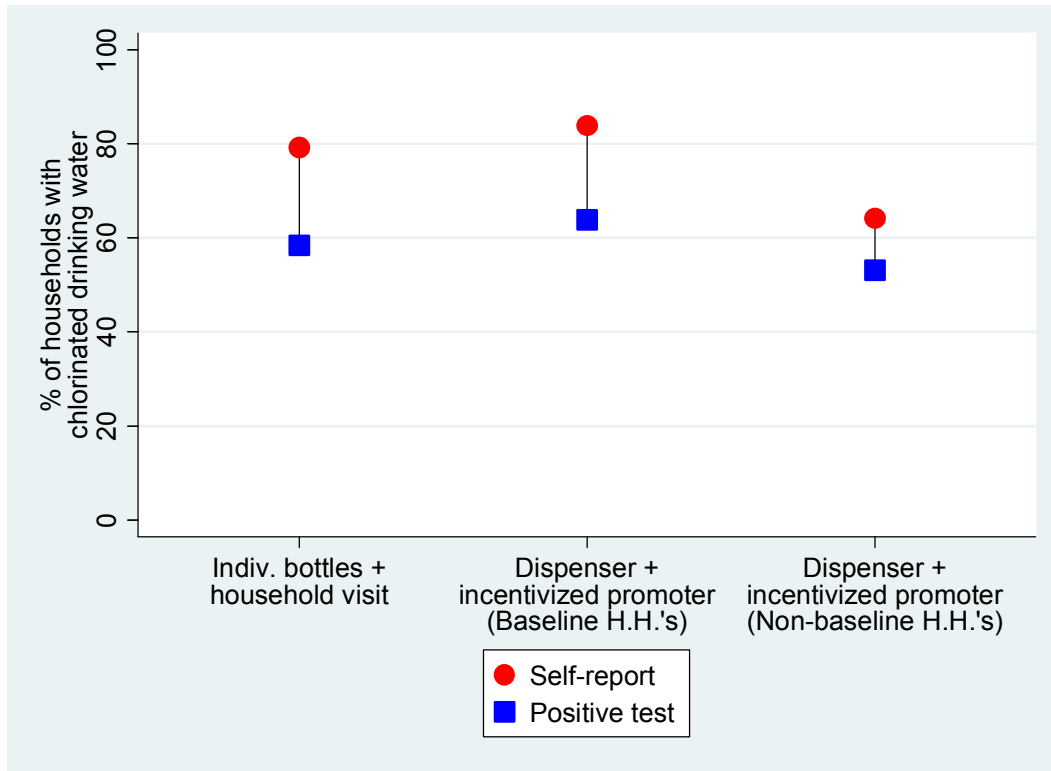
Notes: Data from shop-keepers records. 210 households who received free WaterGuard were also given a set of 12 coupons for 50% off the retail price of WaterGuard purchased at local shops. One coupon expired each month starting two months after the distribution of free WaterGuard and coupons. If all households had redeemed all of their coupons, the histogram would show 12 bars each with a height of 100% and in a new shade of gray; in actuality no more than 15% of households redeemed a coupon in a single month and some households did not redeem their first coupon until eight months into the coupon program. Both the percent of households redeeming any coupon in a given month (the full height of the bars) and the percent of households who redeemed all of their coupons (the new shade at the top of each bar) are steadily falling through the course of the program.

Figure 5: Alternative strategies to promote take-up



Notes: Bands depicted in graph above are not confidence intervals, but rather reflect an upper and lower bound measure of take-up (self-reported chlorination and positive chlorine tests, respectively). A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. See section 2.2 for a full description of the treatment arms: 0=Comparison (no intervention), 1A=Household persuasion script, 1B=Community persuasion script, 1C=Both household and community persuasion scripts, 2A=Flat-fee promoter plus one coupon for free WaterGuard per surveyed household, 2B=Incentivized promoter plus one coupon for free WaterGuard per surveyed household, 3=Incentivized promoter plus unlimited supply of free chlorine via a point-of-collection dispenser.

Figure 6: Take-up of free WaterGuard



Notes: Bands depicted in graph above are not confidence intervals, but rather reflect an upper and lower bound measure of take-up (self-reported chlorination and positive chlorine tests, respectively). A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. Data on individual bottles plus a household visit come from the follow-up visit during the first phase of the research (2-7 months after free WaterGuard was distributed). Data on dispensers plus promoters come from the medium-run follow-up during the second phase of the research (3-6 months after dispensers were installed). Non-baseline were randomly selected from among the non-surveyed households in the community to be added to the sample in the short-run follow-up and did not receive the same promotional messages from the survey enumerators. Households in the first phase of the research and baseline households from the second phase received similar promotional messages delivered by the survey enumerators as part of the interventions.

Table 1: Baseline descriptive statistics, distribution of free WaterGuard and coupons

	Household received WaterGuard		Comparison		WaterGuard – Comparison
	<i>Mean</i> (<i>s.d.</i>)	<i>Obs.</i>	<i>Mean</i> (<i>s.d.</i>)	<i>Obs.</i>	(<i>s.e.</i>)
<i>Panel A: Household summary statistics</i>					
Household's "assigned" spring protected by IPA ^(a)	0.50 (0.50)	670	0.50 (0.50)	664	0.00 (0.04)
Ln. <i>E. Coli</i> MPN (CFU/ 100 ml)	3.24 (2.17)	668	3.22 (2.17)	659	0.02 (0.12)
Water is high quality (<i>E. Coli</i> MPN ≤ 1)	0.14 (0.34)	668	0.14 (0.35)	659	0.00 (0.02)
Water is high or moderate quality (<i>E. Coli</i> MPN <100)	0.73 (0.44)	668	0.75 (0.43)	659	-0.02 (0.02)
Water is poor quality (<i>E. Coli</i> MPN 100-1000)	0.20 (0.40)	668	0.18 (0.38)	659	0.03 (0.02)
Water is very poor quality (<i>E. Coli</i> ≥ 1000)	0.07 (0.25)	668	0.07 (0.26)	659	-0.01 (0.01)
Walking distance to closest water source (minutes)	8.62 (8.01)	664	8.12 (7.46)	659	0.50 (0.40)
Respondent years of education	5.66 (3.62)	667	5.71 (3.61)	663	-0.06 (0.20)
Children under age 12 in the compound	4.05 (2.42)	670	4.03 (2.54)	664	0.02 (0.14)
Children under age 3 in the compound	1.43 (1.39)	670	1.41 (1.28)	664	0.02 (0.08)
Iron roof indicator	0.70 (0.46)	648	0.70 (0.46)	640	0.00 (0.03)
Household has a pit latrine	0.86 (0.35)	669	0.87 (0.34)	662	-0.01 (0.02)
Respondent reported cholera in community in past 2 years ^(a)	0.14 (0.34)	673	0.09 (0.29)	645	0.04 (0.02)**
Water in the home treated with WaterGuard, self-report ^(b)	0.08 (0.27)	610	0.07 (0.25)	610	0.01 (0.02)
Respondent had ever used WaterGuard ^(b)	0.30 (0.02)	614	0.27 (0.02)	608	0.03 (0.03)
Respondent had heard of WaterGuard ^(b)	0.73 (0.44)	614	0.73 (0.44)	610	0.00 (0.03)
Yesterday's drinking water was boiled indicator	0.25 (0.43)	668	0.29 (0.45)	656	-0.04 (0.03)
Respondent diarrhea prevention knowledge score	3.06 (2.09)	670	3.22 (2.25)	664	-0.17 (0.13)
Respondent said "dirty water" causes diarrhea	0.68 (0.47)	670	0.68 (0.47)	664	0.00 (0.03)
Household has soap in the home	0.92 (0.27)	669	0.89 (0.31)	663	0.03 (0.02)*
Respondent's number of close contacts ^{(b), (c)}	4.06 (1.90)	611	3.87 (1.96)	612	0.20 (0.12)*
Number of close contacts to respondent ^(b)	3.59 (0.06)	681	3.49 (0.06)	691	0.10 (0.11)

Notes: In the final column, Huber-White robust standard errors are presented (clustered at the spring level when using household or child level data), significantly different than zero at * 90% ** 95% *** 99% confidence.

Household data are from the 2004 survey, except where noted. Child-level data are from the 2006 survey and are restricted to those age 3 and under.

Household survey respondent is the mother of the youngest child in the compound (or the youngest adult woman available).

(a): At the time of the WaterGuard intervention in the third (2006) survey round.

(b): Because of changes in survey design, responses to these questions are not available for the first (2004) round of data collection and are instead taken from the second (2005) round.

(c): Close contacts are defined as households with whom the respondent reports talking 2-3 times per week or more.

(d): Diarrhea is defined as three or more “looser than normal” stools per day.

(e): Using the first available diarrhea data for children age 3 and under in survey round 3 (2006).

Table 2: Baseline descriptive statistics, alternative strategies to promote take-up

	Comparison	Treatment Arm:					
		1A	1B	1C	2A	2B	3
		Household Script Only	Community Script Only	Household + Community Script	Flat Fee Promoter + Coupon	Incentivized Promoter + Coupon	Incentivized Promoter + Dispenser
	Mean, (s.d.)	Treatment – Comparison, (s.e.)					
<i>Panel A: Household summary statistics</i>							
	<i>N</i> =137	<i>N</i> =118	<i>N</i> =115	<i>N</i> =120	<i>N</i> =341	<i>N</i> =337	<i>N</i> =334
Respondent years of education	5.30 (3.41)	-0.020 (0.356)	0.109 (0.441)	0.126 (0.420)	0.527 (0.396)	0.243 (0.381)	0.361 (0.390)
Children under age 5 in the compound	1.95 (1.61)	-0.008 (0.205)	-0.036 (0.160)	0.076 (0.180)	0.069 (0.148)	-0.021 (0.164)	-0.200 (0.140)
Iron roof indicator	0.438 (0.498)	0.045 (0.052)	0.151 (0.081)*	0.104 (0.078)	0.041 (0.059)	0.098 (0.066)	0.109 (0.058)*
Household has a pit latrine	0.832 (0.375)	0.015 (0.049)	0.044 (0.056)	0.008 (0.051)	0.032 (0.047)	-0.008 (0.048)	0.045 (0.045)
Water in the home treated with any chlorine, self-report	0.073 (0.261)	0.004 (0.025)	0.051 (0.035)	0.071 (0.043)*	0.045 (0.036)	0.011 (0.030)	-0.004 (0.028)
Water in the home treated with WaterGuard, self-report	0.058 (0.235)	0.001 (0.020)	0.039 (0.032)	0.042 (0.034)	0.033 (0.031)	0.001 (0.029)	0.002 (0.028)
Respondent had ever used WaterGuard	0.292 (0.456)	0.055 (0.040)	0.097 (0.068)	0.078 (0.065)	0.093 (0.054)*	0.021 (0.051)	0.049 (0.049)
Respondent had heard of WaterGuard	0.891 (0.313)	-0.018 (0.023)	0.039 (0.030)	0.000 (0.036)	0.009 (0.031)	-0.004 (0.031)	-0.001 (0.031)
<i>Panel B: Child demographics and health</i>							
	<i>N</i> =267	<i>N</i> =229	<i>N</i> =220	<i>N</i> =243	<i>N</i> =679	<i>N</i> =646	<i>N</i> =580
Child age (years)	2.74 (1.56)	-0.068 (0.126)	0.066 (0.126)	-0.191 (0.128)	-0.145 (0.110)	-0.125 (0.114)	-0.055 (0.116)
Child male (=1)	0.52 (0.50)	-0.050 (0.037)	-0.020 (0.040)	0.008 (0.036)	-0.005 (0.025)	-0.010 (0.029)	-0.002 (0.025)
Child had diarrhea in past week indicator	0.237 (0.426)	-0.075 (0.037)**	0.019 (0.043)	-0.004 (0.056)	-0.017 (0.034)	-0.030 (0.038)	-0.031 (0.039)

Notes: In the treatment arm columns, Huber-White robust standard errors are presented (clustered at the spring leve), significantly different than zero at * 90% ** 95% *** 99% confidence.

Data are from the baseline survey (Sept-Nov 2007 for wave 1 and April-July 2008 for wave 2). Child-level data are restricted to those age 5 and under. Household survey respondent is the mother of the youngest child in the compound (or the youngest adult woman available).

Table 3: Take-up impacts, distribution of free WaterGuard

<i>Dependent Variable:</i>	(1)		(2)		(3)	
	A: Self-report	B: Pos. test	A	B	A	B
Household received free WaterGuard indicator	0.691 (0.032)***	0.515 (0.034)***	0.696 (0.024)***	0.526 (0.025)***	0.689 (0.066)***	0.572 (0.074)***
Protected spring indicator	0.049 (0.026)*	N.A.	0.051 (0.025)**		0.052 (0.024)**	
<i>Interactions with WaterGuard indicator:</i>						
Protected spring indicator	0.010 (0.040)	N.A.				
Baseline ln(spring water <i>E. Coli</i> MPN)			0.001 (0.008)	-0.004 (0.010)		
Baseline latrine density					0.001 (0.178)	0.108 (0.204)
Baseline diarrhea prevention score					-0.004 (0.013)	-0.003 (0.015)
Baseline knowledge of safe water					0.008 (0.056)	0.017 (0.060)
Baseline boiled water yesterday indicator					0.099 (0.052)*	0.065 (0.062)
Baseline mother's years of education					-0.004 (0.007)	-0.003 (0.008)
Baseline number of children under 3					-0.009 (0.028)	0.030 (0.029)
Baseline number of children under 3 with diarrhea					0.028 (0.084)	-0.108 (0.005)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Survey rounds	2-4	3-4	2-4	3-4	2-4	3-4
R ²	0.57	0.52	0.57	0.51	0.59	0.53
Observations (spring clusters)	3784 (184)	2563 (184)	3760 (183)	2547 (184)	3416 (184)	2243 (184)
Number of households	1413	1406	1405	1398	1215	1209
Mean (s.d.) of dependent variable prior to intervention	0.06 (0.24)	0.02 (0.14)	0.06 (0.24)	0.02 (0.14)	0.06 (0.24)	0.02 (0.14)

Notes: Estimated using OLS. Huber-White robust standard errors (clustered at the spring level) are presented, significantly different than zero at * 90% ** 95% *** 99% confidence. Self-reported chlorine use (A) is available for survey rounds 2-4; chlorine tests (B) were only conducted in survey rounds 3-4. A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color.

Baseline values of all variables are from the third (2006) survey round in which the intervention took place. In column 3 baseline number of children (under age 12), baseline number of children with diarrhea, baseline iron roof and baseline iron roof density within spring community are included as additional control variables. Baseline spring water quality, latrine density, diarrhea prevention score, mother's education, number of children, number of children under 3, number of children with diarrhea, number of children under 3 with diarrhea, and iron roof density are demeaned. Survey round and month fixed effects included in all regressions but not reported. When interactions are included, baseline variables are interacted with survey round in addition to interactions with WaterGuard indicator. These coefficients not reported in the table.

Table 4: Testing whether price serves as a screening mechanism

	<u>Price=0</u> Free bottles + household visit (1) <u>Water treated with CL</u>		<u>Price=10</u> Coupon data from shops (2) Share of coupons redeemed	<u>Price=20</u> No intervention; purchased from shop (3) <u>Water treated with CL</u>	
	A: Self-report	B: Pos. test		A	B
<i>Panel A: All households</i>					
Number of observations:	79%	58%	9.2%	7.0%	3.5%
	628	627	2520	3194	1942
<i>Panel B: Children under age 3 in the household?</i>					
Yes	79%	59%	8.3%	6.6%	3.5%
No	80%	57%	11.4%	8.1%	3.3%
p-value (equality of means)	0.86	0.56	0.01	0.12	0.86
Number of observations:					
Yes	421	419	1764	2257	1372
No	207	208	756	937	570
<i>Panel C: Respondent volunteered "dirty water" as a cause of diarrhea?</i>					
Yes	81%	61%	10.1%	7.8%	3.9%
No	75%	53%	7.5%	5.8%	3.0%
p-value (equality of means)	0.07	0.07	0.04	0.04	0.34
Number of observations:					
Yes	402	400	1548	2091	1241
No	185	187	828	991	591

Notes: Self-reported chlorine use (A) is available for survey rounds 2-4; chlorine tests (B) were only conducted in survey rounds 3-4. A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. Data for price=0 are from the follow-up survey for households who received free WaterGuard. Data for price=10 are from coupons for discounted WaterGuard (12 per household) distributed to subset of the households who received free WaterGuard; redemption data were collected from shopkeepers for the duration of the coupon program after the household survey rounds had been completed. Data for price=20 are from all households prior to the distribution of free WaterGuard and comparison households at follow-up.

Table 5: Take-up impacts, intensive social marketing scripts and coupons in addition to distribution of free WaterGuard

<i>Dependent variable:</i>	A: Self-report	B: Pos. test
Household received free WaterGuard indicator	0.66 (0.03)***	0.52 (0.04)***
Additional social marketing script indicator	0.04 (0.04)	-0.02 (0.06)
Household received coupons indicator	0.09 (0.05)*	0.04 (0.06)
Interaction of script and coupon indicators	-0.03 (0.08)	-0.01 (0.11)
Household fixed effects	Yes	Yes
Survey rounds	2-4	3-4
R ²	0.47	0.40
Observations (spring clusters)	3784 (184)	2563 (184)
Number of households	1413	1406
Mean (s.d.) of the dependent variable prior to the intervention	0.06 (0.24)	0.02 (0.14)

Notes: Estimated using OLS. Huber-White robust standard errors (clustered at the spring level) are presented, significantly different than zero at * 90% ** 95% *** 99% confidence. Self-reported chlorine use (A) is available for survey rounds 2-4; chlorine tests (B) were only conducted in survey rounds 3-4. A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. Survey round and month fixed effects included in all regressions but not reported.

Table 6: Take-up impacts, alternative strategies

<i>Dependent variable:</i>	Short-run (~3 weeks)			Medium-run (3-6 months)		
	(1)	(2)		(3)	(4)	
		A: Self-report	B: Pos. test		A	B
<i>Panel A</i>	<i>N</i>	<i>Mean (s.d.)</i>		<i>N</i>	<i>Mean (s.d.)</i>	
T0: Comparison	169	0.074 (0.263)	0.037 (0.189)	170	0.118 (0.324)	0.080 (0.273)
<i>Panel B</i>	<i>N</i>	<i>Treatment-Comparison, (s.e.)</i>		<i>N</i>	<i>Treatment-Comparison, (s.e.)</i>	
T1A: Household script only	99	0.080 (0.033)**	0.017 (0.019)	128	0.061 (0.041)	0.017 (0.037)
T1B: Community script only	150	0.157 (0.046)***	0.074 (0.029)**	145	0.007 (0.035)	-0.015 (0.031)
T1C: Household + community scripts	106	0.134 (0.055)**	0.090 (0.038)**	118	0.037 (0.052)	0.011 (0.040)
<i>Panel B</i>	<i>N</i>	<i>Treatment-Comparison, (s.e.)</i>		<i>N</i>	<i>Treatment-Comparison, (s.e.)</i>	
T2A: Flat-fee promoter + coupon	332	0.570 (0.058)***	0.402 (0.049)***	302	0.400 (0.064)***	0.298 (0.065)***
T2B: Incentivized promoter + coupon	356	0.559 (0.044)***	0.373 (0.040)***	352	0.427 (0.046)***	0.349 (0.045)***
T3: Incentivized promoter + dispenser	375	0.669 (0.042)***	0.372 (0.037)***	344	0.671 (0.041)***	0.532 (0.055)***

Notes: In the treatment arm columns, Huber-White robust standard errors are presented (clustered at the spring level), significantly different than zero at * 90% ** 95% *** 99% confidence. Short-run follow-up surveys occurred approximately 3 weeks after the baseline visit; medium-run follow-up visits occurred between 3 and 6 months after the baseline visit. A positive chlorine test result (B columns) is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color.

Table 7: Changes in conversation patterns following WaterGuard distribution

	Topic and frequency of conversation, as reported by respondent household:					
	<u>WaterGuard</u>		<u>Drinking water</u>		<u>Children's health</u>	
	Many times (1)	Ever (2)	Many times (3)	Ever (4)	Many times (5)	Ever (6)
Treatment (WaterGuard) indicator for respondent household in pair	0.07 (0.02)***	0.20 (0.03)***	0.06 (0.02)	0.13 (0.03)	0.03 (0.02)	0.06 (0.03)**
Treatment indicator for non-respondent household in pair	0.05 (0.01)***	0.13 (0.02)***	0.04 (0.02)	0.07 (0.02)	0.01 (0.02)	0.03 (0.02)
Interaction of respondent and non-respondent households' treatment indicators	0.03 (0.02)	-0.02 (0.03)	0.07 (0.03)	-0.01 (0.03)	0.02 (0.03)	0.02 (0.03)
R ²	0.03	0.06	0.02	0.05	0.01	0.02
Household pair observations (spring clusters)	6557 (183)	6557 (183)	6622 (184)	6622 (184)	6531 (183)	6531 (183)
Mean (s.d.) of the dependent variable in survey round 2	0.04 (0.19)	0.10 (0.30)	0.18 (0.39)	0.41 (0.49)	0.25 (0.43)	0.51 (0.50)

Notes: Estimated using OLS. Huber-White robust standard errors (clustered at the spring level) are presented, significantly different than zero at * 90% ** 95% *** 99% confidence. The dependent variable is a binary indicator equal to 1 if the respondent household reported conversing on the given topic at the given frequency with the household in question (each respondent was asked about each of the other study households at their spring). Data are from the fourth survey round. Columns 1-4 include a control for whether or not the respondent reported ever having a conversation on the given topic with the household in question during the second survey round. Data on conversation patterns are only available for the second and fourth survey rounds.

Table 8: Social networks and take-up, distribution of free WaterGuard

<i>Dependent variable:</i>	(1)		(2)		(3)		(4)	
	A: Self-report	B: Pos. test	A	B	A	B	A	B
Household received free WaterGuard indicator	0.71 (0.04)***	0.53 (0.04)***	0.71 (0.05)***	0.53 (0.06)***	0.69 (0.03)***	0.52 (0.03)***	0.69 (0.03)***	0.52 (0.03)***
High-intensity treatment indicator	0.09 (0.03)***	0.03 (0.03)	-0.01 (0.04)	0.01 (0.04)	-0.01 (0.04)	0.00 (0.04)	-0.01 (0.04)	0.00 (0.04)
Interaction of WaterGuard and high-intensity indicators	-0.07 (0.05)	-0.03 (0.06)						
<i>Interactions of baseline network characteristics with post-intervention indicator:</i>								
Proportion of all close contacts who received free WaterGuard ^(a)			0.10 (0.05)*	0.04 (0.06)	-0.01 (0.06)	-0.05 (0.07)	0.04 (0.05)	-0.02 (0.06)
Interaction of WaterGuard indicator and Proportion who received free WaterGuard			-0.04 (0.07)	-0.03 (0.09)				
Proportion of close contacts to same tribe who received free WaterGuard					0.12 (0.06)**	0.10 (0.06)*		
Proportion of close contacts to community leaders who received free WaterGuard ^(b)							0.08 (0.05)*	0.07 (0.04)*
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey rounds	2-4	3-4	2-4	3-4	2-4	3-4	2-4	3-4
R ²	0.57	0.52	0.57	0.52	0.57	0.57	0.57	0.57
Observations (spring clusters)	3784 (184)	2563 (184)	3443 (184)	2230 (184)	3443 (184)	3443 (184)	3443 (184)	3443 (184)
Number of households	1413	1406	1223	1216	1223	1223	1223	1223
Percentage of relationship pairs of given type	N.A.	N.A.	60%	60%	21%	21%	36%	36%
Mean (s.d.) of the dependent variable prior to the intervention	0.06 (0.24)	0.02 (0.14)	0.06 (0.24)	0.02 (0.14)	0.06 (0.24)	0.02 (0.14)	0.06 (0.24)	0.02 (0.14)

Notes: Estimated using OLS with household fixed effects. Huber-White robust standard errors (clustered at the spring level) are presented, significantly different than zero at * 90% ** 95% *** 99% confidence. Self-reported chlorine use is available for survey rounds 2-4; chlorine tests were only conducted in survey rounds 3-4. A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. At “high-intensity” treatment springs 6 of 8 households were assigned to the treatment group whereas only 2 of 8 households were assigned to treatment at the remaining “low-intensity” treatment springs. Additional control variables in all columns include survey round & month fixed effects and the interactions of the post-intervention indicator with baseline total number of close contacts and baseline number of close contacts of a particular type. Columns 2-4 also include indicator variables for zero close contacts and zero contacts of a particular type interacted with the post-intervention indicator.

(a): Close contacts are defined as households with whom the respondent reports talking 2-3 times per week or more.

(b): Includes self-identified leaders of women's groups, farmer/agricultural groups, water group/well committee, credit/savings/insurance groups, prayer or bible study groups, burial committees, and school committees or clubs.

Table 9: Promoter payments

<i>Dependent variable:</i>	Positive CL	<u>Payments</u>		
	Tests (1)	Min. (2)	Max. (3)	Mean (4)
<u>Short-run (~3 weeks)</u>				
T2A: Flat Fee + Coupon	44%	\$6.43	\$6.43	\$6.43
T2B: Incentivized + Coupon	38%	\$2.00	\$8.00	\$4.27
T3: Incentivized + Dispenser	41%	\$1.43	\$6.57	\$4.14
<u>Medium-run (3-6 months)</u>				
T2A: Flat Fee + Coupon	43%	\$6.43	\$6.43	\$6.43
T2B: Incentivized + Coupon	41%	\$2.00	\$6.86	\$4.27
T3: Incentivized + Dispenser	61%	\$2.00	\$8.00	\$5.48

Notes: Incentivized promoters were paid a flat fee of 100 Ksh (~\$1.43) per follow-up visit plus 20 Ksh (~\$0.29) per positive chlorine test. The two payment schemes are equivalent at a take-up rate of 70% with 25 chlorine tests per community. In communities with fewer than 25 respondents at follow-up, chlorine test results were scaled proportionally in order to determine payment.

Table 10: Did promoters target households they knew would be sampled?

<i>Dependent variable:</i>	Non-baseline households				Baseline households			
	(1)	(2)	(3)		(4)	(5)	(6)	
	<i>N</i>	Reported being encouraged by promoter	<u>Water treated with CL</u> A: Self-report B: Pos. test		<i>N</i>	Reported being encouraged by promoter	A	B
<u>Short-run (~3 weeks)</u>								
T2A: Flat Fee + Coupon	56	27%	16%	11%	276	61%	75%	51%
T2B: Incentivized + Coupon	69	46%	13%	8%	287	57%	75%	49%
T3: Incentivized + Dispenser	92	60%	67%	39%	283	64%	77%	42%
<u>Medium-run (3-6 months)</u>								
T2A: Flat Fee + Coupon	46	63%	27%	18%	256	71%	57%	42%
T2B: Incentivized + Coupon	73	78%	34%	23%	279	85%	60%	49%
T3: Incentivized + Dispenser	87	70%	64%	53%	257	77%	84%	64%

Notes: Promoters were aware that all 20 households sampled at baseline would be revisited at follow-up and that 5 more households would be randomly chosen from the community for chlorine tests at the short-run follow-up. No new households were added for the medium-run follow-up, so by this point promoters knew all of the households whose water would be tested for chlorine. Respondents were asked if the promoter had encouraged them to use WaterGuard (yes/no). A positive chlorine test result is defined conservatively as sodium hypochlorite of at least 0.1 mg/L with pink color or 0.2 mg/L or greater regardless of color. Non-baseline were randomly selected from among the non-surveyed households in the community to be added to the sample in the short-run follow-up and did not receive the same promotional messages from the survey enumerators as those households sampled at baseline.