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Throwing the Baby Out with the Drinking Water

Unintended Consequences of Arsenic-Mitigation Efforts in Bangladesh

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Water contamination is a central cause of morbidity and mortality in developing countries. In most settings, the primary waterborne threat is fecal-oral pathogens, which lead to diarrheal diseases and are the second-most common cause of infant and child mortality worldwide. However, in Bangladesh and a handful of other countries, toxic heavy metals that naturally seep into groundwater are a parallel concern. Based on tests conducted by the British Geological Survey in 1998, an estimated 20 million Bangladeshis had been consuming well water that contained more than the government's recommended maximum arsenic level of 50 µg per liter, and many more consumed well water above the World Health Organization's 10 µg cutoff. Although the health effects of arsenic were poorly understood, many believed the Bangladeshi population to be in danger of serious health effects from long-term arsenic exposure.

In 1999, with help from international donors and nongovernmental organizations, the government initiated a massive campaign to test more than 5 million tube wells throughout the country and actively encouraged households to abandon contaminated wells. This international effort to move households away from water sources containing arsenic constitutes one of the most successful public health campaigns in recent history. In a strikingly short amount of time, awareness-building efforts alone led around 20 percent of the population to transition from backyard wells to less-convenient drinking-water sources, including deep tube wells outside the home and surface water. According to household survey data, by 2004 there was a high level of awareness of arsenic contamination in endemic regions, and the majority of households had stopped drinking from wells known to be contaminated.

While it reduced chronic arsenic exposure, the nationwide shift away from backyard tube wells also appears to have inadvertently increased rates of diarrheal diseases, with the largest health consequences for children under five. This is because shallow tube wells—which frequently contain arsenic—are also the most appropriate technology in terms of microbiologically clean water. Tube-well water is very unlikely to be contaminated with fecal bacteria at the source, and because shallow wells are located inside the residence, it faces little risk of becoming contaminated in storage. This makes shallow tube wells an extremely valuable prophylactic in settings such as Bangladesh, where surface-water contamination frequently causes cholera, dysentery, and other potentially fatal waterborne diseases. As a result, public health efforts in the early 2000s to move households away from shallow tube wells contaminated with

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arsenic made households more vulnerable to diarrheal diseases because they turned to drinking surface water.

To investigate this tradeoff, we quantify the impact of switching water sources in response to the arsenic-awareness campaign on child mortality by making use of the high degree of natural variation among villages in the level of arsenic in backyard groundwater. Small-scale spatial variability enables us to compare households living relatively close to one another that tested negative for arsenic contamination to those that tested positive and hence were differentially motivated to abandon shallow tube wells. To identify households that were encouraged to stop using shallow tube wells, we collect water samples from each household's kitchen storage tank and closest tube well. Consistent with government water tests, our tube-well tests indicate that more than 65 percent of households in our subdistricts had been drawing water from contaminated tube wells prior to 2000. Meanwhile, our storage-tank tests show that only 1 percent of households were still drinking arsenic-contaminated water by 2009. This implies that almost all affected households in our study area switched from shallow tube wells to either deep tube wells or surface water in the decade after testing.

We then compare health outcomes of children born before and after well testing took place within these two subsamples. Although the concentration of arsenic in groundwater in certain villages is due to their position relative to the water table, concentrations are highly variable over short distances, and nearly all contaminated villages contain pockets of clean groundwater that are impossible to predict. Hence we control for differences in average characteristics between relatively exposed and unexposed villages arising from potential correlations between the macro spatial distribution of arsenic and other household characteristics (such as income) that can influence child health. In that manner, our strategy relies on the fact that the spatial distribution of arsenic is believed to be quasi-random within distances as small as villages, which our data support.

Our results indicate that while mortality rates were almost identical between contaminated and uncontaminated households before 1999, these outcomes sharply diverged immediately after the switching campaign: after 2000, households with arsenic-contaminated wells exhibited a 46 percent increase in child mortality relative to those with arsenic-free wells, which coincides with the moment at which contaminated households were pushed to switch to more remote sources.

To more firmly attribute the mortality increase to reduced use of shallow tube wells, we also test whether households experience less of a mortality decline when they have access to deep tube wells, which varies across space and over time. When there is a deep tube well nearby, switching away from backyard tube wells should entail little increase in water-storage time or use of surface water, and hence have no adverse effects on child health. As predicted, the mortality effects of abandoning shallow tube wells increase sharply with household distance to deep tube wells. Contaminated households with more than one deep tube well within 400 meters per 10 village child births do not experience a measurable increase in child mortality, whereas households with no deep tube well within 400 meters experience a sharp and significant increase in infant and child deaths. This pattern supports our interpretation that the increase in mortality after 2000 is driven by a decrease in access to pathogen-free water among households that are encouraged to abandon arsenic-contaminated tube wells.

Given the scarcity of microbiologically clean and convenient alternative water sources in much of rural Bangladesh, this finding raises the question of whether the use of shallow tube wells contaminated with arsenic should continue to be discouraged. Clearly, policy recommendations must weigh the health effects of contaminated water against the health consequences of arsenic exposure. However, our estimates of the impact of arsenic exposure on adult mortality indicate no measurable effect of arsenic ingestion on life expectancy in this setting, increasing the case for promoting shallow tube wells as a drinking-water source—at least for young children—even when such wells may contain arsenic.

NOTE:

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