Demand for Information on Environmental Health Risk, Mode of Delivery, and Behavioral Change: Evidence from Sonargaon, Bangladesh

Ricardo Maertens
Alessandro Tarozzi
Kazi Matin Ahmed
Alexander van Geen*

August 2018

Abstract

Millions of villagers in Bangladesh are chronically exposed to arsenic by drinking contaminated water from private wells. Free testing for arsenic has been shown to encourage households with unsafe wells to switch to safer sources that are often within walking distance. However, the safety status of millions of tubewells remains unknown because there is no well-established market for well tests and wells continue to be installed. We describe results from a cluster randomized controlled trial conducted in 112 villages in Bangladesh, to determine, first, to what extent charging a modest fee for an environmental test limits demand. Second, we evaluate whether either informal inter-household agreements to share water from wells that are found to be safe, or visual reminders of well status in the form of metal placards mounted on the well pump, can increase risk-mitigating behavior. At a price of about USD0.60, only one in four households purchased a test and sales were not increased by risk-sharing agreements or visual reminders. However, switching away from an unsafe wells almost doubled in response to agreements or placards relative to the one in three proportion of households who switched away from an unsafe well after only purchasing a test.

JEL: I12, I15, I18, Q53
Key words: Arsenic, Bangladesh, Environmental Health Risk

*We are very grateful to Prabhat Barnwal for conversations about risk-sharing that started this project. We acknowledge partial support from the Earth Clinic at the Earth Institute, Columbia University and from NIEHS grant P42 ES010349. We thank Dr. Zahed Masud of the Arsenic Mitigation and Research Foundation for obtaining the necessary approvals in Bangladesh and for managing the finances of the project. We are also grateful to the survey team and in particular Ershad Bin Ahmed for their work during the data collection. We also thank Mr. Saifur Rahman from the Department of Public Health Engineering for his insights throughout the project concerning arsenic mitigation. The paper benefited from constructive comments and suggestions from many colleagues at Lund University, Helsinki Center of Economic Research, the Workshop on Health Economics and Health Policy (Heidelberg), Université Catholique de Louvain, University of Bristol, Venezia Cà Foscari, CEPREMAP India-China Conference (PSE, Paris), the VI Navarra Center for International Development (Fundación Ramón Areces, Madrid), Oxford (CSAE), Stanford, Uppsala, Università di Torino, Waikato University, and the 14th CEPAR Summer Workshop in the Economics of Health and Ageing at University of New South Wales, Sydney. The study was approved by the Columbia University IRB (Protocol AAAN9900) and the Government of Bangladesh NGO Affairs Bureau. Maertens: Department of Economics, Harvard University; Tarozzi (corresponding author), Department of Economics and Business, Universitat Pompeu Fabra, Barcelona GSE and CRES, alessandro.tarozzi@upf.edu; Ahmed, Department of Geology, Faculty of Earth and Environmental Sciences University of Dhaka, Dhaka 1000, Bangladesh; van Geen, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY10964, USA. All errors are our own.

1 Introduction

Poor health stands out as a common feature of life in less developed countries (LDCs). Several factors contribute to the persistence of the problem, ranging from the poor availability and high cost of good quality health care, to the insufficient investment in prevention, and to the frequent reliance on ineffective and sometimes unnecessarily expensive treatments, see Dupas (2012), Dupas and Miguel (2016), and Tarozzi (2016) for recent reviews. Information campaigns on health risks are sometimes seen as an appealing tool in environmental and other health policy, because they can be relatively inexpensive to run when compared to other options, such as investments in infrastructure or public health measures needed to eliminate the risk at its root. In addition, some health conditions are in principle easily preventable if appropriate behavior is adopted to avoid environmental exposures. However, governments in LDCs may lack the resources or the political will to carry out even simple information campaigns (let alone campaigns that provide reports specific to each household), and information alone is often not sufficient to promote positive changes in behavior.

In this paper, we describe the results of a randomized controlled trial (RCT) carried out in Sonargaon sub-district, Bangladesh, to study, first, demand for information on the quality of drinking water and, second, the adoption of risk-mitigating behavior conditional on the information received. Despite much progress in numerous health indicators (Chowdhury et al. 2013), Bangladesh remains in the midst of an extremely severe health crisis due to the widespread presence of low-dose, naturally occurring arsenic (As) in shallow aquifers, see Ahmed et al. (2006), Johnston et al. (2014), and Pfaff et al. (2017). The problem, due to the widespread presence in the country of geological conditions conducive to accumulation of arsenic in groundwater, is compounded by millions of households in rural areas relying on water from privately owned, un-regulated shallow tubewells for drinking and cooking. Using nationwide data from 2009, Flanagan et al. (2012) estimated that, in a country of more than 150 million people, about 20 million were likely exposed to arsenic levels above the official Bangladesh standard of 50 ppb (parts per billion, or micro-grams per liter), while almost one third of the population was likely exposed to levels above the significantly lower threshold of 10ppb adopted by the World Health Organization (WHO).

The most visible health consequences of chronic exposure to arsenic from drinking tubewell water in South Asia, such as cancerous skin lesions and loss of limb, were recognized in the state of West Bengal, India in the mid-1980s (Smith et al. 2000). It has since then been shown on the basis of long-term studies in neighboring Bangladesh that arsenic exposure increases mortality due to cardiovascular disease, and may inhibit intellectual development in children and be detrimental for mental health (Wasserman et al. 2007, Argos et al. 2010, Rahman et al. 2010, Chen et al. 2011, Chowdhury et al. 2016). These health effects are accompanied by significant economic impacts: exposure to arsenic has been estimated to reduce household labor supply by 8% (Carson et al. 2011) and household income by 9% per every earner exposed (Pitt et al. 2015), while Flanagan et al. (2012) calculated that a predicted arsenic-related mortality rate of 1 in every 18 adult deaths represents an additional economic burden of USD13 billion in lost productivity alone over the next 20 years.

Piped water from regulated and monitored supplies would likely be the most effective policy answer, but such solution would require immense investments in infrastructure that may not be sustainable or cost-effective for the foreseeable future, so that identifying short-term mitigation strategies remains essential. The consensus view now is that household-level water treatment, dug wells, and rain-water harvesting are not viable alternatives for lowering arsenic exposure, also because of the cost and logistics of maintaining such systems in rural South Asia (Ahmed et al. 2006; Howard et al. 2006; Sanchez et al. 2016). In contrast, and despite being the main source of arsenic exposure, tubewells may also offer an effective way of providing safe drinking water to the rural population of Bangladesh. With the exception of the most severely affected areas of Bangladesh, the spatial distribution of high- and low-arsenic wells is highly mixed, even over small distances. At the same time, whether a well is contaminated with arsenic or not rarely changes over time (van Geen et al. 2007; McArthur et al. 2010). Therefore, exposure among users of arsenic-contaminated wells can often be avoided by switching to a nearby safe well, be it a shallow private well or a deeper—which usually means safer—community well (van Geen et al. 2002; van Geen et al. 2003). Previous studies in Bangladesh have documented switching rates from an unsafe to a safe well after testing of between one-third and three-quarters, with higher switching rates typically coming from trials that provided information campaigns on arsenic health risks, and repeat visits, in some cases with health measurements taken (Chen et al. 2007; Madajewicz et al. 2007; Opar et al. 2007; George et al. 2012; Bennear et al. 2013; Balasubramanya et al. 2014; Inauen et al. 2014; Pfaff et al. 2017).

Well-sharing as an effective risk mitigation strategy, however, relies on knowledge about the safety of both one's own water source and that of neighbors. Between 1999 and 2005, the World Bank, DANIDA, and UNICEF, in collaboration with other NGOs and the Bangladesh Department of Public Health Engineering (DPHE), conducted a blanket testing campaign that tested with a field kit close to 5 million wells, and identified them as 'safe' or 'unsafe'—according to the Bangladesh standard of 50ppb—by painting the well spout with green or red paint, respectively. Unfortunately, such a testing campaign, coordinated through the Bangladesh Arsenic Mitigation and Water Supply Program (BAMWSP), has not been repeated. Meanwhile, millions of new wells have sprouted in the country, and in most cases users do not know the arsenic level of the water. There are a few commercial laboratories in Dhaka with the capability to test wells for arsenic, but few rural households are aware of these services.[1] The cost of well testing is greatly reduced and the logistics are greatly simplified by the use of field kits, which have become increasingly reliable and easy to use (George et al. 2012; van Geen et al. 2014), but even these tests are rarely available, and the willingness to pay for them is not known.

The first objective of this paper is to evaluate the sustainability of a market for arsenic field tests, in a context where the cost of these test (and other materials) are covered by donors, but where delivery costs are not. To this end, in 49 randomly selected villages in Sonargaon sub-district, we offered field tests at a price of BDT45 (about USD0.60, close to the price of one kg of rice in Dhaka), an amount

[1]In addition, the cost of the laboratory analysis is as high as 25-40 USD, *not including* the cost of the kits necessary for the collection of the water sample.

estimated to be just enough to cover for the salary of the surveyors hired for the project. Although in our study area we never offered the tests for free, in earlier studies conducted in neighboring locations virtually no household refused a test offered at no cost. Despite low prices and widespread awareness about the arsenic problem coupled with little information about the safety status of individual wells, we found that only about one in four households purchased the test. In this arm, conditional on learning about the unsafe status of one's drinking water, we find that 30% of households stated that they switched to a different source at the time of our return visit, about eight months later. Our results contribute to a growing literature that documents low demand for health-protecting technologies in developing countries for a variety of such products, ranging from insecticide-treated nets (Cohen and Dupas 2010, Dupas 2014, Tarozzi et al. 2009, Tarozzi et al. 2014), to de-worming drugs (Kremer and Miguel 2007) and water-disinfectant (Ashraf et al. 2010).

The second and more novel objective of our study was thus to determine whether a different mode of test delivery, leveraging within-village solidarity networks, could increase health-protective behavioral responses. A large literature documents the importance of village networks to cope with shocks, including health shocks, see Fafchamps (2011) for a review. In an additional subset of 48 villages, we study demand for arsenic tests—at the same price of BDT45—to self-formed *groups* of up to ten individuals, where group members were asked to sign an informal agreement according to which those with safe wells would share their well with others in the group whose well water was found to be unsafe. Immediately after conducting the tests, the result of all tests were communicated to all group members. The agreement was not binding legally, but our prior was that it would increase rates of switching from unsafe sources through two mechanisms. First, by making sharing more likely through a form of soft-commitment and, second, by facilitating the spread of information about the safety of wells, thereby increasing the salience of safe options within the village. Although we find that demand for tests remained about the same as with sales that did not involve informal water-sharing agreements, we estimate that switching rates relative to individual sales almost doubled from 30 to 56%, while the 95% confidence interval of the difference-in-differences (DD) adjusted for baseline covariates is $0.012 - 0.392$.

We also examine the impact of a second mode of information delivery, in the form of metal placards attached to the well spout, and typically visible to community members, to convey test results. Budget limitations, however, only allowed us to include 15 villages in this experimental arm, so that statistical power was lower than ideal. In these villages, individuals who purchased a test at the usual price were also given a metal placard of a color depending on the arsenic level: blue for arsenic below 10ppb, green if between 10 and 50, and red if 'unsafe', that is, above the government threshold of 50ppb. Similar metal placards have been used before in some testing campaigns (Opar et al. 2007, van Geen et al. 2014), as a more durable alternative to the routine strategy—adopted for instance during the BAMWSP testing campaign—of applying to the well spout red or green paint that would often become invisible within a year (Pfaff et al. 2017). Such visible indicators of safety can act both as a reminder about the safety of the well water, and as a means to facilitate the spread of information about which wells are safe within a village. In different contexts, other researchers have found large impacts of reminders on health-related behavior, for instance through the use of SMS messages, see Pop-Eleches et al. (2011) and Raifman et al. (2014). However, the cost of the placards (about BDT80) is high enough to increase significantly the total cost of testing campaigns. It was thus important to determine whether they made any difference relative to the alternative solution (adopted in the two experimental arms described earlier) of informing the household via a simple and inexpensive laminated card to be kept in the house, with the indication of the test result. While we find that demand for testing was barely affected by the concurrent offer of a metal placard, the switching rates more than doubled (from 30 to 72%, 95% C.I. of adjusted DD 0.165-0.553) relative to those recorded when test results were communicated individually via a simple laminated card.

Our work complements the literature on the demand for health-protecting technologies by looking at demand for health-related *information* that can be exploited by households to devise risk mitigation strategies. More precisely, we focus on the offer of information that is specific to the buyer (the test measures arsenic contamination in the water from a specific well), in contrast to general information (for instance, on the likelihood of arsenic contamination, or the health risks associated with unsafe water). While we focus on demand for information on environmental factors, earlier work has looked at demand for information on health status. Cohen et al. (2015) study how subsidies for rapid-diagnostic tests (RDTs) for malaria affect both the demand for the tests as well as demand for anti-malarial drugs. They find that while heavy subsidies increase considerably demand for RDTs, about half of individuals who test negative for malaria still decide to purchase anti-malarial drugs. Bai et al. (2017) study demand for commitment contracts to schedule preventive doctor visits by hypertensive patients in rural Punjab, India. They find that a large share of patients purchase these contracts but do not follow through with the commitment, leading to monetary losses. Thornton (2008) show that monetary incentives increased substantially demand for HIV testing in rural Malawi, but she also finds that behavioral responses, in the form of increased demand for condoms, were muted. Using data from Kenya and Tanzania, Gong (2015) finds that individuals surprised by an HIV-positive test increased risky sexual behaviour. These studies suggest that even among households willing to pay for information, behavioral responses may not be optimal from a public health perspective, so that it is important to study whether the mode of delivery of information can help achieving desirable policy objectives.

Our paper relates to that of Barnwal et al. (2017), who estimate a demand curve for arsenic tests in Bihar, India, another location with a groundwater arsenic problem. They find that test uptake fell from 69% to 22% of households when the price increased from INR10 to INR50, where the latter was about equivalent to the daily per capita income. Further, they estimate that at INR40 (about BDT49) uptake was 25%, which is about the same as what we estimated at a very similar price of BDT45. In addition, they find that conditional on buying a test and learning that one's well is unsafe, the price paid was not significantly related to switching behavior. Unlike Barnwal et al. (2017), however, we examine the role of non-price factors on demand and behavioral responses to information. In our setting, demand was not sensitive to the introduction of informal agreements or the use of placards, but conditional on demand, these nudges led to large and significant increases in switching relative to simpler, private sales.

The paper proceeds as follows. In the next section we provide additional background information on the extent of the arsenic problem in the study area and describe the experimental design. In Section 3, we describe the data collection protocol, present selected summary statistics, and show that by chance the means of some covariates were not balanced at baseline, highlighting the importance of controlling for baseline characteristics in our estimates (the adjusted and unadjusted estimates remain similar). In Section 4 we present the conceptual framework that guided the study design and that will be useful to interpret the results, which are then described in Section 5. Finally, we conclude in Section 6.

2 Study design

This study was carried out in Sonargaon, a sub-administrative unit (or *upazila*) of Narayanganj district, located approximately 25 kilometers south-east of the capital Dhaka. According to the 2011 Census of Bangladesh, Sonargaon had a population of about 400,000, and administrative records at the time of the study listed a total of 365 villages, in a 171 squared kilometers territory. Sonargaon is located in a part of the country where arsenic contamination of shallow tubewell water is widespread. According to a blanket testing conducted in 1999-2000, under the supervision of the Bangladesh Arsenic Mitigation and Water Supply Program (BAMWSP), in about 80 percent of villages 40 percent or more of tubewell water had arsenic levels above the Bangladesh standard of 50ppb, while the median proportion of unsafe wells was a high 86% (Chowdhury et al., 2000).[2]

For this paper, we first selected all 128 villages in Sonargaon with more than 10 wells and with a share of unsafe wells between 40 and 90 percent according to data from the BAMWSP blanket testing campaign conducted years earlier. A lower bound was chosen to focus on areas where a sizeable fraction of new untested wells were likely to be unsafe, while the upper bound was designed to avoid areas where switching to safe wells was not likely to be a viable option for most households.[3]

In each study village, surveyors would walk across the whole area identifying all wells, regardless of their ownership status or of evidence of having been tested before. For privately owned wells, the surveyors would identify which household owned the well, while for public wells they identified which household was the main caretaker or user. Surveyors then conducted a home visit, where they would explain the risk of consuming arsenic-contaminated tubewell water to an adult—typically the most senior woman—and then offer to test the well for a fee. Additionally, surveyors recorded the geographic coordinates of all wells using the GPS receiver of their smartphone, regardless of whether the owner bought a test or not. When a test was purchased, tubewell water was tested using the Arsenic Econo-Quick (EQ) test kit, which has been shown to be reliable when used in the field, and can deliver results

[2]Blanket testing in Sonargaon was carried out by BRAC, a partner NGO of BAMWSP. A total of 25,048 tubewells were tested for arsenic.

[3]According to BAMWSP data, in 42% of villages in the sub-district more than 90% of wells were unsafe according to Government of Bangladesh standards.

within ten minutes, see George et al. (2012) for details. The kit's test strip is evaluated visually and the result classified in the following sequence (in ppb) $\{0, 10, 25, 50, 100, 200, 300, 500, 1000\}$. The tests cost USD0.30 for volume purchases, although the total cost per test was estimated to be about USD2.4 per test, for a testing campaign that also covered the costs of trained personnel and metal placards to be attached to the tubewell spouts (van Geen et al. 2014).

Surveyors also administered a short household questionnaire and distributed color-coded laminated cards with the hand-written test result (in case of purchase) and well identification number. All cards included the following warnings: (i) that arsenicosis is not a communicable disease, (ii) that arsenic cannot be removed by boiling water, (iii) that testing tubewell water for arsenic is important, and (iv) that the Bangladesh safety standard for arsenic concentration in water is 50ppb. Black cards were given to households who did not buy a test, while in case of test purchase the laminated card was blue (if arsenic was 10ppb or below), green (if it was 25 or 50ppb), or red (if the test showed an arsenic concentration above 50ppb, 'unsafe' by Government of Bangladesh standards). Owners of unsafe ('red') wells were also encouraged face-to-face to switch to a safe (blue or green) well, while owners of wells with concentrations below 10ppb were encouraged to share their well water with their neighbors. Green card holders were both encouraged to share their water and to switch to a safer (blue) well, if possible.

Our experimental variation comes from differences in selling schemes for arsenic tubewell water tests across villages. In a first group of villages, which we term group A, surveyors offered to test tubewell water for a fee of BDT45 (about USD0.60). This fee was expected to cover the salary of the testers and their supervisor. Of the BDT45 charged per test, testers kept BDT30 to cover their transportation expenses and salary, and handed over the remaining BDT15 to their supervisor. The price was determined assuming that a field worker would test about 15 wells/day for 20 days/month, leading to a monthly salary of BDT9,000 (USD115/month), which is roughly what village-health workers were paid for blanket testing in the neighboring Araihazar in 2012-2013 (van Geen et al. 2014). According to the same scenario, the supervisor of 10-15 workers would earn BDT45,000-67,500 (USD578-867), a range that spans what he earned while supervising the testing in Araihazar in 2012-2013. Across all experimental arms, the cost of the field kits (USD0.30/test) was covered by the project.

In a second group of villages (B), groups of at most 10 households were gathered and asked (i) if they wanted to test their water for a fee of BDT45 each and (ii) if they wanted to sign an agreement to share any safe water among the signatories—before conducting any testing. The agreement had no legal standing, and was meant to serve as a soft commitment device. Anecdotal information from the field indicated that buyers were sometime uncomfortable about signing a document, in which case a verbal agreement took place instead. All neighbors that committed to sharing their tubewell water were allowed to see the test results from all other neighbors in the group. Both well owners that committed to share their well (formally or verbally) and those who did not could purchase the test.

The comparison of demand for and responses to tests between arms A and B was the primary objective of the study. Assuming that the testing campaign would uncover five unsafe wells per village, that 30% of households with unsafe wells would switch in the control group (a rate at the lower end of what observed in previous studies), and an intra-village correlation of 12%, we determined that 50 villages per arm would ensure 80% power for a two-sided test of equality at the 5% significance level, and with 15 percentage points difference in switching rates between arms.[4] Given that the available funding allowed the inclusion of a larger number of villages, we opted for the inclusion of additional experimental arms, although in this case sample size was dictated by budget constraints rather than power calculations.

In a third group of 16 villages (C), households were again assigned to receive individual test offers at BDT45 (as in group A). However, in the case of purchase, a color-coded stainless steel placard was attached to the well's pump-head. Placards displayed both in text and color whether the arsenic concentration was below 10ppb (blue), between 10ppb and 50ppb (green), or above 50ppb (red). Further, as shown in Figure 1, they displayed two hands holding drinking cups, one hand holding a drinking cup, and a large cross over a hand holding a drinking cup, depending on the arsenic concentration.

The split of the test fee between the tester and supervisor in groups B and C was the same as in group A, but in B the project further gave a bonus of BDT12 to testers per every household that signed the well-sharing agreement or that verbally committed to sharing their well within the group of buyers.[5]

The assignment to treatment arms was done by the principal investigators using random assignment, using the Stata software, after stratification. Strata were determined by whether the share of unsafe wells in the BAMWSP testing campaign carried out years earlier was below or above the median, and by union (an administrative unit).[6] There were two deviations from the experimental protocol. First, while programming the mobile application used for data collection, 27 villages were assigned by mistake to a treatment different from the original one. The partial re-assignment of treatments was thus due to a data-entry error, and not to imperfect implementation of the protocol in the field. In addition, the checks for balance in covariates are very similar if we use assigned or actual treatment (see below). For this reason in the analysis we define treatment status as *actual* treatment. Second, in four cases, surveyors were unable to differentiate a village from the one adjacent to it. While we have data from households in these four villages and the ones adjacent to them, we can only

[4] In this scenario the effect size is $0.15/\sqrt{0.3 \times 0.7} = 0.33$.

[5] The experimental design also included two exploratory arms, with only six villages each, where tests were sold individually either at a village-level price of BDT45 or BDT90, but with payment required only in case of 'good news', that is, in case of arsenic level no higher than 50ppb. The inclusion of these proof-of-concept conditional sales were motivated by the observation made during focus group that a number of respondents were averse to the idea of 'paying for bad news'. Sales conditional on the results may have thus increased demand (a prediction strongly supported by the observed purchased rates), although the conditional payment also generates a reduction in the (expected) price and a different selection into purchase conditional on beliefs about the safety of the well water. Because of these confounding factors and because of the very small number of villages assigned to these sales, we do not discuss the results in detail although these are available upon request from the authors.

[6] Unions are the third smallest administrative unit, and are formed by several *mouzas*, which in turn are composed of two to three villages. The 128 study villages belong to nine unions.

distinguish pairs, and both villages in each pair received the same treatment. For this reason, in the statistical analysis we have effectively 112 clusters divided into experimental arms A (49 clusters), B (48), and C (15). For simplicity, in the rest of the paper we will refer to the cluster as 'villages'.

The spatial distribution of villages in our intervention is displayed in Figure 2. As expected, the randomization—with the caveats described above—led to large spatial variation in treatments.

3 Data

Between January and June 2016, surveyors completed a census of all wells in the 112 study villages, and for each well they identified the household who owned it or, for a small number of community-owned wells, the primary user. Almost all wells (98.6%) were privately owned, and for simplicity in the rest of the paper we will somewhat loosely use the term 'owner' to refer to the household who owned the well, or to the household who was the primary user of community wells.

All households were then offered an arsenic test under one of the three selling schemes. Concomitantly, enumerators administered a short household ('baseline') survey and recorded information on sales and, in case of purchase, the result of the test. The result was immediately communicated to the buyer. Additionally, surveyors recorded GPS coordinates of all wells and whether, at the time of the visit, there were already any visible labels attached to the well indicating the arsenic-safety status. A total of 12,606 wells were listed at baseline, and the baseline questionnaire was completed for all but three of the corresponding owners. It is important to note that, while our data give us a complete census of *wells* at the time of the baseline, we do not have a census of *households*. An implication of this is that we only have information on households who owned a well, and while these were the majority, we make no claim that well owners are a representative sample of the study population. The choice to survey only owners was due to budgetary constraints, but of course an implication of it is that we cannot study whether the choice of the primary source of drinking water changed also among non-owners.

The endline survey was completed between August 2016 and January 2017.[7] The average time elapsed between baseline and endline surveys was 7.7 months, and 86% of households had their follow-up interview between seven and nine months after the baseline interview. Both the baseline and the follow-up surveys recorded whether a household used the well for cooking and drinking.

At the time of the endline survey, interviewers were instructed to return to the wells identified during the test sales, and to verify whether the corresponding household was using the well as primary source of water for cooking and drinking. In case of a negative answer, the surveyor would ask the respondent to accompany him/her to the actual source, and then would record the new GPS location, verify the presence of visible indicators of arsenic safety (for instance the presence of one of the metal placards distributed during our intervention), and then would ask the respondent about perceived safety of the new source as well as about the primary reason for switching to a different source.

[7] Unlike the baseline survey, where the wages of surveyors and the supervisor were covered mainly from test fees, the cost of the follow-up survey was paid for by the project.

3.1 Summary Statistics at Baseline

We present selected summary statistics measured at baseline in Table 1. Throughout this paper, unless otherwise noted, we restrict our analysis to the large majority of households (91%) that used their own well at baseline, as this is the sample for which we can determine baseline water source and post-intervention switching.[8] All summary statistics except those on the first line of Table 1 are thus calculated for households who used the well for drinking and cooking.

The head was male in 85% of households, while 29% of the heads were wage-workers and 42% were self-employed, with the remaining largely occupied in domestic activities. Household heads had low levels of educational attainment on average, with the majority having only primary schooling or less. Most households were poor, with only 17% of the houses having a concrete roof (an indicator of wealth), while the rest had tin or (in rare cases) mud roofs. Further, most households were small in size, with an average of 3.6 members in total, of which 1.5 where children.

The average well owner in our study area lived in a village where 75% of the wells tested by BAMWSP between 1999 and 2000 were unsafe with respect to arsenic. Despite the BAMWSP blanket testing campaign, a large majority of respondents (76%) did not know whether their well was safe or unsafe with respect to arsenic. In contrast, only 7% of them thought that their well was unsafe, while the remaining 17% reported having a safe well. It is also important to note that, despite about one quarter of respondents saying that they knew the status of their well, more than 99% of wells had in fact no visible sign of safety status, such as the spout painted red or green, or a metal placard attached to it. Information on the safety of the minority of wells that had been tested was thus not immediately observable by other households, although in principle knowledge could have been shared with others privately. Using geographic coordinates, we estimate that the average well owner had about 0.02 wells labeled as safe within 50m, out of an average of nearly 12 wells within that distance.

The immense public health challenge due to widespread arsenic contamination of well water has been widely discussed and advertised in Bangladesh, and this is clearly reflected in our data. Virtually all respondents replied 'yes' to the question "[h]ave you ever heard about arsenic in tubewell water?" Similarly, all but a handful of respondents replied yes when asked "[a]re you aware of the health risks of drinking tubewell water containing arsenic?"

Almost all wells (98.6%) were privately owned and on average relatively shallow (179 feet, or 55 meters) and about nine years old—which again suggests that a significant proportion of wells were installed after the BAMWSP blanket testing. The average reported installation cost of wells in our sample was BDT7,560, or about USD323 using the PPP exchange rate from World Bank (2015).[9] This implies that the BDT45 price charged for the test in our study represented slightly more than

[8] Wells not used for drinking were on average significantly shallower, and thus more likely to be contaminated with high levels of arsenic. Of the 1,193 wells not used for drinking, only 14 (about 1%) were believed to be safe by the owner. We did not record the choice of water source for households who did not use the well for drinking, and so for this latter subset we cannot verify switching behavior.

[9] Using the nominal exchange rate, the average price was about USD100. Well depth is a key predictor of installation costs: in our data, the elasticity of cost with respect to depth is 0.72 (s.e. 0.04).

one half of a one percent of the installation cost.

It is interesting to note that well-sharing was already common in our study area: while the average household had fewer than four members, the average number of individuals using water from a well for drinking was 8.8, and in more than half of the sample wells the number of users was larger than household size.[10]

Column 7 of Table 1 shows the p-value for the null hypothesis of equality of means across the three treatment arms. The null is rejected in 5 of 26 cases at the 10% level. The differences among arms was just due to chance and recall that, because baseline data were collected at the time of the arm-specific sales, we had very limited ability to enforce balance through stratification. The figures show that in a few cases there were substantively large differences among arms along likely important characteristics such as the education of the household head, or knowledge about the safety status of one's well with respect to arsenic. For instance, while on average 19% of household heads in our study area had no schooling, this number drops to about 5% in treatment C and is close to 26% in arm A. Or, the fraction of respondents who did not know the status of their well ranged from 68% in arm A to 90% in arm C, while the fraction with a well described as safe ranged from 4% in C to 22% in A. Both the group-specific means and the tests of significance are very similar if we repeat the estimation using treatment as initially randomized rather that actual treatment (recall that there were some discrepancies due to clerical errors in programming the smartphones used for the survey).[11]

Because these characteristics may affect test purchase decisions and switching behavior upon receiving news of having an unsafe well, we will also show results that control for observed covariates, and we will show that in general estimates are robust to such inclusion.

At the bottom of Table 1 we look at attrition. Overall, 8.8% of the households drinking from the index well could not be matched to the endline data, either because of true attrition (6 percentage points) or because errors in inputting the identifiers—which appear as duplicates in the data—did not allow the match. The null of equality among the three arms is not rejected at conventional levels for any of our attrition measures.

4 Conceptual Framework

Before discussing the results, it is useful to think about the main factors likely to influence purchase choices and, conditional on test results, risk-mitigating behavior. In doing so we will not use a formal model but rather offer a conceptual framework that should help interpreting the results, also in light of ex-ante predictions about the impact of factors that were experimentally varied.

We illustrate a schematic and simplified illustration of the key components of the decision process faced by prospective buyers in Figure 3, although we acknowledge that other factors may have been

[10] Recall that we did not survey households who did not own a well.

[11] In terms of statistical significance, the only differences are that "Wells within 50m labeled safe" becomes significant at the 10% level (instead of 5) and the fraction of privately owned wells become significant at the 1% level, despite very similar means across arms that range from 97.8 to 99.7%. The full results are available upon request from the authors.

relevant for choice besides those illustrated here. A first necessary condition for demand at positive prices (labeled 'Knowledge' in figure) is that the test result provides new information. A second condition ('Relevance') is that the prospective buyer believes that there are health and/or economic costs associated with continued use of arsenic-contaminated water. Third, the new information will likely be perceived as useful to reduce such costs if there is an expectation that there will be safe (or at least *safer*) mitigation strategies available ('Solution'). Demand for testing will thus depend on whether these factors are gauged to be sufficiently important to warrant the payment of the price, given budget constraints. In case of purchase, the result of the test should be the primary driver of the decision to switch to a different source of water for drinking and cooking ('Result'). A key consideration is that any difference in switching between any two experimental arms could have emerged, in principle, either from different selection into purchase (because buyers in different arms may have been of different 'type', and hence reacted differently to the same information) or from the way information was provided (in which case even identical buyers may have reacted differently).

In Section 3.1 we have already shown that the first condition (Knowledge) held for most households, given that 76% of respondents did not know whether their well water was safe or unsafe to drink, and even those who reported to know the status of the well may have been not completely certain of their belief. In addition, we have also seen that almost all wells had no visible sign of safety status (such as paint or metal placards on the tubewell spout) so even households certain of the safety status of their well water may have attached some value to test results that could have been easily disseminated among others, either showing to others the laminated colored cards, or through the group-wide communication of the arsenic levels (in arm B), or via the metal placards posted on the spout (in arm C). Note that the value attached to the diffusion of the test results needs not be positive. For instance, households may have been worried about the negative consequences of unsafe well water for land value, or for the perceived health status of household members.[12] Or, in a country where arsenic contamination of well water is a well-known public health emergency, there may be stigma associated to using arsenic-contaminated water. On the one hand, earlier research has shown that households very rarely refuse testing when offered for free, even when the results are posted on the wells (see for instance Madajewicz et al. 2007, Opar et al. 2007 and Bennear et al. 2013), suggesting that fear of disseminating negative results was unlikely to be an important driver of demand, although in principle it may have reduced demand in arms B and C relative to A, especially among those who thought that their well may be unsafe. On the other hand, in Table 1 we have shown that at baseline there were significant differences in prior knowledge about well status between arms, and so it will be important to control for such differences when looking at demand. Finally, willingness to pay for the tests will also depend on trust towards the test result. There is now growing evidence that lack of trust in health-related information may hinder the adoption of behavior that could reduce health risks (Cohen et al. 2015, Bennett et al. 2017, Alsan and Wanamaker 2017, Martinez-Bravo and

[12] Indeed, in Bihar, India, Barnwal et al. (2017) find that placards indicating unsafe arsenic levels were more likely to be removed by households than those indicating low levels of arsenic two years after installation, although such behavior may have also been justified by the desire not to be reminded constantly about the health risks.

Stegmann 2017). Although we do not have direct measures of trust, we have explained that many wells had already been tested in the past in Sonargaon, so the local population was likely used to water samples being tested. However, although we cannot completely rule out that a degree of mistrust affected demand, we do not have compelling reasons to think that any such mistrust should have been different across treatment arms A, B and C.

Moving now to the second factor affecting demand (Relevance), in Table 1, we have already seen that virtually all respondents knew—at least in a general sense—about the presence and health risks of arsenic in tubewell water. Indirect support for the existence of both a high degree of awareness as well as variation in perceived health risks comes from data on subjective risk perceptions collected in 2008 in the neighboring Araihazar sub-district.[13] These data, collected for a different population, cannot be used in a regression framework as a proxy for user-specific risk perceptions in our sample, but they are interesting because they come from a very similar and geographically close rural area. Respondents were asked to state the perceived probability that a child or an adult will develop either skin lesions (a frequent marker of arsenicosis) or more generic "serious health problems" as a consequence of drinking water from a well with unsafe levels of arsenic. The survey instrument described "serious health problems" as conditions that can impair normal daily activity such as working, going to school, playing or helping out with household chores. The probabilities were assessed using different lengths of exposure, ranging from one month to 20 years. In Figure 4 we display the empirical distribution of beliefs for different time horizons. The histograms show a large degree of variation in risk perceptions, but overall they also document a fairly sophisticated understanding of the risks, with progressively higher perceived risk as the time horizon lengthens. For instance, almost no one reported a probability of serious health damage above 30 percent for a 1-month exposure (the 'true' probability being most likely close to zero), while more than half of respondents thought that health damage would certainly appear after 20 years of exposure (a grim assessment that may not be too far from the truth). Overall, we thus found that data collected a few years earlier in neighboring areas were consistent both with a high degree of awareness about arsenic risk, and a good deal of heterogeneity in risk perceptions.

Individual-level access to information and the ability to process it—most likely affected by schooling—were likely important drivers of heterogeneity in perceived risk, and given that schooling of the household head was not balanced across arms (see Table 1), it will be important to control for this in the results. Additional sources of heterogeneity in the perceived cost of continued use of contaminated water were also household composition (parents may have been particularly concerned about their children), variation in perceived productivity losses due arsenic-related illness, and more generally taste for health.[14] While none of our interventions affected the health costs of arsenic exposure, all of

[13]Such data were collected in the context of a RCT that evaluated the impact of providing information on arsenic contamination, free of charge, using scripts that highlighted to a different extent the fact that arsenic risk increases with arsenic concentration, and is not merely 'binary' (that is, 'safe' vs. 'unsafe'), as many mistakenly understand it, see Bennear et al. (2013).

[14]The health risk posed by arsenic is also a function of factors such as genetic traits and nutrition that may influence arsenic metabolism in complex ways that will be almost impossible to gauge for most people (Ahsan et al. 2006, Ahsan et al. 2007).

them likely increased their salience. In arm B, group sales may have facilitated group discussions on arsenic risk that could have led to hard-to-predict peer effects on demand and possibly switching rates. On the one hand, in arm C our prior was that the offer of the placards would not have been a primary driver for demand. On the other hand, the metal placards posted on the wells may have acted as a constant reminder of arsenic risk for the owners of unsafe wells, potentially increasing, everything else being the same, the likelihood of switching among buyers whose well water turned out to be unsafe relative to arms A and B.

The third key factor affecting decisions (Solution) was the perceived availability of alternative sources of drinking water. Demand may have been dampened by the belief that no better sources were available, and the switch to better alternatives would of course be possible only when such alternatives were known and feasible to users of unsafe wells. We have already discussed that well-sharing was already practiced in the area, but earlier work carried out in the neighboring Araihazar sub-district found that distance from safer alternatives was an important predictor of switching behavior (Madajewicz et al. 2007). From this perspective, our prior was that both B and C would increase the prevalence of switching from unsafe wells relative to A. First, while buyers were privately informed about the test result in treatment A, information was public within groups of buyers in treatment B, and it was public in treatment C, where a metal placard indicating the test result was attached to the well spout. In addition, a guiding factor in our project was our hope that, in arm B, the informal commitment to share water would be a sufficiently powerful nudge to increase switching relative to the simple individual sales in arm A. These same factors may have also increased demand relative to A, if the prospective buyers were sophisticated enough to anticipate that both B and C likely offered better alternatives in case of bad news.

Lastly, conditional on test results, we expected that the decision to change source would depend primarily on the test result (Result) and the utility cost of switching, which in turn would also depend on Solution. Our prior was that the difficulty in predicting arsenic contamination without a test would mean that the likelihood of having an unsafe well, even if conditional on purchase, would be uncorrelated with the mode of sale.[15]

We summarize the prediction of this simple conceptual framework in Table 2. Overall, we expected that buyers with unsafe wells in arms B and C would be more likely to switch relative to A, while we did not have clear priors about the switching rates in B relative to C. Our predictions for demand were less clear: while we expected factors leading to higher willingness to react to information to also lead to higher willingness to pay for it, key factors such as health risks and availability of alternative sources were likely to become more salient after the realization of the test result.

[15] In principle, the ability to predict water safety may have led to complex selection into group purchases in arm B: for instance households more optimistic about the safety of their well may have been less likely to be part of a group purchase if they were worried about congestion, especially if the group included other households likely to have contaminated wells.

5 Results

In this section, we first estimate the effect of our selling schemes on uptake rates. Next, we describe the information on arsenic levels that was revealed by the tests, and finally we discuss to what extent such information changed household behavior in terms of choice of water source for drinking.

5.1 Demand

Of the 11,410 households who used their own well for cooking and drinking at baseline and who were offered an arsenic test, 2,829 (25%) bought a test under one of our selling schemes. We also found that 139 of 1,193 households (12%) who were *not* using their well at baseline purchased the test, but we will not analyze their responses to the result because for them we cannot verify if they switched to a different source.

To estimate the average treatment effect of selling schemes B and C relative to A, we estimate the following equation using a linear probability model:

$$buy_{svh} = \beta^B B_v + \beta^C C_v + \gamma X_{svh} + \delta_s + \epsilon_{svh}, \tag{1}$$

where buy_{svh} is equal to one if household h in village v and stratum s bought a test at baseline, and zero otherwise, B_v and C_v are village-specific indicator variables for the respective treatments, X_{svh} is a set of predetermined household and tubewell characteristics, and ϵ_{svh} is an error term. To account for the stratified design, we further include strata fixed effects (δ_s). Recall that we stratified treatment by the prevalence of unsafe wells based on BAMWSP data and by union. All standard errors and statistical inference are robust to the presence of intra-village correlation of residuals.

In Figure 5 we show graphically the simple comparison of take up rates across arms without the inclusion of controls. A first clear result is that neither the incentives for group sales nor the addition of the metal placard made any appreciable difference for demand. A second finding is that demand was overall quite low, with about one quarter of households purchasing the test in each of three experimental arms. As in many earlier studies looking at demand for health-related preventive products, even a relatively small fee, for potentially vital health-related information, led to low demand among potential beneficiaries. In Figure 6 we also show, for each experimental arm, histograms of village-level purchase rates. The figure shows that the similar purchase rates in groups A, B and C are also reflected in similarly-shaped histograms, with some purchases almost everywhere, most purchase rates in the 10 to 30% range, and few outliers with very high demand.

We show the regression results in Table 3, where recall that consistent with equation (1) we adopt arm A as the reference group, so that the arm-specific coefficients represent the differences relative to the mean in A. Not surprisingly, the small differences in demand between arms A, B and C are also not statistically significant. A comparison of the results in columns 1 and 2 shows that the inclusion of the strata fixed effects barely changes the point estimates, although the estimates become substantially more precise.

In group B, where our survey team encouraged the (optional) formation of risk-sharing groups, our data indicate that such option was indeed chosen by many households: out of a total of 1,185 households purchasing the test, 464 (39%) chose this option. In addition, there are two reasons why this figure is actually a lower bound for the actual number that agreed to well-sharing at the time of purchase. First, the choice to sign a group agreement was mistakenly left unspecified for 129 wells (11%). Second, the surveyors indicated that several households agreed verbally to the informal risk-sharing arrangement but refused to sign a document: in such cases, our data thus indicate that the agreement was not *signed*, although it did exist in oral form.

In column 3 we show that the results are also robust to the inclusion of controls. This is important, because we have seen that despite the randomization there were some potentially important differences in means among experimental arms. We thus include controls for the demographic structure of the household, the gender, education and occupation of the head, the age, depth and cost of the tubewell, an indicator for the quality of housing, the number of wells and of wells visibly labeled as safe within 100 meters, the fraction of unsafe wells in the village at the time of the BAMWSP blanket campaign, indicators for whether the well itself was visibly labeled as safe, and finally indicators for whether the respondent believed the well water to be safe, or believed it to be unsafe. Because missing values in one or more of the controls lead to the loss of about 20% of observations, in column 4 we show that the results remain similar if we re-estimate the model without controls but including only the observations used in column 3. In this case, the main differences is that $\hat{\beta}^C$ (0.06, s.e. 0.034) is positive and significant, although only at the 10% level.

The controls in Table 3 are not exogenous, and so the corresponding coefficients cannot be interpreted as causal. Despite this, it is informative that the estimates are broadly consistent with the conceptual framework described earlier. Having completed only primary schooling predicts a 7 percentage points decline in demand, while the coefficient for having no schooling is almost twice as large in magnitude. This is consistent with education leading to more awareness about the arsenic problem, although it could also proxy for higher income or wealth and thus higher ability to pay. Other indicators of higher socio-economic status also predict more demand. Coefficients are positive and significant for both better quality roofing and more expensive wells. Larger households are more likely to purchase the test, but the increase in demand predicted by one more child (0.052) is only slightly larger than that observed with one more adult (0.039). The number of wells nearby does not predict demand, but the presence of one well within 100 meters that is visibly labeled as safe increases demand by 5 percentage points (significant at the 10% level). This is consistent with households' purchase decisions taking into account expectations about viable alternatives. Finally, well owners thinking that their well is safe stand to gain little from buying a test, and indeed they are 12 percentage points less likely to purchase the test (p-value<0.01). The belief that the water is *unsafe* also decreases the probability of purchase, although by less than half as much ($\hat{\beta} = -0.048$, p-value<0.01). These results show that even respondents who stated that they knew about well status did not feel completely confident about their priors, given that a fraction of them decided to purchase the test.[16] In column 5 we show

[16]When we pool together all treatment arms we find that the purchase rate was 14.3% among respondents who believed

that the interactions between beliefs about safety and treatment were not significant, suggesting that the different selling schemes did not affect the way priors about water safety influenced selection into purchase.

5.2 Test Results

Although the purchase rate was far from 100%, our intervention generated a large increase in the number of tested wells in Sonargaon. Before looking at the responses to the information made available by the tests, it is useful to first describe such information. The test results are summarized in Table 4, where we also include the detailed summary statistics about switching behavior that we will describe later, and so we focus on the 10,412 households (91.3% of the total) that could be tracked in the endline survey. In addition, in Figure 7 we plot the spatial distribution of safe (diamonds), unsafe (triangles), and untested wells (black dots) across the whole study area in Sonargaon. Although only wells of buyers were tested, the map shows that there was considerable heterogeneity in water quality, even within small areas. Visual inspection of this general pattern becomes even more apparent by looking at each village at a time. As an illustration, in Figure 7 we also provide a magnified view of the spatial distribution of wells in a randomly chosen village (belonging to treatment A). In this specific example (in no way unique) it is easy to see that, first, there was a very dense network of wells and, second, all unsafe wells were not far from other wells with arsenic levels below the Bangladesh safety standard.

Overall, 19% (455/2417) of the tested wells which had been used for drinking at baseline had 'unsafe' arsenic levels based on the Government of Bangladesh standards. Notably, the fraction was much lower than what observed at the time of the BAMWSP testing campaign, about 10 years earlier: in fact, recall that we included in our study only villages where BAMWSP estimated a fraction of unsafe wells in the 40 to 90% range. The reduction in the fraction of unsafe wells over time is consistent with a degree of learning about local arsenic risk, but also with economic development leading to an increasing number of households able to afford deeper wells, which are on average safer but are also more expensive to drill. Our data are broadly consistent with both hypotheses. First, we find that more recent wells, dug no more than 10 years earlier, were 22% deeper and 25 percentage points less likely to be unsafe relative to older ones.[17] Second, and although the majority of households were not sure about the safety of their wells, we also find that their beliefs about safety were strong predictors of actual safety status, suggesting a degree of sophistication, although of course we can only gauge the relationship for households who purchased the test. If we regress a dummy equal to one for unsafe wells on dummies for whether the respondent thought that the well is safe, or unsafe, we find that the belief of drinking from a safe well *decreases* the predicted probability of the well being unsafe by 15 pp while the belief of the well being unsafe *increases* it by 41 pp (both coefficients are significant at

their well to be safe, and 8.3% among those who believed that it was unsafe.

[17]The average depth for older wells was 154 feet, while more recent ones were on average 34 feet deeper. The fraction of unsafe wells was 23 and 17% among the older and more recent wells, respectively. The test of equality is rejected at the 1% level for depth and at the 5% level for safety.

any standard level).[18]

There was also some variation in the test results across different treatments, see also Figure 8 where we show the whole arm-specific distributions of arsenic. Recall that we are looking at results *conditional on demand* so that the randomization across treatments was in no way a guarantee of similar distributions across arms, even in large samples. The distribution of arsenic was overall similar among arms A and B, the two largest arms. Arm C has more unsafe wells (27%, versus 19 and 16% in arms A and B, respectively), although the null of equality among these three arms cannot be rejected at standard levels (p-value= 0.32). Again consistent with the existence of a degree of awareness about arsenic risk, group C was by far the one with the smallest fraction of respondents thinking that their well was safe, although the fraction believing the well being unsafe was fairly similar between groups, see Table 1. The larger share of unsafe wells in arm C may thus have been the result of lack of balance at baseline arising by chance, and made possible by the relatively small number of units (15) in this treatment arm.

5.3 Responses to test results

Next, we gauge to what extent households responded to information by using data collected at endline, about eight months after the test sales, on the main source of water for cooking and drinking. Overall, we estimate that at this time, of all the wells found to be unsafe, 30% had wells identified as safe within 25 meters, 57% had at least one within 50 meters, and 78% had at least one within 100 meters. This confirms that, in principle, switching to a nearby safe well was indeed a feasible strategy to mitigate arsenic risk for the large majority of households.[19] In addition, and consistent with the similarity across arms in the prevalence of purchases and unsafe results, we find that the different testing strategies produced very similar frequencies of safe alternatives nearby high-arsenic wells. At distances of 25, 50, and 100 meters, such frequencies ranged across arms A, B and C, from 27 to 33%, from 55 to 60% and from 73 to 85%, respectively, and the null of equality in the frequencies is never rejected at standard levels.

In Figure 9, we show the switching rates observed in each experimental arm, for owners of unsafe wells (the most critical target of the campaign) but also for owners of safe or untested wells. We did not expect to observe much change among the two latter categories, and indeed our data strongly confirm our prior: barely anyone moved from a well tested as safe (12/1,950), while less than 3% of untested wells (224/7,995) stopped being used for drinking. In contrast, the results related to tested wells for which the result showed As> 50ppb (in the top graph) show very interesting patterns. First, 30% of households (60/200) switched from unsafe wells in arm A. Although far from negligible, such figure is at the lower end of the range of switching rates observed in earlier studies, some of which

[18] A degree of consistency between beliefs about safety and actual safety status was also found in (van Geen et al., 2014, Figure 4).

[19] Note also that these figures underestimate the potential role of switching to reduce arsenic risk, given that they do not take into account the likely presence of safe wells nearby whose status was unknown because the owner did not purchase the test.

documented rates above 2/3 (see Opar et al. 2007, Chen et al. 2007, Madajewicz et al. 2007, Bennear et al. 2013, Balasubramanya et al. 2014, George et al. 2012 and Inauen et al. 2014). On the one hand, this may appear surprising, given that in earlier studies the information had been provided for free, and so there was no self-selection into purchase of households that may have been expected to be relatively more responsive to information. On the other hand, in a number of such early studies tests were conducted in the context of intensive research efforts that may have contributed to a stronger response (Chen et al. 2007, Madajewicz et al. 2007). Moreover, free testing campaigns could have also led to larger switching rates by revealing a larger number of safe wells.

Looking now at the switching rates observed in arms B (sales with 'commitment') and C (with metal placards posted on the pump head), we found that rates in both were much higher relative to A. In B, 56% of households switched, while in C the rate was even higher, at 72%. In column 1 of Table 5 we show the corresponding regression results for households whose well was identified as being unsafe, confirming that the differences relative to the 'standard sales' in A are not only very large but also statistically significant at the 5% level or below. The difference in switching rates between B and C is substantively important (16 percentage points) but is not estimated precisely and so is not significant at standard levels.

Overall, the estimates remain very similar when we include strata fixed effects (column 2) and they become smaller but remain large and significant when we include baseline controls (columns 3 and 5), suggesting (as for demand) that the impacts are not substantively biased by differences in the level of observed confounders. In all models the presence of placards was associated with more switching relative to the group agreements, although the null of equality is never rejected at standard levels.

These results confirm our prediction that group signing or metal placards would lead to more switching relative to privately provided information, although we cannot separate how much of this was due to an increase in the information about alternatives, or to the (soft) commitment, in arm B, or to the added salience of the placards, in arm C. In B, we do find that having signed the agreement increased the predicted probability of switching by 20 percentage points (relative to 45% among those who did not sign). However, the decision to sign was endogenous and thus this finding cannot be interpreted as causal. In addition, if we also include controls for all confounders included in column 3, the increase in the predicted probability becomes much smaller (= 0.01) and is no longer significant. Recall also that several households did agree to well-sharing despite refusing to do so in writing, which further limits the likely predicted power of the dummy equal to one for households that signed. In arm C, at the time of the return visits, the vast majority of the 348 placards installed on the well spout at the time of the test were still in place, regardless of their color. In particular, surveyors found that of the 95 red placards installed on unsafe wells 90 were still visible, while no placard was visible in two wells and a 'black' placard was found on the remaining three. Almost all blue and green placards remained similarly in place during the study period. This suggests that the testing campaign led to a persistent increase in the salience and visibility of information in villages included in arm C, an important consideration given that households were free to remove the placards, which would have considerably reduced the difference between the testing campaigns in arms A and C. This also shows that households were not actively hiding information about the unsafe arsenic levels of their well, suggesting that neither the perceived cost of showing this information to others (including because of stigma) nor the desire to avoid being continuously reminded of the arsenic risk were sufficient motives to remove the tags in our context. This result stands in contrast with Barnwal et al. (2017), who found that placards indicating unsafe arsenic levels in Bihar, India, were significantly more likely to be removed by households, although such actions were observed two years after installation, a much longer time interval relative to the average of eight months in our study.

The results in column 3 are also interesting because they allow us to look at predictors of switching, although once again these results should not be interpreted causally given that the covariates may be correlated with unobserved factors that also matter for the choice of water source. Most coefficients are small and not significant at standard level. Conditional on test purchase, households with a better educated head were *not* more likely to change the source of drinking water, a finding that contrasts with earlier work that evaluated switching behavior following arsenic testing offered at no cost, see Chen et al. (2007), Madajewicz et al. (2007), Pfaff et al. (2017). This suggests that in our sample more years of schooling was not associated with an increase in arsenic risk-avoiding behavior conditional on information, although recall that demand for tests was lower among households with a less educated head. A notable—and perhaps disheartening—result is that prior beliefs about the well being safe reduced predicted switching by 11 percentage points, although the coefficient is not significant at standard levels. Beliefs about water safety may have thus been rather persistent for some households, despite the evidence offered by the tests (recall that we are now looking at wells that were identified as being unsafe by the field test). Recall also that in our study the minimum arsenic level communicated to owners of 'unsafe' wells was 100ppb, so this finding was not due to respondents who thought that the well was unsafe but then learned that it was instead 'barely unsafe'. Another concerning result is that, again conditional on the well being unsafe, higher levels of arsenic did *not* predict more switching. To the contrary, and using 100 as the omitted category, dummies for the arsenic level being equal to 200, 300 or 500/1000ppb are *negative* and in some case very large and statistically significant. This finding is consistent with most households gauging safety primarily in a binary way, an unfortunate possibility given that in reality arsenic health risk is to first order proportional to arsenic concentration.[20] In Figure 10 we show indeed that, with the exception of arm B, switching rates as a function of the test result were well approximated by a step function jumping from about 0 for arsenic levels up to 50ppb to a larger and rather constant level for 'unsafe' arsenic level of 100 or above.

In column 4 we also include as regressor a dummy for the presence of a safe well within 50 meters, where we define a neighboring well as safe when it was identified as such by our research team. Recall that, at baseline, very few wells could be identified as safe by visible signs such as placards or paint on the well spout. In this model we lose some observations due to errors in the geo-location of the wells. We also control for the number of wells in a 50-meter radius, and we interact the dummy for

[20]In a RCT carried out in 2008 in the neighboring Araihazar sub-district, Bennear et al. (2013) showed that attempts to highlight the existence of such gradient did not lead to more switching, with some evidence that it actually *decreased* it.

safe wells with the treatment indicators. Among owners of unsafe wells in arm A we find that, as expected, having a safe alternative nearby increases switching. The coefficient is large (27 percentage points) and significant at the 1% level. In group B, this association is substantively weaker, given that the interaction ($= -0.19$) is *negative* and its magnitude is about two-thirds of that observed in arm A. This is consistent with group signing or verbal commitment leading some households to share wells with other group members, with less concern of geographical distance, something which may have happened if geographical proximity was a poor proxy for sorting into the same risk-sharing group. This remains, however, a conjecture, given that our data do now allow us to determine with certainty if the well being used at endline belonged to a group member. The interaction between distance to a safe well and the treatment C dummy is again negative ($= -0.08$) but small and not significant at standard levels.

Finally, in column 5 we show that if we re-estimate the same basic model as in column 2 (with strata fixed effects), but including only the observations with non-missing covariates used in column 4, the differences in switching rates between arms, conditional on test purchase, remain large and statistically significant at all standard levels.

A limitation of our data is that we cannot gauge to what extent switching was associated to a reduction in arsenic risk. Surveyors were asked to record the GPS location of the new source of drinking water, but the GPS system we used—with an approximate precision of 10m at best—was not sufficiently precise to identify uniquely the well, also due to the dense network of wells within the study area. The lack of biomarkers measuring arsenic exposure also limits our ability to evaluate the health impacts of our intervention, although earlier work in neighboring Araihazar sub-district found strong evidence of such benefits following testing campaigns, see Chen et al. (2007). Despite these limitations, some useful information can be gleaned from reports from households that changed the source of drinking water. Of the 217 'switchers', almost all (214) listed safety concerns as the primary reason for their decision. However, about one third of these (79/217) had switched to a different well which was itself perceived as being unsafe, while 88 had switched to a well reported as being safe, and the remaining 50 households did not know the status of the well. In principle even a switch to an unsafe well, if the new well is *safer*, can reduce exposure to arsenic, but this finding suggests that in our study area a degree of arsenic exposure remained even among a sizeable fraction of households who reacted to the new information by switching to a different water source for drinking and cooking.

The results in columns 1-5 of Table 5 only use information from wells identified as unsafe, but in column 6 we also compare switching rates for all wells which had been used for drinking at baseline. In other words, these are the *unconditional* switching rates, regardless of purchase decision or test result. These results show that in group A only 3.7% of households switched well, while in B the fraction was 1 percentage point higher (not significant at standard levels) and in C it was 4 percentage points higher (significant at the 5% level).

Given that switching from safe wells is rare, it would have been interesting to compare these patterns with the fraction of unsafe wells in each arm, which could be seen as the fraction of households needing mitigation of arsenic risk. Unfortunately, given that we know the arsenic status only for tested wells, such fractions are unobserved. On the other hand, recall that treatment assignment was stratified based on geographical area and fraction of unsafe wells as estimated years earlier by the BAMWSP blanket testing campaign, so we would expect the fractions of unsafe wells to be approximately the same among treatment arms. That this was the case is also suggested by the similarity across arms in terms of depth and cost of wells (see Table 1), which as we explained are strongly (negatively) correlated with arsenic contamination. Recall also that the fraction of wells that turned out to be unsafe upon testing was similar across arms, ranging from 16% in B to 27% in C (see Table 4). Given that the large majority of households did not know the safety of their well, it is probably safe to assume that the actual prevalence of safe wells was similar to these figures in all experimental arms, and therefore in the 15-30% range. Taken together, these back-of-the-envelope estimates suggest that, despite the many tests sold, switching rates achieved by our test sales program remained well below the likely fraction of unsafe wells.

6 Discussion and Conclusions

Information on household-specific environmental health risks can be a relatively inexpensive policy tool, but the design of information campaigns often has to contend with low demand and with resistance to behavioral change even when the presence of such risks has been revealed to target households. This may be especially true in developing countries, where poverty, low literacy and other constraints may severely limit the effectiveness of such campaigns, especially if targeted information is only supplied for a fee. These considerations are salient in Bangladesh, a country where millions of people use water from shallow tubewells for drinking and cooking, and where a large fraction of such water is estimated to be contaminated by naturally occurring arsenic in concentrations high enough to have extremely deleterious health consequences in case of long-term exposure. This is generating one of the most severe public health crisis worldwide (Ahmed et al. 2006). Given that wells with unsafe water are often located at walking distance from safe wells, the provision of information on well-specific arsenic levels represents a potentially life-saving tool to allow households to undertake risk-avoiding behavior, by simply changing their primary source of drinking water. Unfortunately, the public sector is no longer providing free testing of tubewell water, and a private market for tests still does not exist. It is thus imperative to both learn more about ways to increase demand for testing, and to identify ways to induce households informed of the unsafe nature of their water to switch to different sources.

In this paper we have described the results from a randomized field experiment where we study the effect of different arsenic test selling schemes on test uptake and, conditional on learning that one's well is unsafe, their effect on well switching. Our results show that relatively subtle differences in the way information was sold and provided, while leading to small differences in uptake, led to very substantial gaps in behavioral responses: both group sales that leveraged informal local solidarity networks, and the addition of metal placards posted on the wells more than doubled the fraction of users of unsafe wells that reported having switched to a different water source at the time of our return visits, relative to simple, individual sales where test results were provided privately to the buyers.

Our results are consistent with a conceptual framework where the adoption of health-protecting behavior is increased by pre-commitment to share drinking water (despite the absence of enforcing mechanisms), by the ease of access to information on safe sources, and by 'reminders' on water safety provided by placards affixed to the tubewell spouts. These findings should be useful for the design of information campaigns that aim at providing measures of risk exposure that vary at the household level. In our context, information was supplied for a fee only to household who chose to purchase a test, but we conjecture that similar considerations will likely be relevant also when information is provided for free, for instance through blanket testing campaigns such as the one conducted now more than 10 years ago by BAMWSP.

On the one hand, and despite the positive fees, our team of surveyors managed to sell more than 2,800 tests for a total of about 11,400 wells. This allowed to uncover the presence of hundreds of wells with arsenic levels above the threshold adopted by the Government of Bangladesh, and overall about half of the users decided to switch to a different source of drinking water. On the other hand, to the extent that our results can be extrapolated to the rest of the country, we have shown that tests-for-fee campaigns can only provide a partial solution to the public health crisis due to arsenic in shallow aquifers. In our study area, about three quarters of wells remained untested, despite the fact that in a large majority of cases the users had no idea about the safety of the water they routinely used for drinking and cooking. In addition, and despite the likely selection into purchase of households more responsive to arsenic-related information, about half of users of unsafe wells were still using the same source at the time of the return visit. Further, among those who switched to a different source, many switched to a well that was either still unsafe (although possibly *safer*) or with unknown contamination levels. That more guidance is needed to facilitate switching to safe water sources is also consistent with findings from the neighboring Araihazar sub-district, where Pfaff et al. (2017) document that following the BAMWSP blanket testing campaign, about 30% of households whose well water was found to be unsafe had switched to other wells identified as unsafe or of unknown status.

Although our study did not include an experimental arm where *all* wells were tested, the relatively low behavioral responses were likely at least in part due to the fact that fees, by causing many wells to remain untested, substantially reduced the set of safe alternatives available for many households relative to what could have been achieved with blanket testing. In other words, although exposure to arsenic is not an infectious disease, there are clear positive externalities in the decision to test a well, and given the low demand observed even at very low prices this may be another case where free provision may be the optimal policy strategy (Cohen and Dupas 2010).

In sum, and until game-changers such as regulated piped water become widely available, much remains to be learned about the optimal design of campaigns for the provision of information on environmental health risks. Our results suggest that facilitating the spread of information on safe options, reminders, and mechanisms that leverage the presence of peer groups may represent promising ways to maximize the adoption of risk-avoiding behavior. However, and although this cannot be gauged directly from our analysis, we also conjecture that these strategies may be best adopted while providing tests for free and disseminating widely information on safe sources. Given the magnitude of the public health problem in Bangladesh, this would require significant investments from the government or from donors, but free provision would also avoid screening out individuals with low ability to pay, and it would possibly facilitate switching decisions by increasing the number of viable safe options.

References

Ahmed, M. F., S. Ahuja, M. Alauddin, S. J. Hug, J. R. Lloyd, A. Pfaff, T. Pichler, C. Saltikov, M. Stute, and A. van Geen (2006). Ensuring safe drinking water in Bangladesh. *Science 314*, 1687–1988.

Ahsan, H., Y. Chen, M. G. Kibriya, V. Slavkovich, F. Parvez, F. Jasmine, M. V. Gamble, and J. H. Graziano (2007). Arsenic metabolism, genetic susceptibility, and risk of premalignant skin lesions in Bangladesh. *Cancer Epidemiology and Prevention Biomarkers 16*(6), 1270–1278.

Ahsan, H., Y. Chen, F. Parvez, L. Zablotska, M. Argos, I. Hussain, H. Momotaj, D. Levy, Z. Cheng, V. Slavkovich, A. van Geen, G. R. Howe, and J. H. Graziano (2006). Arsenic exposure from drinking water and risk of premalignant skin lesions in Bangladesh: Baseline results from the health effects of arsenic longitudinal study. *American Journal of Epidemiology 163*(12), 1138–1148.

Alsan, M. and M. Wanamaker (2017). Tuskegee and the health of black men. *Quarterly Journal of Economics Forthcoming.*

Argos, M., T. Kalra, P. J. Rathouz, Y. Chen, B. Pierce, F. Parvez, T. Islam, A. Ahmed, M. Rakibuz-Zaman, R. Hasan, G. Sarwar, V. Slavkovich, A. van Geen, J. Graziano, and H. Ahsan (2010). Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study. *Lancet 376*, 252–258.

Ashraf, N., J. Berry, and J. Shapiro (2010). Can higher prices stimulate product use? Evidence from a field experiment in Zambia. *American Economic Review 100*(5), 2383–2413.

Bai, L., B. Handel, E. Miguel, and G. Rao (2017, August). Self-control and demand for preventive health: Evidence from hypertension in India. Working Paper 23727, National Bureau of Economic Research.

Balasubramanya, S., A. Pfaff, L. Bennear, A. Tarozzi, K. M. Ahmed, A. Schoenfeld, and A. van Geen (2014). Evolution of households' responses to the groundwater arsenic crisis in Bangladesh: information on environmental health risks can have increasing behavioral impact over time. *Environment and development economics 19*(5), 631–647.

Barnwal, P., A. van Geen, J. von der Goltz, and C. K. Singh (2017). Cost-sharing in environmental health products: evidence from arsenic testing of drinking-water wells in Bihar, India. *Journal of Environmental Economics and Management Forthcoming.*

Bennear, L., A. Tarozzi, H. B. Soumya, A. K. Matin, A. Pfaff, and L. van Geen (2013). Impact of a randomized controlled trial in arsenic risk communication on household water-source choices in Bangladesh. *Journal of Environmental Economics and Management 65*, 225–240.

Bennett, D., S. A. A. Naqvi, and W.-P. Schmidt (2017). Learning, hygiene, and traditional medicine. *The Economic Journal Forthcoming.*

Carson, R., P. Koundouri, and C. Nauges (2011). Arsenic mitigation in Bangladesh: a household labor market approach. *American Journal of Agricultural Economics 93*(2), 407414.

Chen, Y., J. H. Graziano, F. Parvez, M. Liu, V. Slavkovich, T. Kalra, M. Argos, T. Islam, A. Ahmed, M. Rakibuz-Zaman, R. Hasan, D. Levy, A. van Geen, and H. Ahsan (2011). Arsenic exposure from drinking water and cardiovascular disease mortality: A prospective cohort study in Bangladesh. *British Medical Journal 342*, d2431.

Chen, Y., A. van Geen, J. H. Graziano, A. Pfaff, M. Madajewicz, F. Parvez, A. I. Hussain, V. Slavkovich, T. Islam, and H. Ahsan (2007). Reduction in urinary arsenic levels in response to arsenic mitigation efforts in Araihazar, Bangladesh. *Environmental Health Perspectives 115*(6), 917–923.

Chowdhury, A., M. Hossain, R. Nickson, M. Rahman, M. Jakariya, and M. Shamimuddin (2000). Combating a deadly menace: Early experiences with a community-based arsenic mitigation project in Bangladesh. *BRAC Research and Evaluation Division, Research Monograph Series* (16).

Chowdhury, A. M. R., A. Bhuiya, M. E. Chowdhury, S. Rasheed, Z. Hussain, and L. C. Chen (2013). The Bangladesh paradox: exceptional health achievement despite economic poverty. *The Lancet 382*(9906), 1734–1745.

Chowdhury, S., A. Krause, and K. F. Zimmermann (2016). Arsenic contamination of drinking water and mental health. Industrial Relations Section Working Paper no. 607, Princeton University.

Cohen, J. and P. Dupas (2010). Free distribution or cost-sharing? Evidence from a randomized malaria prevention experiment. *Quarterly Journal of Economics 125*(1), 1–45.

Cohen, J., P. Dupas, and S. G. Schaner (2015). Price subsidies, diagnostic tests, and targeting of malaria treatment: Evidence from a randomized controlled trial. *American Economic Review 105*(2), 609–645.

Dupas, P. (2012). Health behavior in developing countries. *Annual Review of Economics 3*, 425–449.

Dupas, P. (2014). Short-run subsidies and long-run adoption of new health products: Evidence from a field experiment. *Econometrica 82*(1), 197–228.

Dupas, P. and E. Miguel (2016). Impacts and determinants of health levels in low-income countries. NBER Working Paper 22235.

Fafchamps, M. (2011). *Risk Sharing Between Households*, Volume 1A of *Handbook of Social Economics*, Chapter 24, pp. 1255–1280. San Diego and Amsterdam: North-Holland.

Flanagan, S. V., R. B. Johnston, and Y. Zheng (2012). Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. *Bulletin of the World Health Organization 90*(11), 839–846.

George, C. M., A. van Geen, V. Slavkovich, A. Singha, D. Levy, T. Islam, K. M. Ahmed, J. Moon-Howard, A. Tarozzi, X. Liu, P. Factor-Litvak, and J. Graziano (2012). A cluster-based randomized controlled trial promoting community participation in arsenic mitigation efforts in Bangladesh. *Environmental Health 11*(1), 41.

George, C. M., Y. Zheng, J. H. Graziano, S. B. Rasul, Z. Hossain, J. L. Mey, and A. Van Geen (2012). Evaluation of an arsenic test kit for rapid well screening in Bangladesh. *Environmental science & technology 46*(20), 11213–11219.

Gong, E. (2015). HIV testing and risky sexual behaviour. *The Economic Journal 125*(582), 32–60.

Howard, G., M. Ahmed, A. Shamsuddin, S. Mahmud, and D. Deere (2006). Risk assessment of arsenic mitigation options in Bangladesh. *Journal of Health, Population and Nutrition 24*(3), 346–355.

Inauen, J., R. Tobias, and H.-J. Mosler (2014). The role of commitment strength in enhancing safe water consumption: Mediation analysis of a cluster-randomized trial. *British journal of health psychology 19*(4), 701–719.

Johnston, R., S. J. Hug, J. Inauen, N. I. Khan, H.-J. Mosler, and H. Yang (2014). Enhancing arsenic mitigation in bangladesh: Findings from institutional, psychological, and technical investigations. *Science of the Total Environment 488*, 477–483.

Kremer, M. and E. Miguel (2007). The illusion of sustainability. *Quarterly Journal of Economics 122*(3), 1007–1065.

Madajewicz, M., A. Pfaff, A. van Geen, J. Graziano, I. Hussein, H. Momotaj, R. Sylvi, and H. Ahsan (2007). Can information alone change behavior? Response to arsenic contamination of groundwater in Bangladesh. *Journal of Development Economics 84*(2), 731–754.

Martinez-Bravo, M. and A. Stegmann (2017). In vaccines we trust? The effect of anti-vaccine propaganda on immunization: Evidence from pakistan. CEMFI Working Paper No. 1713.

McArthur, J., D. Banerjee, S. Sengupta, P. Ravenscroft, S. Klump, A. Sarkar, B. Disch, and R. Kipfer (2010). Migration of As, and 3 H/3 He ages, in groundwater from West Bengal: Implications for monitoring. *Water Research 44*(14), 4171–4185.

Opar, A., A. Pfaff, A. A. Seddique, K. Ahmedc, J. H. Graziano, and A. van Geen (2007). Responses of 6500 households to arsenic mitigation in Araihazar, Bangladesh. *Health and Place 13*(1), 164–172.

Pfaff, A., A. Schoenfeld, K. Ahmed, and A. van Geen (2017). Reduction in exposure to arsenic from drinking well-water in Bangladesh limited by insufficient testing and awareness. *Journal of Water Sanitation and Hygiene for Development*, 331–339.

Pitt, M. M., M. R. Rosenzweig, and N. Hassan (2015). Identifying the cost of a public health success: Arsenic well water contamination and productivity in Bangladesh. Working Paper 21741, National Bureau of Economic Research.

Pop-Eleches, C., H. Thirumurthy, J. P. Habyarimana, J. G. Zivin, M. P. Goldstein, D. De Walque, L. Mackeen, J. Haberer, S. Kimaiyo, J. Sidle, et al. (2011). Mobile phone technologies improve adherence to antiretroviral treatment in a resource-limited setting: a randomized controlled trial of text message reminders. *AIDS (London, England) 25*(6), 825.

Rahman, A., L.-Å. Persson, B. Nermell, S. El Arifeen, E.-C. Ekström, A. H. Smith, and M. Vahter (2010). Arsenic exposure and risk of spontaneous abortion, stillbirth, and infant mortality. *Epidemiology 21*(6), 797–804.

Raifman, J., H. Lanthorn, S. Rokicki, and G. Fink (2014). The impact of text message reminders on adherence to antimalarial treatment in northern Ghana: A randomized trial. *PLoS One 9*(10), e109032.

Sanchez, T. R., D. Levy, M. H. Shahriar, M. N. Uddin, A. B. Siddique, J. H. Graziano, A. Lomax-Luu, A. van Geen, and M. V. Gamble (2016). Provision of well-water treatment units to 600 households in Bangladesh: A longitudinal analysis of urinary arsenic indicates fading utility. *Science of the Total Environment 563*, 131–137.

Smith, A., E. Lingas, and M. Rahman (2000). Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. *Bulletin of the World Health Organization 78*(9), 1093–1103.

Tarozzi, A. (2016). Health interventions in low income countries: A (not so) low hanging fruit? Els Opuscles del CREI, no. 42.

Tarozzi, A., A. Mahajan, B. Blackburn, D. Kopf, L. Krishnan, and J. Yoong (2014). Micro-loans, bednets and malaria: Evidence from a randomized controlled trial in Orissa (India). *American Economic Review 104*(7), 1909–1941.

Tarozzi, A., A. Mahajan, J. Yoong, and B. Blackburn (2009). Commitment mechanisms and compliance with health-protecting behavior: Preliminary evidence from Orissa, India. *American Economic Review Papers and Proceedings 99*(2), 231–235.

Thornton, R. L. (2008). The demand for, and impact of, learning HIV status. *American Economic Review 98*(5), 1829–1863.

van Geen, A., E. B. Ahmed, L. Pitcher, J. L. Mey, H. Ahsan, J. H. Graziano, and K. M. Ahmed (2014). Comparison of two blanket surveys of arsenic in tubewells conducted 12 years apart in a 25^2km area of Bangladesh. *Science of the Total Environment 488*, 484–492.

van Geen, A., K. Ahmed, A. Seddique, and M. Shamsudduha (2003). Community wells to mitigate the arsenic crisis in Bangladesh. *Bulletin of the World Health Organization 81*(9), 632–638.

van Geen, A., H. Ahsan, A. Horneman, R. Dhar, Y. Zheng, I. Hussain, K. Ahmed, A. Gelman, M. Stute, H. Simpson, S. Wallace, C. Small, F. Parvez, V. Slavkovich, N. Lolocano, M. Becker, Z. Cheng, H. Momotaj, M. Shahnewaz, A. Seddique, and J. Graziano (2002). Promotion of well-switching to mitigate the current arsenic crisis in Bangladesh. *Bulletin of the World Health Organization 80*(9), 732–737.

van Geen, A., Z. Cheng, Q. Jia, A. A. Seddique, M. W. Rahman, M. M. Rahman, and K. M. Ahmed (2007). Monitoring 51 community wells in Araihazar, Bangladesh, for up to 5 years: implications for arsenic mitigation. *Journal of Environmental Science and Health Part A 42*(12), 1729–1740.

Wasserman, G. A., X. Liu, F. Parvez, H. Ahsan, P. Factor-Litvak, J. Kline, A. van Geen, V. Slavkovich, N. J. LoIacono, D. Levy, Z. Cheng, , and J. H. Graziano (2007). Water arsenic exposure and intellectual function in 6-year-old children in Araihazar, Bangladesh. *Environmental Health Perspectives 115*(2), 285–289.

World Bank (2015). Purchasing power parities and the real size of world economies: A comprehensive report of the 2011 International Comparison Program. Technical report, World Bank. doi:10.1596/978-1-4648-0329-1.

Figure 1: Metal Placards

Notes: The three pictures show examples of the stainless steel placards that were attached in case of test purchase to tubewell spouts in arm C. The pictures show placards attached to, from left to right, safe (blue, $As \leq 10ppb$), marginally safe (green, $10 < As \leq 50ppb$), and unsafe (red, $As > 50ppb$) wells, respectively.

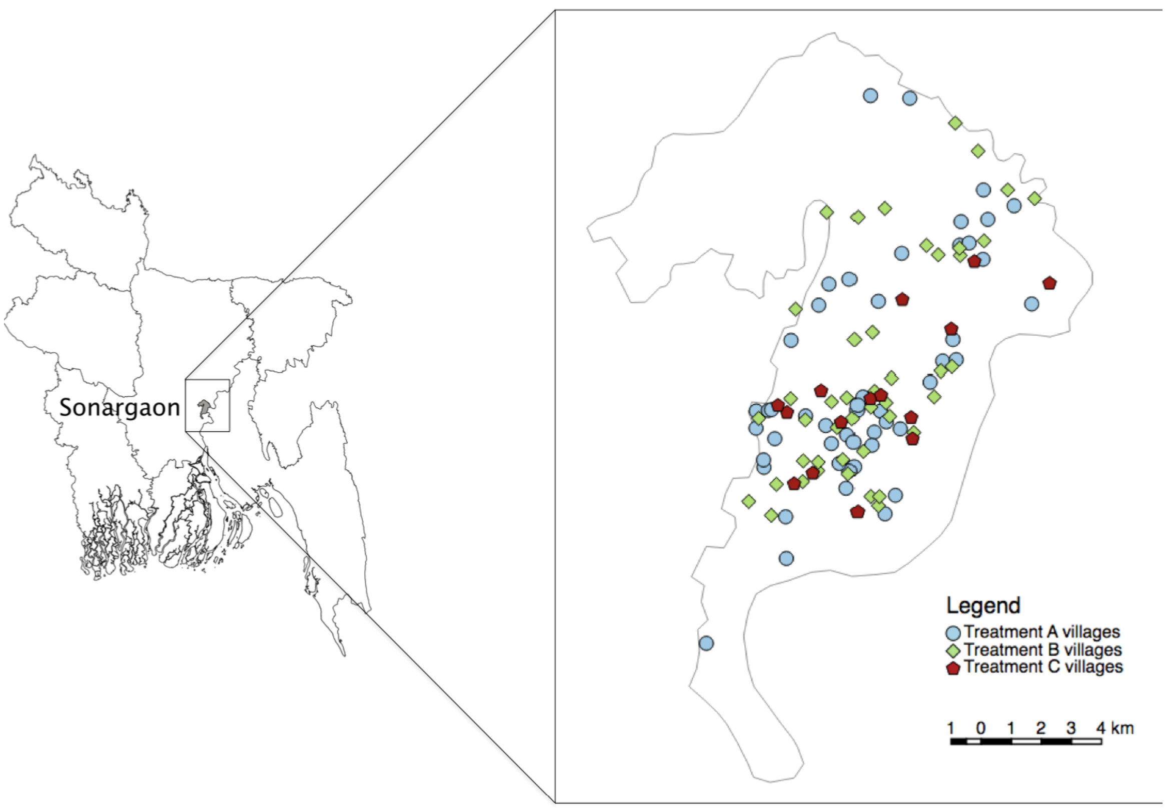

Figure 2: Study area and treatment assignment

Notes: Author's illustrations from the geo-location of study villages recorded at baseline. Each village is placed at the mean latitude and longitude of all well-owners interviewed at baseline in the village.

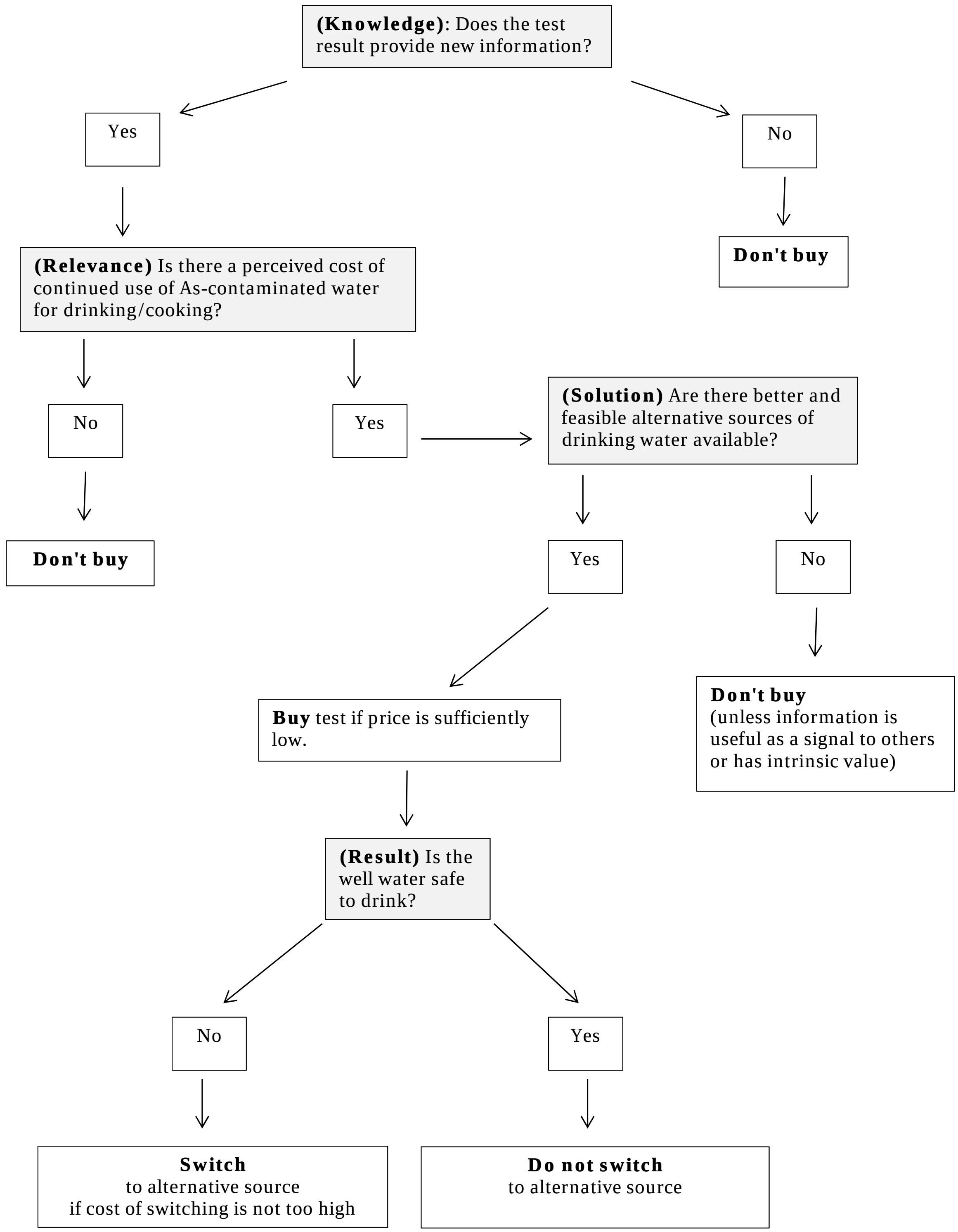

Figure 3: Scheme of decision process faced by prospective buyers

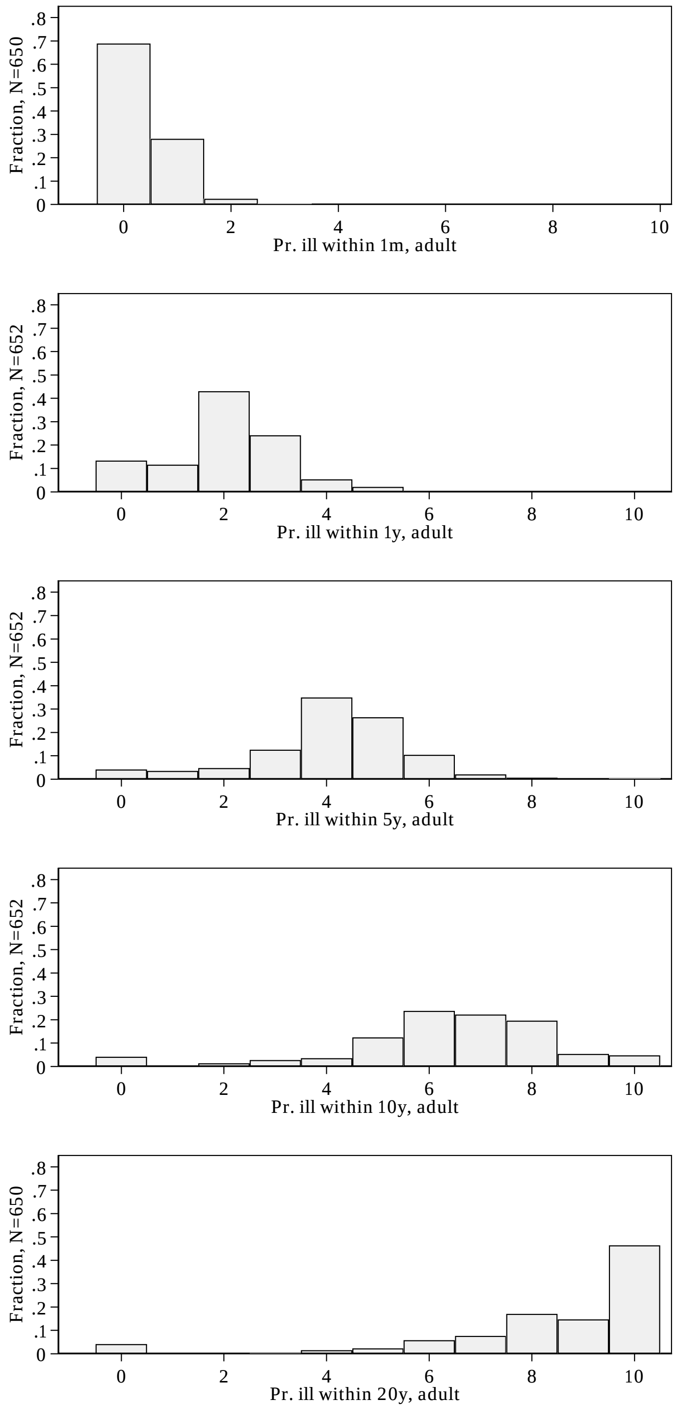

Figure 4: Subjective perceptions about Arsenic health risk

Source: Authors' estimations with 2008 data from Araihazar sub-district (bordering Sonargaon to the North). Each graph shows histograms of subjective probabilities, elicited from respondents, of an adult developing 'serious health conditions' as a consequence of drinking from an arsenic-contaminated well, within a time horizons ranging from one month (top) to 20 years (bottom). Beliefs were measured in discrete steps on a scale from 0 (event perceived as impossible) to 10 (perceived as certain).

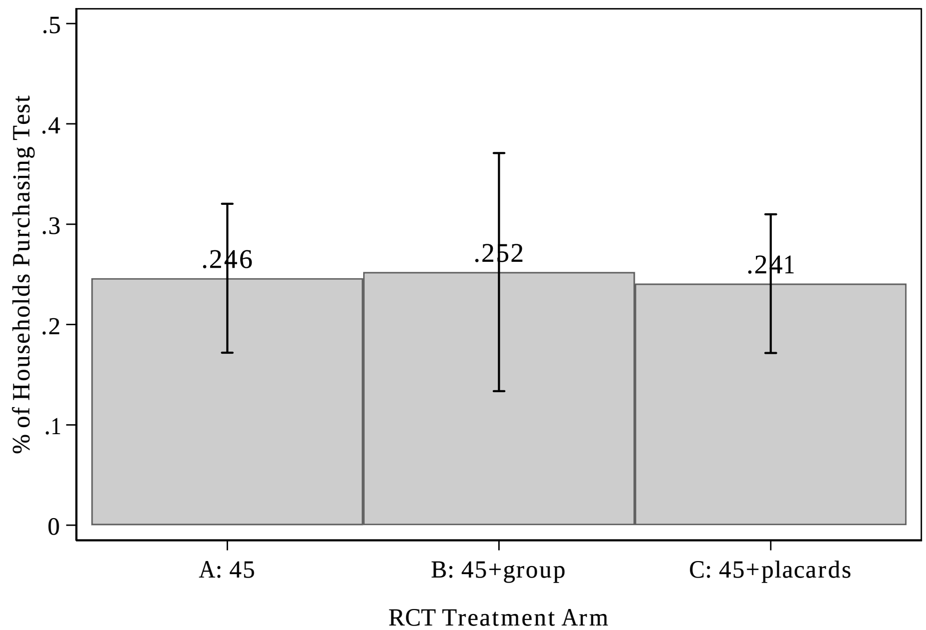

Figure 5: Demand for Tests of Arsenic Concentration in Well Water

Source: Authors' estimations from baseline data (January to June 2016). Each bar is labeled with the arm-specific purchase rate. The vertical intervals represent 95% confidence intervals, estimated allowing for intra-village correlation of residuals. The number of observations by arm are, from left to right, $n = 5,164$ (A), 4,697 (B), and 1,549 (C).

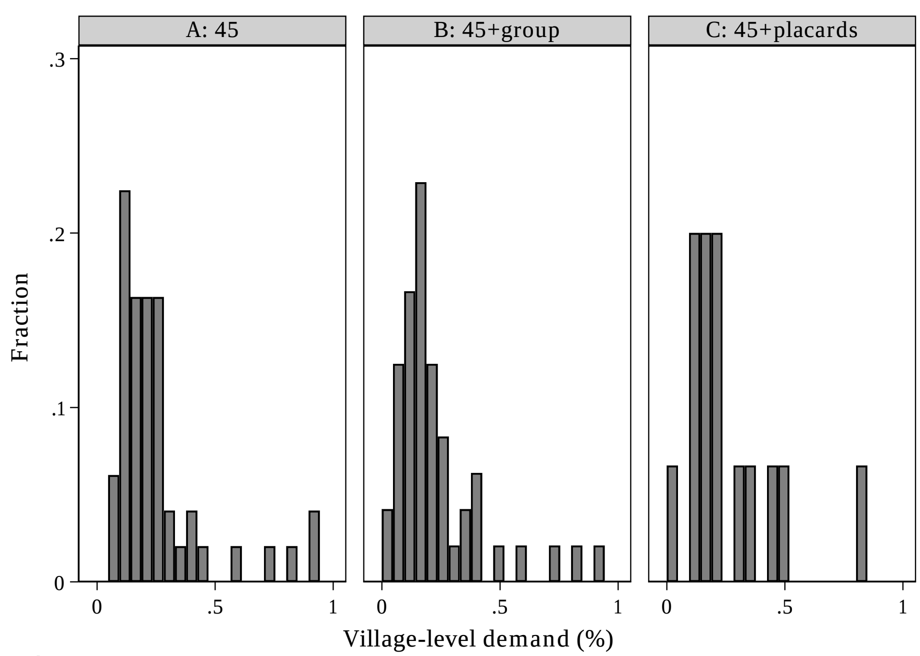

Figure 6: Distribution of purchase rates across villages by experimental arm

Source: Authors' estimations from baseline data (January to June 2016). Each figure shows an arm-specific histogram of village-level purchase rates of tests. The number of villages in each arm was 49 (A), 48 (B), and 15 (C).

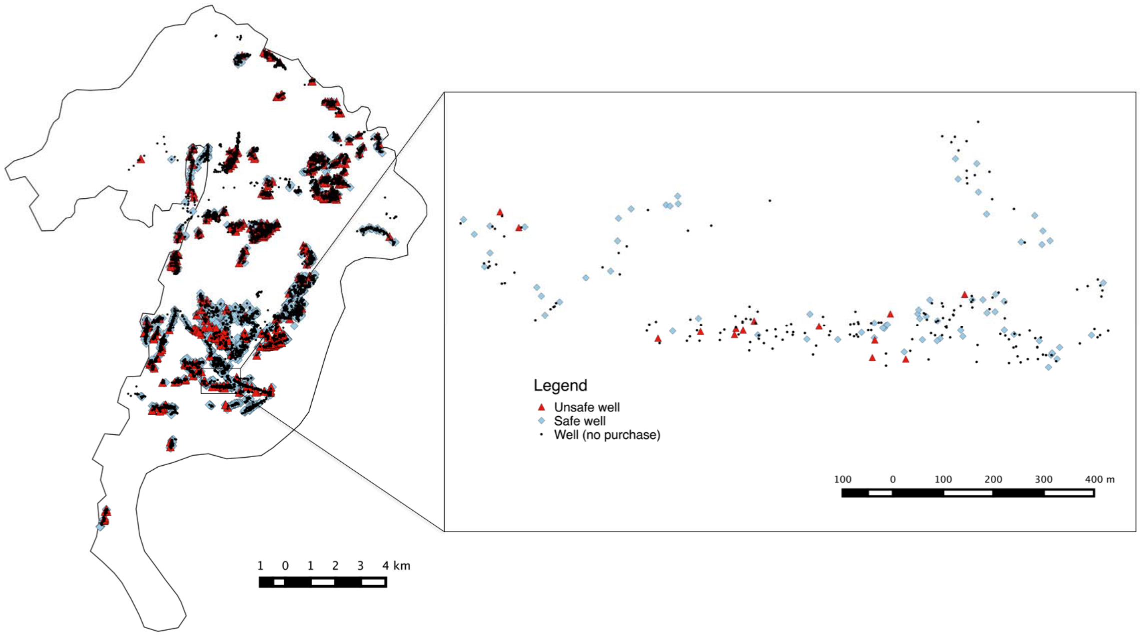

Figure 7: Test uptake and results

Notes: Author's illustrations from baseline data (January to June 2016). The figure in the box illustrates test uptake and results in one randomly selected village who was part of experimental arm A.

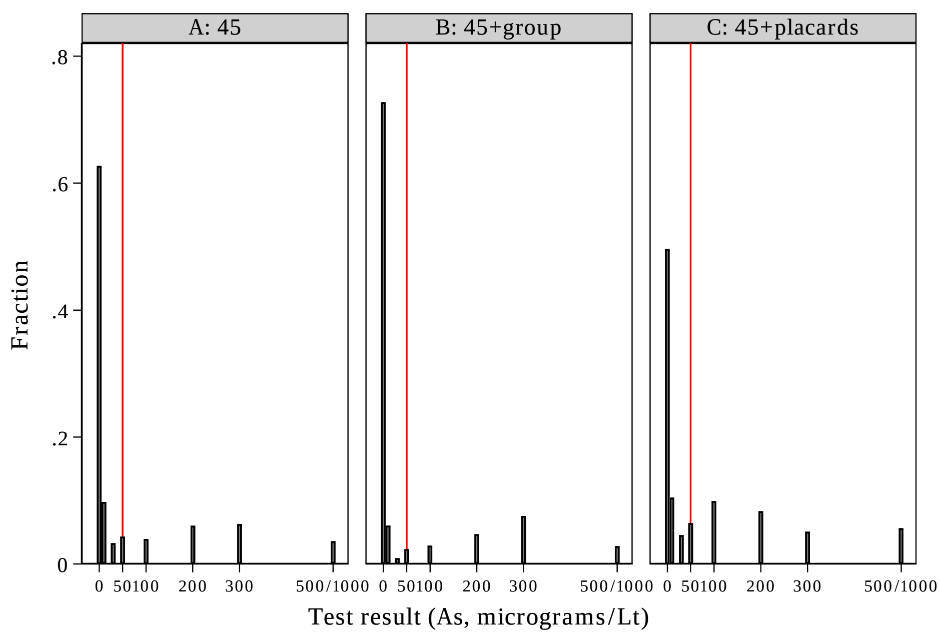

Figure 8: Distribution of Arsenic by experimental arm

Source: Authors' estimations from the result of the tests purchased at baseline (January to June 2016). Each figure shows an arm-specific histogram of arsenic (in ppb, or micrograms per litre). The field tests identified the arsenic level as a value in the set $\{0, 10, 25, 50, 100, 200, 300, 500, 1000\}$. Results of As=1000 were rare and hence we pool 500 and 1000 together.

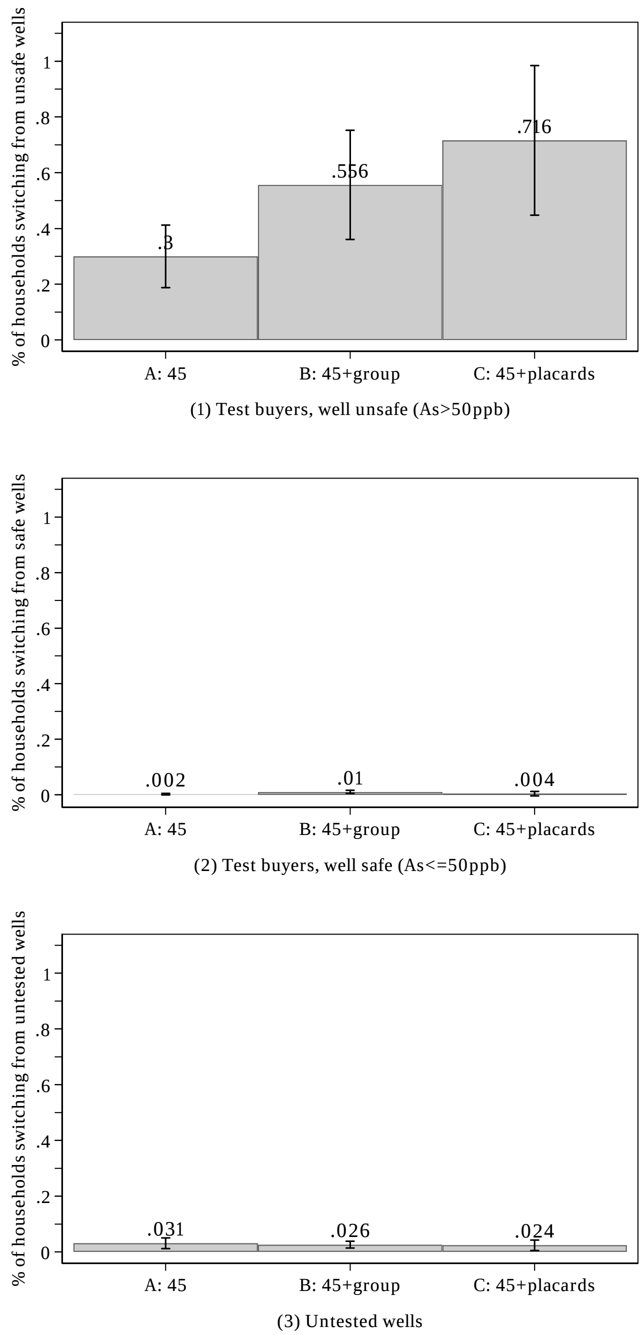

Figure 9: Switching rates by arm and by test result

Source: Authors' estimations from endline data (August 2016 to January 2017). Each figure shows the fraction of households who stopped using the baseline well for drinking and cooking and switched to a different water source, by experimental arm. Switching rates are shown separately for wells that tested unsafe (graph 1 on top), safe (2, middle) and for wells that were not tested because the test had not been purchased (3, bottom). The vertical intervals within each bar are 95% confidence intervals robust to intra-village correlation. The number of wells n_T, $T \in \{A, B, C\}$ used in each bar are as follows: unsafe wells (graph 1 on top), $n_A = 200$, $n_B = 160$, $n_C = 95$; safe wells (graph 2), $n_A = 838$, $n_B = 869$, $n_C = 253$; untested wells (graph 3), $n_A = 3639$, $n_B = 3252$, $n_C = 1104$.

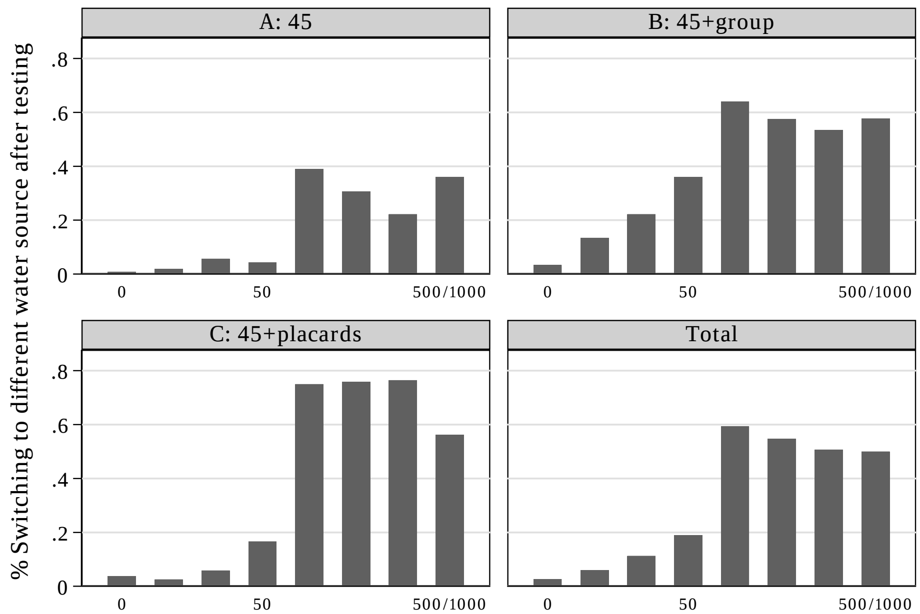

Figure 10: Switching rates from tested wells, by arsenic level and experimental arm

Source: Authors' estimations from baseline (January to June 2016) and endline (August 2016 to January 2017) data. Each figure shows an arm-specific histogram of arsenic (in ppb, or micrograms per litre). The field tests identified the arsenic level as a value in the set $As \in \{0, 10, 25, 50, 100, 200, 300, 500, 1000\}$. Results of As=1000 were rare and hence we pooled 500 and 1000 together. A household was described as having switched if, at the time of the endline survey, the respondent stated that the main source of water used for drinking and cooking was no longer the well used at baseline.

Table 1: Baseline Summary Statistics and Balance across Treatment Arms

	(1)	(2) Overall	(3)	(4)	(5) Means by experimental arm	(6)	(7) p-values
	Obs.	Mean	St.Dev.	A	B	C	H_0: A=B=C
Drink from well at baseline	12603	0.905	0.293	0.930	0.884	0.891	0.2520
Household head is male	11410	0.848	0.359	0.843	0.850	0.860	0.9210
Household head wage worker	10890	0.285	0.452	0.247	0.298	0.378	0.4260
Household head self-employed	10890	0.419	0.493	0.440	0.438	0.285	0.3390
Household head no schooling	10890	0.193	0.395	0.262	0.163	0.054	<0.001***
Household head primary school	10890	0.328	0.470	0.317	0.343	0.319	0.7900
Heard about As in well water	11410	0.996	0.062	0.996	0.996	0.997	0.7430
Aware of health risks of As	11410	0.998	0.044	0.997	0.998	0.999	0.2950
House has concrete roof	11252	0.173	0.378	0.175	0.184	0.133	0.4060
Household members	11045	3.600	1.300	3.630	3.570	3.590	0.8270
Number of Children	11045	1.460	1.040	1.480	1.430	1.470	0.6920
Well As status unknown (belief)	10515	0.758	0.428	0.684	0.789	0.903	0.0005***
Well As status unsafe (belief)	10515	0.069	0.253	0.097	0.042	0.057	0.2590
Well As status safe (belief)	10515	0.173	0.379	0.220	0.168	0.041	<0.001***
Well labeled safe	10515	0.002	0.040	0.003	0.001	0.001	0.1020
Wells within 50m	10260	12.300	15.600	10.400	14.500	12.100	0.2530
Wells within 50m labeled safe	10260	0.015	0.128	0.028	0.003	0.007	0.0302**
Share unsafe wells (BAMWSP)	11410	0.746	0.132	0.759	0.720	0.782	0.4120
Well is privately owned	11410	0.986	0.117	0.980	0.991	0.992	0.1690
Well depth ($\times$100 feet)	11410	1.790	1.080	1.830	1.770	1.730	0.8800
Well age (years)	11410	9.130	7.570	8.860	9.490	9.000	0.0105**
Well cost ($\times$10000 BDT)	11410	0.756	0.642	0.763	0.764	0.707	0.7340
Persons drinking from well	11343	8.840	11.100	8.880	8.490	9.750	0.5710
Attrition	11410	0.088	0.283	0.094	0.089	0.063	0.3150
Lost after baseline	11410	0.055	0.228	0.058	0.055	0.045	0.5990
Duplicate I.D. at baseline	11410	0.032	0.177	0.036	0.033	0.018	0.4170

Notes: Author's calculations from baseline data (January to June 2016). The unit of observation is the primary household attached to a specific well. The number of clusters (villages) in the five arms are 49 (arm A, $n = 5,551$ wells), 48 (B, $n = 5,316$) and 15 (C, $n = 1,739$). Except for the first variable ("Drinks from well at baseline") all variables are summarized for household who used the specific well for cooking an drinking at baseline. Differences in the number of observations across these variables are explained by missing entries during the data collection. The p-values in column 7 are for tests of the null of equal means across treatment arms (robust to intra-village correlation). Asterisks denote test significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 2: Predicted magnitudes of demand and switching relative to arm A

	Predicted impact relative to Group A (Individual sales with private information) on Demand		on Switching from unsafe wells	
	B (group sales)	C (placards)	B (group sales)	C (placards)
Knowledge	0	0	0	0
Relevance	0/+	0/+	0	+
Solution	0/+	0/+	+	+
Result	0	0	0	0

Predicted impacts of the different factors likely to affect demand for and behavioral responses to tests, as illustrated by Figure 3.

Table 3: Demand for tests

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Indicator = 1 if household purchased test				
B: 45+group	0.006	-0.004	-0.010	-0.001	-0.022
	(0.071)	(0.037)	(0.018)	(0.018)	(0.021)
C: 45+placards	-0.005	0.034	0.028	0.059*	0.020
	(0.051)	(0.032)	(0.029)	(0.034)	(0.032)
Household head is male			-0.069***		-0.071***
			(0.018)		(0.019)
Household head works for wage			0.005		0.005
			(0.016)		(0.016)
Household head self-employed			0.037**		0.038***
			(0.015)		(0.014)
Household head has no schooling			-0.128***		-0.128***
			(0.014)		(0.014)
Household head has primary only			-0.069***		-0.068***
			(0.012)		(0.012)
Concrete house roof			0.074***		0.074***
			(0.014)		(0.014)
No. household members besides children			0.039***		0.039***
			(0.009)		(0.009)
No. of children of head in household			0.052***		0.052***
			(0.006)		(0.006)
No. of wells within 100m			-0.000		-0.000
			(0.000)		(0.000)
No. of visibly safe wells within 100m			0.052*		0.052*
			(0.031)		(0.031)
% of unsafe wells in village (BAMWSP)			0.093		0.101
			(0.084)		(0.086)
Well depth ('00 feet)			0.032***		0.032***
			(0.009)		(0.009)
Well age (years)			-0.001		-0.001
			(0.001)		(0.001)
Well cost ('0000 BDT)			0.029**		0.029**
			(0.014)		(0.014)
Believes well is safe			-0.116***		-0.136***
			(0.018)		(0.023)
Believes well is unsafe			-0.048***		-0.063***
			(0.015)		(0.023)
B× believes well is safe					0.046
					(0.036)
B× believes well is unsafe					0.041
					(0.037)
C× believes well is safe					0.041
					(0.046)
C× believes well is unsafe					0.021
					(0.049)
Observations	11,410	11,410	8,892	8,892	8,892
R-squared	0.000	0.130	0.110	0.040	0.110
Controls	No	No	Yes	No	Yes
Strata FE	No	Yes	Yes	Yes	Yes
Mean in A	0.246	0.246	0.246	0.246	0.246
Clusters	112	112	102	102	102

Source: Authors' estimations from baseline data (January to June 2016). The dependent variable is binary and is = 1 if the household purchased the test at baseline. All regressions are estimated with OLS. Regressions with strata fixed effects include union fixed effects and a dummy = 1 in villages where the % of unsafe wells in the village (estimated by BAMWSP) was below the median. Standard errors are clustered at the village level. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Number of wells by safety status and switching decision

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Tested						Not tested	
	Total wells used for drinking and cooking	Total	Unsafe (proportion)	Safe Switched Yes	Safe Switched No	Unsafe Switched Yes	Unsafe Switched No	Total	Switched Yes
A: BDT45	4,679	1,040	0.192	2	838	60	140	3,639	113
B: BDT45+Group	4,281	1,029	0.155	9	860	89	71	3,252	85
C: BDT45+Placards	1,452	348	0.273	1	252	68	27	1,104	26
Total	10,412	2,417	0.188	12	1,950	217	238	7,995	224
Tests of equality (p-value)									
H_0 : A=B=C			0.3174						

Notes: Authors' calculations using information from a total of 11,635 wells that were used at baseline for drinking and cooking purposes. We exclude from the analysis 768 wells used by households that could not be re-contacted at endline, and 406 wells with a duplicate ID at baseline which can thus not be matched to endline data on switching decisions.

Table 5: Choice of water source at endline among users of unsafe wells

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Indicator = 1 if switched (no longer uses same well at baseline)					
	Unsafe wells (As> 50ppb)					All wells
B: BDT45+group	0.256**	0.273**	0.185**	0.344***	0.257***	0.010
	(0.113)	(0.106)	(0.087)	(0.097)	(0.096)	(0.012)
C: BDT45+placards	0.416***	0.463***	0.400***	0.392***	0.330***	0.038**
	(0.142)	(0.117)	(0.105)	(0.124)	(0.102)	(0.017)
Household head is male			-0.063	-0.069		
			(0.079)	(0.091)		
Household head works for wage			-0.034	0.011		
			(0.056)	(0.058)		
Household head self-employed			0.235***	0.208***		
			(0.070)	(0.057)		
Household head has no schooling			0.075	0.149		
			(0.096)	(0.117)		
Household head has primary only			0.032	0.028		
			(0.060)	(0.063)		
Concrete house roof			0.026	0.077		
			(0.079)	(0.079)		
No. household members besides children			-0.054*	-0.057		
			(0.032)	(0.045)		
No. of children of head in household			0.013	0.013		
			(0.028)	(0.030)		
Well depth ('00 feet)			0.009	-0.037		
			(0.032)	(0.041)		
Well age (years)			-0.004	-0.002		
			(0.004)	(0.004)		
Well cost ('0000 BDT)			-0.076**	-0.066*		
			(0.033)	(0.037)		
Believes well is unsafe			0.060	0.028		
			(0.081)	(0.076)		
Believes well is safe			-0.113	-0.122		
			(0.108)	(0.124)		
As = 200ppb			-0.043	0.011		
			(0.059)	(0.060)		
As = 300ppb			-0.155***	-0.158**		
			(0.057)	(0.060)		
As = 500 or 1000ppb			-0.152**	-0.112		
			(0.067)	(0.074)		
Number of wells within 50m				-0.002		
				(0.005)		
There is at least one safe well within 50m				0.271***		
				(0.087)		
B × at least one safe well within 50m				-0.188		
				(0.124)		
C × at least one safe well within 50m				-0.077		
				(0.126)		
Observations	455	455	407	355	355	10,412
R-squared	0.112	0.169	0.261	0.298	0.197	0.012
Controls	No	No	Yes	Yes	No	No
Strata FE	No	Yes	Yes	Yes	Yes	Yes
Mean in A	0.300	0.300	0.300	0.300	0.300	0.0374
Test of equality $B = C$, p-value	0.331	0.163	0.0629	0.71	0.525	0.124
Clusters	76	76	71	66	66	112

Notes: Authors' estimations from baseline and endline data. All regressions in columns 1-5 include only observations for which the well was used for cooking and drinking purposes at baseline, a test was purchased, and the test indicated unsafe levels of arsenic in the water ($As > 50$ppb). In column 3, the decrease in the number of observations is due to missing values in one or more of the controls, and similarly in column 4 a number of observations are lost because the GPS location was not recorded correctly. The model in column 5 is the same as in column 2 but uses only observations used in the results in column 4. The results in column 6 show switching rates *not* conditional on purchase or test result, including all households who used the well at baseline and who could be matched between baseline and endline surveys. All regressions are estimated using a linear probability model where the dependent variables is a dummy equal to one if the well was no longer used for cooking and drinking at endline. Standard error are clustered at the village level. Asterisks denote statistical significance: *** p<0.01, ** p<0.05, * p<0.1.