Sanitation and Education*

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Abstract

One in five children worldwide does not complete upper-primary school, with particularly high drop-out rates among pubescent-age girls that may limit economic opportunities and perpetuate gender inequality. This paper tests whether educational attainment is stymied by endemically inadequate school-sanitation infrastructure that threatens children's health, privacy, and safety. Using annual school-level data from India, disaggregated by student sex and grade, I compare schools that receive sanitation infrastructure during a national school-latrine-construction initiative to similar schools using a differences-in-differences empirical methodology. I estimate that latrine construction increases enrollment of all students. At younger ages, girls and boys both benefit substantially from a latrine, regardless of whether it is unisex or sex-specific; at older ages, however, separate latrines become crucial. Pubescent-age girls do not benefit from unisex latrines, and their enrollment increases substantially after the construction of separate sex-specific latrines. These effects persist at least three years after construction, in contrast to the impact of many educational interventions that fade over time. Investments in school sanitation support education of pubescent-age girls, yet that focus should be expanded to reflect the importance of health, safety, and privacy for pubescent-age boys and younger children as well.

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Worldwide, one in five children of upper-primary-school age are out of school, including one in four children in South Asia (UNESCO 2010).[1] Girls in developing countries disproportionately drop out of school, particularly around puberty, which some have attributed to the lack of school sanitation facilities for menstruating girls (Herz and Sperling 2004, Moojiman *et al.* 2005, Sommer 2010).[2] Education provides opportunities for upward economic mobility (Becker 1962, Angrist and Krueger 1991, Ashenfelter *et al.* 1999, Card 1999, Duflo 2001, Oreopoulos 2007), and gender equality in education and economic opportunity has been associated with a broad range of social and economic benefits (Schultz 1993, Summers 1994, Lavy 1996, Behrman *et al.* 1999, Dollar and Gatti 1999, Glewwe 1999, Barro 2000, Beaman *et al.* 2009, Duflo 2012).[3] The Millennium Development Goals reflect a call from the international policy community to expand access to education and to address a gender gap in enrollment that is particularly pronounced among adolescents.[4]

Investments in child health can improve educational outcomes (Miguel and Kremer 2004, Bleakley 2007, Weil 2007), though health needs often differ dramatically by gender and age. The "Menstruation Hypothesis" is that menstruation creates an obstacle to female schooling, contributing to high drop-out rates among pubescent-age girls. This belief has motivated efforts to provide sex-specific sanitation in schools, which could increase girls' health, privacy, and safety (Fentiman *et al.* 1999, Burgers 2000, Human Rights Watch 2001, Leach *et al.* 2003, Lidonde 2004, WaterAid Ethiopia 2005, Kirk and Sommer 2006, INEE 2009, CARE 2010, Raising Clean Hands 2010, Sommer 2010, WHO 2010).

Qualitative studies often indicate important impacts of school sanitation on girls' enrollment (Birdthistle *et al.* 2011), yet there is little quantitative support for the "Menstruation Hypothesis" (Oster and Thornton 2011).[5] While the quantitative evaluation of menstruation-management technologies may show no benefits where school absences are rare during girls' few menstrual days each month (Oster and Thornton 2011), a broader "Menstruation Hy-

[1] "Upper-primary school" refers to grades six, seven, and eight. It is categorized as UNESCO's International Standard Classification of Education (ISCED) Level 2 and is also known as middle school or lower-secondary school.

[2] Approximately 25 percent of girls in the world do not complete primary school, compared with 15 percent of boys (UNICEF 2003).

[3] Education may support economic growth at a national level (Schultz 1961, Nelson and Phelps 1966, Krueger 1968, Psacharopoulous 1984, Lucas 1988, Barro 1991, Mankiw *et al.* 1992, Benhabib and Spiegal 1994, Barro and Sala-i-Martin 1995, Aghion *et al.* 2009), though these impacts may be overstated (*e.g.,* Bils and Klenow 2000).

[4] The Millennium Development Goals were established at the Millennium Summit of the United Nations by the World Bank, the United Nations, the 189 UN member states, and at least 23 international organizations in 2000 (WHO 2004).

[5] Kremer (2012) expresses skepticism that school latrines impact girls' enrollment, referencing Oster and Thornton's finding of no impact on school attendance from providing menstrual cups to girls in four schools in Nepal, though Kremer mainly emphasizes the need for evidence from additional settings.

pothesis" might emphasize how girls are impacted every day by the physical, emotional, and societal changes that happen along with the onset of menstruation. Pubescent-age girls' educational decisions may be more impacted by addressing every-day concerns for health, safety, and privacy, such as through the provision of sex-specific school latrines. In addition, a narrow focus on the "Menstruation Hypothesis" might neglect other factors that influence education decision-making for pubescent-age boys and younger children, obscuring a broader link between school sanitation and education.

In this paper, I examine how improving the school environment through latrine construction influences the educational decisions of both girls and boys across different ages. Using annual school-level data from India, disaggregated by student sex and grade, I compare schools that receive latrines during a national school-latrine construction initiative to similar schools using a differences-in-differences empirical methodology. I find that school sanitation increases enrollment of pubescent-age girls, particularly when providing sex-specific school latrines, and that sanitation also benefits pubescent-age boys and younger children. As India is home to 25 percent of the world's out-of-school children (World Bank 2002), with large gender gaps among adolescents, there are substantial potential impacts from expanding and re-directing policy efforts in India. More broadly, this large-scale policy initiative provides the first systematic empirical view of the link between school sanitation and education outcomes.

I use administrative data that I obtained from the Indian government, which provide a large sample of schools throughout the country. These data include periods prior to those now widely-released by the Indian government.[6] I explore how school sanitation influences educational attainment by estimating how school-latrine construction impacts student enrollment.[7] Further, I estimate how the impacts of unisex and sex-specific latrines vary by student sex and grade. Finally, I examine student achievement on state board exams.

In exploring linkages between school sanitation and education, the primary empirical challenge is that schools with latrines may differ systematically from schools without latrines. This cross-sectional selection bias can be overcome using the Indian government's latrine-construction initiative in 2003: estimating changes in schools that received a latrine in 2003, relative to schools that did not receive a latrine. The remaining empirical concern, however, is that government officials may have targeted schools that would have changed differently even in the absence of latrine construction. The institutional details cast doubt on

[6]To understand these data and better match data across years, I accompanied post-enumeration survey teams on school visits.

[7]Student enrollment is measured three months into the school year, which better reflects school attendance than pre-term enrollment. I also look at effective enrollment, as measured by appearance for state board exams.

officials' capacity to allocate latrines to schools that would otherwise have increased student enrollment.

Much of the empirical analysis is concerned with the potential for schools that received latrines to have otherwise changed differently. The empirical analysis focuses on comparing initially-similar "treatment" and "control" schools, either by controlling for initial school characteristics or by matching on initial school characteristics. The main empirical assumption is that new latrine construction is uncorrelated with other changes after 2003, conditional on school fixed effects, district-year fixed effects, and the included school-level controls interacted with year. I also explore using alternative comparison groups, such as comparing schools that received a latrine in 2003 to schools that received a latrine shortly thereafter. I further probe robustness by accounting for changes in other school infrastructure, limiting the sample to villages with only one school to avoid displacement effects, restricting the sample to strictly-coeducational schools, and quantifying potential mean-reversion bias.

I estimate that school latrines positively impact all students. Access to school sanitation increases student enrollment and lowers dropout. These changes are also reflected in the number of students who show up and pass the middle-school board exam.[8] In contrast to the impact of many educational infrastructure interventions that fade out over time, I find that the impact of latrines on enrollment is still present or even slightly stronger three years later.[9] These persistent results are particularly striking, as the latrine-construction initiative did not specifically target latrine maintenance.

To explore the mechanisms behind these impacts, I test some implications of the "Menstruation Hypothesis." I find that latrines generally increase female enrollment more than male enrollment. Latrine type matters greatly, however. Unisex latrines have a greater impact on pubescent-age boys than pubescent-age girls. Pubescent-age girls benefit little from a unisex latrine but benefit greatly from sex-specific latrines.[10] Privacy and safety appear to matter sufficiently at older ages that school sanitation only reduces gender disparities with the construction of sex-specific latrines; by contrast, the construction of unisex latrines exacerbates gender disparities at older ages.

Inconsistent with a narrow focus on pubescent-age girls and menstruation, I find that

[8]Impacts on student achievement reflect the net effect of the introduction of a school latrine: new students may perform well on the exams; previous students may perform better due to improvements in the school environment; and/or previous students may perform worse due to overcrowding.

[9]The direct impacts of educational interventions often fade out over time (Krueger and Whitmore 2001, Kane and Staiger 2008, Jacob *et al.* 2008, Almond and Currie 2011), though there may remain long-term benefits for students (Chetty *et al.* 2011).

[10]Concerns about selection bias may be exacerbated when considering the impact of latrines of different types, though a central part of the empirical analysis will be to analyze the data in different ways to address related concerns.

younger girls (and boys) experience larger benefits than pubescent-age girls (and boys). The large impact of sanitation on younger children suggests that latrines have important impacts through child health, particularly as unisex latrines are mostly sufficient at younger ages. Sex-specific latrines have some additional impacts at younger ages, which is consistent with concerns of bullying at younger ages for both boys and girls.

As an additional potential mechanism through which sanitation impacts education, I look at whether latrines affect students through increased female teacher attendance. Female teachers may be more often absent from schools that lack sanitation facilities (Chaudhury *et al.* 2005, Moojiman *et al.* 2005). I show that the impact of latrines is not generally higher in schools that had a higher initial share of female teachers, which suggests either that female teachers did not reduce their absenteeism relative to male teachers or that female teachers' work attendance did not impact student enrollment.[11] I do find that school-latrine construction increases the share of female teachers at schools, especially when sex-specific latrines are built, which may disproportionately benefit female students and encourage their enrollment.[12]

Using the broad geographic scope of my data, I examine whether the impact of latrines varies with proxies for local gender norms and wealth. These estimates help understand how the impact of latrines might vary across different settings worldwide, based on the substantial variation in social and economic conditions within India.[13] Estimates suggest there is not much systematic difference in impacts across districts with different average income. There are some indications that the impact of latrines is larger in areas that otherwise have greater gender parity, perhaps because other conditions are more suitable to increasing female education. However, the impact of latrines remains substantial even in contexts with lower gender parity within India.

Overall, the results highlight how every-day concerns over health, privacy, and safety influence educational decision-making for girls and boys of different ages. School latrines have the potential to improve gender parity at older ages, but the construction of sex-specific latrines is necessary for older girls. Sex-specific latrines also benefit children at younger ages, but unisex latrines may be sufficient for younger children when resources are scarce. While substantial sums are being spent on school sanitation, it is useful to know how

[11] The analysis of female teachers is limited to smaller samples, however, which might not detect important effects.

[12] In some schools, teachers use separate faculty facilities; in other schools, teachers share the same facilities as the students. The presence of student latrines could also serve as a signal of a better working environment for female teachers.

[13] The variation across sample districts, comparing districts with average income at the 10th and 90th percentiles, is comparable to variation across countries between the 5th and 25th percentiles of the world income distribution (*e.g.*, Rwanda and Nepal vs. Georgia and Ukraine).

scarce resources might be directed to maximize their desired effect.

In considering the importance of school sanitation, a broader view is needed than the current emphasis on pubescent-age girls and the "Menstruation Hypothesis." School sanitation has large effects on younger girls and boys, which is often neglected in the focus on pubescent-age girls. Impacts on younger children are particularly important given the critical role of early childhood education in cognitive development.

Many primary schools and upper-primary schools worldwide lack sanitation facilities, but there is a growing resolve from governments and NGOs to invest in school-latrine-construction initiatives. Amidst the current focus on improving infrastructure in developing countries, it is important to remember basic needs. On the basis of empirical estimates from India's national initiative, efforts to improve sanitation worldwide might be expanded and re-directed to increase their impact. While there are many deep roots to problems of gender inequality, improving school sanitation is one opportunity to increase gender equality for pubescent-age girls. School sanitation has broader impacts on pubescent-age boys and younger children, however, which suggests a central role for improving health, privacy, and safety in increasing educational attainment worldwide.

I Policy Context

I.A Education and Basic Needs in India

India is home to 25 percent of the out-of-school children in the world, with over 20 million children not enrolled in school (World Bank 2002). Girls are disproportionately not in school, which is of tremendous concern to policy-makers because of the sense that childhood access to education shapes adults' economic and social lives.[14] The Millennium Development Goals identified eight priorities for improving the lives of the world's poorest people, which included the elimination of gender disparity in education. There was a particular focus on educating pubescent-age girls, who experience the highest drop-out rates.[15]

Improved school sanitation may help accomplish several of the Millennium Development Goals. Increasing school sanitation may help achieve universal primary education (Goal 2), and increases in education of girls would help promote gender equality (Goal 3). School latrines help to contain waste in otherwise high-risk areas, combating disease and encour-

[14] A UNICEF (2004) report cites statistics that educated girls are much less likely to die in childbirth and experience much lower infant mortality rates. Literate women tend to have families that are smaller, healthier, and wealthier (Summers 1992). Female education is even associated with higher average economic growth (Dollar and Gatti 1999).

[15] In India, the net enrollment ratio (defined as the total enrollment of school-aged children divided by population of school-aged children) of upper-primary-school students in 2005-06 was 43 percent (MSPI 2006) and of primary-school students in 1997 was 77 percent (MHRD 1997). In 2000, the drop-out rate among primary-school children was 55 percent (52 for boys, 58 for girls), and the drop-out rate among upper-primary-school children was 68 percent (67 for boys, 71 for girls) (MHRD 2000).

aging environmental sustainability (Goals 6 and 7). By encouraging students to eat and drink at school, and by lowering the incidence of water-related diseases that inhibit nutrient absorption, school latrines may also help reduce hunger (Goal 1).

In the year 2000, the Indian government began promoting universal primary education through the *Sarva Shiksha Abhiyan* (SSA) program. Government officials realized that basic needs may prevent traditionally-disadvantaged children from going to school. Indian government policy began to focus on providing basic needs through schools, such as food and clothing. One identified basic need was access to sanitation facilities, which might be provided to large effect through the construction of school latrines.

In India, roughly half of schools lacked basic sanitation facilities in 2002.[16] A natural question is why so many schools continued to lack sanitation facilities. A majority of the schools in my field visits did not have sanitation facilities available to students, and during my interviews, headmasters expressed a common sentiment that children followed regimented hygiene routines that did not require them to need sanitation facilities during the school day.[17] By contrast, in my interviews with children, access to latrines was an important issue that affected their education.[18] In the absence of government support and the provision of resources, schools may not be particularly responsive to the needs of traditionally-disadvantaged children.

I.B A Large School-Latrine-Construction Initiative in India

Sanitation has been an important part of the national agenda in India for the past 60 years, beginning with India's first "five-year plan" in 1951. Only 1 percent of households in rural India had latrines in 1981, which increased to 9 percent by 1991, 22 percent by 2001, and 44 percent in 2011 (Census of India 1991, 2001, 2011). Much of this recent increase can be attributed to the Indian government's Total Sanitation Campaign (TSC), which was launched in 1999.

The School Sanitation and Hygiene Education program (SSHE) was an important component of the TSC, which emphasized school sanitation as a mechanism to bring about broader social change in sanitation practices.[19] The primary goal of the SSHE program was to increase school latrine coverage in rural areas to 100 percent for two main purposes: (1)

[16]By contrast, in OECD countries, all schools are supposed to have latrines and, in particular, sex-specific latrines (Inter-Agency Network for Education in Emergencies 2009, Lang 2010).

[17]Mariel Snel from the International Rescue Committee (2003) calls this "innocent ignorance," the idea that decision-makers are well-intentioned but uninformed of the benefits of sanitation.

[18]I discuss further details on the qualitative-research methods, locations, and participants in the Data Appendix.

[19]There is a tradition of viewing schools as a concentrated setting to influence social change (see, *e.g.*, Goldstein 1995, Davis *et al.* 2002, Onyango-Ouma *et al.* 2005, Mwanga *et al.* 2008), and this feature was central to the design of the SSHE program (Snel 2003).

creating a healthier environment through the elimination of open defecation, reducing disease and worm infestation; and (2) reducing security risks for girls attending school, particularly for pubescent-age girls.[20]

In 2003, the national government began committing substantial financial resources to support widespread school-latrine construction.[21] Resource constraints meant that the program was rolled out gradually over the subsequent decade. In Figure 1, I present the number of school latrines built in each year between 2001 and 2006, as recorded by the Indian Ministry of Drinking Water and Sanitation. The number of schools building latrines was similar in academic years 2001-02 and 2002-03, but the number of schools building latrines increased substantially in academic year 2003-04 due to increased resources from the SSHE program. My school-level data do not indicate whether latrines were constructed through the SSHE program or through other means, but the impacts of latrine construction after 2002-03 will mainly reflect the efforts of the SSHE program.

The national government provided resources to state governments, which in turn implemented the latrine construction through local district governments.[22] Districts varied in their implementation of latrine construction: some districts attempted to prioritize schools with the greatest demonstrated need, some districts claim to have followed a lottery-style selection process, and other districts simply began by constructing latrines in schools closest to the district office (DDWS 2007).

Some schools may have received resources for latrine construction based on a sense of their initial enrollment. For example, some districts granted funds for one additional latrine to be constructed for every 120 students enrolled. Data challenges are substantial in India, however, both for researchers and government officials. At this time, prior to the widespread release of DISE data (discussed below), many district governments would not know how

[20]The "Hygiene Education" portions of the SSHE program received many fewer resources. Hygiene education was implemented sporadically and generally took the form of printed handouts distributed to teachers or posters displayed on walls. The primary hope was that constructing school latrines might encourage general latrine usage through habit formation. For example, in the state of Odisha, efforts to promote handwashing were mainly confined to delivering schools a bucket and a cup for the directed purpose of handwashing.

[21]By contrast, in the first few years, limited financial support from the national government had constrained progress.

[22]It has not been possible to obtain systematic data on SSHE program roll-out, but there are some illustrative cases drawn from state and district field reports. In 2000, the Government of India selected 67 districts from 22 states to pilot components of the Total Sanitation Campaign. Five districts in Madhya Pradesh received funds for TSC-related projects in 2000 (Rs. 3900 Lakhs), three additional districts received TSC funds in 2002 (Rs. 3900 Lakhs), and the remaining 37 districts in MP were given TSC funds in 2003 (Rs. 34400 Lakhs). In the Alwar district of Rajasthan, the SSHE program was first piloted in 5 blocks and then extended to all 14 blocks by 2003, covering over 1600 primary and middle schools. By contrast, in the Cuttack district of Odisha, district officials did not start latrine-construction efforts until 2005. While headmasters were given advanced funds to build a school latrine by the Rural Water Supply and Sanitation department, they were given no time frame within which they had to have started latrine construction.

many schools were in their district and were in little position to know which schools had latrines or greater initial enrollment (Aggarwal 2001). These features of the Indian context give some additional confidence that schools were not receiving latrines based on detailed projections of increased student enrollment or changes in gender composition.

School-latrine construction through the SSHE program was generally managed by water and sanitation government departments, rather than by education officials. Schools received additional resources for school latrines with no explicit tradeoff in other educational inputs, and I have seen no accounts of an informal tradeoff between receiving a latrine and receiving other resources.[23]

The SSHE program was a part of the broader Total Sanitation Campaign, but the construction of school latrines was not explicitly combined with local efforts to improve household sanitation. Further, household latrines built through the Total Sanitation Campaign have been found to increase the health and cognitive skills of infants but not of school-age children (Spears 2012). Impacts in early childhood may eventually impact school-age outcomes (see, *e.g.*, Almond and Currie 2011), but would not generally appear within the sample period analyzed in this paper.

I.C Potential Impacts of School-Latrine Construction

Similar initiatives to the SSHE program in India have been implemented in six other countries (Burkina Faso, Colombia, Nepal, Nicaragua, Vietnam, and Zambia), but there has been no quantitative empirical evaluation of large-scale latrine-construction initiatives (Snel 2003, Bolt *et al.* 2006, Birdthistle *et al.* 2011). Nonetheless, a wide body of research suggests reasons why school latrines may be important for educational outcomes, particularly for pubescent-age girls.

One commonly-discussed concern is that pubescent-age females may leave school, in part, due to stigma and threats associated with menstruation and the lack of private sanitation facilities (Fentiman *et al.* 1999, Burgers 2000, Human Rights Watch 2001, Leach *et al.* 2003, WaterAid Ethiopia 2005, Kirk and Sommer 2006, Raising Clean Hands 2010, WHO 2010).[24] Pubescent-age females may be disinclined to use public spaces as latrines due to privacy concerns and embarrassment or the threat of verbal and physical harassment (Human Rights Watch 2001, UNICEF 2005, Leach *et al.* 2003).[25] The absence of latrines may discourage

[23] In extensions to the main empirical analysis, I do not estimate that schools receiving latrines thereby received differential support along other dimensions. Robustness checks control for changes in other measures of school infrastructure.

[24] Lidonde (2004) claims that the absence of latrines discourages ten percent of school-age African females from attending school during their menstruation days, which leads to an increased likelihood of falling behind in class and then dropping out of school. Another study in western Kenya reports that access to proper water and sanitation facilities reduced school absenteeism in girls by 37 percent (CARE 2010).

[25] Female workers of menstruating age exhibit higher absenteeism and lower wages than comparable men

females from attending school while menstruating, though the direct impact of menstruation on absenteeism may also be overstated (Mensch and Lloyd 1998, Oster and Thornton 2011, Rockoff and Hermann 2012).[26]

In the absence of school latrines, safety concerns may discourage parents from enrolling their pubescent-age daughters in school. Beyond the direct safety benefits of latrines, the presence of a school latrine may signal to parents that the school is dedicated to protecting their child's safety and dignity (Human Rights Watch 2001, Nekatibeb 2002, Snel 2003, Kirk and Sommer 2006). These effects may be particularly important for communities worldwide that place a cultural premium on privacy and modesty during a girl's menstrual cycle.

If safety and privacy are primary concerns, it may be most important to have access to separate, sex-specific latrines, especially for pubescent-age girls, rather than simple access to unisex school latrines (UNICEF and IRC 1998, Burgers 2000, Leach *et al.* 2003, IRC 2005, Sommer 2009, Raising Clean Hands 2010). For example, girls were observed missing school during their menstrual periods when their school latrines lacked a door (WaterAid 2004). By contrast, female school attendance increased by 11 – 15 percent following the provision of separate sanitation facilities to girls in Bangladesh (WHO 2001, UNICEF 2005). When females have to share latrines with males, or otherwise seek private spaces away from the school, they risk harassment or assault from male classmates and teachers (Mensch and Lloyd 1998, Burgers and Tobin 2003, Abrahams *et al.* 2006, Kirk and Sommer 2006).[27]

During my field work, young girls highlighted safety and privacy concerns during interviews at their homes. One 12-year-old discussed her passion for school but that she failed out because of her absence due to monthly menses during mandatory exams that could not be retaken. My visits to schools revealed an absence of private locations for students to relieve themselves. When I asked about where students could go to the restroom, they often pointed to various places on the school premises such as behind a school sign, next to the building, or behind trees. One young female recounted a story of a friend who was sexually assaulted while urinating behind bushes. She described an atmosphere of fear where males would target females who were isolated from view, which discouraged her and her friends

and older females (Ichino and Moretti 2009).

[26]For example, Oster and Thornton (2011) studied girls in four schools in one Nepali district and found that they were not more likely to miss school during their periods and that the provision of menstrual cups had no effect on their attendance. However, the physical, emotional, and societal changes that happen along with the onset of menarche impact girls every day, whereas menstrual-management technologies can only benefit girls for a few days each month. Technology that provides every-day protection, safety, and privacy (such as a latrine with walls and a door) may have greater impacts on female educational decisions.

[27]To clarify, unisex latrines can either take the form of a set of doorless latrines in an open room or individual stalls that can be used either by boys or girls. In the former, a girl would be physically exposed any time she chose to urinate or defecate. In either instance, however, a girl could be isolated by a boy and sexually harassed or assaulted.

from eating, drinking, and relieving themselves during the school day.

While the literature often focuses on girls, there are also reasons why boys would also be affected by access to latrines. Boys may be intimidated to use open urinals in the presence of others (Moore and Frost 1986) and also face the threat of harassment and molestation at school (Mensch and Lloyd 1998, IRC 2005). A psychology literature emphasizes that boys also care about privacy, both at puberty and younger ages (Brown and Larson 2009). Boys express fear of being teased and bullied when using latrines (Moore and Frost 1986, Vernon *et al.* 2003, Njuguna *et al.* 2009). Boys may be more likely than girls to be victims of bullying, and primary school children are more likely to be victims of bullying than adolescents (Boulton and Underwood 1992, Whitney and Smith 1993).[28]

Access to school latrines may also affect boys and girls through health channels, particularly for children of younger ages. If the absence of a school latrine causes children to refrain from eating or drinking during the day, the resulting discomfort and malnourishment or dehydration may worsen education outcomes (WHO 2004). Prolonged avoidance of urination or defecation can cause urinary-tract infections, incontinence, or constipation (Hellstrom *et al.* 1991, Taylor 2000, Vernon *et al.* 2003, Lundblad and Hellstrom 2005). A lack of waste containment around schools makes children, especially younger children, more susceptible to pathogen-based diseases.[29] A lack of latrines can cause the contamination of groundwater and surface soil, contributing to worm-related infections that interfere with learning, cognition, and growth (Nokes *et al.* 1992, Crompton and Nesheim 2002, Raising Clean Hands 2010). Improved child health is often reflected in better educational outcomes (Miguel and Kremer 2004, Glewwe 2005, Glewwe and Kremer 2006, Spears and Lamba 2012), as many school days are missed due to water-related illnesses (UNDP 2006).

[28]During my field work in India, males never indicated "safety," "privacy," or "sanitation" as a reason for dropping out of school. Typical responses were related to working, moving, health problems, or family responsibilities. These responses may reflect males' unwillingness to acknowledge these concerns or may reflect interviewer bias because I am a female, and young males may not have wanted to discuss privacy or safety concerns with me. However, boys (and girls) were more willing to share anecdotes about boys they knew being harassed or assaulted, either by other boys or by teachers. These stories are corroborated by newspaper accounts of physical and sexual bullying of boys in schools worldwide (*e.g.*, The Straits Times 1999, Daily Post 2003, Razak 2006, Sikand 2011, Express News Service 2011, Western Morning News 2011, Burke and Lestch 2013). Incidents of sexual assault are vastly under-reported, especially those where children are the victims (AACAP 2011), so these accounts only provide a glimpse at the problem.

[29]Latrines concentrate and manage waste, thus reducing water contamination and soil pollution and improving public health (Bradley 1977, Alvarez *et al.* 1990, Payment and Franco 1993, Emerson *et al.* 2004). Examples of pathogens that can be managed by the provision of adequate sanitation facilities include *Salmonella typhi*, *Shigella* spp., Hepatitis A Virus, Hepatitis E Virus, *Helicobacter pylori*,and *Schistosoma* spp. (Pond 2005). Inadequate sanitation is estimated to account for roughly half of all hospitalizations in the developing world (Nath *et al.* 1999, Black *et al.* 2003, Kosek *et al.* 2003). Examples of such health problems include diarrhea (Nath *et al.* 1999, Burgers 2000), blinding eye-trachoma (Burgers 2000, Kuper *et al.* 2003, Emerson *et al.* 2004, Cumberland *et al.* 2005), typhoid fever (Alvarez *et al.* 1990), and Hepatitis A (Rajaratnam *et al.* 1992).

School latrines may also impact student enrollment, especially female enrollment, through direct impacts on female teachers. Teachers may be more likely to work at schools, or show up for work at schools, when those schools have a functioning latrine (Burrows *et al.* 2004, Chaudhury *et al.* 2005, WaterAid Ethiopia 2005). Teacher absenteeism, and female-teacher absenteeism in particular, has been seen to greatly reduce school attendance of girls and have less impact on boys (Banerjee *et al.* 2000). The presence of female teachers is generally thought to increase girls' enrollment (Herz *et al.* 1991, Rugh 2000, World Bank 2001), potentially by providing role models and increasing girls' safety (Nixon and Robinson 1999, WaterAid Ethiopia 2005, Kirk and Sommer 2006). Parents in some conservative communities do not allow their daughters to be taught by a male teacher due to safety concerns (Brock and Cammish 1997, Nekatibeb 2002). Some girls also fear sexual harassment by male teachers and feel safer with female teachers (Mensch and Lloyd 1998, Fentiman *et al.* 1999, Human Rights Watch 2001, Jewkes *et al.* 2002, Nekatibeb 2002, Leach *et al.* 2003, IRC 2005, Abrahams *et al.* 2006).

I.D Research Questions

Every-day concerns over health, privacy, and safety can influence educational decision-making differently for girls and boys of different ages. In this paper, I test whether educational attainment is impeded by endemically inadequate school sanitation that threatens children's health, privacy, and safety. Specifically, my main analysis examines how school-latrine construction impacts student enrollment. I look at differential impacts by gender and age. Beyond changes in enrollment, I look at impacts on achievement outcomes from state board exams. I also examine the persistence of impacts over time.

To try to understand the mechanisms underlying these impacts, I explore whether these estimates are consistent with the "Menstruation Hypothesis." In particular, I consider differential impacts by latrine type. Some schools received resources to build sex-specific latrines, whereas other schools received resources to build unisex latrines. In an extension of my initial analysis, I estimate the importance of latrine type for girls and boys of pubescent-age and at younger ages. These differential impacts help illustrate potential mechanisms, such as privacy and health, but are also of practical importance in deciding where to direct scarce resources.

As an additional exercise to help understand the mechanisms, I look at the impact of latrine construction on the share of female teachers.[30] I also explore whether enrollment effects are larger in schools with more female teachers initially, which might reflect increased female teacher attendance.

[30]Work by Chaudhury *et al.* (2005) indicates that one reason female teachers may be absent from school is due to the absence of sanitation facilities.

An important advantage to studying a national policy initiative, in combination with a large administrative dataset, is that it is possible to explore geographic heterogeneity in the effects across states and districts. In particular, I examine how the impact of latrines varies across contexts with different cultural norms and average income. Comparing estimates from different parts of India can help inform how the relationship between sanitation and education might vary across developing countries worldwide.

II Data Construction

II.A DISE Data Collection

The main dataset is drawn from the *District Information System for Education* (DISE) database, which can be used to create an annual school-level panel dataset in India.[31] For each year, these data include: the number of enrolled students by sex and age, the presence of latrines by latrine type, other measures of school infrastructure, the number of teachers by sex, and examination outcomes for middle-school board exams.

The Indian government currently only makes DISE data widely-available for years after 2005, but I was able to obtain and clean the raw data from earlier years.[32] DISE data collection was initiated as a pilot in 1995, but systematic data-collection mechanisms were not established until 2001. While schools move in and out of the sample in some years, particularly in early years, I have been able to construct a large, continuous panel of schools for academic years 2002-2003, 2003-2004, and 2005-2006. Note that, for simplicity, I will refer to academic years by the year in which the fall term occurs (*e.g.*, academic year 2002-03 is 2002).

Limiting the analysis to these three years reflects a trade-off between a larger balanced panel of schools and more time periods. Data from before 2002 have much more limited coverage of schools. Data from after 2005 often cannot be matched to schools in earlier periods, which exacerbates concerns about attrition and sample selection. Most of the data from 2004 was lost due to a server error in India. Data from these three periods allow a comparison of schools before and after the first large wave of school-latrine construction and permit an analysis of whether initial effects persist three years later. It is useful to focus on these first waves of data because, as SSHE program resources were increasingly spent, the

[31] DISE was established by the Ministry of Human Resource Development of the Government of India and UNICEF. It is administered by The National University of Educational Planning and Administration (NUEPA).

[32] The largest data-cleaning challenge was in matching school codes to create a panel dataset, as the original school codes could only be matched from year to year through a separate crosswalk. The given school codes do not necessarily match the same school from one year to the next. Each digit of the school code corresponds to geographic info about the school such as its state, district, block, and village. The school code changes when boundaries between towns and districts (or even states) shift, thus needing to be matched via a separate master village list.

sample of schools that still lacked latrines may have become increasingly selected.

DISE data are intended to cover all registered primary and upper-primary schools.[33] There are surely schools missing from the data in each year, however, given the fluctuation in when schools are included. The main analysis uses a three-year panel dataset of 121,206 primary schools (grades one through five) and 17,796 upper-primary schools (grades six through eight) that are observed in each year. The primary school sample covers between 13.6 million and 13.8 million students in each year, whereas the upper-primary school sample covers between 1.8 and 2.0 million students. Initial power calculations suggest that my sample is more than sufficient to detect the impacts of latrines on student enrollment.[34]

It is logistically challenging to collect data from throughout India, but the DISE data reflect a careful multi-state data-collection process. First, school headmasters answer a nationally-standardized survey-questionnaire. Second, cluster officials verify responses for completeness and accuracy. Third, district officials aggregate the data and check it for computational and consistency errors. Fourth, state-level officials conduct further consistency checks. In a final step, each state is responsible for hiring external agents to conduct post-enumeration audits and cross-check data with site visits.[35]

The final sample of schools is mainly from seven states and 269 districts throughout India, as the government had yet to expand DISE data coverage to all states before 2006.[36] Based on data from the 2001 Census of India, the districts in my sample have similar characteristics to the national rural average.[37] Figure 2 shows a map of India that indicates the districts

[33]In the upper-primary-school sample, 4.4 percent of the schools are privately-run without government aid and 2.3 percent of the schools are privately-run with government aid. In the primary-school sample, 1.9 percent of the schools are privately-run without government aid and less than one percent of the schools are privately-run with government aid.

[34]There are 32,820 primary schools and 7,625 upper-primary schools in the treatment group in my sample. Duflo (2001) found a standardized effect size ranging from 0.07 to 0.10 when estimating the effect of school construction on years of educational attainment in Indonesia. A school-latrine construction intervention may have a smaller effect, so I conducted my power calculations using a conservative estimate of 0.05. I would need a minimum sample size of 814 schools to detect a conservative 0.05 standardized effect size, which assumes: statistical power of 0.80, a Type I error rate of 5 percent, 65 students per school, and an intra-school correlation of 0.05. If I expected the same effect size as found by Duflo (2001), I would need 612 schools. For a similar test of whether the impact of latrines is greater for females than for males, I calculated that I would need a minimum sample size of 1,058 schools.

[35]For checking data, states select sample blocks from at least 10 percent of the districts by stratifying on educational development (literacy, urban, fraction Scheduled Caste or Scheduled Tribe). Within each sample block, 5 percent of schools are randomly selected for verification (Kaushal 2010).

[36]In my upper-primary-school sample, 31 percent of schools are from Madhya Pradesh, 18 percent are from Uttar Pradesh, 13 percent are from Maharashtra, 10 percent are from Rajasthan, 9 percent are from Tamil Nadu, 8 percent are from Odisha, 7 percent are from Karnataka, 2 percent are from West Bengal, and 1 percent are from Uttaranchal. In my primary-school sample, 21 percent are from Uttar Pradesh, 19 percent of schools are from Madhya Pradesh, 13 percent are from Rajasthan and Odisha, 11 percent are from Maharashtra, 9 percent are from Tamil Nadu and West Bengal, 4 percent are from Karnataka, and 1 percent are from Uttaranchal.

[37]For example, the average literacy rate in my sample districts is 58.4 percent in 2001, compared to the

represented in the final sample. There is substantial variation in wealth and gender norms across these states and districts, which I use in extensions to the main analysis.

The empirical analysis focuses on comparing schools within the same district. On average, in my main sample, there are 174 villages in each district and 30 districts in each state. All villages have a primary school and students generally attend school only within their village, which reduces concerns that students may be shifting from one school to another in response to latrine construction.[38] In robustness checks to the main analysis, I exclude villages with more than one school.

II.B Variable Definitions

Latrines and Other School Infrastructure. The DISE data include detailed information on school infrastructure, including whether the school has a latrine. The data include whether there is a "unisex latrine" and/or a "girls' latrine." In practice, the presence of a unisex latrine and a girls' latrine reflects separate latrines for boys and girls.

My initial analysis combines these data and constructs a single measure of the presence of any latrine, which is equal to one if the school has either a girls' latrine or a unisex latrine. For my later analysis that examines the impact of latrine type, I construct three variables: a dichotomous variable equal to one if the school has a unisex latrine and no girls' latrine, a dichotomous variable equal to one if the school has separate, sex-specific latrines for girls and boys, and a dichotomous variable equal to one if the school has a girls' latrine and no unisex latrine (which is relatively rare).

My main sample is limited to schools that had no latrine in 2002.[39] Among these sample schools, 43 percent of upper-primary schools received a latrine in 2003 and 27 percent of primary schools received a latrine in 2003.[40] Among the upper-primary schools that built a latrine, 38 percent built unisex latrines and 50 percent built separate, sex-specific latrines. Among the primary schools that built a latrine, 48 percent built unisex latrines and 46 per-

national rural average of 58.7 percent. Similarly, the average sex ratio of females per 1000 males in my sample districts is 955 compared to the national rural average of 946.

[38] In my sample, 93 percent of villages have only one upper-primary school, and 76 percent of villages have only one primary school.

[39] In robustness checks, I also include comparison schools that had a latrine in 2002. For these schools, I drop the small number of schools that appear to have lost a latrine in later years. The process of losing a latrine, either through negligence or measurement error, seems sufficiently different than the process of gaining a latrine that the two should not be treated symmetrically.

[40] In each state, the fraction of schools in my upper-primary school sample that received a latrine is: 79 percent in Karnataka, 68 percent in Tamil Nadu, 66 percent in West Bengal, 60 percent in Uttar Pradesh, 57 percent in Rajasthan, 50 percent in Uttarakhand and Maharashtra, 27 percent in Odisha, and 12 percent in Madhya Pradesh. The fraction of schools in my primary school sample that received a latrine is: 43 percent in Uttar Pradesh, 41 percent in Tamil Nadu, 39 percent in Karnataka, 28 percent in Uttarakhand, 27 percent in Maharashtra and West Bengal, 25 percent in Rajasthan, 15 percent in Odisha, and 10 percent in Madhya Pradesh.

cent built separate, sex-specific latrines. There is no direct information on whether latrines were built using funds from the SSHE program, but the large increase in latrine construction reflects the SSHE program.

The DISE data also include other measures of school infrastructure. I examine baseline differences between treatment and control schools in 2002, and then control for differential changes associated with the baseline presence of: blackboards, computers, electricity, library, regular medical checkups, playground, ramps, and water source.[41] These characteristics vary some over time, but are generally persistent, and I find no indication of changes in these other characteristics that are correlated with receiving a latrine. Robustness checks control for changes in these other school-infrastructure variables.

School Participation. Enrollment data approximate the number of students who generally attend school, although direct data on attendance is unavailable. The DISE measure of enrollment is taken at least three months into the school year, at which point enrollment numbers are generally more stable (Aggarwal and Thakur 2003). School enrollment is also of particular interest in this setting, rather than school attendance, because it more directly reflects parental decisions about education.

DISE data include enrollment by student sex and grade, which permits further analysis of how latrines impact boys and girls of different ages. I generally analyze changes in log enrollment, which reflect how school enrollment is affected in percentage terms, but there is sometimes zero enrollment for particular student sexes in particular years. Following standard practice, the main analysis looks at impacts on the logarithm of school enrollment plus one. I also report estimated changes in the level of enrollment and report robustness of the results to restricting the sample to schools that have positive enrollment of boys and girls in each year.

Direct measures of student drop-out are unavailable, but I use the enrollment data to construct a cohort-based measure of drop-out. For students of gender g in school s, cohort c, and year t, I define the fraction of students who drop out as the expected enrollment (derived from the previous year's enrollment) minus the current year's enrollment, divided by the expected enrollment: $(Enrollment_{gs(c-1)(t-1)} - Enrollment_{gsct})/Enrollment_{gs(c-1)(t-1)}$. For this measure, a negative coefficient indicates a decrease in the fraction of students who drop out. This is only a measure of net drop-out, as this could reflect new students in an area in addition to previously-enrolled students who drop out from school.

Examination Outcomes. For students in eighth grade in Uttar Pradesh, data are available for their performance on the middle-school state-board exams, taken nine months into the

[41] For any variables that are missing, I code the variable as having a value of zero and control for an indicator variable equal to one if the variable is missing.

academic year.[42] These data include the number of students who pass the examination and the number of students who score above a high mark threshold. The data also include the number of students who appeared for the examination, and, as 98 percent of students appear for the exam, this provides an independent verifying measure of school participation. If students appear for and then pass the examination, it suggests that these students are attending school on a somewhat regular basis (though 96 percent of students pass the exam). Only 34 percent of students score high marks on the examination. The cut-off for "high marks" is a threshold set at the state-level and a relatively high bar for traditionally-disadvantaged students from rural areas.

Supplementary Data Sources. I use supplemental data from the 2001 Census of India and from the Indian Planning Commission to explore whether the impact of latrines varies with state or district characteristics. These data provide local measures of income and gender parity. I define a district-level measure of gender parity as the average number of girls enrolled in upper primary school for each boy enrolled in upper primary school, which is then normalized to have a mean of zero and standard deviation of one. I also define a district-level measure of per capita income, which is also normalized to have a mean of zero and a standard deviation of one. I also have limited data on teachers for 8,003 schools in two states (Rajasthan and Madhya Pradesh), which includes the number of female and male teachers at a school each year.

II.C Average School Characteristics and Baseline Differences

In column 1 of Tables 1 and 2, I present average school characteristics in 2002 for the "treatment" upper-primary schools and primary schools that receive a latrine in 2003. Column 2 reports average school characteristics in 2002 for the main "control" group, which includes all schools that never had a latrine from 2002 through 2005. Column 3 reports average school characteristics in 2002 for an alternative control group, which did not have a latrine in 2002 or 2003 but received a latrine by 2004 or 2005. Column 4 reports average school characteristics in 2002 for another alternative control group, which either had no latrine in 2002 and 2003 or had a latrine in both 2002 and 2003. Across columns 1 through 4, boys' enrollment is consistently higher than girls' enrollment in both higher and lower grades. Average enrollment is lower in higher grades, particularly for female students.

In columns 5, 6, and 7, I report the difference between the values in column 1 and the values in columns 2, 3, and 4. On average, schools that built a latrine in 2003 tend to be larger than schools that did not build a latrine (column 5). Schools that built a latrine in 2003 are more similar to schools that built a latrine in 2004 or 2005 (column 6), and similar or

[42] One advantage of limiting the analysis to one state is that everyone is taking the same test.

somewhat smaller than the combined sample of schools that always had a latrine and never had a latrine (column 7). The various measures of school infrastructure are substantively similar across each group, although there are often statistically-significant differences given the large sample sizes.

While Tables 1 and 2 highlight some baseline differences in the raw data, the empirical analysis focuses on comparing treatment and control schools that were similar in 2002. The empirical specifications either control for school enrollment in 2002 (overall school enrollment or school enrollment by student sex), or match on school enrollment in 2002. In addition, the empirical specifications control for all of the measures of school infrastructure reported in Tables 1 and 2, or match on these measures of infrastructure.

III Empirical Methodology

III.A Initial Analysis

In my main analysis, I use a differences-in-differences empirical strategy. I subtract the average value of the outcome variable in 2002 in the treatment schools (*i.e.*, schools that built a latrine in 2003) from those schools' average outcome value after building the latrine (the "first difference"). I then estimate a similar difference in the comparison group of schools that did not build a latrine in 2003, and subtract this "second difference" from the "first difference" to adjust for changes in enrollment that may have taken place in the treatment group over the same period in the absence of building a latrine. Under particular assumptions, the difference between the changes in treatment schools and the changes in comparison schools provides a causal estimate of the impact of latrine construction.

Underlying my research design is the identifying assumption that schools that received latrines in 2003 would have undergone changes over time that were similar, on average, to schools in the comparison group that did not receive latrines. Treatment and control schools may be generally different, but the empirical analysis assumes that these schools would not have *changed* differently over the narrow time frame under analysis. Tables 1 and 2 report some initial differences between treatment and control schools, but the empirical analysis also allows for differential changes in schools that differ along these observable dimensions. Further robustness checks match treatment and control schools on observable characteristics or explore the sensitivity of the results to different comparison groups.

Formally, the empirical analysis begins by estimating a linear regression model. I regress enrollment in school s, district d, and time t on an indicator variable for whether the school has a latrine (L_{st}), school fixed effects (α_s), district-by-year fixed effects (λ_{dt}), and a year-

interacted vector of schools' initial characteristics (X_s):

$$Y_{sdt} = \beta L_{st} + \alpha_s + \lambda_{dt} + \gamma_t X_s + \epsilon_{sdt}. \quad (1)$$

The estimated parameter β is the coefficient of interest, which reflects the difference between the "first difference" and "second difference" described above. This parameter captures the average effect on all students' enrollment from a school building a latrine. If estimates of β are positive and statistically significant, then building a latrine is indicated to cause an increase in school enrollment.

In the above equation, the inclusion of additional control variables helps to increase confidence in the identifying assumption. The vector of school fixed effects (α_s) captures any school-level time-invariant characteristics, observed or unobserved, where α_s represents the average of each school.[43] I also include a vector of dichotomous district-year fixed effects (λ_{dt}) to control for district-specific shocks that affect schools the same, on average, in each district. By including district-year fixed effects, the empirical analysis compares treatment schools to control schools within the same district. I include baseline school characteristics interacted with a dichotomous variable indicating the academic year ($\gamma_t X_s$) to allow for the possibility of differential changes in schools that differed initially in school size and the presence of blackboards, computers, electricity, library, regular medical checkups, playground, ramps, and type of water source.[44]

An extended regression equation allows for differential impacts of latrines on female and male enrollment. I regress enrollment for students of gender g in school s, district d, and time t on similar variables to those above:

$$Y_{gsdt} = \beta_g L_{st} + \alpha_{gs} + \lambda_{gdt} + \gamma_{gt} X_s + \epsilon_{gsdt}. \quad (2)$$

There are two estimated β parameters: β_f for female students and β_m for male students. Each parameter captures the average effect of a school receiving a latrine on school enrollment for female students and male students, respectively. As above, these parameters provide the difference between the "first difference" and the "second difference" for females and males. School-latrine construction causes an increase in school enrollment for female students and male students if estimates of β_f and β_m are positive and statistically significant. I also

[43] This vector of school fixed effects absorbs the "main effect" that a treatment group dummy would represent in a basic differences-in-differences model.

[44] In my main specifications, I allow the impact of school characteristics to vary in each year. I also verify the estimates' robustness to imposing a linear time trend interacted with each of these baseline school characteristics (i.e., year 2002 is assigned a value of zero, year 2003 is assigned a value of one, and year 2005 is assigned a value of three).

compare β_f to β_m to test whether the impact of school latrines is greater for females than for males. If the difference is statistically significant and positive, then I can conclude that building a latrine has a larger impact on the enrollment of female students.

For this extended regression equation, the control variables are also doubled. The vector of school-student gender fixed effects (α_{gs}) controls for time-invariant differences, observed and unobserved, among females in schools and males in schools, where α_{gs} represents the average for each school-student gender pair. I also include a vector of dichotomous student gender-district-year fixed effects (λ_{gdt}) to control for any district-specific shocks that differentially affect males or females. For example, these controls allow for gender-specific policies that may differentially impact females in a district. For all specifications in the paper, I adjust the standard errors to allow for heteroskedasticity and correlated outcomes among students within the same school.

III.B Exploring Mechanisms

In extensions to the main analysis, I explore possible mechanisms through which latrines may impact student outcomes. First, I extend equation (2) to estimate different impacts for the presence of unisex latrines only (L^U), the presence of sex-specific latrines (L^S), and the presence of a female-specific latrine only (L^F):

$$Y_{gsdt} = \beta_g^U L_{st}^U + \beta_g^S L_{st}^S + \beta_g^F L_{st}^F + \alpha_{gs} + \lambda_{gdt} + \gamma_{gt} X_s + \epsilon_{gsdt}. \tag{3}$$

There are two estimated β parameters for each type of latrine. The parameter β_f^U captures the average effect on females from the construction of a unisex latrine, whereas the parameter β_m^U captures the average effect on males from the construction of a unisex latrine. The parameters β_f^S and β_m^S capture the average effect on females and males from the construction of sex-specific latrines. The parameters β_f^F and β_m^F capture the average effect on females and males from the construction of a female-only latrine, though this is relatively rare in the data.

After estimating these parameters, I can compare them to test various hypothesis. For example, I can compare β_f^S and β_f^U to test whether females are more affected by sex-specific latrines than by a unisex latrine. In addition, I can compare β_f^S and β_m^S to test whether females are more-affected by sex-specific latrines than males. Finally, I can compare the difference between β_f^S and β_f^U to the difference between β_m^S and β_m^U to test whether the additional impact of providing sex-specific latrines (beyond simply providing a unisex latrine) is greater for females than for males. All of the analysis is done separately for upper-primary schools and for primary schools, which allows a comparison of the estimates across ages.

A second extension to the main analysis explores whether latrines impact student out-

comes through impacts on female teachers. One component of this analysis looks at whether the impact of latrines is greater in schools with more female teachers initially, as female teachers may be more likely to show up for school after latrine construction. I extend equation (2) to include an interaction term that is the school's initial female share of teachers:

$$Y_{gsdt} = \beta_g L_{st} + \beta_g^F L_{st} \times FemaleTeacher_s + \alpha_{gs} + \lambda_{gdt} + \gamma_{gt} X_s + \epsilon_{gsdt}. \quad (4)$$

The estimated β_f^F and β_m^F indicate whether female or male student outcomes are more affected by latrines in schools that have a greater initial share of teachers that are female.[45] Extended versions of this specification examine whether a school's female-teacher share affects the impact of different latrine types.

In a second component of this teacher analysis, I estimate whether latrine construction increases the fraction of teachers at a school that are female. Female teachers may be more willing to work at schools with latrines, which may then affect educational outcomes for female students in particular. For this analysis, I estimate equations (1) and (3) and define the outcome variable as the fraction of teachers in each school that are female.

A third extension to the main analysis explores variation in the impact of latrines across states and districts. Similar to equation (4), I extend equation (2) to include an interaction term between latrines and some district-specific characteristic (D_d), such as average district income or gender parity:

$$Y_{gsdt} = \beta_g L_{st} + \beta_g^I L_{st} \times D_d + \alpha_{gs} + \lambda_{gdt} + \gamma_{gt} X_s + \epsilon_{gsdt}. \quad (5)$$

Each district characteristic D is normalized to have a mean of zero and a standard deviation of one, so the estimated β_g parameters continue to reflect the average impact of a latrine.[46] Because income and gender parity are district-level measures, I cluster the standard errors by district given the possibility of common district-wide shocks for this set of specifications.

The estimated parameters β_g^I capture whether the impact of latrines is different in districts with a one standard deviation higher measure of D. For example, if D reflects average district income, then β_f^I and β_m^I capture whether the impact of latrines is greater in higher-income districts. If D reflects some measure of districts' gender parity, then β_f^I and β_m^I capture whether the impact of latrines is greater in districts with higher gender parity. These estimates help explore mechanisms through which latrines might impact boys and girls, but these estimates also help indicate how the impact of latrines might vary across

[45] Note that the gender-school fixed effects absorb the "main effect" of schools' initial share of female teachers.

[46] Note that the gender-district-year fixed effects absorb the "main effect" of district characteristics.

different settings worldwide.

IV Estimated Impacts of School-Latrine Construction

IV.A Initial Results

Average Impact on Enrollment. In Table 3, columns 1 and 3, I present estimated impacts of latrine construction on average enrollment in upper-primary schools and primary schools, respectively. From estimating equation (1), panel A reports impacts on log enrollment: an eight percent increase in upper-primary schools' enrollment, and a twelve percent increase in primary schools' enrollment. These effects are highly statistically significant and substantial in magnitude. These estimates imply that latrine construction in sample schools increased upper-primary-school enrollment by 75 thousand students and increased primary-school enrollment by 607 thousand students.[47] Panel B reports impacts on the level of enrollment that are also statistically significant and substantial, though the implied percent increase is somewhat smaller than estimated in panel A.

Impacts by Student Sex. In Table 3, columns 2 and 4, I report estimated impacts of latrine construction on female and male enrollment for upper-primary schools and primary schools. From estimating equation (2), panel A reports impacts on log enrollment and panel B reports impacts on the level of enrollment. School-latrine construction increased enrollment of both girls and boys, with only moderately larger impacts for girls in some specifications. The difference between impacts on females and males is largest for upper-primary schools, rather than primary schools, which serves as weak support for the literature's focus on latrines and pubescent-age girls.

Impacts by Student Age. In Table 3, I report estimated impacts on primary-school enrollment that are always larger than impacts on upper-primary school enrollment. By contrast, the policy literature tends not to emphasize the importance of latrines for younger children. Younger children may be primarily affected by latrines through health channels. Health issues from waste contamination generally affect younger children more than older children. Privacy and safety can also be important to younger children, though perhaps less than for older children.

Student Drop-out. Latrine construction has similar impacts on the predicted fraction of students who drop out of school. In Appendix Table 1, I present estimated impacts on the fraction of students who drop out of school. For upper-primary schools, latrines reduce the fraction of students who drop out by 5.3 percentage points (standard error of 1.5 percentage

[47] In the sample, approximately 0.9 million upper-primary students and 4.7 million primary students were attending a school in 2002 that received a latrine in 2003 (Tables 1 and 2, column 1). The total implied increases in enrollment are found by multiplying these numbers by the estimated percent increases in enrollment (Table 3, panel A, columns 1 and 3).

points). For primary schools, latrines reduce student drop-out by 12.2 percentage points (standard error of 0.5 percentage points). By student sex, the impacts are only moderately larger for females than males: 5.4 (1.6) for females and 4.6 (1.6) for males in upper-primary school, and 12.5 (0.5) for females and 11.2 (0.5) for males in primary school.

Persistence of Impacts. Impacts of interventions often fade over time, and, in this context specifically, one concern is that latrine maintenance may be so poor that latrines quickly become unusable and ineffective. The SSHE program targeted latrine construction, with no specific provisions for ongoing latrine maintenance, so there may be concerns that the estimated impacts would be short-lived.

In Table 4, I present separately estimated impacts of latrines after one year (in 2003) and after three years (in 2005). The impact of latrines does not appear to fade over this time horizon and, if anything, the impact is slightly larger after three years. The impact of latrines continues to be moderately larger for females than males, and the impact of latrines continues to be higher in primary schools than in upper-primary schools.

Impacts on Student Achievement. In Table 5, I present estimated impacts of latrines on eighth-grade students' performance on the Uttar Pradesh state-board exam.[48] In columns 1 and 2, I report estimated increases in the number of students appearing for the eighth grade exam. In columns 3 and 4, I report estimated increases in the number of students passing the eighth grade exam. These estimates are not statistically distinguishable from the estimated increases in enrollment, for eighth graders in these schools in Uttar Pradesh, as 98 percent of enrolled students appear for the exam and 96 percent of enrolled students pass the exam.[49] While attendance data are unavailable, the estimated increases in appearing for the exam and passing the exam suggest that students are attending school throughout the year.

In Table 5, columns 5 and 6, I report that latrine construction had a precisely-estimated zero impact on the number of students scoring high marks on the exam. Only 34 percent of students score high marks on the examination, which sets a relatively high bar for traditionally-disadvantaged students from rural areas. Student test scores may be increasing at other points in the test score distribution, but data limitations preclude such analysis. It is fairly common to not find increases in test scores from educational interventions that increase enrollment (*e.g.*, Miguel and Kremer 2004, Vermeersch and Kremer 2005, Glewwe *et al.* 2009), yet bringing more children into school still generates standard returns to education.

These estimates reflect a net impact of latrines on student achievement and do not indi-

[48] On average, 41.59 students are enrolled in eighth grade, 40.59 students appear for the board exam, 39.87 students pass the exam, and 14.08 students score high marks on the exam.

[49] As a comparison, the introduction of a latrine increases these schools' eighth-grade student enrollment by 1.476 students, with a standard error of 0.755. Enrollment increases by 1.351 females (standard error of 0.374) and by 0.202 males (standard error of 0.554).

cate what would have happened to average achievement for students who would have gone to school in the absence of the intervention. These effects may be due to existing students performing better or new students performing well because of a better school environment in which they are more able to concentrate and more likely to attend. Alternatively, if latrines increase enrollment without an associated increase in other school inputs, these effects could be picking up indirect negative effects on existing students due to potential classroom crowding, shortages in learning materials, or diffused teacher attention.

IV.B Robustness of the Initial Results

Matching on Baseline School Characteristics. The initial regressions estimate relative changes in schools that received a latrine in 2003, controlling for changes that are correlated with schools' baseline characteristics in 2002. Alternative approaches could match treatment schools to control schools that are similar along the observed baseline characteristics in 2002, with the idea that these matched schools would otherwise be expected to change similarly. In Appendix Table 2, columns 1 through 6, I show that the initial estimates are similar to those obtained from different propensity-score matching methods (Rosenbaum and Rubin 1983, Leuven and Sianesi 2004): column 1 reports estimates from nearest-neighbor matching (Abadie and Imbens 2006), column 2 reports estimates from coarsened exact matching (Blackwell *et al.* 2009), column 3 reports estimates using nearest-neighbor matching without replacement (Abadie and Imbens 2006), column 4 reports estimates from kernel-based matching (Heckman *et al.* 1997), column 5 reports estimates using Mahalanobis matching (Rosenbaum and Rubin 1985), and column 6 reports estimates from radius matching (Dehejia and Wahba 2002). The estimated impacts by student sex are also robust to these alternative matching techniques.

Alternative Comparison Groups. The initial regressions compare schools that receive a latrine in 2003 to schools that never have a latrine through 2005. In Appendix Table 3, columns 1 and 2, I report these estimated impacts on enrollment in 2003 only, as a basis for comparison. In columns 3 and 4, I report estimated impacts in 2003 from comparing schools that receive a latrine in 2003 to an alternative comparison group of schools that had no latrine in 2002 or 2003 and built a latrine in 2004 or 2005. In columns 5 and 6, I report estimated impacts in 2003 using another comparison group of schools that had no change in latrine between 2002 and 2003 but also includes schools that had a latrine in 2002.

In Appendix Table 3, columns 3 to 6, I report estimates that generally remain positive and statistically significant, though the magnitudes are smaller than those estimated using my main comparison group. There generally continues to be a larger effect on females than males, and the impacts continue to be larger in primary schools than in upper-primary

schools.

These alternative comparison groups are more similar to treatment schools along some observed dimensions in 2002 (from Tables 1 and 2), though this need not imply that changes in these schools more closely approximate changes that would have occurred in treatment schools. Schools that will soon receive a latrine may be predisposed to experience prior increases in enrollment, as it seems more plausible that latrine construction responds to enrollment increases than latrines are constructed in anticipation of later enrollment increases. Schools that initially had a latrine may be in more-developed areas or otherwise reflecting different local economic and social environments, and my other estimates show that the impact of latrines is increasing moderately over time. Given these concerns, my preferred specifications use schools in the main comparison group and control for initial characteristics or match on initial characteristics.

Other School Interventions. Indian schools have been exposed to a variety of education reforms over the last decade, so one concern may be that the impacts of school-latrine construction are confounded with impacts from another government initiative. There might also be concerns that schools received funds for latrines instead of funds for other education purposes, though the school-latrine funds were generally managed by water officials rather than education officials. Indeed, I estimate no correlation between latrine construction and other changes in school infrastructure. Further, in column 1 of Appendix Table 4, I report that the estimates are robust to controlling for any changes in school infrastructure after 2002.

Student Transfers. In principle, some of the increase in enrollment for treatment schools may reflect students moving from comparison schools, which would cause the empirical estimates to overstate the aggregate impact on school enrollment. In practice, however, children go to school within their village and most villages have only one school. In Appendix Table 4, column 2, I report that the estimates are robust to limiting the sample to schools that are the only school within their village.

Functional Form. The original specifications estimate changes in the logarithm of enrollment plus one, in addition to estimating changes in the level of enrollment, because estimating changes in the logarithm of enrollment can become difficult to interpret for schools that have no females or males enrolled for some year. Alternatively, in column 3 of Appendix Table 4, I report that the estimates are robust to limiting the sample to schools that have positive enrollment of each sex in each year. For this restricted sample, I report in column 4 of Appendix Table 4 that the estimates are robust to estimating changes in log enrollment (rather than the logarithm of enrollment plus one).[50] As a final modification to the

[50]When looking at the impact by student sex for the estimates in columns 3 and 4, the impact of latrines

functional-form assumptions, I report in column 5 of Appendix Table 4 that the estimates are not sensitive to replacing the year-interacted measures of baseline school characteristics with linear time trends for each baseline school characteristic.

Standard Errors. In the main results, I cluster standard errors to allow for correlated outcomes among students within the same school, because the treatment occurs at the school level. However, common district-wide shocks could lead to correlated outcomes among students within the same district. In Appendix Table 4, column 6, I report that the standard errors increase when I cluster at the more-conservative district level; however, the statistical significance of the estimates remains.

Measurement Error. Measurement error in the enrollment data would typically increase the standard errors on the estimates, but there is a potential concern about mean reversion in the data. If district governments have independent information in allocating latrines to schools with higher initial enrollment, and schools' initial enrollment is measured with error in my data, then treatment schools may tend to have more initial students in reality than do comparison schools with the same measured initial enrollment. In this case, treatment schools would experience a relative increase in measured enrollment in the next period after their new measurement. This is a concern in theory, though it seems less applicable to the Indian context where district officials are unlikely to be allocating latrines to schools based on independent (accurate) information on their enrollment. Two years prior, many of these officials did not know how many schools were in their district and DISE data collection was scaled up to provide the government information on schools and their characteristics.

One way to quantify the potential bias, however, uses the data from eighth-grade state-board exams as an independent measure of student enrollment. I replicate my main estimating equation but for estimating cross-sectional differences in 2002 for an outcome variable defined as: log(number of students appearing for the exam) – log(number of students enrolled). If these are two independent measurements of school enrollment, then mean reversion would be reflected in a positive coefficient on the treatment variable in the year 2002. I estimate a small and statistically-insignificant effect for all students (0.004 with a standard error of 0.004), female students (0.002 with a standard error of 0.004), and male students (0.004 with a standard error of 0.004). These estimates reject mean-reversion bias contributing more than a 1.2 percent increase in school enrollment, under the assumption that the two measures of enrollment are independent and identically-distributed draws.

is moderately larger for males than for females; for the other robustness checks, the impact of latrines tends to be moderately larger for females than for males.

IV.C Mechanisms and Extended Results

Impacts by Latrine Type. The initial results show only weak evidence that the impact of latrines is larger for girls than for boys, but the average impact of a latrine might obscure important differences by latrine type. In Table 6, I report the estimated enrollment impacts on girls and boys from the three different latrine types (sex-specific, unisex, female-only).[51]

For upper-primary schools, I find that the construction of sex-specific latrines substantially increases female enrollment. However, the construction of unisex latrines only slightly increases female enrollment. Enrollment of boys increased similarly with the construction of a unisex latrine and sex-specific latrines. Comparing the impacts of sex-specific latrines and unisex latrines, by student sex, increasing female enrollment was more heavily dependent on the provision of separate, sex-specific latrines.

By contrast, for primary schools, the construction of sex-specific latrines had similar impacts to the construction of a unisex latrine. Sex-specific latrines had some greater impact on females' enrollment than a unisex latrine, but females in primary school benefited substantially from the construction of a unisex latrine. Enrollment continues to be impacted more in primary schools than in upper-primary schools, though the differential impact between girls and boys is generally greater for pubescent-age students than for younger students.

I also report estimates for the impact of only constructing a female-only latrine, though this case includes only six percent of primary schools in the treatment group and eleven percent of upper-primary schools in the treatment group.[52] It may seem surprising that female-only latrines impact male primary-school enrollment but, in practice, primary school boys would likely be directed to use the only available latrine even if it were officially reported as being female-only.

The estimated differential impacts by latrine type are useful in thinking about the mechanisms underlying the main effects of latrines. In upper-primary schools, the importance of sex-specific latrines suggests that privacy and sexual safety may be important channels. In primary schools, the relative sufficiency of unisex latrines suggests that student health may be the most important channel. Sex-specific latrines are still somewhat useful at younger ages, however, which is consistent with concerns of bullying at younger ages for both boys and girls.

These estimates are also useful, from a pure policy-design perspective, in directing resources toward what types of latrines might be built in what contexts. Sex-specific latrines benefit children at younger ages, but unisex latrines may be sufficient for younger children

[51] These estimates are generally insensitive to the robustness checks reported for the initial results.

[52] By contrast, in the primary-school sample, 48 percent of the schools in the treatment group built unisex latrines and 46 percent built separate latrines for both sexes. In the upper-primary-school sample, 39 percent built unisex latrines and 50 percent built separate latrines for both sexes.

when resources are scarce. By contrast, school latrines only improve gender parity among older children when sex-specific latrines are constructed, as pubescent-age girls benefit little from the construction of a unisex latrine. In upper-primary schools, female-only latrines benefit girls but not boys; by contrast, the designation of female-only latrines appears to be disregarded in primary schools.

Impacts through Female Teachers. School latrines might impact students by changing female teachers' willingness to work at these schools. First, current female teachers might have improved work attendance when schools receive latrines (Chaudhury *et al.* 2005). Second, additional female teachers might begin to work at schools that receive latrines. Both of these effects might increase student enrollment, especially girls' enrollment.

In Table 7, I show that the impact of latrines is not generally higher in schools that had a higher initial share of female teachers. These estimates suggest that either female teachers did not reduce their absenteeism relative to male teachers, or that female teachers' work attendance did not impact student enrollment. Teacher data are only available for two states, however, so these small sample sizes may fail to detect important effects.

In Table 8, I show that school latrine construction increases the share of female teachers at schools. The construction of sex-specific latrines and female-only latrines most impact the share of female teachers, though it is relatively rare for a school to only construct a female-only latrine. In columns 3, 4, 5, and 6, I report placebo estimates that show latrines did not impact the share of teachers in particular disadvantaged castes.[53] Other studies often find that female students especially benefit from having female teachers, so these estimates suggest one potential channel through which latrines impact female students.

Geographic Heterogeneity in the Impacts. The impact of latrines may vary across India, reflecting differences in underlying social factors or local economic opportunities. Indeed, using the substantial variation in district characteristics across India, directly estimating geographic heterogeneity in the impacts can help inform how school sanitation might impact educational outcomes in other settings worldwide.[54]

In Figure 3, I show histograms plotting the average effect of the introduction of a latrine for upper-primary and primary schools in each district.[55] There is substantial variation around the average effect of a latrine, denoted by the vertical dashed line, which could

[53]There is also no impact of latrines on teachers of "other castes."

[54]For example, the impact of latrines may be larger in areas with greater gender parity, where females might otherwise be encouraged to enroll in school. Alternatively, the impact of latrines might also be larger in areas with lower gender parity, where there is the most unfulfilled potential for females to increase educational enrollment.

[55]For clarity, I have omitted from Figure 3 those districts in the upper and lower five percent of the distribution. The main empirical results are not sensitive to omitting these districts with the largest or smallest estimated impacts, which generally reflect small sample sizes within the district.

reflect random noise or be systematically correlated with district characteristics.

In Figure 4, I present further motivating results at the state level, which show how the impact of latrines varies with state gender parity and state per capita income.[56] The measure of gender parity reflects the number of female students enrolled per male student enrolled. In panel A, I show some tendency for states with higher gender parity to have a greater impact of latrines on total enrollment. In panel B, there is also some tendency for states with higher income per capita to have a larger impact of latrines.[57]

Further empirical analysis uses district-level variation in gender parity and per capita income. In Table 9, panel A, I report the average impact of a latrine and how the impact changes for districts with a one standard deviation higher measure of gender parity. In panel B, I report how the impact of latrines varies with districts' per capita income. In panel C, I report how the impact of latrines varies when including both district measures.[58]

The average impact of latrines does not change substantially with districts' gender parity. Some estimates show higher impacts in districts with higher gender parity, though the magnitudes are fairly small and the estimates are not consistently statistically significant.[59] From panel A, in the upper-primary sample, the difference in the effect of a latrine when going from schools in the 25th percentile to the 75th percentile of district gender parity is 1.4 standard deviations, or a difference in effect of 2 percentage points. The difference in the effect of a latrine when going from a district with very low gender parity (10th percentile) to a district with very high gender parity (90th percentile) is 2.6 standard deviations, or a difference in effect of 4 percentage points.[60]

The estimated impact of latrines is similar across districts with different average per capita income, despite there being substantial variation in districts' average income.[61] The variation across sample districts, comparing districts with average income at the 10th and 90th percentiles, is comparable to variation across countries between the 5th and 25th per-

[56]For Figure 4, I allow the estimated impact of latrines to vary by state. The size of the circles corresponds to the number of sample schools in that state.

[57]For both figures, there are similar patterns for both female enrollment and male enrollment.

[58]In these specifications, standard errors are clustered at the district level to reflect district-level variation in gender parity and income.

[59]Recall that the gender-parity index variable is normalized to have a mean of zero and a standard deviation of one. The mean of the pre-normalized gender parity index is 0.80 (with a standard deviation of 0.15). In other words, the average ratio of enrolled upper-primary girls to enrolled upper-primary boys in a district is eighty percent, and one standard deviation in the data is fifteen percent.

[60]The implied total enrollment effect of a latrine in an upper-primary school in a 90th-percentile district is 0.09, and the implied effect of a latrine in an upper-primary school in a 10th-percentile district is 0.05.

[61]For the regressions in Table 9, the per-capita income variable is normalized such that it has a mean of zero and a standard deviation of one. The mean of the pre-normalized per-capita income variable is Rs. 17,955 (standard deviation of Rs. 6,757) in the upper-primary-school sample and Rs. 16,887 (standard deviation of Rs. 6,496) in the primary-school sample.

centiles of the world income distribution (*e.g.*, Rwanda and Nepal vs. Georgia and Ukraine). Looking at a well-developed district, with average income at the 90th percentile, there is a small and statistically insignificant decrease in the effect of a latrine in upper-primary schools, and a small and statistically insignificant increase in the effect of a latrine in primary schools.

These estimates suggest that the educational impacts of school sanitation are similar across a range of under-developed contexts worldwide, expanding the external validity of estimates from within India. While India is home to 25 percent of the world's out-of-school children, it is important to know how the other 75 percent of out-of-school children might be encouraged to enroll. In the absence of direct quantitative studies on sanitation and education in other contexts, the substantial heterogeneity in conditions within India can be used to explore how the impact of sanitation on education varies across contexts. There appears to be little variation in the impact of school latrines across wealthier and poorer districts within India. Further, while there are some indications of larger impacts in areas that have greater gender parity, perhaps because other conditions are more suitable to increasing female education, the impact of latrines remains substantial even in contexts with lower gender parity within India.

V Conclusion

One in five children worldwide does not complete upper-primary school, which may exacerbate societal inequality. Amidst the current focus on improving infrastructure in developing countries, the most rudimentary of human needs are often overlooked. Inadequate school sanitation threatens children's health, privacy, and safety, potentially limiting educational attainment.

Particularly high drop-out rates among pubescent-age girls in developing countries perpetuate gender inequality. Some have attributed these high drop-out rates to the lack of school sanitation facilities for menstruating girls. This "Menstruation Hypothesis" has motivated efforts to provide sex-specific sanitation in schools, which could increase girls' health, privacy, and safety. Improving the school environment may have broader impacts, however, on the educational decisions of female and male children of different ages.

I examine the relationship between school sanitation and education in developing countries, through an analysis of the Indian government's large-scale school-latrine-construction initiative in 2003. Drawing on administrative school-level data from throughout India, which I obtained and matched for years prior to those generally available, I use a differences-in-differences methodology to compare schools that received a latrine in 2003 to schools that did not receive a latrine. Further, using data disaggregated by student sex and grade, I examine how latrine construction influences the educational decisions of both girls and boys across

different ages. The empirical analysis focuses on comparing initially-similar "treatment" and "control" schools, either by controlling for initial school characteristics or by matching on initial school characteristics. The empirical estimates are robust to a variety of alternative specifications.

I estimate that latrine construction increases student enrollment and lowers dropout for all students. These enrollment increases are reflected in the number of students who appear for and pass the middle school board exam, though there is no increase in the number of high-performing students. While the impact of educational infrastructure interventions often fade over time, the impact of latrines on enrollment is slightly stronger three years later. India's latrine-construction initiative did not specifically target latrine maintenance, suggesting even greater potential from policies that also devote resources to latrine maintenance.

I generally find that latrine construction increases female enrollment more than male enrollment, though latrine type matters greatly. Pubescent-age girls benefit substantially from the construction of sex-specific latrines, but benefit little from a unisex latrine. The importance of separate sanitation facilities for pubescent-age girls is consistent with a broader version of the "Menstruation Hypothesis," which emphasizes pubescent-age girls' everyday concerns for privacy and safety rather than on only those days when menstruating. Privacy and safety matter sufficiently for girls at older ages that school sanitation only reduces gender disparities with the construction of sex-specific latrines. Latrine construction may also benefit female students, in part, by increasing a school's share of female teachers.

The estimates also suggest a more general link between school sanitation and education, whereas a narrow focus on the "Menstruation Hypothesis" would neglect factors that influence education decision-making for pubescent-age boys and younger children. The large impact of sanitation on younger children suggests that latrines have important impacts through child health, particularly as unisex latrines are mostly sufficient at younger ages. The estimated impacts of sanitation are generally largest at younger ages and, as these early years are a critical period for cognitive development (NSCDC 2007), there should be increased emphasis on the importance of sanitation for primary schools.

As the Indian government continues to devote resources to improving school sanitation, these estimates have implications for how scarce resources might be directed to greater effect. While younger children benefit substantially from latrines, unisex latrines may be sufficient for younger children when resources are scarce. By contrast, addressing gender inequality at older ages requires the construction of separate, sex-specific latrines. School-latrine construction represents an opportunity to address the Millennium Development Goals, both by expanding access to education and by reducing a gender gap in enrollment that is particularly pronounced among adolescents.

A natural question is whether the estimates are externally valid for other contexts, though India is home to 25 percent of the world's out-of-school children. Using my large sample of schools from throughout India, I examine whether the impact of latrines varies with districts' average income and gender parity. The variation across sample districts, comparing districts with average income at the 10th and 90th percentiles, is comparable to variation across countries between the 5th and 25th percentiles of the world income distribution (*e.g.*, Rwanda and Nepal vs. Georgia and Ukraine). There is no systematic difference in impacts across districts with different average income, and only limited evidence of larger impacts in districts with greater gender parity. In the absence of systematic quantitative evidence on the link between sanitation and education in other developing countries, estimates from India are informative throughout a large range of developing-country contexts.

The results highlight that concerns over health, privacy, and safety influence educational decision-making for girls and boys of different ages. While there are many deep roots to problems of gender inequality in developing countries, improving school sanitation is one opportunity to increase gender equality for pubescent-age girls. In considering the importance of school sanitation, however, a broader view is needed than the current emphasis on pubescent-age girls and the "Menstruation Hypothesis" that neglects the importance of sanitation for boys and younger girls. School sanitation has additional large impacts on pubescent-age boys and younger children, which suggests a central role for improving the school environment in increasing educational attainment in the developing world.

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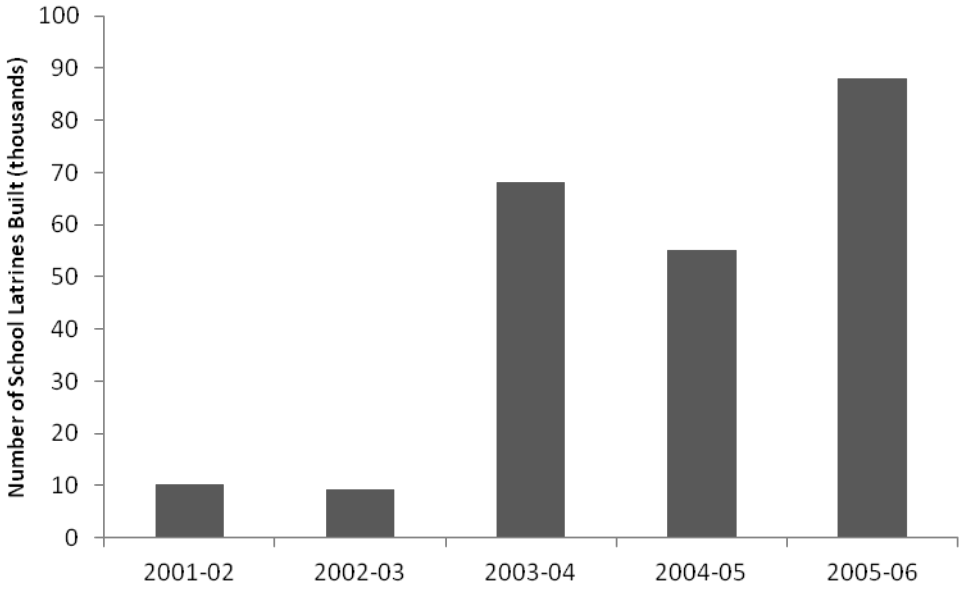
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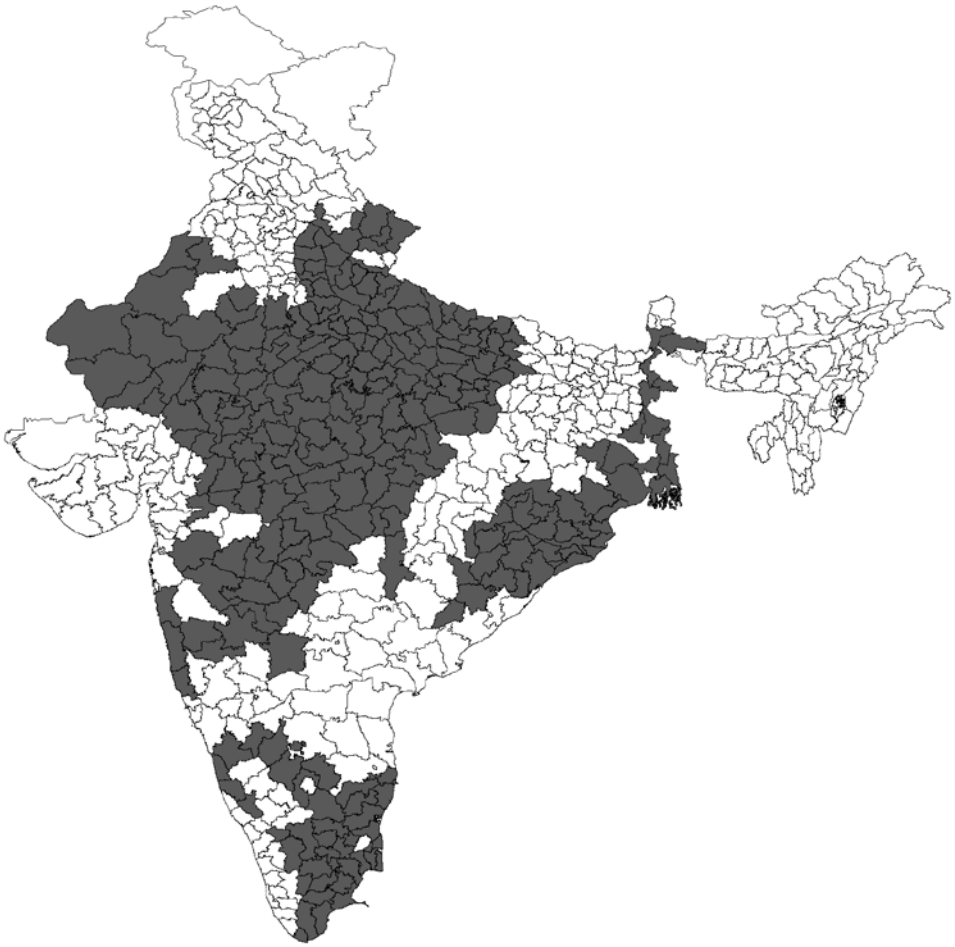
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Figure 1. Number of School Latrines Built Over Time



Notes: This figure shows the number of school latrines built over time, according to the Ministry of Drinking Water and Sanitation, NIC-MDWS Informatics System Cell (2013).

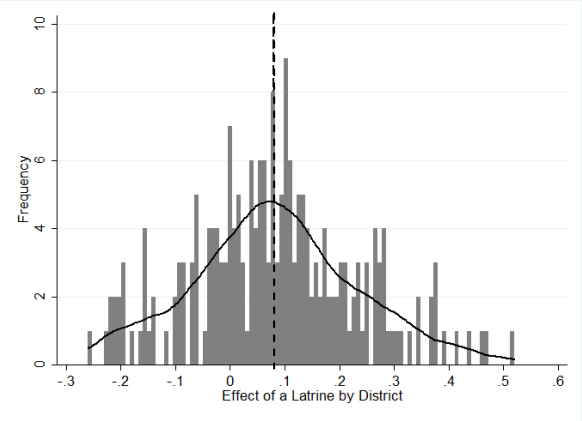
Figure 2. Map of Indian States in Sample



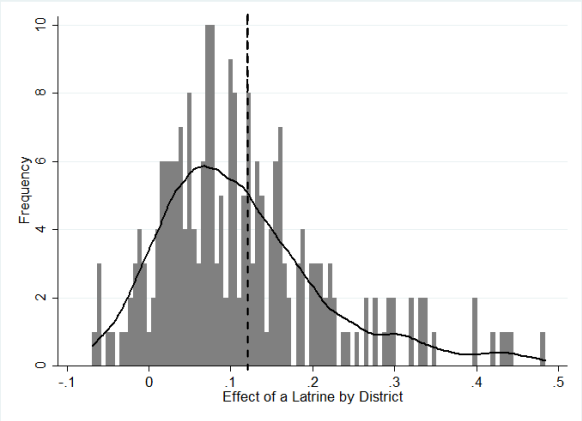
Notes: The gray areas mark the districts in India included in the main sample.

Figure 3. Histogram of Effect by District

Upper-Primary Schools (6th-8th Grades)



Primary Schools (1st-5th Grades)

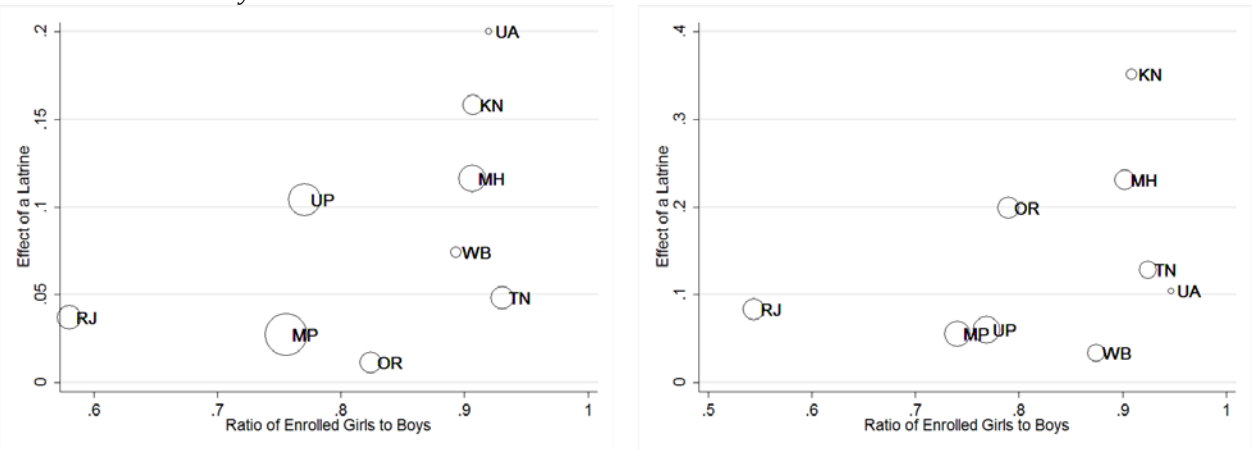


Notes: This is a histogram plotting the average effect of the introduction of a latrine in each district. Overlaid is a kernel density plot. For clarity, the districts in the upper and lower five percent of the distribution have been omitted. The vertical dashed line represents the estimated average effect of a latrine in the entire sample region.

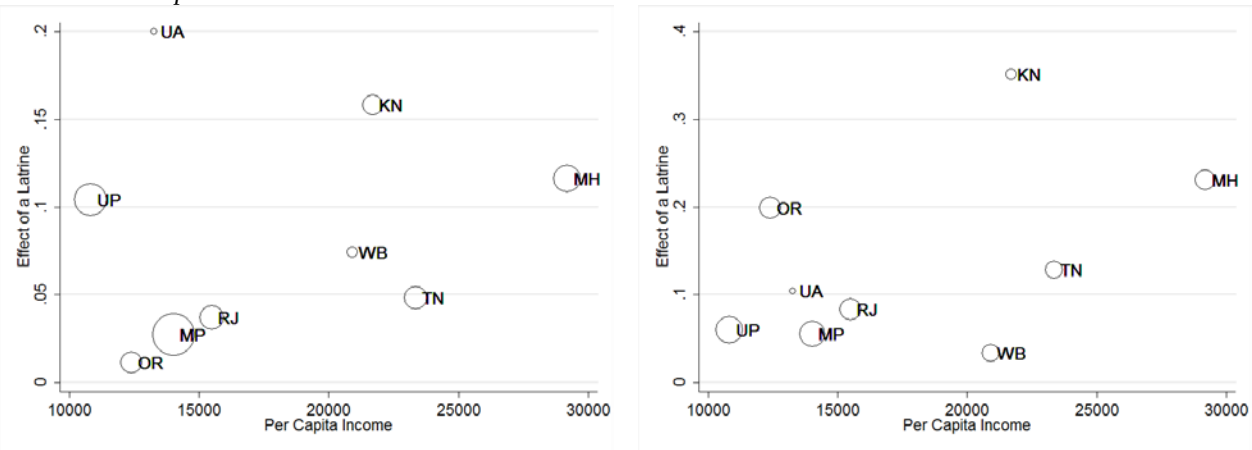
Figure 4. Relationship between Enrollment Effect from a Latrine and Gender Norms and Income, by State

Upper-Primary Schools (6th-8th Grades) | Primary Schools (1st-5th Grades)

Panel A. Gender Parity Measure



Panel B. Per Capita Income Measure



Notes: The gender parity measure in this table is a continuous ratio of the average number of enrolled upper-primary girls in a district at baseline to the average number of enrolled upper-primary boys in a district at baseline, calculated from DISE. The income measure is a per capita income measure, calculated from Census of India 2001 and Economic Survey 2005. The Y-axis signifies the estimated enrollment effect of a latrine by state. Each circle represents one state in India. The size of the circle is weighted by the number of schools in that state, in the sample.

Table 1. Baseline School Characteristics in 2002, Upper-Primary Schools (6th - 8th Grades)

	Treatment Group:	Main Control Group:	Alternative Control Groups:				
	Built Latrine	No Latrine	Built Latrine	No Latrine		Within-District	
	Between	From	Between	Built Between		Differences:	
	02-03 and 03-04	02-03 through 05-06	03-04 and 05-06	02-03 and 03-04	(1) - (2)	(1) - (3)	(1) - (4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Number of Schools	7,625	10,171	9,544	51,450			
Total Enrollment	119.7	88.6	104.1	150.8	21.9**	13.4**	-21.5**
	(124.1)	(81.6)	(103.5)	(166.3)	(1.79)	(1.67)	(1.49)
Female Enrollment	51.9	35.6	42.6	67.8	11.3**	6.81**	-11.7**
	(61.8)	(37.2)	(49.8)	(97.9)	(0.889)	(0.839)	(0.800)
Male Enrollment	67.9	53.0	61.5	83.0	10.6**	6.63**	-9.79**
	(83.2)	(56.4)	(68.1)	(106.0)	(1.29)	(1.16)	(1.04)
Presence of:							
Blackboard	0.956	0.953	0.949	0.971	-0.000	0.005	-0.012**
Computer	0.065	0.075	0.061	0.176	0.013*	0.010**	-0.098**
Electricity	0.352	0.196	0.261	0.547	0.067**	0.047**	-0.184**
Library	0.395	0.446	0.388	0.539	0.016+	0.006	-0.088**
Medical Checkups	0.645	0.610	0.639	0.641	0.010	-0.005	-0.003
Playground	0.574	0.466	0.543	0.682	0.065**	0.025**	-0.110**
Ramps	0.041	0.058	0.046	0.059	0.012**	0.004	-0.012**
Water Source: Pump	0.445	0.542	0.505	0.442	0.017*	-0.010	0.016**
Water Source: Tap	0.235	0.109	0.174	0.315	0.040**	0.033**	-0.087**
Water Source: Well	0.046	0.066	0.042	0.077	-0.000	0.006+	-0.019**

Notes: In column 1, I report the average values of the treatment schools at baseline. In column 2, I report the average values of the primary-comparison schools at baseline (AY 2002-03). In columns 3 and 4, I report the average values of the alternative-comparison schools at baseline (AY 2002-03). In column 5, I report the within-district difference between the average values of the treatment- and primary-comparison-school characteristics at baseline. In columns 6 and 7, I report the within-district difference between the average values of the treatment- and alternative-comparison-schools characteristics at baseline. Robust standard errors are reported with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 2. Baseline School Characteristics in 2002, Primary Schools (1st - 5th Grades)

	Treatment Group:	Main Control Group:	Alternative Control Groups:				
	Built Latrine Between 02-03 and 03-04	No Latrine From 02-03 through 05-06	Built Latrine Between 03-04 and 05-06	No Latrine Built Between 02-03 and 03-04	Within-District Differences: (1) - (2)	(1) - (3)	(1) - (4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Number of Schools	32,820	88,386	55,920	205,521			
Total Enrollment	143.7	100.6	123.5	143.0	32.6**	17.6**	-7.42**
	(106.8)	(79.5)	(94.7)	(123.9)	(0.713)	(0.733)	(0.649)
Female Enrollment	69.5	48.2	59.0	68.2	15.8**	8.80**	-2.96**
	(54.2)	(40.6)	(47.0)	(63.2)	(0.365)	(0.373)	(0.331)
Male Enrollment	74.2	52.4	64.5	74.8	16.7**	8.80**	-4.46**
	(58.8)	(44.6)	(52.9)	(69.1)	(0.399)	(0.410)	(0.363)
Presence of:							
Blackboard	0.963	0.946	0.961	0.965	0.010**	0.003+	-0.002+
Computer	0.036	0.040	0.035	0.066	0.008**	0.005**	-0.031**
Electricity	0.163	0.076	0.120	0.220	0.072**	0.043**	-0.091**
Library	0.517	0.487	0.501	0.552	0.021**	0.010**	-0.032**
Medical Checkups	0.645	0.616	0.637	0.621	0.020**	0.005+	-0.004
Playground	0.500	0.393	0.460	0.524	0.063**	0.026**	-0.046**
Ramps	0.044	0.059	0.051	0.055	0.008**	0.005**	-0.004**
Water Source: Pump	0.558	0.520	0.517	0.572	0.032**	0.005+	0.008**
Water Source: Tap	0.150	0.082	0.135	0.156	0.038**	0.020**	-0.039**
Water Source: Well	0.038	0.049	0.038	0.047	0.004**	0.005**	-0.004**

Notes: In column 1, I report the average values of the treatment schools at baseline. In column 2, I report the average values of the primary-comparison schools at baseline (AY 2002-03). In columns 3 and 4, I report the average values of the alternative-comparison schools at baseline (AY 2002-03). In column 5, I report the within-district difference between the average values of the treatment- and primary-comparison-school characteristics at baseline. In columns 6 and 7, I report the within-district difference between the average values of the treatment- and alternative-comparison-schools characteristics at baseline. Robust standard errors are reported with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 3. Overall Effect of a School Latrine on Student Enrollment, by Student Sex and Age

	Upper-Primary Schools (6th-8th)		Primary Schools (1st-5th)	
	All Students	By Student Sex	All Students	By Student Sex
	(1)	(2)	(3)	(4)
Panel A. Dependent Variable: Log (Enrollment + 1)				
Built a Latrine	0.079**		0.121**	
	(0.008)		(0.003)	
Built a Latrine * Females		0.071**		0.111**
		(0.011)		(0.004)
Built a Latrine * Males		0.047**		0.097**
		(0.010)		(0.004)
R^2 Statistic	0.326	0.246	0.154	0.130
Number of Observations	53,388	106,776	363,618	727,236
Number of Schools	17,796	17,796	121,206	121,206
Panel B. Dependent Variable: Enrollment Levels				
Built a Latrine	5.252**		11.809**	
	(0.844)		(0.476)	
Built a Latrine * Females		2.953**		5.851**
		(0.485)		(0.246)
Built a Latrine * Males		2.243**		6.026**
		(0.553)		(0.251)
R^2 Statistic	0.147	0.152	0.149	0.147
Number of Observations	53,388	106,776	363,618	727,236
Number of Schools	17,796	17,796	121,206	121,206

Notes: The sample in this table includes schools that did not have a latrine in AY 2002-03 and received a latrine the following year and schools that never received a latrine. Columns 1 and 3 report the average enrollment effect on all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the year was after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). In Columns 2 and 4, all right-hand-side variables are interacted with student sex.

The dependent variable in Panel A is the natural logarithm of enrollment plus one. The dependent variable in Panel B is enrollment in levels. The estimates are drawn from AY 2002-03, AY 2003-04, and AY 2005-06. The unit of observation in Columns 1 and 3 is school-year; thus, there are three observations per school. The unit of observation in Columns 2 and 4 is school-student sex-year; thus, there are six observations per school. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 4. Effect of a School Latrine over Time

	Upper-Primary Schools (6th-8th)			Primary Schools (1st-5th)		
	All Students	Females	Males	All Students	Females	Males
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Dependent Variable: Log (Enrollment + 1)						
Built a Latrine * 1 year after	0.073**	0.063**	0.041**	0.119**	0.110**	0.099**
	(0.008)	(0.011)	(0.011)	(0.003)	(0.004)	(0.004)
Built a Latrine * 3 years after	0.086**	0.079**	0.053**	0.122**	0.112**	0.096**
	(0.010)	(0.013)	(0.013)	(0.004)	(0.004)	(0.004)
R^2 Statistic	0.326	0.246		0.154	0.130	
Number of Observations	53,388	106,776		363,618	727,236	
Number of Schools	17,796	17,796		121,206	121,206	
Panel B. Dependent Variable: Enrollment Levels						
Built a Latrine * 1 year after	4.385**	2.409**	1.902**	11.723**	5.824**	6.028**
	(0.828)	(0.474)	(0.550)	(0.501)	(0.261)	(0.265)
Built a Latrine * 3 years after	6.119**	3.496**	2.584**	11.895**	5.879**	6.024**
	(1.090)	(0.604)	(0.697)	(0.579)	(0.295)	(0.302)
R^2 Statistic	0.147	0.152		0.149	0.147	
Number of Observations	53,388	106,776		363,618	727,236	
Number of Schools	17,796	17,796		121,206	121,206	

Notes: Columns 1 and 4 report the average enrollment effect on all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on presence of a latrine interacted with a dichotomous variable indicating how many years the time period is after the policy push (after AY 2002-03), an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). Columns 2&3 and 5&6 report the average effect on females and males from primary school and upper-primary school respectively, estimated from a single regression. In these regressions, all right-hand-side variables are interacted with student sex.

The dependent variable in Panel A is the natural logarithm of enrollment plus one. The dependent variable in Panel B is enrollment in levels. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 5. Effect of a School Latrine on Student Achievement, by Student Sex

	Change in Number of Enrolled Students Who					
	Appeared for Exam		Passed the Exam		Scored High Marks	
	All	By Sex	All	By Sex	All	By Sex
	(1)	(2)	(3)	(4)	(5)	(6)
Built a Latrine	2.045**		2.097**		-0.039	
	(0.719)		(0.736)		(0.587)	
Built a Latrine * Females		1.086**		1.152**		-0.044
		(0.376)		(0.382)		(0.281)
Built a Latrine * Males		1.199**		1.163*		0.065
		(0.447)		(0.455)		(0.372)
R^2 Statistic	0.184	0.178	0.177	0.176	0.061	0.060
Number of Observations	7,502	15,004	7,502	15,004	7,502	15,004
Number of Schools	3,751	3,751	3,751	3,751	3,751	3,751

Notes: The sample in this table includes schools that did not have a latrine in AY 2002-03 and received a latrine the following year and schools that never received a latrine. Columns 1, 3, and 5 report the average achievement effect on all students, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the year was after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year. In Columns 2, 4, and 6, all right-hand-side variables are interacted with student gender.

Analysis is drawn from AY 2002-03 and AY 2003-04. The dependent variables are the number of enrolled students who appeared for the examination (columns 1 and 2), who passed the examination (columns 3 and 4), and who scored high marks (columns 5 and 6) on the Uttar Pradesh Middle School board examination. The unit of observation in Columns 1, 3, and 5 is school-year. The unit of observation in Columns 2, 4, and 6 is school-student gender-year. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 6. Effect of a School Latrine by Latrine Type

	Upper-Primary Schools (6th-8th)				Primary Schools (1st-5th)			
		Changes by Student Sex				Changes by Student Sex		
	All Students	Females	Males	(2) – (3)	All Students	Females	Males	(6) – (7)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Dependent Variable: Log(Enrollment + 1)								
Built separate latrines for both boys and girls	0.096**	0.099**	0.058**	0.041**	0.129**	0.121**	0.101**	0.020**
	(0.009)	(0.012)	(0.012)	(0.014)	(0.004)	(0.005)	(0.005)	(0.005)
Only built a female-only latrine	0.092**	0.111**	0.013	0.098**	0.152**	0.156**	0.085**	0.071**
	(0.012)	(0.016)	(0.017)	(0.022)	(0.007)	(0.008)	(0.009)	(0.011)
Only built a unisex latrine	0.053**	0.022+	0.044**	-0.022	0.107**	0.094**	0.095**	-0.001
	(0.009)	(0.013)	(0.012)	(0.014)	(0.004)	(0.004)	(0.004)	(0.004)
R^2 Statistic	0.327	0.247			0.155	0.130		
Number of Observations	53,388	106,776			363,618	727,236		
Number of Schools	17,796	17,796			121,206	121,206		
Panel B. Dependent Variable: Enrollment Levels								
Built separate latrines for both boys and girls	7.096**	4.130**	2.912**	1.218+	13.528**	6.732**	6.865**	-0.133
	(1.067)	(0.600)	(0.673)	(0.692)	(0.576)	(0.292)	(0.312)	(0.219)
Only built a female-only latrine	5.100**	4.048**	0.928	3.120*	15.041**	8.375**	6.704**	1.671**
	(1.603)	(1.044)	(1.060)	(1.369)	(1.014)	(0.598)	(0.543)	(0.543)
Only built a unisex latrine	2.861**	1.070*	1.779**	-0.709	9.627**	4.604**	5.097**	-0.493*
	(0.945)	(0.501)	(0.632)	(0.635)	(0.510)	(0.266)	(0.272)	(0.199)
R^2 Statistic	0.148	0.152			0.149	0.148		
Number of Observations	53,388	106,776			363,618	727,236		
Number of Schools	17,796	17,796			121,206	121,206		

Notes: Columns 1-4 represent the results from the primary-school sample. Columns 5-8 represent the results from the upper-primary-school sample. The dependent variable in Panel A is the natural logarithm of enrollment plus one. The dependent variable in Panel B is enrollment in levels. Columns 1 and 5 report the average enrollment effect on all students, in which the dependent variable for each school is regressed on the presence of a female-only latrine and no unisex latrine interacted with whether the time period is after the policy push (after AY 2002-03), the presence of a unisex latrine and no female-only latrine interacted with whether the time period is after the policy push, the presence of separate, sex-specific latrines interacted with whether the time period is after the policy push, baseline school characteristics interacted with year, a year-district fixed effect, and a school fixed effect. Columns 2 and 3 represent a single regression, and columns 6 and 7 represent a single regression. They report the average effect on females and males, in which all right-hand-side variables are interacted with student sex. Columns 4 and 8 report the difference in the estimated effect for females and males. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 7. Effect of Initial Share of Female Teachers and a Latrine on Student Enrollment

	Upper-Primary Schools (6th-8th)			Primary Schools (1st-5th)		
	All Students	Females	Males	All Students	Females	Males
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Dependent Variable: Log (Enrollment + 1)						
Built any Latrine * Initial Share of Female Teachers	-0.087	0.036	-0.233+	0.004	0.046	-0.039
	(0.066)	(0.107)	(0.134)	(0.029)	(0.045)	(0.051)
Built any Latrine	0.120**	0.010	0.134*	0.077**	0.069**	0.025
	(0.037)	(0.069)	(0.056)	(0.015)	(0.020)	(0.021)
R^2 Statistic	0.371	0.255		0.122	0.088	
Number of Observations	1,270	2,540		6,087	12,174	
Number of Schools	1,270	1,270		6,087	6,087	
Panel B. Dependent Variable: Enrollment Levels						
Built any Latrine * Initial Share of Female Teachers	-3.890	0.405	-5.515+	-0.514	2.118	-3.356+
	(5.023)	(3.630)	(3.267)	(3.153)	(2.282)	(1.828)
Built any Latrine	6.416*	-0.165	6.456**	6.685**	4.051**	2.279*
	(2.892)	(1.551)	(2.405)	(1.536)	(0.883)	(1.015)
R^2 Statistic	0.170	0.168		0.105	0.095	
Number of Observations	1,270	2,540		6,087	12,174	
Number of Schools	1,270	1,270		6,087	6,087	

Notes: Columns 1 and 4 report the average enrollment effect on all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on presence of a latrine interacted with how many years the time period is after the policy push, presence of a latrine interacted with the initial share of female teachers in 2002 and whether the time period is after the policy push, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). Columns 2&3 and 5&6 report the average effect on females and males from primary school and upper-primary school respectively, estimated from a single regression. In these regressions, all right-hand-side variables are interacted with student sex.

The dependent variable is the natural logarithm of enrollment plus one. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 8. Estimated Change in Teacher Share by Teacher Gender and Caste as a Result of School-Latrine Construction

	Female	Female	General Caste	Scheduled Caste	Scheduled Tribe	"Other Backwards Classes"
	(1)	(2)	(3)	(4)	(5)	(6)
Built a Latrine	0.018**		0.006	-0.005	-0.003	0.003
	(0.005)		(0.007)	(0.007)	(0.006)	(0.008)
Built both types of latrine		0.023**				
		(0.007)				
Only built a female-only latrine		0.044**				
		(0.012)				
Only built a unisex latrine		0.011+				
		(0.006)				
R^2 Statistic	0.084	0.084	0.009	0.027	0.037	0.008
Number of Observations	24,009	24,009	24,009	24,009	24,009	24,009
Number of Schools	8,003	8,003	8,003	8,003	8,003	8,003

Notes: The sample in this table includes schools that did not have a latrine in AY 2002-03 and received a latrine the following year and schools that never received a latrine. Column 1 reports the average effect of a school having a latrine on the share of female teachers at a school, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the time period is after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year. Column 2 reports the average effect on the share of female teachers, in which the dependent variable for each school is regressed on a dichotomous variable for the presence of a female-only latrine and no unisex latrine interacted with whether the time period is after the policy push (after AY 2002-03), the presence of a unisex latrine and no female-only latrine interacted with whether the time period is after the policy push (after AY 2002-03), the presence of separate, sex-specific latrines interacted with whether the time period is after the policy push (after AY 2002-03), an academic year-district fixed effect, a school fixed effect, and vector of controls for baseline school characteristics interacted with year. Columns 3-6 report the average effect of a school having a latrine on the share of teachers by caste at a school, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the time period is after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of baseline school characteristics interacted with academic year.

The dependent variable in columns 1 and 2 is the share of female teachers at a school (the number of female teachers divided by the total number of teachers at a school). The dependent variable in columns 3-6 is the share of teachers by caste at a school (the number of teachers by caste divided by the total number of teachers at a school). Categorization of caste is defined by the Government of India. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Table 9. Effect of a Latrine by Districts' Baseline Gender Parity and Per Capita Income

	Upper-Primary Schools (6th-8th)			Primary Schools (1st-5th)		
	All	Females	Males	All	Females	Males
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.Gender Parity						
Built a Latrine	0.078**	0.068**	0.047**	0.116**	0.106**	0.093**
	(0.011)	(0.014)	(0.014)	(0.014)	(0.013)	(0.012)
Built a Latrine * Gender Parity Measure	0.015	0.022	0.003	0.020+	0.023*	0.021+
	(0.010)	(0.014)	(0.015)	(0.011)	(0.010)	(0.011)
R^2 Statistic	0.326	0.246		0.154	0.130	
Number of Observations	53,388	106,776		363,618	727,236	
Number of Schools	17,796	17,796		121,206	121,206	
Panel B.Income Measure						
Built a Latrine	0.076**	0.067**	0.043**	0.156**	0.143**	0.124**
	(0.015)	(0.021)	(0.018)	(0.022)	(0.021)	(0.020)
Built a Latrine * Income Measure	-0.010	-0.008	0.006	0.014	0.017	0.015
	(0.014)	(0.022)	(0.018)	(0.014)	(0.014)	(0.013)
R^2 Statistic	0.324	0.240		0.160	0.128	
Number of Observations	37,737	75,474		235,200	470,400	
Number of Schools	12,579	12,579		78,400	78,400	
Panel C. Gender Parity and Income						
Built a Latrine	0.064**	0.051+	0.021	0.153**	0.139**	0.115**
	(0.020)	(0.026)	(0.023)	(0.024)	(0.022)	(0.024)
Built a Latrine * Gender Parity Measure	0.024	0.032	0.044	0.007	0.008	0.019
	(0.023)	(0.030)	(0.028)	(0.028)	(0.026)	(0.031)
Built a Latrine * Income Measure	-0.018	-0.018	-0.008	0.012	0.015	0.009
	(0.016)	(0.023)	(0.019)	(0.015)	(0.015)	(0.014)
R^2 Statistic	0.324	0.240		0.160	0.128	
Number of Observations	37,737	75,474		235,200	470,400	
Number of Schools	12,579	12,579		78,400	78,400	

Notes: The gender parity measure in this table is a continuous normalized ratio of enrolled upper-primary-school girls to boys in 2002, calculated as the ratio of the average number of enrolled upper-primary girls in a district at baseline to the average number of enrolled upper-primary boys in a district at baseline minus the mean ratio divided by the standard deviation of the ratio. Income is defined as the normalized average per capita income in each district in 2002. Panel A report the average impact of a latrine and how the impact changes for districts with a one standard deviation higher measure of gender parity. Panel B reports how the impact of latrines varies with districts' per capita income. Panel C reports how the impact of latrines varies when including both district measures. Columns 1 and 4 report the average enrollment effect on all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on presence of a latrine interacted with how many years the time period is after the policy push, presence of a latrine interacted with the gender parity measure (in Panels A and C), presence of a latrine interacted with the per-capita income measure (in Panels B and C), and whether the time period is after the policy push, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). Columns 2&3 and 5&6 report the average effect on females and males from primary school and upper-primary school respectively, estimated from a single regression. In these regressions, all right-hand-side variables are interacted with student sex.

The dependent variable is the natural logarithm of enrollment plus one. Robust standard errors clustered by district are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Appendix Table 1. Effect of a School Latrine on Student Drop-Out

	Upper-Primary Schools (6th-8th)		Primary Schools (1st-5th)	
	All Students	By Student Sex	All Students	By Student Sex
	(1)	(2)	(3)	(4)
Built a Latrine	-0.053**		-0.122**	
	(0.015)		(0.005)	
Built a Latrine * Females		-0.054**		-0.125**
		(0.016)		(0.005)
Built a Latrine * Males		-0.046**		-0.112**
		(0.016)		(0.005)
R^2 Statistic	0.067	0.067	0.036	0.036
Number of Schools	17,796	17,796	121,206	121,206

Notes: The sample in this table includes schools that did not have a latrine in AY 2002-03 and received a latrine the following year and schools that never received a latrine. Columns 1 and 3 report the average effect on the drop-out of all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the year was after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). In Columns 2 and 4, all right-hand-side variables are interacted with student sex.

The dependent variable is defined as the fraction of students who drop out as the expected enrollment (derived from the previous year's enrollment) minus the current year's enrollment, divided by the expected enrollment. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Appendix Table 2. Robustness: Matching Techniques, Overall Effect of a Latrine

	Nearest Neighbor Matching	Coarsened Exact Matching	Nearest Neighbor, No Replacement	Kernel-Based Matching	Mahalanobois Matching	Radius Matching
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Upper-Primary Schools (6th-8th Grades)						
Built a Latrine	0.069**	0.067**	0.074**	0.062**	0.058**	0.068**
	(0.011)	(0.008)	(0.008)	(0.008)	(0.010)	(0.011)
R^2 Statistic	0.300	0.310	0.303	0.298	0.306	0.333
Number of Observations	45,750	51,408	45,750	53,388	45,750	53,388
Number of Schools	11,048	17,136	15,250	17,796	11,279	17,796
Panel B: Primary Schools (1st-5th Grades)						
Built a Latrine	0.108**	0.116**	0.109**	0.109**	0.108**	0.125**
	(0.006)	(0.004)	(0.004)	(0.003)	(0.007)	(0.004)
R^2 Statistic	0.171	0.155	0.161	0.162	0.170	0.180
Number of Observations	196,920	361,785	196,920	363,618	196,920	363,618
Number of Schools	43,013	120,595	65,640	121,206	43,863	121,206

Notes: The dependent variable is the natural logarithm of enrollment plus one. These estimates use matching techniques to estimate the effect of a latrine, as noted in the column headings. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Appendix Table 3. Effect of a School Latrine, Using Alternative Comparison Groups

	No Latrine From 2002 through 2005		Built Latrine Between 2003 and 2005		No Latrine Built Between 2002 and 2003	
	All Students	By Student Sex	All Students	By Student Sex	All Students	By Student Sex
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Upper-Primary Schools (6th-8th Grades)						
Built a Latrine	0.073**		0.045**		0.029**	
	(0.008)		(0.007)		(0.005)	
Built a Latrine * Females		0.063**		0.034**		0.027**
		(0.011)		(0.009)		(0.007)
Built a Latrine * Males		0.041**		0.025**		-0.004
		(0.011)		(0.009)		(0.007)
R^2 Statistic	0.343	0.238	0.335	0.226	0.236	0.135
Number of Observations	35,592	71,184	34,338	68,676	118,150	236,300
Number of Schools	17,796	17,796	17,169	17,169	59,075	59,075
Panel B. Primary Schools (1st-5th Grades)						
Built a Latrine	0.119**		0.054**		0.093**	
	(0.003)		(0.003)		(0.002)	
Built a Latrine * Females		0.110**		0.053**		0.085**
		(0.004)		(0.004)		(0.003)
Built a Latrine * Males		0.099**		0.041**		0.070**
		(0.004)		(0.004)		(0.003)
R^2 Statistic	0.153	0.134	0.165	0.140	0.128	0.109
Number of Observations	242,412	484,824	177,480	354,960	476,682	953,364
Number of Schools	121,206	121,206	88,740	88,740	238,341	238,341

Notes: This table reports the results using alternative comparison groups. The comparison group in columns 3 and 4 includes schools that did not have a latrine in AYs 2002-04 but that did have a latrine by AY 2005-06. In columns 5 and 6, the comparison group includes schools that had a latrine every year between AYs 2002-06 and schools that never had a latrine between AYs 2002-06. The table reports the average enrollment effect in which the dependent variable for each school is regressed on presence of a latrine interacted with how many years the time period is after the policy push (after AY 2002-03), an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year. All right-hand-side variables in columns 2, 4, and 6 are interacted with student sex.

The analysis is drawn from AY 2002-03 and AY 2003-04. The dependent variable is the natural logarithm of enrollment plus one. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Appendix Table 4. Further Robustness Checks, Overall Effect of a Latrine

	Controls for Changes in Baseline Characteristics	Villages with Only One School	Coeducational Sample	Coed Sample: Log(Enrollment)	Baseline Controls Interacted with Linear Time Trend	Clustering Standard Errors at the District Level
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Upper-Primary Schools (6th-8th Grades)						
Built a Latrine	0.077**	0.076**	0.066**	0.068**	0.079**	0.079**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)
R^2 Statistic	0.356	0.338	0.313	0.317	0.326	0.326
Number of Observations	53,388	49,668	49,008	49,008	53,388	53,388
Number of Schools	17,796	16,556	16,336	16,336	17,796	17,796
Panel B: Primary Schools (1st-5th Grades)						
Built a Latrine	0.107**	0.124**	0.119**	0.122**	0.121**	0.121**
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.014)
R^2 Statistic	0.196	0.171	0.155	0.155	0.154	0.154
Number of Observations	363,618	276,588	351,261	351,261	363,618	363,618
Number of Schools	121,206	92,196	117,087	117,087	121,206	121,206

Notes: The dependent variable is the natural logarithm of enrollment plus one. The main specifications report the average enrollment effect on all primary-school and upper-primary-school students respectively, in which the dependent variable for each school is regressed on a dichotomous variable for whether a school had a latrine interacted with whether the year was after AY 2002-03, an academic year-district fixed effect, a school fixed effect, and a vector of controls of baseline school characteristics interacted with academic year (including initial enrollment, presence of electricity, a school library, water by source, ramps, regular medical checkups, and a playground in AY 2002-03). In column 1, the specification includes controls for changes in baseline characteristics over time. Column 2 limits the sample to schools that are in villages with only one school. Columns 3 and 4 limit the sample to schools with positive enrollments of boys and girls with the logarithm of enrollment as the dependent variable in column 4. In column 5, the controls are interacted with a linear time trend instead of a flexible time trend. In column 6, the standard errors are clustered at the more-conservative district level instead of the school level. Robust standard errors clustered by school are reported in parentheses with ** denoting statistical significance at the 1 percent level, * at the 5 percent level, and + at the 10 percent level.

Data Appendix: Details on Qualitative Research

I conducted structured interviews primarily in four states in India: Madhya Pradesh (MP), Andhra Pradesh (AP), Tamil Nadu (TN), and Uttar Pradesh (UP). The estimated per capita income of MP and UP are comparable to other major North Indian states (Rs. 7,000-10,000), just as the estimated per capita income of TN and AP are comparable to other major South Indian states (Rs. 10,001-13,000) (Census of India 2001).

Research participants were drawn from an arbitrary and convenient sample found in fields (farmers, fieldworkers), households (parents, children), schools (principals, students), and roadside shops (shop owner, customers). In MP, research participants were located in the rural districts of Sehore (population of 1,078,972) and Vidisha (pop. 1,214,857). The sample included 53 private citizens (farmers, fieldworkers, shop keepers, mothers, fathers, etc.), 20 government officials, 6 school officials, and 1 bank manager. The research participants in AP were located in the rural Nalgonda district (pop. 3,247,982). The sample included 34 private citizens and 6 school officials. In UP, 8 private citizens and 3 school officials were interviewed in the rural Bhakshi Ka Talab area outside of Lucknow (pop. 2,186,000). In TN, interviewees were 10 private citizens who resided in the rural Tiruvallur District (pop. 2,738,866). In addition to the interviews, I conducted a survey of 133 households in this district of TN, which included questions about financial decisions families would make if their budgets were less constrained.

Interview lengths ranged from five minutes to two hours. Participants answered questions about educational and financial decisions and sometimes gave tours of their schools, homes, or villages.[62] The interviews were usually conducted in participants' homes, classrooms, office spaces, or in public places such as restaurants, cafes, camel carts, and roadside shops.

In addition, I conducted less-structured interviews and site visits, in which I embedded myself in the community. For example, I worked with the Environmental Sanitation Institute (ESI) and Safai Vidyalaya, two nongovernmental organizations in the state of Gujarat (GJ), on community sanitation projects to understand the issues from the perspective of the service provider (engineers, NGOs, government) in addition to the beneficiaries of latrines. For

[62]Questions to parents included inquiries about whether they send their children, why they send their children to school, what are factors that dissuade them from sending their children to school, etc. Questions to children included whether they attended school, whether they liked school and why, what they wished was different about school, what were the reasons they did or did not attend school, did their friends, siblings, and cousins attend school, etc. I asked headmasters about their jobs, their satisfaction in their jobs, what innovations they were excited about in their schools, what they would do with additional money for the school, how they motivate the teachers in the school, what they wish was different about the school, why they think that children attend or do not attend school, the importance of existing or possible school infrastructure (*e.g.* latrines, etc.), etc. I asked other government officials about their roles, their understanding of the local school situation, how they thought schools could be improved, what they would do if given extra money to improve schools, current school-financing schemes, why they think children do or not attend school, etc.

example, I accompanied ESI on a Nandini Sanitation and Health on Wheels project, in which a group of volunteers traveled to villages to provide sanitation-related education. During this time, I participated in latrine construction, assisted with hygiene-education provision, and conducted interviews and participant observations in three villages. This included living with local families during the visits. Second, I assisted with household interviews in a large slum in the city of Ahmedabad, Gujarat to understand the sanitation situation. As part of these interviews, we asked parents and guardians about the factors that influence the education decisions they make for their children.