Long-Term Human Capital Impacts of a Community-Led Total Sanitation Campaign*

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Abstract

Poor sanitation has large negative impacts on environmental quality, health, and well-being. Sanitation infrastructure is particularly lacking in India, where in 2011 roughly 90% of rural households did not own a toilet. Child health is particularly impacted by sanitation, with over 300,000 Indian dying yearly from diarrheal-related diseases. We exploit an experimental sanitation campaign in rural Odisha, India to examine the relationship between sanitation improvements in early childhood and long-term cognitive development. We build on literature linking child health improvements to cognitive development and labor market outcomes and show that improvements in sanitation can have large human capital returns. Using treatment assignment as an instrument for latrine adoption, we find that children who belonged to a household with a latrine score significantly higher on a cognitive test measuring analytic ability ten years later. We find that this effect is much stronger among girls than boys.

1 Introduction

Early-life health is a critical input to long-term human capital development and labor market outcomes (Currie, 2009; Grossman, 2000; Strauss and Thomas, 1998). Research has established a strong causal link between early childhood health and cognitive development (Barham, 2012;

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Bleakley, 2007; Case and Paxson, 2008; Paxson and Schady, 2007). Cognitive development subsequently impacts labor market outcomes both through occupational choice (Vogl, 2014) and earnings (Hanushek and Woessmann, 2008; Heckman et al., 2006).

Most of the research linking early childhood health to cognitive development has been conducted in developed countries; however, many of the poorest childhood disease environments exist in developing countries. In this paper, we focus on the impacts of improved sanitation on cognitive development. Approximately 2.5 billion people lack access to improved sanitation (World Health Organization and UN Water, 2014). Without proper sanitation infrastructure such as toilets or latrines, many people practice open defecation, which is a major contributor to the global burden of disease (Pruss-Ustun and Corvalan, 2006). Open defecation is particularly problematic in India, where an estimated 66% of the population practices open defecation and 386,600 children die annually from diarrheal diseases (UNICEF and WHO, 2009; WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2012).

In this paper, we explore the extent to which access to improved sanitation in early childhood can affect long-term cognitive development. We track children that were part of a randomized control trial that used a suite of demand-side levers to increase latrine coverage in treatment villages. Ten years after the initial intervention, we examine the impact of this improved sanitation in early childhood on cognitive test scores. While there is a growing literature linking improved sanitation and short-term health outcomes (Dickinson et al., 2015; Hammer and Spears, 2016; Kumar and Vollmer, 2013; Pickering et al., 2015), there is only one study to-date that investigates how access to improved sanitation in early childhood affects cognitive development (Spears and Lamba, 2016).

Our paper makes three primary contributions to the literature. First, we add evidence to a relatively sparse literature that sanitation improvements can have large and significant impacts on cognitive development. This contribution is important because it suggests that open defecation behaviors, which are widely practiced in India, might be more costly than previously thought, particularly when accounting for the strong link between cognitive development and future earnings (Hanushek and Woessmann, 2008; Heckman et al., 2006).

Second, while Spears and Lamba (2016) provide important evidence documenting how sanitation affects test scores in young children, we provide the first longitudinal evidence linking the impact of sanitation in early childhood to long-term human capital development. We build on the existing literature showing the short-term health and cognitive gains of sanitation by documenting that cognitive improvements from sanitation are sustained in the long-run. Most research to-date studying the returns from health investments focus on short-run returns. However, often these short-term benefits are not sustained in the long-run (Kremer and Miguel, 2007). More research is needed to document when short-term returns also result in long-term gains. We provide one such study by showing that improved sanitation in early childhood has positive long-term impacts on cognitive development regardless of whether the improved sanitation behaviors were continued in the long-term. This finding is consistent with other literature documenting that health improvements in early childhood have the largest human capital returns (Cunha et al., 2010).

Disaggregating the cognitive returns by child gender is the third primary contribution of our paper. Improved sanitation may affect girls and boys differently for several reasons. There is a growing literature suggesting that Indian parents differentially invest in the health of their male and female children (Barcellos et al., 2014; Jayachandran and Kuziemko, 2011; Oster, 2009). If boys are healthier at baseline, they may be able to capitalize on the additional returns of improved sanitation and thus receive larger cognitive gains. Alternatively, if we assume a concave human capital production function (Almond and Currie, 2010), then girls may experience cognitive improvements from sanitation improvements. We present the first evidence of the cognitive returns from sanitation disaggregated by gender and show that the cognitive gains are largely received by girls.

Our paper proceeds as follows. In Section 2 we further discuss both the epidemiological and economic literature linking sanitation and cognitive development. Section 3 contains an overview of the experimental background and our data. In Sections 4 and 5, we describe our empirical approach and present our main results. In Section 6, we discuss a number of mechanisms that may be driving the differences that we observe across gender. In Section 7, we summarize and discuss the implications of our findings.

2 Background

2.1 Epidemiological Literature on Sanitation and Cognition

Both epidemiological and economic literatures have shown that improving sanitation can significantly reduce rates of diarrhea (Fewtrell et al., 2005; Kumar and Vollmer, 2013; Pickering et al., 2015; Pruss-Ustun and Corvalan, 2006; Watson, 2006). Guerrant et al. (1999) and Niehaus et al. (2002) find a negative association between rates of diarrhea during ages 0-2 and cognitive performance six years later in Brazil. However, Tartelton et al. (2006) do not find any significant direct associations between cognitive performance and diarrheal incidence among 191 Bangladeshi children. Berkman et al. (2002) similarly does not find a direct association between diarrhea in early childhood (ages 0-2) and cognitive performance 7 years later among children in Peru. Using a pooled dataset of low and middle-income countries, Fischer Walker et al. (2012) also fails to find significant associations between diarrheal incidence and cognitive performance.

In a review of the epidemiological literature studying the association between diarrhea and cognition, MacIntyre et al. (2014) suggests that environmental enteropathy–a less commonly known health risk from open defecation behaviors–may play a large role in inhibiting cognitive development. Environmental enteropathy, also known as environmental enteric dysfunction and tropical enteropathy, "refers to an incompletely defined syndrome of inflammation, reduced absorptive capacity, and reduced barrier function in the small intestine" (Crane et al., 2015). This condition is largely caused by the ingestion of faecal bacteria during early childhood, which is particularly problematic in areas lacking improved water and sanitation (Crane et al., 2015; Humphrey, 2009; Mbuya and Humphrey, 2016; Petri et al., 2014). Environmental enteropathy has been shown to be a significant contributor to stunting (Griffiths and Kikafunda, 2015; Guerrant et al., 2016; Huda et al., 2013; Lin et al., 2013; Mbuya and Humphrey, 2016; Ngure et al., 2014; Petri et al., 2014) and also the odds of being underweight (Crane et al., 2015; Gilmartin and Petri, 2015; Guerrant et al., 2016; Humphrey, 2009; Lin et al., 2013; Petri et al., 2008, 2014).

The epidemiological literature suggests strong associations between environmental enteropathy and cognitive development. Griffiths and Kikafunda (2015) suggest that the stunting from environmental enteropathy early in life may result in microcephaly (smaller head circumference), thus hindering cognitive development. Indeed, there is a growing literature showing that stunting is significantly correlated with lower cognitive function (Berkman et al., 2002; Fischer Walker et al., 2012; Tartelton et al., 2006). Petri et al. (2008) suggests that low weight resulting from environmental enteropathy may also affect cognitive development as underweight children often suffer from nutrient absorption or inflammation issues (Gilmartin and Petri, 2015), which affect cognitive performance (Jiang et al., 2014; Petri et al., 2008).

2.2 Economic Literature on Sanitation and Cognition

Despite the growing medical and epidemiological literature documenting the link between poor sanitation and environmental enteropathy, there has only been one longitudinal economic study to-date exploring the impact of sanitation on long-term cognitive development. Spears and Lamba (2016) uses a difference-in-differences design to study the effect of India's Total Sanitation Campaign on cognitive scores. Specifically, they exploit temporal and geographic variation in the implementation of the Total Sanitation Campaign. They use latrines per capita by district to identify the relationship between district sanitation coverage and test scores of children 6 year olds who were 0-2 years old at the time of campaign intensity. Our study corroborates the findings of Spears and Lamba (2016) by using a different cognitive test and also testing children 7-15 years of age, thus showing that their findings are robust to the cognitive test instrument and that sanitation has long-lasting cognitive development impacts.

Our study also offers two major methodological improvements. First, we observe the children (not just district) in our study at baseline so can test for baseline child balance and also better control for baseline child characteristics. Second, we are able to estimate the effect of specific household latrine ownership rather than per capita district latrine ownership. While improved sanitation offers important positive externalities for the entire community (Alderman et al., 2003; Fuller et al., 2016; Watson, 2006), certain hygiene benefits accrue more strongly to households owning the latrine. We are able to test how much higher village latrine ownership affects cognition (through our ITT strategy), but also test how specific household latrine ownership affects cognition (through our TOT strategy).

3 Data

3.1 Experiment Background

In 1999, the government of India launched a Total Sanitation Campaign (TSC), aimed at reducing high rates of open defecation. The TSC included two main components: 1) households below the poverty line (BPL) received substantial subsidies for purchasing an individual household latrine, and 2) panchayats (local governments) were provided economic incentives to develop information, education, and communication tools to improve public knowledge of how improved sanitation relates to health (The Water and Sanitation Program, 2010). By 2001, the national campaign had not shown strong effects in rural India, with over 80% of households lacking access to improved sanitation (WHO/UNICEF Joint Monitoring Programme, 2017).

Responding in part to the lackluster effects of the TSC in Odisha, researchers designed an intensive community-level behavioral intervention to increase the adoption of individual household latrines. Working with governments in intervention villages, researchers designed an intensive community-led total sanitation (CLTS) intervention. CLTS, popularized by Kamal Kar, uses a combination of tools designed to invoke a sense of social shame around the negative externalities that individual open defecation behaviors have on entire communities (Kar and Chambers, 2008). There were three primary CLTS tools used in intervention villages. First, "the walk of shame" was a community-wide walk through the village designed to draw attention to poor hygiene and sanitation practices and thus triggering a collective shame response. Second, "defecation mapping" involved a large community meeting in which community members mapped out common defecation sites and noted their relative distances to water sources, crop fields, and other important community resources. This exercise was designed to highlight the negative external effects of private open defecation behaviors. Lastly, "faecal calculations" involved collecting the total volume of faecal matter in the village. This activity was designed to both trigger a collective shame response and to show to show the negative external effects of private behaviors. In addition to the CLTS campaign, researchers worked with local governments to also set up sanitation marts in each village and trained members of the community in latrine-part construction and engineering.

3.2 Sampling

The intervention took place within Bhadrak district, Odisha, India. Bhadrak was selected because of its particularly low levels of sanitation coverage in 2005 and its road accessibility. To ensure a somewhat homogeneous sample, villages with fewer than 70 households and villages with greater than 500 households were eliminated. Additionally, to minimize potential spillovers, one village per panchayat was randomly selected and contiguous villages were removed from the sample. In total, 40 villages were selected to participate in the study. Out of those 40, half were randomly assigned to receive the CLTS treatment described above. A mapping team listed every household in the village with a child under the age of 5, and from that list approximately 26 households per village were randomly selected to be tracked over the course of the study. Households with children under the age of 5 were selected to measure potential child health improvements. Households were interviewed in 2005, 2006, and 2016.[1] The short term (2006) latrine adoption and child health impacts from the intervention have been documented in Pattanayak et al. (2009) and Dickinson et al. (2015). Figure 1 provides an overview of the timeline of the intervention. The focus of this paper is the long-term (2016) human capital impacts of the intervention. For a more detailed account of the intervention or the sampling methodology, refer to Pattanayak et al. (2009).

3.3 Baseline Sample and Short Term Impacts

Households identified from the sampling procedure described above were interviewed about their current sanitation and hygiene practices, attitudes and perceptions of sanitation, household members' health histories, and household socioeconomic indicators. Additionally, detailed anthropometric information was gathered for children under the age of five.

Table 1 provide baseline descriptive statistics and randomization balance checks at the village and household level. Over half the sample is below the poverty line (BPL) and educational attainment for household heads is low. Households display poor water, sanitation, and hygiene (WASH) behaviors. Less than half of the sample uses an improved water source and very few report treating their drinking water in any way. Less than 1/3 of the sample reports washing

[1] An abbreviated wave of data collection was also conducted in 2010.

hands after handling child's feces and roughly 1/4 report washing hands after defecation. Most households practice open defecation, with only 10% owning a latrine.[2] For most village and household-level variables, treatment and control groups appear well-balanced. Notably, the difference in latrine ownership between treatment and control households is statistically significant at the 90% significance level. Since initial latrine ownership is higher in control villages, we argue that this initial imbalance will actually bias our results downwards.

Table 2 shows baseline descriptive child health statistics. We conduct balance tests across both treatment status and gender. Overall, we see high rates of childhood diarrhea (0.42 2-week diarrhea incidence), stunting (0.566), and malnutrition–50% of our sample was categorized as low-weight using WHO definitions. Many of these poor health indicators are likely influenced in part by poor household WASH behaviors. We do not observe many differences for child health variables between treatment and control groups. Children in treatment villages appear slightly less likely to be breastfed, but the effect size is small. When looking at differences between boys and girls, we observe that girls are more likely to be severely underweight and girls in treatment communities have lower arm circumference z-scores. These poorer nutritional measures for girls are consistent with a larger literature documenting fewer health investments for girls in India (Barcellos et al., 2014; Jayachandran and Kuziemko, 2011; Oster, 2009).

Households were tracked one year after the initial intervention. The treatment effect for differences in latrine adoption was 28.7% ($p = 0.000$) (Pattanayak et al., 2009). Children in treatment villages also showed significant health improvements; specifically, children in treatment villages were significantly more likely to have higher arm circumference z-scores, height z-scores, and weight z-scores (Dickinson et al., 2015). These findings suggest that the CLTS intervention worked to not only increase latrine adoption, but that this sanitation improvement also led to improved child health outcomes in the short-term. Conditional on owning a latrine, there were no reported latrine use differences between treatment and control communities. An abbreviated survey was conducted in 2010 and revealed that almost all of the latrines adopted since 2005 were still functional and being used.

[2] There were no community latrines in any of the villages in the study.

3.4 2016 Wave

Households were re-tracked in 2016, ten years after the initial intervention. The purpose of this follow-up was to: a) measure the sustainability of the sanitation changes of the initial intervention (a subject of another paper), and b) to measure the long-term human capital effects of being exposed to improved sanitation in early childhood. Households completed a similar survey to the baseline survey to measure changes in socioeconomic status, WASH behaviors, and health histories. Of the 1,086 original households, 25 (2%) were lost to attrition (see column 1 in Table 3. The largest predictor of household attrition was experiencing a recent serious burden or crisis. However, we do not observe differential household attrition between treatment and control villages ($p = 0.169$).[3] Attriting households were replaced with neighboring households.

Table 4 shows how key households characteristics changed between waves. Household size shrunk as did the number of children under age five, though the decrease in household size was not as large in treatment households. Household heads were less likely to be male, particularly in treatment households, and were older. Fewer households report treating water, which is likely driven by higher use rates of improved water sources. While households report being less likely to wash hands after handling a child's feces, they also report being more likely to wash hands after defecation. On the whole, household socioeconomic status is improved in the later wave– households are less likely to be below the poverty line, more likely to own their house, and report greater asset ownership. The change in BPL (poverty line) status was not as large in treatment households, with them remaining in the BPL classification at higher rates.

3.4.1 Human Capital in the 2016 Wave

To measure long-term human capital impacts of early-life exposure of improved sanitation, children completed an abbreviated version of the Raven's Colored Progressive Matrices (RCPM) test. The RCPM challenges children to make pattern associations and measures advanced analytic ability (Raven, 1998). The test has been used in a number of other developing country settings and is highly predictive of labor market productivity and earnings (Glewwe, 1996; Pitt et al., 2012; Vogl, 2014). The version of the RCPM test that we used was suggested for children

[3] Table 13 in Appendix A contains comparisons of attriting households and non-attriting households.

ages 7-15. This age range corresponds to children that were 0-5 or not yet born during the intervention.

This test was administered in the home of each household visited. If children were not home at the time of the survey, enumerators returned up to three times to administer the test. In households with multiple children eligible for the test, children were asked to sit in separate areas of the house and different versions were given to each child. The test versions differed in the ordering of questions, but not in the content. The enumerator also remained present during the test. The test did not have any time limit; on average, children took 15 minutes to complete the test. In total, 1825 children took the test. Table 5 shows the breakdown of these children. The majority of the RCPM test sample (65%) were children who were 0-5 in the original sample and were successfully tracked over time. Also, a large number of 7-9 year olds in the sample (22%) who were not yet born at the time of the 2005 intervention. The remaining sample comprises 10-15 year olds who did not belong to the household in 2005, but had moved into the household at the time of the 2016 wave (3%), children from replacement households (1%), or children whose age was originally miscoded (9%). The breakdown of these categories does not differ by treatment status. Figure 2 shows the distribution of the test score (out of 16 questions total). Male children, on average, scored 7.7, while females scored 7.3 ($p = 0.01$).

3.4.2 Child Attrition

While overall household attrition was low across waves, one may also be concerned about child-specific attrition since the primary focus of this paper is on long-term human capital outcomes. Of the 1754 children ages 0-5 at baseline, 1401 were found to still be living in their households in the 2016 wave. As indicated in Table 3, we do not observe differential child attrition by treatment status or gender. The primary reason given for child attrition was the child moving to live with another relative.[4]

Out of the 1401 of the original child sample reported to still be living in the household in 2016, 1186 children from this original sample took the RCPM test. This discrepancy results from 215 children not being available to take the test during any of the three visits to the household. There is also no difference in child availability to take the test by treatment status ($p = 0.265$).

[4] See Appendix A for a more detailed characterization of child attriters.

4 Empirical Strategy

We conduct both intent to treat (ITT) and treatment on the treated (TOT) analyses. The ITT analysis, represented by Equation 1, measures the impact of a child (i) living in a household (j) receiving the CLTS treatment ($Treatment_{j,2005}$) on child cognitive performance ten years later ($Score_{i,2016}$).

$$Score_{i,2016} = \alpha + \gamma Treatment_{j,2005} + \delta Age_{i,2016} + \psi Female_i + \beta X_{j,2005} + \epsilon_{it} \tag{1}$$

We control for child age and gender as well as a vector of baseline covariates ($X_{j,2005}$) and cluster standard errors at the village-level. We use a set of village and household covariates (similar to those used in Dickinson et al. (2015)) to account for baseline differences in wealth, household composition, and initial latrine ownership. To investigate the differences of the impact of the treatment (γ) by gender, we conduct this analysis with both the full sample and with gender subsamples (omitting the gender indicator).

The TOT analysis, as depicted in Equation 2, measures the impact of living in a household that owned a latrine on subsequent cognitive scores of children ten years later. The analysis takes the same form as the ITT, but the variable of interest is now household ownership of a latrine ($Latrine_{j,2006}$) rather than belonging to a household receiving the CLTS campaign.

$$Score_{i,2016} = \alpha + \rho Latri\hat{n}e_{j,2006} + \delta Age_{i,2016} + \psi Female_i + \beta X_{j,2005} + \epsilon_{it} \tag{2}$$

Since selection into latrine ownership is endogenous, we instrument for latrine ownership with randomized treatment assignment and present both OLS and IV versions of Equation 2. We also conduct these analyses with the full sample of children and with gender subsamples.

Our ITT analysis can be interpreted as the effect of belonging to a village with higher latrine coverage on cognitive test score, because the treatment assignment was highly predictive of latrine adoption in these villages. Our TOT analysis, on the other hand, measures the effect of actually owning a latrine (or belonging to a household that owns a latrine) on cognitive test scores. The extent to which the effect size from these two analyses is differentt indicates the degree of private returns from latrine ownership.

5 Results

In this section, we first present our ITT results which show the effect of belonging to a treatment village on subsequent test scores before presenting our TOT results which show the impact of owning a latrine on subsequent test scores. Figure 3 shows the raw test scores for children belonging to households in 2006, disaggregated by gender. Test scores for children belonging to households that owned latrines in 2006 are significantly shifted right, and this effect is particularly strong for girls compared to boys. Our ITT and TOT results which use randomized treatment assignment provide evidence for the causal relationship between latrine ownership and improved cognitive development.

5.1 Intent-To-Treat Results

Table 6 displays the ITT results from Equation 1. Belonging to a household in a treatment village improved child test scores, on average, by 0.8-1.1 points. This finding is robust to the inclusion of different covariates. The sign of the other covariates matches what we would intuitively expect. Age, baseline asset ownership, and open caste status all are positively correlated with test performance, while gender is negatively correlated with test score. In subsequent tables, we suppress the presentation of the control variables, though the results are similar.

Columns 2 and 3 in Table 6 presents the same models by gender subsample. Treatment assignment is not significant in any of the boy subsample models, but is positively significant in all of the girl subsample models. Thus, the overall positive treatment effect observed in Column 1 is being driven by girls who, on average, score 1.2-1.6 points higher on the RCPM test if they belong to a treatment village. The treatment effect is significantly greater among girls than boys (as indicated by the Gender Treatment p-value in Table 6). Taken together, these results suggest that being in a treatment village had no effect on boy test scores, but did have a strong and positive impact on girl test scores.

5.2 Treatment on the Treated Results

In this section, we explore the effect of latrine ownership in 2006 (one year after the intervention) on child test scores ten year later. Note that we do not use current latrine ownership because we are interested in exploring the effects of early childhood latrine ownership on later test scores. Columns 1-3 in Table 7 show the OLS results, indicating that latrine ownership in early childhood has positive effects on subsequent test scores.

Since selection into latrine ownership is non-random, we instrument for latrine ownership using treatment assignment. The first-stage is shown in Columns 4-6 of Table 7, and Columns 7-9 show the results from the IV regression. Both the OLS and IV models suggest that latrine ownership in early childhood has positive and significant impacts on cognitive development; however, the IV estimates are larger than the corresponding OLS estimates. While such a result may seem counterintuitive, recall that households below the poverty line received subsidies from the Indian Government Total Sanitation Campaign for latrine purchases. As a result, poorer households were actually more likely to adopt latrines.[5] Assuming that children in poorer households also have lower cognitive scores, we would, in fact, expect that the OLS models to underestimate the effect of latrines on test scores because these same households were more likely to select into latrine ownership.

Looking at the gender subsamples in Columns 8 and 9, we note that the results are qualitatively similar results to those presented in the ITT analysis: latrine ownership in early childhood has strong and positive effects on subsequent test scores for girls, but not for boys. Looking at column 9, we can conclude that belonging to a household with a latrine in early childhood improved girl test scores by 7.332 points relative to girls belonging to households without latrines. Recall that the RCPM test had 16 questions in total; thus, these results show very large gains in this measure of cognitive development.

These gender differences in test scores are consistent with short-term health improvements from latrine ownership. We include a gender interaction term in a replication of the main results from Dickinson et al. (2015), which tests the effect of treatment on child anthropometric outcomes (see Appendix C). We find that improvements in weight for age z-scores resulting from the treatment are particularly concentrated among girls. Our cognitive findings are thus consistent with the epidemiological literature suggesting that poor sanitation can result in low-weight status which can subsequently affect cognitive development (Gilmartin and Petri, 2015;

[5]Recall that these subsidies were available in both treatment and control villages. However, the combination of the CLTS treatment and subsidies greatly increased latrine adoption in treatment villages relative to control villages, particularly among BPL households (Pattanayak et al., 2009).

Jiang et al., 2014).

6 Investigating Mechanisms

In the previous section, we document that latrine ownership in early childhood results in large cognitive gains for girls, but not for boys. In this section, we explore different mechanisms that may explain the differential gender impacts of latrine ownership on cognitive scores. Specifically, we investigate differential early-life health investments, selection into latrine ownership, latrine use, and educational impacts of latrine ownership.

6.1 Differential Early-Life Health Investments

Research has documented that male children in India tend to receive more early-life health investments in the form of vaccinations, breastfeeding time, and vitamin supplementation than female children (Barcellos et al., 2014; Jayachandran and Kuziemko, 2011; Oster, 2009). As boys tend to receive these health inputs at differentially higher rates than girls, their child health status is likely to also be relatively better. Consistent with this literature, we observe in Table 2 that girls are more likely to be severely low weight and that girls in treatment communities have lower arm circumference z-scores.

Assuming a concave health production function (Almond and Currie, 2010), the additional health benefits offered by household latrine ownership could have a higher marginal benefit for female children who start at lower levels of health. Indeed, we find that short-term weight gains from improved sanitation are concentrated among girls (see Appendix C). However, if differential early life health investments was the driving mechanism, we would expect that the treatment effect would be larger for children who had poorer health measurements at baseline (controlling for baseline socioeconomic characteristics). In fact, we observe the opposite. Table 8 shows that the treatment effect is larger for children with higher weights at baseline. We find similar results when we break up the sample by baseline stunting status; treatment effects are larger for children who were taller at baseline. This set of findings suggests that differential baseline health investments are likely not driving the cognitive gender differences.

6.2 Selection into Latrine Ownership by Child Gender

Since households provide more health inputs to male children, they may similarly select into a state of latrine ownership based on child gender. If child gender affects a household's decision to adopt a latrine, this selection may explain the differential cognitive test results. If households select into latrine ownership based on child gender, household unobservables for households with female children that choose to adopt latrines may drive higher improved cognitive performance in females.

Table 9 shows that child gender did not affect whether a household adopts a latrine in 2006. None of the three measures of gender of children in the household–oldest child under 5 being male, oldest child in the household being male, and the proportion of children under five that are male–are significant predictors of latrine ownership.

6.3 Differential Latrine Use

The differential cognitive impacts may also be explained by differences in latrine use between female and male children. Many benefits from improved sanitation accrue to the entire community as lower rates of open defecation are associated with less contaminated water and crops (Alderman et al., 2003; Fuller et al., 2016; Watson, 2006). These external benefits of improved sanitation should not vary by gender. However, there are also private benefits to improved sanitation–those using latrines and toilets may be less exposed to others' feces. Exposure to faecal material is the driving cause of environmental enteropathy (Humphrey, 2009). While young children (ages 0-2) may not be able to use the latrine, differential latrine use among older children (ages 3 and up) may result in differences in cognitive development.[6].

Our dataset, unfortunately, only has latrine use by adult male, adult female, and children. We observe the highest use rates among adult females and children, but are unable to disentangle use by child gender. A study conducted in five Indian states finds that even among small children, girls use latrines at higher rates than boys, though the difference is not large.[7] To the extent that this result holds in our study setting, differences in latrine use between girls and boys may

[6]Epidemiologists report that children up to age 5 are the most at risk for the adverse effects of environmental enteropathy (Gilmartin and Petri, 2015; Oria et al., 2016)

[7]The study assessed sanitation quality and use in Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Haryana.

explain the differential cognitive results.

6.4 Education

Girls in India enroll in school at lower rates than their male counterparts (DHS 2008). Since improved sanitation produces significant health returns, latrine ownership could potentially induce higher rates of school enrollment or attendance for girls. Thus, improvements in education thus are another possible mechanism to explain the gender differential in cognitive test score results. Ortiz-Correa et al. (2016) rely on variation in features of water and sanitation service provision to show that improved sanitation increases number of years of schooling in Brazil. To explore whether latrine ownership impacted school attainment, we use school enrollment data from 2006 (the first follow-up) and enrollment and attendance data 2016 (the long-term follow-up). We reproduce the main results from Tables 6 and 7 using school enrollment and school attendance as the main outcome variables rather than cognitive test scores.

6.4.1 Short-term Educational Changes (2006)

The 2006 survey measures school enrollment, but not attendance for children ages 5 and over. Since most of the children in our sample were too young to enroll in school in 2006, we present school enrollment results for the full set of children age 18 and under. We assume that the school enrollment effects of these older children reflects the future school enrollment effects for the younger children in our sample. Table 10 shows the ITT and IV results measuring how treatment status and latrine ownership affected school enrollment. One year after the intervention (2006), we do not observe any impacts of latrine ownership on school enrollment. While we are relying on an older sample to infer future enrollment for younger children, we also conduct the same analysis on children ages 5-6 in our tracking sample, and find qualitatively similar results (See Appendix D.)

Of course, it is possible that while treatment did not have an impact on short-term school enrollment, it still may have had an impact on short-term school attendance. Unfortunately, we do not have school attendance data for the 2006 wave of data collection so are unable to test the impact of treatment on short-term school attendance.

6.4.2 Long-term Educational Changes (2016)

However, we can test the impact of the treatment on long-run school enrollment (Table 11) and long-run school attendance (Table 12). Similar to the short-term results, we do not observe any impact of treatment on long-term school enrollment or long-term school attendance. While positive significant treatment effects would indicate that changes in educational attainment might be playing an important role in driving cognitive performance, we cannot interpret the absence of significant results as the absence of a potential education effect. We are missing school attendance data in the short and medium term, when changes in health and thus school attendance were most likely to occur. Thus, we cannot rule out the possibility that elementary-school aged girls enrolled and/or attended school at higher rates because of sanitation improvements.

7 Discussion

This paper adds to the sparse literature on the long-term human capital impacts of improved sanitation. We show that household ownership of a latrine in one's childhood has large long-term positive impacts on cognitive development. This finding is particularly important given the literature linking cognitive development to labor market outcomes (Hanushek and Woessmann, 2008; Heckman et al., 2006; Vogl, 2014). In Mexico, Vogl (2014) found that a one standard deviation on a similar RCPM test is associated with a 9% increase in future earnings. Overall, this evidence suggests that improved sanitation in one's childhood has long-term economically significant impacts.

We find that these cognitive gains are largely concentrated in girls. We can rule out differential early life health investments and selection into latrine ownership as the mechanisms driving this result. However, we cannot definitely isolate a mechanism explaining the gender difference in cognitive impacts, though differential latrine use and school attainment may be important factors. Looking at effect sizes, we see that girls without latrines in early childhood are scoring far behind their male peers, which is likely due to different health and education inputs that girl children receive in India (Barcellos et al., 2014; Jayachandran and Kuziemko, 2011; Oster, 2009). However, girls with latrines in early childhood are scoring on par with their male peers, suggesting that sanitation may be a tool to even out human capital differences between females and males in India.

The overall findings are especially relevant given the widespread open defecation practices in India. As of 2012, 77% of rural India was practicing open defecation (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2012). Our findings suggest that these behaviors have significant human capital costs. Previous cost-effectiveness analyses accounting for health gains and time savings benefits showed that latrines are highly cost-effective investments (Dickinson et al., 2015). Such analyses may have actually understated the benefits of improved sanitation by not accounting for long-term potential human capital gains, which make latrines an even more attractive investment. While the Indian government is devoting large amounts of resources to make India "open defecation free" through its Swachh Bharat Mission, previous national efforts (such as the Total Sanitation Campaign) proved unsuccessful at significantly changing sanitation practices. Thus, more research investigating barriers to latrine adoption and sustained use is critical if these long-term human capital benefits are to be realized on a large scale.

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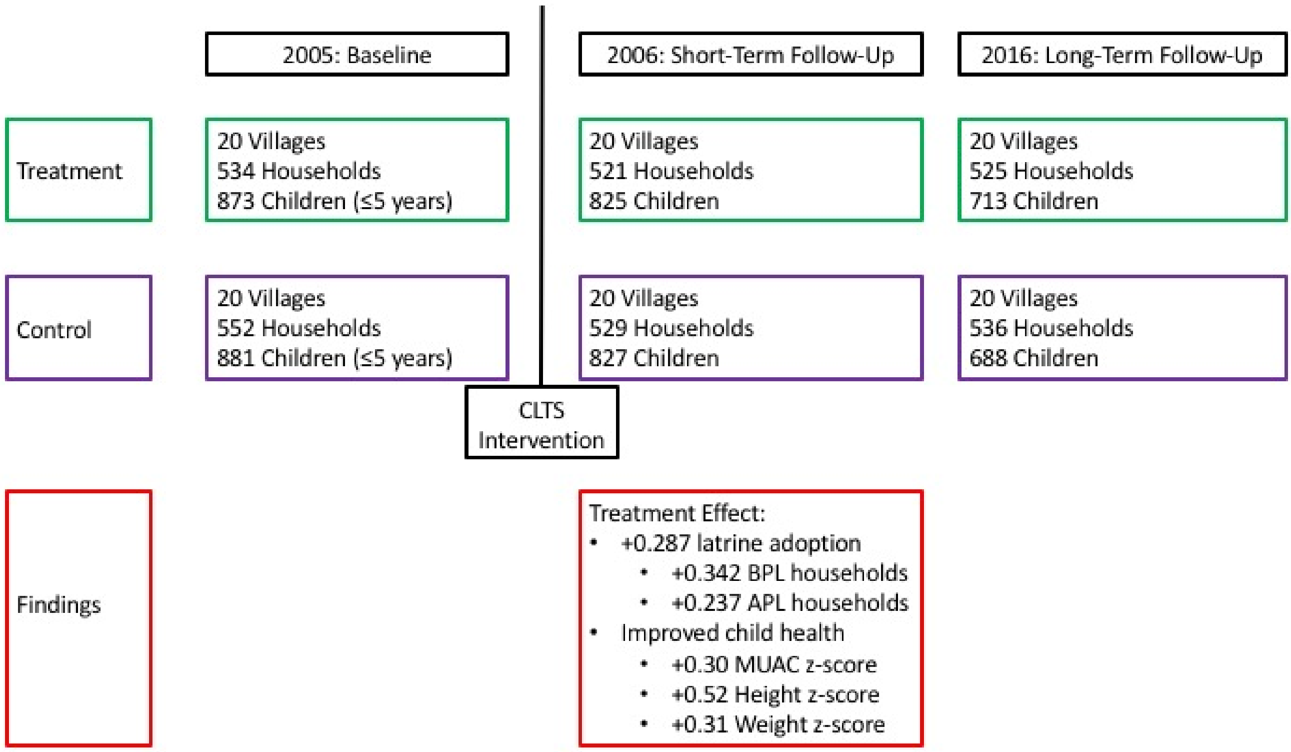
8 Figures

Figure 1: Timeline of Sanitation Intervention Study



Latrine adoption impacts are reported in Pattanayak et al. (2009) and child health impacts are reported in Dickinson et al. (2015).

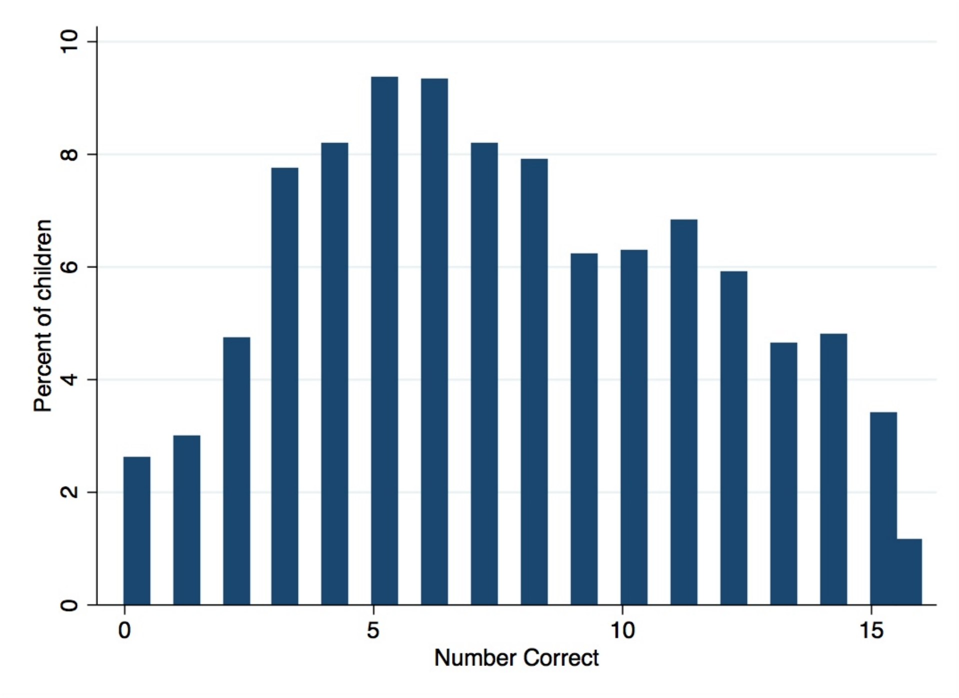


Figure 2: Number of Questions Answered Correct on Cognitive Test

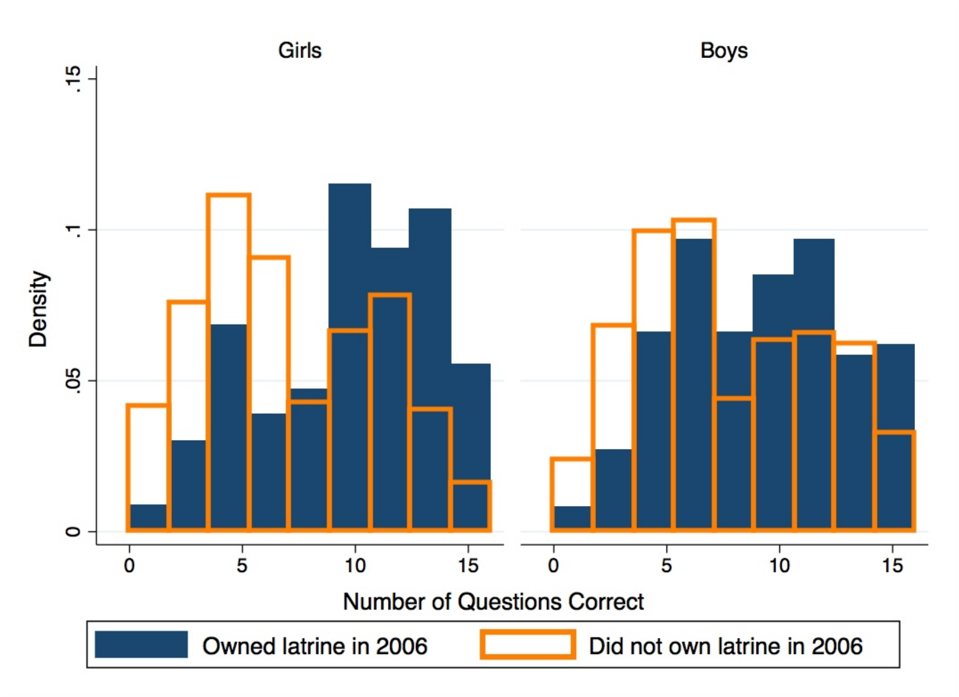


Figure 3: Cognitive Test Scores by Latrine Status and Gender

9 Tables

Table 1: Descriptive Statistics and Balance in Baseline Sample (2005)

	Treatment	Control	p-value[a]
Panel 1: Village-level	n=20	n=20	
Village population density	12.55	29.51	0.112
Distance from village center to main road	49.75	37.20	0.379
Panel 2: Household-level	n=534	n=552	
Household size	6.968	6.996	0.910
Number of children age 5 or under	1.557	1.596	0.458
Household head is male	0.916	0.889	0.321
Age of household head	47.92	48.54	0.613
Years of education for household head	2.348	2.298	0.601
Owns latrine	0.060	0.127	0.060
HH uses improved water source	0.375	0.418	0.605
HH treats drinking water	0.094	0.130	0.205
Washes hands before eating	0.918	0.909	0.830
Washes hands after handling child's feces	0.341	0.301	0.458
Washes hands after defecation	0.745	0.730	0.717
Below the poverty line	0.562	0.605	0.383
Attended a Gram Sabha meeting in the last month	0.558	0.509	0.420
Owns house	0.989	0.980	0.314
Faced a serious burden or crisis within the past year	0.451	0.522	0.299
Owns an animal plow	0.419	0.359	0.369
Owns an electric fan	0.172	0.268	0.205
Owns a bicycle	0.519	0.562	0.390
Owns a mosquito net	0.957	0.969	0.385
Owns a mattress	0.908	0.929	0.327

Standard errors for household variables were adjusted for clustering at the village level. Improved drinking water sources include tube-wells and piped water, while unimproved sources include surface water or rainwater. The poverty line in 2005 was defined as a monthly per capita consumption expenditure of 356 rupees. Gram Sabha meetings are community-wide meetings to discuss issues in the community. Burden and crises are defined as: major illness or death in the family, crop or livestock disease, floods, droughts, unexpected social or religious event, loss of job, loss of livestock, or super cyclones.

Table 2: Child Descriptive Statistics and Balance in Baseline Sample (2005) (N=1754)

	Treatment	Girl	Treatment*Girl	Control Mean
Girl (=1)	0.026			0.459***
	(0.023)			(0.039)
Child Age	-0.102	0.053	-0.017	2.546
	(0.121)	(0.074)	(0.154)	(0.073)
Weight z-score	0.100	-0.100	-0.046	-2.056***
	(0.144)	(0.125)	(0.147)	(0.188)
Height z-score	0.023	0.122	-0.137	-2.305***
	(0.172)	(0.150)	(0.209)	(0.221)
Stunted	0.029	0.004	0.007	0.566***
	(0.050)	(0.044)	(0.057)	(0.068)
Severely stunted	-0.005	-0.005	0.016	0.387***
	(0.040)	(0.038)	(0.052)	(0.054)
Low weight	-0.001	0.043	-0.013	0.490***
	(0.052)	(0.042)	(0.053)	(0.065)
Severely low weight	-0.012	0.064*	-0.000	0.243***
	(0.038)	(0.037)	(0.045)	(0.049)
BMI Z-score	0.108	-0.058	0.024	-1.001***
	(0.196)	(0.205)	(0.263)	(0.252)
Arm circumference Z-score	0.022	0.079	-0.211*	-0.896***
	(0.095)	(0.094)	(0.126)	(0.135)
Child diarrhea (2 week incidence)	0.041	-0.004	-0.021	0.420***
	(0.049)	(0.028)	(0.053)	(0.051)
Malaria incidence (1 year)	-0.022	-0.009	-0.010	0.051***
	(0.020)	(0.016)	(0.023)	(0.018)
TB incidence (1 year)	-0.005	0.000	0.002	-0.002
	(0.003)	(0.005)	(0.006)	(0.003)
Cholera incidence (1 year)	-0.002	0.000	0.007	-0.004
	(0.002)	(0.004)	(0.008)	(0.004)
Ever breastfed	-0.099*	-0.025	0.054	0.972***
	(0.055)	(0.027)	(0.034)	(0.032)
Total months exclusive breastfeeding	-0.915	-0.007	-0.552	4.085***
	(0.781)	(0.466)	(0.623)	(0.542)
Number of vaccinations	0.232	-0.268	0.046	3.892***
	(0.234)	(0.217)	(0.275)	(0.312)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors were adjusted for clustering at the village level. A child is stunted if the height z-score< -2 and is severely stunted if the height z-score< -3. Similarly, a child is low-weight if the weight z-score< -2 and is severely low-weight if the weight z-score< -3. Child vaccine charts were used to record if children had received the following vaccines: BCG, Polio0, Polio1, Polio2, Polio3, DPT1, DPT2, DPT3, and Measles.

Table 3: Household and Child (ages 0-5) Attrition Between 2005 and 2016

	(1) Household	(2) Child
Treatment	-0.012	-0.023
	(0.009)	(0.033)
Boy		0.030
		(0.024)
Treatment*Boy		-0.011
		(0.035)
Control Mean	0.029	0.200
	(0.007)	(0.019)
Observations	1086	1754
R^2	0.002	0.002

Standard errors were adjusted for clustering at the village level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Changes in Households Over Time (2005-2016)

	Treatment	2016 Wave	Treatment*2016	Baseline Control Mean
HH size	-0.028	-0.944***	0.347*	6.996***
	(0.249)	(0.136)	(0.177)	(0.149)
Number of children under 5	0.039	-1.279***	-0.001	1.596***
	(0.052)	(0.051)	(0.065)	(0.041)
Head of HH=male	0.026	-0.041***	-0.043**	0.889***
	(0.026)	(0.015)	(0.019)	(0.019)
Head of HH age	-0.626	6.662***	-0.257	48.55***
	(1.228)	(0.443)	(0.880)	(0.770)
Uses improved water source	-0.044	0.576***	0.044	0.418***
	(0.084)	(0.060)	(0.084)	(0.060)
Treats water in some way	-0.037	-0.056*	0.027	0.130***
	(0.029)	(0.031)	(0.036)	(0.023)
Washes hands before eating	0.008	0.049	-0.035	0.909***
	(0.038)	(0.030)	(0.043)	(0.025)
Washes hands after handling child's feces	0.040	-0.147**	-0.046	0.301***
	(0.054)	(0.051)	(0.079)	(0.039)
Washes hands after defecation	0.015	0.248***	-0.012	0.730***
	(0.042)	(0.029)	(0.043)	(0.027)
BPL	-0.043	-0.137***	0.081*	0.605***
	(0.049)	(0.032)	(0.045)	(0.032)
Attended a Gram Sabha meeting in the last month	0.049	-0.465***	-0.061	0.509***
	(0.060)	(0.041)	(0.061)	(0.040)
Owns House	0.009	0.015**	-0.003	0.980***
	(0.009)	(0.007)	(0.009)	(0.006)
Faced a serious burden/crisis in the past year	-0.070	-0.269***	0.106*	0.522***
	(0.067)	(0.044)	(0.059)	(0.051)
Owns an electric fan	-0.096	0.615***	0.059	0.268***
	(0.074)	(0.055)	(0.078)	(0.056)
Owns a bicycle	-0.043	0.287***	0.015	0.562***
	(0.049)	(0.034)	(0.051)	(0.038)
Owns a mosquito net	-0.012	0.011	0.016	0.969***
	(0.014)	(0.011)	(0.018)	(0.009)
Owns a mattress	-0.021	0.051***	0.032	0.929***
	(0.021)	(0.018)	(0.025)	(0.014)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors were adjusted for clustering at the village level. Improved drinking water sources include tube-wells and piped water, while unimproved sources include surface water or rainwater. The poverty line in 2005 was defined as a monthly per capita consumption expenditure of 356 rupees. Gram Sabha meetings are community-wide meetings to discuss issues in the community. Burden and crises are defined as: major illness or death in the family, crop or livestock disease, floods, droughts, unexpected social or religious event, loss of job, loss of livestock, or super cyclones.

Table 5: Sample Description of Children Taking RCPM Test

	Total	Treatment	Control
Tracked children aged 0-5 in 2005	1186	593	593
Children from replacement households	11	5	6
New children ages 10-15	59	33	25
Children ages 7-9	405	192	213
Children for whom age was miscoded	164	89	76
Total children completing RCPM test	**1825**	**912**	**913**

Table 6: Effect of Treatment Status on RCPM Test Scores: ITT

	(1) Full Sample	(2) Boys	(3) Girls
Child in treatment village	1.105***	0.613	1.632***
	(0.364)	(0.396)	(0.428)
Age (years)	0.252***	0.256***	0.249***
	(0.034)	(0.051)	(0.053)
Girl (=1)	-0.416**		
	(0.199)		
Baseline Latrine Ownership	1.449***	1.064*	1.937***
	(0.458)	(0.599)	(0.644)
Open caste	0.554**	0.626*	0.466*
	(0.268)	(0.362)	(0.264)
Owns land	0.157	0.417	-0.121
	(0.332)	(0.358)	(0.369)
Owns TV	1.548***	0.965*	2.386***
	(0.427)	(0.535)	(0.483)
Uses an improved water source	0.351	0.507	0.189
	(0.329)	(0.354)	(0.429)
Treats water in some way	0.384	0.152	0.668
	(0.349)	(0.466)	(0.417)
Household size	-0.006	0.003	-0.023
	(0.036)	(0.049)	(0.046)
Population density	0.003	0.006	0.006
	(0.006)	(0.007)	(0.007)
Distance to road	-0.004	-0.003	-0.004
	(0.004)	(0.004)	(0.004)
Constant	3.626***	3.657***	3.165***
	(0.549)	(0.752)	(0.769)
Observations	1804	920	884
R^2	0.089	0.069	0.120
Gender Treatment p-value			0.012

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
The dependent variable in all of the models is the number of questions (out of 16) that the child answered correctly on the RCPM test. Standard errors are adjusted for clustering at the village level. All covariates (except age) use baseline (2005) measurements. Gender Treatment p-value provides the results from a Wald test, which tested whether the treatment coefficient between the Boys and Girls models was equivalent.

Table 7: Effect of Latrine Adoption on RCPM Test Scores: OLS and IV Models

	OLS Dep Var: Score on RCPM Test			First-stage Dep Var: Latrine Ownership in 2006			IV Dep Var: Score on RCPM Test		
	All (1)	Boys (2)	Girls (3)	All (4)	Boys (5)	Girls (6)	All (7)	Boys (8)	Girls (9)
Household owned latrine in 2006	1.335***	0.759*	2.010***				4.642***	2.437	7.332***
	(0.326)	(0.390)	(0.460)				(1.550)	(1.566)	(1.900)
Child in treatment village				0.240***	0.258***	0.223***			
				(0.063)	(0.066)	(0.064)			
Age (years)	0.250***	0.253***	0.245***	-0.0002	-0.001	0.001	0.251***	0.255***	0.244***
	(0.035)	(0.050)	(0.053)	(0.002)	(0.004)	(0.005)	(0.033)	(0.049)	(0.057)
Girl (=1)	-0.369*			-0.015			-0.338*		
	(0.204)			(0.013)			(0.202)		
Constant	4.044***	3.902***	3.836***	-0.009	-0.018	-0.016	3.673***	3.714***	3.279***
	(0.506)	(0.722)	(0.790)	(0.055)	(0.080)	(0.060)	(0.572)	(0.732)	(0.784)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1804	920	884	1804	920	884	1804	920	884
R^2	0.085	0.068	0.112	0.289	0.284	0.292	0.001	0.044	0.095
First-stage F-stat				14.31	15.28	12.20			
Gender p-value			0.025			0.177			

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Standard errors are adjusted for clustering at the village level. Control variables are the same set of controls used in the ITT models in Table 6. Gender p-value measures whether the difference in coefficients between the corresponding Boys and Girls model is equal to zero.

Table 8: Baseline Weight Status and Long-Term Cognition

	ITT		IV	
	(1)	(2)	(3)	(4)
	Normal Weight	Low weight	Normal Weight	Low weight
Child in treatment village	1.776***	0.466		
	(0.465)	(0.421)		
Household owned latrine in 2006			5.673***	2.054
			(1.910)	(1.689)
Age (years)	0.234**	0.323***	0.233**	0.298***
	(0.103)	(0.081)	(0.114)	(0.080)
Girl (=1)	0.0758	-0.743**	0.392	-0.743***
	(0.396)	(0.277)	(0.365)	(0.278)
Constant	4.199***	3.775***	3.561**	3.915***
	(1.431)	(1.084)	(1.529)	(1.060)
Controls	Yes	Yes	Yes	Yes
Observations	418	748	418	748
R^2	0.132	0.071	0.029	0.063
First stage F-stat			16.28	10.78
Gender p-value		0.009		

Standard errors are adjusted for clustering at the village level. A child is considered low-weight if the weight-for-age z-score< -2. Control variables are the same set of controls used in the ITT models in Table 6. Gender p-value measures whether the difference in coefficients between the corresponding Boys and Girls model is equal to zero. In the IV specification, we instrument for household latrine ownership with treatment status.

Table 9: Selection into Latrine Ownership (2006) Based on Child Gender

	(1)	(2)	(3)
Gender measure	-0.020	-0.015	0.00662
	(0.021)	(0.022)	(0.021)
Child in treatment village	0.243***	0.232***	0.251***
	(0.077)	(0.070)	(0.067)
Gender measure*Treatment	0.022	0.052	0.006
	(0.050)	(0.039)	(0.041)
Constant	0.100	0.093	0.087
	(0.070)	(0.069)	(0.068)
Controls	Yes	Yes	Yes
Observations	1086	1085	1086
R^2	0.322	0.325	0.322

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

The definition of the variable, gender measure, changes based on the model (column). In column 1, gender measure is an indicator for whether the oldest child age 5 or under is male. In column 2, gender measure is an indicator for whether the oldest child in the household is male. In column 3, gender measure is the proportion of children five or under that are male.

Standard errors are adjusted for clustering at the village level. Control variables are the same set of controls used in the ITT models in Table 6.

Table 10: Treatment Effect on Short-term School Enrollment (2006)

	ITT			IV		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Child in treatment village	0.014	0.009	0.013			
	(0.028)	(0.033)	(0.032)			
Household owned latrine in 2006				0.053	0.029	0.056
				(0.103)	(0.109)	(0.131)
Girl (=1)	-0.013			-0.013		
	(0.017)			(0.017)		
Age	-0.032***	-0.021***	-0.040***	-0.032***	-0.021***	-0.040***
	(0.003)	(0.005)	(0.004)	(0.004)	(0.005)	(0.004)
Constant	0.914***	0.824***	0.969***	0.910***	0.822***	0.964***
	(0.065)	(0.075)	(0.081)	(0.065)	(0.074)	(0.082)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2146	1014	1132	2146	1014	1132
R^2	0.073	0.035	0.120	0.071	0.033	0.120
First-stage F-stat				13.35	14.93	10.03
Gender p-value			0.737			

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Standard errors are adjusted for clustering at the village level. Control variables are the same set of controls used in the ITT models in Table 6. Gender p-value measures whether the difference in coefficients between the corresponding Boys and Girls model is equal to zero. In the IV specification, we instrument for household latrine ownership with treatment status.

Table 11: Treatment Effect on Long-term School Enrollment (2016)

	ITT			IV		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Child in treatment village	-0.012	-0.016	-0.012			
	(0.013)	(0.013)	(0.018)			
Household owned latrine in 2006				-0.045	-0.056	-0.046
				(0.046)	(0.046)	(0.067)
Girl (=1)	-0.032***			-0.032***		
	(0.009)			(0.009)		
Age (years)	-0.036***	-0.024***	-0.048***	-0.036***	-0.025***	-0.047***
	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)	(0.008)
Constant	1.429***	1.275***	1.545***	1.431***	1.283***	1.541***
	(0.058)	(0.061)	(0.090)	(0.056)	(0.060)	(0.089)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1377	698	679	1377	698	679
R^2	0.078	0.056	0.099	0.080	0.049	0.102
First-stage F-stat				15.58	13.51	15.99
Gender p-value			0.820			0.385

Standard errors are adjusted for clustering at the village level. Control variables are the same set of controls used in the ITT models in Table 6. Gender p-value measures whether the difference in coefficients between the corresponding Boys and Girls model is equal to zero. In the IV specification, we instrument for household latrine ownership with treatment status.

Table 12: Treatment Effect on Long-term School Attendance (2016)

	ITT			IV		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Child in treatment village	-0.083	-0.114	-0.078			
	(0.073)	(0.082)	(0.098)			
Household owned latrine in 2006				-0.304	-0.392	-0.301
				(0.260)	(0.272)	(0.376)
Girl (=1)	-0.162***			-0.165***		
	(0.050)			(0.050)		
Age (years)	-0.225***	-0.152***	-0.293***	-0.223***	-0.154***	-0.288***
	(0.031)	(0.031)	(0.044)	(0.031)	(0.032)	(0.045)
Constant	8.551***	7.644***	9.246***	8.558***	7.701***	9.213***
	(0.348)	(0.367)	(0.537)	(0.334)	(0.366)	(0.522)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1373	694	679	1373	694	679
R^2	0.080	0.058	0.103	0.081	0.047	0.108
First-stage F-stat				15.49	13.40	15.67
Gender p-value			0.201			

Standard errors are adjusted for clustering at the village level. Control variables are the same set of controls used in the ITT models in Table 6. Gender p-value measures whether the difference in coefficients between the corresponding Boys and Girls model is equal to zero. In the IV specification, we instrument for household latrine ownership with treatment status.

Appendix A Household and Child Attrition

Table 13: Baseline Characteristics of Attriting Households (n=1086)

	Attrited in 2016	Treatment	Treatment* Attrited	Control Mean
HH size	-1.992***	-0.0503	-0.123	7.054***
	(0.420)	(0.249)	(0.623)	(0.150)
Number of children under 5	-0.0345	0.0316	0.406	1.597***
	(0.165)	(0.055)	(0.334)	(0.043)
Head of HH is male	-0.0793	0.0244	0.0520	0.892***
	(0.097)	(0.027)	(0.151)	(0.020)
Head of HH age	0.0802	-0.476	-8.815	48.54***
	(4.351)	(1.261)	(6.058)	(0.828)
Head of HH education	0.0896	-0.0409	0.208	2.410***
	(0.581)	(0.074)	(0.732)	(0.044)
Uses an improved water source	-0.0448	-0.0483	0.229	0.420***
	(0.102)	(0.085)	(0.178)	(0.061)
Treats water in some way	-0.0700	-0.0410	0.201	0.132***
	(0.066)	(0.029)	(0.142)	(0.023)
Washes hands before eating	0.0289	0.00761	0.0549	0.909***
	(0.052)	(0.038)	(0.059)	(0.025)
Washes hands after handling a child's feces	-0.181**	0.0331	0.286	0.306***
	(0.090)	(0.055)	(0.184)	(0.040)
Washes hands after defecation	-0.108	0.0135	0.0282	0.733***
	(0.121)	(0.041)	(0.170)	(0.026)
BPL	-0.173	-0.0501	0.279*	0.610***
	(0.106)	(0.049)	(0.163)	(0.031)
Attended a Gram Sabha meeting recently	0.184	0.0525	-0.0733	0.504***
	(0.149)	(0.060)	(0.207)	(0.039)
Owns House	-0.173	0.00350	0.184	0.985***
	(0.123)	(0.008)	(0.123)	(0.006)
Faced a serious burden in the past year	0.299***	-0.0616	-0.306	0.513***
	(0.098)	(0.068)	(0.185)	(0.052)
Owns an animal plow	-0.176**	0.057	0.089	0.364***
	(0.090)	(0.066)	(0.200)	(0.037)
Owns an electric fan	-0.019	-0.095	-0.044	0.269***
	(0.120)	(0.075)	(0.157)	(0.057)
Owns a bicycle	0.001	-0.044	0.037	0.562***
	(0.169)	(0.050)	(0.235)	(0.039)
Owns a mosquito net	0.032***	-0.010	-0.101	0.968***
	(0.009)	(0.014)	(0.098)	(0.009)
Owns a mattress	0.008	-0.019	-0.141	0.929***
	(0.061)	(0.021)	(0.159)	(0.014)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Standard errors were adjusted for clustering at the village level. Improved drinking water sources include tube-wells and piped water, while unimproved sources include surface water or rainwater. The poverty line in 2005 was defined as a monthly per capita consumption expenditure of 356 rupees. Gram Sabha meetings are community-wide meetings to discuss issues in the community. Burden and crises are defined as: major illness or death in the family, crop or livestock disease, floods, droughts, unexpected social or religious event, loss of job, loss of livestock, or super cyclones.

Table 14: Baseline Household Characteristics of Attriting Children (n=1754)

	Attrited	Treatment*Attrited	Female*Attrited	Treatment*Fema Attrited
HH size	1.488***	-0.739	0.263	-0.009
	(0.488)	(0.633)	(0.537)	(0.736)
Number of children under 5	0.465***	-0.376**	-0.221	0.369*
	(0.153)	(0.175)	(0.158)	(0.199)
Head of HH is male	-0.113*	0.112	0.120**	-0.183**
	(0.065)	(0.073)	(0.061)	(0.078)
Head of HH age	5.202**	-2.935	-0.266	3.072
	(2.127)	(3.336)	(2.447)	(3.579)
Head of HH education	0.044	0.195	0.214	-0.280
	(0.234)	(0.254)	(0.209)	(0.281)
Uses an improved water source	0.008	-0.007	0.020	0.013
	(0.053)	(0.074)	(0.080)	(0.123)
Treats water in some way	0.017	0.053	0.072	-0.091
	(0.052)	(0.070)	(0.048)	(0.078)
Washes hands before eating	0.092***	-0.103**	-0.083	0.125
	(0.024)	(0.042)	(0.057)	(0.080)
Washes hands after handling a child's feces	-0.034	-0.048	0.077	0.118
	(0.072)	(0.084)	(0.069)	(0.095)
Washes hands after defecation	-0.074	0.066	0.031	0.030
	(0.057)	(0.071)	(0.060)	(0.079)
BPL	0.000	0.084	0.023	-0.047
	(0.061)	(0.082)	(0.070)	(0.097)
Attended a Gram Sabha meeting recently	-0.002	0.001	-0.084	0.136
	(0.066)	(0.079)	(0.074)	(0.107)
Owns house	-0.000	-0.010	-0.016	0.039
	(0.012)	(0.023)	(0.018)	(0.030)
Faced a serious burden in the past year	-0.015	-0.012	-0.057	0.106
	(0.077)	(0.093)	(0.081)	(0.118)
Owns animal plow	-0.009	-0.045	0.103	0.005
	(0.057)	(0.083)	(0.075)	(0.098)
Owns an electric fan	0.057	-0.088	0.090	-0.027
	(0.067)	(0.069)	(0.055)	(0.072)
Owns a bicycle	0.111**	-0.105	0.009	0.103
	(0.046)	(0.089)	(0.063)	(0.096)
Owns a mosquito net1	0.033*	-0.027	0.006	0.012
	(0.017)	(0.030)	(0.014)	(0.031)
Owns a mattress	0.054***	-0.036	-0.031	-0.065
	(0.019)	(0.041)	(0.035)	(0.059)

Table 15: Baseline Child Health Characteristics of Attriting Children (n=1754)

	Attrited	Treatment*Attrited	Female*Attrited	Treatment*Female* Attrited
Child is Female	-0.44	0.014		
	(0.036)	(0.056)		
Child Age	-0.0572	-0.399*	-0.0428	0.0300
	(0.145)	(0.229)	(0.255)	(0.276)
Weight z-score	0.485***	-0.331	-0.388	0.534
	(0.131)	(0.274)	(0.238)	(0.376)
Height z-score	0.257	-0.0729	0.0722	0.337
	(0.274)	(0.351)	(0.297)	(0.469)
Stunted	-0.0763	0.0329	0.0918	-0.127
	(0.056)	(0.080)	(0.061)	(0.111)
Severely stunted	-0.0449	0.0921	0.0543	-0.118
	(0.068)	(0.085)	(0.061)	(0.093)
Low weight	-0.126***	0.122*	0.123*	-0.102
	(0.039)	(0.069)	(0.065)	(0.102)
Severely low weight	-0.0540	0.0243	0.0970	-0.167*
	(0.042)	(0.064)	(0.079)	(0.102)
BMI z-score	0.337	-0.496	-0.446	0.688
	(0.215)	(0.372)	(0.382)	(0.528)
Arm circumference z-score	0.132	0.281	-0.0372	-0.146
	(0.100)	(0.183)	(0.177)	(0.273)
Child diarrhea (2 week incidence)	-0.0313	0.00739	0.0222	0.0367
	(0.031)	(0.056)	(0.067)	(0.088)
Malaria incidence (1 year)	-0.0134	0.00722	-0.0121	0.00323
	(0.038)	(0.045)	(0.050)	(0.059)
TB incidence (1 year)	-0.00504*	0.00432*	0.0132	0.00139
	(0.003)	(0.002)	(0.012)	(0.017)
Cholera incidence (1 year)	0.0111	-0.0124	-0.0154	0.00971
	(0.010)	(0.011)	(0.011)	(0.010)
Ever breastfed	0.0578	-0.0303	-0.0390	0.0945
	(0.038)	(0.060)	(0.044)	(0.072)
Total months exclusively breastfed	0.162	-0.260	0.983	-1.376
	(0.827)	(1.079)	(1.061)	(1.343)
Number of vaccinations	-1.179***	0.368	0.822**	0.162
	(0.350)	(0.506)	(0.406)	(0.601)

Appendix B Robustness Checks of Main Results

Table 16: Main ITT Results with Different Samples and Controls

	Model 1			Model 2			Model 3		
	All (1)	Boys (2)	Girls (3)	All (4)	Boys (5)	Girls (6)	All (7)	Boys (8)	Girls (9)
Child in treatment village	1.105***	0.584	1.607***	0.821*	0.384	1.278**	1.076***	0.630	1.480***
	(0.380)	(0.453)	(0.449)	(0.455)	(0.454)	(0.515)	(0.392)	(0.503)	(0.434)
Age (years)	0.193***	0.252**	0.148	0.247***	0.268***	0.223***	0.216**	0.315**	0.118
	(0.067)	(0.114)	(0.093)	(0.033)	(0.050)	(0.056)	(0.080)	(0.138)	(0.122)
Girl (=1)	-0.462*			-0.553***			-0.511**		
	(0.230)			(0.203)			(0.242)		
Weight-for-age Z-score (2005)							0.115	0.0457	0.206
							(0.102)	(0.155)	(0.125)
Height-for-age Z-score(2005)							0.135	0.0690	0.201
							(0.113)	(0.136)	(0.161)
Arm circumference Z-score (2005)							0.0201	0.162	-0.176
							(0.162)	(0.160)	(0.222)
Constant	4.895***	3.655**	5.475***	4.529***	4.500***	4.025***	5.220***	3.133*	6.656***
	(0.931)	(1.401)	(1.329)	(0.528)	(0.669)	(0.775)	(1.075)	(1.819)	(1.541)
Main Controls	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Only Baseline Sample	Yes	Yes	Yes	No	No	No	No	No	No
Observations	1186	604	582	1825	933	892	921	481	440
R^2	0.082	0.069	0.111	0.035	0.029	0.042	0.088	0.073	0.134
Gender p-value			0.020			0.038			0.084

Table 17: Main IV Results with Different Samples and Controls

	Model 1			Model 2			Model 3		
	All (1)	Boys (2)	Girls (3)	All (4)	Boys (5)	Girls (6)	All (7)	Boys (8)	Girls (9)
Household owned latrine in 2006	4.226***	2.017	6.660***	4.204**	1.958	6.603***	4.324**	2.218	7.036***
	(1.484)	(1.622)	(1.853)	(2.020)	(2.169)	(2.185)	(1.700)	(1.858)	(2.179)
Age (years)	0.175***	0.260**	0.0675	0.245***	0.268***	0.219***	0.222***	0.324**	0.123
	(0.063)	(0.108)	(0.083)	(0.034)	(0.049)	(0.054)	(0.076)	(0.129)	(0.127)
Girl (=1)	-0.381			-0.400*			-0.409		
	(0.237)			(0.211)			(0.258)		
Weight-for-age Z-score (2005)							0.115	0.0366	0.232*
							(0.105)	(0.160)	(0.126)
Height-for-age Z-score(2005)							0.0719	0.0385	0.0602
							(0.098)	(0.129)	(0.169)
Arm circumference Z-score (2005)							0.115	0.160	0.192
							(0.157)	(0.163)	(0.241)
Constant	4.807***	3.414**	6.078***	4.028***	4.256***	3.476***	4.834***	2.727	6.663***
	(0.985)	(1.381)	(1.298)	(0.632)	(0.711)	(0.830)	(1.171)	(1.799)	(1.835)
Main Controls	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Only Baseline Sample	Yes	Yes	Yes	No	No	No	No	No	No
Observations	1186	604	582	1814	928	886	921	481	440
R^2	0.016	0.055	0.038	0.002	0.039	0.088	0.009	0.047	0.036
First stage F-stat	15.87	16.42	13.37	7.636	7.164	7.491	13.27	14.22	8.592

Appendix C Replication of Short-Term (2006) Child Health

Table 18: Replication of Short Term (2006) Child Health with Gender Interaction

	(1)	(2)	(3)
	z_arm	z_height	z_weight
Treatment	0.375***	0.467**	0.133
	(0.124)	(0.199)	(0.139)
Female	0.0254	-0.0656	-0.323***
	(0.078)	(0.168)	(0.113)
Female * Treatment	-0.137	0.106	0.342*
	(0.154)	(0.262)	(0.178)
z_arm (2005)	1.923***		
	(0.187)		
z_height (2005)		1.081***	
		(0.146)	
z_weight (2005)			1.153***
			(0.201)
Constant	-1.144**	-9.381***	-2.654***
	(0.514)	(1.890)	(0.680)
Observations	671	724	775
R^2	0.148	0.187	0.100

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors were adjusted for clustering at the village level. Control variables used in all three columns are the same used in Dickinson et al. (2015): Baseline diarrhea incidence, mother's health indicators, population density, distance to road, open caste, mother's education, land ownership, ln(expenditures), TV ownership, mother handwashing behaviors, improved water source, an indicator for whether the child was currently breastfeeding, and child age.

Appendix D School Enrollment for Five and Six Year Olds (2006)

Table 19: Short-Term (2006) Effects of Treatment on School Enrollment for Five and Six Year Olds

	ITT			IV		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Child in treatment village	0.007	0.014	-0.011			
	(0.063)	(0.081)	(0.062)			
Household owned latrine in 2006				0.023	0.042	-0.039
				(0.205)	(0.234)	(0.218)
Girl (=1)	0.049			0.049		
	(0.034)			(0.033)		
Age	0.342***	0.345***	0.332***	0.341***	0.348***	0.335***
	(0.039)	(0.069)	(0.059)	(0.039)	(0.068)	(0.063)
Constant	-1.127***	-1.196***	-0.961**	-1.127***	-1.209***	-0.975***
	(0.239)	(0.338)	(0.356)	(0.234)	(0.339)	(0.367)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	563	280	283	563	280	283
R^2	0.121	0.119	0.134	0.125	0.127	0.126
First-stage F-stat				20.14	15.95	17.69
Gender p-value			0.737			