

A conversation with Prof. Prabhat Barnwal, Prof. Alexander van Geen, and Prof. Jack Willis, February 10, 2021

Participants

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- Prof. Jack Willis – Assistant Professor of Economics, Columbia University
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Note: These notes were compiled by GiveWell and give an overview of the major points made by Prof. Barnwal, Prof. van Geen, and Prof. Willis.

Summary

GiveWell spoke with Prof. Barnwal of Michigan State University and Prof. van Geen and Prof. Willis of Columbia University as part of its investigation into arsenic exposure mitigation in Bangladesh. Conversation topics included background information on arsenic contamination of drinking water in Bangladesh, types of arsenic mitigation interventions, the cost-effectiveness of these interventions, Bangladesh's upcoming arsenic testing campaign, and the current funding landscape for arsenic mitigation.

Background on arsenic contamination in Bangladesh

The first signs of arsenic poisoning in the region were discovered by a dermatologist in West Bengal, India in the mid-1980s. In the mid-1990s, scientists in Kolkata realized that the geology of West Bengal was similar to that of Bangladesh and that arsenic contamination was likely to be a problem there as well. An International Conference on Arsenic was held in Dhaka in 1998, where the scale of the problem was brought to international attention. The government of Bangladesh and the international community began taking steps to address the issue in 1999-2000.

At that time, the health effects of arsenic contamination were not yet well known and it was a significant problem in the United States as well. The Columbia University Superfund Research Program was being funded by the U.S. government to study arsenic contamination both domestically and internationally. It was the only large organization funded to conduct long-term research on arsenic internationally, and it spent a lot of time in the field in Bangladesh, studying both the sources and potential solutions for arsenic contamination. Arsenic exposure remains a significant public health problem in both the United States and Bangladesh.

Health impacts of arsenic exposure

Public health experts estimate that about 100,000 deaths in Bangladesh each year result from arsenic exposure. Skin lesions are the most visible symptom of arsenic exposure, but they are not the most deadly. Arsenic exposure leads to stillbirths, spontaneous abortions and infant deaths as well as cardiovascular disease and cancer. A study co-authored by Prof. van Geen found that cardiovascular disease was the primary cause of increased mortality among adults exposed to arsenic.

Sources of arsenic exposure

One of the primary sources of arsenic exposure in Bangladesh is drinking water collected from household wells. An increasing number of households now collect their drinking water from underground aquifers using tubewells in an effort to reduce microbial contamination, which is more prevalent in surface water. This has largely been a positive change for public health in terms of pathogen contamination, but well water contaminated by arsenic of natural, geologic origin has become a significant problem. Even within a small area, wells can vary significantly in their level of arsenic contamination, and arsenic is undetectable by sight, smell, or taste, making it difficult for people to know whether their wells are contaminated.

Arsenic mitigation interventions

Water treatment

One solution that has been proposed for mitigating arsenic exposure is to install water treatment systems at the household or village level. These types of solutions have won philanthropic prizes in the past, but Prof. Barnwal, Prof. van Geen, and Prof. Willis' team is skeptical that this is the most efficient way to reduce arsenic exposure. Very few households in rural Bangladesh drink treated groundwater today.

Individual water treatment systems

Household water treatment systems can be expensive, but a study co-authored by Prof. van Geen shows that cost is not the primary barrier to uptake. In the study, researchers donated water treatment systems to 600 households, removing the cost factor from the equation. Initially, urinary arsenic levels among the treatment population decreased, but after a year, they had gone back up, even though people reported that they were continuing to treat their water. These results indicated that over time, people had stopped using the treatment systems as frequently as they claimed to. Self-treating drinking water is inconvenient and costly, and the lack of immediate sensory feedback as to whether your water is safer after treating it could lead to a lack of motivation to continue doing so.

Village-level water treatment systems

Supplying an entire village with piped, treated water could be a promising solution, but it is unlikely to be implemented in Bangladesh in the near future. The governments of developing countries generally consider piped water to be a reliable

solution to address water quality problems, but they often do not have the financial resources to move forward with it. It appears unlikely that piped water supplies will be implemented on a large scale in the region for at least several decades.

In 2007, an international team of engineers at Lehigh University won a Grainger Challenge Prize for Sustainability for their arsenic filtration system for well water. Their methodology did not involve testing well water prior to installing filtration systems, and they found that people were willing to pay for access to community water supply systems. However, [Jamil et al. 2019](#), a study co-authored by Prof. van Geen and Prof. Barnwal, found that piped water supply systems were much more costly than other mitigation strategies.

Shifting to alternative water sources

When a person is told that their household well is contaminated by arsenic, their response is often to seek out an alternative water source. In a wealthy country like the United States, this might involve purchasing bottled water or a treatment system at home, but that option is too costly for most people living in Bangladesh. Instead, many people will begin collecting water from a neighbor's well, if it is known to be safer than their own. [Jamil et al. 2019](#) found that testing household wells for arsenic and informing households of their wells' contamination status, prompting them to switch to an alternative water source nearby, was the most cost-effective arsenic mitigation strategy.

Installing intermediate-depth wells

Due to geological variability, the arsenic contamination in groundwater can vary significantly in different locations and at different depths, but researchers have found patterns that allow them to predict where arsenic levels are likely to be lowest. Essentially, "aquifers" (layers of permeable rock through which groundwater can flow) deposited more than 10,000 years ago are less likely to contain arsenic. These safer aquifers can be found below a certain depth threshold, though the specific threshold can differ, depending on the area. For example, a household may find a low-arsenic aquifer at a depth of 45-90 meters, even if its current well of less than 30 meters in depth draws water from a high-arsenic aquifer. Prof. Barnwal, Prof. van Geen, and Prof. Willis' team's perspective is that taking advantage of the natural variability of arsenic content in groundwater by digging wells in low-arsenic locations and at safer depths is likely to be a more effective mitigation strategy than water treatment.

Household wells

In some villages, installing a household well at a safe depth can increase the cost of the well from about \$100 to between \$200 and \$300. However, in other villages, low-arsenic aquifers are located much deeper, and a safe household well would cost closer to \$1,000, which is too costly for most households in Bangladesh. The installation of these deeper wells (usually deeper than 90 meters) must often be funded by the government or by non-governmental organizations (NGOs). The depth

threshold for a "safe" well is based on the probability that wells will contain low arsenic, not an absolute guarantee. It's possible that even a deep well will be contaminated, though compared to shallow (usually less than 45 meters) or intermediate-depth (usually 45-90 meters) wells, it is much less likely. It is important to understand the depth profile and also to conduct testing after installation. The quality of the work during construction must also be monitored.

Information is often a key barrier to installing safe, intermediate-depth wells. First, wells must be tested in order to determine their arsenic content. Second, individuals must be informed enough to know that installing a deeper well may be a solution to the problem and up to what depth they should go. There is a key trade off in that the risk of high arsenic decreases with well-depth while the cost increases. Local well installation companies may be aware that this is the case, but individuals often do not have independent knowledge about what they should do in the case of a contaminated well.

[Jamil et al. 2019](#) found that installing an intermediate-depth household well was the second most cost-effective mitigation strategy for arsenic exposure. One possible solution for overcoming the financial barriers of this mitigation strategy would be to offer individual households subsidies, loans, money-back guarantees (i.e., insurance to cover the risk households may face when they decide to install an expensive well, which still has some chance of turning out to be high in arsenic), or even cash transfers, which could allow them to afford the upfront cost of installing a new well. On average, a well is estimated to last for about ten years.

Community wells

Intermediate-depth and deep-depth wells could also be installed at the community level and treated as a local public good, providing safe water to those whose household wells were discovered to be contaminated. The community wells could be installed by the government or be NGOs. Currently, the government of Bangladesh subsidizes the installation of community wells, but it requires that 10% of the costs come from local communities. Often, the wealthiest people in a community are the only ones who can afford to contribute to the cost of the well, and they sometimes reserve use of the well for themselves, preventing less wealthy community members from accessing it.

Debate over very shallow wells

There has also been some debate over whether installing very shallow wells would be a safe mitigation strategy for arsenic exposure. Aquifers near the surface of the earth, especially in sandy environments, often contain low levels of arsenic as well, because the oxygen present in these aquifers prevents the chemical reaction that releases arsenic into groundwater.

However, some researchers have theorized that groundwater from very shallow wells could be contaminated with microbes. Though others have suggested that the dangers of microbes are unlikely to outweigh the dangers of arsenic, installing wells

at deeper depths appears to be a better long-term solution, as they would not be affected by other sources of acute surface contamination, such as latrine overflows. In addition, the level of arsenic content in groundwater from very shallow wells could still be higher than would be considered safe by the World Health Organization (WHO), which recommends that drinking water should contain no more than 10 micrograms of arsenic per liter.

Cost-effectiveness of arsenic exposure mitigation

[Jamil et al. 2019](#) estimated the cost-effectiveness of several arsenic exposure mitigation strategies. It estimated that the cost of testing wells for arsenic and informing households of their wells' contamination status costs about \$1 per person whose exposure is reduced, while installing deeper household wells costs about \$30 per person whose exposure is reduced. Installing a deep community well provided by the government costs about \$150 per person whose exposure is reduced. However, observational data suggested that the community wells in the study were not allocated optimally. If community wells were allocated more efficiently, the cost could be brought down to about \$15 per person.

Government-led arsenic testing

The government of Bangladesh's Department of Public Health Engineering (DPHE) is currently undertaking a \$250 million, taxpayer-funded arsenic testing project. The government is planning to conduct blanket testing of roughly half the country's wells and marking those that contain unsafe levels of arsenic. This will be the second round of blanket arsenic testing in Bangladesh; the first took place between 2000 and 2005.

After the previous round of testing, surveys showed an increase in well installation rates in areas with high arsenic levels. It appears likely that interest in replacing existing shallow wells and building new intermediate- and deep-depth wells will increase after the upcoming round of testing as well, which will make the need of financial interventions enabling people to install new wells even more important in the near future.

Testing is scheduled to begin in March 2021 and will likely occur over a period of about six months. The government is partnering with NGOs to train thousands of government hires and to conduct the testing. The first shipment of testing kits has already arrived from Germany. The chemistry behind arsenic testing was developed in the 1800s and is well understood, so the testing kits are expected to be effective. Prof. Barnwal, Prof. van Geen, and Prof. Willis' team has offered to assist the government with calibrating the testing kits to make sure that they are functioning as intended.

Information-sharing

The government's testing program will provide a large quantity of valuable information to individual households about their wells' arsenic contamination

levels, but the information may become even more valuable if shared between households. For example, it will be important for individuals to know, not only the contamination status of their own wells, but also of the nearby wells they may turn to as alternative water sources. The government may also be able to use the large-scale testing data to place community wells in optimal locations. It's also possible that allowing individuals to see the correlation between well depth and arsenic levels will persuade more people that installing deeper wells is a worthwhile endeavor.

Nolkup app

Testing results will be recorded on smartphone software and, if all goes according to plan, the results will be made available via an app called Nolkup, which means "tube well" in Bangla. The app has already been developed and is available for download on the Google Play store. It is currently connected to the SurveyCTO data collection platform and is displaying a small sample of testing data from a testing campaign conducted in 2012. The ultimate goal is to connect the app to a government server and display the millions of test results that will be collected during the government's blanket testing project.

The majority of households in Bangladesh own at least one smartphone and may be able to use the app to access valuable information about wells in their area, including which wells are designated as community wells and available for public use. The app will display a score that gives individuals an idea of the arsenic contamination intensity of wells in their area. Hopefully, the government will be able to use this information to install community wells in the areas with the most need.

Reliance on the nonprofit sector

In Bangladesh, the nonprofit sector plays an important role in providing programs and services to individual households, especially for programs aiming to achieve universal coverage. It's unlikely that the government will be willing to spend large amounts of taxpayer money on arsenic mitigation on a long-term basis, so the nonprofit sector will likely need to play a role in providing a sustainable solution to the arsenic exposure problem, despite the government's blanket testing program. It's possible that the for-profit sector could also be involved if, for example, insurance companies offered insurance policies to individual households installing new wells, which would pay out if a well installed at a "safe" depth turned out to contain unsafe levels of arsenic anyway.

Funding landscape

UNICEF and the World Bank

Bangladesh's first round of arsenic testing was funded primarily by UNICEF and the World Bank. The World Bank also funded projects involving the installation of piped water supply systems for some time, although this support is no longer ongoing. A former adviser for these projects stated that the effectiveness of the programs had

been limited and that there had been significant barriers to getting systems installed.

USAID

Prof. Barnwal, Prof. van Geen, and Prof. Willis' team is currently working on a small-scale project to test whether the Nolkup app affects individual decision-making in the short-term, which is being funded by USAID's Development Innovation Ventures (DIV). DIV employs a multi-stage funding process, where the feasibility of an intervention is tested on a small scale first, followed by a pilot project, followed by a scaled-up version of the program. DIV has so far provided \$200,000 for the first stage of testing on the app. It's possible that DIV will eventually provide funding for a scaled-up version of the app's rollout, but it's possible that funders focused on Water, Sanitation, and Hygiene (WASH) interventions will be more interested in funding the project than DIV.

MacArthur Foundation

Prof. Barnwal, Prof. van Geen, and Prof. Willis' team applied for a MacArthur Foundation grant of \$100 million which they planned to use for arsenic mitigation programs, including deploying the Nolkup app. Their application and another application for arsenic mitigation in Bangladesh, which was submitted by a different organization, were included in the top 100 applicants, although neither was ultimately selected to receive the grant. There appears to be some donor interest in funding arsenic interventions in Bangladesh, although the COVID-19 pandemic has caused a significant reallocation of philanthropic attention and funding.

Water.org

Prof. Barnwal, Prof. van Geen, and Prof. Willis' team has also done work funded by Water.org, an NGO focused primarily on WASH interventions. Prof. Barnwal, Prof. van Geen, and Prof. Willis' team proposed to test an intervention that offered insurance policies to individual households installing intermediate-depth wells. However, the collaboration with the microfinance institution (MFI) that Water.org had partnered with on the project met with a regulatory roadblock on maximum interest (including insurance premium) it could charge.

When the COVID-19 pandemic began, Water.org decided to shift funding away from the project midstream, redirecting the funding to COVID-19-related programs instead. In hindsight, the project may have been more successful if it had been funded by another organization or in partnership with a for-profit insurance company.

Current room for more funding

Prof. Barnwal, Prof. van Geen, and Prof. Willis' team believes that once the government's blanket testing project is complete, scale-up of arsenic mitigation interventions should be the responsibility of either the government or NGOs.

Scaled-up programs would have the potential to reveal broad, indirect effects of the intervention that might not be visible during small-scale testing.

Prof. Barnwal, Prof. van Geen, and Prof. Willis' team is currently preparing an application for funding from the US National Science Foundation (NSF) for a policy-oriented project, which would involve providing incentives to local government officials to install safe wells in optimal locations, based on the government's testing results. However, NSF is able to make decisions less quickly and less flexibly than an independent philanthropic funding organization and may not be the optimal funding resource for large-scale arsenic mitigation interventions.

Other resources for GiveWell

- **Prof. Kazi Matin Ahmed** – Professor of Geology, University of Dhaka. Prof. Ahmed is involved in arsenic research and has served as a government advisor.
- **Saifur Rahman** – Superintending Engineer, Bangladesh Department of Public Health Engineering. Mr. Rahman is a senior government official working to address arsenic exposure in Bangladesh.
- **Peter Ravenscroft** – Water Resources Management Specialist, 2030 Water Resources Group. Mr. Ravenscroft was involved in the first arsenic survey conducted in Bangladesh.
- **Prof. Mushfiq Mobarak** – Professor of Economics, Yale University. Prof. Mobarak is a development economist who has contributed to arsenic research in the past.

*All GiveWell conversations are available at
<http://www.givewell.org/research/conversations>*