Policy brief
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IGC
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Piloting a Novel Delivery Mechanism of a Critical Public Health Service in India

Arsenic Testing of Tubewell Water in the Field for a Fee

In brief

- Arsenic in tubewater is associated with impaired intellectual and motor function in children, and in a recent study has been shown to have led to an increase the number of deaths in Bangladesh. Exposure to arsenic through drinking groundwater has led to the need of millions of rural households across the Indo-Gangetic Plain to have their tubewell tested for arsenic.

- The study seeks to determine the willingness of rural households in the state of Bihar, India, to have their tubewell tested for arsenic for a fee. Five prices were tested across 26 small- to medium-sized villages in 2010: 10, 20, 30, 40 and 50 Rs.

- Results show that the proportion of households buying the test gradually declined from 80-97% at the 10Rs price, to 22-55% at the 50Rs price. Ownership of a cell phone, fridge, TV, washing machine, car or motorcycle increases as price of test increases.

- Only 28 households out of 1,804 households claimed to know whether their well was safe.

- The intervention shows that a tester could earn a living testing most wells in a village by collecting a 20Rs fee from 10-20 households a day, without discriminating against poor households.

- Under the experiment conditions, most households were not willing to cover the estimated total cost of a test of 100-150Rs, including kit reagents, a handheld GPS unit for data entry and some form of quality-control provided by a supervisor.

We thank Pascaline Dupas (Stanford University) for her input

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Summary

The goal of this study was to determine the willingness of rural households in the state of Bihar, India, to have their tubewell tested for arsenic for a fee. Following public information sessions describing the health risks associated with drinking high-arsenic drinking water, a total of 1,804 households distributed across 26 small- to medium-sized villages were offered a test between October and December 2012. The price of the test was the same within each village and set at 10, 20, 40, or 50 Rs in four groups of five randomly selected villages, respectively, and at 30 Rs in another six villages. The proportion of households buying the test gradually declined from 80-97% at 10 Rs to 22-55% at 50 Rs. The wealth of households that agreed to purchase the test increased with price according to several indicators. The intervention has demonstrated that a tester could earn a living, cover transportation costs, and test most wells in a village by collecting a ~20 Rs fee from 10-20 households a day without unduly discriminating against poorer households. Under the conditions of the experiment, most households were not willing to cover the estimated total cost of a test of 100-150 Rs, including kit reagents, a hand-held GPS unit for data entry, and some form quality-control provided by a supervisor.

"Chronic exposure to arsenic by drinking groundwater at over 10 times the level of the current [WHO] guideline...has recently been shown to double all-cause deaths in a large cohort study conducted in Bangladesh

Background

This project was a response to the need of tens of millions of rural households across the Indo-Gangetic Plain to have their tubewell tested for arsenic (Fendorf et al., 2010). Chronic exposure to arsenic by drinking groundwater at over 10 times the level of the current World Health Organization guideline of 10 microgram per liter has recently been shown to double all-cause deaths in a large cohort study conducted in Bangladesh (Argos et al. 2010). Arsenic in tubewell water has also been associated with impaired intellectual and motor function in children (Wasserman et al., 2004; Parvez et al., 2011). Because the distribution of arsenic in groundwater is highly variable spatially, and temporal variability is limited, field testing effectively distinguishes the subset of wells within a village that can be used for drinking and cooking from those suitable only for washing (Ahmed et al., 2006; Opar et al., 2007; Madajewizcz et al., 2007; Chen et al., 2007; Bennear et al., 2012; George et al., 2012a).

Methods

Approval for this field experiment was obtained from the State Health Society of Bihar and the Columbia University IRB.

Co-PI Singh and local supervisor Vijay Ojha recruited 10 college graduates from a local university to carry out the testing. The testers were shown how to use the ITS Econo-Quick Arsenic kit (George et al., 2012b) and how to enter the data, along with additional well and household information, directly onto a hand-held Garmin 76Cx GPS receiver. The trained testers worked mostly in pairs and were randomly assigned to a village for which the price of the test had previously been set randomly as well. Approximately once a week, each GPS receiver was connected to the supervisor's laptop to upload the data. The data were then sent to the Co-PI who generated village maps in Google Earth.

When reaching a village for the first time, each pair of testers displayed a billboard-sized map of that village generated in Google Earth to attract attention (Fig. 1). A public-health message describing the risks of drinking high-arsenic groundwater was delivered and a second map showing tests results for a neighboring village was shown. The spatial variability of the test results and the opportunity for sharing wells it entails was pointed out. The testers then announced that they were going to offer to test wells at a given price over the next several days by going door-to-door through the village. Households were not aware that a different price might be charged in another village. Although every effort was made to speak with a member of each household owning a well, an estimated ~10-20% of the owners could not be contacted because they were away. The testers also asked if there were any community wells associated with a school, temple, or mosque and typically tested those sources first.

The test results were posted on each pumphead with a metal placard (Fig. 2) colored red (>50 ug/L arsenic), green (>10-50 ug/L), or blue (<10 ug/L) to categorize wells relative to the national standard for arsenic at the time of 50 ug/L and the WHO guideline of 10 ug/L (the government of India has since matched its standard for arsenic in drinking water to the WHO guideline). Smaller placards with an individualized well ID were also attached to each pumphead in anticipation of a future response survey.

After the entire testing campaign was completed, a new Google Earth map showing the test results was posted at a central location in each of the 25 villages. The position of the wells was jittered by 20-40 m in order to limit the possibility of identifying specific households. The PI calculated the proportion of households that agreed to pay for a test for each of the 25 villages along with an error estimate. A compilation of all the data was then sent to Pascaline Dupas for further analysis.

Results

"The data show that the proportion of households buying at test gradually declined as the price increased"

The 26 small- to medium-sized villages that were selected for this study are distributed across a 250 km^2 low-lying area south of the Ganges River (Fig. 3). A total of 1,804 households owning a well were contacted and their location was recorded. The number of households per village contacted averaged 58 and ranged from 21 to 109 (see Appendix for individual village maps). Of the 1,804 households, 1,195 agreed to have their well tested for a fee (an additional 29 community wells were tested for free). On the basis of the test results, blue, green, and red placards were attached to 773, 215, and 247 private wells, respectively (19 out of 29 community wells were labeled blue or green and the others red). The proportion of wells within a village that were labeled red ranged from 0 to 81%. Only 28 households claimed to know the status of their well and, in all cases, believed it was safe. Of the 22 households that believed their wells to be safe and agreed to have it tested, 19 were correct according to the test relative to the previous national standard of 50 ug/L.

The data show that the proportion of households buying at test gradually declined as the price increased, even if this proportion also varied at any given price by +20% from one village to the other (Fig. 4). OLS regressions confirm that the proportion of households paying for a test declines as the price increases relative to the mean of 0.84 at 10 Rs, and this with $p<0.01$ for prices of 30 Rs and above (Table 1). The demand for tests was slightly greater in villages where a community well was tested ($p<0.03$). The outcome of the test of a community well did not appear to have an impact (Table 1).

Another set of regressions indicates that the characteristics of the buyers changed with the price of the test (Table 2). For a linear specification across the price range, the results show an increase in the number of cell phones per household member, the ownership of a fridge, TV, or washing machine, and the ownership of a car or motorcycle increases as the price of the test increases ($p<0.01$). Even though the price of test was small compared to the cost of installing a tubewell (2,500-7,500 Rs), wealth played in the households decision to purchase a test.

Implications

"The 20 Rs price that more than 2/3 of households in a village are willing to pay would be sufficient to cover the salary and transportation of a tester with secondary education"

To our knowledge for the first time in India, this experiment demonstrated that there is a market to have tubewells tested for arsenic. The 20 Rs price that more than 2/3 of households in a village are willing to pay would be sufficient to cover the salary and transportation of a tester with secondary education, assuming 10-20 tests/day, but not the estimated total cost of testing when the quality control by a supervisor, a durable metal placard with the test results, kit supplies, and a GPS unit are included (100~150 Rs altogether). These additional costs would therefore have to be covered centrally in a future, sorely needed, testing campaign.

We will contact the State Health Society of Bihar to share these results and discuss the possibility of a state-wide expansion of the tubewell testing campaign. We also intend to submit a follow-up proposal to IGC Central India or IGC Bihar to determine what proportion of households switched to a low-arsenic well. The response survey will also seek to identify household characteristics that are more or less likely to lead to switching. This information will be valuable for maximizing the impact of an expanded testing program supported through the state government in the future. The follow-up data will also set the stage for an academic paper evaluating the entire intervention that will be submitted to a peer-reviewed journal.

We are planning a workshop of senior civil servants responsible for arsenic mitigation from Pakistan, Nepal, India, Bangladesh, Myanmar, Cambodia, Vietnam, and China with selected academics from the same countries to be held during the week of January 6-10, 2014 in Yangon during which the IGC/Bihar results will be presented. We will argue that other S/SE Asian countries should initiate fee-based testing of tubewells for arsenic.

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Figure 1: Display of test results from neighbouring village as maps produced in Google Earth

Figure 2: Metal placards with test results attached to pumphead

Figure 3: Map of study villages in the state of Bihar. Abbreviated village names are followed by the price (in Rs.) of testing charged in that village

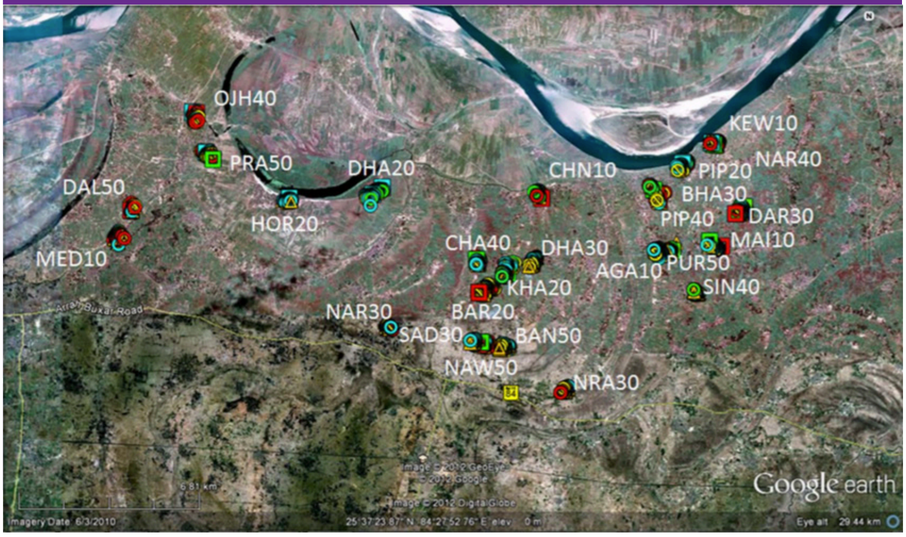

Figure 4: Relationship betwen the demand for testing for each of the 26 villages and the price charged

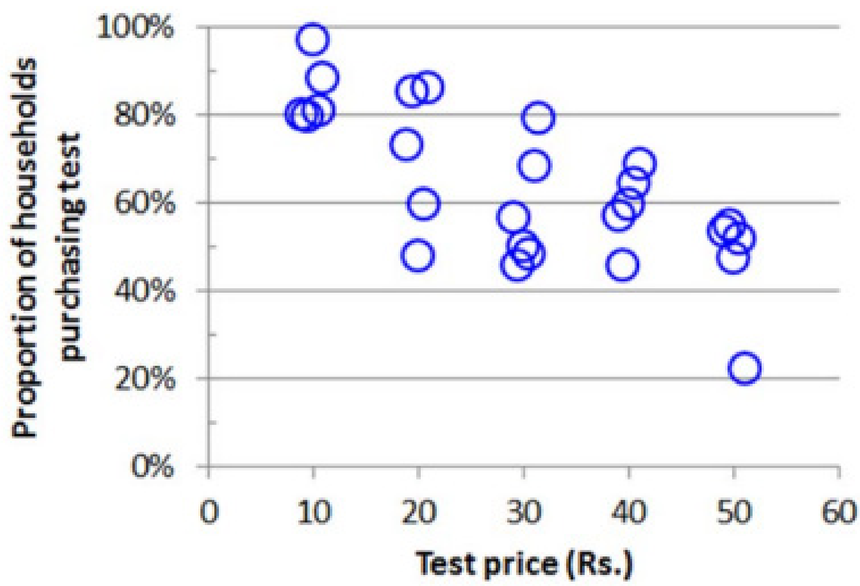

Table 1: Effect of Price on Demand

	(1)	(2)	(3)
	Dependent Variable: Household Purchased Test		
	Mean at price = 10Rs: .84		
Test price = 20 (Rs.)	-0.129 (0.072)*	-0.15 (0.065)**	-0.146 (0.077)*
Test price = 30 (Rs.)	-0.227 (0.064)***	-0.239 (0.060)***	-0.239 (0.058)***
Test price = 40 (Rs.)	-0.25 (0.044)***	-0.253 (0.050)***	-0.254 (0.048)***
Test price = 50 (Rs.)	-0.409 (0.073)***	-0.425 (0.071)***	-0.424 (0.069)***
Number of community wells tested for free in the village		0.044 (0.026)*	0.041 (0.036)
At least one community well tested and identified as "Red"			0.01 (0.069)
Observations	1804	1804	1804
R-Squared	0.08	0.09	0.09

*Notes: Each column corresponds to an OLS regression. Standard errors clustered at the village level. ***, **, * indicate significance at 1, 5, 10 percent*

Table 2: Selection Effects of Higher Prices

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Among household who purchased the test				
	# of Cell Phone Users	# of Family Members	Cell phones per capita	Appliance ownership (fridge, TV, washing machine)	Ownership of Car or Bike
Panel A: Linear Specification					
Price (Rs.)	0.011 (0.004)**	-0.023 (0.030)	0.002 (0.001)***	0.007 (0.002)***	0.004 (0.001)***
Panel B: Breakdown by price points					
Test price = 20 (Rs.)	-0.056 (0.192)	2.732 (1.292)**	-0.005 (0.024)	0.04 (0.030)	0.01 (0.040)
Test price = 30 (Rs.)	0.122 (0.135)	-0.859 (1.039)	0.047 (0.024)*	0.105 (0.050)**	0.123 (0.054)**
Test price = 40 (Rs.)	0.239 (0.180)	-0.399 (0.978)	0.047 (0.021)**	0.165 (0.067)**	0.065 (0.051)
Test price = 50 (Rs.)	0.474 (0.175)**	0.386 (1.171)	0.09 (0.039)**	0.351 (0.089)***	0.174 (0.040)***
Observations	1195	1195	1195	1195	1195
Mean among purchasers at price = 10 Rs.	1.28	10.92	0.14	0.14	0.22

*Notes: Each column corresponds to an OLS regression. Standard errors clustered at the village level. ***, **, * indicate significance at 1, 5, 10 percent*

About the authors

Alexander (Lex) Van Geen is a Lamont Research Professor at the Lamont-Doherty Earth Observatory, Columbia University. Research interests include: geochemical cycling of trace elements in natural and perturbed environments, particularly redox-sensitive processes affecting metals and metalloids; and applications to mine tailings, coastal sediment, estuaries, and groundwater, as well reconstructions of past climate change in nearshore environments. More recent interests include the bridging of disciplines, including the health and social sciences, to address multi-faceted environmental problems.

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