From Awareness to Action: Long Run Effects of Information and Enabling Access to Clean Water in India

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November 2024

Contaminated Water & Child Health

- More than 2,000 children under 5 die every day from water related diseases
- India alone accounts for 24 percent of world's total under 5 mortality
- In social sciences, studies have focussed on infant/child health
- Currie et. al. (2013); Galiani, Gertler, and Schargrodsky (2005)
- In India: Greenstone and Hanna (2014) and Brainerd and Menon (2012)

Contaminated Water & Child Health

- Bacteria more prevalent in surface water than groundwater
- Heavy metals (sulphates, iron, fluorides, nitrogen, chlorides, and arsenic) more abundant in groundwater
- Industrial and agricultural activities can worsen soil features, affecting groundwater
- Climate change is reducing the rate at which rainwater seeps underground
- Increase in the concentration of toxins in groundwater (McArthur, Ravenscroft, Safiulla & Thirlwall, 2001)

Arsenic Poisoning

- "*World's largest mass poisoning of a population in history*" (WHO)
- In Bangladesh and India, million exposed to arsenic in drinking water at levels beyond 10 $\mu g/L$
- 70 million people across 35 districts of India, mostly Assam and West Bengal, exposed to arsenic
- Short run effects: vomiting, diarrhoea, skin lesions
- Long term effects: cancer, neurologic, pulmonary, cardiovascular diseases, hypertension, diabetes

Arsenic and Children

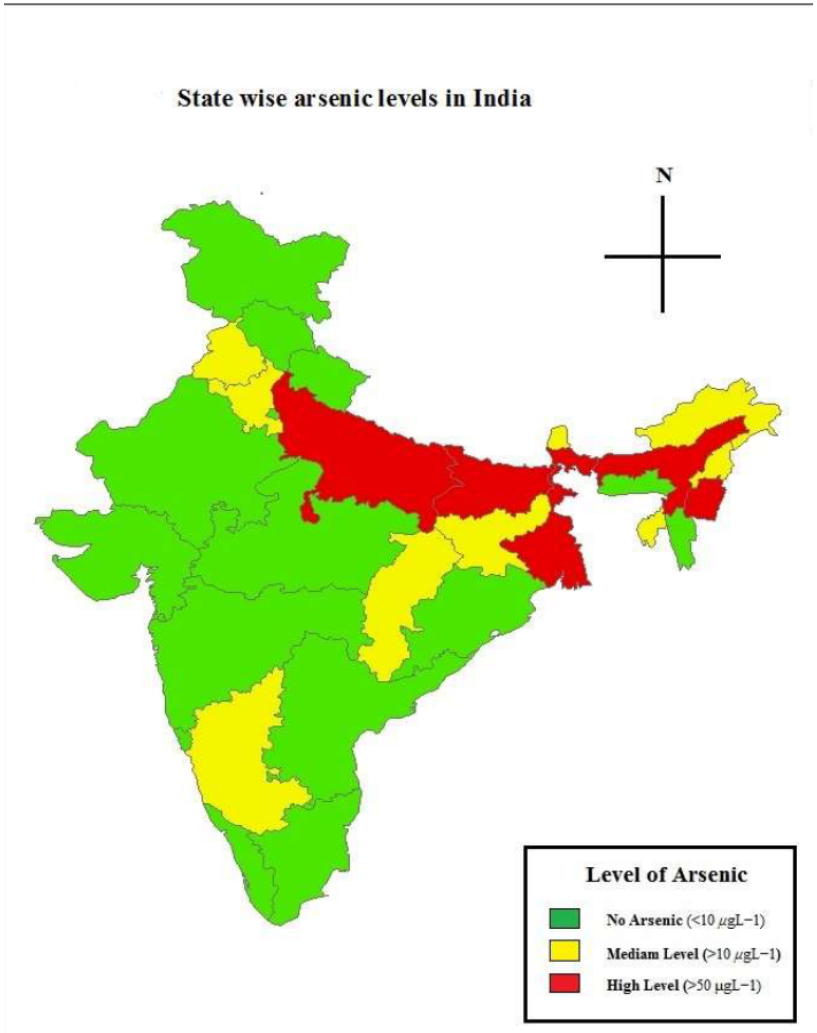
- Children more susceptible due to low immunity and greater proportion of water in body
- Epidemiological evidence suggests that arsenic affects child growth outcomes
- Higher absenteeism, grade retention, and lower test scores (Aggarwal, Barua and Vidal-Fernandez. 2024)
- Lower HAZ and WAZ scores (Aggarwal and Barua, 2023)

Pregnant Women

- In-utero exposure and breastfeeding

1. pregnant women drinking arsenic contaminated water have infants with lower birth-weight (Kile et. al. 2016)
2. Higher prevalence of stillbirths among women exposed to arsenic during pregnancy
3. Benefits of breastfeeding longer in regions with arsenic: lower mortality rates and diarrhea (Keskin et. al. 2013)

Arsenic in India



Arsenic in India

- Partly stem from anthropogenic activities like intense exploitation of groundwater
- Food is the second largest contributor to arsenic intake
- 70 million people affected: Assam (65%), Bihar (60%), West Bengal (44%)
- Despite the adverse health implications, rural households continue to rely on groundwater for drinking
- *Economic theory suggests atleast 3 explanations for this low demand for water quality*

1. Information Costs

- First, households make choices based on their knowledge of the health production function (Gronau, 1997)
- If there is incomplete information about the health function, households may make sub-optimal choices
- Madajewicz et al. (2007) in Bangladesh; Jalan and Somanathan (2008); Barnwal et. al. (2017) in India

2. Liquidity Constraints

- Households may face liquidity constraints that leads to under-investment in household infrastructure
- Barnwal et. al. (2017); Devoto et. al. (2012)

3. Transaction Costs

- Third, government schemes that provide universal access to electricity, gas and water supply involve transaction costs
- Costs: Application procedures, necessary documentation, investment of time
- Blankenship et. al. (2020); Peter, Sievert & Toman (2019)

Objectives of this Study

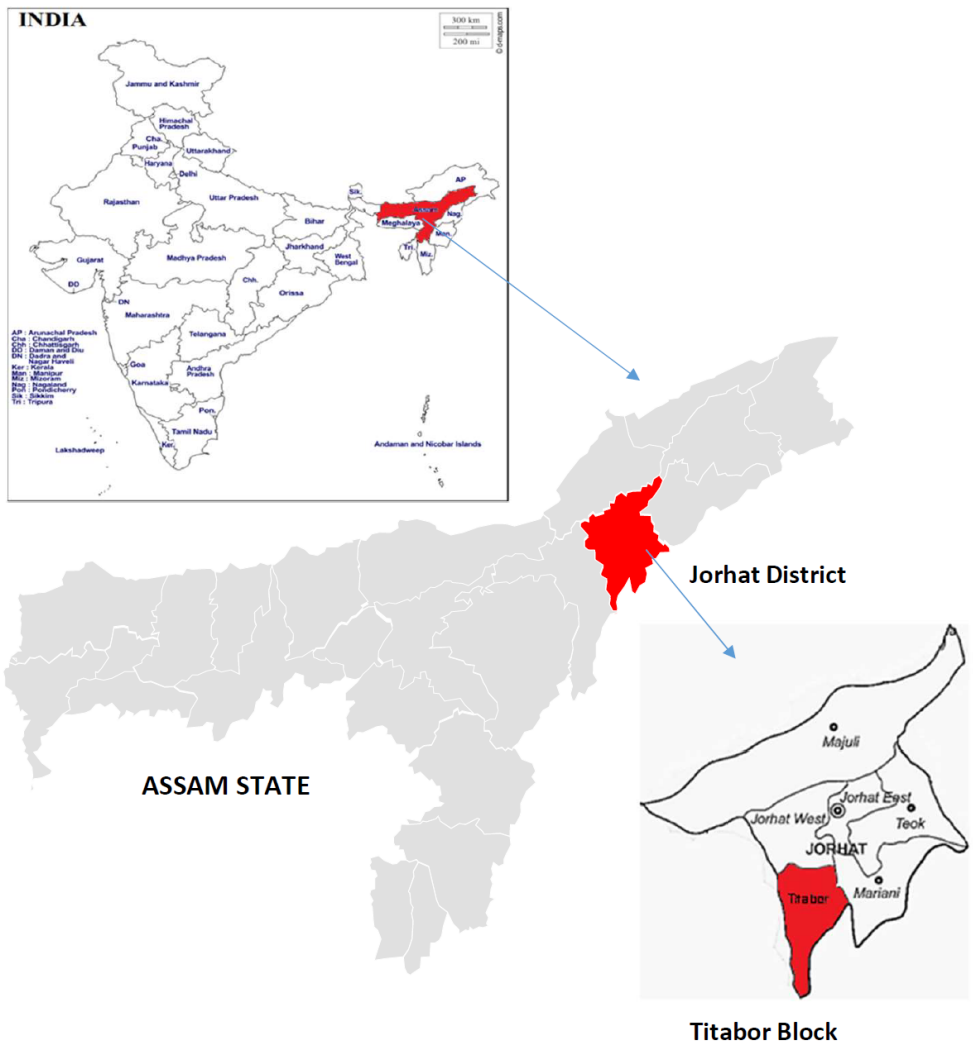
- Cluster RCT partnered with MoHFW and Public Health Engineering Department (PHED)
- We study the constraints faced by rural households in accessing clean water in a heavily arsenic contaminated region
- Focus on households with young children and households with pregnant women

Objectives of this Study

- Treatment 1: information about arsenic and awareness about alternative safe water sources
- Treatment 2: T1 + facilitate access to clean tap water via the governments flagship tap water programme (JJM)
- Households were sampled from the administrative database of rural public health workers
- households with young children (below 6 years of age) and households with pregnant women.

Geography: Titabor in Assam

Figure 1: Geographical location of Titabor Block in Jorhat District of Assam



Geography: Titabor in Assam

- A state with the problem of plenty!
- One of the most contaminated groundwater in India: fluorides, arsenic, iron
- Fourth highest IMR and the highest MMR in the country
- In Titabor:

Rural: households engaged in tea plantation and rice cultivation

Concentration of arsenic varies between 194 to 491 microgram per liter

Water Supply Schemes in Titabor

- 2008: Greater Titabor Water Supply Scheme (GTWSS)
- In 2019, the government of India launched Jal Jeevan Mission (JJM)
- Aims to provide tap water to every rural household at affordable charges
- **Our intervention preceded the rollout of JJM information campaign or the actual provision of water through the JJM**

Partnerships & Admin Data

- Late 2021: PHED provided access to admin data on # of households in Titabor with access to tap water
- 110 villages had low/non-existing tap water connections
- Within these villages, ASHA worker data on all households with children (0 to 6 years) and pregnant women
- Admin data on the name and contact (village, phone number) of the mother/pregnant woman and the details of children.
- ASHA data for 83 villages and approx 4000 households
- *25 ASHA serviced households from each village randomly chosen:* **Total sample of 2075 households**

Summary Stats Baseline

Table 2: Baseline Summary Statistics of Key Health & Information Variables

	(2)	(3)
	Means	Standard Deviations
Mothers < 36 months child		
Duration (planned) of breastfeeding (in months)	26.29	12.42
In the last 3 months, child was taken to a medical facility due to stomach problems, skin issues, diarrhoea, vomiting?	0.146	0.353
Health Conditions		
Black, white or red spots over the body	0.052	0.223
bone/muscular diseases	0.041	0.198
respiratory diseases	0.022	0.146
organ damage/diseases	0.032	0.177
Fatigue/unhealthy weight loss/nauseas/vomitting/stomach ailments	0.042	0.199
Knowledge and Information		
Heard of arsenic	0.771	0.414
Awareness of arsenic in the region	0.219	0.414
Awareness of surface water schemes in Titabor	0.504	0.500
Inquired/applied/considered for piped water connection	0.219	0.413
Awarness of PHED as the agency responsible for providing safe drinking water	0.447	0.497
Awareness of paper & procedures	0.358	0.480
Awareness of costs	0.375	0.484

N=2064

Randomization

- 83 villages randomly assigned to the two treatments and one control group
- Stratification at village level done to avoid the problem of cross-contamination across groups
- The criteria for stratification: % of tap water usage in a village based on PHED admin data
- **Control** (28 villages, 698 households), **treatment 1** (27 villages, 671 households) and **treatment 2** (28 villages, 695 households)

Balance

Table 3: Baseline Balance Regressions for Household Demographic and Outcome Variables

	(1)	(2)
	Information Treatment	Information & Transaction
Number of Children	-0.032	0.007
	(0.036)	(0.039)
Religion (Hindu)	-0.019	0.005
	(0.037)	(0.031)
Caste (OBC)	-0.038	-0.045
	(0.058)	(0.052)
Caste (SC/ST)	0.036	0.056
	(0.048)	(0.050)
Income Ranking	0.098	0.062
	(0.086)	(0.062)
Male Household Head	-0.027	0.062*
	(0.046)	(0.036)
Age Household Head	0.498	-0.024
	(1.575)	(1.554)
Household Head is Married	0.004	0.025
	(0.018)	(0.018)
Household Head Education more than Secondary	0.040	0.023
	(0.044)	(0.041)
Type of House	0.050	0.041
	(0.045)	(0.038)
# of Household Members	0.146	0.023

Intervention: Information treatment

- Households in T1 (information only treatment) were shown an 8 min. video about arsenic contamination of groundwater
- The video included information on
  - safe and unsafe sources of water in the region, importance of filtering and boiling
  - health impact of arsenic on children and adults
  - interview with a doctor: arsenic induced ailments and importance of breast-feeding
  - school teacher who discussed absenteeism due to arsenic induced illnesses
  - a resident who was diagnosed with a kertosis
  - a senior PHED official who discussed alternate sources of safe water available including the provision of tap water under JJM.

Intervention: Information treatment group 1

- Pamphlets were also provided to each of the treatment households

Intervention: Information+access treatment group 2

- For T2 along with the video and pamphlets, further information was provided about the JJM
- This information included administrative details and application process, information on cost of the private tap water connection
- Further, we offered to assist with filling and submitting a PHED designed Letter of Intent
- Households were also given an alternative option to submit the form directly to the PHED office
- Control group: a generic SMS with information on provision of private tap water connections under JJM

Letter of Interest for Government Supply Water under the Jal Jeevan Mission, Jorhat, Assam.

To,

The Assistant Executive Engineer (PHE), Titabor Sub-Division, Jorhat, Assam.

Respected Sir,

With due respect, I .....(name), resident of.....(permanent address), Phone No..... express my interest in seeking Government Supply water connection under The Jal Jeevan Mission. My ID (Aadhaar Card/Driving License/Voter ID) no. is..... . I am attaching a xerox copy of the ID herewith.

There will be a community contribution equivalent to 5 % of the capital cost of the village water supply project.

This contribution will be in Cash and/or kind and/or labour and will be divided between the total household in a village benefitting from the project.

In addition, monthly tariff (user charge) will be around Rs.100 - 150. The exact amount will be fixed by the VWSC/ Paani Samiti/ User's Committee after commissioning of the Scheme.

Yours Sincerely

(Name & signature)

Midline and Endline

- Post intervention surveys:

April/May 2022 (midline or short run)

Jan/March 2024 (endline or long run)

- Admin data at endline (long run): PHED water connections, medical camps, mother-child ASHA cards

Methods

- Letting T be an indicator for whether an individual was assigned to treatment and Y be an indicator of the outcome variables:

  $$Y_{iv} = \beta_0 + \beta_1 T_{iv}^1 + \beta_2 T_{iv}^2 + \beta_x X_{iv} + \varepsilon_{iv}$$

- Where Y is the outcome of interest for household i in village v.
- T_{iv}^1 is the dummy variable for assignment to treatment 1 while T_{iv}^2 indicates assignment to treatment 2
- X_{iv} are the household level covariates and ε is a mean-zero error-term.
- Include stratification fixed effects and control for baseline variable
- Standard errors are clustered at the village level to correct for heteroscedasticity
- This is an "intent-to-treat" analysis

Methods

- Correcting for multiple inference since some coefficients may emerge significant simply by chance (Romano and Wolf, 2005)
- Following Anderson (2008), we create summary indices of key outcomes of interest using a GLS-weighting procedure
- Increases efficiency by ensuring that highly correlated indicators receive less weight than uncorrelated indicators
- This approach assigns higher weights to variables that represent "new" information

1. Arsenic awareness index

- Are you aware of arsenic in groundwater in the region? Yes/No
- Arsenic is poisonous to human health. Yes/No
- Arsenic is visible in water. Yes/No
- Arsenic poisoning leads to visible symptoms in humans. Yes/No
- Arsenic adversely impacts infants and child health. Yes/No
- Breastmilk is safe from arsenic contamination. Yes/No
- If arsenic is found in tube well water, you should switch to safe source. Yes/No
- Boiling water removes arsenic. Yes/No

Arsenic awareness index

Information Treatment	0.232***
	(0.067)
Information and Access Treatment	0.321***
	(0.056)
(Information+Access)-Information	0.089
F-statistic	2.14
P value	0.147

2. Index of knowledge of paperwork, costs and mitigation effort

- PHED supplies safe drinking water in rural areas of Assam. Yes/No
- Are you aware of surface water schemes in Titabor block. Yes/No
- Are you aware of the paperwork and procedures for the application. Yes/No
- Are you aware of how much it costs to get the private water connection. Yes/No

Index of knowledge of Government Programs

Information Treatment	0.154*
	(0.079)
Information and Access Treatment	0.305***
	(0.094)
(Information+Access)-Information	0.151*
F-statistic	3.39
P value	0.067

3. Index of water safety

- Whether the household has (not) tested it's groundwater for contaminant
- Are you taking any remedial measures at home against arsenic contamination in drinking water. Yes/No
- Frequently of filtering drinking/cooking water before usage using different techniques.

Index of water safety

Information Treatment	0.278***
	(0.073)
Information and Access Treatment	0.344***
	(0.071)
(Information+Access)-Information	0.066
F-statistic	1.29
P value	0.260

4. Water Demand index

- Have you ever inquired/applied//submitted LOI/considered applying for a piped water scheme?
- How much expense are you willing to incur for safe drinking water supply in a month (In Rupees)
- How much time are you willing to spend to procure water from a safer source (in minutes)

Water Demand index

Information Treatment	0.001
	(0.083)
Information and Access Treatment	0.602***
	(0.088)
(Information+Access)-Information	0.601***
F-statistic	82.51
P value	0.000

Demand: Transaction costs or cheap talk?

- Primary reason for why households applied for tap water:

government/NGO campaigned for water (7)

costless to apply (5), did not give it much thought before applying (6)

Others (majority): safety concerns, health/time costs of getting water at home, scarcity of potable water in the region

- Demand also increased among households that had previously applied for tap water under the GTWSS **but did not receive**

Demand: Transaction costs or cheap talk?

Table 12: Mechanisms: Water Dem

	(1)
	Water Demand Inde
Treatment A	0.057
	(0.122)
Treatment B	0.690***
	(0.122)
Treat A * Employed	
Treat B * Employed	

Breast-feeding behavior index: probability & duration

Information Treatment	0.023
	(0.087)
Information and Access Treatment	0.179**
	(0.078)
(Information+Access)-Information	0.156**
F-statistic	4.98
P value	0.028

Breastfedding: Costs and Benefits

- Both treatments explained benefits of breastfeeding longer
- But only the combined treatment gave visibility of the time costs
- Titabor has a significant population of tea garden labourers, the time costs could be substantial for these women.

Breastfeeding Results Explained

- Do you think it is important to breastfeed for more than 24 months? If yes, why?
- We test if treatment increases the probability of choosing options related to cost of breastfeeding

	Cost of breastfeeding
Information	0.075
	-0.076
Information and Access	0.199***
	-0.008
Observations	1,771

Long Run Results: Knowledge, Behavior and Demand

	Water supply	Demand for piped water	Awareness about JJM index	Arsenic awareness index	Knowledge about public water schemes index	Remedial measures
Treatment effect	0.228*	0.04	0.099	0.150**	-0.048	0.178*
	(0.138)	(0.086)	(0.078)	(0.066)	(0.077)	(0.101)
Observations	1863	1513	1861	1861	1861	1834

- Water supply from administrative PHED data

Long Run Results: Willingness to Pay

- Common approach used in Environment/Health to ellicit WTP: Contingent Valuation Method (CVM)
- We asked the respondent whether they are willing to pay (monthly fee): Rs. 0, Rs. 50, Rs. 100, Rs. 150 till Rs. 500.
- WTP is the max value till which the respondent accepted to pay for piped water, above which they refuse to pay for piped water.
- On an average, treatment increased WTP by INR15, with larger effects for the combined intervention.
- Baseline WTP was INR50, so treatment increased marginal WTP by 30%.

Long Run Results: Self-Reported Health

Variables	Skin problem	Nervous system problem	Respiratory prob
Treatment effect	0.009	-0.009	-0.118*
	-0.064	-0.066	-0.07
Observations	11,166	11,166	11,166

- Marginal positive effects on BMI among children (in medical camps) and age-specifc developmental milestones

Conclusion

- Information sufficient to increase health awareness
- However, actual demand for tap water increased only in the combined intervention
- Transaction costs reduced by the combined intervention
- Allowed mothers to weigh costs and benefits of breastfeeding longer
- Two years later, households continue to be informed and adopt preventive measures
- 30% increase in WTP for water and 23% increase in piped water supply

Policy Implications

- Timely and important for public policy: conducted right before the implementation of JJM
- Suggesting ways to increase take up of govt water supply and improve adult and child health outcomes
- Combine water quality awareness (via advertisements, pamphlets and media platforms) with
- A door to door campaign to increase water demand
- Use existing frontline workers (ASHA, Anganwadi): JJM, Assam has signed a MoU with MoHFW