Can Information Alone Change Behavior?
Response to arsenic contamination of groundwater in Bangladesh[*]

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Abstract

We study how effectively information induces people to avoid a health risk. We provide information about concentrations of arsenic in household wells in Bangladesh. The resulting change in behavior is large and rapid; knowing that their well is unsafe raises the probability that the household changes to another well within one year by 0.43. The effect of information is causal since arsenic levels are uncorrelated with household characteristics. Our door-to-door campaign provides well-specific test results which the media does not provide, but it is more expensive and only slightly more effective than the media in communicating general information about arsenic.

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1. Introduction

As many as one billion people in the world drink unsafe water (WSCC, 1999). Over two million deaths from diarrhea are estimated to have occurred in 1998, mainly among children (WHO, 1999). People drink unsafe water because they are not informed about the risks to their health and because they lack access to safe water. Providing information is a less expensive and simpler policy than providing safe sources of water. Therefore, it is important to know if and when information alone can induce people to seek safe water with their own resources.

We study how people react to information about high concentrations of arsenic in their drinking water in Bangladesh. First, we determine the probability that a person who learns that her well is unsafe seeks another source of water. Second, we compare the effectiveness of two different types of information campaigns, a door-to-door campaign and a campaign based on the media, in communicating information about arsenic other than well-specific test results.

One-third or more of the wells in Bangladesh have arsenic concentrations above the Bangladeshi safety standard of 50 micrograms per liter (µg/L).[1] At least 37 million people are consuming unsafe water. (BGS/DPHE 2001) Arsenic contamination surfaced in Bangladesh after a successful health campaign promoted drinking groundwater rather than surface water in the 1980s. The change in behavior reduced the incidence of water-borne diseases, but exposed people to arsenic.

Long-term exposure to arsenic causes a variety of potentially lethal health problems whose gestation periods vary from 5 to 20 years.[2] Since the majority of the population has been using wells since the early 1990's, the country may now be in the early stages of an epidemic described by Smith et al in the WHO Bulletin (2001) as "… the largest case of mass poisoning in history."

We provided two types of information to households in our study area, Araihazar district. First, we tested each well, labeled it as safe or unsafe and communicated the result to the users of the well.

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[1] The World Health Organization lowered its standard for safe concentrations from 50 to 10 µg/L in 1993.
[2] See section A.2 of the appendix. Some references are Chang et al (2004), Chiu et al (2004), Hopenhayn-Rich et al (1996), Lokuge et al (2004), Moore et al (1997), Wasserman et al (2004).

Second, we organized information sessions about the dangers of drinking water from unsafe wells. Households in Araihazar and in four control areas, in which we did not provide information, were also exposed to information about arsenic disseminated by the government through TV, radio and newspapers.

Our most striking result is the strong response to the well tests. Sixty percent of people who learn that the well they used before the information campaign is unsafe change to another well,[3] while only 14% of people whose baseline well is safe change, and only 8% of people change in control areas. In a regression, having an unsafe baseline well increases the probability that a respondent seeks drinking water from a different well by 0.43. Ninety-eight percent of people in Araihazar can correctly state whether the baseline well is safe. Few people in control areas claim to know the status of their well. Therefore, the change in behavior in Araihazar appears to be a response to information about one's well.

We argue that we identify the causal effect of information about the baseline well on households' behavior. The above result could be biased if households whose wells are unsafe switch due to factors other than arsenic which are correlated with arsenic levels. However, we show that levels of arsenic are not correlated with observable household characteristics within villages. Furthermore, arsenic occurs naturally, not as an industrial pollutant, and the process by which it dissolves from the soil into the water does not suggest a mechanism which could correlate concentrations with household characteristics.[4]

The response to well tests suggests that information alone may result in a rapid and large change in behavior to avoid a risk to health. The change has significantly reduced exposure to arsenic according to data on arsenic concentrations in the urine collected by public health researchers.[5] Nevertheless, the size and rapidity of the response, which occurs within twelve months of receiving information, are surprising. Only 6% of people in our study area have symptoms of arsenic poisoning. (Ahsan et al 2006a

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[3] Opar et al (2006) report the same descriptive statistic based on a later survey in Araihazar.
[4] See for example Nickson et al (1998), Nickson et al (2000), McArthur et al (2001).
[5] Chen et al (2006)

and 2006b) Also, the response requires walking further for water and/or incurring monetary costs, since the main short-term options are neighbors' private wells, community wells or installing a new well.[6]

Furthermore, the response contrasts with most examples in the economic literature, which emphasize that behavior changes slowly in response to accumulation of information and the example of other people's behavior.[7] The context in our paper is different from contexts studied in the literature, therefore an outstanding question is under what conditions a large and rapid response can be expected.[8]

We provide a tentative lower bound for the WTP for the average reduction in arsenic resulting from changing to another well. We base it on the increase in the length of time spent walking for water.

Our second point is that the media campaign may be more cost-effective for disseminating general information about arsenic than is our door-to-door campaign. This is surprising since about a third of people own neither a radio nor a TV and only about 15% read newspapers. The probability that a resident of Araihazar, who was exposed to both the door-to-door and the media campaigns, is better informed than is a resident of the control areas, who received information only from the media, ranges from 0.21 to – 0.10, but the cost of the door-to-door effort is orders of magnitude larger. However, the media does not offer well test results, without which behavior cannot change.

The remainder of the paper proceeds as follows. Section 2 presents a simple model. Section 3 describes the project and the data. In Section 4, we discuss the effect of knowing whether one's well is safe on the decision whether to change to another well. We also present a tentative estimate of WTP to reduce exposure to arsenic. In Section 5, we analyze the difference between the effect of the door-to-door campaign and the media campaign. Section 6 concludes.

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[6] Arsenic concentrations vary greatly within hundreds of feet, therefore a household whose well is unsafe often has neighbors whose wells are safe. (van Geen et al 2002)

[7] Munshi and Myaux (2002), Conley and Udry (2002), Foster and Rosenzweig (1995), Besley and Case (1994), Munshi (2004), Jalan et al. (2004)

[8] For example, Munshi and Myaux (2002) study the speed with which people begin to use contraceptives in Bangladesh. Adoption of contraceptives in the Bangladeshi culture requires a change in social norms and in the bargaining power within households. Changing to a different source of water in our context does not.

2. Model

We provide a simple one-period model which determines how much safe water an individual seeks.[9] The model suggests a way to measure WTP for avoiding consumption of unsafe water.

Each individual maximizes her health outcome, measured as the number of days of work or school missed because of illness, subject to a budget and a time constraint. The number of days missed is h(d,b), where d is the effective exposure to arsenic, and b is the amount of medical intervention sought to reduce the effects of arsenic. Effective exposure to arsenic, $d(a,s_q,s_t)$ depends on a, the amount of arsenic in the water the individual consumes, s_q, the quantity of safe water which the individual purchases, and s_t, the amount of time which the individual spends obtaining safe water , e.g. by walking further for water. The distinction between s_q and s_t allows the cost of obtaining safe water to have components which have different prices, the market price of water and the opportunity cost of time respectively. We can write the number of days missed as $h(a,s_q,s_t,b)$.

In general, safe water may require both monetary compensation and an investment of time. In our context, the quantity of safe water purchased may be thought of as water from a new well, which must be installed and maintained, or water from a well belonging to a neighbor, who has to be compensated for the use of the water, or water from a community well, which requires a contribution to the community. If the source is someone else's well or a community well, then an individual also has to walk further for water in order to avoid arsenic, incurring the opportunity cost of time.

The maximization problem is the following

$$\max_{s_q,s_t,b,f,X} U(X,f,h)$$

$$s.t. \qquad I + p_w(T - f - h - s_t) \geq X + p_{s_q}s_q + p_b b$$

In this problem, X is a composite, private good purchased by the individual, f is leisure time, T is the total amount of time available, p_w is the wage, p_{s_q} is the price of a safe source of water and p_b is the price of

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[9] The model is essentially the one-period version of Grossman's (1972) model presented in Freeman (1993).

the medical services. The expression $(T - f - h - s_t)$ represents the total amount of time spent earning an income.

The first-order conditions for the quantity of safe water purchased and the time spent obtaining safe water are

$$\frac{\partial U}{\partial h} - \lambda p_w = \frac{\lambda p_{s_q}}{\partial h / \partial s_q} \qquad (1)$$

and

$$\frac{\partial U}{\partial h} - \lambda p_w = \frac{\lambda p_w}{\partial h / \partial s_t} \qquad (2)$$

where λ is the Lagrange multiplier on the budget constraint.

The above maximization problem yields the demand function for s_q, $s_q*(I, p_w, p_{s_q}, p_b, a)$ and an analogous one for s_t. Empirically, we will consider one demand function for safe water.

The model also yields an expression for WTP for avoiding arsenic as a function of information observable in our data. The expression below follows directly from the derivation in Freeman (1993), p. 350, using the above first-order conditions.

$$w_a = \frac{\partial h / \partial a}{\partial h / \partial s_q} p_{s_q} = p_w \frac{dh}{da} + p_{s_q} \frac{\partial s_q^*}{\partial a} + p_w \frac{\partial s_t^*}{\partial a} + p_b \frac{\partial b^*}{\partial a} - \frac{\partial U / \partial h}{\lambda} \frac{dh}{da} \qquad (3)$$

where asterisks denote demand functions. The left-hand side is the marginal WTP for a reduction in exposure, because one can show that marginal WTP is equal to the marginal rate of substitution between pollution and any input which determines health, multiplied by the price of that input. Cost minimization in the production of health requires that the values of marginal products of all inputs be equal.

The first four terms on the right-hand side of expression (3) are observable in principle. They can be approximated with information about observed changes in days spent ill due to exposure to arsenic, expenditures on safe water, the value of time spent walking for safe water and expenditures on medical assistance. Applying data to expression (3) should yield an underestimate of the marginal WTP. The last

term, which is unobservable, is positive since $\frac{\partial U}{\partial h} < 0$. Therefore, the true marginal WTP is higher than the measured one.

Our data allows only a partial estimation of what expression (3) suggests. We estimate the WTP for the average change in arsenic resulting from a change to a different well by a household whose baseline well is unsafe. We do not know to which well the household changed for enough households to determine the resulting change in arsenic levels.

Second, we estimate only two components of WTP, the value of additional time spent walking for water as a result of the change to another source and the value of this and all other costs of the new source as reflected in the difference between household expenditures of those households who change and those who do not among those whose baseline wells are unsafe. Therefore, we underestimate WTP, because we do not observe the first and the fourth terms on the right-hand side of (3) in addition to the last term.

3. Project and data

The project is a joint effort by geochemists, public health researchers and economists to study the arsenic problem in Bangladesh and to help design policy responses. The study took place in a 25km^2 section of the Araihazar district, 20 km south-east of Dhaka, with a population of 70,000 and with 6500 wells in 54 villages. We also conducted surveys in a subdistrict of each of four other districts in the country in order to provide a control for the analysis in Araihazar. The other subdistricts are Jessore Sadar in Jessore district, Nikli in Kishoreganj, Tangail Sadar in Tangail and Ghior in Manikganj.

In Araihazar, we provided three main pieces of information: the results of well tests, general information about the health consequences of drinking water which has unsafe levels of arsenic, and the results of a health exam. The geochemists tested every one of the 6500 wells and labeled each with a picture denoting whether the well is safe or not and the level of arsenic.[10] (van Geen et al 2003) Contemporaneously with the well tests, the public health team interviewed 4,803 married couples and

2140 other married individuals, telling respondents whether the well which they primarily use for drinking water is safe and the level of arsenic in it. They also conducted a health exam, which included a urine and blood sample, and told each respondent if they had symptoms of an arsenic-related illness. (Ahsan et al 2006a and 2006b, Parvez et al 2006)

After the public health interviews, a team of three educators held meetings in each neighborhood to communicate information about arsenic through skits, songs and conversation using materials designed for an illiterate audience. The meetings were conducted during working hours. Thirty-one percent of the people in our sample attended a meeting. The information included health problems which arise from drinking water with unsafe levels of arsenic, the fact that these are not contagious, the fact that commonly known treatments of water, such as boiling, do not remove arsenic, and an explanation of the labels on the wells. They suggested that people whose wells are unsafe switch to safe wells, exhorted those with safe wells to allow others to use them and warned against using surface water unless people boil it.

The data for this paper is from a survey which we carried out six to twelve months after the education campaign and from the earlier public health survey. From the public health survey, we know the baseline well for each household and whether or not they had heard of the arsenic problem before our information campaign. All other data documents conditions *after* information was provided.

In our post-education-campaign survey, we interviewed 2680 individuals who responded to the public health survey. The sample for the public health survey consisted of randomly chosen married couples or individuals at each of the 6500 wells. We randomly selected 2000 wells and then randomly chose one of the couples from the public health sample who use that well. Our sample consists of 1089 married couples, 414 married women and 87 married men.[11]

We asked questions in the following categories: characteristics of the household and its members, what the respondent knows about the arsenic problem, which source of water the household currently uses

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[10] The picture denoting whether the well is safe is understandable to the 55% of the population who are illiterate.
[11] We could not interview the couple at every well, nor could we always interview both members of the couple.

and why they did or did not change to a different source, household expenditures on food and non-food items, savings, remittances and assets. Tables 1 and 2 present descriptive statistics of selected variables.

During the last months of our survey in Araihazar, we collected information in control areas, in which neither we nor anyone else had tested all wells nor conducted a door-to-door education campaign.[12] We interviewed 200 married couples in Jessore Sadar and 100 each in Tangail Sadar, Nikli and Ghior. Jessore Sadar includes one of the largest cities in Bangladesh, Jessore. In this area, we selected 3 city neighborhoods, 4 mixed urban/rural neighborhoods and 3 villages. All were chosen randomly from a list of neighborhoods and villages. We interviewed 20 couples randomly chosen in each neighborhood or village. In all other areas, we randomly chose 5 villages from the list of all villages and randomly chose 20 couples in each village.

We collected the same categories of information in each control area as in Araihazar. We did not know which well the household was using six to twelve months earlier, i.e. when households in Araihazar received information about their wells, so we asked each respondent to recall whether they had changed to a different source of water in the last twelve months. We provide a time line of the project in section A.1 of the appendix.

4. Effect of information on behavior

We estimate the effect of information that the baseline well is unsafe on whether or not the respondent obtains drinking water from another well. The alternative sources of water available to people whose wells are unsafe are constrained by the short period of time which has elapsed since information was provided. The great majority of wells in Araihazar are privately owned by households and another household's private well is the most readily available option. Close to 90% of households in our study area live within 100 meters of a safe well, even though only 46% of wells are safe. (van Geen at al 2002)

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[12] We were working with non-profit, non-government organizations (NGOs) which were planning to test wells and provide information. We are grateful to UNICEF, BRAC, The NGO Forum for Water and Sanitation, EPRC and Unnayan Samannay for their collaboration.

Among those who change to another well in our sample, 63% change to a neighbor's private well, 24% install their own new well and 13% change to an existing community well.

We estimate the equilibrium relationship between information and behavior. Our hypothesis is that information about one's well affects one's demand for another source of water. However, we may be underestimating the demand effect since the information is also correlated with supply. Arsenic levels are positively correlated, therefore a household whose well is unsafe is more likely to have neighbors whose wells are unsafe and therefore has fewer safe wells in the vicinity. We include the percent of neighbors within a 100 meter radius whose wells are unsafe and their average arsenic in the regression to control partly for the supply effect.

We estimate the effect of information using only Araihazar data. Araihazar data are sufficient for this purpose, as we discuss below. Also, information in control areas is not easily comparable to that in Araihazar. In Araihazar, 98% of the 2,071 respondents who answered the question can correctly state whether the baseline well is safe or not and the information is publicly available on well labels. In control areas, 20% of respondents claim to know the status of the well they were using 12 months before, but we do not know whether their information is based on well tests or if they are simply claiming to be informed.[13] Also, the information is not public, therefore people cannot easily find a safer well.

The Araihazar data are sufficient to obtain an unbiased estimate of the effect of information about one's well as long as the status of the baseline well and whether the household knows the status are orthogonal to household characteristics which may affect the decision to change to another well. We supply evidence that arsenic is not correlated with observable household characteristics within villages in Table 3. The first two columns show means of various characteristics for respondents whose wells are safe and those whose wells are unsafe. Respondents whose wells are unsafe on average have slightly lower household expenditures, lower assets, and they are slightly older. However, in the regression reported in column 3, in which we include village fixed effects, whether or not a well is safe is correlated

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[13] Eighty-eight percent of respondents in control areas who claim to know the status of their wells say that their wells are safe, while on average 35% of wells in control areas are unsafe.

only with age. The chi squared test for whether the coefficients on all independent variables except the village fixed effects are zero has a p value of 0.19.

Although the distribution of arsenic in aquifers of Araihazar and elsewhere in Bangladesh is highly variable spatially, this variability is geological and unlikely to be related to any characteristics of the individual respondents.[14] One potential relationship to patterns of human activity is based on the fact that the amount of arsenic released in shallow groundwater is related to the age of groundwater.[15] Age, in turn, appears to be related to the permeability of nearby soils.[16] In principle, this relationship could generate a correlation between arsenic contamination and patterns of cultivation, and therefore perhaps income and wealth. For instance, a high-arsenic village surrounded by fine-grained, impermeable fields could conceivably be better off because less irrigation water is needed to produce rice. In rice paddies cultivated in sandy, and therefore permeable, fields irrigation pumps have to run considerably longer than in clayey fields to compensate for the water lost to percolation. (van Geen et al., 2006) However, the mechanism would yield a positive correlation between expenditure or assets and arsenic, while we find a negative correlation. Furthermore, the mechanism does not suggest a reason why arsenic may be correlated with household characteristics *within villages*.

A second potential source of correlation is that wealthier households are more likely to have deeper wells and depth of well is correlated with the level of arsenic. However, depending on location and the depth of the well, deeper wells may have higher or lower levels of arsenic than shallower wells.

Two factors which may be correlated with the status of the baseline well may result in a different response to information about the well in areas other than Araihazar. First, the response to unsafe wells may be different in areas in which more people have health problems due to arsenic than in Araihazar.

Second, the distribution of arsenic in the area may affect a household's decision whether or not to change to another well. If neighbors influence each others' behavior, then the percentage of neighbors

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[14] BGS/DPHE (2001), van Geen et al (2003), Yu et al (2003)
[15] Stute et al (2006)
[16] Aziz et al (2006), Weinman et al (2006)

who have unsafe wells may affect the decision. We control for this effect partly using information about arsenic in wells belonging to neighbors who live within 100 meters.

4.1   Methodology

We estimate a probit regression in which the binary outcome is whether respondent i in village j changes to another well or not. Our estimator of the effect of information is the coefficient on the binary variable which indicates whether the respondent's baseline well is safe. Other independent variables include: the level of arsenic in the baseline well, the percentage of the respondent's neighbors who live within 100 meters whose wells are unsafe, the average level of arsenic in those neighbors' wells, characteristics of the individual's baseline well such as the relationship to the owner of the well and the distance to the well, respondent's characteristics and village fixed effects.

We also report results obtained using the regression discontinuity approach. If a concern remains that levels of arsenic are correlated with respondents' unobserved characteristics, then respondents whose wells have similar arsenic levels should have similar characteristics.[17] Even if this assumption does not hold, but the relationship between characteristics and arsenic levels is smooth, then the effect of the discontinuity point should still constitute a valid estimate of the effect of information when we control smoothly for arsenic. Therefore, we compare the probability that the respondent changes to a different well in a restricted range of arsenic levels, i.e. just below and just above the safe threshold of 50 µg/L.

4.2   Results

The most remarkable result which we document is that 60% of the 1522 respondents in Araihazar whose baseline wells are unsafe change to a different well. Only 14% of households whose wells are safe change and only 8% of people change in control areas over the same period of time.[18] These statistics strongly suggest that households whose wells are unsafe and who change are responding to information about arsenic in their wells.

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[17] Angrist and Lavy (1999), Chay and Greenstone (2005), Cook and Campbell (1979)
[18] Households whose wells are safe or who do not know whether their wells are safe may change, because the well malfunctions or the quality of the water deteriorates. Opar et al (2006) document broken wells.

Having an unsafe well increases the probability of changing to another well by 0.49, relative to the probability of changing when the baseline well is safe, when we do not control for the continuous level of arsenic in the full sample, as shown in column 1 of Table 4. The effect is 0.43 when we do control for the level, as shown in column 3. The estimates remain the same if we do not control for household characteristics, as columns 2 and 4 show. The latter result is consistent with the evidence that arsenic is uncorrelated with respondent characteristics within villages.

The behavior of those households whose baseline wells have arsenic concentrations just below the safe threshold of 50 µg/L is significantly different from the behavior of those whose wells are just above this threshold, as we show graphically in Figure 1. In the regression discontinuity framework, we restrict the sample to observations near the safe threshold. Having an unsafe well increases the probability of changing for households whose baseline wells have arsenic levels between 0 and 100 µg/L by 0.47 if we do not control for continuous levels of arsenic, as reported in column 5 of Table 4. The effect in the 25 to 75 µg/L range is 0.45, in the 35 to 65 µg/L it is 0.45 and in the 40 to 60 µg/L range it is 0.33.[19] These are all significant at 2% or less.

The effect of having an unsafe well in the 0 to 100 µg/L range of arsenic is 0.27 if we control for continuous levels of arsenic, as shown in column 6 of Table 4. It is 0.30 in the 25 to 75 µg/L range and significant at 1%. It is 0.4 in the 35 to 65 µg/L and 40 to 60 µg/L ranges, but not statistically significant. The coefficient on the binary variable declines more when we include level of arsenic in the regression in the narrower ranges of arsenic than it does in the full sample, while the coefficient on level of arsenic is always significant and progressively larger as the range of arsenic in the sample becomes narrower. One interpretation of these results is that the effects of level of arsenic and the indicator variable for the safe threshold become more difficult to distinguish statistically as the range of arsenic shrinks.

We also tested the difference between the effect of an increase in arsenic from 30 µg/L to 40 µg/L and the increase from 40 µg/L to 50 µg/L, and several other pairs of intervals of ten µg/L each below and

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[19] The last two estimates are based on 212 and 114 observations, respectively. These samples have 10 observations per village on average.

above the safe threshold. The difference in behavior is statistically significant only between the intervals of 40 to 50 and 50 to 60. This again suggests that the effect of the safe threshold is not due to unobservables which are correlated with arsenic.

Respondents self-report whether they changed to another well or not. One may be concerned that people whose wells are unsafe are more likely to report that they changed to another well even if they do not in order to please the interviewers. Two pieces of evidence suggest that our result is not biased. First, urinary arsenic declined in 47% of those with unsafe baseline wells who report not switching, while it declined in 63% of those who report switching. The difference is significant with a p value close to 0.[20] Second, we asked people whose wells are safe how many households began to use their wells after being informed about arsenic. The report should underestimate the number who changed since it does not reflect the number of those who installed new wells or who changed to a community well. On average, two households began to use each safe well. This implies a larger percentage of households with unsafe wells switching to other wells than we find.

Above, we explain behavior with the actual arsenic concentration in the well, not what the household believes it to be. The increase in probability of switching predicted by whether the respondent thinks the baseline well is unsafe is 0.53 in a regression with continuous arsenic and other controls. Those who are wrong about the status of the well are overwhelmingly more likely to have an unsafe well; out of 50 people who are wrong 43 have unsafe wells and 7 have safe wells.

The change in behavior is remarkable, since few people have personal experience which tells them that the water is unsafe. Only 6% of people in our sample know of someone who has either fallen ill or died as a result of arsenic exposure. In addition, changing to another source of water is costly.

We analyze who among the respondents with unsafe baseline wells is more likely to change to another well in order to determine which households require assistance in securing access to safe water.[21] People are no more likely to change as the level of arsenic in the well increases until the level of arsenic

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[20] Based on data used in Chen et al (2006).
[21] The results are available from the authors.

reaches 300μg/L. The finding is troubling since long-term exposure to concentrations of 250μg/L is far more dangerous than is exposure to levels of, for example, 55μg/L.

The household is more likely to change to another well if more neighbors who live within 100 meters have safe wells. A one standard deviation increase in the percent of neighbors who have safe wells, which is 0.38, increases the probability of changing by 0.08.

Family networks appear to play a large role in the decision whether or not to change to another well. The probability that people who own their well switch is 0.22 less than is the probability that people who use wells owned by non-relatives switch. The probability that someone who uses a well owned by a relative within the family compound, called a bari, switches is 0.14 less. Both of these results hold when we control for the distance to the well, thus reflecting an effect other than distance. Furthermore, those who have safe wells report that 93% of other people using their wells are relatives. People seem to be reluctant to use the wells of neighbors who are not relatives.

People in the lowest quartile of asset ownership seem to be disadvantaged in terms of access to safe water. The probability that a respondent in the lowest quartile changes to another well is 0.11 smaller than is the probability for a respondent in the second quartile.

Secondary and higher education increase the probability of changing relative to no education, but primary education does not.[22] The respective increases in probability are .15 and .18. Education may affect the evaluation of the risk imposed by drinking contaminated water conditional on being informed. Also, education could affect one's social status and thereby access to others' wells. Jalan et al (2004) find that education has a large effect on the decision to adopt some method for purifying drinking water. They interpret education as a proxy for how informed people are. In our sample, there is almost no variation in how informed people are about the safety of their wells, therefore the effect of education is conditional on being informed about the safety of the well.

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[22] Primary education consists of years 1 – 5, secondary 6 – 10, and higher of years 11 and up.

4.3 Willingness to pay for safe water

We estimate two components of the WTP for a reduction in exposure to arsenic in the Araihazar sample: the opportunity cost of time, and all other costs associated with changing to another well. Those who change to someone else's well or a community well have to walk farther for water. The time is likely to have an opportunity cost in terms of foregone income or housework. Furthermore, use of someone else's well or a community well may require either explicit payments or implicit compensation in the form of helping to maintain the well or otherwise assisting the owner of the well. Those who install their own wells pay for the cost of installation and maintenance.

We estimate the effect of changing to another well on the additional time that respondents spend walking for water and, separately, on household expenditure. If labor markets were perfect, the cost of the additional time spent walking for water would appear in foregone earnings and therefore in reduced expenditure or savings.[23] However, in Bangladesh, women walk for water and employment opportunities for women are limited. The additional time women spend walking may not appear in reduced expenditure or savings unless income-earning household members have to work less and help at home more as a result. Thus, WTP may actually be a sum of the value of additional time spent walking and any effect on expenditure, where the latter reflects the monetary costs of the source.

The two components do not include other dimensions of WTP for reduction in exposure and therefore they are lower bounds. They ignore the costs of seeking medical remedies. Few people in Araihazar incurred these, therefore they would not be reflected in expenditure. Our estimates also ignore costs reflected in reduced savings and they do not account for the disutility of being ill.

4.3.1 Methodology

The following is the regression model which estimates the effect of changing to another well on additional time spent walking for water. The model for the effect on a household's monthly per capita expenditure is identical except for the dependent variable.

$$t_{ij} = s_{ij}\kappa + \mathbf{x_{ij}}\boldsymbol{\alpha} + \mathbf{v_j}\varphi + \varepsilon_{ij} \qquad (4)$$

$$s_{ij} = a_{ij}\delta + \mathbf{x_{ij}}\boldsymbol{\alpha} + \mathbf{v_j}\varphi + \nu_{ij} \qquad (5)$$

$$s_{ij} = 1 \qquad \text{if } i \text{ in village } j \text{ changes to another well}$$

$$= 0 \qquad \text{otherwise}$$

The dependent variable, t_{ij}, is the difference between the length of time respondent i in village j walks for water now and the length of time she walked to the baseline well. It is zero for those respondents who did not change to another well. The vector $\mathbf{a_{ij}}$ contains the indicator for whether the baseline well is safe and the level of arsenic in the baseline well. The vector $\mathbf{x_{ij}}$ contains household and respondent characteristics and characteristics of the baseline well. The vector $\mathbf{v_j}$ contains village fixed effects. The errors in (4) and (5), respectively, are ε_{ij} and ν_{ij}.

We assume that the errors, ε_{ij} and ν_{ij}, are correlated. The motivation to seek safe water may be correlated with unobservable characteristics, e.g. entrepreneurial spirit or utility derived from health, which may also affect one's relationship with the neighbors and/or one's status in the community and therefore the distance to an available safe well. When expenditure is the left-hand-side variable, there is also a simultaneity problem caused by the fact that wealthier households are more likely to be able to afford their own new well.

Whether or not the respondent's baseline well is safe and the level of arsenic in this well serve as instruments for changing to a different well. When expenditure is the dependent variable, arsenic may not satisfy the exclusion restriction if respondents exposed to high levels of arsenic suffer health problems which affect expenditure. In this case, the impact of changing to a different source may actually be the effect of the health shock on expenditure. However, arsenic-related medical expenditures are unlikely to affect our results. Among the few people who had arsenic-related symptoms at the time of the survey, even fewer had sought any medical attention, partly because no medical services were available until the public health team established a clinic towards the end of our survey.

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[23] We do not use the data on savings since it may have large errors. The question required the respondent to recall the amount saved over the previous year, which is a long recall period.

The coefficient of main interest, κ, should be the effect of changing to another well on those households whose baseline wells are unsafe.[24] We expect the effect to be positive for the additional time spent walking and negative for expenditures, since we do not include in expenditures money spent on water and expenditures on medical interventions have been limited if any.

In a specification in which only the binary indicator for whether the well is unsafe serves as the instrument, the instrumental variable estimator can be interpreted as a difference-in-difference estimator, which yields an estimate of the difference in time spent walking for water between those households who changed to another well and those who did not among those households exposed to unsafe levels of arsenic minus this difference among those households whose baseline wells are safe.

4.3.2   Results

The mean time spent walking to the baseline well was .13 minutes and the median was 0 minutes. Only 5% of respondents walked more than 1 minute, with 6 minutes being the longest time. After our information campaign, the mean time is 1 minute, the median is still 0, but 32% of the sample walk 1 minute or more and the maximum time is 20 minutes.

Changing to another well on average raises the time the respondent walks one way for water by 2.15 minutes, as we report in the first column of Table 5. This is an increase of 2.02 minutes over the mean time of .13 minutes. Women bring water several times a day, therefore an increase of 4 minutes in the round trip is large, especially relative to the time they had to devote to the activity before.

We also examine the effect using the regression discontinuity framework. Additional time spent walking rises sharply at the safe threshold of 50µg/L, as Figure 2 shows. In a regression in which we restrict the sample to households whose arsenic levels are between 0 and 100 µg/L, the effect is a slightly smaller increase in time of 1.82 minutes, as shown in column 4 of Table 5. The result for households whose arsenic levels are between 25 and 75 µg/L is essentially identical.

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[24] The coefficient should be an estimator of the effect of treatment on the treated. Wooldridge (2002), p.632

Changing to a different well does not have a significant impact on expenditure, as the fourth column in Table 5 shows. The result may suggest that labor markets are indeed imperfect, so people can pay for a new source of water with time but not money. However, it may also mean that people are drawing down savings rather than reducing expenditures.

We can obtain a lower bound on respondents' WTP for a reduction in exposure to arsenic by valuing the increase in the time spent walking for water at an appropriate wage. However, women obtain the water and their employment opportunities are limited, therefore a market wage would be highly inaccurate. We do not have the data to estimate a household production function. The following exercise is purely illustrative. The average male wage in our data is about 30 taka per hour. Assume that women walk for water once for every meal, i.e. 3 times a day, and value their time at half the male wage. Then the implied WTP per household is 90 taka per month, or about $1.50.[25]

The increase in the time spent walking may be the primary cost of changing to another well for those households who do not install their own new wells. Respondents report that they do not pay money for water, but rather compensate the owner of the new well in kind and that the compensation is voluntary and not large.[26] Also, a World Bank report cites similar estimates of WTP for arsenic-free water, between 125 and 162 taka per household per month.[27] (Ahmad et al 2002, p. 12)

The estimate of WTP potentially enables us to conduct a preliminary cost-benefit analysis of our information campaign. However, our project involved costs associated with a large, multidisciplinary research project which would not be incurred by an intervention designed only to inform. We can obtain an underestimate of the costs from two components. The cost of wages necessary to bring general information about arsenic to our entire study area was $9000, which is $0.77 per household. The cost of a

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[25] At the time of the survey, the exchange rate was about 58 taka for one U.S. dollar.
[26] Respondents may be reluctant to admit monetary payments because of the Islamic injunction against demanding payment for drinking water.
[27] The report focuses on the results of a contingent valuation survey. However, it also provides WTP estimates based on costs of obtaining safe water incurred by households, which are the figures we cite. They note that the increase in time spent obtaining water is the main cost, but they do not provide the wage at which they value the time.

test of well water for arsenic is $0.50.[28] These two costs ignore the cost of materials needed to communicate the general information, the cost of wages required to conduct a well test, and the cost of well labels. The sum of the two one-time costs is less than the per month WTP for another source of water, which suggests that the benefit of the information provided exceeded the cost.

5.   Comparison of two information campaigns

We determine whether the door-to-door information campaign carried out in Araihazar contributed to the amount of general information which people have about the arsenic problem over and above the government media campaign. Both households in Araihazar and in the control areas were exposed to information about the dangers associated with drinking water contaminated with unsafe levels of arsenic transmitted through TV, radio and newspapers.

In this section, we focus on information which is not well-specific. The campaigns clearly differ in terms of the information provided about the safety of one's own well. The media campaign has not induced people to test their wells in large numbers. We do not know whether the reason is that people do not seek the tests or because the tests are not available or are too expensive. In principle, the media inform people that local offices of the Department of Public Health and Engineering (DPHE) provide free well tests, but we do not know how responsive DPHE offices are.

5.1   Methodology

We consider whether people in Araihazar are more aware that the arsenic problem exists than are people in control areas, and whether they are more likely to know that boiling water does not remove arsenic and that diseases caused by arsenic are not contagious.[29] The main independent variable of interest

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[28] This cost is based on a test with a portable field kit, not a laboratory test.
[29] The misperception that skin conditions caused by arsenic are contagious causes considerable hardship. Reports that women who are affected are abandoned by their husbands and even banished from their villages are common.

is the treatment variable which takes the value one if the person resides in Araihazar and 0 if she resides in a control area.

Simple probit estimates may be biased since we only have one treatment region, four control regions and none of them were chosen randomly. Araihazar was chosen for its accessibility from the capital, Dhaka. The control areas are much farther away from Dhaka. They were chosen from among areas in which our partner NGOs were planning to implement arsenic awareness programs in the future. Table 2 compares a number of characteristics of households in Araihazar and in control areas. Monthly per capita household expenditure in Araihazar does not differ from the average for the control areas. However, the average Araihazar household has less per capita wealth in assets and its adult residents have two fewer years of education. If education or assets are correlated with unobservable characteristics which make people more informed, then the estimate of the treatment effect in Araihazar may be biased downward. On the other hand, the proximity of Araihazar to the capital may bias our results toward finding a bigger treatment effect than is really due to our information campaign.

In order to address the bias, we calculate estimates based on propensity score matching. We report a range of estimates obtained using several approaches: kernel-based matching method using the Gaussian kernel, nearest neighbor matching with equal weights placed on the nearest neighbors in case of a draw, and stratification matching, which yields the average of treatment effects calculated within the blocks of observations in which treatment and control observations do not differ with respect to any observables included in the analysis.[30] No one of these approaches seems to be a priori preferable to the others. In all cases standard errors were obtained by bootstrapping.

Propensity score estimators have been found to perform well when the same data sources are used for treatment and control groups, the two groups reside in similar economic environments and a rich set of pre-treatment variables is available to estimate the probability of treatment. (Heckman et al 1997, 1998) The first condition certainly holds in our data. The second is less satisfied since some control areas are

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[30] Dehejia (2002), Heckman (1997) and (1998), Smith and Todd (2001)

more urban and some more rural than Araihazar and Araihazar is more industrialized than the others. Also, we collected the data after the treatment. However, we have a number of variables which could not have been affected by the treatment such as age, gender, education, household size and number of relatives who live in the area. We also use household expenditure and assets to obtain the propensity score, since they could have been affected by treatment only if the household changed to another well and we find that changing to another well does not affect them.

5.2   Results

Ninety-nine percent of respondents in Araihazar are aware that well water may be contaminated with arsenic, while 84% of people in control areas are aware. According to propensity score estimates, the probability that a resident of Araihazar is aware is higher than is the probability for a resident of a control area by 0.20 with the kernel method and the nearest neighbor matching method, reported in column 3 of Table 6, and by 0.21 with the stratification method. All estimates are significant at 1%.

Fifty-two percent of respondents in Araihazar know that boiling water does not remove arsenic and 43% know that diseases caused by arsenic are not contagious. The respective percentages in control areas are 62% and 60%. The probability that a resident of Araihazar knows that boiling water does not remove arsenic is lower by 0.04, which is significant at 5%, according to the kernel method and it is the same as the probability for a resident of a control area according to the other two methods. The results for the nearest neighbor method are in column 5 of Table 6. The probability that a resident of Araihazar knows that arsenic-related diseases are not contagious is lower by 0.12 according to the kernel and stratification methods and by 0.1 according to nearest neighbor. These estimates are significant at 1%.

More people in Araihazar appear to be aware of the arsenic problem than in control areas, but fewer are informed about the other two issues. The small difference between the effect of our campaign and the effect of the media is surprising given the intensive presence of our project in Araihazar and the limited reach of the media. People in Araihazar spoke to researchers who were testing wells, researchers who were conducting physical exams, and interviewers, and they saw project staff walking around most

days. The presence of foreigners working for a well-known U.S. university is very noticeable to people in rural areas. Also, people in Araihazar learned whether their own well is safe or not, which considerably raised the value of knowing whether arsenic is a serious enough danger to be avoided or not. Finally, ownership of televisions and radios is far from universal and only about 15% of people read newspapers.

The benefit of adding the door-to-door information delivery to a media one does not seem to justify the large cost of the former. We do not know how effective the door-to-door campaign would have been without the media one. In Araihazar, 97% of respondents report learning about arsenic from our project staff, while 76% of people in control areas report that they learned about arsenic from the media, 72% of them from the TV. This suggests that the door-to-door campaign may have attained the same result by itself as it did in addition to the media, but even in this case the media are a more cost-effective way of delivering the general information.[31]

We studied the determinants of being informed in order to identify categories of people who did not benefit from these information campaigns. The determinants are similar in Araihazar and in control areas.[32] The most striking results are the importance of education and lack of importance of household expenditure and assets. Completing between 6 and 10 years of school raises the probability of being informed by 0.2 to 0.29. Completing more than 10 years of school raises the probability by a further 0.39 to 0.43 for women and a further 0.08 to 0.32 for men. Level of education is likely to be correlated with unobservable characteristics which affect how informed a person is. However, being informed about a health risk may also be a significant return to education.

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[31] The cost of wages required to bring information door-to-door throughout the country once in the course of a year would be about $17 million, using the wage which our project paid. This ignores all other costs involved.
[32] The results are available from the authors.

6. Conclusion

Our principal finding is that information alone can rapidly induce a large percentage of people who face a risk to health to change their behavior in order to avoid the risk, even if the change is costly. The important implication is that investment of public resources in providing information can be effective even when resources for a more elaborate intervention, such as alternative sources of water, are lacking.

We provide information about the level of arsenic in the water in people's wells. Having an unsafe well increases the probability that the person will change to another well within six to twelve months of receiving information by 0.43. The response to information is particularly striking since few people were sick from arsenic at the time of our survey and switching to another well is costly.

The crucial effect of our house-to-house information campaign was to provide information specific to the individual, whether her/his well is safe. Ninety-eight percent of people in our study area know whether their well is safe, while 20% claim to know in control areas. People exposed only to the media information campaign have not obtained well tests.

On the other hand, the media seem to provide a more cost-effective method of communicating general information about arsenic despite the fact that only two-thirds of households own a TV or a radio. People in Araihazar are only slightly better informed, while the media campaign is considerably cheaper.

The contrast between our results and prior literature raises an important question for future research; under what circumstances is a large and rapid change in behavior in response to information likely to occur? One potential explanation, which we explore in Madajewicz, Pfaff, Robalino (2005), is the influence which neighbors have on each others' behavior. If such influence is strong, even if only a few people are convinced of the need to act, their behavior may spread through the community. Such strong effects may help design information campaigns which target only a few people in a group.[33]

Explaining the effect we observe requires understanding which components of our intervention were crucial in eliciting the behavioral response. For example, would a media campaign together with a

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[33] See for example Katz and Lazarsfeld (1955) for a sociological discussion of this idea.

well test yield the same outcome, or did other parts of our intervention such as the repeated surveys and the daily contact between residents and project staff promote a sense of urgency about the problem? The geochemists are documenting the percentage who change to another well in areas in which only well tests were conducted by the Bangladesh Arsenic Mitigation Water Supply Project in addition to the media campaign. Their data may help to shed light on the question.

A number of questions remain for future research. Future surveys will reveal whether the change in behavior which we document is a long-term or a temporary one. We want to understand the long-term impact of the decision to change on welfare. The change in behavior may have consequences other than avoiding diseases caused by arsenic, such as reduced schooling for children, worse nutrition, etc. An important question is whether relatives or any other social networks help people gain access to safe water, thereby providing insurance in this health crisis. Finally, we want to determine whether information can lead to more complex behavioral responses. Access to safe water in the medium and long run is likely to require an organized response by communities, the public sector or the private sector to drill wells into deeper aquifers which are free of arsenic, to pipe water from safe wells, and/or to clean up surface water. The questions arise whether an information intervention is sufficient to catalyze collective action and what types of organization are most effective in different types of communities.

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Table 1: Descriptive statistics for Araihazar data

Variable	Mean	Std. Dev.	Min	Max
Arsenic level (micrograms/liter)	108	119	5	879
Well is safe (takes value 1 if arsenic < 50)[a]	0.43	0.50	0	1
Age of respondent	37	11	16	80
Respondent is female	0.56	0.50	0	1
Number of people in household	5.8	2.3	2	24
Can read and write	.45	.50	0	1
Highest grade completed was at primary level	0.24	0.43	0	1
Highest grade completed was at secondary level	0.22	0.42	0	1
Highest grade completed was at higher level	0.03	0.17	0	1
Attend religious services: 1-never, 2-few times/year, 3-every month, 4-every week, 5-every day	2.83	1.51	1	5
Number of relatives who live in the area	17	17	0	250
Changed to another well for drinking water	0.40	0.49	0	1
Distance to original well (minutes walking)	.13	.5	0	6
Distance to new well (minutes walking)	1.05	2.26	0	20
Change in walking time due to change of well	0.93	2.26	-5	20

[a] Seventy-seven percent of wells in Araihazar have arsenic concentrations which exceed the stricter WHO standard of 10 micrograms per liter.

Table 2: Comparison of Araihazar and control areas

	Araihazar	Control areas	Ghior	Jessore	Nikli	Tangail
% of high arsenic wells[a]	56.8	34.9	30.4	26.4	12.9	63.3
Years of education*	3.18 (0.07)	5.34 (0.15)	4.5 (0.30)	7.26 (0.21)	2.83 (0.27)	4.88 (0.35)
Monthly per capita household expenditure (taka)	1,363 (32.13)	1,336 (55)	1,162 (134)	1,473 (82)	927 (57)	1,560 (159)
Per capita household assets* (taka)	73,097 (4,188)	136,781 (8,659)	81,171 (12,270)	151,617 (11,840)	53,476 (5,121)	246,383 (32,068)
Days of work or school missed due to illness last year*	13.82 (0.66)	17.07 (0.91)	10.43 (1.49)	18.23 (1.37)	19.02 (1.69)	24.91 (5.59)
Fraction use own well*	0.34 (0.009)	0.63 (0.02)	0.35 (0.03)	0.89 (0.02)	0.21 (0.03)	0.73 (0.03)
Fraction use well in bari*	0.47 (0.01)	0.13 (0.01)	0.34 (0.03)	0.07 (0.01)	0.06 (0.02)	0.1 (0.02)
Fraction use community well*	0.01 (0.002)	0.11 (0.01)	0.04 (0.01)	0.02 (0.007)	0.48 (0.04)	0.06 (0.02)
Hours watch television per month*	27.06 (0.75)	35.03 (1.3)	22.84 (2.08)	56.24 (2.45)	17.15 (1.92)	23.58 (1.7)
Hours listen to radio per month*	8.63 (0.37)	18.69 (0.9)	15.61 (1.78)	25 (1.71)	18.22 (1.98)	10.28 (1.1)
Days read newspaper per month*	2.48 (0.14)	7.11 (0.36)	3.87 (0.63)	12.05 (0.66)	1.94 (0.43)	6.06 (0.77)
Number of observations[b]	2680	997	199	397	201	200

Table contains means of each variable for each area. Figures in parentheses are standard errors of the sample mean estimate.

* Asterisks denote variables whose means are different for Araihazar and for control areas at a level of statistical significance of 0.05.

We have not conducted a mean comparison test for levels of arsenic.

[a] The percentage for Araihazar is from our own data. It is based on tests of every one of the 6000 wells in our study area, which is a small portion of the Araihazar district. Percentages for control areas come from UNICEF and are based on a sample of wells from each district: 11,000 wells in Ghior, 35,000 in Jessore, 10,000 in Nikli and 20,000 in Tangail.

[b] This is the total number of observations we have in each area. Not all of these observations were used to calculate the mean for each variable since different variables have different numbers of missing values.

Table 3: Determinants of whether a well is safe or not

	Mean for those with safe wells	Mean for those with unsafe wells	Is well safe? (1 if yes) Probit [a][b]
			Dependent variable
Years of education	3.23	3.13	-
	p value for mean test	0.48	
Primary education (1 if yes)	-	-	.04 (.032)
Secondary education (1 if yes)	-	-	.06 (.038)
Higher education (1 if yes)	-	-	.005 (.011)
Monthly household expenditure (taka)	8399	7230	-
	p value for mean test	0.002	
2nd quartile of expenditure (binary)	-	-	.003 (.037)
3rd quartile of expenditure (binary)	-	-	.03 (.042)
4th quartile of expenditure (binary)	-	-	.002 (.046)
Household assets (taka)	533,660	376,352	-
	p value for mean test	0.06	
2nd quartile of assets (binary)	-	-	.03 (.037)
3rd quartile of assets (binary)	-	-	.03 (.041)
4th quartile of assets (binary)	-	-	.03 (.045)
Own baseline well (=1 if used one)	.36	.33	.06
	p value for mean test	0.12	(.049)
Baseline well in bari (=1 if used one)	.45	.48	-.02
	p value for mean test	0.22	(.043)
Number of relatives in the area	18	16.6	-.0007
	p value for mean test	0.03	(.0007)
Days missed because of illness last year	13.44	14.04	-.0002
	p value for mean test	0.66	(.0004)
Age	36.5	37.3	-.003**
	p value for mean test	0.06	(.0017)
Village fixed effects	-	-	Yes
N	-	-	2107
Pseudo R^2	-	-	.23
p value for Chi^2 test	-	-	.00

[a] The column reports marginal effects calculated from a probit regression. Robust standard errors clustered by household are in parentheses. Other independent variables in the regression are how often attend religious services, how far walk to baseline well, household size. Their coefficients and the differences in means are not significant. Continuous education, expenditures and assets are also not significant if used instead of the binary categories.
[b] The chi squared test for the H_0 that coefficients on all independent variables except the village fixed effects are zero has a p value of 0.19.
* denotes significance at 0.1. ** denotes significance at 0.5.

Table 4: Response to information that well is unsafe

	Full sample (1)	**Full sample** (2)	**Full sample** (3)	**Full sample** (4)	**RD[a]** (5)	**RD[a]** (6)
		Dependent variable: Whether or not changed to another well (1 if yes)				
Well is unsafe (1 if unsafe)	.49** (.032)	.49** (.030)	.43** (.039)	.43** (.038)	.47** (.047)	.27** (.091)
Level of arsenic	-	-	.0009** (.0002)	.0008** (.0002)	-	.003** (.001)
Other controls	Yes	No	Yes	No	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	1943	2137	1943	2137	1159	1159
Pseudo R^2	.25	.23	.26	.24	.23	.24
P value for Chi^2 test	.00	.00	.00	.00	.00	.00

Table reports marginal effects calculated from probit regression. Robust standard errors clustered by household are in parentheses.

Other independent variables in regressions in columns 1, 3, 5 and 6 are percent of neighbors who live within 100 meters whose wells are unsafe, average arsenic level in wells of neighbors who live within 100 meters, education, monthly household expenditure, household assets, whether used own baseline well, whether used baseline well in bari, how long walked to baseline well, days missed due to illness last year, number of relatives in the area, how often attend religious services, household size, age.

Other independent variables in regressions in columns 2 and 4 are percent of neighbors who live within 100 meters whose wells are unsafe and average arsenic level in wells of neighbors who live within 100 meters. The estimate values change only in the third decimal place if we exclude these two controls.

[a] Sample consists of households whose baseline wells have arsenic levels between 0 and 100 µg/L.

* denotes significance at 0.1. ** denotes significance at 0.5.

Table 5: Impact of changing to a different well on additional time spent walking for water and on monthly household expenditures

	Dependent variable: time to current well minus time to baseline well[a]				Dependent variable: log of per capita monthly expenditure[b]		Dependent variable: whether or not changed[a]
	IV	OLS	OLS RF[d]	RD[c]	IV	OLS	OLS RF[d]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whether or not changed (1 if yes)	2.15** (.257)	1.52** (.124)	-	1.82** (.345)	0.03 (.074)	.009 (.032)	-
Whether well is unsafe (1 if unsafe)	-	-	.68** (.152)	-	-	-	.37** (.037)
Level of arsenic	-		.002** (.009)	-	-	-	.0007** (.0002)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1994	1994	1995	1225	1975	1975	1997
R^2	.20	.22	.16	.09	.36	.36	.32

Robust standard errors clustered by household are in parentheses.

[a] Other controls in these regressions are percent of neighbors who live within 100 meters whose wells are unsafe, average arsenic level in wells of neighbors who live within 100 meters, education, monthly household expenditure, household assets, whether used own baseline well, whether used baseline well in bari, how long walked to baseline well, days missed due to illness last year, number of relatives in the area, how often attend religious services, household size, age.

[b] Other controls in these regressions are percent of neighbors who live within 100 meters whose wells are unsafe, average arsenic level in wells of neighbors who live within 100 meters, education, household assets, whether used own baseline well, whether used baseline well in bari, how long walked to baseline well, days missed due to illness last year, number of relatives in the area, how often attend religious services, household size, age.

[c] This regression uses only households whose baseline wells have arsenic levels between 0 µg/L and 100 µg/L.

[d] Reduced form regression.

** denotes significance at 0.05 or less. * denotes significance at 0.01 or less.

|	Dependent variable								
	Is aware of arsenic (1 if yes)			Knows that boiling does not remove arsenic (1 if yes)			Knows that arsenicosis is not contagious (1 if yes)		
	Mean diff.[a] (1)	Probit[b] (2)	Propensity score[c] (3)	Mean diff.[a] (4)	Probit[b] (5)	Propensity score[c] (6)	Mean diff.[a] (7)	Probit[b] (8)	Propensity score[c] (9)
	.15** (.00)	-	-	-.10** (.00)	-	-	-.17** (.00)	-	-
Resides in Araihazar (1 if yes)	-	.16** (.020)	.20** (.025)	-	-.02 (.027)	-.03 (.032)	-	-.06* (.028)	-.10** (.036)
Other controls	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
Village fixed effects	-	No	No	-	No	No	-	No	No
N	3648	2986	Treat: 2384 Control: 562	3462	3000	Treat: 2384 Control: 458	3457	2998	Treat: 2384 Control: 460
Pseudo R^2	-	.40	-	-	.07	-	-	.09	-
p value for Chi^2 test	-	.00	-	-	.00	-	-	.00	-

[a] The values in this column are differences between the percentage who know in Araihazar and percentage who know in control areas. P value of t test is in parentheses.

[b] Columns report marginal effects calculated from probit regression. Standard errors are in parentheses. The other controls are household size, age, gender, education, monthly household expenditure, household assets, religious attendance, number of relatives in area, how many hours watch TV and listen to radio, how many days read newspapers.

[c] The approach is nearest neighbor matching with equal weights in case of a tie. Bootstrapped standard errors are in parentheses. The estimation uses only observations in the region of overlapping support. Eight observations in control areas were outside the common support region. Variables included in the calculation of the propensity score are household size and three higher order terms, age and two higher order terms, gender, number of relatives who live in the area, education and five higher order terms, monthly household expenditure and three higher order terms, household assets and two higher order terms.

** denotes significance at 0.05 or less. * denotes significance at 0.01 or less.

Figure 1
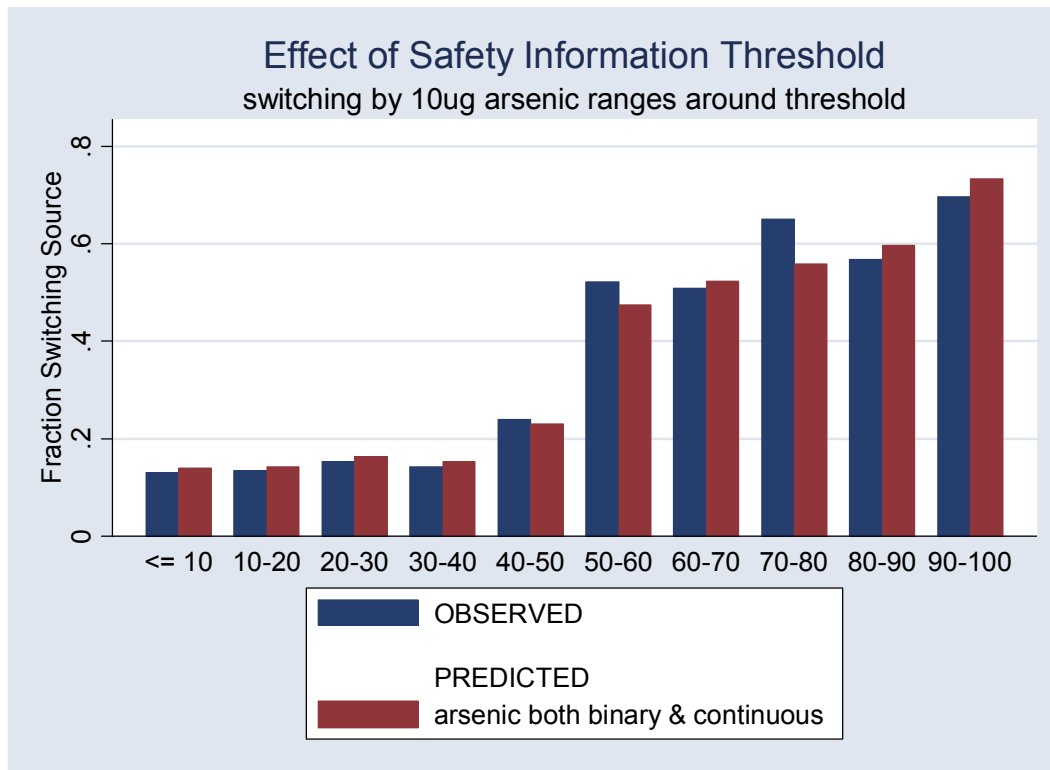
Arsenic concentrations in µg/L are on the x axis and percentage of people who change to another well is on the y axis.

The first bar in each interval is the observed percentage who change. The second bar is the percentage of those who change predicted with the regression reported in column 4 of Table 4.

Figure 2
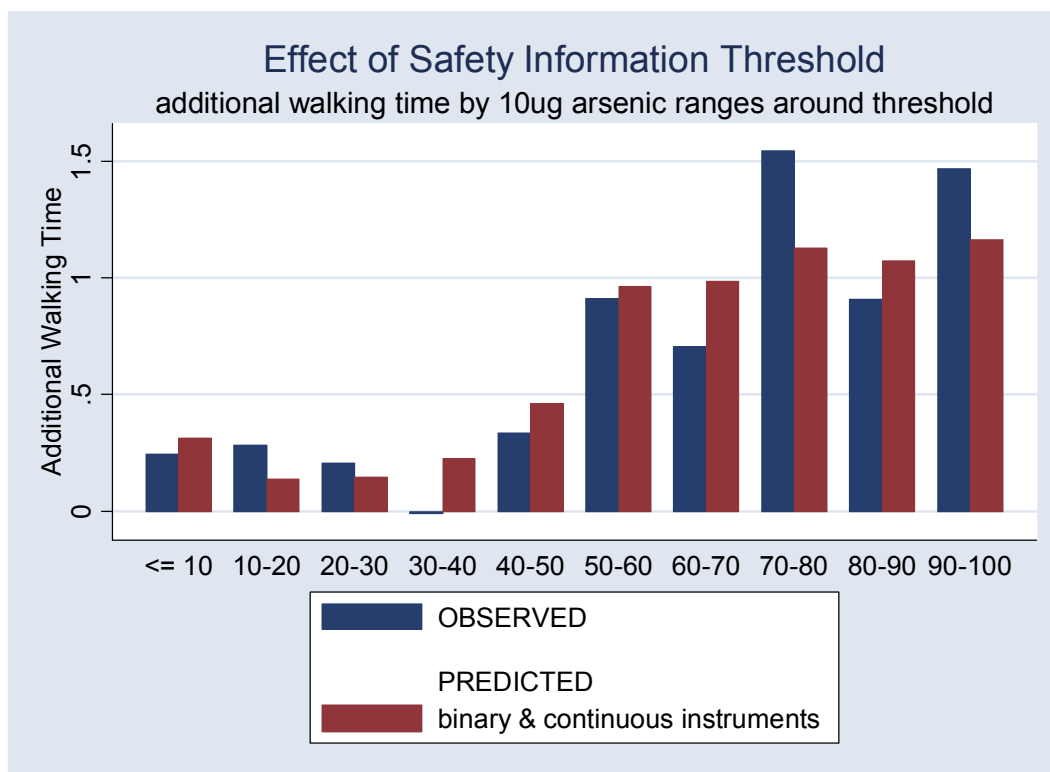
Arsenic concentrations in μg/L are on the x axis and average increase in the time spent walking to the well is on the y axis.

The first bar in each interval is the observed increase in the time spent walking. The second bar is the increase predicted with the regression reported in column 1 of Table 5.

Appendix

A.1   Time line of our project

Year 2000:	Baseline survey documents all wells in the study area and asks a random sample of people whether they have heard of arsenic
Years 2001 – 2002:	1) Project tests and labels all wells

2) Contemporaneously with #1, public health team conducts physical exams, communicates well test result, and asks what they know of arsenic for a random sample of married couples. People have not begun to switch to other wells yet, but they have been exposed to project staff for over a year, thereby learning about arsenic.

3) Following the public health interviews, a team of educators travels around the area, summons as many people as will come to a meeting in each neighborhood and conveys a number of facts about arsenic poisoning. Meetings are on weekdays, during the day.

4) Six to twelve months after the team of educators has been to a particular area, we conduct a survey of a random sample of those individuals interviewed by the public health team in #2. We document whether they have changed to another well, how much they know about the arsenic problem and collect socio-economic data. All socio-economic data, including household expenditure, is from this survey.

Year 2002:   Surveys of households in control areas occur before NGOs have started their information campaigns. No systematic well tests have been done except those conducted by UNICEF on a small sample of wells, which were chosen independently of our sample. We ask questions about the well which people were using 12 months ago, i.e. at the time when well tests were being conducted in Araihazar and what they knew about arsenic then. We also ask whether people have changed to another well during the last twelve months, what they know about arsenic now, and collect socio-economic data.

A.2   Health effects of arsenic[34]

The effects of arsenic are cumulative. Up to a point, effects can be reversed if exposure to arsenic ceases. However, eventually even complete elimination of exposure cannot reverse the changes in health.

Keratosis has the earliest onset, with a gestation period of 5 to 15 years. It has a number of symptoms. The most common ones are a darkening of the pigmentation of the skin, and a hardening of the skin on the palms and the feet. As the hardening progresses, the flesh eventually cracks, gangrene may set in, and the victim often loses her limbs. The spots of darkened pigmentation may eventually become cancerous.

Continued exposure to arsenic can affect most organs in the body. It can lead to liver, lung, kidney and bladder malfunctions. It can cause hypertension, strokes and heart disease. Eventually, it leads to a number of types of cancer.

Arsenic exposure can also lead to developmental problems in children.

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[34] Please see footnote 3 for references relevant for this section.