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Heterogeneous Effects of Information on Household Behaviors to Improve Water Quality

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Abstract

Providing information about health risks only sometimes induces protective action. This raises questions about whether and how risk information is understood and acted upon, and how responses vary across contexts. We stratified a randomized experiment across two periurban areas in Cambodia, which differed in terms of socioeconomic status and infrastructure. In one area, showing households specific evidence of water contamination altered their beliefs about health risk and increased their demand for a treatment product; in the other area, it had no effect on these outcomes. These findings highlight the importance of identifying specific drivers of responses to health risk information.

Keywords: Health risk, health seeking behavior, water-borne disease, environmental health, risk information, randomized intervention, Cambodia

JEL Codes: C93, D10, I12, I15, O13, Q53

1. Introduction

Diarrheal disease continues to be a leading cause of death in many less developed countries (UNICEF 2012; Liu et al. 2012; Jeuland et al. 2013). This disease burden persists despite the fact that it is largely avoidable through community-level interventions or household-level technological and behavioral adjustments, at least some of which appear to be inexpensive in terms of time and money (Waddington et al. 2009, Prüss-Üstün and Corvalán 2006). Demand for cheap and apparently cost effective household-level technologies appears low (Null et al. 2012, Ahuja, Kremer, and Zwane 2010), while there is higher demand for solutions like high quality piped water systems which require substantial capital investment and coordination among many actors (Whittington et al. 2008). Why don't more households adopt apparently cost-effective health-promoting behaviors and technologies? This puzzle raises important questions—not only about mismeasured costs or benefits of alternative solutions, but also about whether and how information about health risks is understood and acted upon.

In Cambodia, diarrheal disease due to contaminated drinking water causes thousands of deaths each year (WHO 2004). In the most recent Demographic and Health Survey, 15% of Cambodian children younger than five were reported to have experienced diarrhea in the previous two weeks (DHS 2010). As in many less-developed countries, the diarrheal disease burden in Cambodia is concentrated among those living in periurban or rural areas, and among the less educated (DHS 2010). These households may have lower willingness to pay to prevent diarrheal disease, for example due to income constraints and competing health priorities; there is evidence that income effects may play a role in driving demand for health-protective technology (Dupas 2009). Non-urban and poorly educated households may also face higher time or money costs of adoption, for example if they are located farther from public supplies of water and sanitation services (Whittington et al.

2012). There may be other unobserved costs to adoption; for technologies like chlorination, households appear sensitive to features such as poor taste and inconvenience (Arnold and Colford Jr 2007, Jeuland et al. 2013). There may also be mismeasurement of benefits, for example owing to improper accounting for negative externalities related to poor hygiene, water and sanitation behaviors of others in the community (Brown and Clasen 2012, Pattanayak and Pfaff 2009).

In addition to income effects and opportunity costs, information may play an important role in explaining the disproportionate burden of water-borne disease on periurban households and those with low levels of education. These households may have more limited access to information and be at higher risk of misperceiving environmental health risks, including those related to their own drinking water quality (Figueroa et al. 2007, Zwane and Kremer 2007, Kremer et al. 2008, Ashraf, Jack, and Kamenica 2013, Bennear et al. 2012). There is evidence that delivering salient information about household water quality increases adoption of protective behaviors and technologies (Madajewicz et al. 2007); most of this evidence, however, indicates only modest and short-lived effects of information on demand for water treatment (Hamoudi et al. 2012, Jalan and Somanathan 2008, Luoto, Levine, and Albert 2011, Lucas, Cabral, and Colford Jr 2011).

This study is aimed at evaluating not only *whether* households change behavior in response to specific information about their own drinking water quality, but also *how* responses vary across different types of households. We provided information about the safety of personal drinking water to a randomly-selected subset of periurban Cambodian households, and evaluated the impact of that information on: subjective beliefs about the health risks posed by their source water; and adoption of protective household-level behaviors, including in particular responses to a sales pitch developed to encourage purchase of a point-of-use chlorine-based treatment product known by its trade name "Aquatabs". Building on the findings of preparatory surveys conducted a year prior to our experiment, we chose two distinct study settings in order to shed light on how and whether the effectiveness of information interventions may be conditioned by context. One location had higher quality water infrastructure, a better (though still risky) disease environment, and higher average socioeconomic status than the other. Our conceptual framework highlights potential roles that these characteristics can play in conditioning responses to information—in addition to standard characteristics like individual tastes, income, and prices. We exploit important differences in public infrastructure, prior beliefs, and socioeconomic conditions within and between the two study sites, to document how responses varied conditional on those characteristics.

In addition to documenting how responses to a signal of water quality varied across households conditional on relevant characteristics, our data also allow us to investigate the role of specific factors that may mediate relationships between testing and behavior. Previous experimental studies on the effects of testing have raised important questions about the link between information provision and adoption of protective behaviors. When water quality tests are observed to drive up demand for household water treatment technologies, is that solely the effect of the information *itself* (the "message")? Alternatively, could some of the observed response be the result of the "medium"—for example, a psychic effect of seeing technicians carrying water quality testing equipment, thereby increasing the salience of questions around water quality (Pfaff et al. 2005), or the result of interacting with interviewers or sales people trained to market specific products aggressively[1]? If households see evidence that their water is safe, do they redirect attention *away* from diarrhea risk and toward other priorities? Do effects wane as information recedes in memory? Do they wax as households have time to reflect on the information they have been shown?

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[1] Aggressive salesmanship may of course involve *mis*information. For example, mineral pot filters in Southeast Asia are often said to prevent cancer, though they do not.

Our study addresses each of these questions. To specifically identify the effects of the water quality "message," we designed the experiment to hold "medium" constant across participant households by testing *all* households' drinking water and marketing water treatment products in *all* households, but only revealing test results to a randomly selected subset. We also measured participants' beliefs specifically about the safety of their water both before and after testing, to assess how they processed the content of observed information. In order to assess whether effects wax or wane with time, we measured them both in the hours after information was revealed, and again six weeks later.

We find that water quality information revelation affected households' subjective beliefs about health risks posed by their source water. Consistent with intuition, perceived safety declined among those who saw a signal indicating contamination, while it increased among those who saw the opposite. The effect was over four times larger in one of the study locations than in the other, however, and was only significantly different from zero in the former. Nonetheless, information affected behavior in both of our study areas, but the specific behaviors affected differed across the two settings. In the location with better local water infrastructure, households who observed a signal that their water may be contaminated reported increases in hand-washing with soap; in the area where infrastructure is poorer and the significant effect on beliefs was observed, they were more likely to react by purchasing Aquatabs. The effects of information revelation on *beliefs* did not wane over our six week follow-up period. Households' use of Aquatabs, however, was substantially less intense than recommended over the follow-up period; this may indicate that the impact of the signal on *behavior* did wane. On the other hand, we see evidence that households might have been intentionally rationing or hoarding their Aquatabs. In neither location did receiving the signal about contamination lead to measured reductions in drinking water contamination six weeks later or in the incidence of diarrheal disease.

Taken together, our results shed light on questions about health-related behaviors, and raise important new ones. Especially in the location where average socioeconomic status was lower and water infrastructure was of poorer quality, specific information about the quality of households' own drinking water had substantial impacts on self-reported subjective beliefs and on propensity to purchase a point-of-use disinfectant. This suggests that there may be contexts in which risks persist because they are not recognized or fully appreciated, and thus that interventions to provide salient information may be beneficial. However, even in that setting, the fact that the disinfectant was not used according to recommendations despite being apparently cheap to procure and use may indicate that there are important subtleties in the private net benefits of such technologies—including for example households' perceived value of precautionary holding of disinfectant in anticipation of conditions when water quality might be especially compromised. This underscores the need for research that further elucidates the nature of health risk management behaviors in general, and the costs and benefits of these types of technologies in particular. The evidence of heterogeneity in response to information in the two different study settings, furthermore, highlights a question that may not have received the attention it deserves. What contextual characteristics condition responses to information? Our conceptual framework and empirical analyses highlight several observed differences between the two settings that may play a role, but we emphasize that this study cannot settle the empirical question about whether or how any specific contextual characteristics affect responses to information; instead, we intend it to motivate and inform the design of future studies.

2. Conceptual Framework

Our approach builds from a standard dynamic human capital model of health (Grossman 1972, Strauss and Thomas 2007, Anderson and Grossman 2009). There are three key features in any such model. First, each family member's current overall health and nutritional status is responsive to observed and unobserved endowments (including genetic or epigenetic characteristics), to an entire history of stochastic or deterministic time-varying factors (including changes in public health environment, biological aging, stress, epidemics, seasonality, and so on), to an entire history of past investments of time and other resources by family members (including water, sanitation and hygiene behaviors), and to interactions among these. Second, each family member's productivity in the labor market and in household production depends in part on current and past health and nutritional status. Third, health and nutritional status have a substantial stock component so that shocks and investments today can impact productivity in the future.

A family's optimization problem in such a model involves taking expectations over uncertain future outcomes in order to program current and future investment (including investment in health), current and future consumption, and current and future market and non-market labor supply; the family's chosen program will maximize current and expected future welfare subject to time constraints and an intertemporal budget constraint. Accordingly, family members' health investments will depend not only on standard conditioning factors from the constraint side (like local prices and wages) or the preference side (like time discounting, attitudes toward health risk, and other preference characteristics), but also on subjective expectations about uncertain future outcomes as well as contextual factors that affect shadow prices and productivity of investment.

We describe our experiment in detail in section 3.2; it involved providing households with specific information, in the form of a clear binary signal, about potential health risks posed by their drinking water. It was designed to catalyze households' updating of subjective beliefs about the probability (conditional on status quo behavior) of future exposure to bacteria that might cause diarrheal disease. Almost any model of learning would imply that the *content* of the signal would affect its impact on that subjective belief. If family members are shown evidence that their water is contaminated, they would be expected to revise beliefs upward, if they revise at all. Conversely, if shown evidence that it is not contaminated, they would be expected to revise downward, or not at all. Furthermore, the same information may affect beliefs differently in different families, for example because families that have already received more or higher quality signals may be less affected by one more piece of information, or because more educated families may have more capacity to understand the implications of the information, or because different families may have different levels of trust in the information source (Pfaff et al. 2005, Balasubramanya et al. 2013).

If family members revise their subjective beliefs about the probability (conditional on status quo behavior) of exposure to disease-causing bacteria, how might that in turn alter their future behavior? The answer will likely depend not only on tastes, income, prices, and the opportunity cost of time, but also on contextual factors affecting perceived returns to changes in behavior, including especially the quality of local infrastructure or institutions that provide drinking water (Pattanayak and Pfaff 2009). There are likely to be substantial complementarities between public water infrastructure and private investments in drinking water safety. For example, if water is piped to a household, and is very likely to arrive uncontaminated, then investments of time or money in chemical treatment at the point of delivery might generate only small marginal returns, compared with changes like better hygiene and safer storage of drinking water before consumption. By contrast, if the cost of obtaining clean water is very high, then in-home treatment may generate substantially higher returns than other behaviors. Finally, the marginal value of behavioral or other adjustments to cope with low drinking water quality will partly depend on the behaviors of other households and influential peers, as well as their geographical and social proximity (Dickinson and Pattanayak 2009, Miller and Mobarak 2013). If infrastructure is poor enough, and the local disease environment risky enough, then families might perceive any investment behavior to be futile, such that information could affect beliefs while having no impact on behavior.

3. Methods

3.1 Study site and sample composition

The study was implemented in two periurban areas located around Phnom Penh, Cambodia, mapped in figure 1. Area 1 consisted of two neighboring communes comprising villages scattered across space, whereas area 2 was contained almost entirely within a single commune in which villages were strung linearly along a minor road. These two areas had been selected for participation in a 2011 survey on perceptions of water quality and demand for water treatment products. Our experiment was conducted a year later, on the same sample of households. One reason these two areas had been selected was the fact that area 1 relied significantly more on piped water than did area 2, but both had widespread access to convenient water supplies. In addition, both had sufficiently high prevalence of diarrhea to suggest that the quality of water from these convenient supplies was variable, and that an intervention to improve water quality might therefore be valuable (Orgill et al. 2013). Data used for the analysis in this study were collected in three waves—the first (pre-baseline) during the summer of 2011, followed by round 1 of our experiment in June/July 2012, and round 2 in August 2012, about six weeks after round 1.

During the initial round of preparatory surveys (summer 2011), a random sample of 921 households was constructed by counting off every nth household in order to obtain a representative sample from each of the 42 villages located within the two study areas (where n=8 in area 1 and n=5 in area 2). No households refused to be interviewed, although 9 did not complete the interview, yielding a final pre-baseline sample of 912 (467 from Area 1, and 445 from Area 2). The pre-baseline questionnaire included information on basic family composition and household demographics; diarrhea prevalence; water sources, treatment, and storage; hygiene behaviors; willingness to pay (WTP) for improved water quality; preferences for various attributes of water sources such as taste and cleanliness; and subjective beliefs about drinking water safety. In addition, a limited number of water samples was collected from households that had working piped water connections. These samples were taken to Phnom Penh to be tested for the presence of *E. coli* bacteria, a standard measure of water contamination. The complete design and results of the WTP and other preference analyses are discussed in detail elsewhere (Orgill et al. 2013, Jeuland et al. 2013). The two key findings of these analyses which are relevant to this study are: first, actual baseline water safety was observed to be higher in area 1 but perceived water safety was slightly higher in area 2; and second, demand curves for water quality improvements were shifted down in area 1 relative to area 2. Those earlier findings motivated this study's testing for differences between the two areas of the effect of water quality information on demand for water treatment.

Round 1 took place between mid-June and early July 2012. At that time, a new team of interviewers returned to resurvey the participant households from the previous summer, and to implement the information experiment (detailed in Section 3.2). Round 2 revisits occurred roughly six weeks later, from late July to mid-August. All but 64 households from the pre-baseline (about 93%) participated in round 1. The 64 who did not participate had either moved away or could not be found by interviewers due to missing or inaccurate GPS and address information; they were observed to be younger, smaller, and more asset poor on average than the 848 who participated. An additional 9 households attrited between Round 1 and Round 2. Since the results presented in this paper are based only on this final remaining sample of 839 households, inferences drawn from our study may not generalize to subpopulations with higher propensity to migrate. Whenever possible (that is, in analyses that only involve Round 1 measures), we also estimated impacts in the original sample of 848 households. We found no differences compared to estimated impacts in the final sample of 839.

The round 1 and 2 questionnaires included most of the same modules as the original 2011 survey, except that the questions related to willingness-to-pay and preferences for different attributes of water treatment were removed. Subjective perceptions of drinking water in all three rounds were elicited using a procedure described in more detail by Orgill et al (2012)—essentially, respondents were handed 10 candies, and asked to divide them between two piles, as follows:

> In one pile, put the candies indicating that you think the water… is safe. In the other pile, put the candies to indicate that the water is not safe. So, if you think the water is definitely safe, you should put all the candies in the safe pile. If you think that the chance that it is safe is slightly higher than the chance that it is unsafe, maybe place 6 to 8 candies in the safe pile and the rest in the unsafe pile. If you think the water is definitely not safe, place all of the candies in the unsafe pile.

This approach to eliciting beliefs about probabilities has been employed elsewhere and may be cognitively easier for respondents than stating probabilities in percentage point terms (Delavande, Gine, and McKenzie 2011). The beliefs we analyze in this study refer to the safety of drinking water at the time of its collection at the source, before any in-house treatment, handling, or storage; the measure of a household's subjective beliefs is an integer score ranging from 0 to 10, equal to the number of candies they placed in the "safe" pile.

During the visit, water quality was tested in all households using a hydrogen sulfide test described in section 3.2, and a chlorine-based water treatment product—known by its trade name, "Aquatabs"—was demonstrated. Most of the survey households had previously heard of Aquatabs; the product is promoted in Cambodia by Population Services International (PSI). However, at the time of this experiment, PSI was not marketing Aquatabs in the study zone; participants' only prior experience with Aquatabs was from the 2011 pre-baseline survey, when households in one of the areas had been given the opportunity to purchase limited quantities as part of the demand study. About a quarter of them took up that opportunity. Among the remaining households, only 3 reported using any "product that can be added to water to make it safe to drink."

3.2 The experiment

Prior to Round 1, every sample household was randomly assigned either to observe the results of their water quality test, or to not observe them. Assignment was independent across individual households. During the Round 1 interview, test vials were filled with samples of untreated water from each household's main drinking water storage container, regardless of treatment assignment. These test vials contain hydrogen sulfide (H_2S) test strips produced by Research Development International-Cambodia. Bacteria that may be harmful to health produce H_2S as a byproduct of metabolism. If there is H_2S in the water, it will cause the strips to turn brown or black after a few hours, indicating the presence of these germs. The test strips do not produce a quantitative measure of bacterial contamination, nor do they indicate the true severity of the risks associated with consuming a particular water sample (Pathak and Gopal 2005). Nonetheless, they are easy to use, simple to interpret, and do not require special equipment or handling like refrigeration. Comparisons with results obtained from microscopy, which is a "gold standard" test of contamination, have indicated good sensitivity and specificity of the H_2S test (Edberg et al. 2000, Khush et al. 2013).

The "Uninformed" Treatment Arm. In households assigned to the uninformed group, interviewers administered the main questionnaire, then collected water samples for the H_2S test and elicited beliefs about water quality, and finally attempted to sell Aquatab strips to respondents, all in a single visit. The sales pitch was based on a script (available upon request) developed in collaboration with social marketing specialists at Watershed-Cambodia, and was pre-tested in focus groups and pilot surveys. Interviewers were given freedom to adapt the script in circumstances where they felt doing so would make the pitch more effective. The pitch included a briefing about seven behaviors that could help respondents protect themselves against water contamination, including safe water handling, treatment, and storage behaviors. One of these seven behaviors was chemical treatment with Aquatabs. At the end of the sales pitch, interviewers recorded how many strips households purchased. Interviewers were not given extrinsic incentives for selling Aquatabs, and were not briefed on study hypotheses. The price of an Aquatab strip (which treats 200 liters—roughly two weeks' worth of drinking water for an average household in the sample) was 500 Riel (about US$0.12, or 2% of daily expenditure for an average household in the sample). At the end of the visit, interviewers took the H_2S test vial away with them, so that the result could be observed by the study team after a few hours, but not by the respondents themselves.

The "Informed" Treatment Arm. The interview process in households assigned to the informed group was similar, except that after the main questionnaire was administered, three H_2S test vials were filled, rather than only one. The first of these was filled in exactly the same way as for the uninformed households; this one was kept by the survey team. The second was filled with a sample of the same water as the first, but was left behind so that the household could observe the result. The third was filled with a sample of the household's water that had been treated with Aquatabs for 30 minutes, to demonstrate the effectiveness of this product in removing bacterial contamination. The interview then paused overnight to give the three H_2S test strips time to change color (or not). When interviewers returned the next day, they checked the vials that had been left with the household. In 94% of cases, the third vial—demonstrating the effectiveness of Aquatabs—displayed the expected uncontaminated result; as we show below, the same was not true of the vials that contained the household's usual drinking water. Then, interviewers discussed the results with respondents, and next elicited beliefs about water safety. After reporting their beliefs, respondents received further information about what the test results meant—with emphasis on the fact that a change in color of the test strip indicates contamination but does not *necessarily* indicate that anyone consuming the water will become sick. They were then presented with the same Aquatabs sales pitch that was delivered to the uninformed group.

As we have discussed, one objective of the experiment was to isolate the impact of the water quality *signal* itself (the "message") from the psychic impact of testing procedures, or the sales pitch, or other elements of the "medium" by which the signal is generated and delivered. Accordingly, it is important that the main difference between the informed and uninformed groups be that only the former group observes the water quality signal. In that light, it is important to note that the information treatment involved visits on two consecutive days (since the water sample was collected on the first day and incubated overnight, and then the next day, the result was observed and Aquatabs were offered). By contrast, the uninformed households received only a single visit. In section 5, we discuss evidence that this does not generate a difference in terms of "medium" between the two groups that contaminates the identification of the effect of the "message."

Round 2 Interviews. The Round 2 questionnaire, conducted six weeks after the Round 1 visits, included the same questions about household health and water and sanitation behaviors and water safety beliefs as in Round 1, and the Aquatabs sales pitch from was repeated. In addition, for the purposes of assessing changes in water quality over time, one vial of every household's drinking water was again tested using the same H_2S tests, and interviewers also took a sample of water treated by Aquatabs if the household had any available. These Round 2 test vials were kept by the interviewers; the results of these follow-up tests were seen only by the study team.

3.3 Analysis

Does seeing a household-specific water quality signal affect a household's *beliefs* about their drinking water? Does it affect their *behavior*? If so, how? To explore these questions, we test the effect of assignment to the information treatment on the following outcomes: subjective beliefs about risks posed by source water in both rounds, purchase of Aquatabs in both rounds, use of Aquatabs between rounds and adoption of other protective behaviors, H_2S test results at Round 2, and self-reported cases of diarrheal disease in the household between rounds 1 and 2. In our main regressions, each of these outcomes for household *h*, in village *v*, in area *c*, survey round *r* (y_{hvcr}) is regressed against an indicator for assignment to the information treatment (T_{hvc1}=1 if household *h* was assigned to observe its test result, and 0 otherwise). Interviewer fixed effects ($\mathbf{e}_{hvcr}$) are included where the outcomes are related to sales of Aquatabs, in order to absorb any differences in salesmanship across interviewers.[2]

$$y_{hvcr} = \alpha + \theta T_{hvc1} + \boldsymbol{e}_{hvcr} + \varepsilon_{hvcr} \qquad [1]$$

Standard errors are computed from a bootstrap estimator of the variance/covariance matrix, with resampling by village; it is robust to arbitrary forms of heteroskedasticity and to potential non-independence of observations within villages. Assuming independence across all observations has no substantive effect in terms of statistical significance for the results we report.

[2] Many of these outcomes may vary with household demographic composition (for example, households with more children might have higher downside risk from contamination and therefore respond differently to the Aquatabs sales pitch). Therefore, we repeated all analyses including flexible controls for household demographic composition on the right hand side; the results of those analyses are substantively identical to the results we report in section 4.

4. Results and Discussion

4.1 Descriptive Statistics

Table 1 describes the analytical sample of 839 households interviewed during rounds 1 and 2. Households were split almost evenly across the two areas; the 420 households in area 1 were less poor on average than the 419 in area 2. Median total household expenditure in area 1 was about US$6.10 per day, compared with US$3.70 for area 2 and asset ownership was generally higher in area 1 (except for tractors); however, these differences may be influenced by the fact that the average household in area 1 contained more adults than in area 2. Adults in area 1 had more years of education than those in area 2. There was evidence of widespread contamination risk in the drinking water of sample households; during the first visit in July 2012, the H_2S tests of drinking water samples indicated evidence of contamination in four-fifths of households in area 1, and more than 90% of those in area 2. As we discuss in section 3.2, a positive Hs_2S test does not indicate the precise level of disease risk, but samples testing positive have been observed by direct microscopy to contain more potentially dangerous bacteria than those testing negative.

Table 1 indicates that there are differences between the two study areas. This is deliberate; the areas were chosen in part because they differed in certain observed ways. In figure 2 and table 2, we further characterize some of these differences. Households in area 1 are on average of higher socioeconomic status than those in area 2; they also are at lower risk of having drinking water that tested positive for contamination. In figure 2, we use polychoric correlation matrices to combine 17 indicators of asset wealth into a single index, and to combine 8 indicators of hygiene and sanitation behaviors into another index (Kolenikov and Angeles 2009, Filmer and Pritchett 2001). Households' self-reported hygiene and sanitation behavior is less healthy on average in area 2 than in area 1. Area 2 is more asset poor on *average*, but the *variance* is larger for area 1. There is substantial overlap in the support of the two within-area distributions—especially with regard to hygiene and sanitation.

One of the main reasons for choosing these two areas for this experiment is shown in first row of table 2. Piped water infrastructure coverage in area 1 is higher than that in area 2; accordingly, almost no households in area 2 use water supplied through piped networks to their home or yard as their primary source. Households in area 1 were also more familiar with chemical water treatment products like Aquatabs, although almost nobody in either area used them. Educational differences between the areas are consistent with the other socioeconomic differences observed in figure 2 and table 1. Diarrheal disease risk and water contamination risk were both higher in area 2. The last two rows of table 2 provide more detail on the differences that are presented graphically in figure 2. We conclude the discussion of between-area differences by emphasizing that although hygiene/sanitation index scores were lower in area 2, and contamination risk was higher, we nonetheless observed that an individual household's hygiene/sanitation score was a poor predictor of the contamination test result of its water. Each standard deviation increase in the hygiene/sanitation score is associated with only a 1.8 percentage point decline in risk of a positive test, and furthermore the standard error around that association is 1.4 percentage points (results not shown).

4.2 Balance Tests

A randomly selected 431 households were shown the result of their own contamination test. Table 3 reports the result of balance tests for that random assignment. The first column of table 3A reports the mean and standard error of the difference between the "informed" and "uninformed" columns from table 1. Of the 14 characteristics tested, 1 was observed to be unbalanced at the 10 percent level (with informed households being less likely to report doing at least 3 of 6 recommended protective behaviors at Round 1). Many of our analyses are stratified by test result and by area. By design, the treatment assignment is orthogonal to these stratifying characteristics; the rest of table 3A and table 3B confirm that relevant characteristics are also balanced *within* area and result strata. However, as we showed in tables 1 and 2, water from the vast majority of households tested positive for contamination; the last row indicates that there were only 82 uncontaminated households in area 1, and 28 in area 2. Accordingly, tests of information effects among uncontaminated households, further stratified by area, are likely to be underpowered; we thus only report a restricted set of such results.[3]

4.3 Main Results

Our main analyses begin with table 4, which shows estimates of θ from regression equation [1], with reported beliefs about the safety of the household drinking water source on the left-hand side. Covariates include perceptions as measured at the pre-baseline interview, a year prior to testing; in that sense, estimates indicate the impact of information revelation on the updating of beliefs. The top panel examines the effect of information revelation on beliefs as reported at the round 1 interview (at the same time that the signal was observed by the informed households); the bottom panel, beliefs as reported at the round 2 interview (six weeks later). Consistent with our discussion in section 2, the results in table 4 indicate that in both areas, observing a test result that indicates contamination drove households to become more pessimistic about the safety of their water sources. However, that effect was statistically indistinguishable from zero for households in area 1; by contrast, the effect of the information signal is almost 4 times stronger and is significantly different from zero for households in area 2. Observing a test result indicating the absence of contamination has the opposite effect, and is again stronger in magnitude

[3] In addition to low power, analyses involving small numbers of households might raise concerns about whether hypothesis tests that rely on asymptotic properties of the test statistic are appropriate. We have retested all hypotheses discussed in this section using resampling methods (Efron and Tibshirani, 1994), rather than relying on distributional assumptions of the test statistic. All of our inferences are robust to this alternative approach.

and statistically significant only in area 2. The effects of information on beliefs appear stable over the six week follow-up period.

Why does the same information signal drive households in area 2 to change beliefs about the safety of their water source, but not in area 1? As we discussed in section 4.1, adult household members in area 1 had higher levels of educational attainment and asset wealth than in area 2, and reported sanitation and hygiene behavior was healthier in area 1 than in area 2. If socioeconomic status or propensity to engage in healthier hygiene/sanitation behavior is related to, for example, ability to understand and interpret the test result or the diffuseness of prior beliefs about water quality, then this could generate variation in the impact of the information signal on beliefs. Within each area, we find no evidence that the degree of updating varies systematically with education or wealth, but we do find evidence that observing a contaminated result has a stronger effect on the beliefs of households whose hygiene and sanitation behavior was less healthy at the time that the signal was revealed (results not shown). The signal of possible contamination may have deviated more from expectation for these households, or their prior beliefs may have been more diffuse. Notwithstanding these observations, we emphasize that this study cannot settle the empirical question about why belief updating may differ across the two areas. Our data, experimental design, and sample size do not allow us to identify how information effects are conditioned on specific individual or contextual characteristics like socioeconomic status, education, prior beliefs, trust in the H_2S test result, or the quality of water infrastructure.

Having observed that a signal of possible contamination only had a significant effect on beliefs in area 2, we next investigate how the signal affected behavior in the two areas. Table 5 reports estimates of θ from equation [1] with Round 1 purchase of Aquatabs on the left-hand side, stratified by area and by test result.

The top row indicates that the information signal had no significant effect on area 1 households' propensity to purchase Aquatabs, regardless of the result; this is arguably consistent with the patterns in table 4, which indicated that the signal had no effect on these households' perception of the risk (conditional on status quo behavior) that their drinking water was "safe." The results in the second row, however, indicate a substantially different story in area 2. In that area, 53% of households who tested positive for contamination but who were not informed of that fact purchased Aquatabs. The first column in the second row indicates that simply informing households about their positive test result increased the propensity to purchase by about 23% (12.2 percentage points). Observing a signal that their water was uncontaminated had the opposite effect. These also parallel the effects of information on beliefs in area 2.[4]

Overall among households that purchased Aquatabs, 90% bought 6 or fewer strips, which translates to 60 or fewer tabs. If those households consumed the recommended 2.5 liters of drinking water per person per day, and followed usage recommendations, which are to add one tab to every 20 liters of drinking water, then virtually all of would them would have depleted their supply of Aquatabs between the two survey rounds. However, in analyses not shown, we observed that information had no effect on the purchase of additional Aquatabs at the round 2 interview, which raises questions about the persistence of the effect.

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[4] However, when we estimate the effects of the contamination signal *conditional* on belief updating by adding flexible controls for a household's pre-baseline and round 1 reported beliefs that their water is "safe," we observe no change in the difference between the two areas in the signal's effect on purchase (results not shown). This indicates that even when the information treatment had similar effects on the beliefs of a household in area 1 and a household in area 2, the two households' propensity to purchase Aquatabs was not similarly affected. The dynamics by which information affects beliefs and behavior is likely to be complicated by complementarities between updating, wealth, quality of public infrastructure, and other contextual characteristics like the local disease environment and externalities associated with neighbors' behaviors.

It is possible that households did not replenish their supplies because they still had Aquatabs on hand, or because they had decided that they did not like the product. At the end of the Round 1 visit, households who purchased Aquatabs were told, “We will return in about six weeks to see how the product is working for you. At that time, only if you have kept the packaging—for both used and unused tablets—we will give you a gift.” Despite the extrinsic incentive, only about three-fifths of households who had purchased Aquatabs in round 1 kept their packaging and presented it at the round 2 visit. Therefore, it is difficult for us to investigate the longer-term effects of the information signal on Aquatabs use—including for example whether those who purchased them went on to become regular users, intermittent users, or non-users. Nonetheless, of those who still had their packaging, only about a third had used more than half of the Aquatabs they had purchased, implying that at least among that group, compliance with usage recommendations was low.

In table 6, we decompose the information effects reported in table 5. In each area, the information effects sum to zero by construction, since each row represents one of four mutually exclusive and communally exhaustive outcomes. The bottom three rows of the third column indicate that in fact, the information signal appears to have mostly increased the propensity of households to purchase Aquatabs, but then to not use most of them over the 6 weeks between survey rounds—a slower rate of consumption than the usage recommendations imply.

Does this mean that the effect of information on behavior waned over the 6 week followup period? Some households who purchased Aquatabs might have decided to stop using them, for example if they decided that water treated with Aquatabs tastes bad; abandonment of similar technologies over time has previously been documented in the literature on water point-of-use water treatment (Luoto et al. 2012). However, abandonment is not the only possibility. Some households may ration or hoard their Aquatabs—for example by not treating all their water, or by using a tab to treat more than the recommended 20 liters—in order to make their supply last longer or make sure the tabs will be available when they feel a particular need to use them (for example, during outbreaks of diarrheal disease).

We did not request any explicit ex post rationalization from households for why they consumed the Aquatabs they purchased at a slower rate than usage recommendations would imply. However, one question in the Round 2 survey may shed light on whether households who purchased Aquatabs had entirely abandoned their use. Respondents were asked, "Does your household use a chemical disinfectant—like bleach, chlorine, etc.—to treat your drinking water?" Possible answers included that the household "never uses" a disinfectant, "is currently using" a disinfectant, "sometimes uses, but is not currently using" a disinfectant, or "only rarely uses/uses as needed" a disinfectant. Virtually all (99.5%) of the households who reported "currently using" a disinfectant in round 2 had purchased Aquatabs in round 1, consistent with the fact that very few disinfectant products were available elsewhere in the market. Among those who purchased Aquatabs, only about 20% reported that they were still "currently using" disinfectants as of the Round 2 interview. It seems reasonable to expect that these households would have been more likely to have used Aquatabs regularly over the span of those six weeks In the top row of table 7, we investigate whether the information signal had any impact on a household's likelihood of reporting in the round 2 interview that they were "currently using" a chemical disinfectant. The results in the top row of table 7 present a contrasting picture from those in table 6, and the contrast may have important implications for information interventions. On the one hand, a signal indicating possible contamination increased households' propensity to report that they are still "currently using" a chemical disinfectant, even six weeks after they observed it. On the other hand, the evidence seems to indicate that this self-reported "current use" was substantially below recommended intensity, and may therefore not have had the intended effect of improving their health. This may reflect misreporting (that is, the signal may increase respondents' propensity to give a report that they believe interviewers want to hear, even if that report is false), or it may reflect discrepancies between how respondents understand their own behavior and the functional implications of that behavior. Either way, the ultimate health impacts of information provision were likely curtailed by the fact that nearly two-thirds of households who purchased Aquatabs used them less intensively than recommendations would imply, and nearly 80% of purchasers reported not "currently using" them on the day of the Round 2 interview.

Using Aquatabs is not the only protective behavior available to households; during the Round 1 visit, they were specifically reminded of 6 actions other than treatment with chemical products like Aquatabs that could reduce their health risks from drinking potentially contaminated water: 1) boiling or filtering their water; 2) storing drinking water for no more than a day before drinking it; 3) washing hands with soap "especially after using the toilet, handling child feces, cleaning animals, and so on"; 4) regularly cleaning their water storage container; 5) using a clean utensil or tap to extract drinking water, rather than letting it come in direct contact with hands; and 6) keeping storage containers securely covered whenever possible. In the second row of table 7, we report the estimated impacts of information revelation on these behaviors. At the round 2 interview, half of households reported engaging in up to two of these behaviors routinely; therefore, we test whether information revelation affects the likelihood of engaging in 3 or more of these behaviors. Information had a stronger effect on this outcome in area 1, compared with area 2—opposite to the pattern of information impacts on Aquatab purchase and on belief updating. Most of this effect is driven by an impact of information revelation on self-reported hand washing behaviors in Round 2; when we tested the 6 behaviors one by one, we found hand washing to be the only one that was significantly affected by information revelation (results not shown). Hand washing is likely to be substantially cheaper in terms of time and effort when piped water is more readily available, as it is in area 1.

Notwithstanding its effects on beliefs and behavior, the information signal did not appear to improve the safety of drinking water. In analyses not shown here, we tested whether information revelation had any reduced-form effect on two important health outcomes: self-reported diarrheal disease prevalence, and water quality as revealed by the H_2S test. There is no evidence that revealing test results had any effect on the risk of diarrheal illness in either area—in fact, in area 2 we observe a slightly *higher* risk of reported illness among those who had been shown their test result, although the difference is not significantly different from zero at any traditional confidence level. We also observe that among households who had tested positive for contamination during the round 1 visit, those who observed the test result were only 3.0 percentage points more likely to have remedied the problem such that their water tested negative by the round 2 visit; however, that difference is also not significantly different from zero. Among those 55 households who specifically provided a sample of Aquatabs-treated water, the contamination levels were much lower – 22% and 34% in areas 1 and 2, respectively – than baseline levels (80% and 93%).

5. Conclusion

We implemented a randomized experiment to test the impact of information about potential drinking water contamination on water and hygiene-related risk avoidance behaviors. By testing a sample of drinking water from *every* household—including those who did not observe the results of the test, we are able to isolate the effects of the *signal* of possible contamination from the effects of having water tested, or of merely being at *risk* of contamination. We purposively selected two distinct study locations—which differed from each other in terms of the quality of water infrastructure, local disease environment, and average socioeconomic status—in order to examine whether and how the impacts of the signal varied conditional on these characteristics.

The logic behind information interventions generally follows from the observation that water-related risks are invisible and difficult to fully appreciate, in which case, people may benefit from direct, salient information indicating their level of risk. For example, prior research in our study location has shown that individuals' perceptions of the risk posed by their own drinking water appear unrelated to objective measures of health risk (Jeuland et al. 2013). Meanwhile, studies in other locations have indicated that revealing information that is salient and personalized does affect adoption of protective behaviors where the risk of diarrheal disease is high (Lucas, Cabral, and Colford Jr 2011). Still, these studies leave open questions about whether and how the information in the message is understood by target beneficiaries, whether effects on behavior persist over time, whether and how responses to information vary with context and household characteristics, and whether behavioral change is sufficient to positively affect water quality and health outcomes. Understanding the answers to these questions is important to the design of more effective interventions.

Our experiment sheds light on each of these issues. First, we find that the content of the information provided by the water quality tests did affect households' subjective beliefs about the risks posed by their drinking water source. Households who tested positive for contamination and observed that result revised upward their beliefs about risks that their drinking water sources posed to health relative to those who tested positive and did not observe the result; the opposite pattern was observed among those who tested negative. Six weeks later, the effects of information revelation on beliefs had not waned. This effect on beliefs was much stronger (by a factor of four), however, and only statistically significant, in area 2. This may indicate that households in area 1 had less diffuse prior beliefs than those in area 2. They may also have internalized the information in a different way, for example not trusting that the tests were reliable.

We next considered behavioral responses to this information, focusing especially on households' willingness to purchase and use a chemical product known by its trade name "Aquatabs," which reduces contamination of drinking water by chlorinating it. Similarly to previous studies (Hamoudi et al. 2012, Jalan and Somanathan 2008), we found that the provision of household-specific information on water contamination increases the short-term demand for water treatment. Importantly, we only observed this effect in the location with poorer quality infrastructure and lower average socioeconomic status; households in the informed group in that location were about 12 percentage points more likely to purchase Aquatabs (corresponding to a more than 20% increase in purchasing rates relative to the uninformed group). This effect was only seen among households that tested *positive* for signs of contamination. Consistent with these increased purchases, we also found that in that same area, observing a positive result for contamination of drinking water increased the households' propensity to report that they were "currently using" Aquatabs during a follow-up visit 6 weeks later. Notwithstanding this pattern in self-reported behavior, these households were found to be using Aquatabs less intensively than is recommended.

In contrast to these results for area 2, the provision of water quality information did not significantly change purchase or use of Aquatabs in area 1. Nonetheless, information revelation did affect the reported propensity to engage in another protective behavior– hand washing with soap. This variation in results across the two sampled areas suggests that the effects of information on risk-avoidance behavior may vary with context. Our sample size, measurement, and experimental design do not allow us to distinguish what about these contexts drove the heterogeneity in observed effects. Nonetheless, worthwhile objectives for future experiments would include identifying the extent to which socioeconomic characteristics, prior hygiene/sanitation behaviors, experience with health protective technologies, quality of local infrastructure, and local disease environment condition how a household internalizes and reacts to information. Each of these factors varied across our two study locations.

The information treatment involved visits on two consecutive days (the water sample was collected on the first day and incubated overnight; the next day, the result was observed and Aquatabs were offered). By contrast, the uninformed households received only a single visit. Might some of the observed treatment effects reflect not just the effect of information, but also the fact that two visits to a household have a more powerful effect on behavior than just one visit? This seems unlikely, since it would not explain why impacts on purchasing behavior and on perceived risk varied based on the test outcome, or why they were significant in one area but not the other.

A subset of the households in area 1 had some prior experience with Aquatabs from an earlier study; it might therefore be reasonable to surmise that the reason these households did not respond to evidence of contamination with more purchase of Aquatabs was due to dissatisfaction with the taste or other aspects of the product (Luoto et al. 2012, Kremer and Miguel 2007). However, prior experience with Aquatabs specifically is unlikely to explain why households in area 1 were also less likely to revise their beliefs about health risks in response to a signal of possible contamination.

Finally, despite the fact that information provision increased demand for Aquatabs, we did not detect significant changes in self-reports of diarrheal disease or in results of subsequent water quality tests. This may reflect the fact that the product appears to have been used less intensively than recommended. It may also reflect the fact that diarrheal disease is related to a complex set of behaviors, such that the induced adjustments in behavior were insufficient to improve these outcomes (Boisson et al. 2013). Finally, it may be that our study was not powered to detect such impacts, or, for the case of diarrheal disease reports, may reflect limitations inherent in self-reported health outcomes (Zwane et al. 2011). Larger samples, more precise measures of water quality and illness, and careful consideration of the confounding effects of seasonality on water quality and diarrheal disease risk may be necessary to detect the effects of information revelation on these outcomes. For example, in this study, we observed roughly 50% lower two-week prevalence of diarrheal disease in round 2 than in round 1.

In conclusion, our results indicate that interventions to provide salient information about health risks may sometimes affect beliefs and behavior—thus implying that that there may be contexts in which disease prevalence remains unnecessarily high because risks are not recognized or fully appreciated. Yet they also suggest the need for caution prior to prescribing information provision as a means to encourage uptake of specific preventive health technologies. While information provision is often cheap, it may not always be effective, either due to heterogeneity in responses to it, or because the induced responses are insufficient to improve outcomes. Elucidating questions around how and why relationships between information, beliefs, and behavior vary across different contexts may help to inform more effective interventions, and may therefore be a valuable direction for future research.

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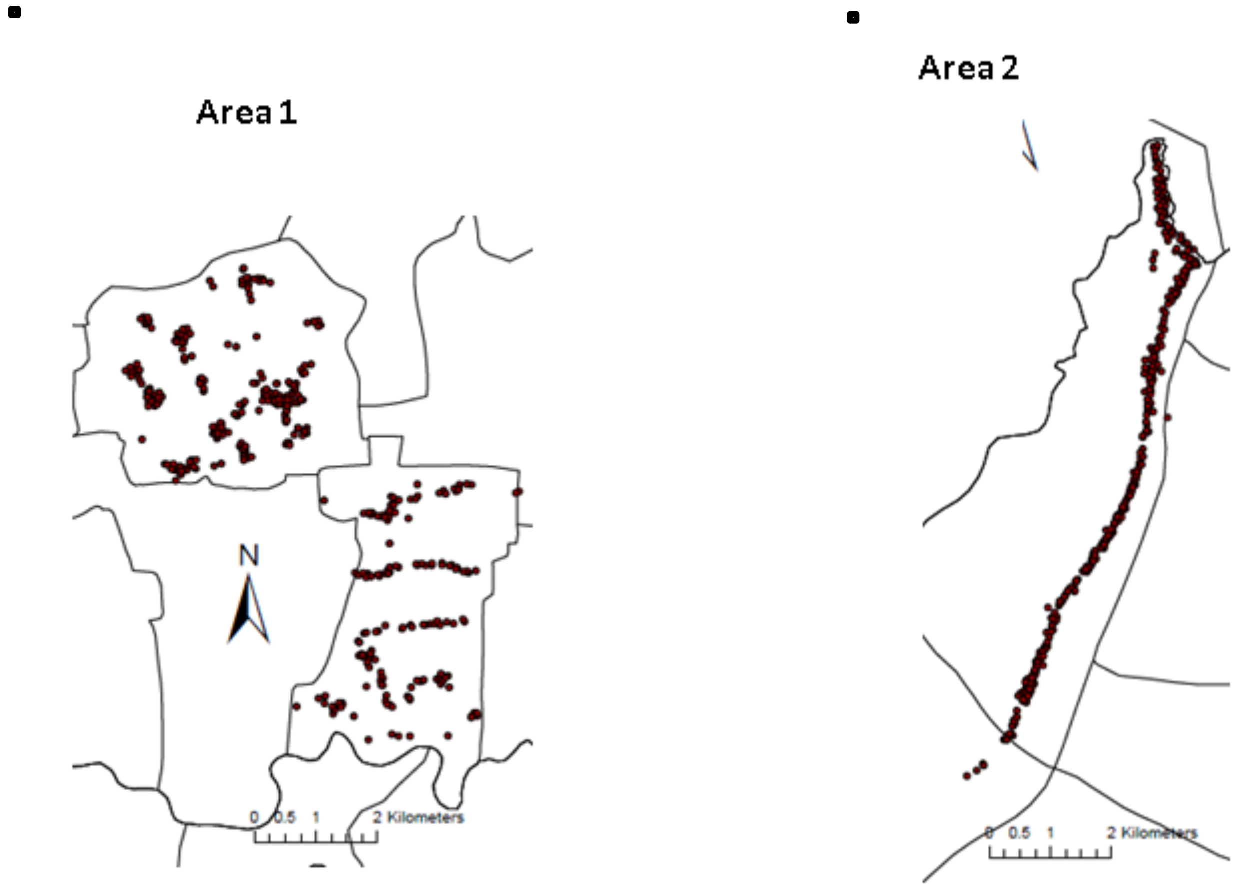
Figure 1. Map of Survey Household Locations



NOTES FOR FIGURE 1: Participant households were identified by selecting every 8th household in area 1, and every 5th household in area 2 in order to obtain a representative sample of residents in the two zones. The areas themselves were chosen purposively based on characteristics identified in an earlier 2011 study. For more details, see section 3.1 in the text.

Table 1. Summary Statistics, Analytical Sample

Characteristic		*Statistic*	Overall sample	*Informed of result? (randomized)* Informed	Not Informed	*Study Area* Area 1 (Less Poor)	Area 2 (More Poor)
A. Round 1[a] Characteristics							
Respondent's age in July 2012		*Mean [Std.Dev.]*	44.0 [14.8]	43.7 [15.1]	44.3 [14.5]	43.6 [14.9]	44.5 [14.7]
Number of adults in household		*Mean [Std.Dev.]*	3.4 [1.6]	3.4 [1.6]	3.4 [1.6]	3.7 [1.8]	3.1 [1.4]
Number of children in household		*Mean [Std.Dev.]*	1.9 [1.3]	1.9 [1.4]	1.8 [1.3]	1.8 [1.3]	1.9 [1.4]
Owned crop land (past 2 years)		*Fraction*	13.5%	13.8%	13.3%	13.5%	13.6%
Rented (in) land (past 2 years)		*Fraction*	12.6%	12.4%	12.8%	8.6%	16.5%
Leased (out) land (past 2 years)		*Fraction*	5.1%	4.9%	5.4%	2.9%	7.4%
Total household Expenditures (dollars/month)		*Median [IQR]*	150 [98, 244]	150 [98, 200]	150 [98, 244]	183 [122, 250]	112 [73, 195]
Years of education of household adults		*Mean [Std.Dev.]*	6.0 [3.1]	6.0 [3.1]	6.1 [3.2]	6.8 [3.0]	5.2 [3.1]
Asset Ownership (Number of units owned for each type of asset)	Cows	Median [Fraction owning zero]	0.0 [55.9%]	0.0 [56.1%]	0.0 [55.6%]	0.0 [56.4%]	0.0 [55.4%]
	Refrigerators		0.0 [98.7%]	0.0 [97.9%]	0.0 [99.5%]	0.0 [97.4%]	0.0 [100%]
	Fans		1.0 [48.3%]	1.0 [49.9%]	1.0 [46.6%]	1.0 [22.6%]	0.0 [74.0%]
	Televisions		1.0 [16.0%]	1.0 [18.1%]	1.0 [13.7%]	1.0 [7.6%]	1.0 [24.3%]
	Bicycles		1.0 [25.5%]	1.0 [27.8%]	1.0 [23.0%]	1.0 [26.2%]	1.0 [24.8%]
	Motorcycles		1.0 [31.6%]	1.0 [34.1%]	1.0 [28.9%]	1.0 [16.7%]	1.0 [46.5%]
	Automobiles		0.0 [91.4%]	0.0 [90.0%]	0.0 [92.9%]	0.0 [87.4%]	0.0 [95.5%]
	Tractors		0.0 [93.4%]	0.0 [94.9%]	0.0 [91.9%]	0.0 [96.4%]	0.0 [90.5%]
	Cell Phones		2.0 [9.9%]	2.0 [10.4%]	2.0 [9.3%]	2.0 [4.8%]	1.0 [15.0%]
	Mosquito Nets		3.0 [0.8%]	3.0 [0.5%]	3.0 [1.2%]	4.0 [1.2%]	3.0 [0.5%]
Reports chemically treating own drinking water, Round 1[a]		*Fraction*	0.4%	0.5%	0.2%	0.0%	0.7%
At least 3 of 6 recommended protective behaviors[b], Round 1[a]		*Fraction*	47.7%	44.5%	51.0%	53.8%	41.5%
Household drinking water test result was H_2S+ (contaminated): July 2012		*Fraction*	86.9%	88.4%	85.3%	80.5%	93.3%

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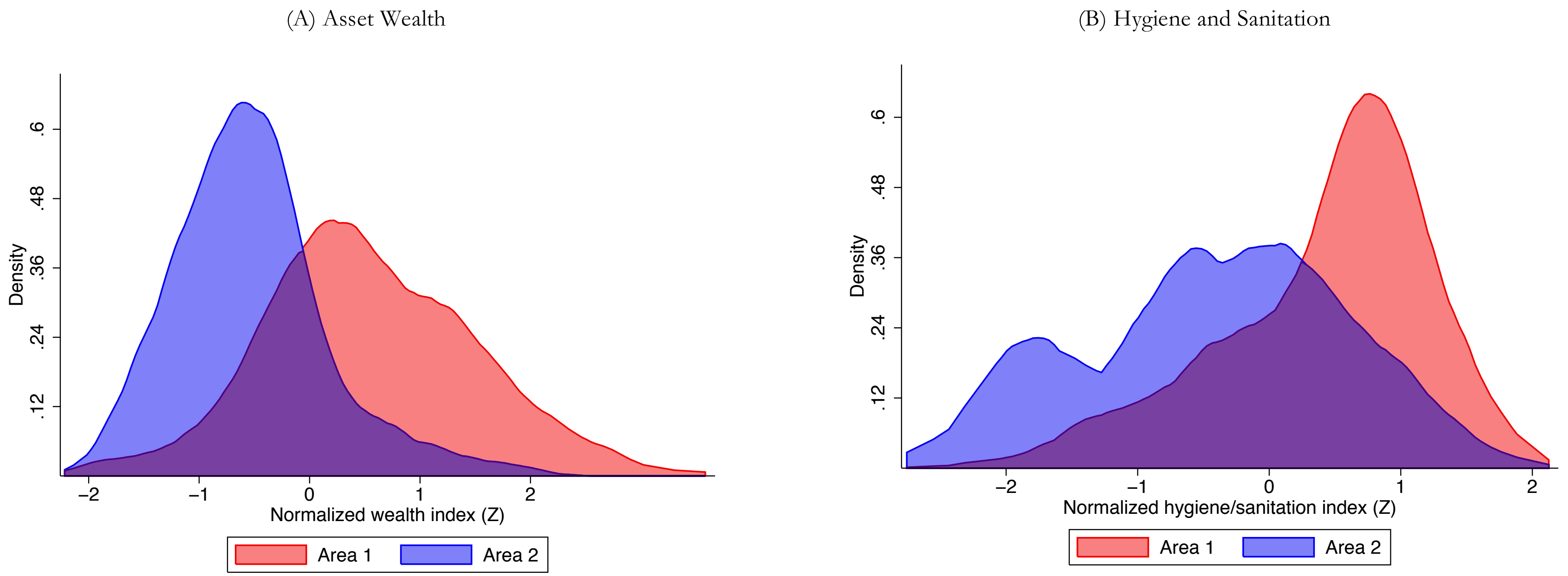
Characteristic	Statistic	Overall sample	Informed of result? (randomized) Informed	Informed of result? (randomized) Not Informed	Area A1 (Less Poor)	Area A2 (More Poor)
			B. Dependent Variables			
Purchased Aquatabs[c], Round 1[a]	*Fraction*	52.3%	55.9%	48.5%	49.0%	55.6%
Number of tabs purchased (conditional on >0)	*Mean [Std.Dev]*	3.1 [3.1]	3.0 [2.9]	3.2 [3.4]	3.4 [3.7]	2.8 [2.5]
Purchased Aquatabs[c], Round 2[a]	*Fraction*	20.7%	20.7%	20.6%	20.8%	20.6%
Reports chemically treating own drinking water, Round 2[a]	*Fraction*	11.1%	13.2%	8.8%	8.3%	13.8%
At least 3 of 6 recommended protective behaviors[b], Round 2[a]	*Fraction*	33.4%	36.0%	30.6%	40.0%	26.7%
Perceived safety of drinking water[d] (0: least safe; 10 safest): pre-baseline[a]	*Median [IQR]*	4.0 [2.0, 5.0]	3.5 [1.0, 5.0]	4.0 [2.0, 5.0]	3.0 [1.0, 5.0]	4.0 [2.0, 5.0]
Perceived safety of drinking water[d] (0: least safe; 10 safest): Round 1[a]	*Median [IQR]*	3.0 [0.0, 5.0]	3.0 [0.0, 5.0]	3.0 [0.0, 5.0]	3.0 [0.0, 5.0]	3.0 [1.0, 5.0]
Perceived safety of drinking water[d] (0: least safe; 10 safest): Round 2[a]	*Median [IQR]*	3.0 [1.0, 5.0]	3.0 [0.0, 5.0]	3.5 [1.0, 6.0]	3.0 [0.0, 5.0]	4.0 [1.0, 5.0]
Household drinking water test result was H_2S+ (contaminated): Round 2[a]	*Fraction*	83.8%	83.4%	84.2%	76.1%	91.5%
Any episodes of diarrhea previous two weeks, Round 2[a]	*Fraction*	11.3%	12.1%	10.5%	6.7%	16.0%
Number of respondents		*839*	*431*	*408*	*420*	*419*

NOTES FOR TABLE 1: The analytical sample comprises these 839 households, divided about evenly across two areas as shown in the right two columns. The protective behaviors ("boils water" up to "cleans storage container at least once per week") are measured through self-reports during the Round 2 (August 2012) household interview. In Round 1 (July 2012), all households had drinking water tested for bacterial contamination with a hydrogen sulfide diagnostic kit. "Informed" versus "uninformed" status (middle two columns) was randomly assigned; only the 431 "informed" households observed the result of their hydrogen sulfide test.

a- Pre-baseline occurred in Summer 2011; Round 1, July 2012, and Round 2, about 6 weeks after Round 1. For more details on the project timeline, see section 3.1 in the text.
b- Respondent households were specifically briefed on six behaviors—in addition to chemical treatment—that they could undertake to protect themselves against health risks from contaminated drinking water. These included boiling or filtering water, storing drinking water for no more than a day before drinking it, washing hands with soap frequently, washing storage containers between uses, avoiding direct hand contact with drinking water, and securely covering all water storage containers. This briefing occurred during the round 1 visit, *after* households had already answered questions about whether they engaged in each of these behaviors.
c- "Aquatabs" is a trade name for a chemical treatment product produced by Medentech that disinfects drinking water by chlorinating it.
d- Perceived safety was measured by giving respondents 10 candies, and asking them to distribute the candies into two piles—one representing the likelihood that their water is safe for them to drink, and the other representing the likelihood that it is not (Delavande et al. 2011).

Figure 2. Differences Between Area 1 and Area 2: Hygiene/Sanitation and Wealth



NOTES FOR FIGURE 2: We constructed polychoric correlation matrices among discrete indicators of asset wealth (panel (A)) or hygiene and sanitation(panel (B)) for the 839 households described in table 1. We extracted from each matrix the first principal component, which we then normalized to have mean 0 and variance 1 (Filmer & Pritchett 2001; Kolenikov & Angeles 2009); these serve as our "hygiene/sanitation index" and "wealth index." Panel (A) indicates the smoothed distribution (Epanechikov kernel density estimator) of the asset wealth index across the 420 households in area 1 (red) and the 419 households in area 2 (blue); panel (B), the smoothed distributions of the hygiene/sanitation index.

Panel (A) is based on 17 indicators: whether the household owns any refrigerator(s), automotive vehicle(s), tractor(s), horse(s), or goat(s) (binary indicators), the number that it owns of electric fans (0 to 4), televisions (0 to 3), bicycles (0 to 4), motorcycles (0 to 3), mobile phones (0 to 6), bednets (0 to 7), cows (0 to 6), and pigs (0 to 3), materials used in the home for flooring (0: dirt, up to 5: tile), for walls (0: thatch, up to 7: stone), and for roofing (0: thatch, up to 4: metal), and three binary indicators for whether there was more than one material used for flooring, walls, and roofing. The variables are coded such that a higher score on the index indicates a higher degree of asset wealth.

Panel (B) is based on 8 indicators: whether the respondent had soap on hand in the household when the interviewer asked to see it (binary indicator), whether the interviewer observed animal feces in the living compound (binary indicator), whether the household boils or filters drinking water (two binary indicators), how often the household cleans the primary water storage container (0: never, up to 4: every day), whether household members primarily use a latrine or other sanitary facility when defecating (binary indicator), and how long the household stores drinking water (1: more than a week, up to 4: less than a day). The variables are coded such that a higher score on the index indicates a higher degree of hygiene and sanitation.

Table 2. Round 1[a] Differences Between Area 1 and Area 2: Hygiene/Sanitation and Wealth

Household characteristic	Average in A1	Average in A2	Δ[b]
Primary water source is piped (percentage points)	14	1	13.3 [3.8]
Familiar[c] with chemical treatment products (percentage points)	65	50	14.9 [4.0]
Uses a chemical product to treat drinking water (percentage points)	3.3	1.0	2.4 [1.1]
Educational attainment of **least** educated adult (years)	3.7	2.7	1.0 [0.4]
Educational attainment of **most** educated adult (years)	9.6	7.7	1.9 [0.6]
Average adult educational attainment in household (years)	6.5	4.9	1.6 [0.5]
Self-reported diarrhea prevalence (previous two weeks) (percentage points)	19	29	-9.4 [2.2]
Drinking water test result: H_2S+ (contaminated) (percentage points)	81	93	-12.6 [2.9]
Spent any cash on tobacco or alcohol, previous month (percentage points)	52	62	-10.1 [3.3]
Wealth index[d] (standard deviations)	0.54	-0.55	1.1 [0.1]
Hygiene/Sanitation index[d] (standard deviations)	0.42	-0.42	0.8 [0.1]

NOTES FOR TABLE 2: Area 1 and area 2 were chosen in part because of differences in water infrastructure (row 1). But they also differ in many observed and, almost certainly, unobserved ways as well. This table illustrates some of the observed differences between the areas.

a- Round 1 occurred in July 2012. For more details on the project timeline, see section 3.1 in the text.
b- Standard errors of differences (in square brackets) are estimated based on a bootstrap variance/covariance estimator, with resampling by village. They are robust to arbitrary forms of heteroskedasticity, and to potential non-independence of observations within villages.
c- Respondents were asked, "Have you ever heard of products that can be added to water to make it safe to drink?"
d- For more information on how the "wealth" and "hygiene/sanitation" indices were computed, see the notes to figure 1.

Table 3A. Balance Tests: All water quality results

Characteristic *Δ: (Informed of test result) – (not informed)*	Both Areas	Area 1	Area 2
Average respondent's age in July 2012	-0.6 [1.3]	-0.8 [1.3]	-0.4 [2.1]
Average number of adults in household	-0.02 [0.10]	-0.02 [0.19]	-0.02 [0.07]
Average number of children in household	0.1 [0.1]	0.1 [0.1]	0.1 [0.1]
Fraction of households owning crop land (past 2 years)	0.5% [2.4%]	1.1% [3.3%]	-0.2% [3.8%]
Fraction of households renting (in) land (past 2 years)	-0.4% [2.1%]	1.5% [3.2%]	-2.2% [1.5%]
Fraction of households leasing (out) land (past 2 years)	-0.5% [1.3%]	0.8% [1.6%]	-1.8% [2.0%]
Average log household expenditure (dollars/month)	-0.04 [0.08]	-0.03 [0.07]	-0.05 [0.15]
Average years of education of household adults	-0.09 [0.14]	-0.06 [0.21]	-0.13 [0.16]
Wealth index[a] (standard deviations)	-0.05 [0.08]	-0.02 [0.09]	-0.18 [0.14]
Hygiene/sanitation index[a] (standard deviations)	0.02 [0.05]	0.01 [0.05]	-0.01 [0.10]
Average beliefs about water safety[b] in July 2011	-0.1 [0.2]	-0.1 [0.2]	-0.2 [0.2]
Fraction reporting chemically treating their own drinking water, Round 1[c]	0.2% [0.2%]	0[e] [0]	0.4% [0.4%]
Fraction reporting at least 3 of 6 recommended protective behaviors[d], Round 1[c]	-6.1% [3.3%]	-4.6% [4.8%]	-7.6% [5.3%]
Fraction of households testing H_2S+ (contaminated) in July 2012	3.1% [2.3%]	3.0% [4.2%]	3.2% [2.3%]
Number of respondents	839	420	419

NOTES FOR TABLE 3A:

a- For more information on how the wealth and hygiene/sanitation indices were computed, see the notes to figure 1.

b- Perceived safety was measured by giving respondents 10 candies, and asking them to distribute the candies into two piles—one representing the likelihood that their water is safe for them to drink, and the other representing the likelihood that it is not (Delavande et al. 2011). Balance test was conducted using an ordered logit regression specification; log odds are reported in the table. Linear regression produces similar results in terms of sign and significance.

c- Pre-baseline visit occurred in Summer 2011; Round 1, in July 2012. For more details on timeline, see section 3.1 in the text.

d- Respondent households were specifically briefed on six behaviors—in addition to chemical treatment—that they could undertake to protect themselves against health risks from contaminated drinking water. These included boiling or filtering water, storing drinking water for no more than a day before drinking it, washing hands with soap frequently, washing storage containers between uses, avoiding direct hand contact with drinking water, and securely covering all water storage containers. This briefing occurred during the round 1 visit, *after* households had already answered questions about whether they engaged in each of these behaviors.

e- *All* households in this cell were identical in terms of this outcome.

Table 3B. Balance Tests: Only households with positive (contaminated) water quality results

Characteristic *Δ: (Informed of test result) – (not informed)*	Both Areas	Area 1	Area 2
Average respondent's age in July 2012	-1.5 [1.3]	-2.3 [1.5]	-0.8 [1.9]
Average number of adults in household	-0.02 [0.11]	-0.05 [0.23]	-0.01 [0.04]
Average number of children in household	0.1 [0.1]	0.0 [0.14]	0.1 [0.1]
Fraction owning crop land (past 2 years)	0.5% [2.7%]	0.6% [4.7%]	0.3% [3.0%]
Rented (in) land (past 2 years)	-0.0% [2.2%]	1.6% [3.7%]	-1.3% [2.0%]
Leased (out) land (past 2 years)	-0.2% [1.4%]	2.1% [1.7%]	-2.2% [2.2%]
Average household expenditure [**ln**(dollars/month)]	-0.02 [0.07]	-0.02 [0.07]	-0.01 [0.13]
Average years of education of household adults	0.0 [0.2]	0.1 [0.3]	-0.1 [0.2]
Wealth index[a] (standard deviations)	-0.01 [0.09]	0.04 [0.11]	-0.19 [0.15]
Hygiene/sanitation index[a] (standard deviations)	0.01 [0.05]	-0.01 [0.06]	-0.01 [0.12]
Average beliefs about water safety[b] reported at pre-baseline[c] visit	-0.2 [0.2]	-0.2 [0.3]	-0.3 [0.2]
Fraction reporting chemically treating their own drinking water, Round 1[c]	0.2% [0.3%]	0[e] [0]	0.4% [0.5%]
Fraction reporting at least 3 of 6 recommended protective behaviors[d], Round 1[c]	-5.7% [3.6%]	-4.8% [5.6%]	-6.4% [4.3%]
Number of respondents	729	338	391

NOTES FOR TABLE 3B:

a- For more information on how the wealth and hygiene/sanitation indices were computed, see the notes to figure 1.

b- Perceived safety was measured by giving respondents 10 candies, and asking them to distribute the candies into two piles—one representing the likelihood that their water is safe for them to drink, and the other representing the likelihood that it is not (Delavande et al., 2011). Balance test was conducted using an ordered logit regression specification; log odds are reported in the table. Linear regression produces similar results in terms of sign and significance.

c- Pre-baseline visit occurred in Summer 2011; Round 1, in July 2012. For more details on timeline, see section 3.1 in the text.

d- Respondent households were specifically briefed on six behaviors—in addition to chemical treatment—that they could undertake to protect themselves against health risks from contaminated drinking water. These included boiling or filtering water, storing drinking water for no more than a day before drinking it, washing hands with soap frequently, washing storage containers between uses, avoiding direct hand contact with drinking water, and securely covering all water storage containers. This briefing occurred during the round 1 visit, *after* households had already answered questions about whether they engaged in each of these behaviors.

e- *All* households in this cell were identical in terms of this outcome.

Table 4. Effect of Information Treatment on Updated Perceptions of Safety

Dependent Variable: Perceived safety of water [0: least likely to be "safe to drink"; 10: most likely—integer values only]	*Information effect, stratified by geographic area* Area 1	 Area 2	Δ
Round 1[a]: Same day that information was revealed			
H2S+ (contaminated) test result only	-0.20 [0.26]	-0.88 [0.37]	0.71 [0.48]
H2S- (uncontaminated) test result only	0.30 [0.70]	3.05 [0.43]	-3.43 [0.70]
Round 2[a]: Six weeks after information was revealed			
H2S+ (contaminated) test result only	-0.32 [0.28]	-1.00 [0.24]	0.65 [0.42]
H2S- (uncontaminated) test result only	1.11 [0.61]	3.48 [0.38]	-2.32 [1.04]

NOTES FOR TABLE 4: Each cell represents a separate estimation of regression equation [1] from section 3.3 of the main text; it reports the estimated value of θ from that regression. The dependent variable for each regression is a measure of respondents' perceptions about the safety of their drinking water. Perceived safety was measured by giving respondents 10 candies, and asking them to distribute the candies into two piles—one representing the likelihood that their water is safe for them to drink, and the other representing the likelihood that it is not (Delavande et al. 2011). The dependent variable in each regression is the number of candies that the respondent placed in the pile indicating the likelihood that their water is safe for them to drink. Covariates in each regression include indicators for responses to analogous questions at the pre-baseline interview, a year prior to testing; therefore, estimates reflect the impact of information revelation on the *updating* of beliefs. Standard errors (reported in square brackets) are robust to arbitrary forms of heteroskedasticity and non-independence within villages; they are computed using a bootstrap estimator of the variance/covariance matrix, resampling villages.

a- Round 1 visit occurred in July 2012; round 2, August 2012. For more details on experiment timeline, see section 3.1 of the text.

Table 5. Information Effects on Purchase of Aquatabs in Round 1[a]

Dependent Variable: 100 if purchased Aquatabs at Round 1[a] visit; otherwise 0 [Linear Probability Model]	*Information effect, stratified by Round 1[a] water test result*	
	H_2S+ (**contaminated**)	H_2S- (**uncontaminated**)
Area 1	3.6 [5.0]	4.0 [15.7]
Area 2	12.2 [3.4]	-29 [20]
Δ	-8.6 [6.5]	33 [24]

NOTES FOR TABLE 5: Each cell represents a separate estimation of regression equation [1] from section 3.3 of the main text; it reports the estimated value of θ from that regression. In area 1, 48% of uniformed households who tested positive purchased Aquatabs, and 44% of uninformed households who tested negative; in area 2, the corresponding fractions were 53%, and 52%. For details on stratum-specific sample sizes, see the bottom rows of table 3B. "Aquatabs" is a trade name for a chemical treatment product that disinfects drinking water by chlorinating it. Standard errors (reported in square brackets) are robust to arbitrary forms of heteroskedasticity and non-independence within villages; they are computed using a bootstrap estimator of the variance/covariance matrix, resampling villages. Regressions include interviewer fixed effects (in order to absorb variation in salesmanship across interviewers, who were responsible for selling the Aquatabs).

a- Round 1 visit occurred in July 2012. For more details on experiment timeline, see section 3.1 of the text.

Table 6. Effect of information on Aquatabs use between round 1 and round 2
Sample restricted to households testing H_2S+ (contaminated) in round 1 only

Effect of information on the percent of households in each area who...	Area 1		Area 2	
	Information effect (percentage points)	Number of households	Information effect (percentage points)	Number of households
... did not purchase Aquatabs in Round 1	*-3.6* *[4.7]*	*214*	*-12.2* *[3.1]*	*186*
... purchased Aquatabs in Round 1, and presented **primarily used**[b] packaging during Round 2 interview	-2.0 [2.6]	31	-1.4 [4.2]	57
... purchased Aquatabs in Round 1, and presented **primarily unused**[b] packaging during round 2 interview	4.7 [3.9]	75	12.8 [2.5]	98
... purchased Aquatabs in Round 1, but **did not present any** packaging at round 2 interview	0.9 [3.3]	100	0.8 [4.6]	78

NOTES FOR TABLE 6: Each row in the first column for each area represents a separate estimation of regression equation [1] from section 3.3 of the main text; it reports the estimated value of θ from that regression. Estimates indicate the difference in the prevalence of that outcome among the informed versus uninformed treatment arms in percentage point terms. The four outcomes are mutually exclusive and communally exhaustive, so differences add to zero by construction. "Aquatabs" is a trade name for a chemical treatment product that disinfects drinking water by chlorinating it. Standard errors (reported in square brackets) are robust to arbitrary forms of heteroskedasticity and non-independence within villages; they are computed using a jackknife estimator of the variance/covariance matrix, resampling villages. Regressions include interviewer fixed effects.

a- Round 1 visit occurred in July 2012; the Round 2 visit, about 6 weeks later. For more details on timeline, see section 3.1 of the text.
b- "Primarily used" means they presented used packaging accounting for more than 50% of the Aquatabs they purchased. "Primarily unused" means they presented unused packaging account for more than 50% of the Aquatabs they purchased.

Table 7. Information Effects on Reported Behaviors: Round 2[a]

Dependent Variable: 100 if household reports behavior indicated in row title at Round 2[a] visit; otherwise 0 [Linear Probability Model]	Information effect, stratified by area: **H_2S+ (contaminated) only**		
	Area 1	Area 2	Δ
Chemical treatment of drinking water	2.2 [3.1]	8.1 [1.8]	-5.9 [4.1]
At least 3 of 6 other recommended protective behaviors[b]	13.5 [4.6]	0.85 [1.8]	12.7 [4.7]

NOTES FOR TABLE 7: Each cell represents a separate estimation of regression equation [1] from section 3.3 of the main text; it reports the estimated value of θ from that regression. The dependent variable for each regression is given in the row title. Estimates indicate the difference in prevalence among the informed versus uninformed treatment arms in percentage point terms. Standard errors (reported in square brackets) are robust to arbitrary forms of heteroskedasticity and non-independence within villages; they are computed using a bootstrap estimator of the variance/covariance matrix, resampling villages.

a- Round 1 visit occurred in July 2012; the Round 2 visit, about 6 weeks later. For more details on timeline, see section 3.1 of the text.

b- Respondent households were specifically briefed on six behaviors—in addition to chemical treatment—that they could undertake to protect themselves against health risks from contaminated drinking water. These included boiling or filtering water, storing drinking water for no more than a day before drinking it, washing hands with soap frequently, washing storage containers between uses, avoiding direct hand contact with drinking water, and securely covering all water storage containers.