WATER QUALITY AWARENESS AND INFANT HEALTH: THE ROLE OF BREASTFEEDING

PINAR KESKIN, GAURI KARTINI SHASTRY AND HELEN WILLIS

SEPTEMBER 2014

Motivation

- Water-related diseases pose a major global health problem.
  - 3.5 million deaths each year due to water related causes in the developing world in each year (Pruss-Ustun et al. 2008)

- Eliciting behavior change remains a challenge.
  - Difficult to get people to treat their water
    - Willingness to pay for clean water low (Kremer et al 2011)
    - Information dissemination has modest effect (Jalan and Somanathan 2008, Luoto, Levin and Albert 2011)
  - Impact of information on other health behaviors (mixed)

Our Study

Question:

Do mothers increase duration of breastfeeding in response to concerns about water quality?

Context:

- Millions of people in Bangladesh exposed to arsenic in their drinking water
- Large-scale efforts began in 1999 to test wells and inform households

Health Impacts of Arsenic Exposure

- With chronic exposure, arsenic accumulates in body
  - Usually after 6 months of continuous exposure
- Early symptoms (~1-2 years after first exposure)
  - Skin rashes and irritation, weakness, diabetes, edema, and respiratory problems
- Long-term symptoms (~after a decade of exposure)
  - Increased risk of skin and internal organ cancers, many fatal

Why Breastfeeding?

- Breastfeeding promotes infant and child health, especially in developing countries:
  - Biologically:
    - Inactivates pathogens (Isaac 2005)
    - Prevents pathogens from attaching to the GI tract (Morrow et al., 2005)
  - Mechanically:
    - Infants less likely to consume contaminated food or water, important in areas with poor sanitation (Habicht, DaVanzo, and Butz, 1988).
      - Exclusive breastfeeding is the extreme case
- Despite high maternal exposure to arsenic, low concentrations found in breast milk (Fangstrom et al 2008, Concha et al 2003, Samanta et al 2007)

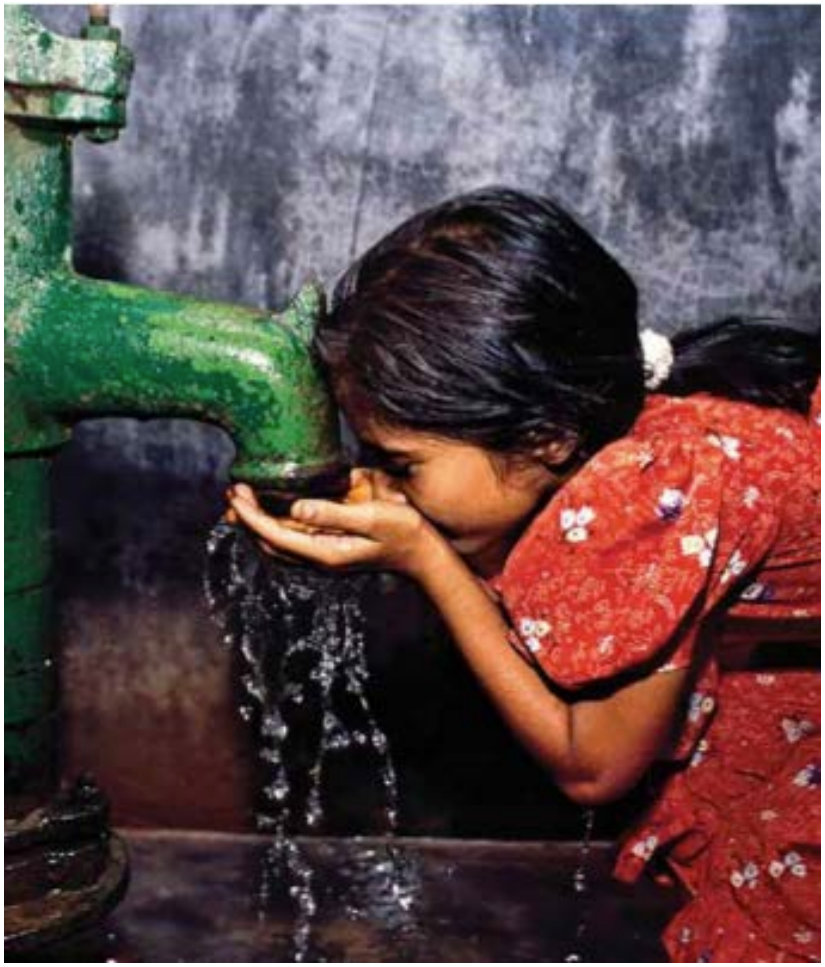
Drinking Water in Bangladesh

- Before the 1970s, households relied almost exclusively on surface water for drinking
  - Water-borne pathogens cause life-threatening diseases, especially among children (diarrheal deaths, e.g.)
- 1970s: millions of tubewells were installed
  - Groundwater became the main source of drinking water
- 1990s: high levels of arsenic were discovered in water from these wells
  - A "major environmental tragedy"
- Comprehensive screening of all shallow tubewells in contaminated regions by the gov't and UNICEF between 1999 and 2006

Well Testing: Information Campaign

- About 4.7 million tubewells tested and painted
  - Contaminated wells: red
    - 1.4M
  - Safe wells: green
    - 3.3M

Well Testing: Information Campaign



- Households encouraged to stop drinking from red tubewells and switch to alternative sources (Jakariya, 2007)
- Disseminated info about arsenic and arsenic poisoning
- High level of awareness: 84% of households had heard of arsenic (BDHS 2004)
- Use of contaminated wells fell (Jakariya 2007, Madajewicz et al 2007, Bennaer et al 2013)

Empirical Strategy

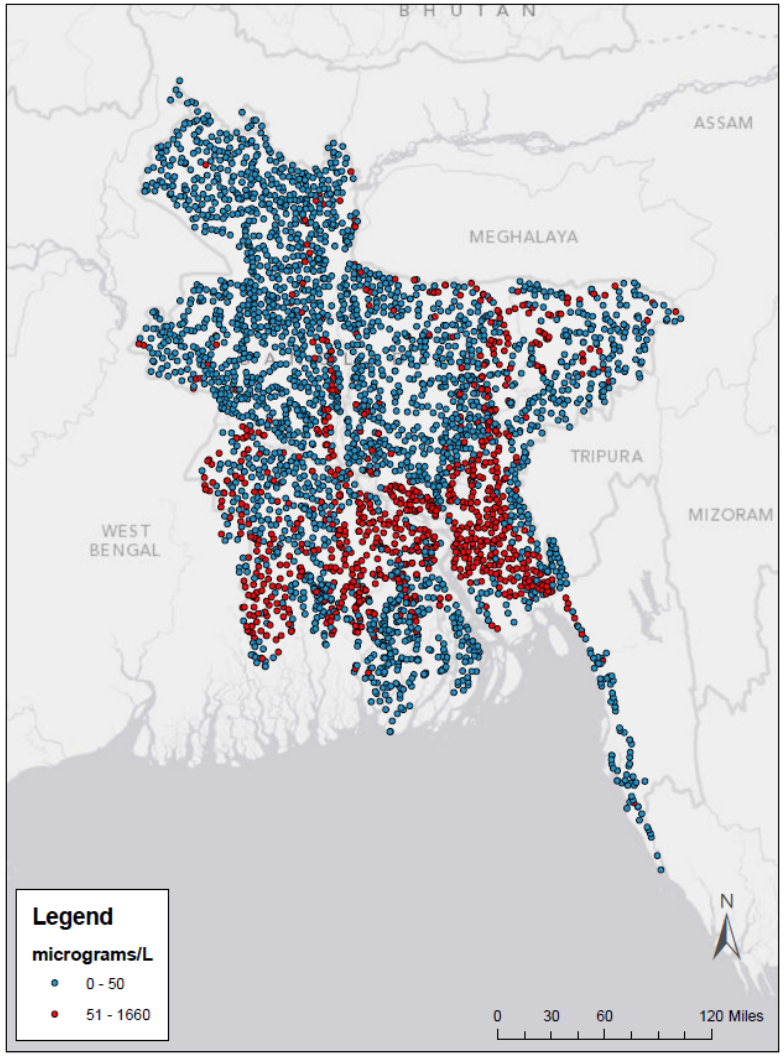
- Difference-in-difference
  - Compare children born before and after 2002
    - Campaign started in 1999, but progressed very slowly before 2002 (World Bank 2007)
  - Compare children living in more and less contaminated villages
    - Information campaign targeted heavily contaminated areas

Empirical Strategy

- Do contaminated areas differ from uncontaminated areas?
  - Why does arsenic contamination vary geographically?
    - Depends on many variables (such as soil depth, sediment geology)
    - Highest levels are concentrated within medium depth soils (10-150m below surface) and where sediment derives from Bengal Delta Plain during the Holocene Age (Kaufmann et al 2002, Mukherjee and Bhattacharya 2001)
  - Fair amount of *local* variation
    - Most contaminated wells have a nearby uncontaminated well (VanGeen et al. 2002)
    - Correlated with some village-level variables, but not within village
- Control for village fixed effects and district-specific trends

Arsenic Data

British Geological Survey



- Data collected in 1998-1999
- Approximately 3500 wells

Household Data

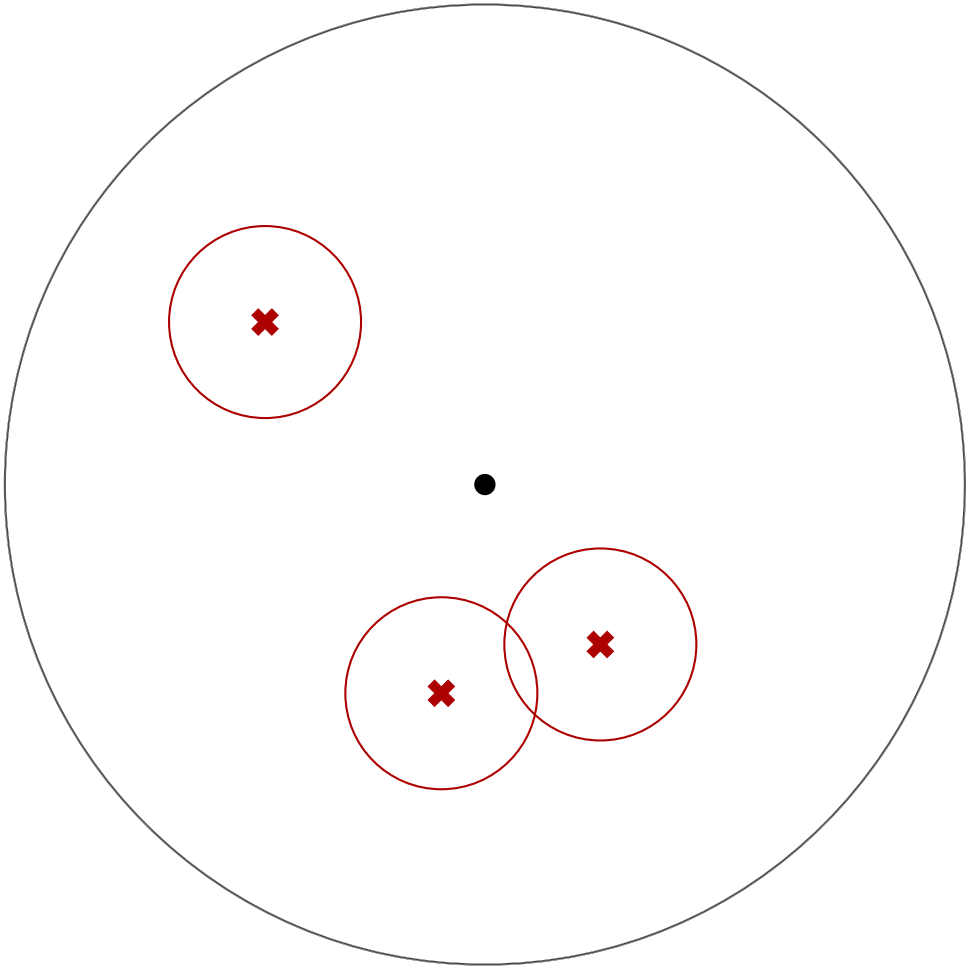
Bangladesh Demographic Health Surveys

(BDHS)

1999
2004
2007

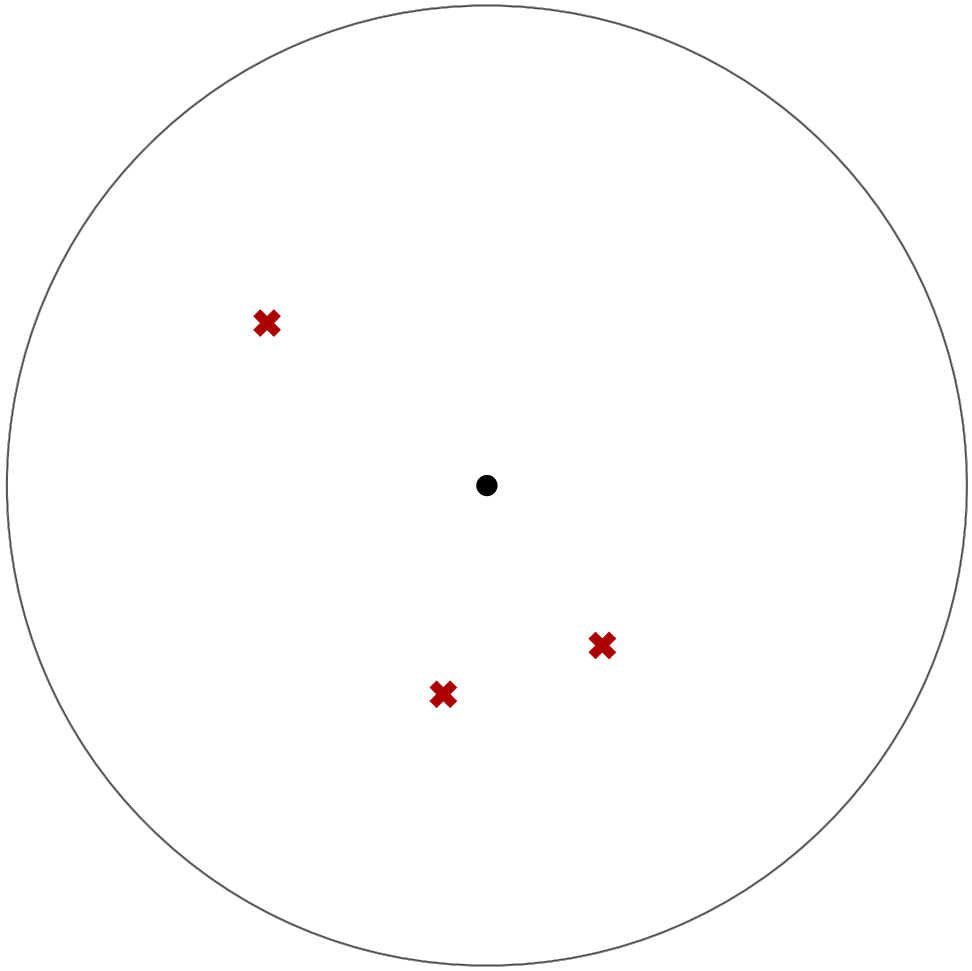
- All children born up to 5 years before survey
  - Pre: 1995-2001
  - Post: 2002-2007
- About 360 clusters (~villages) included in each wave of the survey
- Surveys include demographic characteristics, duration of breastfeeding, and variables on child health
  - In 2004 (only), the BDHS tested HH's drinking water for arsenic and asked about awareness

Measures of Arsenic Exposure



- We know:
  - GPS coordinates of cluster: •
  - GPS coordinates of each sampled contaminated well: x
- Preferred measure:
  - Probability of being within 1 mile of a contaminated well, conditional on being within 5 miles of the cluster
  - Using distance from the cluster to estimate population distribution

Measures of Arsenic Exposure



- Other measures:
  - Number or percent of wells within 5 miles that are contaminated
  - Average contamination level of wells within 5 miles
- All measures are highly correlated: $\rho > 0.710$
  - Also highly correlated with arsenic in HH water (2004)

Summary Statistics (1999)

	Uncontaminated (Mean)	Contaminated (Mean)	Significantly Different?
Child's age (in months)	27.18	26.37	No
Mother's age	25.69	25.91	No
Mother's years of education	2.99	3.30	No
Mother works outside the home	0.20	0.14	No
Household has electricity	0.33	0.33	No
Months breastfed	19.31	18.62	No

Notes: This table shows summary statistics, separately for clusters with lower and higher than median exposure to arsenic (as measured by the weighted probability of being within 1 mile of a contaminated well). Column (3) shows the difference between areas, conditional on district fixed effects. The standard errors used to indicate significant differences are clustered by BDHS cluster.

DID Results: Breastfeeding

Effect on Breastfeeding Duration (Dependent Variable: Months Breastfed)			
	All	Urban	Rural
	(1)	(2)	(3)
Post*contamination	5.948***	3.566	7.020***
	(2.139)	(4.196)	(2.480)
Number of observations	19420	5811	13609
R-squared	0.611	0.561	0.633
Mean dependent variable	19.42	18.95	19.63
Mean contamination	0.0713	0.0698	0.0720
Additional controls			

Notes: Post refers to 2002-2007 period. All regressions control for child age, an indicator for whether the child died and fixed effects for year of birth and BDHS cluster. Robust standard errors, clustered by BDHS cluster, are in parentheses. *p<0.10, **p<0.05, ***p<0.01

DID Results: Breastfeeding

Effect on Breastfeeding Duration (Dependent Variable: Months Breastfed)						
	All	Urban	Rural	All	Urban	Rural
	(1)	(2)	(3)	(4)	(5)	(6)
Post*contamination	5.948***	3.566	7.020***	5.659***	1.420	6.163***
	(2.139)	(4.196)	(2.480)	(1.970)	(3.932)	(2.200)
Number of observations	19420	5811	13609	19420	5811	13609
R-squared	0.611	0.561	0.633	0.618	0.570	0.641
Mean dependent variable	19.42	18.95	19.63	19.42	18.95	19.63
Mean contamination	0.0713	0.0698	0.0720	0.0713	0.0698	0.0720
Additional controls				District trends	District trends	District trends

Notes: Post refers to 2002-2007 period. All regressions control for child age, an indicator for whether the child died and fixed effects for year of birth and BDHS cluster. Robust standard errors, clustered by BDHS cluster, are in parentheses. *p<0.10, **p<0.05, ***p<0.01

Robustness Checks and Other Results

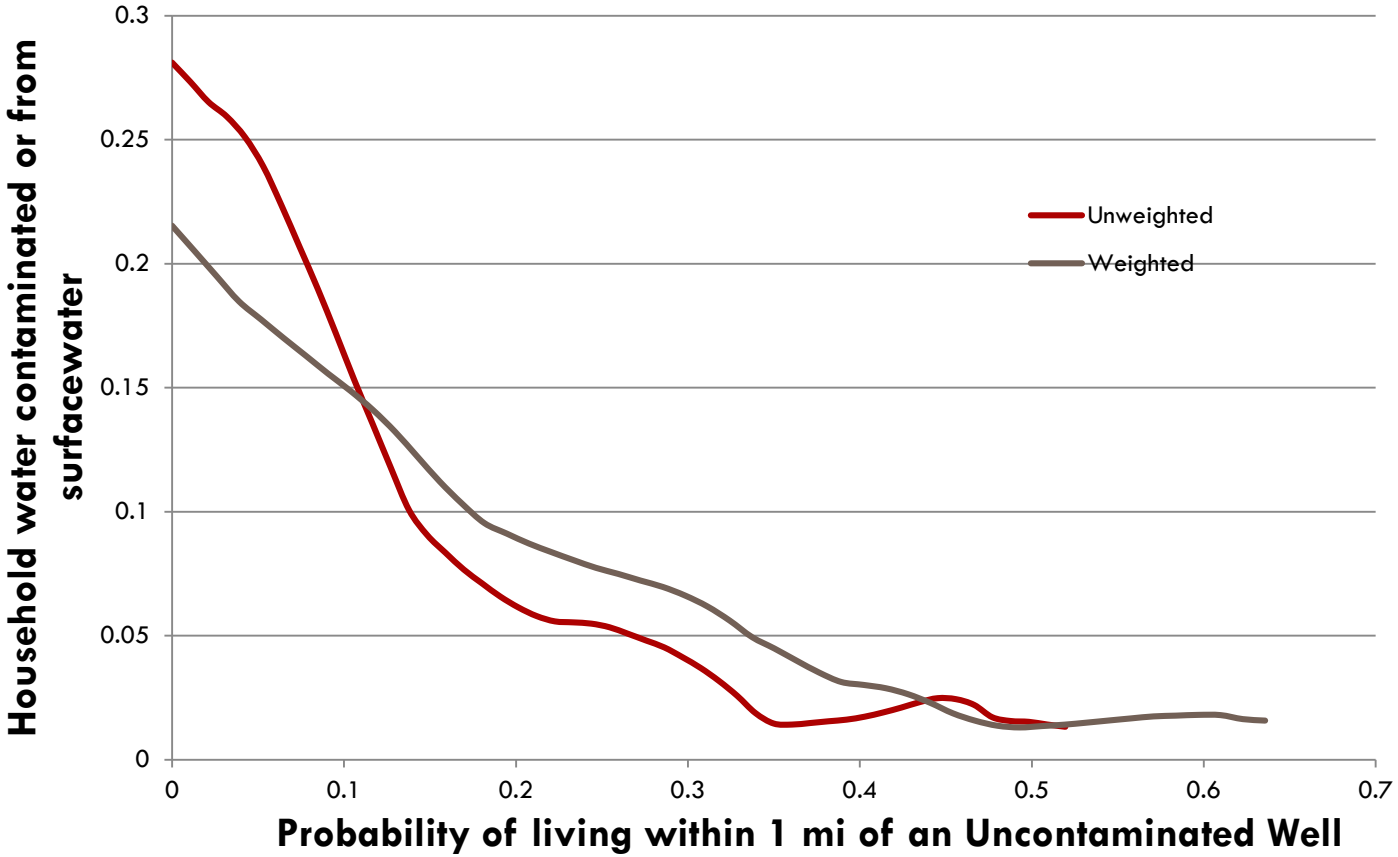
- Results are similar for other breastfeeding outcomes
  - Breastfed for longer than 12 months, exclusively breastfeeding
- Results are similar with other measures of exposure
  - Number or percent of wells that are contaminated
  - Average contamination level of nearby wells
  - Probability of being within 1 mile…, unweighted
- Right-censored dependent variable (months breastfed): children still breastfeeding, children who died while still breastfeeding
  - Include only children who have stopped breastfeeding
  - Replace months breastfed with max in data or with age the child would have been at the time of survey (for those who died)

Triple Difference Strategy

- Contaminated villages could be on different paths from uncontaminated areas (in absence of information campaign)
  - Even after village fixed effects and district trends

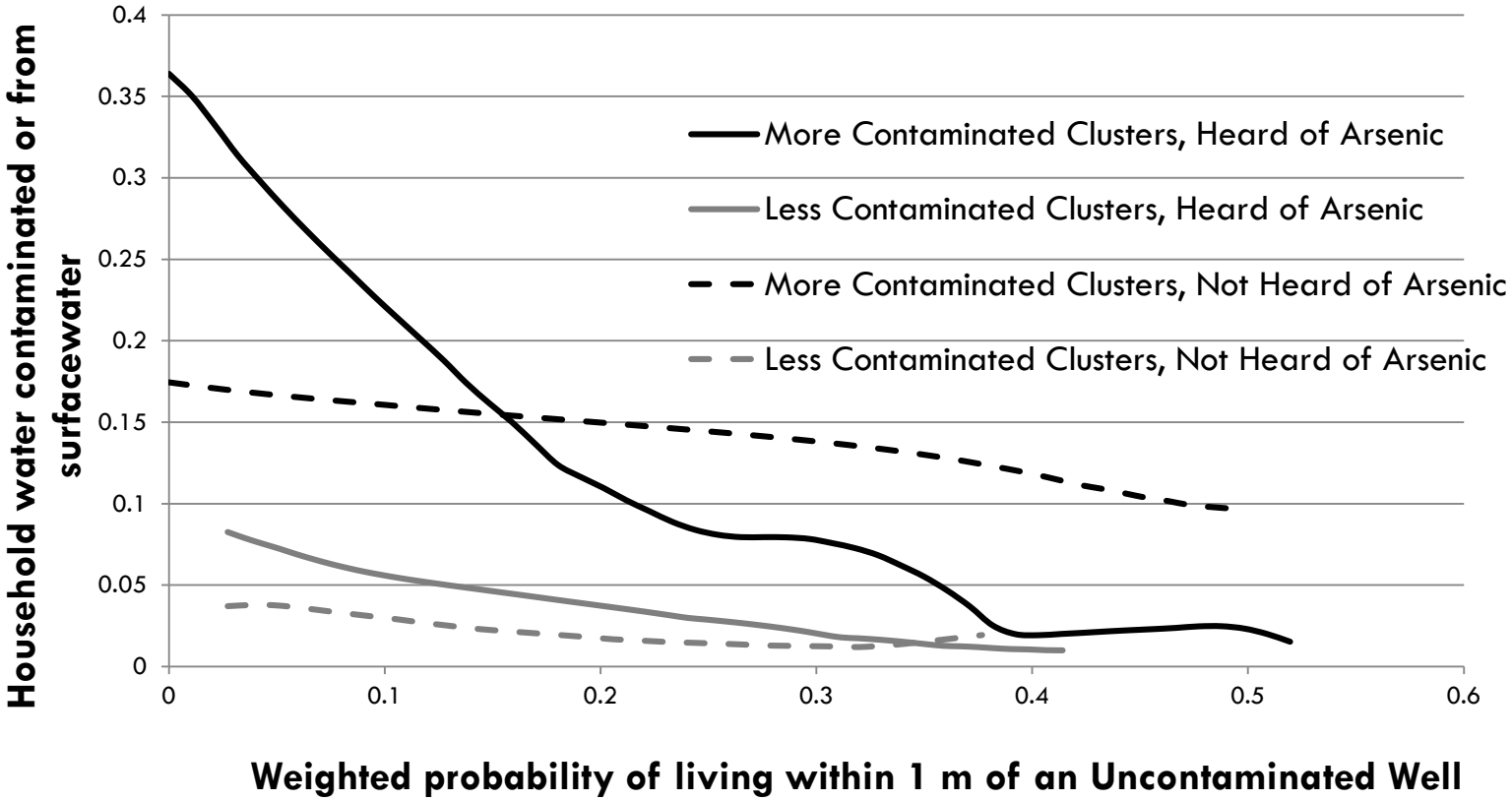
- Triple difference supports our identifying assumptions and helps to rule out alternative explanations:
  - We compare effect for women who live close to clean wells and those who do not.
  - Women who live close to clean wells are more likely to switch to clean wells.
  - Households that switch to clean wells do not need to modify their breastfeeding decisions to protect children from arsenic.

Clean Well Access and Water Source



Note: This figure plots a Kernel-weighted local polynomial of the relationship between a household's access to a clean well and whether a household gets water from a contaminated well or surface sources. The plots uses an epanechnikov kernel and bandwidth 0.05.

Clean Well Access and Water Source



Note: This figure plots a Kernel-weighted local polynomial of the relationship between a household's access to a clean well and whether a household gets water from a contaminated well or surface sources. We exclude clusters with zero tested wells. The plots uses an epanechnikov kernel and bandwidth 0.05.

Triple Difference Results

Measure of distance to uncontaminated well: Probability of being within 1 mile of uncontaminated well			
	Months Breastfed	Breastfed for >=12 months	Exclusively breastfeeding
	(1)	(2)	
Post*contamination	11.50***	0.236***	0.160**
	(3.435)	(0.0799)	(0.0768)
Post*contamination	-41.28**	-0.862*	-0.293
*measure of distance	(19.02)	(0.488)	(0.382)
Number of observations	13609	10241	7056
R-squared	0.641	0.0629	0.376

Notes: Post refers to 2002-2007 period. All regressions control for child age, an indicator for whether the child died, the main effects and two-way interactions and fixed effects for year of birth and BDHS cluster, as well as district-specific linear trends. Robust standard errors, clustered by BDHS cluster, are in parentheses. *p<0.10, **p<0.05, ***p<0.01

Heterogeneous Effects by Age

Dependent Variable: Dummy for Exclusive Breastfeeding			
Ages	< 6 m	6 - 14 m	> 12 m
	(1)	(2)	(3)
Post*contamination	0.849*	0.358**	0.0267
	(0.476)	(0.162)	(0.0557)
Number of observations	1351	1839	4332
R-squared	0.384	0.261	0.107
Mean dependent variable	0.506	0.0527	0.0180
Mean contamination	0.0766	0.0719	0.0667

Notes: Post refers to 2002-2007 period. All regressions control for child age, the fraction contaminated, fixed effects for year of birth, survey year and nearest 2004 BDHS clusters, as well as district-specific linear trends. Robust standard errors, clustered by BDHS cluster, are in parentheses.
*p<0.10, **p<0.05, ***p<0.01

- Similar results for "Had plain water in past 24 hours"

Health Outcomes by Age

Dependent Variable: Child died before the age of …			
Age (in months)	6	12	24
	(1)	(2)	(3)
Post*contamination	-0.108**	-0.120*	-0.0413
	(0.0502)	(0.0628)	(0.0877)
Number of observations	12238	11004	8309
R-squared	0.0390	0.0437	0.0539
Mean dependent variable	0.0557	0.0646	0.0749
Mean contamination	0.0716	0.0715	0.0711

Notes: Post refers to 2002-2007 period. All regressions control for child age, the fraction contaminated, fixed effects for year of birth, survey year and nearest 2004 BDHS clusters, as well as district-specific linear trends. Robust standard errors, clustered by BDHS cluster, are in parentheses. *p<0.10, **p<0.05, ***p<0.01

Health Outcomes by Age

Dependent Variable: Health status of children			
Age (in months)	0 – 12 m	12 – 24 m	24 – 36 m
	(1)	(2)	(3)
Incidence of diarrhea	-0.426***	0.0807	-0.0690
in previous two weeks	(0.157)	(0.224)	(0.186)
Weight for height Z-Score	1.225**	1.488*	0.0781
	(0.620)	(0.826)	(0.617)
Height for age Z-Score	0.292	1.098	0.275
	(0.808)	(0.963)	(0.721)
Number of observations	2769	2567	2562

Notes: Post refers to 2002-2007 period. All regressions control for child age, the fraction contaminated, fixed effects for year of birth, survey year and matched 2004 clusters, as well as district-specific linear trends. Robust standard errors, clustered by BDHS cluster, are in parentheses. *p<0.10, **p<0.05, ***p<0.01

Is This Health Behavior Change?

- Productivity shock due to reduced arsenic exposure
  - Could cause women to breastfeed more
    - Ruled out by triple difference
  - Could cause women to breastfeed less
    - Seems improbable
      - Short-term health effects are minor
      - Would women substitute away from breastfeeding towards other types of home production?
- Clean water is more costly
  - Increased time cost is fairly small: 4-18 min per day
- Contraceptive motivation for breastfeeding
  - No effect on desired total number of children, actual birth spacing or desired birth spacing

Conclusion

- Arsenic contamination information campaign in Bangladesh
  - A possible behavioral response to concerns about water quality: breastfeeding
- We find evidence of increased breastfeeding: more months and more likely to be exclusive for the youngest children
  - Response strongest for women who would have found it harder to switch to uncontaminated wells → suggests behavioral response
  - Suggestive consistent evidence of fewer deaths and lower incidence of diarrhea among infants
- Arsenic awareness campaign in Bangladesh still poses a puzzle!
  - Many papers, including this one, have found that this campaign had tremendous success in motivating behavior change (even including some changes with adverse consequences).
  - Current research agenda → Why?