Subjective Risk Assessment and Reactions to Health-related Information: Evidence from Bangladesh

Alessandro Tarozzi
Lori Bennear
Soumya Balasubramanya
Alex Pfaff
Ahmed Kazi Matin
Lex van Geen

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Abstract

Arsenic-contaminated drinking water is a serious public health problem in several countries, including Bangladesh. In this paper we contribute to the literature on the relationship between information provision and health seeking behavior in developing countries by using data purposely collected in Araihazar district, Bangladesh. We analyze the relationship between the provision of information about arsenic level of tubewell water, elicited perceptions about health risks and choice of source of drinking water. Our findings indicate widespread awareness about the health risk of arsenic as well as about the cumulative negative effects of a prolonged exposure. Respondents' perceptions of health risk are strongly increasing in the arsenic level and also help explaining the decision to switch to alternative sources of drinking water when the current source is unsafe. In addition, we describe the results of a randomized controlled trial which allows us to evaluate the impact of different health-risk communication categories on switching behavior and risk perceptions. A random subsample of households was informed of the arsenic content of their water using a standard "binary" message that only highlighted the benefits of drinking from safe sources. A second subsample was instead exposed to an alternative message that stressed the importance of choosing the source with the lowest arsenic level. In our data, this "continuous" communication mode did not have sizeable impacts on risk perceptions or on switching behavior. Contrary to our expectations, we actually observe that the experimental communication mode decreases the impact of the arsenic level on the probability of switching to a new source of drinking water.

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1 Introduction

Despite considerable advances in water purification technologies and in the treatment of water-borne disease, the lack of safe drinking water still afflicts a large fraction of the world population. In Bangladesh, like in most of South Asia, groundwater remains the primary source of drinking water for a prevalent share of the population. Starting in the 1970s, in the effort of reducing the extent of diarrheal disease associated with the consumption of surface water, the Government of Bangladesh, in collaboration with UNICEF, facilitated the creation of an extensive network of shallow tubewells across the Country. On the one hand, this public health initiative is credited for having substantially contributed to a sharp reduction in infant and child mortality in the 1980s and 1990s. On the other hand, following earlier studies that warned about the possible widespread presence of arsenic in shallow aquifers, the results of a vast water testing campaign led to estimate that approximately one-third of the country's more than 10 million shallow tubewells have water with arsenic concentrations greater than the country limit of 50 micrograms/liter (μg/l or *ppb*), BGS and DPHE (2001).[1] As a safety measure, the arsenic content of the tubewell water was signalled by painting the well spout red, if the arsenic level was above the country limit, or green, if under such concentration. Far from being a health emergency only in Bangladesh, the presence of naturally occurring unsafe levels of arsenic in groundwater is now recognized to be a vast health problem not only in large areas of South Asia but also elsewhere (Alaerts and Khouri 2004). The medical literature has associated chronic exposure to low but unsafe levels of Arsenic to an impressive array of severe health conditions, including skin lesions (perhaps the most visible consequence of arsenic poisoning), cancer and cardiovascular disease.[2]

While much of the policy discourse on arsenic mitigation has focused on technological solutions, there is growing evidence that providing households with simple information on arsenic levels can significantly decrease arsenic exposure. In Araihazar district, Bangladesh (in locations proximate to our study areas, see below), Madajewicz et al. (2007) found that, after controlling for confounding factors, households informed of the unsafe concentration of arsenic in their well water were 37 percent more likely to switch to a different source of drinking water within one year than others

[1] Note also that the 50μg/l limit set by the Government of Bangladesh is five times larger than the limit recommended by the World Health Organization.

[2] An adequate survey of the medical literature is beyond the scope of this paper but an interested reader may start, for instance, from the references in Chen et al. 2007.

whose water was tested as safe. Using data from a subsequent information dissemination in the same areas, Opar et al. (2007) documented a 50 percent increase in the likelihood of switching water source associated with the delivery of information about unsafe arsenic levels. Chen et al. (2007) find significant health improvements among individuals who switched to safer sources in these areas. Such large effects of information on behavior may have been facilitated by the fact that the area has been the subject of an intense interdisciplinary study program led by the Columbia University Superfund Basic Research Program since 2000.[3] However, in neighboring areas not yet covered by the Superfund study Schoenfeld (2005) documented a still remarkable 26 percent increase in the likelihood of switching to a different water source following the delivery of test results for unsafe wells.

Given the relatively low cost of information provision, it is important not only to identify case studies where information campaigns have caused desirable changes in behavior but also to understand the reasons why such changes do not always take place. In particular, individuals who value health may fail to respond to news about unsafe levels of their primary source of drinking water because of the existence of constraints (for instance, the absence of safe wells nearby), but the same behavior could also be due to the unresponsiveness of health risk perceptions to information campaigns. If one observes only behavior, it is hard to disentangle these two alternative explanations which, however, would have very different implications for policy. The distinction is also of theoretical interest, because beliefs about the likelihood of future events such as disease incidence play a separate role from preferences and constraints in explaining behavior. In addition, the policy relevance of understanding the determinants of choice of drinking water is increased by the fact that thousands of new tube wells, which extract water from aquifers with largely unknown arsenic concentrations, are being dug every year. In other words, the testing campaign carried out by the Government of Bangladesh not only covered a mere fraction of all tube wells existing at the time, but also provides insufficient information about the safety level of millions of wells that appeared afterwards.[4]

[3]See, for instance, van Geen et al. 2002, van Geen et al. 2003, van Geen et al. 2003, Parvez et al. 2006 and Chen et al. 2007. The research program studies the health effects, geochemistry, and remediation of Arsenic and Manganese, primarily in groundwater. For more information see `http://superfund.ciesin.columbia.edu/niehsWeb/index.jsp.`

[4]The shallow tube wells that supply the vast majority of drinking water to rural households in Bangladesh can be sunk in one day at relatively low cost. A typical 50-feet (15m) deep well cost (in PPP) approximately 50 dollars (van Geen et al. 2003). Using the 2005 ICP World Bank PPP exchange rates, this corresponds to about 1,000

The first objective of this paper is to use purposely collected data from Araihazar district, Bangladesh, to analyze how perceptions about health risks help explaining the link between information provision and health-seeking behavior. To measure perceptions, we ask respondents to quantify the risk of developing health conditions that may derive from the consumption of arsenic-contaminated water by choosing a number of physical objects increasing in the perceived likelihood of the event. The findings suggests the presence of widespread awareness about the health risk of arsenic as well as about the cumulative negative effects of a prolonged exposure. The data also show a very strong correlation between actual arsenic level and risk perceptions. However, there is considerable variation in perceptions conditional on arsenic level. Also, perceptions appear to be significantly less responsive to the actual arsenic level than to a binary "safety status" indicator equal to one when the arsenic concentration is below the safety threshold set by the Government of Bangladesh.

In addition, we describe the results of a Randomized Controlled Trial (RCT) which allows us to evaluate the impact of different health-risk communication categories on switching behavior and risk perceptions. The standard communication method adopted during the testing campaign led by the Government of Bangladesh up to 2005 was based on a simple binary indicator: the spout of safe wells (with $As < 50$ppb) was painted green, while red was used when arsenic concentration was above the safety threshold. Such binary communication mode has severe drawbacks. First, a well that has, say, $As = 51$ppb and another with 300ppb are signalled as identically unsafe, despite the risk of consuming water from the former well being substantially lower than that from the latter. Second, if a household's main source of drinking water is a red well, then it has to find a green well if it wishes to switch. But if all wells in the set of alternatives are red, then there is no way for a household to know which well is least unsafe. Similarly, a household using a green well cannot identify a safer green well even when this is actually available. In our intervention, the information provided to the users always included not only the binary message (safe or unsafe, signalled by a plate affixed on the tube-well) but also information about the actual arsenic level, as well as about the safety threshold in Bangladesh. However, a random subsample *also* received a further message that highlighted the existence of a gradient in the relationship between arsenic content and health risks. Such randomization, carried out at the village level to reduce the extent of contamination,

Taka (World Bank 2008. See in particular page 23 in `http://siteresources.worldbank.org/ICPINT/Resources/icp-final-tables.pdf`). For perspective, in our sample the median (mean) total expenditure per month per household at baseline was 5000 (6200) takas, that is $220 ($275) in PPP terms.

allows us to study if the provision of details about water safety, coupled with added emphasis on the different risk associated with different levels of exposure, led to behavioral responses that differ systematically from those observed when using a simple safe/unsafe dichotomy. In our data, the "gradient" message did not have a sizeable impact on either risk perceptions nor on switching behavior. Contrary to our expectations, we actually observe that this experimental communication mode decreased the impact of the arsenic level on the probability of switching to a new source of drinking water.

In the context of developed countries and especially the United States, a large literature studies the impact of information provision on health risk-mitigating behavior, for instance in relation to smoking, dietary habits or living arrangements.[5] Much less is known, instead, about the potential role of information as a policy tool to improve health in developing countries. This paper aims at contributing to this area of research, which has recently produced a number of interesting studies. In a series of RCTs in Kenya, Tanzania and Trinidad Coates et al. (2000) show that voluntary counseling and testing reduced self-reported at-risk sexual behavior significantly more than the provision of health information alone. Jensen (2007) use data from the Dominican Republic to shows that information about previously underestimated returns to education reduced drop-out rates among better-off students. Using experimental data from Delhi, India, Jalan and Somanathan (2008) find that households informed of the unsafe levels of fecal bacteria in their drinking water show an increased demand for clean water relative to a control group. Thornton (2008) uses data from an RCT in rural Malawi, and finds that awareness about HIV-positive status increased three-fold the likelihood of purchasing condoms among sexually active individuals, although the number of condoms purchases remains very small. In a study carried out in western Kenya, Goldstein et al. (2008) estimate that learning one's HIV status has a marked impact on women's health-seeking behavior and investment decisions. In an RCT in Kenya, Dupas (2009) finds that girls exposed to information on the age profile of male HIV prevalence led to sizeable changes in self-reported sexual behavior and to a 28% decrease in pregnancies, while no such impact was associated to standard abstinence-only HIV education curriculum.

Our paper also contributes to a growing literature which studies behavior in developing countries using directly elicited information on respondents' beliefs about future outcomes.[6] Subjective

[5] For instance, see Smith et al. (1995), Davis et al. (2009), Downs et al. (2009).

[6] See Manski 2004 for a recent survey of studies using subjective beliefs and expectations data in developed countries, in particular in the United States.

probabilities have been elicited to study topics as different as HIV risk in Malawi (Delavande and Kohler 2007), weather forecasts and their relation to livestock and crop planting decisions in India (Luseno et al. 2003, Giné et al. 2007, Lybbert et al. 2007) and the choice to purchase bednets or to impregnate them with insecticide (Mahajan et al. 2008, Tarozzi et al. 2009).[7]

The rest of the paper is structured as follows. Section 2 describes the data, Section 3 discusses the elicited health risk perceptions and Section 5 studies the choice of source of drinking water and its relationship with risk perceptions and arsenic level communication model. Finally, Section 6 briefly concludes.

2 Data and Experimental Framework

Our study area is located in a 100-km^2 area in the Araihazar district, approximately 30 kilometers east of the capital Dhaka. The starting point for the selection of the households in our data set are the 75 villages examined in Schoenfeld (2005), who studied the relationship between well switching behavior and provision of arsenic tests results in areas not exposed to the intensive research project described in the introduction. Our study uses data from 62 of these 75 villages.[8] To identify the 62 villages, Schoenfeld (2005) used data on arsenic contamination provided by the Bangladesh Arsenic Mitigation Water Supply Program (BAMWSP), which at that time had provided the only well testing in the area, completed in 2003. Initially, 8 of the villages were selected among those with an approximately equal share of safe and unsafe wells, while another 8 were chosen among those with very high (80-100%) prevalence of unsafe wells. Another 46 randomly selected villages with medium to high proportions of unsafe wells were subsequently added.

While collecting the data on switching behavior analyzed in Schoenfeld (2005), field workers drew water samples from any new or previously untested well identified in the study villages. This led to water samples from 558 wells in 48 villages. Of these wells, 533 were subsequently tested. The data used in this paper were collected in two separate household surveys carried out in 2008 in all but three of the 48 villages. Two villages were excluded because they hosted survey pilots, while another was not visited because it only included a single tested well. The first (baseline) survey was

[7] See Delavande et al. (2009) for a recent survey.

[8] The remaining 13 villages were originally selected for their proximity to roads and clinics in areas excluded by the Columbia University project. Such villages were scheduled to become part of a separate study on child health, and were therefore excluded in our project to avoid any form of contamination.

then completed between February and April 2008, at which time we also attempted the delivery of the 507 test results in the remaining 45 villages. Wells were identified based on information on the owner's name as well as on global positioning system (GPS) data. Test results were only delivered for 434 wells, because the remaining had been made deeper, or their pump had been moved to a new location. Interviews were then completed with the household who owned the well as well as with another household who used the same well, if present.[9] In all cases, the interview was attempted with a female adult respondent, if possible with the wife of the household head. The largest section of the questionnaire was filled after the delivery of the test results, but information on household members and part of the assessment of health risk perceptions (see below) were recorded before the provision. Overall, 668 interviews were completed in this way, while another 78 interviews were completed with households that owned the wells whose results were, however, not delivered because the well had been moved or deepened. In these cases, only the questionnaire sections that did not depend on the test delivery were administered. In the rest of the paper we will refer to this first dataset of 668 household as to the "baseline" or Wave I (WI).

In November 2008, a second survey was completed for 605 of the 668 baseline households in 43 villages. We refer to this second survey as to the "follow-up" or Wave II (WII). Two villages were not re-visited for logistical reasons, as they only included one household each. The remaining attrition was mostly due to seasonal migration. Overall, it is clear that our sample is not a random draw from the study area, so that some caution must be exercised in gauging the external validity of our findings.

Table 1 reports selected summary statistics measured at baseline. Overall, households in the sample are relatively large (5.5 members on average), with low education and relatively low income and expenditure.[10] Only 41 percent of household heads are literate and 22 percent have achieved at least a secondary school diploma, although enrolment rates among 6 to 14-year old is relatively high, at 77 percent. Only 25 percent of households make regular use of a sanitary latrine and 13 percent live in a "pukka" (good quality) dwelling. For perspective, the mean total monthly expenditure per head corresponds to approximately 2 USD per day, using a PPP exchange rate

[9]The respondent from the owner household was asked to name any other households who used the same tube well. Households were then recorded in the order mentioned by the respondent. The enumerator approached the households in the order listed and interviewed the first available.

[10]Income and expenditure data are measured using simple, one-shot questions, so these estimates are likely to be measured with considerable error.

conversion. On average, we estimate that individuals of age between 6 and 70 lost 18 days of school or work over the previous year. However, in less than four percent of households (and for 1.2 percent of individuals) we find anyone reported to have any symptoms of arsenic poisoning. In almost all cases, such symptoms consist of skin lesions. This result is interesting, because the widespread awareness about the arsenic problem that we will document in this paper apparently coexists with very low levels of actual visible arsenic-related disease.[11]

The mean level of arsenic is 123ppb, more than twice as large as the threshold used by the Government of Bangladesh to identify "unsafe wells". There is also considerable variation within the sample, as shown by the standard deviation equal to 165. While the high mean is partly driven by some wells with very high levels of arsenic, the median is very high as well (81ppb) and 62 percent of the tested wells had unsafe levels of arsenic. Consistently with the commonly found haphazard geographic distribution of arsenic, we find remarkable heterogeneity in arsenic contamination even within villages. When we estimate a regression of the arsenic content on village dummies, the R^2 is only 0.24. The heterogeneity is also evident in Figure 1, which maps the study area and show the location of safe and unsafe wells over the territory. In our sample, almost 90 percent of households own at least one well. A large majority (69 percent) owns a single well, but ownership of up to eight is observed in our data (see graph A in Figure 2). Close to 90 percent of respondents claim that their household drinks water from a single tube well, but about 8 percent uses more than one well for this purpose (Figure 2, graph B). Finally, the bottom graph of Figure 2 show a histogram of the arsenic levels of the wells in our sample, confirming once again the presence of considerable heterogeneity.

An important feature of the spatial distribution of arsenic is that despite the severe health disorders associated with long-term exposure, tube-well arsenic concentration often appears to be weakly correlated with household characteristics. This is important, because it allows to interpret with more confidence switching decisions that follows the delivery of test results as reactions to information, rather than being the consequence of pre-intervention differences in switching trends between households with different characteristics. In Table 2 we show that such haphazard distribution of arsenic is also largely present in our sample, consistently with the similar results in

[11] Overall, the characteristics of the 63 households that could not be re-contacted are similar to those of the 605 panel households. Among the variables described in Table 1, the null of equal means is rejected at standard levels only for household size (5.4 in panel households vs. 4.8 among the others, p-value= 0.051) and number of days missed to illness (18.7 vs. 14.4 p-value= 0.076).

nearby areas found in Madajewicz et al. (2007). We estimate both a probit model with a dummy for "unsafe well" (that is, $As > 50$ppb) as dependent variable and an OLS model where the dependent variable is the arsenic level. In both regressions we cannot reject the joint null hypothesis that all slopes are equal to zero. Looking at the individual coefficients (or in the case of probit, at the marginal effects), we note that the slopes for all wealth indicators are not significant and small in magnitude. In column 2, an increase from zero to 100 percent in the fraction of household members older than 10 who are literate predicts a 66ppb increase in the level of arsenic (significant at the five percent level), but this effect is almost canceled out if the household head has at least a secondary school diploma. The only coefficients that are significant and very large in magnitude are, not surprisingly, those related to the fraction of household members who are reported as having symptoms of arsenic-related diseases, which in our sample almost always means visible skin lesions. For instance, and keeping everything else constant, if two persons in a five-member household have skin lesions, the predicted probability that the well has unsafe levels of arsenic increases by 28 percentage points ($0.7 \times 2/5$) and the predicted arsenic level in the well increases by 169ppb ($423 \times 2/5$).

2.1 Description of Experimental Framework

All test results within the same village were delivered using one of two communication modes. All well owners were informed about the arsenic level of the tested water. However, to well owners in a first randomly selected subsample of villages, we delivered the test results using a "binary message" that only emphasized that arsenic levels above 50 ppb are not safe. We will refer to this communication mode as to the "standard" or "control" message, because the binary message has been adopted by the countrywide testing campaign led by Government of Bangladesh up to 2005. In the remaining villages, the test result was instead accompanied by a longer explanation, which highlighted the existence of a gradient in the relationship between arsenic levels and health risks ("gradient" message). Households in this second group were explicitly told that

> [...]whatever the level of arsenic in your drinking water now, if you have a choice of water from several wells it is better to drink water from the well with the lowest level of arsenic. For example, if you have a choice between a well with 200 ppb arsenic and a well with 100 ppb arsenic, drinking water from the well with 100 ppb arsenic is better for you. If you have a choice between a well with 40 ppb arsenic and a well with 10 ppb

arsenic, drinking water from the well with 10 ppb arsenic is better for you.

It should be emphasized again that *both* groups were informed about the actual arsenic content of the tested water, so that the fundamental difference between the two groups is only in the emphasis given to the gradient while delivering the results. At the time of the result delivery, a metal plate was also placed securely on the tube spout, indicating the arsenic level. The safety status was also indicated on the plate by a stylized picture of a hand holding a glass, which was crossed for unsafe wells.

We chose to randomize the communication mode by village, rather than by household, in order to reduce the likelihood of informational spillovers among households receiving test results with different messages. Even so, it should be kept in mind that the experimental estimates will only identify an intent-to-treat effect of the communication mode at the village level, while without a more sophisticated estimation strategy our results do not identify an average treatment effect (ATE) or an ATE on the treated, because we cannot exclude that the intervention carried out at the village level led to within-village network effects. Such effects may arise, for instance, because of communication among households that live in the same village. We also note that the randomization was successful in producing groups balanced along different observable characteristics. Table 3 show the results of test of equal means for all variables included in the previous table of summary statistics. All tests are carried out including only the 605 panel households re-interviewed at follow-up and all standard errors and tests are robust to intra-village correlation. The differences in means across the two groups are always small in magnitude and not significant at standard levels. In particular, we cannot reject the null hypothesis that the mean level of arsenic is the same in the two intervention groups (p-value = 0.672).

3 Subjective Health Risk Assessment

Before analyzing the impact of the two different methods of information provision, in this section we describe in detail the data we collected to gauge the subjective perceptions about arsenic-related health risks. Such data, collected both at baseline and follow-up, also included probabilistic assessments of health risks for different demographic groups and at different time horizons. The measurement of such beliefs is complicated by the low schooling and numeracy level of most of our respondents. To overcome the fact that most respondents are not familiar with the concept of probability, we use an eliciting methodology based on counting physical objects such as marbles. A similar approach has been in used, for instance, in Delavande and Kohler (2007). The interviewer gives the respondent ten marbles and a box, and instructs him/her to place a number of objects in the box increasing in the perceived likelihood that a specific event will happen. Hypothetical examples are first introduced by the interviewer to make sure that the respondent understands the rationale. The subjective probabilities are then estimated by dividing the number of marbles in the box by ten.

As in Delavande and Kohler (2007), we use questions related to the probability of two nested events to probe whether the concept of probability was understood by the respondent. We first ask "[i]n your opinion, from 0 to 10, what are the chances that you or someone else in your family will purchase some food tomorrow?" and then we ask the same question, but with a 7-day reference period. By construction, the number of marbles set aside when responding to the former question should be no larger than when responding to the latter one. Note that interviewers were instructed to empty the box after each question, so that respondents were not implicitly led to merely add to the marbles placed in the box after the first question. Figure 3 plots the reported probabilities of purchase within a week against the probability of purchase on the following day, together with the 45 degrees line. In both waves, almost all respondents (indeed *all* of them at baseline) report higher probabilities with the longer time horizon. The number of non-responses was also remarkably low, with two non-responses out of 668 at baseline, and two out of 605 in the follow-up.

In WI, A first battery of questions asked respondents to report the perceived risk for either a child or an adult of developing either skin lesions or more generic "serious health problems" as a consequence of drinking water from a well with unsafe levels of arsenic.[12] 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 risk of health consequences was assessed for exposure durations of one month and then one, five, ten or twenty years. We asked respondents to think of a generic household in a different village who had access to safe water until now and only recently switched to an unsafe water source. The question did not explicitly refer to a specific arsenic content, but rather asked the respondent to think of "a level of arsenic just above the level that the government says makes a well unsafe". While such phrasing has the drawback of implying that different respondents' reports may have different thresholds in

[12] We defined "adults" as individuals more than 15-year old.

mind, it has the advantage of making the reports comparable in their reference to a perceived "just unsafe" water source.

Different conclusions emerge from the histograms in Figure 4, which describe the empirical distribution of the beliefs about risk of developing skin lesions for adults (top panel) and children (bottom panel). First, there is widespread awareness that arsenic may lead to skin lesions. Second, the elicited beliefs clearly show that respondents are aware of the cumulative effect of exposure to arsenic, with progressively higher probabilities of skin lesions reported as the time horizon lengthens. For instance, almost no one reports probability of skin lesions above 30 percent for a 1-month exposure, while the fraction of respondents who believe that skin lesions are a certain consequence of a 20-year exposure is 70 percent for children and 60 percent for adults. For both adults and children the distribution of the reports clearly shift to the right for longer exposures. For children's exposure, the modal probability is 0 for a one-month exposure, 0.3 for a one-year exposure and then 0.5, 0.8 and 1 for five, ten and twenty-year long exposures respectively. A similar pattern emerges for adults' exposure, even if a third conclusion that emerges is that overall arsenic is believed to be more detrimental for child than adult health. The distributions for adult exposures appear in fact to have always more mass on low values relative to the histograms related to child exposure, although the histograms are overall similar. One last but important conclusion that emerges from these pictures is that the elicited beliefs appear overall remarkably credible, with no heaping for focal values such as zero, five or ten, except in cases where such heaping could be expected because of the very likely or very unlikely nature of the event described.

It should be noted that the remarkable consistency of the right-ward shift of the distributions with the increase in the exposure period may have been at least in part cued by the way the questionnaire was structured. Subjective assessments were in fact recorded asking first about a one-month exposure and then moving to increasingly long exposure periods, without randomizing the ordering of the questions. On the other hand, the anchoring that may have resulted from this structure may actually be desirable if it leads respondents to focus on the existence of a gradient between health likely health damage and exposure duration.[13]

Figure 5 shows analogous distributions when the event described in the question is that an individual from the hypothetical family described in the questionnaire will develop serious health

[13]Our decision not to experiment with different formats was largely due to the relatively small scale of the project and to considerations of statistical power.

problems as a consequence of drinking arsenic-contaminated water. These histograms are very similar to those in Figure 4, with the main departure being that the probability of "serious health problems" is overall reported to be lower than the probability of skin lesions.

Overall, the results described in Figures 4 and 5 suggest widespread awareness of the existence of health risks associated with drinking arsenic-contaminated water. On the other hand, the variation in the elicited beliefs also indicates considerable variation in the risk perceptions. Consistently with the fact that the water test results were delivered *after* eliciting these health risk perceptions, such variation is not associated with actual arsenic levels of the well water. If we regress each of the elicited beliefs on the arsenic concentration of the tested tube well, the slopes are always close to zero and never significant at standard levels.[14] This suggests that respondents understood that the questions described above referred to a hypothetical situation, and not to water from the specific well used by the household. This is also confirmed by the fact that, before test delivery, not a single respondent reports to know whether the water regularly used by the household for drinking and cooking would be considered safe by the Government: when respondents are asked to reveal which probability they assign to the event that the arsenic level of the water is below different thresholds, all respondents but one select a "don't know" option. Also, these responses usefully suggest that respondents who cannot evaluate the probability of an event will not use the focal answer "5 stones out of 10" to express uncertainty. This further increases our confidence that the responses described in Figures 4 and 5 are informative about the actual health risk perceptions. The awareness of heath risks from arsenic are confirmed by a separate question where we asked about "tasks for which you should not use arsenic-contaminated water". A large majority of respondents recognize that drinking (84 percent) and cooking (67 percent) should be avoided. Only 17 respondents (of 644) state that no health risk exists, while 79 say they do not know.[15]

The survey instrument also included a second battery of questions we used to measure perceived health risk associated with the consumption of the *tested water*. Given that such questions were

[14] Beliefs about arsenic risk are elicited for twenty categories, as questions refer to five different time horizons (one month, one, five, ten and twenty years) for each of two demographic categories (adults and children) and two health outcomes (skin lesions and serious health consequences). The p-values of the twenty regressions of beliefs on arsenic level range from 0.1433 to 0.9987. All standard errors are heteroskedasticity robust. The detailed results are available upon request.

[15] However, this question was asked after the questions used to elicit beliefs about health risks, so it is difficult to evaluate how answers to this latter question have been affected by prompting due to the earlier ones.

asked after the communication of the test results, we describe the results in the next section, where we start analyzing the impact of the intervention by looking at its impact on risk perceptions.

4 Change in Health Risk Perceptions and Information Provision

The questions about health risks associated with consumption of water from a “generic unsafe well” were also included in WII, completed 7-9 months after the delivery of the test results. Our records indicate that in all cases where the sample household was found again, surveyors were successful in completing the follow-up interview with the same respondent. This is important, because it allows us to rule out that changes in recorded beliefs are actually due to the respondents not being the same in the two waves. Because of the similarity in the elicited beliefs about health risks for children and adults documented in WI, the follow-up survey only measured risk perceptions for one demographic category, that is, for adults. Figure 6 displays the histograms of the elicited beliefs about the health risk of a “generic unsafe well”, so that the five histograms on top should be comparable to those in the bottom panel of Figure 4 and the five histogram underneath should be compared with those at the bottom of Figure 5. It is interesting to note that, despite the delivery of test result completed in spring 2008, 91 percent of respondents say they still do not know the threshold used by the Government of Bangladesh to discriminate between safe and unsafe levels of arsenic. Only 25 of the 57 numeric answers turned out to be correct, while 20 (12) respondents reported a threshold lower (higher) than the actual one.

Similarly to what documented at baseline, the distributions of perceived risk of skin lesions and “serious health problems” are very similar and so in our discussion we focus on the latter. Overall, respondents understand well that the risk from arsenic exposure is cumulative. “No chance” of health risks within a month is indicated by 35 percent of respondents, and almost no one indicates more than a 20% chance. However, the distribution moves steadily to the right when the time horizon increases, to the point that approximately 60 percent of respondents think that the probability of serious health problems is 80% or higher with a 20-year exposure, while the risk is 20 percent or lower in less than 5 percent of responses.

Note, however, that a comparison between the risk assessments observed in WI (Figures 4 and 5) and WII (Figure 6) reveals a shift towards more concerns for the consequences of short-term exposure and less concerns for long-term exposure. It is not clear why this is the case, especially because the information provided by our surveyors did not include any message which emphasized short-term health risks of arsenic relative to longer-term ones. In Table 4 we test formally the hypothesis that the perceived beliefs have changed over time and we examine whether the changes are associated to the communication mode (binary vs. "gradient"). The results in panel (A) confirm the result that risk assessments show growing concern for short-term exposure and lower concern for long-term exposure. For instance, the mean perceived risk of skin lesions associated with 1-month consumption of unsafe water increases from 5.8 percent to 8.2 percent (p-value= 0.000), while the mean perceived risk associated with a 20-year exposure *decreases* from 89.7 percent to 75 percent (p-value= 0.000). The results in panel (B) show that such changes do not appear to be significantly correlated with the arsenic content of the tested well nor do they seem to be associated with the randomized communication mode. In particular, the coefficients related to the latter variable are not only never significant at standard levels but are also always small.

In a separate battery of questions, we also asked respondents to gauge the health risks associated with drinking from the tested well, regardless of whether such well was also the current main source of drinking water. Such questions were asked both at baseline (immediately after the test delivery) and at follow-up. In this case as well, separate questions were asked about the risk of developing either skin lesions or "serious health problems". Once again answers to the two questions were mostly identical, so we only focus on the latter. First, we look at the differences in beliefs distribution as a function of safety status. If the communication of the test results has been successful, the health risk associated with safe levels of arsenic should be significantly lower than for wells found to be unsafe. In Figures 7 and 8 we display histograms for the perceived health risks estimated respectively in WI and WII, separately for unsafe wells (for which $As > 50$ppb) and safer wells (with $As \leq 50$ppb). The graphs in Figure 7 show that, for most respondents, perceptions about water safety did not immediately respond to the result communication. In fact, the histograms are overall remarkably similar for safe and unsafe results, although we note that approximately 10 percent of respondents informed about the "safe" status of their well indicate a zero chance of serious health problems even with very long-term exposure to safe water, while no such pattern can be seen in the "unsafe" group. An alternative explanation for such small reaction in health perceptions is that respondents, at baseline, did not differentiate between the risk perceptions about the tested water and those for the generic unsafe well they were asked to think about in the earlier section of the questionnaire. Indeed, we find that the baseline correlations between these beliefs and the corresponding ones for the generic unsafe well are close to 0.80 for each of the five time horizons. Instead, the same correlations measured in WII are in the 0.40-0.50 range. In addition, the histograms in Figure 8 clearly indicate that, on average, respondents in the follow-up interviews perceived higher health risks when the arsenic content of the tested water is high. For safe wells, 70 percent of respondents think there is no chance of serious health problems associated with drinking the tested water, even after 10 or 20 years or exposure, while in almost no case there is more than a 20 percent risk with exposures of one month or one year. Similarly, only a handful of observations indicate a perceived probability of health risks of 30 percent or higher. Respondents indicate instead consistently higher risk when the result of the test showed an arsenic content of 50 ppb or higher. However, about a quarter of respondents believes there is no chance of health risks even with a 20-year exposure, despite the high arsenic content.[16] Given that the baseline risk perceptions about the tested well appear to be unreliable, in the rest of the paper we will only use the measures elicited in WII.

The graphs in Figure 8 only differentiate between "safe" and "unsafe well". However, a gradient may exist in the relationship between arsenic content and risk perception. This would also be consistent with the results in Madajewicz et al. (2007), who show that households are more likely to switch to a different well when the arsenic contamination increases. In Figure 9, we show non-parametric regressions separately by time-horizon. Each line represents a locally linear regression of beliefs about health risk measured in WII against the arsenic content of the tested well.[17] We use a relatively narrow bandwidth equal to 20 in order to highlight the local shape of the curves. While the level of the health risk assessment increases steadily when longer exposures are being considered, the shape of the four curves is similar. Note in particular that the regressions show a clear upward slope around the threshold of 50ppb, but are relatively flat both for very low arsenic levels and for levels above 75ppb. This suggests that the safety threshold is quite salient in determining risk perceptions.

[16] In principle, it is difficult to exclude that the post-communication beliefs are not at least in part a result of ex-post rationalization: suppose that a household learns about the high arsenic content of the main source of drinking water but still decides not to switch to a safer source. A low elicited probability of health risk could reflect actual beliefs and be the cause of the non-switch, but could also result from the respondent attempting to justify the unchanged choice of water source.

[17] Locally weighted regressions (Fan 1992) have better properties than the traditional kernel regression estimator near the boundaries of the regression, see Deaton (1997) or Pagan and Ullah (1999), Chapter 3.

Next, in Figure 10 we display non-parametric regressions separately by communication mode. To avoid clutter, we only display two pairs of lines, one describing a measure of "short-term" risk perceptions and a second for long-term risk. For each respondent, we construct the former as the mean subjective probability of developing serious health problems within 1 month or 1 year from the beginning of exposure, while we construct the second as the mean risk of a 10 or 20-year exposure. Consistently with the evidence presented earlier, perceived short-term risk is overall very low, although it somewhat increases for very high arsenic levels.[18] Overall, the "binary" and "gradient" lines are remarkably similar up to 150ppb, while for higher values of arsenic relatively large gaps arise, although of alternating sign and showing no meaningful pattern. The results for long-term risks also do not show any clear pattern that could suggest a successful impact of the gradient communication mode in changing the slope of perceived risk relative to arsenic levels. Both lines confirm the very sharp increase in perceived risk at 50ppb, confirming that the "gradient" message did not reduce the salience of the safety threshold. Looking at high levels of arsenic, we find that the two curves show a considerable degree of curvature while neither show a clear positive slope with respect to arsenic levels. Overall, the long-term "gradient" curve lies above the "binary" curve over most of the unsafe range, but the sign of the difference changes in a few occasions so once again we do not find clear evidence of an impact of the communication mode on beliefs. We also note that these results should be interpreted with caution, because while the randomization was successful at producing overall balance between arms along a series of observed characteristics (see Table 3), it is not clear that such balance will survive *conditional* on arsenic level. While we would expect such balance to arise as a result of the randomization in a very large sample, our data set is relatively small (43 villages overall).

The results discussed in this section suggest that risk perceptions about the tested water overall responded strongly to the test results, although not differentially for the two communication modes. In the next section, we move to analyzing whether households responded to the news about arsenic contamination by switching to alternative sources of drinking water and whether such decisions were also affected by the measured risk perceptions.

[18] In our sample, arsenic level is as high as 1600ppb. We choose to display the regressions only up to 300ppb because such level is close to the 95% of the sample distribution of arsenic, and the regressions become extremely noisy beyond this threshold.

5 Choice of Drinking Water Source and Test Results Communication Mode

The findings in Madajewicz et al. (2007), Opar et al. (2007) and Schoenfeld (2005) document that 25-50 percent of sampled households living in or nearby our study area moved to a different water source, when informed of the unsafe status of the well they were using. In our sample, approximately two-thirds of the tested tubewells had water with unsafe arsenic levels (see Table 1). A first look at the data show that, between test results delivery (in February-April 2008) and the follow up survey (in November 2008), 34 percent of users of an unsafe well reported to having switched to an alternative source, while only 8 percent of users of a safe well did. Our results are then almost identical to those in which, however, evaluated the impact of a well-testing campaign completed two years earlier, while in our case the lag between test delivery and follow-up survey was significantly shorter.[19] The first purpose of this section is to evaluate whether the different communication modes had a differential impact on switching rates. Next, we analyze if the perceived health risks described in Section 3 have predictive power, beyond what represented by the actual test results, in explaining switching behavior.

Both the standard (binary) and the experimental (gradient) communication modes emphasized the safety thresholds, so we did not necessarily expect the gradient message to increase the likelihood of switching when informed about the unsafe arsenic level of one's well water. However, we did expect the gradient communication mode to increase the responsiveness of households to the arsenic level. Formally, let A_h denote the arsenic level measured in the well used by household h, and let U_h be a dummy variable indicating wells with unsafe levels of arsenic ($>$ 50ppb). Let also S_h denote a binary variable equal to one when the household switched out of the well between the baseline and the follow up surveys. Finally, let T_h denote a dummy for households in villages where the gradient message was delivered. We estimate the following regression using a Linear Probability Model:

$$S_h = \beta_0 + \beta_U U_h + \beta_T T_h + \beta_{TU} U_h \times T_h + \beta_A \ln(A_h) + \beta_{TA} T_h \times \ln(A_h) + u_h, \qquad (1)$$

where u_h is allowed to have a village-specific component, so that all estimated standard errors will be robust to the presence of intra-village correlation. We have no specific priors about the sign of β_T

[19] In a separate paper we analyze the persistence of the switching decisions described in Schoenfeld 2005 by including in our 2008 survey a large fraction of the households studied in Schoenfeld 2005. We find that the switching decisions are overall remarkably stable and only a handful of households reverted back to using previously used unsafe wells.

and β_{TU}. However, we expect $\beta_U > 0$ (that is, switching should be more likely when the water has unsafe levels of arsenic), $\beta_A > 0$ (switching more likely for higher levels of arsenic, conditional on binary safety status) and $\beta_{TA} > 0$ (the gradient communication mode should increase the fraction of households who switch tubewell when arsenic concentration increases). The results are displayed in Table 5, where we only include households who were using the tested well as the primary source of drinking water at baseline.

The results in column 2 show that all but one of our predictions hold in the data. Switching behavior is more likely with unsafe wells ($\beta_U > 0$) and higher levels of arsenic further increase the likelihood of switching $\beta_A > 0$. Among households who received the standard message, a 10% increase in the level of arsenic predict approximately a 0.3 percentage points increase in the likelihood of changing source of drinking water. Both β_T and β_{TU} are not statistically significant, although β_{TU} is very large (0.162) and positive. However, β_{TA} is negative and statistically significant at the 1% level. Although the point estimate is small, this finding goes counter our expectations. Among households exposed to the gradient message, a 10% increase in As is associated with a 0.2 percentage points *decrease* in the likelihood of changing source of drinking water, conditional on safety. When we include only observations from unsafe wells (column 3), these counterintuitive results are confirmed, with the slope for $\ln As$ equal to 0.24 with the binary message and equal to -0.03 for the gradient communication mode. The net effect of β_T and β_{AT} is such that the probability of switching conditional on the arsenic level is higher with the gradient method up to a level of arsenic equal to 104 and lower for higher values.[20] In our sample, about two thirds of users of unsafe wells had arsenic levels above this threshold, so the model predicts that the gradient message decreased the probability of switching for a large fraction of users. This finding is also confirmed by the graphs in Figure 11, where we display separate non-parametric locally linear regressions of S_h on arsenic level. Although the choice of a relatively narrow bandwidth (equal to 50) makes the curves very irregular, we observe that the "gradient" regression remains above the "binary" one for values of As above 100, consistently with the results of the parametric model.

To explore further this finding, we look at whether, by emphasizing the existence of a gradient, we somehow made the information more confusing or perhaps less salient. First, we look at whether the communication mode affected *knowledge* about the arsenic content of the tested water. In Table 6, we estimate Linear Probability Models with a binary dependent variable equal to one if

[20] The threshold is calculated as the level of As that solves $\ln As\hat{\beta}_A = \hat{\beta}_T + \ln As(\hat{\beta}_A + \hat{\beta}_{AT})$.

the respondent correctly recognizes whether the water has safe levels of arsenic (columns 1 to 4) or whether she identifies the correct arsenic level within 10ppb of the actual value (columns 5 to 7). It should be noted that while only 3 percent of respondent state that they do not know the safety status, about 90 percent admits of not knowing the precise arsenic level.

Overall, 79.2 percent of respondents recognize correctly the safety status of the water, while a negligible 3 percent knows the precise arsenic content. The results in columns 1 to 4 shows that, if anything, the gradient message increases awareness about safety status, although the coefficient is always close to zero and is never significant. Interestingly, the results in model 3 indicate that respondent are much less likely to correctly identify safety when the water has unsafe levels of arsenic.[21] Respondents who received news of unsafe arsenic levels are 26 percent less likely to correctly report the water safety status. This is perhaps surprising, given that one could expect more awareness when unsafe arsenic levels make the decision to switch to a different water source potentially more important for health. On the other hand, it is easy to imagine that there is an asymmetry in the perception about the health risk of water being used. An uninformed respondent may be more likely to assume that the main source of drinking water is safe. However, we have seen that a large fraction of households with unsafe well water switched to a different source after receiving the test results. Is the result in column 3 driven by respondents who did not switch? To test this hypothesis, in model 4 we include a dummy equal to one when the household switched to a different source after the test result delivery together with its interaction with safety status. The estimates suggest that among households who switched to a different source, safety status leaves awareness about unsafe status virtually unchanged. However, among respondents who are still using the same well water, those with unsafe water are 33 less likely to correctly identify unsafe status. Note, however, that this result could be due to both non-switchers being truly uninformed, or to non-switchers ex-post rationalizing their choice not to switch. Very few respondents knew the precise arsenic content of the well so we comment briefly on the results in columns 5 to 7. We only note that, in this case as well, the probability of knowing the level decreases for unsafe wells, while the communication mode appears to be completely irrelevant, both from a statistical and a substantive point of view. At this stage, the finding that the gradient *decreased* households' responses to the actual arsenic level, conditional on binary safety status,

[21] When we estimate model 3 interacting "Unsafe" with "Gradient" the interaction is close to zero and not significant (p-value= 0.455).

remains therefore unexplained.

5.1 Water Source Choice and Risk Perceptions

We now evaluate if the choice to switch to a different source is predicted by the reported perceived health risks of arsenic, conditional on actual safety status and other covariates. Recall that we measure both the risk perception of a "generic" unsafe well, and the perceptions related to the well whose water was tested. For a given time horizon, let denote the former and $P_{W,h}(t)$ the latter. As shown in Figure 8, risk perceptions vary widely regardless of water safety. Therefore, we expect the likelihood of switching to a different water source to increase with $P_{W,h}(t)$, even conditional on actual arsenic level. However, we do not have strong priors about the predictive power of risk perceptions about a generic well. On the one hand, $P_{G,h}(t)$ measures the risk associated with a well different from the one used by the respondent's household at baseline. On the other hand, such risk perception may be used as a proxy for the level or awareness and concern about arsenic poisoning, and so it may predict higher rates of switching, especially among unsafe wells. Given their strong within-respondent correlation, the inclusion of all available measures of risk perceptions would lead to quasi-collinearity and to hard-to-interpret results. We therefore include only measures of long-term concerns, calculated as the mean perceived risk of consumption over a 10 and 20 year period. Among the controls, we also include demographic indicators, well ownership and distance from alternative safe wells.[22] Madajewicz et al. 2007 finds that the last two variables are important correlates of the decision to switch, both leading to lower probability of changing source of drinking water. Given that we have already documented that the delivery of news about the unsafe status of a well leads to a significant and large increase in the probability of switching, here we focus only on the behavior of households that, at the time of the baseline, were using an unsafe well as primary source of drinking water.

The results are displayed in Table 7. In column 1, we estimate a linear probability model

[22] Such information is constructed using GPS information and safety status for all wells in our sample. Recall that we also have such information for wells that are not included in this specific study but were part of the population studies in Schoenfeld 2005. While, in the aggregate, our data are likely to include the large majority of wells in the area, it is likely that some are not included. In particular, we have no information about wells constructed after 2005. Note, however, that the safety of such new wells is almost certainly unknown, because BAMSWP stopped operating in the area in 2003 and the by and large the only well testing in the area is the one carried out by the Columbia University Superfund Basic Research Program Team.

for switching only as a function of risk perceptions, using only information from users of unsafe wells. The coefficients for perceived risk of the tested well (0.018) and a generic well (0.013) are relatively close, but only the former is statistically significant, at the 10 percent level. The slopes are, however, relatively large. An increase in either perceived risk from 0 (no risk) to 10 (certainly of serious health problems) increases the predicted likelihood of switching by 18 or 13 percentage points. When we include the (log of) arsenic level and the dummy for the communication model (as well as its interaction with arsenic), the perceived risk of the tested well remain significant and its coefficient is almost unchanged (0.017), while the slope for the risk of a generic well decreases to 0.009. The two slopes and their significance also remain virtually unchanged (0.018 vs. 0.009) when we include additional controls in column 3, in which case we also note that the slope for the interaction between communication mode and (log) arsenic becomes insignificant, although its point estimate is only marginally reduced. We note instead a few interesting patterns. First, consistently with the results in Madajewicz et al. (2007), well ownership considerably reduces the likelihood of switching, by 10.7 percentage points. Also, the coefficient for the fraction of household members who have symptoms of arsenicosis is very large, although the small fraction of affected individuals in the sample makes the estimation very imprecise (p-value= 0.419). Still, in our sample, having half of the household members with symptoms will increase the predicted likelihood of switching by about 10 percentage points. One surprising results in column 3 is that distance from a safe well does not appear to matter in the switching decision. An increase in the distance to a safe alternative of 100 meters only decreases the likelihood of switching by 0.2 percentage points. In addition, having at least a secondary education for the household head or the respondent *decreases* the likelihood of switching, contrary to our expectations that higher education would be associated with more responsiveness to health risk information. Note also that although the last two coefficients are not individually significant at standard levels, the null that both are zero is strongly rejected (p-value= 0.0029). Of course all these results have to be interpreted with caution, and simplistic causal statements should be avoided. In fact, such simple models are unlikely to perfectly control for any form of unobserved heterogeneity in, say, taste for health, willingness to pay traveling costs to fetch water or cognitive ability to interpret new information.

6 Conclusions

Arsenic-contaminated drinking water is a serious public health problem in several countries, including Bangladesh. In this paper we use data purposely collected in Araihazar district, Bangladesh, to analyze the relationship between the provision of information about arsenic level of tubewell water, elicited perceptions about health risks and choice of source of drinking water. Our findings indicate widespread awareness about the health risk of arsenic as well as about the cumulative negative effects of a prolonged exposure. Respondents' perceptions of health risk are strongly increasing in the arsenic level and also help explaining the decision to switch to alternative sources of drinking water when the current source is unsafe. In addition, we describe the results of a Randomized Controlled Trial which allows us to evaluate the impact of different health-risk communication categories on switching behavior and risk perceptions. A random subsample of households was informed of the arsenic content of their water using a standard "binary" message that only highlighted the benefits of drinking from safe sources. A second subsample was instead exposed to an alternative message that stressed the importance of choosing, whenever possible, the source with the lowest arsenic level. In our data, this "continuous" information did not have sizeable impacts on risk perceptions or on switching behavior. Contrary to our expectations, we actually observe that the experimental communication mode decreases the impact of the arsenic level on the probability of switching to a new source of drinking water.

We also find that subjective risk perceptions about the tested water has relatively large predictive power in explaining switching behavior (even after controlling for actual safety status of the well). This observation may be interpreted as a signal that more efforts should be exerted to change individual perceptions about arsenic risk. Our results, as well as the earlier cited work done by others in the area, show that the simple provision of information on health risk can considerably affect the choice of source of drinking water. However, all this work has also found that not everyone switches to safer sources and this paper suggests that part of the explanation may lie in the fact that in some cases risk perceptions do not respond. On the other hand, at this point our research is largely silent about how such beliefs are formed. We have shown that the communication modes we have experimented with are overall equally able to change perceptions but besides that this work has not explored the endogenous formation of beliefs. Understanding how risk perceptions is potentially very important for policy, because information campaigns should be ideally designed in a way to maximize the awareness about arsenic-related health risk.

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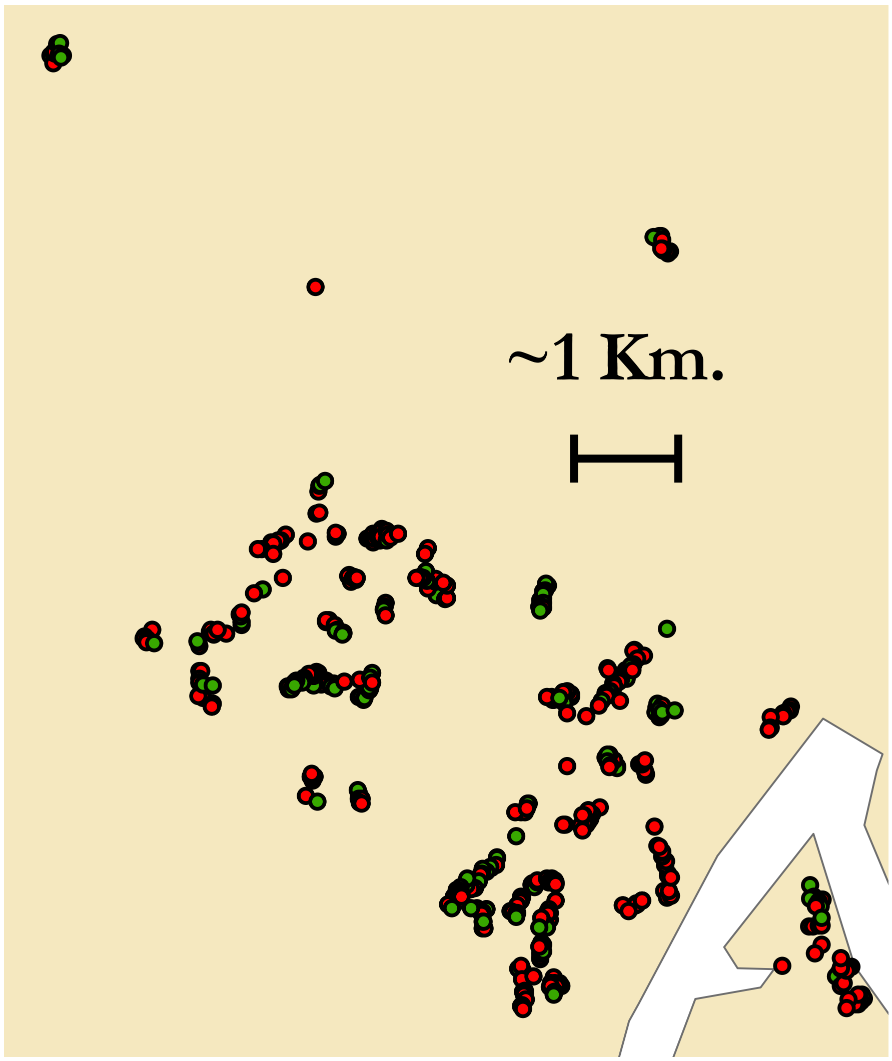

Figure 1: Geographical distribution of arsenic in the study area

Notes: Data from fall 2008 survey. Green circles indicate “safe” wells ($As < 50$ppb), which red circles indicate “unsafe” wells ($As > 50$ppb).

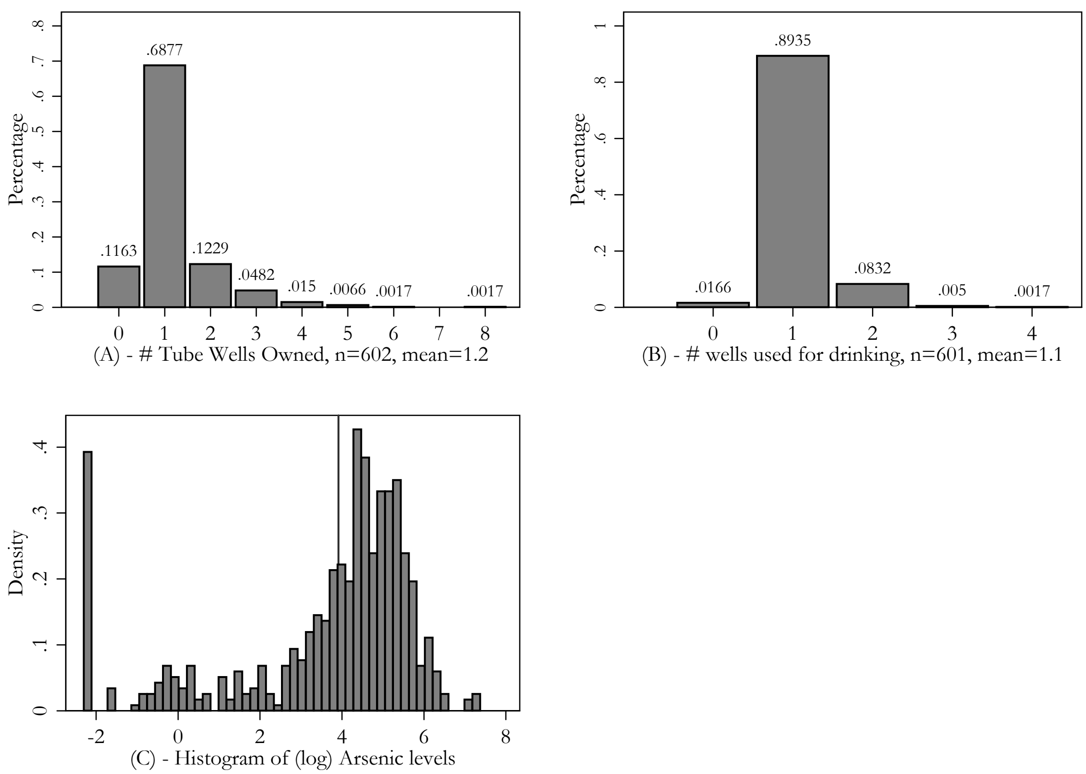

Figure 2: Summary Statistics about Tube Wells

Notes: Data from fall 2008 survey. The vertical line in Graph (C) indicates the safety threshold (50ppb).

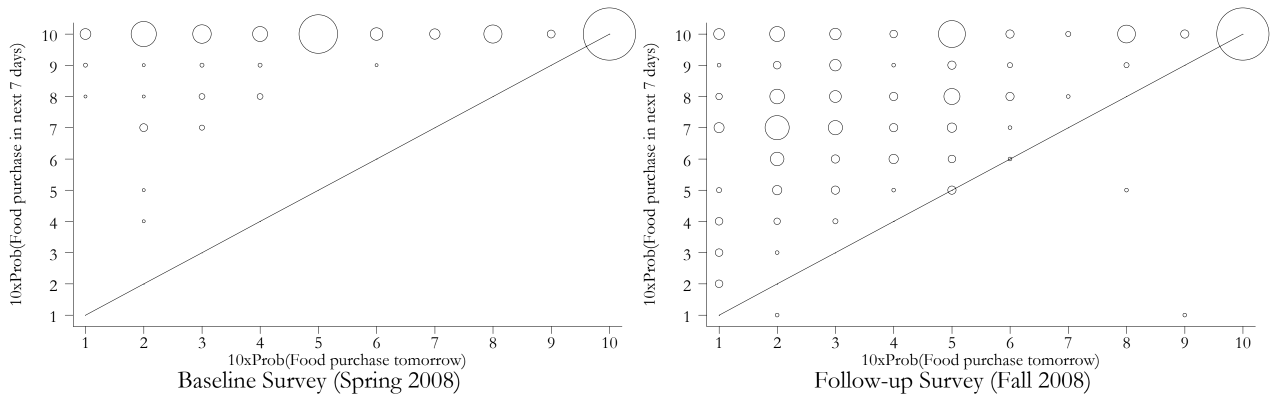

Figure 3: Probability of Food Purchase

Notes: Data from baseline ($n = 666$) and follow-up survey ($n = 603$). The size of the circle is proportional to the number of responses in each cell.

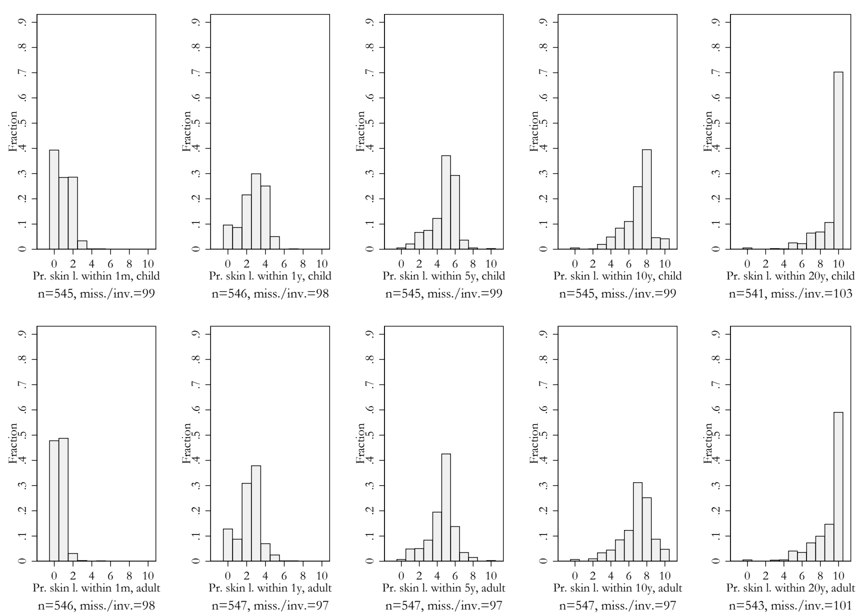

Figure 4: Baseline Beliefs about Risk of Skin Lesions: Generic Unsafe Well Water

Notes: Data from spring 2008 baseline survey.

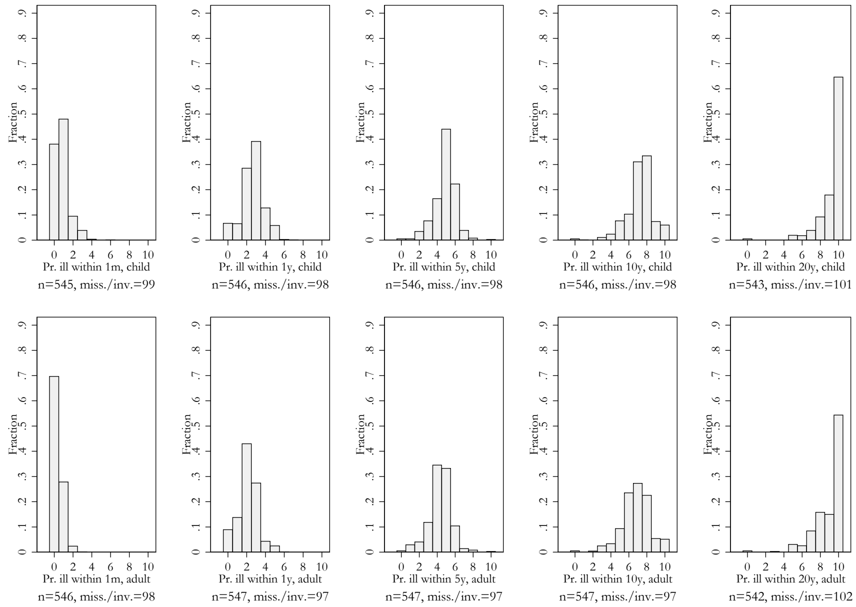

Figure 5: Baseline Beliefs about Risk of Serious Health Consequences: Generic Unsafe Well Water

Notes: Data from spring 2008 baseline survey.

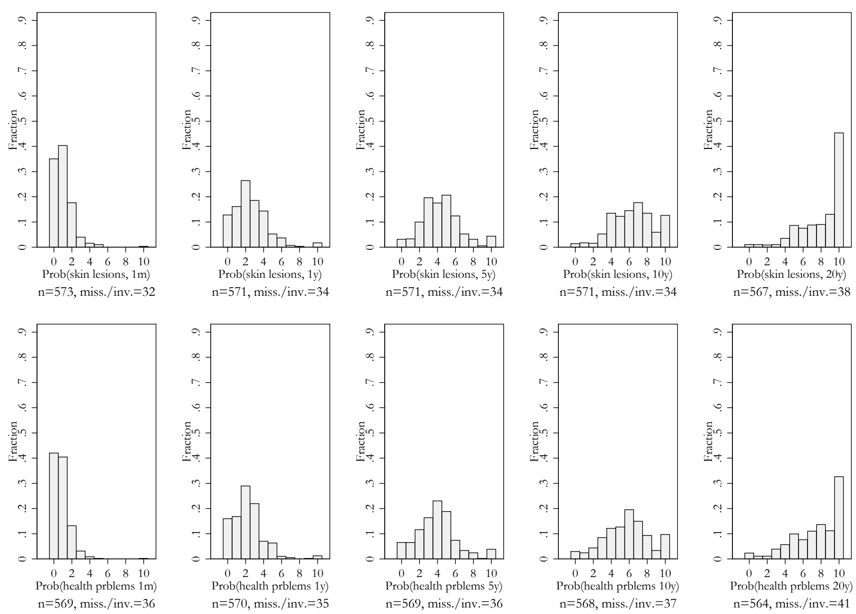

Figure 6: Follow-up Beliefs about Risk of Health Consequences: Generic Unsafe Well Water

Notes: Data from fall 2008 survey.

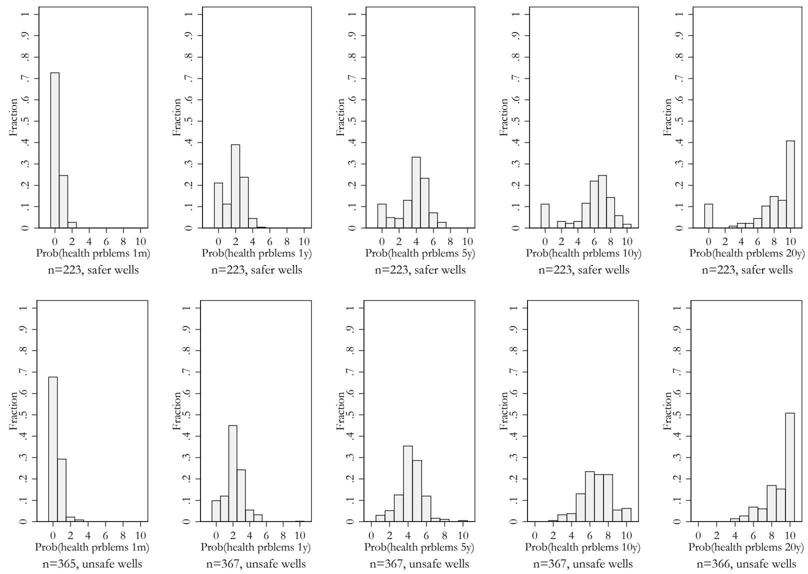

Figure 7: Baseline Beliefs about Risk of Serious Health Consequences: Tested Wells

Notes: Data from spring 2008 (baseline) survey. Risk perceptions were measured immediately after the delivery of the water test results. Safe wells have $As \leq 50$, while unsafe wells are those with arsenic level above this threshold.

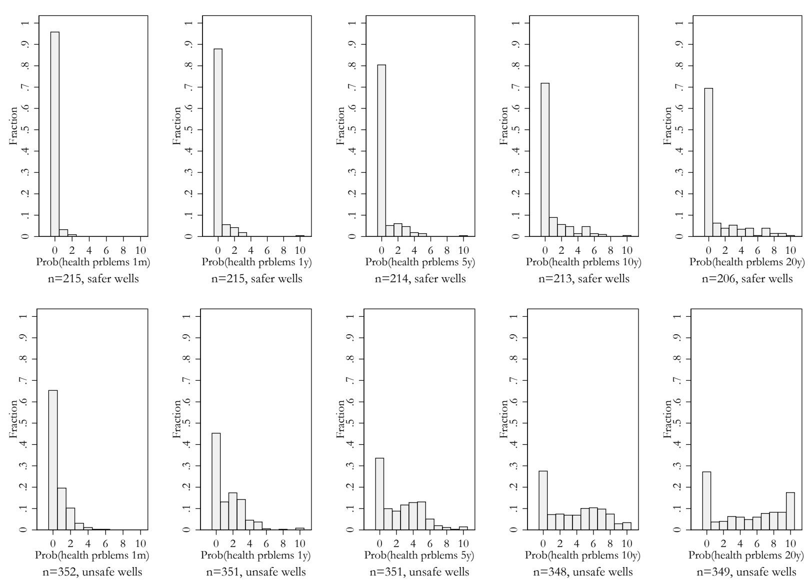

Figure 8: Follow-up Beliefs about Risk of Serious Health Consequences: Tested Wells

Notes: Data from fall 2008 (follow-up) survey. Safe wells have $As \leq 50$, while unsafe wells are those with arsenic level above this threshold.

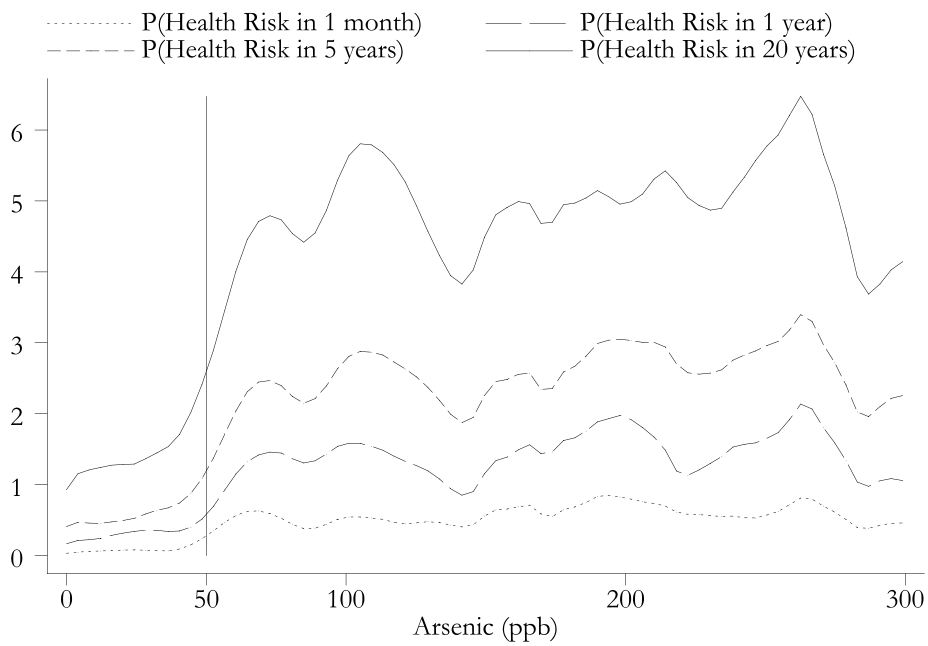

Figure 9: Average Reported Probability of Developing Serious Health Problems as a Function of Arsenic Content

Notes: Data from fall 2008 survey.

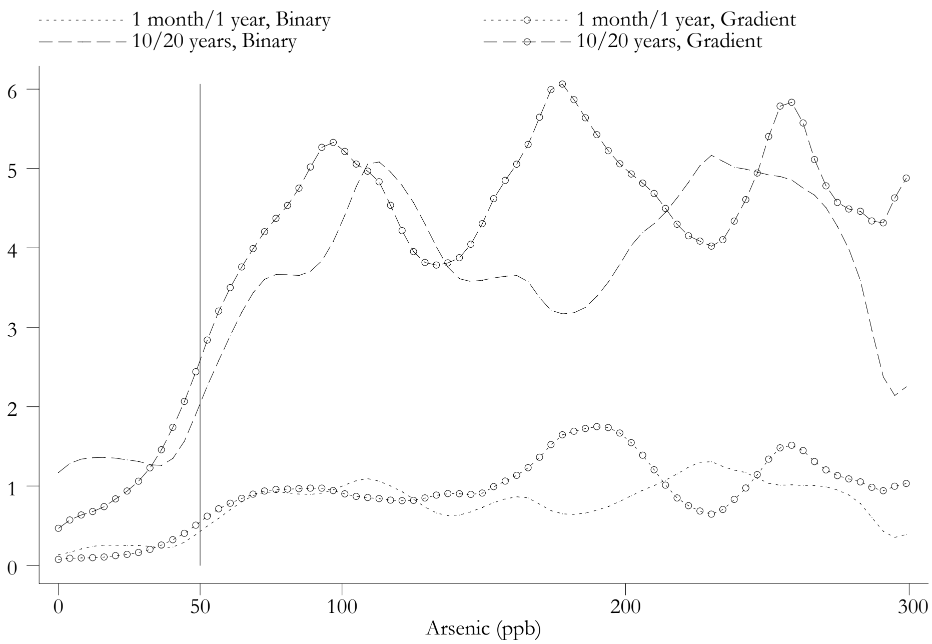

Figure 10: Probability of Serious Health Problems, Arsenic and Communication Mode

Notes: Data from fall 2008 survey. Curved labeled “binary” are constructed with respondents residing in villages exposed to the standard message. Curves labeled “gradient” are for villages where the new message was adopted. Each curve is constructed using respondent-specific means of two elicited risk perceptions, either short-term (1 month/1 year) or long-term (10/20 years). In all lines, the bandwidth is equal to 30. The vertical line is drawn at 50ppb, the safety threshold adopted by the Government of Bangladesh.

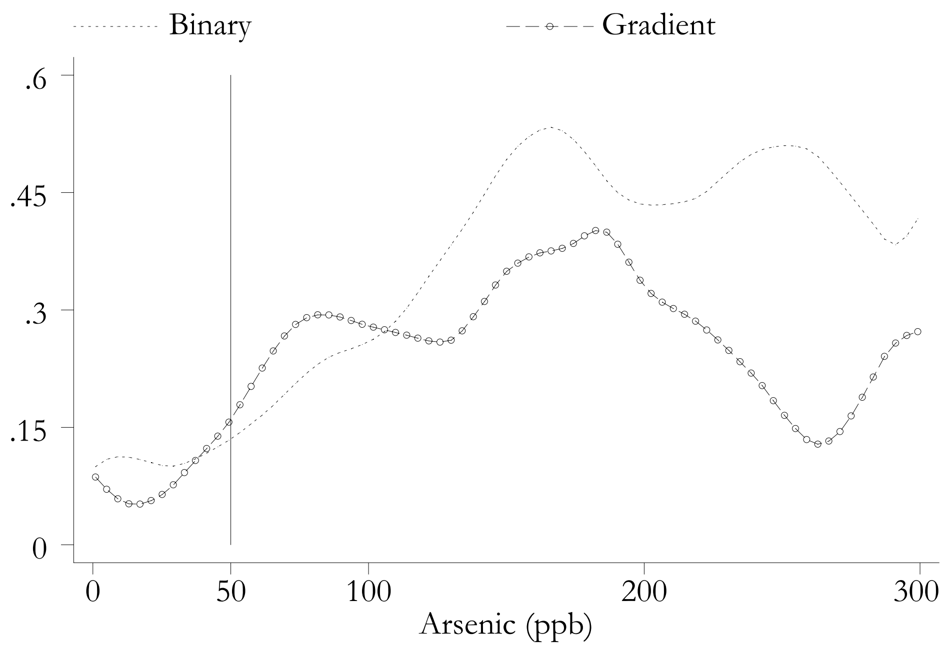

Figure 11: Switching and Communication Mode

Notes: Data from fall 2008 survey. Locally linear non-parametric regressions of switching on arsenic levels. Curves labeled "binary" are constructed with respondents residing in villages exposed to the standard message. Curves labeled "gradient" are for villages where the new message was adopted. The vertical line is drawn at 50ppb, the safety threshold adopted by the Government of Bangladesh.

Table 1: Baseline Summary Statistics

	Obs.	Mean	Median	St.dev.
Well Arsenic Level	668	123	81	165
As > 50ppb	668	.62	1	.48
# household members	668	5.3	5	2.5
Household head: age	655	46	45	15
Household head: can read/write	643	.41	0	.49
Household head: secondary education or above	643	.22	0	.42
Household head: woman	654	.19	0	.39
% of members age > 10 who can read and write	668	.54	.5	.34
% of 6-14 in school	468	.77	1	.37
Owns tested tube-well[1]	599	.7	1	.46
Food expenditure per capita: typical monthly[2]	664	1033	879	755
Total expenditure per capita: typical monthly	658	1257	1000	813
Total income per capita: typical monthly	619	1636	1250	1624
Total medical expenditure per month: last year	641	128	47	348
Uses sanitary latrine	668	.25	0	.44
Pakka (good quality) house or pakka walls	668	.13	0	.34
% of members with symptoms of arsenic poisoning[3]	666	.012	0	.078
Any member with symptoms of arsenic poisoning	666	.036	0	.19
Mean # days of illness last year (age 6 to 70)[4]	666	18	12	24

Notes: Calculations from Spring 2008 data. 1. Information on well ownership was only available for households included in the follow-up survey. 2. Information on income and expenditure is derived from simple, one-shot questions with recall period equal to one week for food, one month for total expenditure and income and one year for medical expenditures. 3. Of a total of 3,975 individuals, only 41 are reported as having any symptom of arsenic poisoning, of which 39 have skin lesions. 4. For each individual this is estimated as the number of days lost to work or school in the last one year.

Table 2: Arsenic and Household Covariates

	Dependent variable (1) Unsafe	Dependent variable (2) Arsenic
# household members	0.014	2.018
	[0.009]	[2.919]
Head's age	0	-0.294
	[0.002]	[0.610]
Household head can read/write	0.014	-25.551
	[0.066]	[22.857]
Household head has secondary education or above	-0.077	-27.669
	[0.070]	[24.721]
Head is a woman	0.023	-3.942
	[0.056]	[22.386]
% of members age> 10 who can read and write	0.036	66.008
	[0.088]	[29.640]**
Food expenditure: typical monthly per capita (×1000)	-0.046	-4.474
	[0.040]	[8.619]
Total expenditure: typical monthly per capita (×1000)	0.029	3.143
	[0.039]	[10.147]
Uses sanitary latrine	-0.025	1.286
	[0.050]	[15.267]
Pakka (good quality) house or pakka walls	-0.001	13.583
	[0.067]	[23.561]
% of members with symptoms of arsenic poisoning	0.7	422.649
	[0.399]*	[231.398]*
Mean # days of school or work lost to illness last year	0.001	-0.066
	[0.001]	[0.219]
Constant		107.429
		[30.884]***
Observations	564	564
H_0: all slopes = 0 (p-value)	0.6429	0.3302

Notes: Data from spring 2008 survey. Heteroskedasticity-robust standard errors in brackets. Column 1 shows marginal effects from a probit model with a binary dependent variable equal to if the well is unsafe ($As > 50$ppb). Column 2 shows OLS estimates with As as the dependent variable. Both regressions are estimated including only the 605 panel households (41 observations are lost because of missing values).

Table 3: Randomization Tests

	Standard		Gradient		p-value
	(1)	(2)	(3)	(4)	(5)
	Mean	s.e.	Difference	s.e.	
Well Arsenic Level	117.500	12.334	14.475	33.993	0.672
As > 50ppb	0.639	0.063	-0.035	0.101	0.729
# household members	5.377	0.265	-0.021	0.303	0.945
Household head: age	46.347	1.187	0.061	1.583	0.970
Household head: can read/write	0.412	0.032	-0.023	0.047	0.620
Household head: secondary education or above	0.222	0.030	-0.011	0.046	0.805
Household head: woman	0.203	0.019	-0.034	0.038	0.371
% of members age > 10 who can read and write	0.549	0.024	-0.018	0.038	0.643
% of 6-14 in school	0.761	0.033	-0.003	0.041	0.950
Owns tested tube-well[1]	0.688	0.020	0.020	0.034	0.561
Food expenditure per capita: typical monthly[2]	1032.605	45.164	-3.765	61.041	0.951
Total expenditure per capita: typical monthly	1276.965	49.322	-38.784	62.410	0.538
Total income per capita: typical monthly	1722.885	133.322	-151.624	149.661	0.317
Total medical expenditure per month: last year	133.130	17.809	-10.347	24.993	0.681
Uses sanitary latrine	0.258	0.032	-0.021	0.060	0.731
Pakka (good quality) house or pakka walls	0.123	0.029	0.006	0.038	0.871
% of members with symptoms of arsenic poisoning[3]	0.010	0.004	0.003	0.007	0.648
Any member with symptoms of arsenic poisoning	0.033	0.011	0.007	0.023	0.770
Mean # days of illness last year (age 6 to 70)[4]	18.989	1.349	-0.523	2.219	0.815

Notes: Data from spring 2008 survey. The results along each row are obtained by regressing the row-specific variable on a dummy for the "gradient" communication mode. All estimates are obtained including only the 605 panel households re-interviewed in fall 2008. The results in columns 1 and 2 show the estimated means for households in villages where the standard message was used. The results in columns 3 and 4 are the coefficients for the dummy and the corresponding standard errors. The figures in column 5 are the p-value for tests of the null hypothesis that the two means are equal. All standard errors and tests are robust to intra-village correlation.

Table 4: Change in Risk Assessments about Generic Unsafe Wells

	1 Month	1 Year	5 Years	10 Years	20 Years
(A)					
Mean at baseline	0.58	2.28	4.51	6.89	8.97
Mean change (WII-WI)	0.241	-0.052	-0.583	-1.163	-1.506
	[0.066]***	[0.117]	[0.156]***	[0.177]***	[0.198]***
Observations	540	540	540	540	540
(B)					
"Gradient"	-0.204	-0.182	-0.012	0.098	0.175
	[0.141]	[0.263]	[0.349]	[0.441]	[0.440]
ln(Arsenic level, ppb)	-0.013	-0.010	-0.046	-0.048	-0.061
	[0.038]	[0.066]	[0.091]	[0.112]	[0.135]
Well is unsafe ($As < 50$)	0.003	-0.044	-0.142	-0.170	0.058
	[0.172]	[0.340]	[0.516]	[0.635]	[0.742]
Constant	0.385	0.100	-0.322	-0.930	-1.409
	[0.138]***	[0.224]	[0.247]	[0.289]***	[0.354]***
Observations	540	540	540	540	540

Notes: In all regressions the dependent variable is the difference between follow-up and baseline in the perceived probability ($\times 10$) of developing skin lesions within a given time frame. Positive figures represent an increase in the perceived risk assessment. "Gradient" is a binary variable equal to one when the test result was accompanied by a message stressing the increased relationship between arsenic content and the likely health consequences. Standard errors are estimated using block-bootstrap with 250 replications, with clustering at the village level.

Table 5: Switching Behavior and Arsenic Levels

	(1)	(2)	(3)
Intercept (β_0)	0.102	0.074	-0.803
	[0.043]**	[0.052]	[0.208]***
Unsafe well (β_U)	0.274	0.166	
	[0.067]***	[0.076]**	
Gradient Message (β_T)	-0.057	-0.002	1.258
	[0.048]	[0.058]	[0.343]***
Unsafe×Gradient (β_{UT})	-0.016	0.162	
	[0.080]	[0.102]	
ln(Arsenic) (β_A)		0.028	0.24
		[0.009]***	[0.041]***
ln(Arsenic)×Gradient (β_{AT})		-0.047	-0.271
		[0.014]***	[0.065]***
Mean dependent variable	0.236	0.236	0.342
Unsafe wells only	No	No	Yes
Observations	534	534	325
R-squared	0.32	0.32	0.37

Notes: Data from fall 2008 survey. Both regressions are estimated using a Linear Probability Model with 534 observations, from 43 villages. "Gradient" is a dummy variable equal to one when the communication of the arsenic content was accompanied by a message stressing the existence of gradient between health risk and arsenic content. All standard errors are robust to the presence of intra-village correlation.

Table 6: Knowledge of Arsenic Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Variable		Knows safety				Knows Arsenic Level	
Constant	0.792	0.780	0.943	0.979	0.030	0.030	0.053
	[0.018]***	[0.026]***	[0.023]***	[0.027]***	[0.008]***	[0.012]**	[0.019]***
Gradient		0.024	0.017	0.011		0.000	-0.001
		[0.037]	[0.036]	[0.042]		[0.016]	[0.016]
Unsafe			-0.260	-0.334			-0.036
			[0.034]***	[0.039]***			[0.018]**
Switched out				-0.196			
				[0.142]			
Sw.×Unsafe				0.315			
				[0.164]*			
Observations	587	587	587	518	605	605	605

Notes: Data from fall 2008 survey. All regressions are estimated using Linear Probability Model. In columns 1 to 4 the dependent variable is a dummy equal to one when the respondent recognizes whether the arsenic level of the tested water is safe. In columns 5 to 7, the dependent variable is equal to one when the reported arsenic level is within 10ppb from the actual level. "Gradient" is a dummy variable equal to one when the communication of the arsenic content was accompanied by a message stressing the existence of gradient between health risk and arsenic content. "Unsafe" indicate wells whose water had arsenic levels above 50ppb. Asterisks denote statistical significance at the 10 (***), 5 (**) and 10 (*) percent level. All standard errors, in brackets, are robust to the presence of intra-village correlation.

Table 7: Switching Behavior and Risk Perceptions

	(1)	(2)	(3)
Health risk of tested well	0.018	0.017	0.018
	[0.009]*	[0.009]*	[0.009]*
Health risk of generic unsafe well	0.013	0.009	0.009
	[0.021]	[0.020]	[0.021]
Gradient		0.703	0.65
		[0.355]*	[0.476]
ln(Arsenic level, ppb)		0.153	0.144
		[0.055]***	[0.046]***
Gradient× lnAs		-0.16	-0.149
		[0.069]**	[0.098]
log(total monthly expenditure per head)			-0.05
			[0.067]
% of members with symptoms of arsenic poisoning			0.199
			[0.243]
Respondent has secondary education or above			-0.114
			[0.083]
Household head has secondary education or above			-0.135
			[0.086]
# household members			-0.001
			[0.017]
Owns the tested well			-0.107
			[0.059]*
Distance to closest safe well (in '00 meters)			-0.002
			[0.011]
Constant	0.178	-0.503	0.028
	[0.149]	[0.324]	[0.595]
$As > 50$ppb (Unsafe)			
Gradient×Unsafe			
Only unsafe wells included	Yes	Yes	Yes
Observations	283	283	265
R-squared	0.02	0.04	0.09

Notes: Data from baseline and follow-up surveys. All regressions are estimated using a Linear Probability Model. "Health risk of tested (generic unsafe) well" is the mean elicited belief of developing serious health problems as a consequence of 10 or 20 year drinking from the tested well (a generic unsafe well). All standard errors are robust to the presence of intra-village correlation.