Throwing the Baby out with the Drinking Water:

Unintended Consequences of Arsenic Mitigation Efforts in Bangladesh

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Motivation

- Diarrheal disease second most common cause of infant and child mortality in developing countries; water contaminated with fecal-oral pathogens major contributor

- Shallow tubewells potentially very cheap way to reduce this contamination in Bangladesh

- But in Bangladesh, naturally occurring heavy metals (arsenic) can contaminate shallow tubewells, and lead to potential trade off between arsenic poisoning and diarrheal disease

- Policy question: **Should we encourage households to abandon tubewells contaminated with arsenic when alternative drinking sources likely more dangerous in terms of diarrheal disease?**
- Approach thus far: Ignore trade-off and advocate abandoning wells contaminated with arsenic at all costs – potential example of wedge between donor objectives and welfare-maximizing policy …

Backyard shallow tube well

Underlying scientific question …

- Do protected water sources matter much for reducing diarrheal disease in settings with high incidence of water-borne disease?
  - When fecal contamination prevalent, clean drinking water may have limited impact on reducing incidence of water-borne disease
  - Currently big debate in the literature: Certain studies show little difference in infant and child mortality between households that utilize protected versus unprotected water sources
  - Evaluating tradeoff between arsenic exposure and exposure to fecal-oral pathogens depends fundamentally on answering this question …

Current attitudes towards tubewells

- Despite potential benefits of shallow tubewells for diarrheal disease, still extensive public health efforts to move households away from them:

From Bangladeshi Ministry of Health Website (March 2010):

"The public health of the country is now facing a severe threat as a section of existing tube-wells are contaminated with arsenic. ***Now time has come to return to our old habit. Because we can keep ourselves safe from arsenic pollution by drinking surface water.****"*

  - In popular press and even scientific journals, arsenic contamination of STWs treated routinely as larger health concern than health benefits of STWs

  - Arsenic contamination of STW is used as a high profile example of how aid causes more problems than it solves

Empirical study

- Measure potential increase in diarrheal disease that resulted from households switching away from contaminated wells during public health campaign of 1999 in which most backyard tubewells in country tested for arsenic exposure and households told whether their well was dangerous

- Extremely successful campaign – according to 2004 DHS data, most households abandoned arsenic-laden drinking water sources almost immediately (60%-95%)

- Comparison groups: Households living in same village whose tubewells tested above and below cutoff for arsenic contamination

- Those above the cutoff switched to alternative water sources, while those below cutoff continued to use shallow tubewells

Identification strategy

- Compare infant and child mortality
  (1) Before and after learning about well contamination
  (2) In high arsenic households (switchers) vs. low arsenic households (non-switchers) within same village

- Study makes use of small-scale variability of underwater contamination patterns -- 88% contaminated wells located within 100 m of uncontaminated wells (van Geen et al. 2003)

- Identifying assumption: within village, households residing on land with high arsenic do not have different trends in mortality than those residing on low concentration land (except for the impact of testing)

- Within villages, households otherwise look the same (e.g. households with arsenic-contaminated wells not poorer or located further form center of village relative to household with safe tubewell water)

- Make sense given that extremely hard to predict before digging the well where arsenic-laden aquifers lie underground

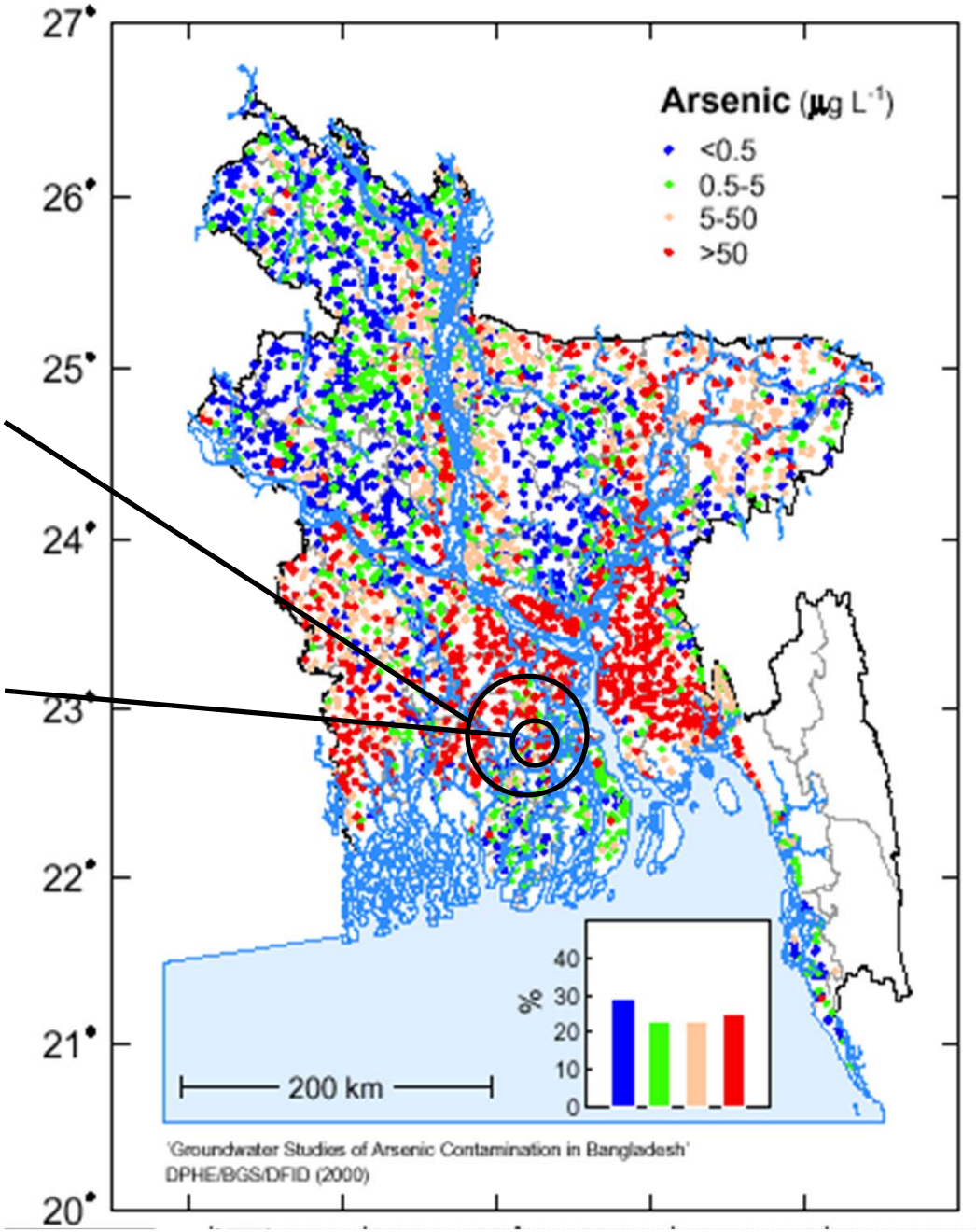
Setting

- Two districts in Barisal division of southwestern Bangladesh
- High (70%+) rates of arsenic contamination within these districts
- “Successful” region: uniquely high rate of switching away from shallow tubewells (93% by 2004)
- Geology of the area made it possible to construct deep tubewells in almost all villages
- Data: 3,158 households in 155 medium size villages surveyed as part of an adolescent empowerment evaluation
- Use data on contamination level of nearest STW to approximate whether household forced to switch water sources
  - Valid assumption as almost all HH have drinking water free of arsenic, so switched from local arsenic contaminated well

Arsenic prevalence

Barisal District
65% wells contaminated

Babuganj and Muladi Upazilas
(surveyed regions)
79% wells contaminated

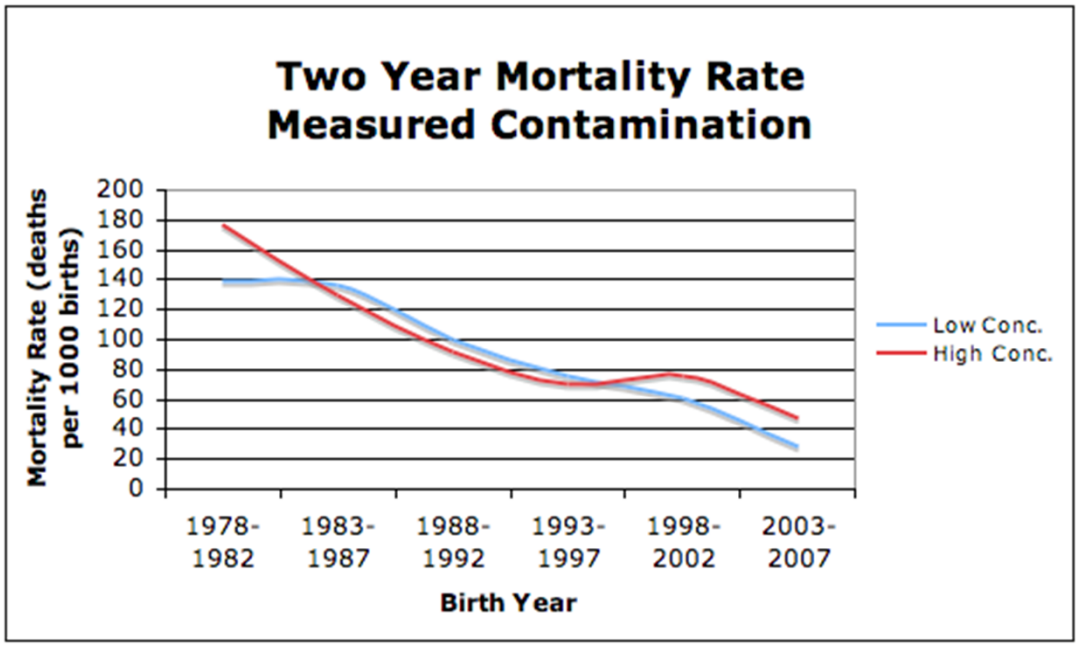


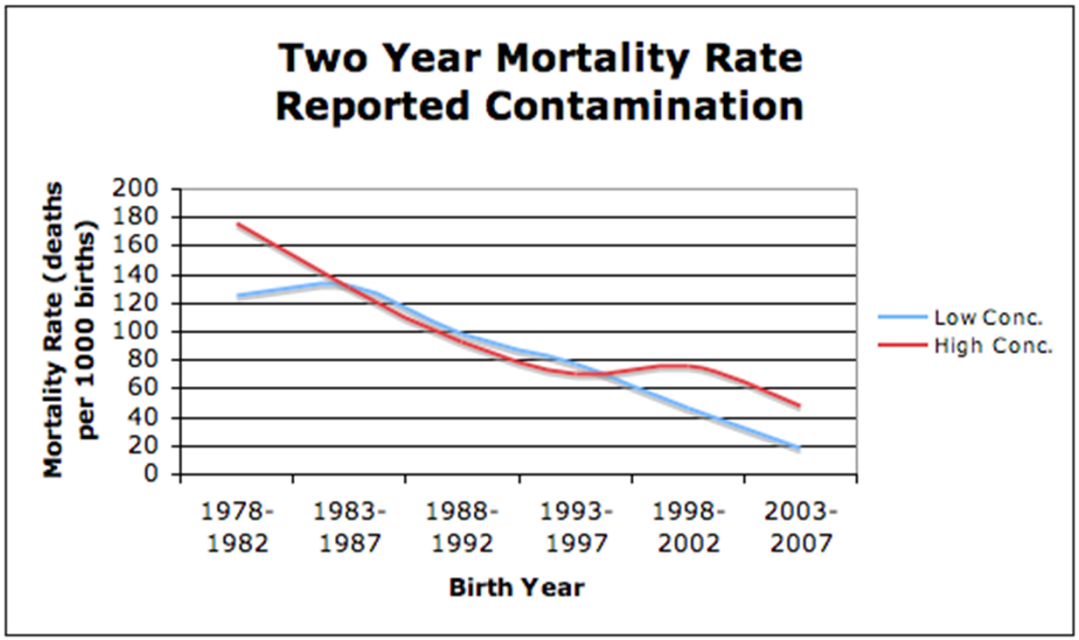
Regression specification

$$Y_{ijv} = \alpha_{ijv} + \gamma * HighConc_{jv} + \delta * EarlyLifeExp_{ijv} + \beta * (HighConc_{jv} * EarlyLifeExp_{ijv}) + \theta_v + \epsilon_{ijv}$$

- Outcome measures one, two, and five year mortality for individual i in household j and village v
- All specifications include village fixed effects and standard errors clustered at household level
- High concentration: measured contamination >60ppb
- Early life exposure: percent of early life *after* testing campaign
  - E.g. if estimating 2 yr mortality, child born before 2000 takes value 0, born in 2000 takes value 0.5,
- Controls: sex, parity, birth year, birth year squared, mothers age, parental educational birth spacing, economic indicators, Muslim

Under two yrs mortality, 1978-2007





Summary of results

- An additional year of exposure associated with 27% percent increase in under-2 mortality in households encouraged to switch water sources

- Implies roughly **doubling of mortality from diarrhea** when households abandon backyard tubewells

- Several reasons why diarrheal disease might be higher:
  - Longer storage time from more distant sources
  - More contaminated secondary sources
  - Quantity effect: could be giving less water to sick kids, if run out of water and harder to refill

- Some evidence in survey data of longer storage time, although also indications that infant mortality rates have started to fall among households that switched, probably because they are building closer and closer DTWs

Implications

- Clean drinking water beneficial for reducing diarrhea even when high contamination

- Policy of encouraging people to switch from convenient STW to less convenient DTW dramatically increasing infant and child mortality

  - Not obvious that we should encourage household to completely abandon shallow tubewells when alternative source more distant or source water dirtier

  - Still a relevant policy issue for millions of Bangladeshi households living in regions where switching rates were low

  - Also evidence that cumulative arsenic exposure dangerous for health of older household members, but not obvious that exposure for 0-5 years during childhood contributes enough to be worth increase in exposure to diarrheal disease