Sanitation and child health in India

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This study

Research question: Do improvements in the sanitation environment improve child health (stunting)?

Mechanisms: Sanitation as a means to isolate (toxic) faeces from the environment → lower exposure → reduce illnesses → improve health (→ improve later life outcomes)

Why we care about sanitation

Necessary condition for economic development?

- Lack of/bad sanitation hampers economic growth:
  - India: 6.4% of GDP (US$53.8 billion)
  - Indonesia: 2.3% of GDP (US $6.3 billion)
  - Nigeria: 1.3% of GDP (US$3 billion) [WSP estimates]
- Largest contributor: Health (health costs, reduced productivity, absenteeism at school and workplace, loss of skills), other: tourism, environment, premature death, etc

Why we care about sanitation

"That such [epidemic, endemic, and other] disease, wherever its attacks are frequent, […], and that where those circumstances are removed by drainage, proper cleansing, better ventilation, and other means of diminishing atmospheric impurity, the frequency and intensity of such disease is abated; and ***where the removal of the noxious agencies appears to be complete, such disease almost entirely disappears****."*

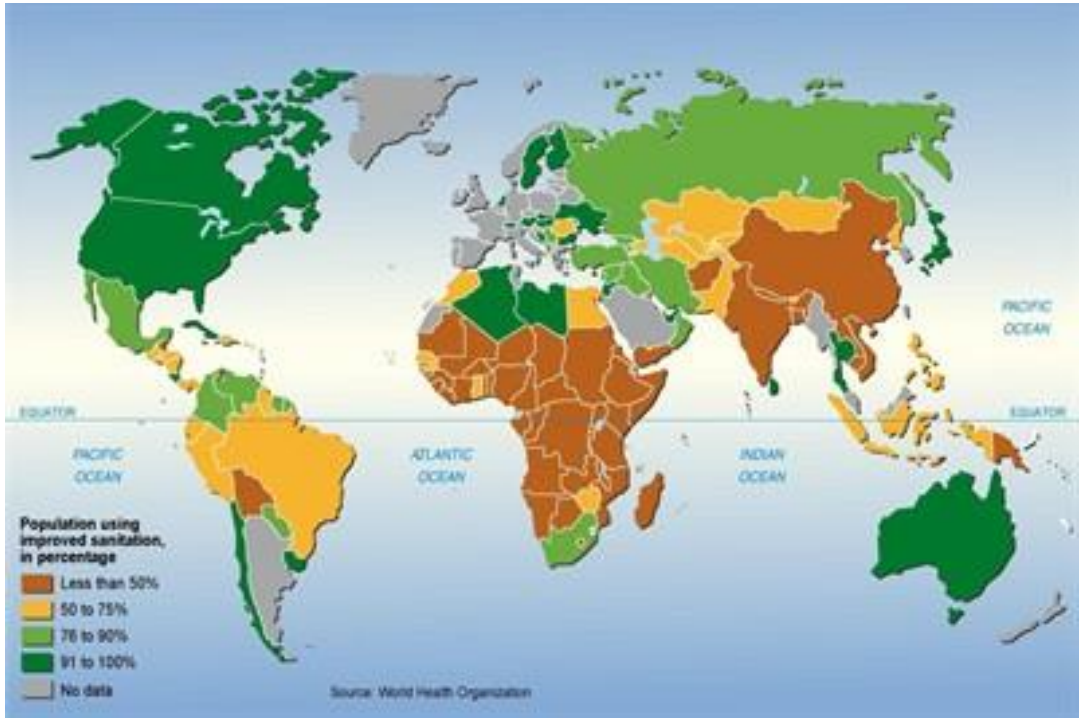
Edwin Chadwick, **1848**, "Report on an inquiry into the sanitary condition of the labouring population of Great Britain"

=> Basic sanitation recognized as indispensable element of disease prevention and primary health care programs (Declaration of Alma-Ata, 1978)

Why we care about sanitation

Missing toilets:

- ~2.5 billion w/o access to improved sanitation
- Main contributing country: India (59% of OD'ers)



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Why we care about sanitation

- Labour force is affected, but most vulnerable group are children:

  UNICEF:

  - About 4 billion cases of diarrhoea per year cause 1.8 million deaths, > 90% among children<5yrs
  - 6,000 child deaths per day due to water- and sanitation related diseases (primarily diarrhoea)

- Importantly, disease (worms, diarrhoea) early in life associated with short (Nokes et al, 1992a, 1992b, Checkley et al, 2008) and long-term effects on human capital (Moore et al, 2001; Almond and Currie, 2011; Bozzoli et al, 2009)

Why we care about sanitation

- Strong focus on policy side:
  - **SDG**: Water and safe sanitation to everyone, everywhere by 2030
  - Ghandi: “Sanitation more important than independence”
  - Modi: “Toilets before temples”
- However:
  - No global agreement on reason for low coverage
  - Efficient program design unclear: What constraints are binding and important to address?

Why we care about sanitation

- While some studies that are able to attribute improved household sanitation to child health (Spears, 2012; Kumar & Vollmer, 2013; Pickering et al, 2015).
- Recent RCT impact evaluations have in most cases not been able to demonstrate health (and other) benefits of low-cost sanitation (interventions) (Clasen et al., 2014; Patil et al, 2014, Briceño et al, 2014)
- Advances in focusing more on *coverage* (Gertler et al, 2014; Geruso & Spears, 2014; Hammer, 2013), in the context of population *density* (Hathi et al, 2014; Spears, 2014; Vyas et al, 2014; Coffey, 2014)

Contribution of this study

- Evidence of the effect of (low-cost) sanitation coverage in developing countries on child health (accounting for endogeneity, IV)
- Urban setting (registered slums and peripheral villages)
- Differential impacts by gender

The context

India:

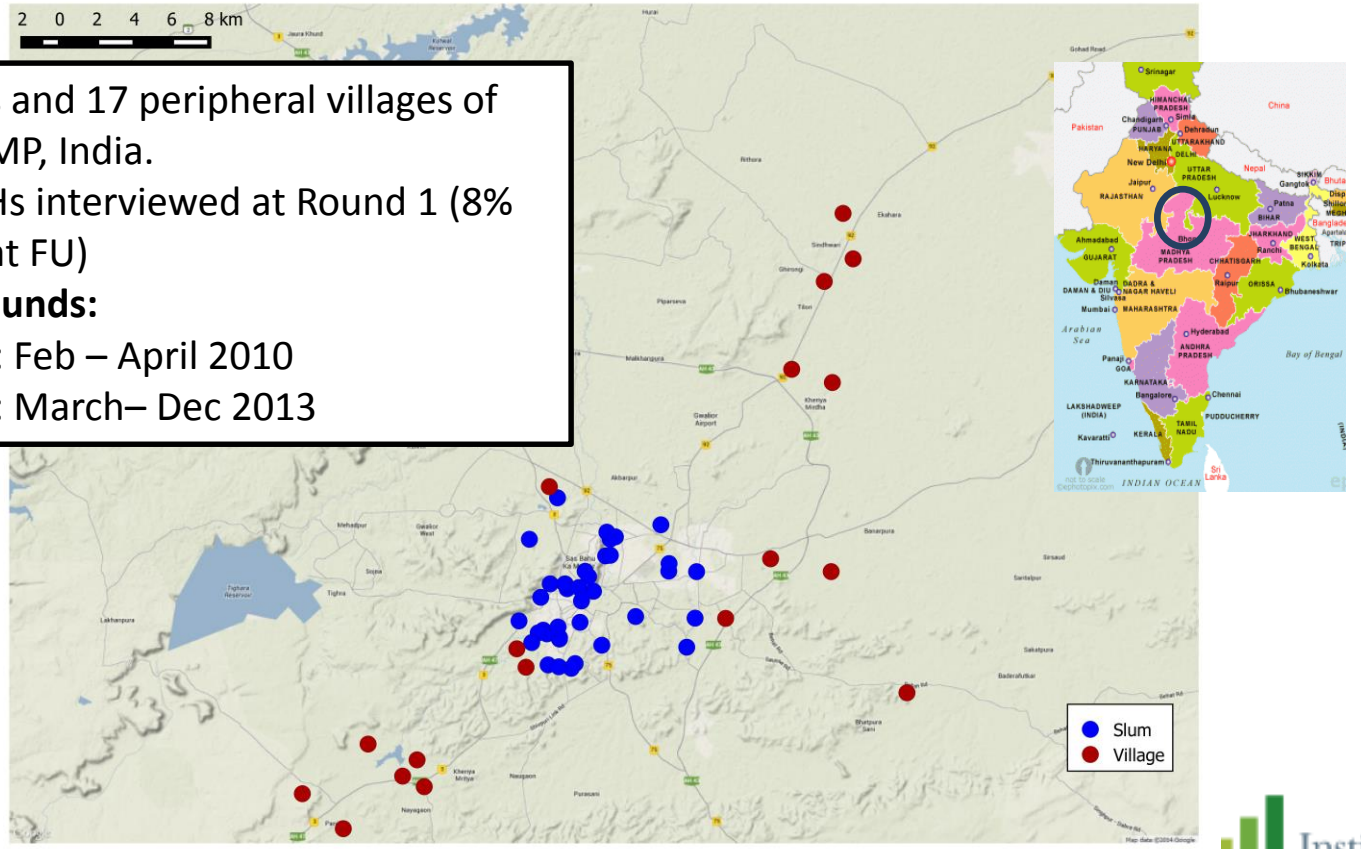
- Sanitation coverage: 22% in 2001, 31% in 2011
- Toilets to be constructed per minute (from 1st Jan 2015):
  - 81 to meet GoI's goal of eliminating OD by 2019
  - 41 to meet United Nation's goal by 2025

Urban/slums:

- 17% of urban population lives in slums
- Slum-dwellers tend to be neglected: 81% inadequate access (2008-09 National Sample Survey Organisation)

Data

- Collected as part of an impact evaluation of a sanitation program in Gwalior, India:



•39 slums and 17 peripheral villages of Gwalior, MP, India.
•1,992 HHs interviewed at Round 1 (8% attrition at FU)
Survey rounds:
•Round 1: Feb – April 2010
•Round 2: March– Dec 2013

Child characteristics

- Focus on children age 5 or younger
  - Average height for age z-score: -1.6 (sd 2.2)
  - ~44% stunted (score <-2)
    - In line with 2013-14 Rapid Survey on Children by Ministry of Women and Child Development & UNICEF
- HH background: mainly Hindu, 6-7 members, annual income ~ US$2,000, strong dwelling structure (60%), 56% of mothers no formal education, 51% own a toilet

Methodology

- Estimate:

$$Q_{i,v} = \alpha + \gamma ES_v + \delta_1 X^c_{i,v} + \delta_2 X^{hh}_{i,v} + \delta_3 X^v_{i,v} + \varepsilon^Q_{i,v}$$

  - $Q_{i,v}$: health (height for age) of child *i*
  - $X_{i,v}$: child, household and community level characteristics

ES_v : % of households in the same slum as child I, that use sanitation infrastructure: $ES_v = \frac{1}{N_v} \sum_{i=1}^{I_v} S_{i,v}$.

  - 51% own a toilet (used by ~90%)
  - 5% of non-owners use toilet

Identification strategy

- ***Instrumental variable approach*** to address endogeneity of ES_v

  (Example: HHs in high density slums with bad health infrastructure possibly more likely to make health investment, improving the disease environment)

- Instrument: Sanitation raw material price

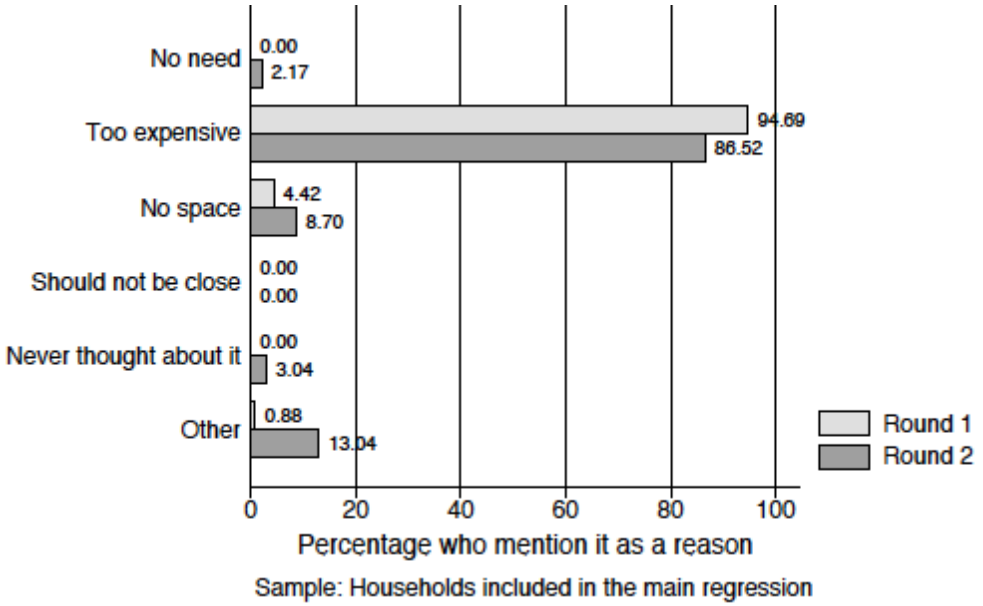
  First stage: $ES_v = \mu_0 + \mu_1 X^c_{i,v} + \mu_2 X^{hh}_{i,v} + \mu_3 X^v_{i,v} + \mu_2 Z_v + \varepsilon^{ES}_{i,v}$

  Motivation: Production function literature (prices affect investment decision, without entering production function directly.)

Identification strategy

Relevance:

- Reported reasons for now owning toilet: Cost!



Sample: Households included in the main regression

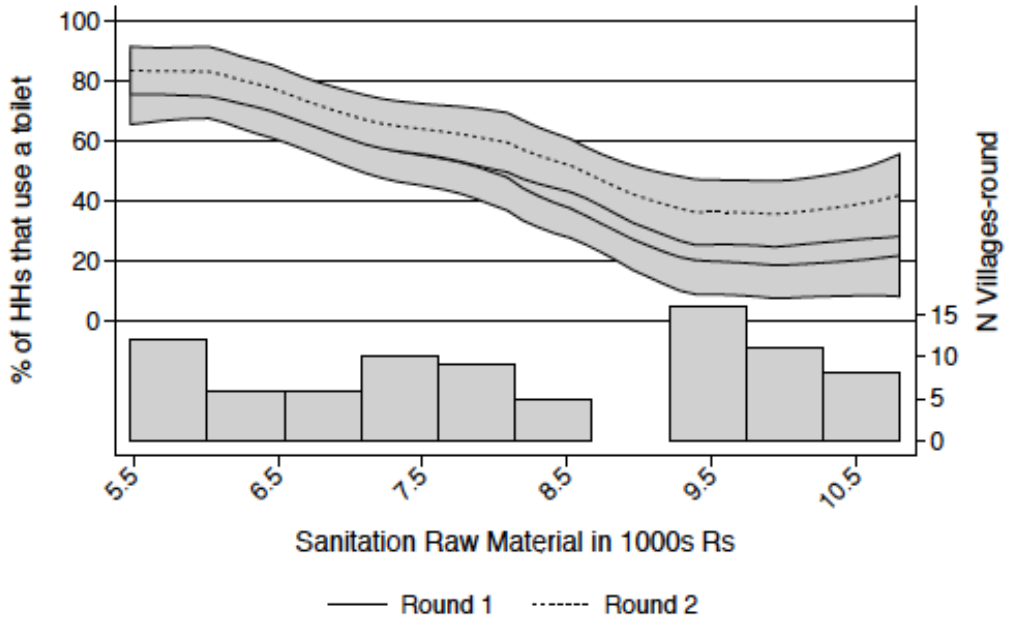
Identification strategy

- Prices: Material input prices (labor costs not used as they might hide worker quality)
  - Prices of cement, pipes, tiles and tin sheds
  - Collected from local suppliers in the study slums
  - Aggregated to price for typical toilet in area (pour flush pit toilet)
  - Average: US$ 178 (at that time)

Identification strategy

Relevance:

- Sanitation raw material prices and uptake:



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Identification strategy

- Uncorrelated with error term, $\varepsilon^{Q}_{i,v}$.
  - Depends on competitive nature of market
  - Market considered well developed in MP (Godfrey, 2008)
  - Prices not specific to toilet construction
  - Demand for toilets unlikely to affect price, especially from slum-dwellers (basic toilets)

Results - overall

- IV: 10% increase in sanitation coverage -> ~0.7cm increase in 4 year old child (F-stat: 12.9)
- OLS downward biased

	(1) OLS	(2) IV
Panel A: Second Stage		
Village % who uses a toilet	0.004	0.017**
	(0.005)	(0.008)
Panel B: First Stage		
Sanitation Raw Mat Price (1000 Rps)		−8.057***
		(2.244)
F-Stat		12.89
Obs	892	864
Clust	41	40
R2 Adj	0.11	0.10

Results - overall

- How do results compare?
- Richard et al (2013), cohort study, impact of diarrhea in first 2 years of life: 0.38cm
- Hammer & Spears (2013), evaluation of programme in MP: increase of toilet ownership of 8.2% leads to 0.3-0.4sd increase (1.3cm in 4yr old)
- Gertler et al. (2014 WP) in India: reduce OD by half (i.e. ~40% increase in coverage), increase of ~ 0.4sd

Results – by gender

- Impacts driven by girls
- 10% increase in sanitation coverage -> 1.05cm

	OLS			IV		
	MALE	FEMALE	BOTH	MALE	FEMALE	BOTH
Panel A: Second Stage						
Village % who uses a toilet	0.002	0.007		0.008	0.025***	
	(0.006)	(0.005)		(0.009)	(0.009)	
Village Avg * Boy			0.003			0.014
			(0.005)			(0.009)
Village Avg * Girl			0.004			0.021***
			(0.005)			(0.008)
Girl			0.017			−0.224
			(0.208)			(0.295)
Panel B: First Stage						
Sanitation Raw Mat Price (1000 Rps)				−8.252***	−8.045***	
				(2.115)	(2.309)	
F-Stat				15.22	12.13	18.65/ 12.93

Results – by gender

Two possible mechanisms

1. ***Continued exposure***: I.e. the environment improved but contact with bacteria decrease only/more for girls.

   Data: If toilet not used by all (12%), it is the males who do not use it (boys and men)

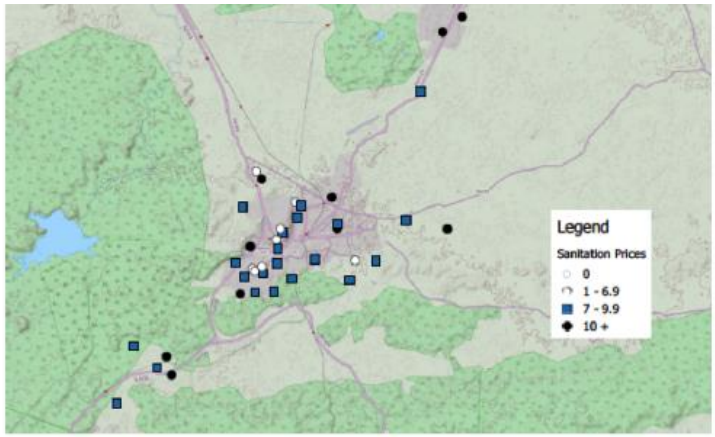
2. ***Differential investment by gender***: i.e. boys preference shown to be important in India, Pande and Astone 2007; differential investment (Barcellos et al, 2014; Das Gupta 1987; Jayachandra and Kuziemko 2010, and others)

   Data: imperfect and not conclusive (breastfeeding, nutrition)

Robustness

- We find that price variation driven by location/access

⇒Are factors that drive price variation correlated with other child health inputs?



⇒Results are robust to inclusion of community location index an

Robustness

- Do estimations suffer from omitted variables, important in determining child health?
  - ➔ Nutrition: Data constraints do not allow to include in analysis (and it would also be endogenous), correlation with instrument suggests, if anything, to be positive with prices

	(1)	(2)	(3)
	Dietary Diversity		
	ALL	HH Cont	MAIN
Raw materials price index	0.053	0.101*	0.094
	(0.054)	(0.053)	(0.057)
Obs	627	520	463
Clust	43	40	40
R2 Adj	0.01	0.07	0.06

Robustness - clusters

- Rule of thumb that one should worry with less than 42 clusters (Bertrand, Duflo, Mullainathan (2004); Cameron, Gelbach and Miller (2008), Angrist & Pischke (2008))
  - ➔ we're roughly (borderline) ok
- However, this is under equal cluster size (MacKinnan & Webb (2016))
  - ➔ Not the case for us!
- We follow Davidson & MacKinnon (2010): "wild restricted efficient residual bootstrap" (different combinations)

		Main beta	Main t-stat	Analytical P-val (cluster "sandwich" formula, the cluster option in Stata)	Wild P-val (Wild Cluster Bootstrap (Davidson-MacKinnon, 2010), clustering as in Cameron, Gelbach and Miller (2008))	Wild Eff. ("Wild Restricted Efficient Residual Boostrap" (correction from Davidson-MacKinnon (2010), robust to weak instruments)	Wild noIV (Cameron, Gelbach and Miller (2008), without considering adjustment for the 1st-stage, but estimated by 2sls-
Overall impact		-0.260	2.104	0.035	0.057	0.056	0.072
Gender impacts	Male	0.014	1.492	0.136	0.116	0.148	0.148
	Female	0.021	2.660	0.008	0.022	0.010	0.006

Conclusion

- Show that increases in sanitation coverage in (semi) urban areas benefit young girl's health, but not boys
- In the process of exploring two possible mechanisms:
  - Continued exposure to faeces due to non-usage
  - Differential investment
- Given the evidence on higher investment in boys, increasing sanitation coverage is a policy that implicitly targets girls

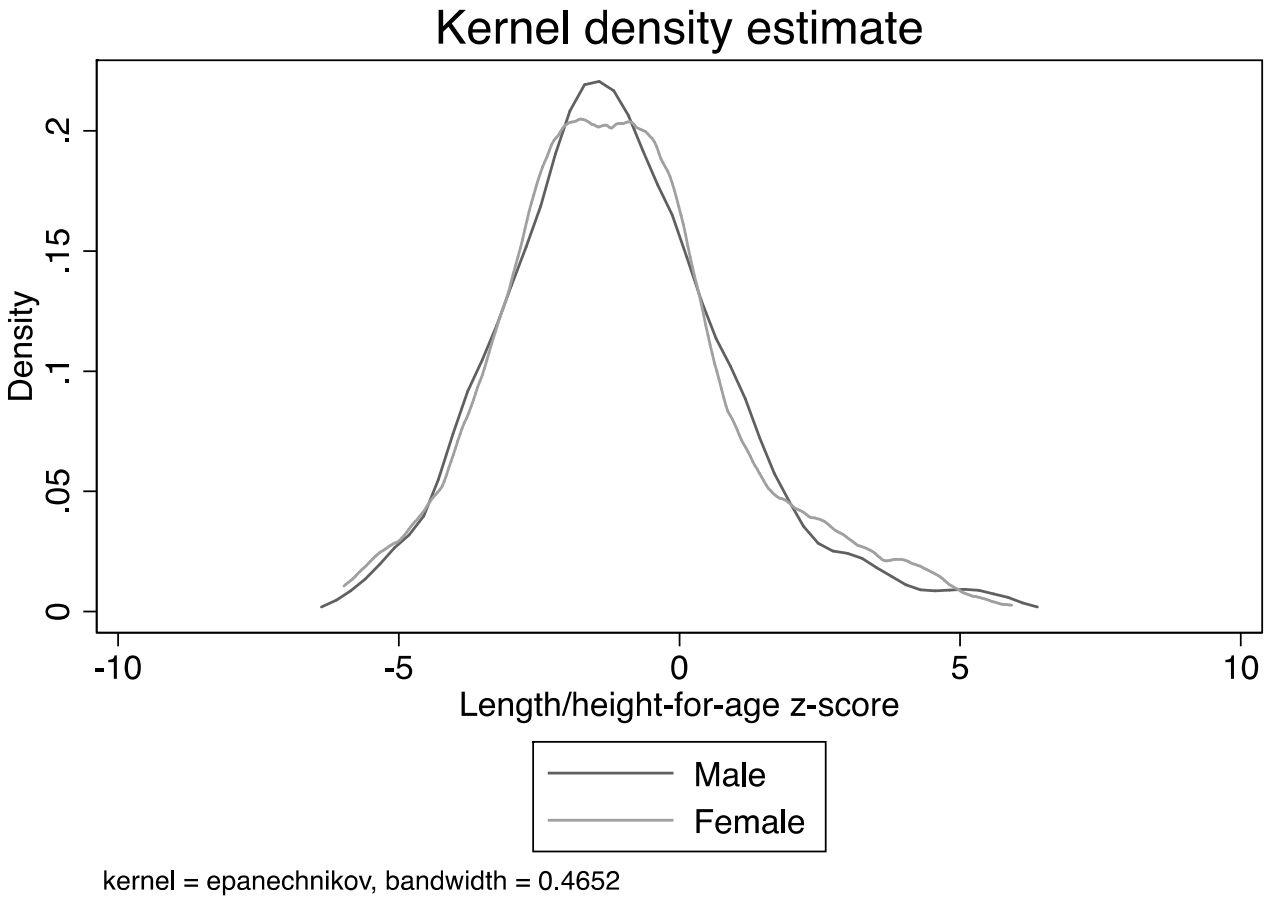
THANK YOU!

APPENDIX SLIDES:

	BASIC		MAIN	
	Mean	SD	Mean	SD
Social background				
Religion: Muslim	22.3%		24.1%	
Caste: Forward caste	18.5%		18.7%	
Caste: Minority backward caste	5.2%		5.7%	
Caste: Scheduled caste or tribe	28.6%		28.8%	
HH Characteristics				
Number of HH members	6.6	2.5	6.5	2.4
Number of children under 5	1.5	0.7	1.5	0.7
Number of male HH members	3.3	1.6	3.2	1.6
Any household shock last 12 months	9.8%		8.2%	
Income†	70.1	47.6	69.0	47.1
Consumption Expenditures†	101.8	81.8	97.6	76.2
Type of dwelling: strong	59.2%		56.7%	
Main woman characteristics				
Education: no formal	56.3%		56.7%	
Education: 1-5 yrs	14.2%		13.9%	
Education: 6-8 yrs	16.2%		16.8%	
Education: 9 yrs +	13.2%		12.5%	
Age (Yrs)	31.5	10.1	31.4	10.1
Height (cm)	149.6	6.7	149.6	6.6
Sanitation and Hygiene				
Owns a toilet	48.8%		48.1%	
Uses a toilet	47.2%		47.0%	
Total Households	299		278	
Households Round 1	267		248	
Households Round 2	440		383	

Notes: Own calculations based on FINISH sanitation household data for

Length/height-for-age z-score distribution (0-5yrs)



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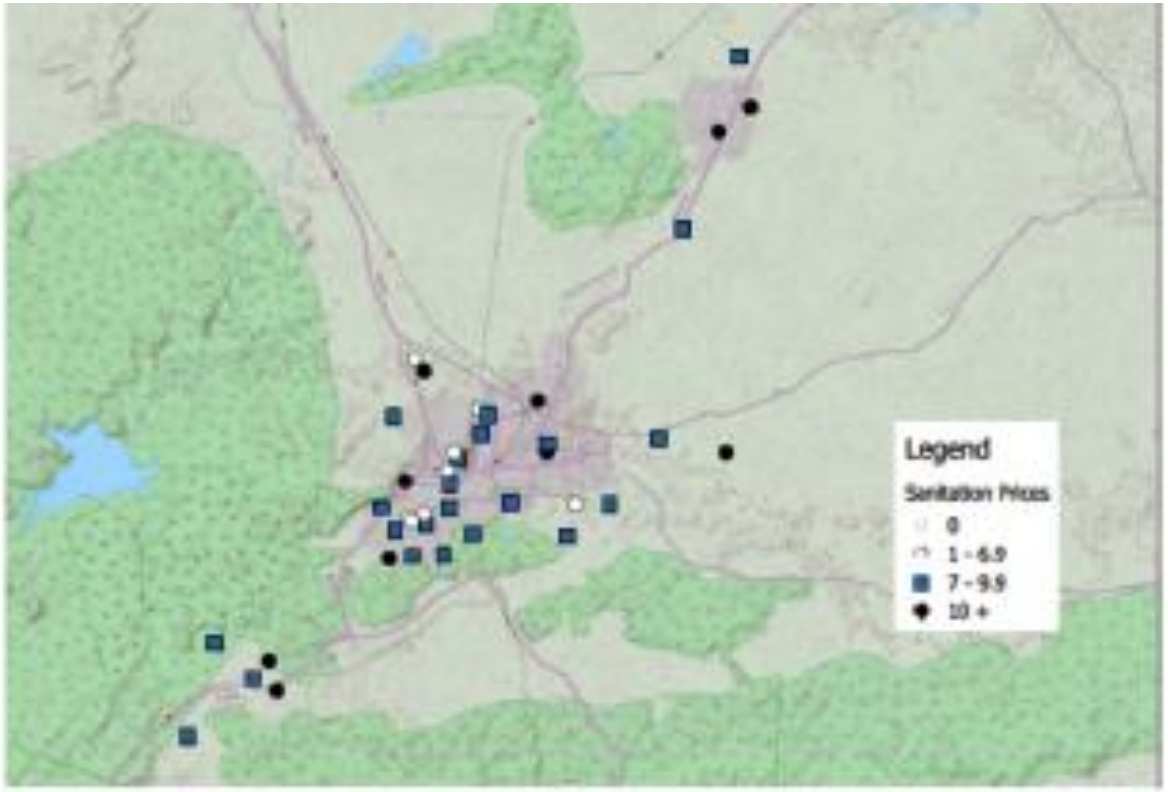
Drivers of variation in Instrument I

- Variation in prices – location/access: the further away from the city centre, the higher the prices:



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Drivers of variation in Instrument II

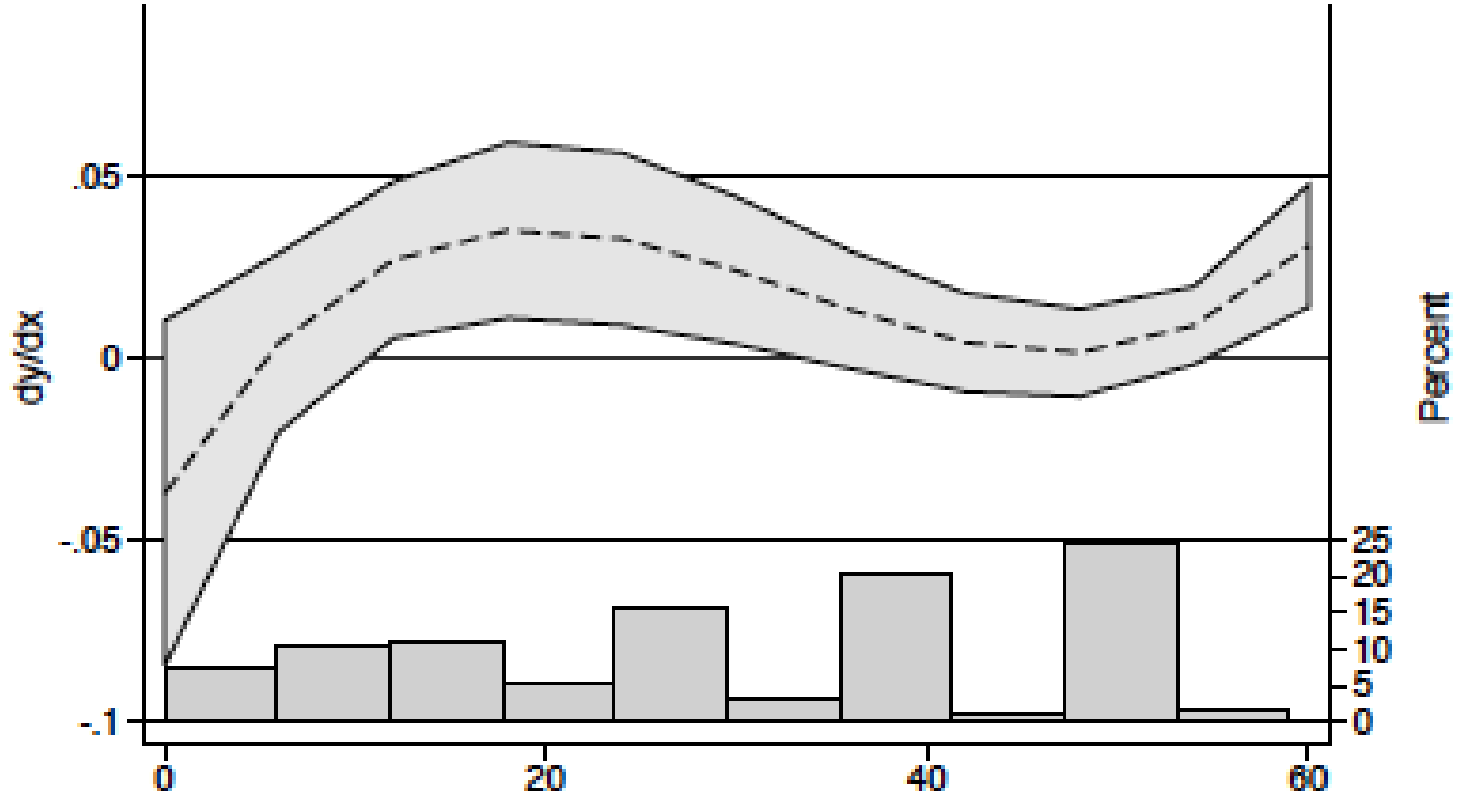
Table 5: Raw Materials Prices and Village Characteristics

OLS regression with Raw Materials Prices as a dependent variable	(1)	(2)	(3)	(4)	(5)
Inner Gwalior area	-1.411***	-1.423***	-1.033**	-1.020*	-0.600
	(0.459)	(0.511)	(0.449)	(0.574)	(0.529)
Village Scale and Location Index		-0.760***			-0.488**
		(0.252)			(0.234)
General Prices Index			-1.013***		-0.931***
			(0.162)		(0.161)
Water and Garbage disposal Index				-0.522	-0.321
				(0.352)	(0.274)
N Observations	78	69	74	75	68
N Villages	43	37	39	40	36
R Sqrd	0.148	0.297	0.459	0.207	0.556

Notes: Own calculations based on FINISH sanitation household data for Gwalior and raw materials prices from Gautam (2016). All specifications include a Round dummy. SE clustered at village level in parenthesis. Significance: * 10%, ** 5%, *** 1%.

Impacts by age

- Impacts primarily age 6-22 months (largest placidity in growth and not exclusively breastfed anymore)



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Robustness checks - controls

	(1) BASE	(2) MAIN
l: Second Stage		
% who uses a toilet	0.012**	0.017**
	(0.006)	(0.008)
Prices Index		
Scale and Location Index		
diversity measure		
3: First Stage		
	17.13	12.89
	964	864
	43	40
	0.09	0.10

- With and without controls

Robustness checks - location

	(2) MAIN	(3) LOC
1: Second Stage		
% who uses a toilet	0.017**	0.017*
	(0.008)	(0.010)
Prices Index		
Scale and Location Index		−0.049
		(0.118)
diversity measure		
3: First Stage		
	12.89	10.20
	864	813
	40	37
	0.10	0.10

- Robust to inclusion of location index

Robustness checks - prices

	(2) MAIN	(4) PRI
1: Second Stage		
% who uses a toilet	0.017**	0.035
	(0.008)	(0.039)
Prices Index		−0.339
		(0.450)
Scale and Location Index		
diversity measure		
3: First Stage		
	12.89	1.28
	864	820
	40	39
	0.10	0.04

- Including prices takes away strength of instrument, we are not able to make conclusion

Robustness checks – nutrition

	(2) MAIN	(5) U18	(6) A18
1: Second Stage			
% who uses a toilet	0.017**	0.022	0.017**
	(0.008)	(0.024)	(0.007)
Prices Index			
Scale and Location Index			
diversity measure			
3: First Stage			
	12.89	8.51	14.97
	864	200	664
	40	37	40
	0.10	0.06	0.11

- Impacts driven by those > 18 months

Robustness checks – nutrition

	(2) MAIN	(7) A18	(8) A18 †
1: Second Stage			
% who uses a toilet	0.017**	0.001	−0.000
	(0.008)	(0.008)	(0.007)
Prices Index			
Scale and Location Index			
diversity measure		0.142***	
		(0.051)	
3: First Stage			
	12.89	17.00	15.94
	864	472	472
	40	40	40
	0.10	0.17	0.16

- However, inclusion of nutrition biases the sample (to those where not impacts observed)

Results – by gender

Differential impacts by gender: increase in sanitation coverage by 10% improving the height for age for girls by 0.27 standard deviations (~1.17cm).

⇒Hammer & Spears (2013): program impact: 0.3-0.4 sd (1.3cm in 4yr old), impact on toilet ownership: 8.2%

⇒Gertler et al, India: reduce OD by half (i.e. ~40% increase in coverage), increase of ~ 0.4sd

⇒Our estimate between these two studies

Possible mechanisms 2

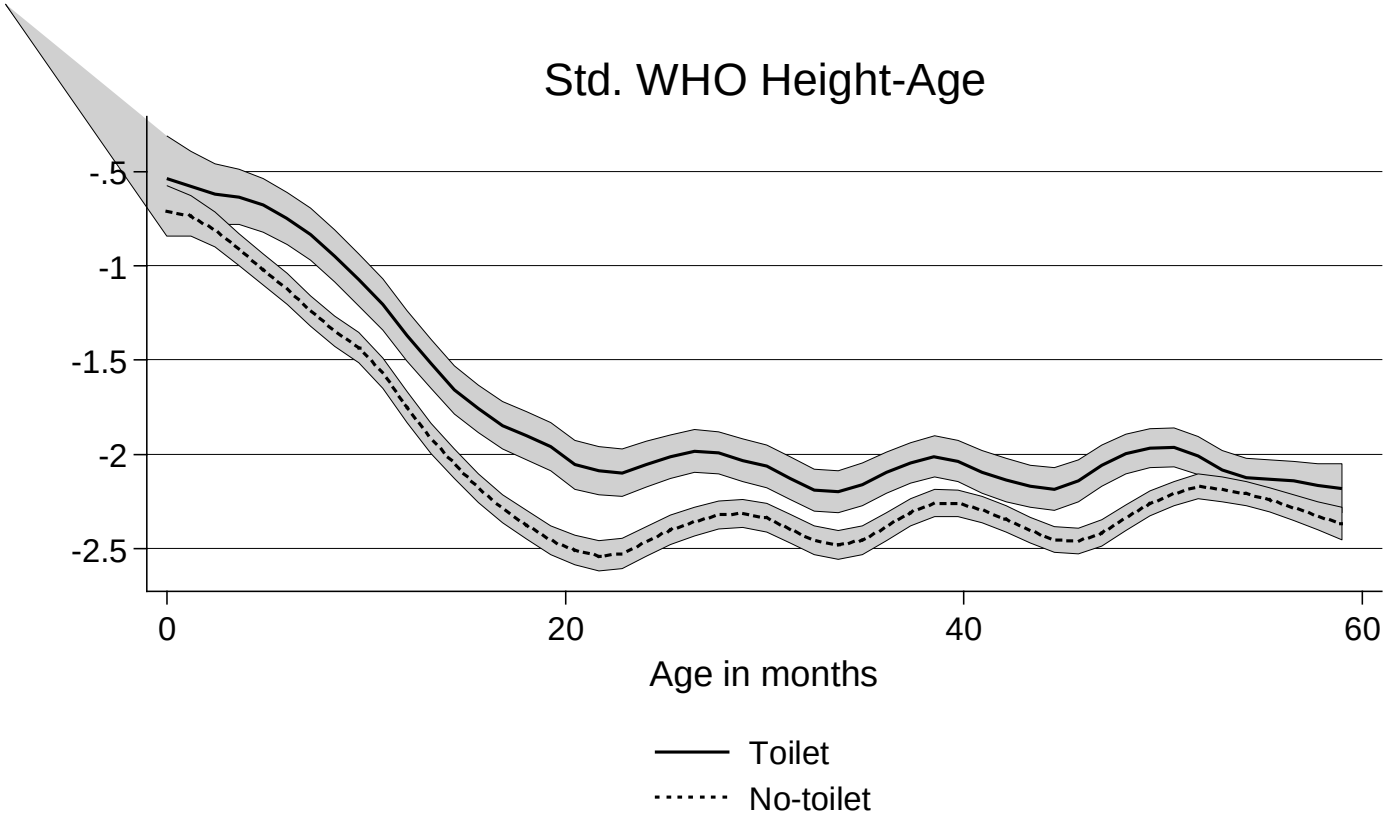
Differential investment by gender:

- India: families have explicit preferences for having sons over daughters (Pande and Astone 2007)
- "[...] boys receive more childcare time than girls, they are breastfed longer and they get more vitamin supplementation" Barcellos et al (2014, AEJ)
  - More nutrition (Das Gupta, 1987)
  - more healthcare (Basu 1989, Ganatra and Hirve, 1994)
  - breastfed for longer (Jayachandra and Kuziemko 2010)
  - more likely to be vaccinated (Borooah 2004)

=> Improvement in sanitation environment more valuable to girls?

Madhya Pradesh, sanitation and health

DHS 2006 data



95% CI. DHS India 2006 for Madhya Pradesh, poorest to midle wealth categories
Local constant estimator using an Epanechnikov kernel, bw=1.8.

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