Interaction of village and school latrines on educational outcomes in India
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ABSTRACT

Research has shown that improved sanitation environments can lead to better educational outcomes. Similarly, there is some evidence that school latrines may also improve school enrollment and attendance, particularly for girls. This paper explores the interaction effect of village-level latrine coverage and school latrines on child educational outcomes. The overall improved sanitation conditions from higher latrine coverage and the presence of school latrines might produce an additive effect and improve educational outcomes even further. Using multiple years of data from the Annual Status of Education Report (ASER) in India, this paper shows that there is no evidence of either an additive effect. However, across multiple models, village-level latrine coverage is associated with lower school dropout rates and higher test scores, particularly among girls. School latrines do not appear to have a strong positive association with educational outcomes.

Key words: education, gender, India, sanitation

INTRODUCTION

As of 2015, 61% of the rural Indian population practiced open defecation (UNICEF 2015). Open defecation has large health, time, and dignity costs (Checkley et al. 2004; Cutler & Miller 2005; Wolf et al. 2014; Caruso et al. 2015; Dickinson et al. 2015; Augsburg & Rodríguez-Lesmes 2018). Recent research has also shown that improved sanitation increases human capital by improving education outcomes (Santiago Ortiz-Correa et al. 2016; Spears & Lamba 2016; Adukia 2017; Orgill-Meyer and Pattanayak 2019). Accounting for these improved human capital benefits is important to consider in sanitation interventions.

In a systematic review by Sclar et al. (2017), the authors propose a causal pathway for the effects of sanitation on educational outcomes, including attendance/absenteeism, enrollment, and test scores. In the review, both household/community sanitation and school sanitation are shown to have an effect on school absences. Access to improved sanitation at the household or community level has been shown to lower the risk of fecal exposure, which in turn lowers the rates of infection and illness. These lower rates of infection and illness both improve cognitive development and increase the ability to attend school. This increased ability to attend school may result in increased school enrollment if the health returns are substantial, decreased school absenteeism, and improved school performance as measured by test scores. Sclar et al. (2017) also theorize that access to improved school sanitation provides a more comfortable learning environment and thus increases the desire to attend school. In this paper, I investigate the interaction between community sanitation and school sanitation on a range of educational outcomes in India. Before discussing this interaction, I first provide an overview of the literatures investigating: (a) the link between household/community sanitation and educational outcomes and (b) the link between school sanitation and educational outcomes.
Household/community sanitation and educational outcomes

There is a strong literature establishing the impact of improved sanitation environments on reductions in infection and illness in children (Wolf et al. 2014; Freeman et al. 2017). Recent research has highlighted the effect of reduced sanitation-related infections and illnesses on cognitive development. Pinkerton et al. (2016) show that diarrhea is a significant predictor of delayed cognitive development among a number of different measures. Cumulative fecal exposure contributes to environmental enteropathy, which inhibits the absorptive capacity of the gut even when otherwise asymptomatic (Petri Naylor & Haque 2014; Crane Jones & Berkley 2015; Mbuya & Humphrey 2016). Reductions in enteric infections contributing to environmental enteropathy are also correlated with improvements in cognitive development (Petri et al. 2008; Jiang et al. 2014; Watanabe & Petri Jr 2016; Kosek 2017).

Beyond the mechanism of infections contributing directly to cognitive development, a growing body of literature investigates the impact of household/community sanitation improvements on other educational outcomes. Reductions in illnesses and infections as a result of improved sanitation environments may increase the ability for children to attend school, which could in turn contribute to enhanced cognitive development (Sclar et al. 2017). Research investigating community-level sanitation improvements on school attendance provides mixed results. A piped sewer intervention in Yemen demonstrated no effect on school attendance (Klasen et al. 2012), whereas an improved drainage intervention in Pakistan was associated with significant improvements to school attendance particularly for girls (Rauniyar Orbeta & Sugiyarto 2011). Notably, both of these interventions were coupled with community-wide water supply improvements, making it difficult to disentangle the sanitation improvements on school outcomes. Santiago Ortiz-Correa et al. (2016) find that sewerage systems in Brazil increase the total years of schooling attained. Research investigating household-level sanitation rather than community-wide sanitation finds that household sanitation is significantly correlated with reduced school absences (Dreibelbis et al. 2015; Park et al. 2015) and improved school attendance (Battiston et al. 2015), though all of these studies are cross-sectional making causal claims difficult.

School sanitation and educational outcomes

School sanitation conditions also play a role in impacting educational outcomes. Access to latrines or toilets in school creates a more comfortable learning environment, thus enhancing the desire to attend school (Sclar et al. 2017). There is mixed empirical evidence on school sanitation and educational outcomes. Grant Lloyd & Mensch (2013) do not find that the presence of school latrines or latrine quality correlates with absenteeism in menstruating girls in Mali, and Caruso et al. (2014) find no impact of a latrine cleaning intervention on school absences in Kenya. School WASH intervention studies have been shown to decrease absenteeism (Freeman et al. 2011; Trinies et al. 2016), though it is difficult to assess the role of sanitation alone in these interventions. Dreibelbis et al. (2013) find that school latrine maintenance is correlated with reduced school absences for both boys and girls. Adukia (2017) and Garn et al. (2013) use school enrollment rather than absenteeism as their outcome of interest. Adukia (2017) finds that the presence of sex-specific latrines increased school enrollment and test scores of pubescent-age girls in India. One explanation for why school latrines may have an effect on school enrollment or attendance for pubescent-age girls is the additional privacy they offer to girls who are menstruating (Alam et al. 2017). Similarly, a school-based WASH intervention increased school enrollment particularly among girls in Kenya (Garn et al. 2013).

Interaction of community and school latrines on education outcomes

In this paper, I explore the interaction of the village sanitation environment and the school sanitation environment on educational outcomes in India. Most of the research to-date that explores the effect of improved sanitation on educational outcomes either uses sanitation improvements at the household/community level or school toilets/latrines as their variable of interest as discussed above and summarized in B1–B3 in Table 1. Only one paper investigates both school and household-level sanitation (Dreibelbis et al. 2013); however, they do not explore the interaction effect and rely on cross-sectional data. This paper adds to this existing literature by being the first to use a panel dataset.
I hypothesize that the more desirable learning conditions from school latrines combined with the reduced infection rates from village latrine coverage produce even greater educational returns (see Table 1). Using absenteeism as an example outcome, existing research shows that improved sanitation environments and school latrines are correlated with lower rates of absenteeism (Freeman et al. 2011; Rauniyar Orbeta & Sugiyarto 2011; Battiston et al. 2013; Dreibelbis et al. 2013; Park et al. 2015; Trinies et al. 2016). If a school latrine offers an additional incentive to attend school, the health conditions resulting from the improved sanitation environment may reduce absenteeism even further. The educational outcome variables that I use to test this hypothesis are school dropout rates and math test scores. I explain this choice of variables further in the following section.

There are two alternatives to the additive hypothesis. First, there may be no interaction effect—that is school latrines, and village sanitation environments produce improved educational outcomes independently and thus there is no complementary effect. Second, there may be a substitution effect, where, in the presence of both school latrines and improved village sanitation environments, educational outcomes actually worsen. The substitution effect would occur if the increased likelihood of having a latrine at home weakens the additional incentive provided by school latrines to enroll in or attend school. In this study, I make use of a large national Indian dataset to test the proposed additive effects shown in B4 in Table 1.

### METHODS

#### Data overview

To investigate this research question, I use data from India’s Annual Status of Education Report (ASER) survey. ASER is an annual survey, which collects data on childhood educational attainment in rural India. Specifically, ASER measures educational outcomes (school enrollment and educational attainment tests) for approximately 600,000 children ages 3–16. ASER surveys 30 villages per rural district and interviews 20 households per village in each year of data collection. Additionally, ASER collects data on one...
government school per village, gathering data on teaching indicators and school infrastructure (including school latrine status). Each year ASER randomly replaces 10 villages from each district. Pooling different years of ASER data results in a repeated cross-section at the household level and an unbalanced panel at the village and school level since most villages and schools are observed for multiple years.

Statistical model

The model used to test the effect of the interaction of school latrines and village latrine coverage on education outcomes is estimated with the ordinary least squares model shown below.

\[
\text{Outcome}_{ijt} = \beta_0 + \beta_1 \text{Vil Latrine}_i + \beta_2 \text{School Latrine}_i + \beta_3 \text{Female}_i + \beta_4 \text{Vil Latrine}_i \times \text{School Latrine}_i + \beta_5 \text{Vil Latrine}_i \times \text{Female}_i + \beta_6 \text{School Latrine}_i \times \text{Female}_i + \beta_7 \text{Vil Latrine}_i \times \text{School Latrine}_i \times \text{Female}_i + \beta_8 \text{Age}_{ijt} + \gamma \text{HHch} + \theta_i + \delta_{kt} + \epsilon_{ijt}
\]

I use two measures of educational outcomes as the dependent variables in the above model: (1) math test scores and (2) a binary variable for whether the child has dropped out of school. ASER does not measure reported school attendance or absenteeism – the two measures often used in the literature on WASH and educational outcomes (Rauniyar Orbeta & Sugiyarto 2011; Battiston et al. 2013; Dreibelbis et al. 2013; Caruso et al. 2015; Park et al. 2015; Trinies et al. 2016). I use math test scores as a proxy for attendance and absenteeism with the assumption that children that attend school more frequently will score higher on these tests. The score, as measured by ASER, ranges from 0 to 4, with 0 meaning that the child was unable to complete any of the questions accurately on the test, 1 indicating that the child correctly identified a number between 1 and 9, 2 representing that the child correctly identified a number between 10 and 99, 3 representing that the child correctly solved a subtraction problem, and 4 indicating that the child correctly solved a division problem. Math test scores have been used as a proxy for impact of sanitation on educational attainment when absenteeism and attendance metrics are unavailable (Spears & Lamba 2016; Adukia 2017). The school dropout indicator acts as a proxy for school enrollment since children who have dropped out of school will not be enrolled. While there is some evidence of the impact of school latrines on girl enrollment (Garn et al. 2013; Adukia 2017), there is no literature that studies the impact of community sanitation environments on school enrollment. Ortiz-corea, Resende, and Dinar (2016) do find that community-wide sanitation improvements increase overall years of completed schooling. I use a linear probability model for this outcome variable, though results are similar when using probit and logistic regressions.

\text{Vil Latrine}_i \times \text{School Latrine}_i \times \text{Female}_i \times \text{Age}_{ijt}

Using the model from Equation (1), I include the full set of school-age children in the ASER data (ages 6–16). Included as controls is the child’s age, \text{Age}_{ijt}, and a vector of household characteristics, HHch, specifically whether the child’s mother attended secondary school (Black Devereux & Salvanes 2005; Carneiro Meghir & Parey 2013) and an index of household wealth discussed below. \theta_i represents village fixed-effects which control for time-invariant village characteristics and \delta_{kt} represents state (k) by year fixed-effects which control for state-level time trends. The ability to include village fixed-effects is an
important feature of ASER data, which allows for the control of many village-level confounding factors that may also affect educational attainment.

The ASER household survey includes a series of asset questions measuring household wealth. Rather than including multiple asset ownership indicator variables as a control, I used principal component analysis (PCA) to create an asset index for each household. The assets included in each index are: household latrines or toilets, electricity connection, televisions, and mobile phones. Using a PCA-created asset index is more appropriate than including separate asset variables when assets are correlated, which they are in the ASER data (Vyas & Kumaranayake 2006). Controlling for household sanitation is important to isolate the main effect of village-wide sanitation (Alderman Hentschel & Sabates 2003; Fuller et al. 2016); however, we also conduct a sensitivity analysis omitting household sanitation from the asset index and do not find significant differences in our main result (see Supplementary Tables 1A and 2A).

Data overview

I use annual ASER data from 2012, 2013, 2014, and 2016 (ASER data were not collected in 2015); I do not use earlier rounds of ASER data because information on school latrines was not collected prior to 2009 and the measurement for school dropout rates is inconsistent prior to 2012. As a result, I focus on the time period 2012–2016 in my analysis. For the math score outcome, I drop 2012 in the analysis since the metrics that ASER used to measure math scores changed in 2013. I drop any child observations in villages where data on usable female latrines in schools were missing, leaving a total sample size of 2,774,585 observations. Mother education was missing for certain households, so the total sample size drops to 2,597,011 observations when including those control variables.

As shown in Table 2, both village-level latrine coverage and the percentage of schools with usable girl toilets/latrines have increased dramatically over time between 2012 and 2016. These trends are also reflected in Figure 1 (which also shows pre-trends starting in 2009). The school dropout rate, on the other hand, does not appear to have changed over time. While the dropout rate is low (3.4% in 2016), ASER only measures if a student is officially not enrolled in school, and thus, this dropout rate does not capture low or no attendance among enrolled students.

RESULTS AND DISCUSSION

Table 3 contains the main results for the school dropout outcome variable from the different models of Equation (1) outlined in the previous section. In each of the models, village latrine coverage is associated with a lower school dropout rate. According to Model 1, moving from no village latrine coverage to full coverage is associated with a 3.3% in school dropout rates. The interaction between Village latrine coverage and Female also indicates that this effect is stronger for female children. This finding is consistent with other literature, suggesting that educational impacts of latrine coverage are more concentrated among female children (Garn et al. 2015; Adukia 2017; Orgill-Meyer & Pattanayak 2020).

Having a usable girls latrine in the school is only associated with a statistically significant reduction in school dropout rates in two models (columns 2 and 4). Moreover, the effect does not appear between female and male children. This finding suggests that overall village latrine coverage matters more for improving school enrollment than the presence of school latrines. Our main result, the additive effect of village latrine coverage and school latrines, represented by the interaction Village

Table 2 Summary statistics over time

| Variable                                      | % in 2012 (n = 392,440) | % in 2016 (n = 400,954) |
|-----------------------------------------------|-------------------------|-------------------------|
| Village latrine coverage                      | 40.3                    | 53.5                    |
| Schools with usable girl toilets/latrines      | 47.2                    | 60.4                    |
| Children (ages 6 and above) having dropped out of school | 3.4                     | 3.4                     |
| Child is female                               | 47.3                    | 48.4                    |
| Mother attended secondary school               | 50.2                    | 54.4                    |
| Household has electricity connection          | 75.6                    | 82.5                    |
| Household has TV                              | 48.8                    | 54.2                    |
| Household has mobile phone                    | 67.4                    | 80.2                    |
**Latrine Coverage × School Latrines**, is negative and statistically significant in the base model (column 1). However, the coefficient does not have statistical significance when including village fixed-effects and other controls (columns 2–4), suggesting no evidence of an additive effect. There are also no differences in this interaction by gender.

### Table 3 | Effect of latrine coverage and school latrines on school dropout rates

|                           | (1)               | (2)               | (3)               | (4)               |
|---------------------------|-------------------|-------------------|-------------------|-------------------|
| Village latrine coverage  | −0.033*** (0.001) | −0.044*** (0.004) | −0.010*** (0.004) | −0.009** (0.004)  |
| School latrine            | 0.000 (0.001)     | −0.006* (0.003)   | −0.001 (0.003)    | −0.005* (0.003)   |
| Female                    | 0.018*** (0.002)  | 0.010*** (0.002)  | 0.010*** (0.002)  | 0.011*** (0.002)  |
| Village latrine coverage  | −0.014*** (0.002) | −0.005** (0.002)  | −0.004** (0.002)  | −0.005** (0.002)  |
| School latrine × female   | −0.004 (0.003)    | −0.000 (0.003)    | −0.000 (0.003)    | −0.001 (0.003)    |
| Village latrine coverage  | −0.005*** (0.001) | 0.003 (0.006)     | −0.000 (0.005)    | 0.006 (0.005)     |
| School latrine × school latrine | 0.004 (0.003) | 0.001 (0.003) | 0.001 (0.003)  | 0.001 (0.003)  |
| Village latrine coverage  | 0.014*** (0.000)  | 0.014*** (0.000)  | 0.017*** (0.000)  | 0.013*** (0.000)  |
| School latrine × female   | 0.001 (0.003)     | 0.001 (0.003)     | 0.001 (0.003)     | 0.001 (0.003)     |
| Village latrine coverage  | 0.004 (0.003)     | 0.000 (0.005)     | 0.000 (0.005)     | 0.006 (0.005)     |
| Village latrine coverage  | 0.005*** (0.001)  | 0.003 (0.006)     | 0.005*** (0.001)  | 0.006 (0.005)     |
| Child age                 | 0.014*** (0.000)  | 0.014*** (0.000)  | 0.017*** (0.000)  | 0.013*** (0.000)  |
| Mother attended secondary school | −0.021*** (0.000) | −0.021*** (0.000) | −0.021*** (0.000) | −0.021*** (0.000) |
| Household asset index     | −0.014*** (0.000) | −0.014*** (0.000) | −0.014*** (0.000) | −0.014*** (0.000) |
| Constant                  | −0.096*** (0.001) | −0.093*** (0.002) | −0.099*** (0.002) | −0.095*** (0.010) |
| Observations              | 1,549,430          | 1,549,430          | 1,448,859          | 1,448,859          |
| $R^2$                     | 0.052              | 0.127              | 0.135              | 0.135              |
| Village FE                | No                 | Yes                | Yes                | Yes                |
| State × year FE           | No                 | No                 | Yes                | Yes                |

Robust standard errors in parentheses; standard errors clustered at the village level. School latrine is defined as having a usable female latrine in the school. ***p < 0.01, **p < 0.05, *p < 0.1.

**Figure 1** | Trends in latrine coverage (2009–2016).
Conducting the same analysis for each state in India reveals positive additive effects for only one India state: Kerala. This lack of additive effect at the state level further suggests that village latrine coverage and school latrines have independent channels of producing educational benefits. When looking at just the village latrine coverage effects on a school dropout rate, there is a lot of heterogeneity at the state level as depicted in Figure 2. This figure maps the coefficient for village latrine coverage for each state. The darkest shaded states have a large negative and statistically significant effect of village latrine coverage on school dropout rates, while the lightest shaded states have no statistically significant effect. Most of the literature on village/household sanitation has used absenteeism and attendance as the dependent variables (Rauniyar Orbeta & Sugiyarto 2011; Battiston et al. 2013; Dreibelbis et al. 2013; Park et al. 2015). This finding is the first that suggests that village-level latrine coverage also can have an impact on school dropout rates. For the most part, the larger effect sizes are concentrated in the relatively wealthier states (with some exceptions – Bihar has a small but significant effect size), suggesting a possible threshold effect.

Table 4 depicts the same models with math scores as the dependent variable. Recall that math scores are being used as a proxy for attendance/absenteeism which is not captured in the ASER data. In the base model (column 1), both village latrine coverage and school latrines are associated with higher math scores, though these coefficients

![Figure 2](https://iwaponline.com/washdev/article-pdf/doi/10.2166/washdev.2020.049/695382/washdev2020049.pdf)
lose significance when including fixed-effects and other controls. Similar to the school dropout outcome, the effects of having higher village latrine coverage on math scores are higher among female children (consistent across all four models). However, there are no differential impacts of having school latrines by gender. Finally, there does not appear to be a statistically significant effect on the interaction of village latrine coverage and school latrines; nor do these coefficients differ by gender.

Taken together, there does not appear to be strong evidence of either an additive effect of village-level latrine coverage and school latrines on educational outcomes for either girls or boys. This lack of significance in the interactions between school and village latrines suggests that the channels through which village latrine coverage and school latrines affect educational outcomes are independent. While there does not appear to be support for an additive effect among school latrines and village latrine coverage, village-level latrine coverage does appear to consistently be associated with improved educational outcomes – reduced dropout rates and higher math scores – particularly among female children. This finding is significant when considering the economic gains that female education produces (Knowles et al. 2002); an important policy lever to achieving such gains could be to improve the overall sanitation environment.

This study also faces a number of limitations. The changes in how ASER data measured school dropout and math scores restrict the number of years in the analysis. Further, the sampling strategy used by ASER produces an unbalanced panel at the village level and repeated cross-sections at the household level. As a result, the analysis can utilize village fixed-effects which control for time-invariant level factors but cannot use household fixed-effects. Controlling for maternal education and household wealth, two factors that contribute to child educational attainment, allows for the elimination of some omitted variable bias, but the analysis still does not produce fully causal results.

### CONCLUSIONS

This paper uses a large dataset from India to analyze the effect of the interaction of village-level latrine coverage and school-based latrines on child educational outcomes. There does not appear to be strong evidence for an additive effect of village and school latrines on school dropout rates or math test scores. All models explored in this paper

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**Table 4 | Effect of latrine coverage and school latrines on math scores**

|                          | (1)            | (2)            | (3)            | (4)            |
|--------------------------|----------------|----------------|----------------|----------------|
| Village latrine coverage | 0.503*** (0.018) | 0.377** (0.225) | 0.245 (0.222)  | −0.006 (0.269) |
| School latrine           | 0.061*** (0.013) | 0.117 (0.184)  | 0.094 (0.176)  | 0.008 (0.176)  |
| Female                   | −0.153*** (0.019) | −0.129*** (0.015) | −0.134*** (0.016) | −0.133*** (0.016) |
| Village latrine coverage × female | 0.081*** (0.021) | 0.058*** (0.016) | 0.059*** (0.017) | 0.059*** (0.017) |
| School latrine × female  | −0.003 (0.028)  | −0.012 (0.023)  | −0.006 (0.024)  | −0.006 (0.024)  |
| Village latrine coverage × school latrine | 0.009 (0.024)  | 0.023 (0.334)  | −0.062 (0.321)  | 0.065 (0.319)  |
| Village latrine coverage × school latrine × female | 0.022 (0.030)  | 0.030 (0.024)  | 0.024 (0.025)  | 0.025 (0.025)  |
| Child age                | 0.262*** (0.001) | 0.259*** (0.001) | 0.261*** (0.001) | 0.261*** (0.001) |
| Mother attended secondary school | 0.228*** (0.005) | 0.227*** (0.005) | 0.228*** (0.005) | 0.227*** (0.005) |
| Household asset index    | 0.163*** (0.004) | 0.162*** (0.004) | 0.162*** (0.004) | 0.162*** (0.004) |
| Constant                 | −0.716*** (0.012) | −0.678*** (0.010) | −0.641*** (0.098) | −0.425*** (0.126) |
| Observations             | 329,689         | 329,689         | 310,038         | 310,038         |
| R²                       | 0.309           | 0.534           | 0.550           | 0.550           |
| Village FE               | No              | Yes             | Yes             | Yes             |
| State × year FE          | No              | No              | No              | Yes             |

Robust standard errors in parentheses; standard errors clustered at the village level. School latrine is defined as having a usable female latrine in the school. ***p < 0.01, **p < 0.05, *p < 0.1.
produce positive associations between village-level latrine coverage and educational outcomes – lower dropout rates and higher test scores, particular for female children. The relationship between school latrines and educational outcomes appears weaker.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this paper is available online at https://dx.doi.org/10.2166/washdev.2020.049.

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