

Do sanitary pads alleviate period poverty and improve girls' educational outcomes?

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Abstract

Using a staggered installation of sanitary pad vending machines across schools in the Indian state of Kerala, we study the impacts of free monthly access to sanitary pads on girls' educational outcomes. We find that the number of dropouts among female students in the 7th-grade decrease by 24 percentage points and the number of girls who pass the upper primary school-leaving examination increases by 82.8 percent after the treatment. Our results are mainly driven by girls in backward-caste, rural schools, and public schools, supporting the idea that free distribution of sanitary pads alleviates cost of obtaining sanitary pads. (*JEL* I21, H75, J13, J16, O12)

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1. Introduction

Globally, an estimated 500 million women and girls lack access to menstrual hygiene products and facilities (World Bank, 2018). According to the United Nations Children’s Fund (UNICEF, 2018), poor menstrual hygiene poses high physical health risks. Educational consequences have been reported as one of the largest impacts of inadequate menstrual hygiene access among school-going girls. World Bank statistics highlight that girls miss four school-days every four weeks due to difficulties associated with menstruation management (Mooijman et al., 2005). In India, reports show that only 12% of the 355 million women use sanitary pads; school-going girls fare worse in menstrual hygiene management, as approximately 23 million Indian girls drop out of school annually due to a lack of proper menstrual hygiene management facilities (AC Nielson and Plan India, 2010). As a result, menstruation-related difficulties undermine girls’ opportunities for education and present a significant challenge to achieving gender equality in educational attainment, which is crucial to social and economic development (Duflo, 2012).

In this paper, we examine the impact of free monthly access to sanitary pads on girls’ educational decisions and outcomes.¹ We explore a novel government-initiated program—the SHE Pad Scheme—that has installed sanitary pad vending machines in schools across the state

¹ Similar programs have been implemented in California and England. See <https://www.theguardian.com/education/2020/jan/18/free-period-products-to-be-available-in-schools-and-colleges-in-england> and <https://www.cnn.com/2021/10/09/us/california-menstrual-products-schools-trnd/index.html>.

of Kerala in India since 2015.² Similar programs have been implemented in all public schools in England and California since 2020 and 2021 respectively, in an effort to tackle period poverty which could cause school absenteeism among girls from disadvantaged economic background. Under the staggered adoption of the SHE Pad Scheme, 765 schools have been installed with sanitary pad vending machines that distribute free sanitary pads to menstruating girls in treated schools every month.

A major empirical challenge in estimating the causal effects of the free distribution of sanitary pads is cross-sectional selection. Treated schools may be systematically different from control schools, resulting in diverging group-specific trends even without treatment. To overcome this bias, our main empirical specification focuses on comparing changes in outcomes of pubescent girls among treatment and control schools with similar initial school characteristics such as enrollment size and school infrastructure, by estimating a panel regression with school fixed effects and block-year fixed effects. We also include school-specific linear time trends to control for potential differential trends across schools, and the year interaction of initial school characteristics to control for school differences in baseline facilities. We thereby compare changes in pubescent girls' educational outcomes among treated schools and untreated schools that are located in the same community development block and have similar baseline school characteristics and growth trajectories of school outcomes. To ensure the robustness of the results, we explore alternative control groups including pubescent students in untreated schools located within the same village and prepubescent students in

² Students' collections of sanitary pads from vending machines are regulated by school administrator, who will keep a record of every collection to ensure a transparent distribution process. This avoids misuse by children for use by family members.

treated schools. We also employ different methods of matching including various matchings on propensity scores, coarsened exact matching and synthetic control methods.

We use Indian school enrollment and facilities data obtained from the District Information System for Education (DISE) from academic year 2013-2014 to 2019-2020.³ We focus on girls in girls-only and mixed-gender schools, and match DISE data to administrative data from the government-initiated SHE Pad Scheme in the state of Kerala using a combination of algorithm matching and manual matching.

Our main outcome variable is the cohort-based dropout rate, which follows closely with both qualitative and quantitative discussions on the linkage between girls' menstruation and schooling outcomes. It is calculated as the percentage change between the current year's enrollment and the next year's enrollment. We further examine the robustness of the results by using a dropout measure that is adjusted for student retention and by restricting the sample to villages with only one school that offers the education level to eradicate nonrandom student transfers. As a further robustness test, we repeat the main specification using log enrollment as the outcome variable.

We find that the free distribution of sanitary pads significantly reduces the dropout of girls in the 7th-grade. As the terminal grade of the primary education stage in Kerala, 7th-grade is the grade in which students make decisions about their transition to secondary school and is also the grade in which an average girl in Kerala experiences her first menstruation. Using a staggered difference-in-differences (DID) empirical strategy, we estimate that the free distribution of sanitary pads in schools causes a 24 percentage points, or 32.66 percent,

³ Adukia (2017) and Adukia, Asher and Novosad (2020) use data from the same source.

decrease in the dropout rate of girls.⁴ We also estimate increases in the number of girls attending, passing, and scoring highly on upper primary school-leaving examinations, indicating academic improvements on the intensive margin in addition to the extensive margin impact on dropouts. These treatment effects persist and increase over time, and survive a broad range of sample restrictions, alternative specifications, and falsification tests.

While recent econometric literature suggests that estimates from staggered DID are likely to be biased when treatment effects are heterogeneous, the results from diagnostic tests validate our DID estimates (Chaisemartin and d'Haultfœuille, 2020; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Goodman-Bacon, 2021). We implement Goodman-Bacon's (2021) (hereafter GB) decomposition and find that less than 3 percent of DID estimates are derived from comparison where early-treated schools are used as the control group for later-treated schools. We also apply diagnostic tests following de Chaisemartin and d'Haultfœuille (2020) (hereafter CD) and find that treatment effects in our baseline specification do not receive any negative weights and that our estimates will only be invalidated under a very large and implausible amount of treatment effect heterogeneity. For further robustness checks, we re-estimate the baseline specification using the DID estimator proposed by CD.

We then explore the mechanisms through which girls' dropouts could be affected by free access to sanitary pads, by examining the heterogeneity of treatment effects by the schools' geographical location, management type, initial student enrollment by caste. We find large point estimates of treatment effects in rural schools, public schools, backward-caste schools and schools located in villages with access to amenities, implying that the estimated treatment impacts on girls' dropouts are largely driven by affordability.

⁴ We divide the treatment estimate of 0.24 by 0.735, the absolute mean value of pre-treatment dropout of treated schools.

We explore several other treatment mechanisms but do not find supportive evidence in the data regarding (i) increased boys' awareness about menstruation; (ii) increased number of female teachers or reduced teacher absenteeism; and (iii) increased pressure from other female family members to continue schooling to help collect sanitary pads for their use.

Our study closely follows a growing body of qualitative and quantitative evidence that has focused on the impact of sanitation facilities on girls' educational outcomes (Duflo, 2012; Caruso et al., 2013; Haver et al., 2013; Long et al., 2013; Adukia, 2017). In particular, Adukia (2017) attributes improved educational outcomes after toilet construction in schools to its effectiveness in creating a safe learning environment that protects girls from sexual abuse and harassment.

Papers most similar to ours that connect school absenteeism and menstruation-related difficulties are by Oster and Thornton (2011), and Phillips-Howard et al. (2016). Using a randomized experiment that provides sanitary cups to 198 girls in Nepal, Oster and Thornton (2011) do not find treatment effects on school absenteeism. In this paper, we do not examine effects on school attendance, and instead we focus on the extensive margin by analyzing treatment impacts on cohort-based dropout rates. Another study that is related to ours is that conducted by Phillips-Howard et al. (2016) who find insignificant treatment effects on school absence and dropout in an experiment that provides sanitary cups and pads to 751 students in Kenya. In contrast to these empirical findings, we find that free monthly access to sanitary pads is effective in increasing girls' likelihood of continuing schooling and improving their academic outcomes. One reason behind this discrepancy is the difference in experimental targets. In Phillips-Howard et al. (2016), participants in the experiment must be between 14 and 16 years old, and the average participant must have experienced at least one year of menstruation. However, most of the marginal students in this age group who are facing menstruation management difficulties would have already dropped out from school during the

first few experiences of menses and hence fall outside of the experimental study group. Recognizing this possibility, we study the dropout decisions of students across all pubescent ages using cohort-level enrollment information from 5th-grade through 10th-grade.

Another major distinction between our study and the abovementioned studies is the nature of the experimental design. We explore a long-term, government-initiated program implemented state-wide while they study small-scale, transitory controlled experiments conducted by nongovernmental organizations. Furthermore, given that schooling decisions involve a long-term commitment and that menstruation is a monthly event for every school-aged girl, controlled experiments that provide one-off or short-term access to sanitary products may not result in material changes in behavior and schooling decisions. In contrast, our study exploits the nontransitory and durable nature of government-initiated programs, which in this case provide female students with long-term assurance of free access to sanitary pads during every menstrual period as long as they remain in school. With this, this paper provides the first rigorous insight into the longer-term impacts of free access to sanitary pads in a large-scale setting.

Last, we argue that the type of sanitary products matter, and that the program implementation design of the SHE Pad scheme, which installs a sanitary pad vending machine in schools, plays a crucial role in reinforcing the link between free access to sanitary pads and education. Contrary to the one-off receipt of reusable menstrual cups or the short-term collection of sanitary pads in the controlled studies, the monthly collection of sanitary pads from vending machines installed in schools under monitored conditions motivates girls to attend school regularly and to continue schooling. Such motivated behavior—to attend school regularly to obtain sanitary pads—coincides with existing evidence that girls perform transactional sex to obtain sanitary pads (Phillips-Howard et al., 2015). Additionally, the inability to detect treatment impacts in short-term controlled experiments may be compounded

by the low adaptation rates and slow initial uptake of menstrual cups, as highlighted in Phillips-Howard et al. (2016).

2. Program Details and Data

2.1 SHE Pad Scheme

The SHE Pad Scheme is a large-scale program initiated by the state government of Kerala that aims to provide free sanitary pads to all menstruating female students across the state. As the first Indian state to implement such a project statewide, the SHE Pad Scheme is the main program under the Menstrual Hygiene Management (MHM) initiative rolled out by the Kerala State Women's Development Corporation (KSWDC) Ltd. The main objective of the program is to raise awareness about menstrual hygiene, reducing stigma associated with menstruation through normalizing public discussions of menstruation by distributing free sanitary pads to school-going children.

Pilot projects were implemented in 2015, two years before the official state-wide implementation of the SHE Pad Scheme in November 2017. Under the scheme, sanitary pad vending machines that distribute free and safe sanitary pads were installed in schools with upper primary, lower secondary and higher secondary classes. From 2015 to 2020, a total of 765 schools were installed with vending machines (Appendix A1).

High-quality sanitary pads are supplied in regular terms to schools by HLL Life Care Limited, a state-owned enterprise, based on the number of menstruating female students in every school. Steel storage container for sanitary pads and incinerators are also supplied by state-owned enterprises. This process ensures that the entire plan outlay for the project reaches the beneficiaries directly. Furthermore, the collection of sanitary pads is regulated and monitored by an appointed school counselor who is responsible for keeping detailed records of sanitary pad collections by students. To ensure that the distribution process is transparent, the records are inspected by an appointed government official.

2.2 Data

2.2.1 District Information System for Education (DISE)

We collect annual school census in the state of Kerala in India from the DISE. It is a government database created by the Ministry of Education of the Government of India and administered by the National University of Educational Planning and Administration (NUEPA). DISE data cover every registered primary and secondary schools in Kerala. We obtain data on school-level enrollment by gender and grade and school infrastructure data from academic years 2013-2014 to 2019-2020⁵.

School-leaving examination outcomes for primary schools reported in the years from 2013 to 2016 are obtained from the DISE. Examination outcome is an informative measure of school participation. For instance, the exam passing rate can be a proxy for school attendance (Angrist and Krueger, 1991; Lamdin, 1996; Kwak, Sherwood and Tang, 2019). Similarly, attendance at school-leaving examinations can be used to assess student dropouts because school transfer certificates that are required for the transition to higher educational levels at other schools can only be obtained on successful completion of school-leaving examinations.

2.2.2 DISE Data and Treatment Information

We construct a school-level panel dataset by combining school-level enrollment and infrastructure information from the DISE with data on school-level participation in the SHE Pad Scheme. The SHE Pad Scheme data include school name, district name, school type, and treatment details including the year of installation of the sanitary pad vending machine. We match the two datasets based on school and district names using a matching algorithm and manually resolve any conflicting matches. The merged dataset includes 16,906 girls-only and

⁵ Hereafter, we refer to academic years by the year in which the first term of the school begins (2013-2014 is referred to as 2013).

mixed-gender schools. Further details on the data and merging process are outlined in Appendix B.

Of the 16,096 schools, 765 schools participated in the SHE Pad Scheme.⁶On average, female student enrollments in treated schools are more than four-times higher than those in untreated schools as most treated schools are schools that provide at least the upper primary school area, which tends to be larger in scale.

School facilities also vary across treated schools and untreated schools. Treated schools have a significantly larger number of classrooms, toilets and books in libraries. A larger fraction of treated schools is accessible by road, have electricity connections, libraries, playgrounds, ramps for disabled children, and computer labs and offer regular medical checkups for students. The main source of drinking water facilities and the type of boundary wall also differ significantly across the treatment and untreated schools. Taken together, treated schools are larger schools that have better school facilities and infrastructure. Appendix A2 tabulates the differences in average baseline characteristics for treated schools and control schools in 2013.

While there are more than 16 thousand untreated schools in the full sample, less than one-fifth of them enter into the regression of treatment effect on dropouts of girls in the 7th-grade. This is mainly because most of the untreated schools are primary schools which do not provide upper primary or lower secondary education section (primary schools tend to be smaller in size) and hence are not targeted by the SHE Pad Scheme. We re-generate baseline summary statistics using the regression estimation sample and report the summary statistics in Appendix A3.

⁶ 5 of the 765 treated schools are not present in the DISE data in 2013 and hence are removed from the estimation sample.

There are no significant differences between treated schools and control schools in the number of classrooms, the number of girls' toilets and toilets for children with special needs, presence of electricity, presence of libraries, presence of computer labs, presence of roads and types of boundary wall structure. However, treated schools have significantly smaller number of classrooms that are in good condition; they are more likely to have playground, ramps, medical check-ups for students, school management committee and school development plan. Nearly 54 percent of the treated schools are located in government-owned buildings, and a larger fraction of them use water from well. In terms of enrollment size, treated schools are approximately 40 percent larger than control schools. Further discussion on the comparability between treated and control schools can be found in the following section and appendix.

3. Analysis

3.1 Effects on the Dropout Rate of Girls

Menarche occurs within the age range of 11 to 16, and the mean age at menarche for girls in Kerala is estimated to be 13.05 years old (Singh and Singh, 2021). For purposes of completeness, we begin our analysis on girls aged between 10 and 16 who are in the 5th-grade to 10th-grade. As the onset of puberty varies across children and ranges from 9-15 years old, these girls are at pubescent ages and may be impacted by the SHE Pad Scheme.

For each c^{th} -grade, we estimate separate difference-in-differences (DID) regressions using the following equation:

$$(1) \quad y_{c,s,b,t} = \beta_0 + \beta_1 \text{After}T_{s,t} + \gamma_t X_s + \pi_s + \delta_s t + \lambda_{b,t} + \varepsilon_{c,s,b,t} .$$

$y_{c,s,b,t}$ is an outcome of interest for female students in c^{th} -grade in school s in block b in year t .⁷ $AfterT_{s,t}$ is an indicator variable of the treatment status of school s , which equals 1 if the school has been treated with a sanitary pad vending machine. The treatment group includes girls in all girls-only and mixed-gender schools that have been installed with the vending machine, and the control group includes girls in all girls-only and mixed-gender schools that have not received a vending machine. We include school fixed effects, π_s , and control for differences in school characteristics by including a year interaction vector of baseline school characteristics, $\gamma_t X_s$, which includes schools' baseline total enrollment and all school-level facilities reported in Appendix A3. We include block-year fixed effects, $\lambda_{b,t}$, to capture shocks that affect all schools in a given block in a given year. We also include school-specific linear time trends, $\delta_s t$, to allow unobserved school outcome propensities to trend linearly over time in each school. Our identifying assumption is that in the absence of treatment, girls in treated schools would have followed the same path as girls in control schools within the same block and with similar school characteristics and trends.⁸ Standard errors are clustered at the school level. Furthermore, all baseline regressions are estimated using a balanced panel by removing schools with missing observations in any periods from 2013 to 2018.⁹

Our main outcome variable is students dropout, which is calculated as the fraction of students who discontinue schooling in the subsequent year. It is defined as the current year's

⁷ India comprises of 28 states, each state is divided into districts, community development blocks, and villages. Kerala is divided into 14 districts and 152 community development blocks (hereafter block).

⁸ We discuss the identifying assumption and comparability between treated and control schools in Appendix C.

⁹ We find consistent baseline results using an unbalance panel (Appendix A4).

enrollment minus the next year's enrollment, divided by the current year's enrollment: $Enrollment_{c,s,t} - Enrollment_{c+1,s,t+1}/Enrollment_{c,s,t}$. A negative coefficient of interest β_1 denotes a decrease in the fraction of students who quit school in the following academic year. Appendix D discusses the choice of main outcome variable in detail.

Baseline Results. Appendix A10 provides a preview of the main findings in this paper: at the block level, approximately 3.5% of female students drop out of school before the treatment program, but this number drops to 1.7% after treatment. Below we empirically examine the causal effects of free sanitary pads on girls' educational outcomes.

Following Equation (1), Table 1 presents estimation results for the average effects of free sanitary pads on dropout rate of girls from the 5th-grade through the 10th-grade. Dropout rates decrease by 24 percentage points, or $0.240/0.735 = 32.66$ percent, for girls in the 7th-grade after the installation of the sanitary pad vending machine.¹⁰ These findings provide a meaningful interpretation: (1) girls in the 7th-grade are approximately 12 to 13 years old, which falls in the mean age at menarche for girls in Kerala, and (2) dropouts in higher grades exhibit a muted treatment response as marginal students who could benefit from the treatment program would have already left school by then.

Figure 1 plots the dynamic treatment effects on the dropout of girls in the 5th-grade through the 10th-grade.¹¹ We find no discernable dynamic treatment effects, either economically or statistically, on the dropouts of girls across all grades, except for the 7th-grade. Treatment

¹⁰ The pre-treatment average dropout rates of 7th-grade girls in the treated schools is -0.735.

¹¹ As a robustness test, we estimate changes in $\log(enrollment)$ and find that girls' enrollment in the 8th-grade, which corresponds to the dropouts of students in the 7th-grade, increases post-treatment (Appendix A8).

effects on dropouts in the pre-treatment years are insignificant, verifying the common trends assumption that underpins the validity of the DID estimates.

Interestingly, there is a sharp decrease in dropout rates of 32.7 percentage points for students in the 7th-grade in the first year of the machine installation. The treatment effects increase in magnitude over time, suggesting that the continued provision of free sanitary pads not only generates persistent treatment effects but also exerts an additive incremental influence on girls' schooling decisions. This important finding underscores the credibility and durability attached to government-initiated long-term programs, which, in this case, provide girls with long-term assurance of receiving free sanitary pads as long as they continue schooling. Considering the differential timing of first menstruation across individuals, our results probably underestimate the true effects of free sanitary pad distribution on dropouts.^{12,13}

3.2 Additional Analyses and Robustness Tests

DID Estimator. Table 2 reports diagnostic tests and results from alternative DID estimators to examine the robustness of our DID estimates. Using GB's decomposition, we find that our DID estimates are largely driven by the comparison of treated schools to never-treated schools, allowing us to draw casual inference from the DID estimates obtained from Equation (1). We also test whether treatment effect heterogeneity poses threat that invalidates our DID estimates following CD. Treatment effects in most of the regressions do not receive any negative weights; the magnitude of $\underline{\sigma_{fe}}$ for Average Treatment on Treated (ATT) is considerably larger than the DID estimates across all columns, suggesting that the estimates will only be invalidated under

¹² Further discussion on our estimated treatment impacts can be found in Appendix E.

¹³ Drawing reference from nutrition literature which indicates earlier menarche among urban girls (Ramraj et al., 2021), Appendix A11 shows that dynamic treatment effects on 6th-grade female students in urban schools demonstrate similar magnitudes and patterns to the baseline.

an implausible amount of treatment effect heterogeneity. For a complete robustness check, we also report coefficients obtained from estimating the DIDM estimator proposed by CD in Appendix A12.

Alternative Control Groups. In Table 3, we find consistent results of treatment effects on dropouts of 7th-grade girls using alternative control groups. In Columns 1 and 2, we eliminate concerns over village-level differences that could be correlated with the treatment assignment by including village-year fixed effects. To verify that our results are not confounded by differences in school-level characteristics between treated and control schools, in Columns 3 to 5, we use prepubescent students in treated schools as the control units and in Column 6 we additionally include school-year fixed effects in the regression.¹⁴ The results are also robust to the use of estimation samples constructed based on various propensity score methods (Appendix A5).

While alternative control groups may resemble treated schools more closely in terms of regional- and school-level characteristics, our preferred specification is to use same-grade girls in untreated schools within the same block as the main comparison group, additionally controlling for the year interaction vector of baseline school characteristics and including school-specific linear time trends. First, spillover effects may induce girls in untreated schools to self-sort to treated schools in the same village, causing an upward bias in the treatment impacts. Second, treatment effects may spill over to students in lower grades in treated schools when children in lower grades selectively enter treated schools, causing a downward bias in the treatment impacts. In addition, the change in the number of dropouts of students in lower grades may not be comparable to that of the 7th-grade students, as the number of dropouts in

¹⁴ Girls in 1st- to 3rd-grades are between 6-9 years old. They are considered as pubescent girls, as girls' median age of pubertal onset is 10.8 (Khadgawat et al., 2016).

students in higher grades is more closely correlated with the local economy, marriage market and social trends (Jensen and Thornton, 2003; Field and Ambrus, 2008).

Robustness Tests. In Column 1 of Table 4, we show that the results are robust to the use of retention-adjusted dropout measures and various restricted samples. Student enrollment at $t + 1$ may contain new student admissions due to random transitions, standard transitions, and treatment-driven transitions. The inclusion of school-specific linear time trends in the baseline helps address the first two categories of student transitions. Additionally, in Column 2, we replace block-year fixed effects with block-school category-year fixed effects to account for the different levels of standard transitions in schools that encompass different grade levels, parsing out any changes in student enrollment due to random and standard transitions. In Column 3, we estimate the treatment effects using a restricted sample that includes the only schools that offer 8th-grade education in the village, following the convention that Indian children do not travel across villages to attend schools. Despite the significant shrinkage in sample size, the estimates are found to have the same direction as the baseline. In an unreported regression, we do not find a significant treatment effect on dropouts in control schools, ruling out the possibility of increased transitions in treated schools from nearby control schools.

Since 2011, KSWDC has been constructing SHE-toilets in Kerala (Appendix A13). As toilet constructions may confound the estimated treatment effects, we remove all schools with SHE-toilets and treated schools with varying numbers of toilets since treatment began (Column 4 and 5). We also find similar results when we replace the year interaction of baseline school controls with time-varying measures of the same set of school characteristics (Column 6).

Indian schools have experienced various interventions since the 2000s, some of which have been menstrual hygiene management (MHM) interventions.¹⁵ As most of these programs are state-wide or nation-wide programs that affect both treated and control schools simultaneously, block-year fixed effects in our baseline help capture school-invariant heterogeneity in time, and school-specific linear time trends help adjust for the possibility that schools have different growth trajectories. In Appendix A14 Panel A, we plot treatment estimates from a placebo test that randomly select a placebo treatment year from 2013 to 2020 for each treated school. The placebo estimates are centered around zero, validating the credibility of our baseline causal estimates. Furthermore, we do not find significant treatment effects from falsification tests using prepubescent girls in the 1st- to 4th-grades in treated schools, and boys in the 7th-grade in treated schools as the treatment groups (Appendix A15). Additional robustness tests can be found in Appendix F.

Are Estimates Reasonable? One may argue that the provision of free sanitary pads is insufficient to address girls' dropout problem if they also lack access to proper sanitation facilities in school.¹⁶ In particular, girls face difficulties in managing their menstruation in school if they do not have access to private facilities (Adukia, 2016). The complementary relationship between access to sanitary pads and access to proper sanitation facilities suggests that the effects of free sanitary pads would depend on the presence of girls' toilets in school, and our estimated effects would be inconsistent with existing evidence if the results show otherwise.

¹⁵ See <https://splash.org/assets/IND-Literature-Review.pdf> for an overview of menstrual programs in India.

¹⁶ See <https://indianexpress.com/article/india/sanitary-napkin-vending-machines-in-schools-is-an-exemplary-step-but-is-it-enough/>.

In Columns 1 and 2 of Table 5, we find that the treatment effects on dropouts are statistically and economically significant only in schools installed with girls' toilets, but not in schools without girls' toilets. In contrast, we do not find a statistically significant difference when we test the difference in treatment effects on treated schools with and without boys' toilets ($P = 0.889$). As most of the treated schools are installed with functional sex-specific toilets, in Columns 5 and 6, we find that treatment effects are present only in schools with a low girls-to-toilet ratio—that is, schools that provide students with adequate access to sex-specific sanitation facilities. Altogether, the findings in this section are consistent with the qualitative evidence on the complementary role of sanitary pads and sanitation facilities in improving girls' educational outcomes.

In addition, we find that conservatism affects treatment impacts on girls' educational outcomes. Conservative Indian parents are more likely to withdraw female children from school around the age of puberty because of concerns over girls' safety. We proxy for conservatism based on students' religion; in particular, we classify schools into Christian schools and non-Christian schools based on the name of the school, and postulate that parents of students attending non-Christian schools are more conservative. Results in Column 7 shows significant treatment effects on dropouts only in non-Christian schools, and the difference in coefficients on treatment effect between Christian and non-Christian schools is statistically significant at 10% ($P = 0.077$). This result highlights the important role of sanitary pads provision in improving educational attainment among girls who are confined by conservatism.

3.3 Effects on Girls' Examination Outcomes

Reduced dropouts shown in the baseline do not directly reflect improved school attendance and hence better school outcomes. We proxy for school attendance with students' examination outcomes, drawing on ample empirical evidence of positive relationship between school attendance and educational outcomes.

Figure 2 presents dynamic treatment effects on the outcomes of girls' upper primary school-leaving examination, the 7th-grade exam.¹⁷ The number of girls appearing at the exam increases by 82.22 percent in the first year of the machine installation and 148 percent in the subsequent year. Similar effects are also found for both passing the exam and passing the exam with distinction: the number of girls passing the exam and the number of girls passing with distinction increase by 82.89 percent and 69.63 percent, respectively, in the first post treatment year, and by 135.97 percent and 98.88 percent, respectively, in the second year of the treatment.

In the bottom row of the same figure, we find that treatment effects trend similarly when we estimate changes in the fraction of girls who appear at, who pass, and who pass the exam with distinction in the cohort. The dynamic treatment effects trend similarly to those in the top row. The fractions of students who attend, who pass, and who score highly on the exam increase by 16.9 percentage points (28 percent), 18.6 percentage points (32 percent) and 16.2 percentage points (34 percent), respectively, in the first year of the machine installation.¹⁸ We also find significant peer effects to male students in treated schools.¹⁹ In contrast, we do not find significant effects on the outcomes of girls' lower primary school-leaving examination, the 4th-grade exam (Appendix A19).

3.4 Mechanisms

Affordability vs. Accessibility. Installations of sanitary pad vending machines in schools reduce the number of girls who drop out in two ways. First, vending machines in schools

¹⁷ The joint-significance tests of pre-treatment period indicators validate the common trend assumptions for all regressions.

¹⁸ The average fractions of students who appear at the exam, who pass the exam, and who pass the exam with distinction are 0.591, 0.587 and 0.475 respectively.

¹⁹ Further discussion can be found in Appendix G.

provide girls with an easy and convenient access to sanitary pads every month. Second, sanitary pads are free to all girls in treated schools, directly addressing affordability issues surrounding menstrual products.

In the absence of student-level enrollment information, we assess the heterogeneity of treatment effects by school-level characteristics: urban or rural schools, public or private schools, and backward-caste or forward-caste schools.²⁰ As proxies for schools that have a larger number of students from low-income families, rural, public and backward-caste schools should see larger treatment impacts if affordability is the main concern. This proposition follows from the qualitative evidence that (1) the majority of India's poor live in rural areas,²¹ (2) children from low-income families are more likely to attend public schools that provide free education, and (3) members from backward-caste are among the most disadvantaged groups in India.

In Table 6 (Columns 1-3), we find that treatment impacts schools across all types, as indicated by the insignificant statistics from the tests for differences in coefficients across school types ($P = 0.772, P = 0.644, P = 0.754$). This is reasonable considering that only marginal students who are at risk of dropping out due to menstruation are affected, and these marginal students are present in all schools including urban schools and private schools.²²

²⁰ We categorize schools into backward-caste schools and forward-caste schools based on the fraction of total enrollment of girls from Scheduled Castes, Scheduled Tribes, and Other Backward Classes in 2013. Schools that have fraction of backward-caste female students larger than the mean enrollment fraction (0.69) in 2013 are classified as backward-caste schools.

²¹ See <https://www.worldbank.org/en/news/infographic/2016/05/27/india-s-poverty-profile>.

²² The RTE Act guarantees 25% reservation in non-minority private schools to children from disadvantaged groups.

Nevertheless, the point estimates of treatment impacts are larger in rural schools, public schools, and schools with a larger fraction of backward-caste students, providing suggestive evidence that supports the affordability as the main issue. These findings are confirmed by additional heterogeneity analyses using village-level amenities as proxies for accessibility level (Appendix H).

Impact through Boys. Installations of sanitary pad vending machines in schools may promote awareness about menstruation to the opposite gender, creating an educational environment that is less stigmatizing for girls (Haver et al., 2013). We test this mechanism by examining heterogeneity across mixed-gender and girls-only schools, and across schools with larger and smaller fractions of male students (Table 6 Columns 4 and 5). We find large point estimates of treatment effects on female dropout rates in girls-only schools despite the small number of girls-only treated schools in the sample. Point estimates are also larger in schools with a smaller fraction of male students, implying direct treatment impacts on treated girls.

Impacts through Female Teachers. Easy access to sanitary products may also benefit female teachers in ways that could indirectly affect students' academic performance. Schools that provide access to sanitary facilities are more likely to recruit and retain female teachers (Burrows, Acton and Maunder, 2004). Female teachers are more willing to show up to school during menstruating days if they have access to sanitary resources (Kremer et al., 2005).

Schools with a larger initial share of female teachers should exhibit larger gains from treatment if the provision of sanitary pads encourages female teachers to be present at school. In Column 6 of Table 6, the larger point estimate of treatment impacts in schools with a smaller initial share of female teachers does not support the proposed treatment mechanism. Additionally, we do not find significant treatment effects on the shares of female teachers and teachers with professional qualifications (Appendix A21).

Impacts through Family Members. Girls in treated schools may be instructed by their family members to attend school occasionally to collect free sanitary pads for their use. In such an event, girls may not benefit from the treatment program and the estimated reduced dropouts from the baseline may be misleading. We argue that such an event is not possible because the distribution of sanitary pads is restricted and supervised.

Large schools may have larger difficulties monitoring students' collection of sanitary pads. If the distribution process is opaque and unmonitored, we should find larger treatment impacts in larger schools. In Columns 7 and 8 of Table 6, we find larger point estimates of treatment effects in smaller schools, rejecting the possibility that the distribution of free sanitary pads does not directly benefit girls.

4. Conclusion

Sanitation and hygiene are crucial factors that influence the schooling decisions of children and, in particular, girls who have reached puberty. Despite the considerable media and research attention that has been given to estimating the connection between menstruation and girls' educational outcomes, empirical evidence from large-scale and long-term programs is still lacking.

In this paper, we explore a government-initiated program that distributes free sanitary pads to school-going girls in schools across the Indian state of Kerala through sanitary vending machines installed in the schools. Using same-grade girls in untreated schools as the main control group, we find that the free distribution of sanitary pads decreases the number of dropouts of girls in the 7th-grade. The reduction in dropouts persists and increases over the posttreatment years. We also find significant improvement in academic outcomes including the number of girls attending, passing and scoring highly on upper primary school-leaving examinations.

We study the mechanisms behind the improved educational outcomes by performing heterogeneity analysis by school geographical locations, school management types and school enrollment by student caste. We find that treatment effects are largely driven by rural schools, public schools, backward-caste schools and schools located in villages with amenities providing accessibility. These estimates provide supportive evidence for affordability, suggesting the importance of ensuring the affordability of menstrual products in promoting safe menstrual hygiene management.

One way to interpret the estimated dropout effect is to aggregate it up to the state- and country- levels, and consider the total effect on educational outcomes in absolute terms. Using the estimated percent change of 32.66 percent in dropouts of 7th-grade students after treatment, we calculate that free access to sanitary pads prevents the dropout of 10 thousand female students in Kerala and of 1.2 million female students in India.²³ This estimate is likely an underestimation, as Kerala is one of the Indian states that has the lowest dropout rate and highest sanitary pad usage according to the India National Family Health Survey 2015-16.²⁴ While such back-of-the-envelope calculations should be interpreted with caution, it is informative to understand the potential lower-bound magnitude of the treatment impact.

²³ We multiply the dropout effect (32.66 percent) with girls' dropout rates in the upper primary and lower secondary school for the state (country) using the UDISE+ 2019-2020 data. We then multiply these numbers with the total female enrollment in the upper primary and lower secondary schools in the state (or country). The final number is interpreted as the total number of female students who could avoid dropouts if all schools across the state (country) were exposed to the treatment program.

²⁴ See <http://rchiips.org/nfhs/NFHS-4Reports/Kerala.pdf>.

Considering that both governmental and nongovernmental organizations continue to devote resources to increasing the availability of and access to sanitary products among school-going children, as demonstrated by the proliferation of pilot projects or campaigns surrounding menstruation, our results provide considerable implications for how the distribution of sanitary products should be delivered at scale on a sustained and effective basis. In particular, increasing accessibility to sanitary products may not be sufficient to improve girls' educational attainment; free access to sanitary pads through schools on a monthly basis helps to reinforce girls' motivation to continue schooling, indirectly improving their long-term academic success.

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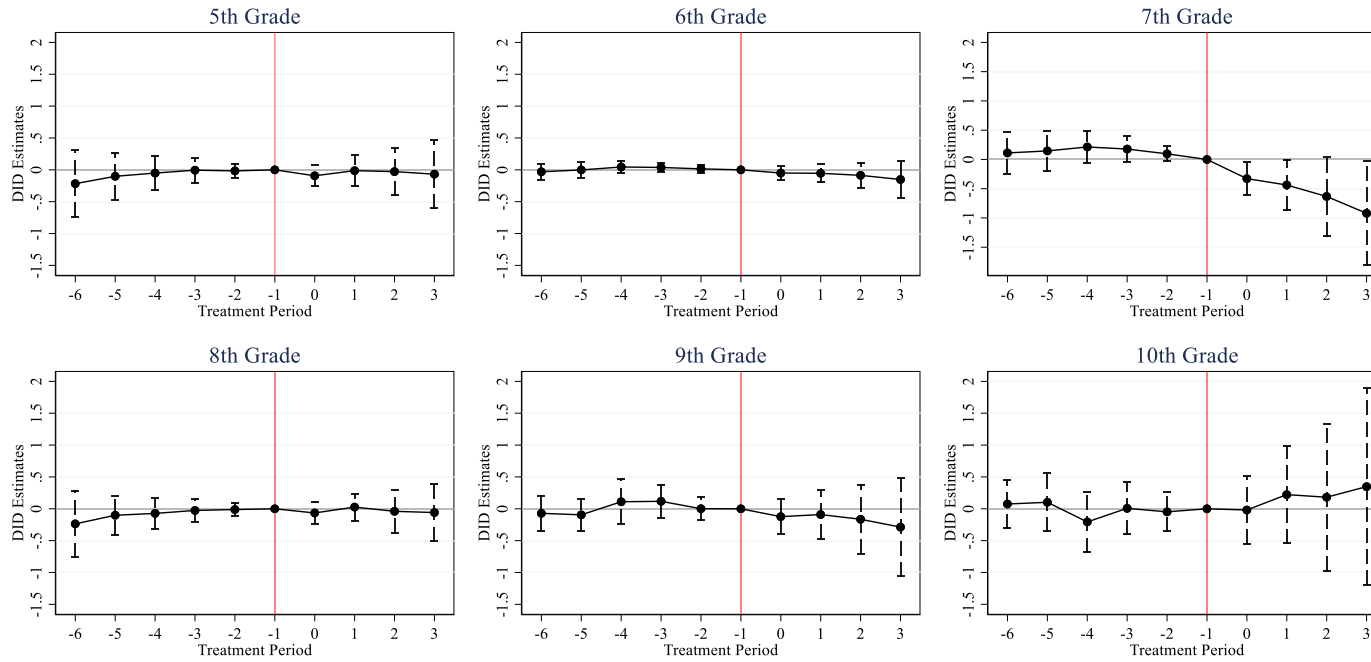
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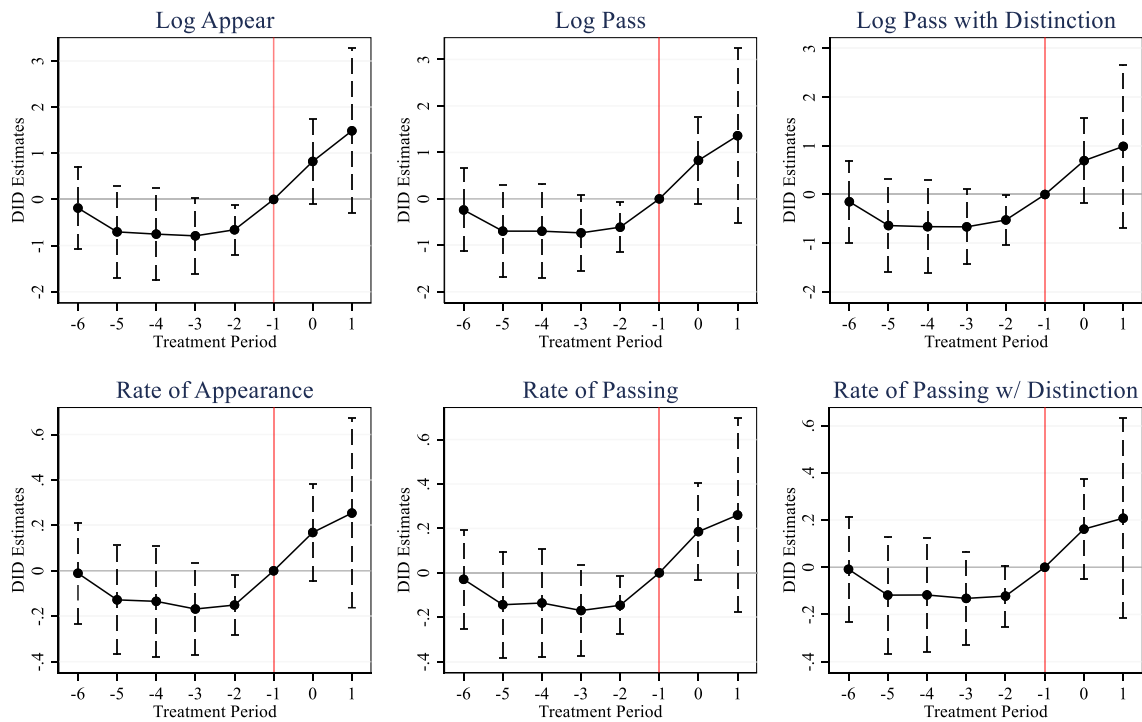
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Figure 1. Dynamic Treatment Effects on the Dropout Rate of Girls in 5th-Grade to 10th-Grade



Notes: The figure shows coefficient estimates from the regression of girls' dropout on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed. The dependent variable is the number of dropout rate of girls in the 5th-grade through the 10th-grade. Year -1 is the omitted reference period while year 0 is the first year in which the sanitary pad vending machine was installed in the school under the SHE Pad Scheme. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Figure 2. Dynamic Treatment Effects on Female Student’s Upper Primary School-Leaving Examination Outcomes (7th-Grade Exam)



Notes: The figure shows coefficient estimates from the regression of upper primary school-leaving examination on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed. Year -1 is the omitted reference period while year 0 is the first year in which the vending machine was installed in the school. School-leaving examination outcomes include: (1) Number of female students who appear at the school-leaving exam, (2) Number of female students who pass the school-leaving exam, and (3) Number of female students who pass the school-leaving exam with distinction. For each panel, the outcome variables in the top row are log examination outcomes plus one, while the outcome variables in the bottom row are ratios of the examination outcomes to the number of female students in the 7th-grade. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Table 1. Average Effects on the Dropout Rate of Girls

	(1) 5 th -Grade Age 10-11	(2) 6 th -Grade Age 11-12	(3) 7 th -Grade Age 12-13	(4) 8 th -Grade Age 13-14	(5) 9 th -Grade Age 14-15	(6) 10 th -Grade Age 15-16
AfterT	-0.101 (0.065)	-0.033 (0.044)	-0.240** (0.115)	-0.074 (0.065)	-0.079 (0.109)	-0.045 (0.217)
R ²	0.430	0.341	0.574	0.366	0.415	0.736
School characteristics × year controls	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y
No. of observations	39,546	39,024	20,484	22,836	21,804	13,848
No. of treated schools	496	504	494	689	687	640
No. of control schools	6,095	6,000	2,920	3,117	2,947	1,668

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using Equation (1) on a balanced panel. Outcome variables are dropout rates of female students in the 5th- through 10th-grade (Columns 1- 6), and the control sample includes all untreated girls-only and mixed-gender schools that have non-missing observations from 2013 to 2018. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Table 2. DID Diagnostic Tests and DIDM Estimator: Average Effects on the Dropout Rate of Girls

	(1) 5 th -Grade Age 10-11	(2) 6 th -Grade Age 11-12	(3) 7 th -Grade Age 12-13	(4) 8 th -Grade Age 13-14	(5) 9 th -Grade Age 14-15	(6) 10 th -Grade Age 15-16
Goodman-Bacon's Decomposition						
Earlier Treated v Later Control	0.011	0.012	0.023	0.030	0.031	0.048
Later Treated v Earlier Control	0.005	0.006	0.011	0.014	0.015	0.023
Treated v Never Treated	0.983	0.983	0.967	0.956	0.954	0.929
de Chaisemartin and d'Haultfœuille's Test for Negative Weights						
% ATTs with negative weights	0	0	0	0	0	0.102
Sum of negative weights	0	0	0	0	0	-0.0001
σ_{fe}	0.852	3.151	0.779	2.831	1.678	0.145
de Chaisemartin and d'Haultfœuille's DIDM Estimator						
AfterT	-0.097* (0.055)	-0.029 (0.041)	-0.193* (0.103)	-0.067 (0.085)	-0.053 (0.108)	-0.080 (0.213)
School characteristics × year controls	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y
No. Observations	26,333	26,022	13,621	15,188	14,497	9,191

Notes: The table reports results from diagnostic tests and regression estimates using DID estimator that takes into account of negative weighting issues in the standard DID estimator. Outcome variables are dropout rates of female students in the 5th- through 10th-grade (Columns 1- 6). The weights of Goodman-Bacon's decomposition are estimated using Stata's *bacondecomp* module; the fraction of negative weights, the sum of negative weights, and σ_{fe} , which is the ratio of the absolute value of the standard DID estimates reported in Table 1 to the standard deviation of the weights, are calculated using Stata's *twowayfeweights* module; the coefficient estimates of *AfterT* are estimated using the DID estimator proposed by de Chaisemartin and d'Haultfœuille (2020) using Stata's *did_multipligt* module. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Table 3. Alternative Control Groups: Average Effects on the Dropout Rate of Girls in the 7th-Grade

Control Group:	(1) 7 th -grade control girls in the same village	(2) 7 th -grade control boys in the same village	(3) ≤ 3 rd -grade treated girls	(4) ≤ 5 th -grade treated girls	(5) ≤ 5 th -grade treated girls and boys	(6)
AfterT	-0.403** (0.189)	-0.378** (0.179)	-0.166 (0.104)	-0.173* (0.094)	-0.183* (0.101)	-0.150* (0.085)
R ²	0.661	0.724	0.829	0.759	0.741	0.810
School characteristics × year controls	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y
Block × year fixed effects	N	N	Y	Y	Y	N
Village × year fixed effects	Y	Y	N	N	N	N
School × year fixed effects	N	N	N	N	N	Y
No. of observations	17,796	18,192	5,772	9,786	16,638	16,596
No. of treated schools	400	400	482	494	494	491
No. of control schools	2,566	2,632	480	1,137	2,279	2,275

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using Equation (1) with several adjustments on a balanced panel. Outcome variable is the dropout rates of female students in the 7th-grade. We compare 7th-grade girls in treated schools to 7th-grade girls in untreated schools within the same village by replacing block-year fixed effects with village-year fixed effects (Column 1); we compare girls in the 7th-grade in treated schools to boys in the 7th-grade in untreated schools within the same village (Column 2) by replacing block-year fixed effects with village-year fixed effects; we compare girls in the 7th-grade in treated schools to girls in the 1st- to 3rd-grade in treated schools (Column 3); we compare girls in the 7th-grade in treated schools to girls in the 1st- to 5th-grade in treated schools (Column 4); we compare girls in the 7th-grade in treated schools to girls and boys in the 1st to 5th-grade in treated schools; Column 6 uses the same control sample as in Column 5, but with block-year fixed effects replaced with school-year fixed effects. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Table 4. Robustness Tests: Average Effects on the Dropout Rate of Girls in the 7th-Grade

	(1)	(2)	(3)	(4)	(5)	(6)
	Adjusted Dropout Measure	Block-Sch. Category-year FE	Only school in village	Schools w/o SHE-Toilet	Treated schools w/ same no. of toilets	Time-varying controls
AfterT	-0.244** (0.115)	-0.314** (0.142)	-0.158* (0.089)	-0.298* (0.165)	-0.302* (0.158)	-0.254** (0.110)
R ²	0.574	0.625	0.888	0.544	0.538	0.601
School characteristics × year controls	Y	Y	Y	Y	Y	N
Time varying school characteristics	N	N	N	N	N	Y
School fixed effects	Y	Y	N	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	N	Y	Y	Y	Y
Block × Sch. Cat × year fixed effects	N	Y	N	N	N	N
No. of observations	20,483	19,943	1,476	18,192	19,818	20,484
No. of treated schools	494	490	64	237	383	494
No. of control schools	2,920	2,873	182	2,795	2,920	2,920

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using Equation (1) with several adjustments on a balanced panel. Outcome variables are dropout rates of female students in the 7th-grade: Column 1 uses adjusted dropout measure that takes into account of the number of repeaters, while Columns 2-6 use unadjusted dropout measure as in the baseline regressions. Column 2 replaces block-year fixed effects with block-school category-year fixed effects; Column 3 keep only schools that are located in villages with only one school that provides 8th-grade courses, and do not include school-specific time trends; Column 4 removes all schools that have received a SHE-toilet since 2013; Column 5 removes treated schools that have varying number of girl toilets since treatment year; Column 6 uses the sample as in the baseline, but replace year-interacted controls with time-varying school-level controls. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Table 5. Heterogeneity by Presence of Toilets and School Religion: Average Effects on the Dropout Rate of Girls in the 7th-Grade

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Girls' Toilet	Functional Girls' Toilet	Boy's Toilet	Functional Boy's Toilet	Schools w/ Large Ratio of 7 th -Grade Girls to Girls' Toilet	Schools w/ Large Ratio of 7 th -Grade Girls to Functional Girls' Toilet	Christian School
AfterT × [Indicator=1]	-0.245** (0.116)	-0.250** (0.117)	-0.239** (0.120)	-0.239** (0.120)	0.001 (0.089)	-0.110 (0.143)	0.004 (0.086)
AfterT × [Indicator=0]	0.098 (0.118)	0.334 (0.219)	-0.290 (0.365)	-0.290 (0.365)	-0.408** (0.184)	-0.322** (0.161)	-0.287** (0.137)
p-value (Indicator=1 –Indicator=0)	0.046	0.020	0.894	0.894	0.047	0.320	0.077
R ²	0.574	0.574	0.574	0.574	0.574	0.574	0.574
School characteristics × year controls	Y	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y	Y
No. of observations	20,484	20,484	20,484	20,484	20,484	20,484	20,484
Share of Treated Sch. with [Indicator=1]	0.992	0.988	0.927	0.927	0.400	0.381	0.146

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using a balanced panel. Outcome variable is the dropout rate of female students in the 7th-grade. The estimates are estimated using Equation (1) with some modifications, where post-treatment dummy is interacted with binary indicators indicating the presence of girls' toilet (Column 1), functional girls' toilet (Column 2), boys' toilet (Column 3), functional boys' toilet (Column 4), whether the school has a ratio of number of 7th-grade girls to number of girls' toilet larger than the mean (Column 5), whether the school has a ratio of number of 7th-grade girls to number of functional girls' toilet larger than the mean (Column 6), and whether the school is a Christian school classified based on the name of the school (Column 7). Functional toilets are toilets that have minimal odour, unbroken seat, working drainage system, closable door, are regularly cleaned/dried and accessible to users. The p-values are derived from the statistical significance test on the differences in estimated coefficients between the two types of schools. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Table 6. Heterogeneity by School-level Characteristics: Average Effects on the Dropout Rate of Girls in the 7th-Grade

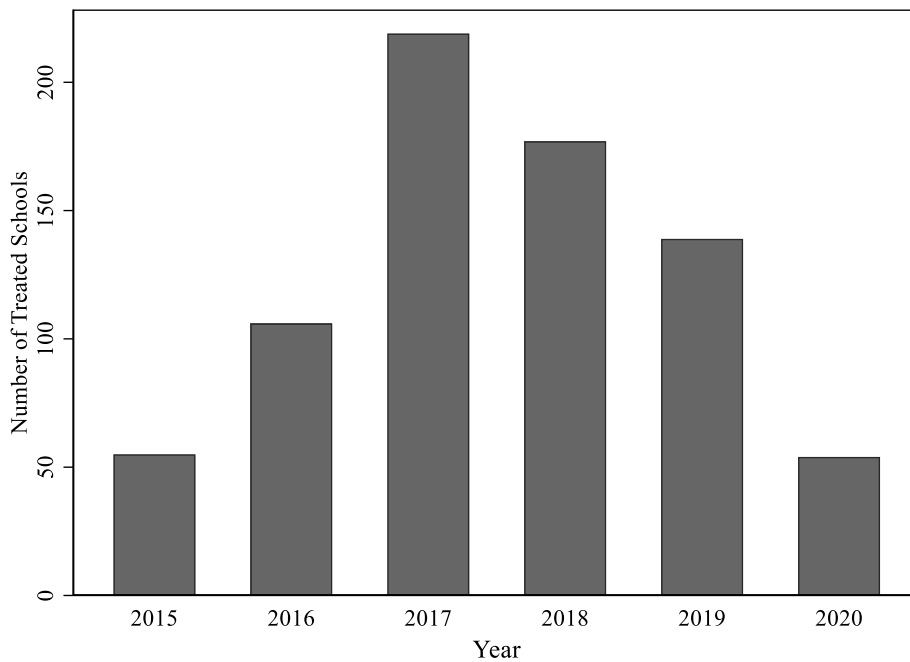
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Rural Schools	Public Schools	Backwar d caste Schools	Girls- Only Schools	Schools w/ Large Fraction of Male Students	Schools w/ Large Share of Female Teachers	Schools w/ Large Initial Total Enrollment	Schools w/ Large Enrollment of Girls in 7 th - Grade
AfterT × [Indicator=1]	-0.257** (0.127)	-0.297* (0.156)	-0.264 (0.163)	-0.290 (0.305)	-0.155 (0.113)	-0.065 (0.092)	-0.137 (0.090)	-0.149 (0.107)
AfterT × [Indicator=0]	-0.178 (0.247)	-0.186 (0.176)	-0.195 (0.140)	-0.236* (0.122)	-0.440 (0.286)	-0.314** (0.158)	-0.436 (0.295)	-0.336* (0.203)
p-value (Indicator=1 –Indicator=0)	0.772	0.644	0.754	0.870	0.358	0.166	0.340	0.410
R ²	0.574	0.574	0.574	0.574	0.574	0.574	0.574	0.574
School characteristics × year controls	Y	Y	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
No. of observations	20,484	20,484	20,484	20,484	20,484	20,484	20,484	20,484
Share of Treated Sch. with [Indicator=1]	0.808	0.545	0.672	0.081	0.713	0.289	0.654	0.506

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using a balanced panel. Outcome variable is the dropout rate of female students in the 7th-grade. The estimates are estimated using Equation (1) with some modifications, where the post-treatment dummy is interacted with binary indicators indicating whether the school is a rural school (Column 1), whether the school is a public school (Column 2), whether the school has an initial fraction of backward-caste students larger than the mean (Column 3), whether the school is a girls-only school (Column 4), whether the school has an initial fraction of boy students larger than the mean (Column 5), whether the school has initial share of female teachers larger than mean (Column 6), whether the school has an initial total enrollment larger than mean (Column 7), and whether the school has an initial enrollment of 7th-grade girls larger than mean (Column 8). Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A: Additional Figures and Table

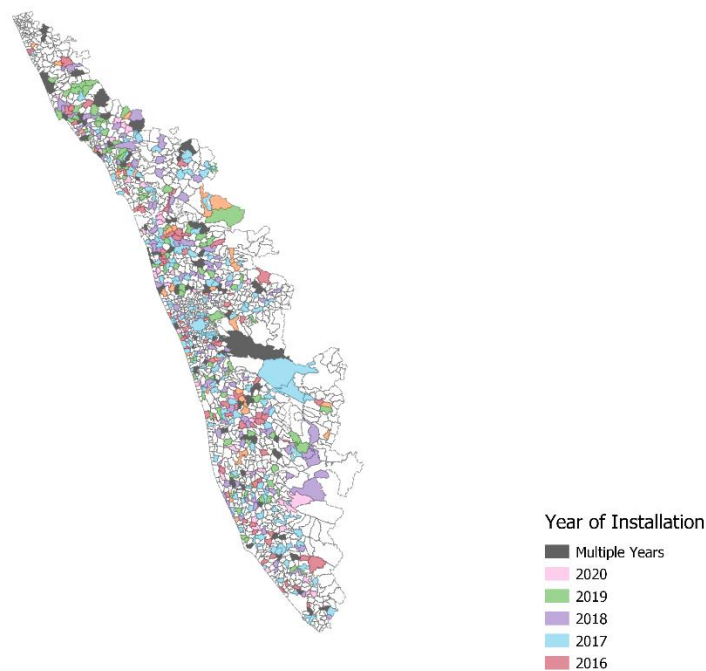
Appendix A1. Installation of Sanitary Pad Vending Machine

Panel A. Number of Schools Installed with Sanitary Pad Vending Machines, by Year



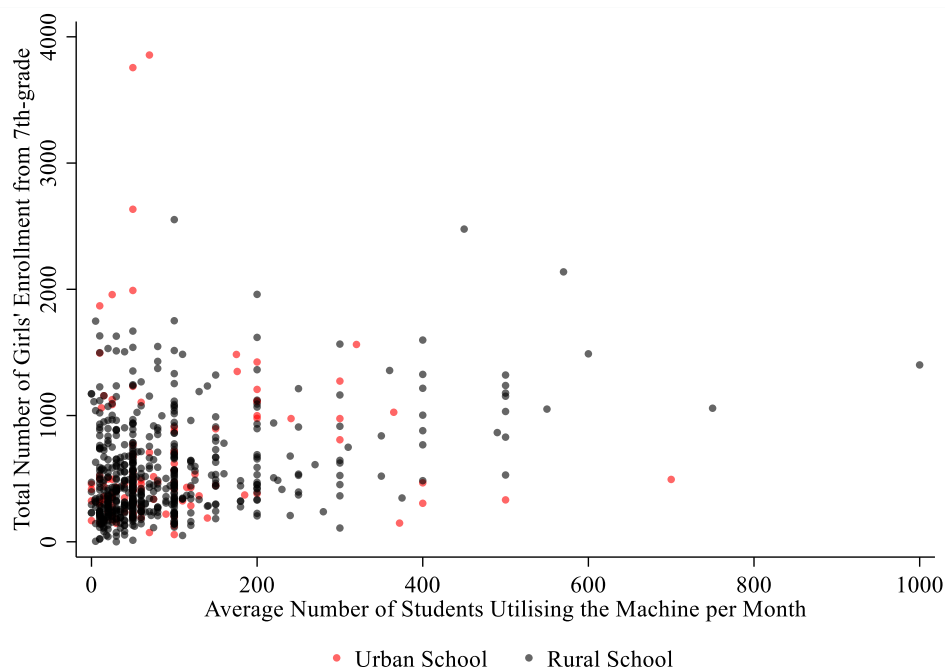
Notes: The figure shows the total number of schools participated in the SHE Pad Scheme over the years from 2015 to 2020. The data is obtained from the Kerala State Women's Development Corporation Ltd.

Panel B. Geographical Distribution of Treated Villages, by Year



Notes: The figure plots the geographical distribution of treated village by the year of machine installation in schools located in the village. Village-level boundaries are collected from the Data{Meet}, and we matched DISE data to the boundary data based on the village and district names using Stata's *matchit* module. Out of the 631 treated villages in our estimation sample, we are able to match 552 treated villages to the village-level boundaries.

Panel C. Total Number of Girls' Enrollment from 7th-grade Onwards vs. Average Number of Students Utilizing the Machine per Month



Notes: The figure shows the scatter plots of the total number of girls' enrollment from 7th-grade through 12th-grade in 2013 vs. average number of students utilizing the sanitary pad vending machine per month.

Panel D. Distribution of the Lowest and Highest Grades Offered in Treated Schools in 2013

Lowest grade offered in school	Highest grade offered in school	Number of treated schools	Fraction
1 st	7 th	1	0.13%
1 st	10 th	20	2.63%
1 st	12 th	168	22.11%
5 th	10 th	33	4.34%
5 th	12 th	340	44.74%
6 th	12 th	3	0.39%
8 th	10 th	26	3.42%
8 th	12 th	165	21.71%
11 th	12 th	4	0.53%
Total		760	100%

Notes: The table shows the baseline distribution of the lowest grade and the highest grade offered by treated schools in 2013.

Panel E. An Example of Sanitary Pad Vending Machine Installed in School under SHE Pad Scheme



Source: Indiatimes (2017), <https://www.indiatimes.com/news/india/in-a-first-kerala-makes-sanitary-napkin-vending-machines-mandatory-in-all-schools-321966.html>.

Appendix A2. Summary Statistics of Full Sample at Baseline

<i>Gender</i>	Full Sample	Treatment Group:	Control Group:		
<i>School Type</i>	Girls	Girls	Girls	Mean	
	Girls-only &	Girls-only &	Girls-only &	Differences	
	Mixed Schools	Mixed Schools	Mixed Schools	(2) - (3)	
<i>Number of Schools at baseline</i>	16,906	760	16,146		
	(1)	(2)	(3)	(2) - (3)	
Total Girls' Enrollment	199.956	771.202	173.066	598.137	***
Total Student Enrollment	350.124	1313.306	304.786	1008.520	***
No. of girls appearing at Upper Primary school-leaving examination	26.662	50.283	24.257	26.026	***
No. of girls passing Upper Primary school-leaving examination	26.548	49.521	24.209	25.313	***
No. of girls passing w/ distinction on Upper Primary school-leaving examination	18.656	32.127	17.284	14.843	***
No. of classrooms	9.949	14.681	9.726	4.955	***
No. of classrooms in good condition	7.628	10.655	7.486	3.160	***
No. of boys' toilets	3.433	5.620	3.107	2.514	***
No. of girls' toilets	4.604	9.968	4.053	5.916	***
No. of toilets for children with special needs	1.066	1.099	1.064	0.035	**
No. of books in library	1,856	6,227	1,650	4577	***
Presence of Electricity	0.940	0.970	0.939	0.031	***
Presence of Library	0.920	0.979	0.917	0.061	***
Presence of Playground	0.709	0.846	0.703	0.144	***
Presence of Ramps	0.573	0.687	0.568	0.120	***
Presence of Regular Medical Check-ups	0.659	0.856	0.65	0.206	***
Presence of Computer Lab	0.529	0.895	0.512	0.383	***
Presence of School Management Committee	0.540	0.768	0.529	0.239	***
Presence of School Development Plan	0.473	0.655	0.464	0.191	***
Access by Road	0.969	0.986	0.969	0.017	***
Water Source: Hand Pump	0.026	0.017	0.026	-0.009	
Water Source: Well	0.624	0.704	0.621	0.084	***
Water Source: Tap	0.294	0.252	0.296	-0.044	***
Water Source: Others	0.050	0.026	0.052	-0.025	***
Building: Government-owned	0.283	0.504	0.273	0.232	***
Building: Under Construction	0.004	0.000	0.004	-0.004	*
Building: Dilapidated	0.003	0.002	0.003	-0.002	
Wall: Brick	0.572	0.657	0.568	0.088	***
Wall: Barbed Wire Fencing	0.028	0.013	0.028	-0.015	**
Wall: Hedges	0.008	0.005	0.008	-0.003	
Wall: None	0.005	0.000	0.005	-0.005	*

Notes: The table reports the average baseline school characteristics in 2013. Column 1 reports the average characteristics of schools in the full sample which includes schools in both treatment and control groups. Column 2 reports the average characteristics of treated schools and Column 3 reports the average characteristics of control schools. Column 4 reports the mean differences in characteristics between the treated and control schools. Two-sided P-values are indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A3. Summary Statistics of Estimation Sample at Baseline

<i>Gender</i> <i>School Type</i>	Treatment Group:	Control Group:	Mean Differences	
	Girls Girls-only & Mixed Schools	Girls Girls-only & Mixed Schools		
<i>Number of Schools at baseline</i>	494 (1)	2,920 (2)	(1) - (2)	
Total Girls' Enrollment	818.803	490.945	327.859	***
Total Student Enrollment	1364.083	843.264	520.820	***
No. of girls appearing at Upper Primary school-leaving examination	66.642	34.613	32.029	***
No. of girls passing Upper Primary school-leaving examination	65.429	34.696	30.733	***
No. of girls passing w/ distinction on Upper Primary school-leaving examination	42.399	24.123	18.276	***
No. of classrooms	17.974	17.650	0.324	
No. of classrooms in good condition	12.769	15.533	-2.764	***
No. of boys' toilets	5.591	8.166	-2.575	***
No. of girls' toilets	10.725	11.253	-0.528	
No. of toilets for children with special needs	1.063	1.084	-0.021	
No. of books in library	6901.014	4496.526	2404.488	***
Presence of Electricity	0.968	0.979	-0.011	
Presence of Library	0.984	0.977	0.007	
Presence of Playground	0.822	0.896	-0.074	***
Presence of Ramps	0.777	0.443	0.334	***
Presence of Regular Medical Check-ups	0.887	0.810	0.076	***
Presence of Computer Lab	0.893	0.882	0.011	
Presence of School Management Committee	0.809	0.378	0.432	***
Presence of School Development Plan	0.709	0.327	0.382	***
Access by Road	0.982	0.984	-0.002	
Water Source: Hand Pump	0.014	0.029	-0.015	*
Water Source: Well	0.715	0.600	0.115	***
Water Source: Tap	0.239	0.328	-0.089	***
Water Source: Others	0.030	0.043	-0.013	
Building: Government-owned	0.538	0.223	0.316	***
Building: Under Construction	0.000	0.004	-0.004	
Building: Dilapidated	0.002	0.002	0.000	
Wall: Brick	0.686	0.690	-0.004	
Wall: Barbed Wire Fencing	0.008	0.026	-0.018	**
Wall: Hedges	0.008	0.005	0.003	
Wall: None	0.000	0.005	-0.005	

Notes: The table reports the average baseline characteristics of schools included in the estimation sample. Column 1 reports the average characteristics of treated schools and Column 2 reports the average characteristics of control schools. Column 3 reports the mean differences in characteristics between the treated and control schools. The significance of each coefficient is indicated by: *** 1 per cent significance ** 5 per cent significance; * 10 per cent significance.

Appendix A4. Average Effects on the Dropout Rate of Girls (Unbalanced Panel)

	(1)	(2)	(3)	(4)	(5)	(6)
	5 th -Grade	6 th -Grade	7 th -Grade	8 th -Grade	9 th -Grade	10 th -Grade
	Age 10-11	Age 11-12	Age 12-13	Age 13-14	Age 14-15	Age 15-16
AfterT	-0.095 (0.064)	-0.029 (0.044)	-0.237** (0.114)	-0.063 (0.065)	-0.082 (0.110)	-0.194 (0.241)
R ²	0.445	0.380	0.641	0.377	0.413	0.754
School characteristics × year controls	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y
No. of observations	43,041	42,673	22,703	24,878	24,408	15,277
No. of treated schools	547	550	548	748	748	721
No. of control schools	7,068	7,026	3,513	3,643	3,613	1,989

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on female dropout rates using Equation (1) on an unbalanced panel. Outcome variables are dropout rates of female students in the 5th- through 10th-grade (Columns 1- 6), and the control sample includes all untreated girls-only and mixed-gender schools that have non-missing observations from 2013 to 2018. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A5. Matching Techniques: Average Effect on the Dropout Rate of Girls in the 7th-Grade

Matching Techniques:	1 - Nearest Neighbor (1)	10 – Nearest Neighbor (2)	Epanechnikov Kernel (3)	Radius Matching (4)	Mahalanobis Matching (5)	Coarsened Exact Matching (6)	Synthetic Control Method (7)
AfterT	-0.174*** (0.006)	-0.187*** (0.005)	-0.252*** (0.005)	-0.252*** (0.005)	-0.161*** (0.006)	-0.222*** (0.065)	-0.355*** (0.144)
R ²	0.839	0.7480	0.570	0.570	0.819	0.764	-
School fixed effects	Y	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y	N
Block × year fixed effects	Y	Y	Y	Y	Y	Y	N
No. of observations	5,034	10,866	20,280	20,280	5,328	1,506	20,484
No. of treated schools	484	485	485	485	491	93	494
No. of control schools	355	1,326	2,895	2,895	397	158	2,920

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on the dropout rate of girls in the 7th-grade. The estimates are estimated with Equation (1) but without including year-interacted controls. The sample in Column 1 is constructed using nearest-neighbor matching with a trimming level of 2%. The sample in Column 2 is constructed using 10-nearest-neighbor matching with a trimming level of 2% and include all match nearest neighbors with identical propensity scores. The sample in Column 3 is constructed using Epanechnikov kernel matching with a trimming level of 2%. The sample in Column 4 is constructed using radius matching with a trimming level of 2% and a caliper of 0.10. The sample in Column 5 is constructed using Mahalanobis matching. The sample in Column 6 is constructed using coarsened exact matching. The estimate in Column 7 is estimated using augmented synthetic control method proposed by Ben-Michael, Feller and Rothstein (2021), we include all baseline school characteristics that were included in the baseline regression as weighting covariates. Standard errors are obtained from 1000 block-bootstrap replications at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A6. Summary Statistics of PSM-matched Sample at Baseline

	Baseline Mean Differences				
	1-Nearest Neighbor	10-Nearest Neighbor	Epanechnikov Kernel	Mahalanobis Matching	Coarsened Exact Matching
<i>Number of Treated Schools at baseline</i>	484	485	485	491	93
<i>Number of Control Schools at baseline</i>	355	1,326	2,895	397	158
Total Girls' Enrollment	78.545**	195.593***	306.503***	200.731***	96.469***
Total Student Enrollment	133.794**	318.017***	485.837***	307.420***	150.194***
No. of girls appearing at Upper Primary school-leaving examination	5.420	15.201***	30.279***	18.021***	7.724
No. of girls passing Upper Primary school-leaving examination	4.470	13.655**	28.960***	17.756***	7.643
No. of girls passing w/ distinction on Upper Primary school-leaving examination	0.793	9.167**	17.215***	9.514**	3.277
No. of classrooms	1.034	1.221**	0.161	1.853***	-0.063
No. of classrooms in good condition	0.303	-0.181	-2.828***	0.630	-0.792
No. of boys' toilets	0.066	-0.140	-2.574***	0.535	0.176
No. of girls' toilets	0.203	0.760	-0.660	1.910***	0.415
No. of toilets for children with special needs	-0.043	-0.009	-0.016	-0.036	-0.152
No. of books in library	114.537	959.370***	2041.552***	1341.849**	631.396
Presence of Electricity	-0.005	-0.003	-0.010	0.003	0.000
Presence of Library	0.002	-0.005	0.011	-0.004	0.000
Presence of Playground	-0.030	-0.018	-0.075***	-0.018	0.000
Presence of Ramps	-0.009	-0.076***	0.330***	0.028	-0.060
Presence of Regular Medical Check-ups	-0.001	-0.008	0.074***	0.002	-0.005
Presence of Computer Lab	-0.008	-0.004	0.008	0.001	0.007
Presence of School Management Committee	0.014	-0.095***	0.427***	0.067**	0.069
Presence of School Development Plan	-0.008	-0.091***	0.378***	0.056*	0.071
Access by Road	-0.007	-0.004	-0.003	-0.003	0.000
Water Source: Hand Pump	0.003	-0.007	-0.014*	-0.004	0.005
Water Source: Well	0.006	0.058**	0.115***	0.032	-0.005
Water Source: Tap	-0.011	-0.042*	-0.089***	-0.029	-0.004
Water Source: Others	0.003	-0.010	-0.013	-0.002	0.005
Building: Government-owned	-0.011	0.099***	0.310***	0.053	0.034
Building: Under Construction	0.000	0.000	0.000	0.000	0.000
Building: Dilapidated	-0.004	0.000	0.000	-0.001	0.000
Wall: Brick	0.008	0.032	-0.009	0.009	0.026
Wall: Barbed Wire Fencing	0.005	-0.003	-0.018**	-0.002	0.000
Wall: Hedges	0.005	0.000	0.003	-0.002	0.000
Wall: None	0.000	0.000	0.000	0.000	0.000

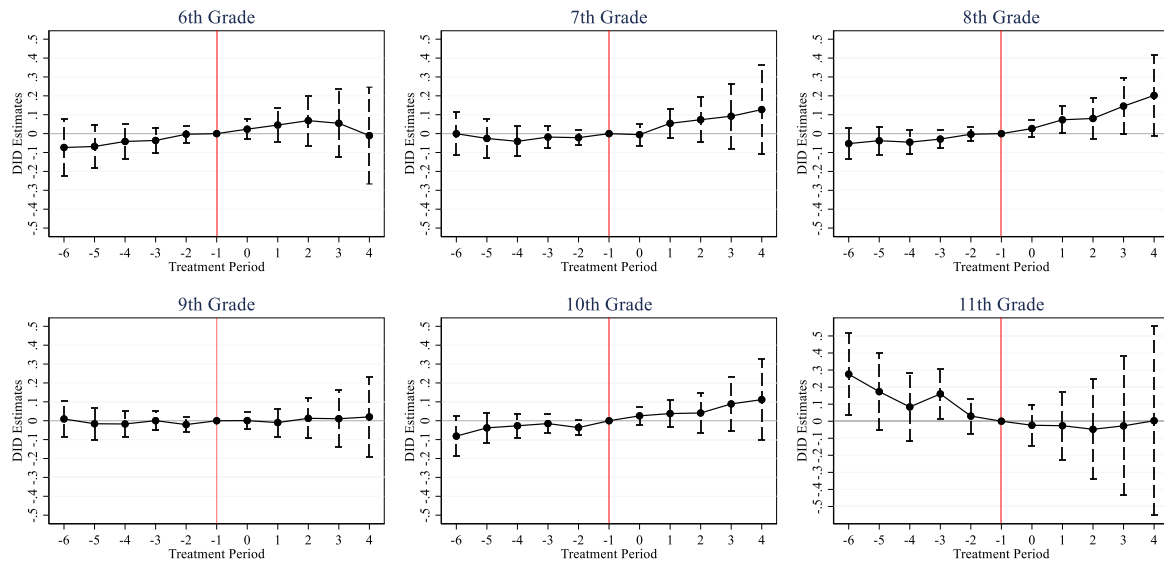
Notes: The table reports the average difference in baseline school characteristics between the treated and control samples. Column 1 reports the average baseline difference between treated and control samples obtained from 1-nearest neighbor matching (Column 1), 10-nearest neighbor matching (Column 2), Epanechnikov kernel matching (Column 3), Mahalanobis matching (Column 4), and coarsened exact matching (Column 5). Two-sided P-values are indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A7. Treatment Selection on Village-level Attributes

	OLS (1)	Probit (2)	Logit (3)
Total geographical area	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Total number of households	-0.0000* (0.0000)	-0.0000* (0.0000)	-0.0000* (0.0000)
Total population	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Total SC population	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Total ST population	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)
Presence of public bus service	0.0039 (0.0091)	0.0042 (0.0093)	0.0039 (0.0093)
Presence of national highway	0.0028 (0.0049)	0.0027 (0.0048)	0.0026 (0.0048)
Presence of community health center	0.0024 (0.0062)	0.0023 (0.0062)	0.0023 (0.0062)
Presence of primary health center	-0.0047 (0.0076)	-0.0043 (0.0073)	-0.0046 (0.0073)
Presence of family welfare center	0.0040 (0.0067)	0.0042 (0.0070)	0.0042 (0.0071)
Presence of maternity & child welfare center	-0.0024 (0.0064)	-0.0026 (0.0065)	-0.0026 (0.0065)
Presence of rural production mart	0.0046 (0.0039)	0.0046 (0.0038)	0.0045 (0.0038)
Presence of private courier service	0.0018 (0.0041)	0.0019 (0.0041)	0.0018 (0.0040)
Presence of community waste disposal system	-0.0034 (0.0065)	-0.0033 (0.0067)	-0.0033 (0.0067)
Presence of post office	-0.0175 (0.0229)	-0.0155 (0.0176)	-0.0146 (0.0169)
Presence of internet cafes	0.0082* (0.0047)	0.0086* (0.0048)	0.0084* (0.0049)
Presence of sports club	0.0088 (0.0100)	0.0089 (0.0113)	0.0094 (0.0117)
Presence of cinema	-0.0004 (0.0041)	-0.0003 (0.0040)	-0.0005 (0.0040)
Presence of public library	-0.0029 (0.0054)	-0.0031 (0.0052)	-0.0029 (0.0051)
Presence of power supply for commercial use	-0.0087 (0.0152)	-0.0087 (0.0137)	-0.0082 (0.0134)
Presence of tap water functioning all year	-0.0015 (0.0045)	-0.0014 (0.0044)	-0.0015 (0.0043)
R ²	0.001		
Log pseudolikelihood		-1764.795	-1764.835
Observations	9,793	9,793	9,793
Treated schools	432	432	432
Control schools	9,361	9,361	9,361

Notes: The table reports (marginal) coefficient estimates of regressing the treatment indicator on village-level characteristics at baseline using OLS (Column 1), Probit regression (Column 2) and Logit regression (Column 3). Standard errors are clustered at the village level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

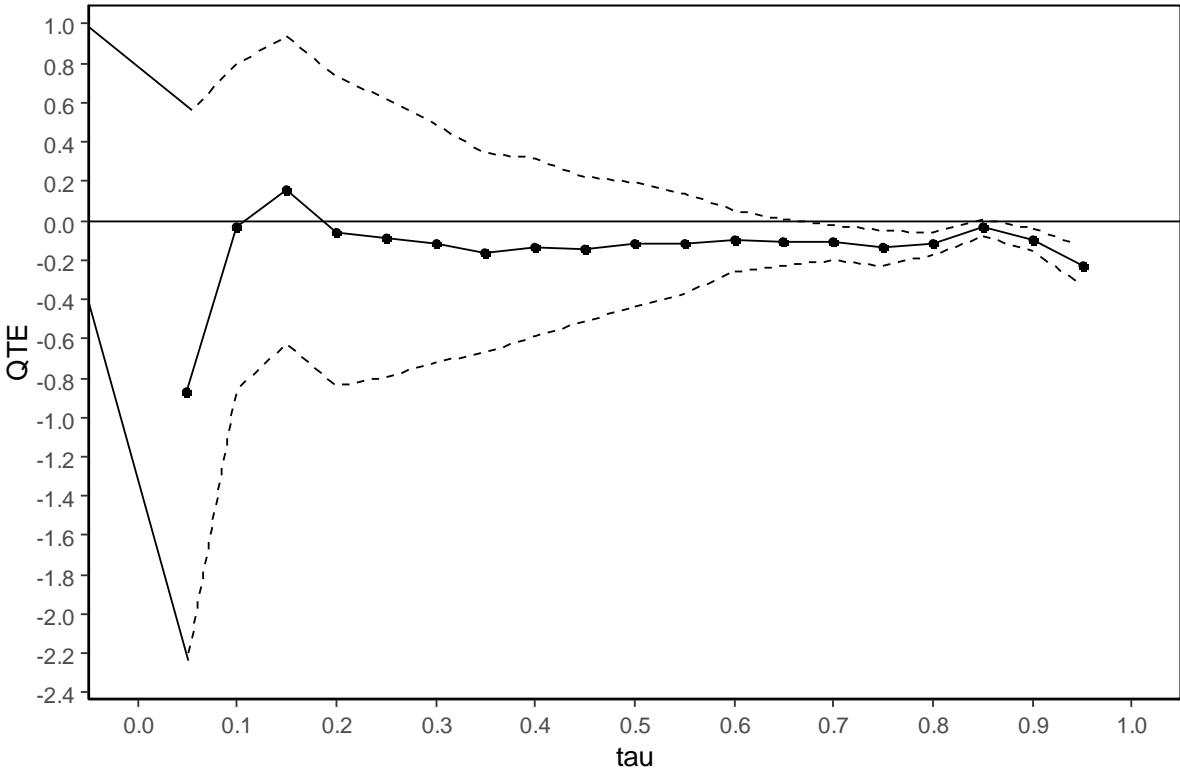
Appendix A8. Dynamic Treatment Effects on the Log Enrollment of Female Students in 6th-Grade to 11th-Grade



Notes: The figure shows coefficient estimates from the regression of log enrollment on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed, using a balanced panel. The dependent variable is log enrollment plus one of female students in the 6th-grade through the 11th-grade. Year -1 is the omitted reference period while year 0 is the first year in which the sanitary pad vending machine was installed in the school under the She Pad scheme. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

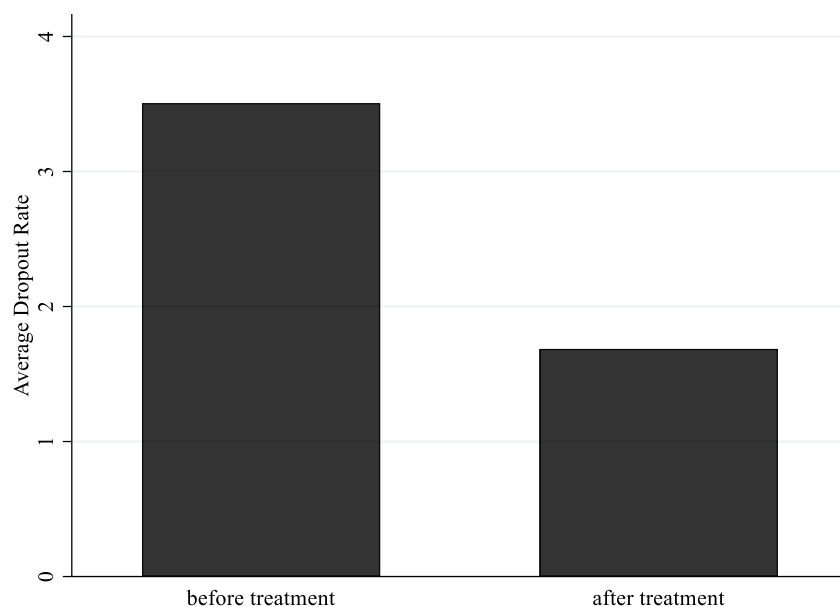
Appendix A9. Quantile Treatment Effects

Dropout for Girl Students in the 7th Grade



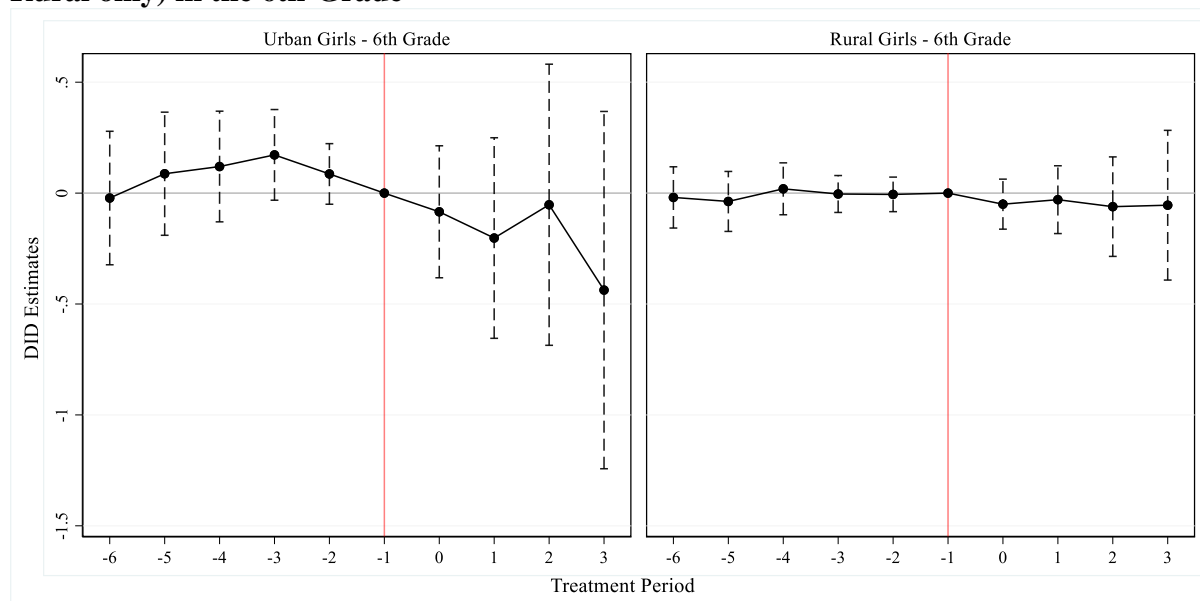
Notes: The figure shows the estimated quantile treatment effects (QTE) with covariates. The outcome variable is the dropout rate of girls in the 7th-grade. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are obtained from 300 bootstrap iterations.

Appendix A10. Average Girls' Dropouts at the Block-Level Before and After Treatment



Notes: The figure shows the average block-level dropout rate of female students in treated blocks—blocks with at least one treated school are included—before and after the treatment of free sanitary pads. The block-level treatment year is defined as the earliest year in which the sanitary pad machine is installed in the school located in the block. The average block-level dropout rate is calculated as the percentage difference between block-level enrollment across all grades c in year t and block enrollment across all grades $c+1$ in year $t+1$, averaged across all blocks.

Appendix A11. Dynamic Treatment Effects on the Dropout Rate of Girls (Urban only or Rural only) in the 6th-Grade



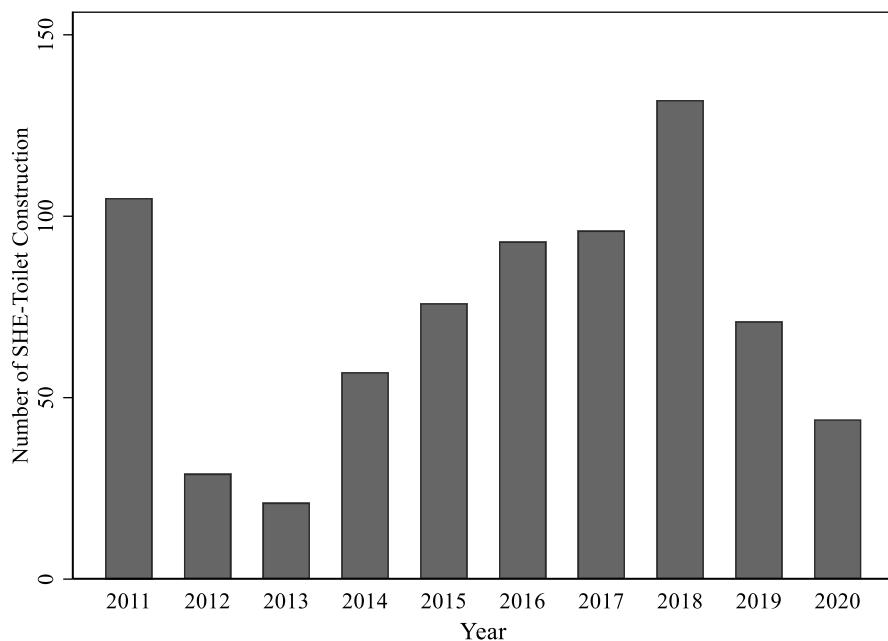
Notes: The figure shows coefficient estimates from the regression of the dropout of girls on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed, using a balanced panel. The dependent variable is the number of dropout rates of girls in the 6th-grade. Regression in the left panel includes girls in urban schools only, while regression in the right panel includes girls in rural schools only. The specification is the same as Equation (2). Year -1 is the omitted reference period while year 0 is the first year in which the sanitary pad vending machine was installed in the school under the She Pad scheme. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Appendix A12. Average Effects on the Dropout Rates of Girls Using DIDM Estimator

	(1) 5 th -Grade Age 10-11	(2) 6 th -Grade Age 11-12	(3) 7 th -Grade Age 12-13	(4) 8 th -Grade Age 13-14	(5) 9 th -Grade Age 14-15	(6) 10 th -Grade Age 15-16
DIDM	-0.097* (0.055)	-0.029 (0.041)	-0.193* (0.103)	-0.067 (0.085)	-0.053 (0.108)	-0.080 (0.213)
Observations	26,333	26,022	13,621	15,188	14,497	9,191

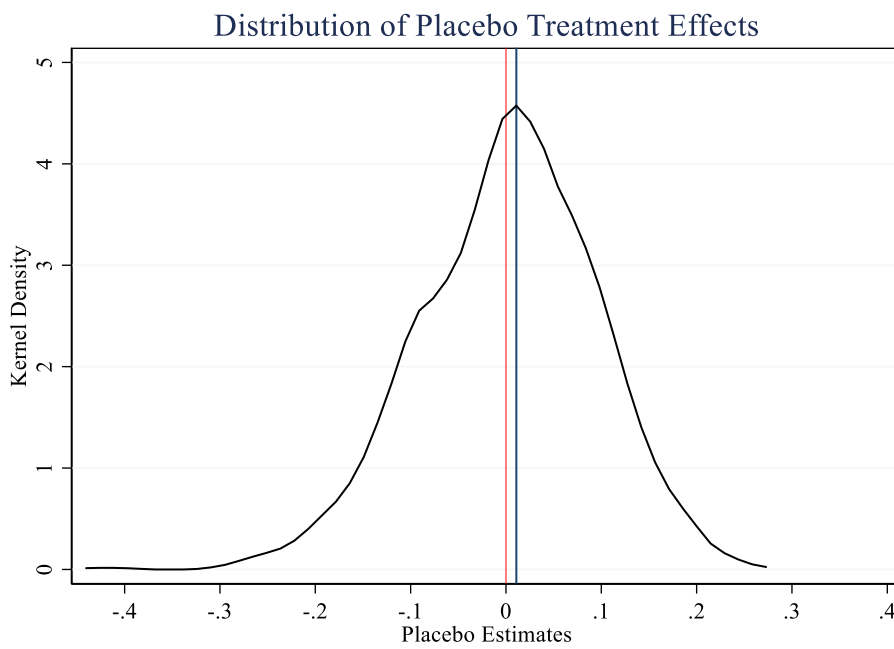
Notes: The table reports coefficient estimates estimated using the estimator proposed by de Chaisemartin and d'Haultfœuille (2020) using Stata's *did_multipligt* module. Outcomes in panels A and B are the number of dropouts of girls in the 5th-grade through the 10th-grade (Columns 1 through 6). The significance of each coefficient is indicated by: *** 1 per cent significance ** 5 per cent significance; * 10 per cent significance.

Appendix A13. Number of Schools that Received SHE Toilet, by Year

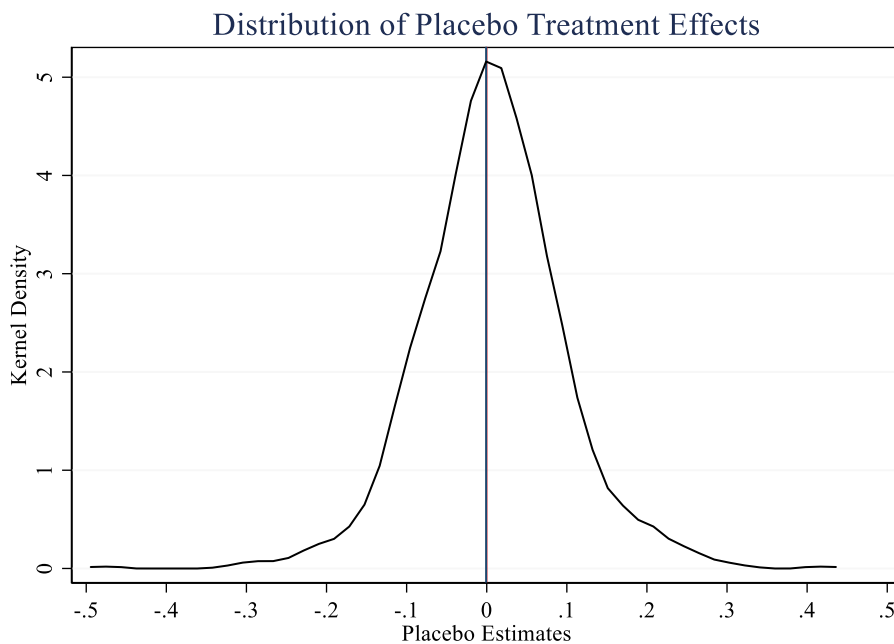


Notes: The figure shows the total number of schools constructed with SHE-toilets over the years from 2011 to 2020. The data is obtained from the Kerala State Women’s Development Corporation Ltd.

Appendix A14. Kernel Distribution of Placebo Treatment Effects
Panel A. Placebo Treatment Year



Panel B. Placebo Treatment Unit



Notes: The figure in Panel A plots the density distribution of estimated coefficient on *AfterT*, β_1 , obtained from a randomization placebo test. For each treated school in the main sample, we randomly select a placebo treatment year (from 2013 to 2020) of installation of sanitary pad vending machine, and estimate Equation (1) on a balanced panel. This estimation process is repeated 1000 times, and the graphs show the distribution of placebo treatment effects on the dropout rate of girls in the 7th-grade. The red vertical line is drawn at the coefficient value of zero and the blue vertical line corresponds to the coefficient value that has the highest density ($\beta_1=0.011$). The figure in Panel B plots the density distribution of the estimated coefficients on *AfterT*, β_1 , obtained from a randomization placebo test. We randomly select 494 schools from the control sample and treat them as treated school. We then randomly select a placebo treatment year (from 2013 to 2020) of installation of sanitary pad vending machine, and estimate Equation (1) on a balanced panel. This estimation process is repeated 1000 times, and the graphs show the distribution of placebo treatment effects on dropout rates of female students in the 7th-grade. The red vertical line is drawn at the coefficient value of zero and the blue vertical line corresponds to the coefficient value that has the highest density ($\beta_1=-0.001$).

Appendix A15. Average Effects on the Dropout Rate of Students in the Falsification Groups

Treatment Group:	Girls in 1 st - grade (1)	Girls in 2 nd - grade (2)	Girls in 3 rd - grade (3)	Girls in 4 th -grade (4)	Boys in 7 th - grade (5)
AfterT	-0.089 (0.064)	-0.017 (0.066)	-0.065 (0.075)	-0.183 (0.158)	-0.452 (0.337)
R ²	0.353	0.338	0.360	0.577	0.522
School fixed effects	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y
No. of observations	71,754	71,136	70,950	33,936	20,682
No. of treated schools	160	159	161	161	503
No. of control schools	11,799	11,697	11,664	5,495	2,944

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on the dropout rate of students using Equation (1) on a balanced panel. In Column 1, we compare girls in the 1st-grade girls in treated schools to girls in the 1st-grade in control schools; in Column 2, we compare girls in the 2nd-grade in treated schools to girls in the 2nd-grade in control schools; in Column 3, we compare girls in the 3rd-grade in treated schools to girls in the 3rd-grade in control schools; in Column 4, we compare girls in the 4th-grade in treated schools to girls in the 4th-grade in control schools; in Column 5, we compare boys in the 7^h-grade in treated schools to boys in the 7th-grade in control schools. Standard errors are clustered at the school level, and are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A16. Robustness Tests: Standard Error Clustering and Sample Redefinition

	Standard error clustering (1)	Remove control schools that were treated (2)	Remove treated schools without treated students (3)	(2) and (3) (4)
AfterT	-0.240** (0.121)	-0.251** (0.116)	-0.252** (0.117)	-0.262** (0.117)
R ²	0.574	0.565	0.573	0.564
School fixed effects	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y
No. of observations	20,484	19,110	20,436	19,062
No. of treated schools	494	494	486	486
No. of control schools	2,920	2,691	2,920	2,691

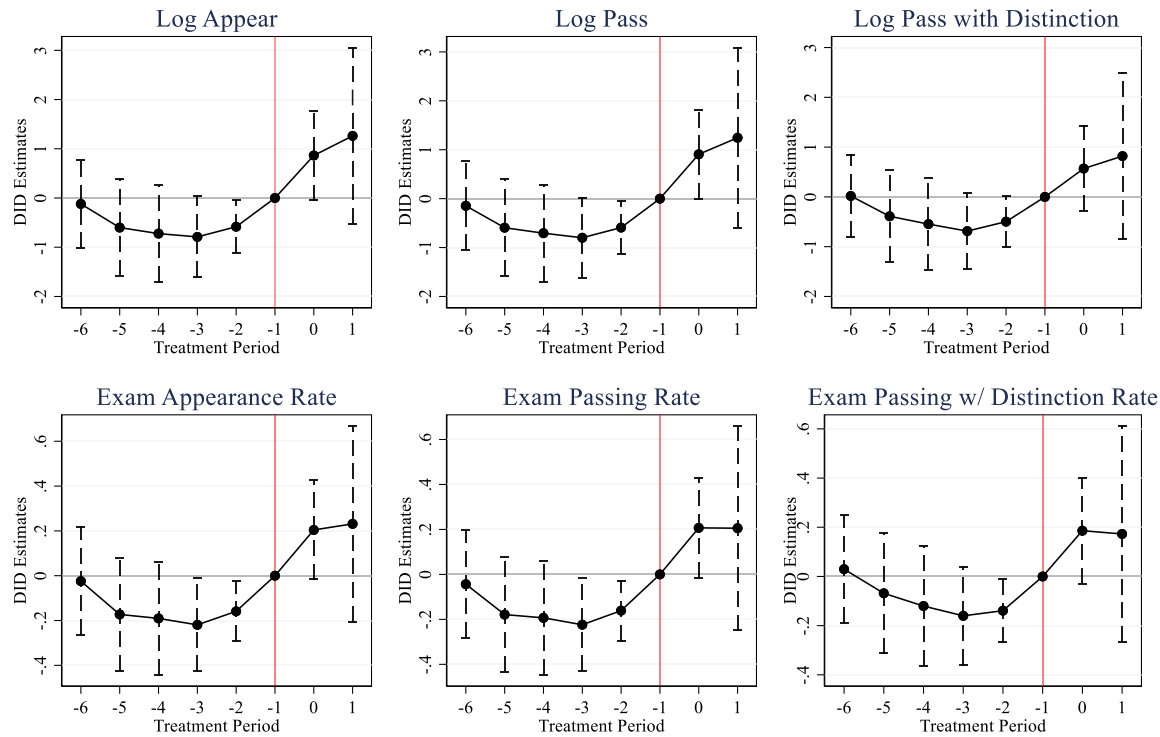
Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on the dropouts of students in the 7th-grade. The estimates are estimated with Equation (1) on a balanced sample. The sample in column 1 uses the same sample as the baseline; the sample in column 2 removes control schools that are not installed with sanitary pad vending machines but receive free sanitary pads regularly from the local government; the sample in Column 3 removes treated schools that do not have students utilizing the sanitary pad vending machine on record; and the sample in Column 4 removes both control schools that receive free sanitary pads and treated schools that do not have students utilizing the vending machine. Standard errors are clustered at the village level (Column 1), and at the school level (Columns 2 to 4), they are shown below the estimates in parentheses. The significance of each coefficient is indicated by: *** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$.

Appendix A17. Additional Falsification Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log (Amount of school development grant receipt)	Log (Amount of funds from other sources receipt)	Log (Amount of school maintenance grant receipt)	Log (Amount of school development grant expenditure)	Log (Amount of funds from other sources expenditure)	Log (Amount of school maintenance grant expenditure)	Log (No. of visits by CRC coordinators)	Log (No. of visits by Block level officer)
AfterT	-0.553 (0.611)	-0.553 (0.611)	-0.146 (0.472)	-0.593 (0.598)	-0.593 (0.598)	-0.164 (0.483)	0.017 (0.062)	-0.009 (0.059)
R ²	0.866	0.866	0.895	0.871	0.871	0.900	0.786	0.730
Observations	13,656	13,656	13,656	13,656	13,656	13,656	20,484	20,484
Treated schools	494	494	494	494	494	494	494	494
Control schools	2,920	2,920	2,920	2,920	2,920	2,920	2,920	2,920

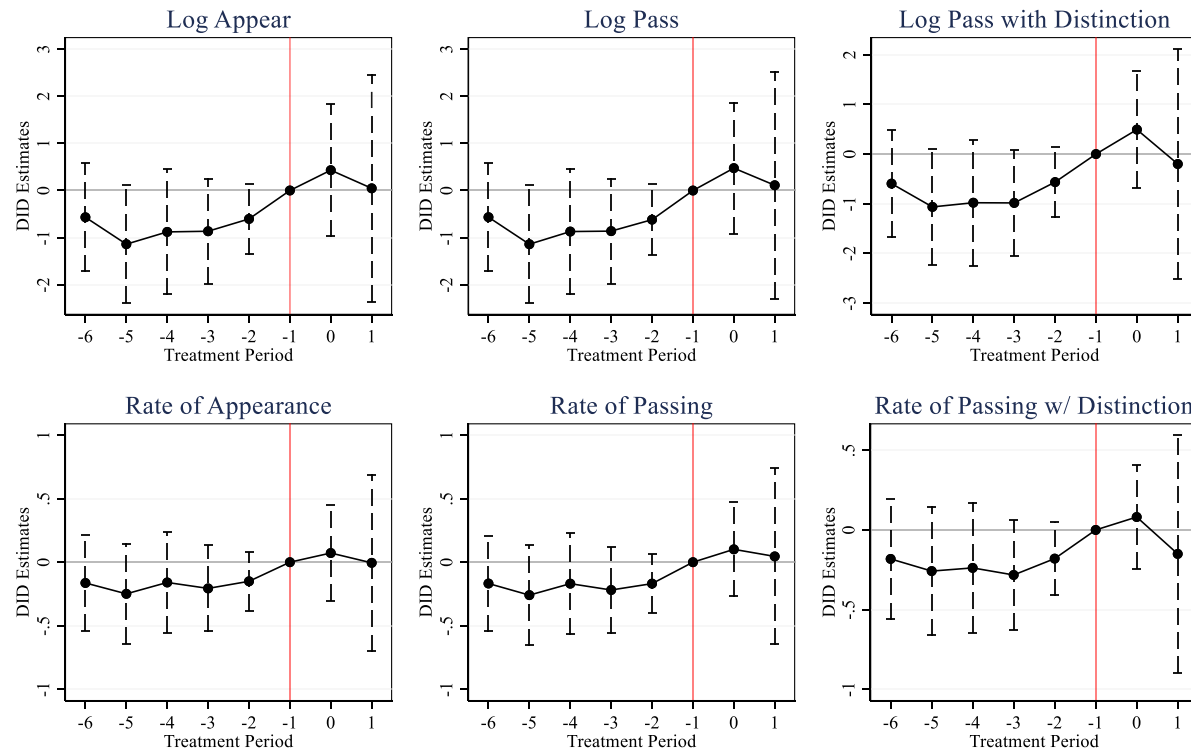
Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on log amount of school development grant receipt (Column 1), log amount of funds from other source receipt (Column 2), log amount of school maintenance grant receipt (Column 3), log amount of school development grant expenditure (Column 4), log amount of funds from other source expenditure (Column 5), log amount of school maintenance grant expenditure (Column 6), log number of visits by cluster resource coordinators (Column 7) and log number of visits by block-level officer (Column 8). The estimates are estimated with Equation (1) using the same sample as Table 1 Column 3. Standard errors are clustered at the school level. The significance of each coefficient is indicated by: *** 1 per cent significance ** 5 per cent significance; * 10 per cent significance.

Appendix A18. Dynamic Treatment Effects on Boy's Upper Primary School-Leaving Examination Outcomes (7th-Grade Exam)



Notes: The figure shows coefficient estimates from the regression of boy's upper primary school-leaving examination outcomes on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed. Year -1 is the omitted reference period while year 0 is the first year in which the vending machine was installed in the school. School-leaving examination outcomes include: (1) Number of students who appear at the school-leaving exam, (2) Number of students who pass the school-leaving exam, and (3) Number of students who pass the school-leaving exam with distinction. The outcome variables in the top row are log examination outcomes plus one, while the outcome variables in the bottom row are ratios of the examination outcomes to the number of students in the exam grade. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Appendix A19. Dynamic Treatment Effects on Girl's Lower Primary School-Leaving Examination Outcomes (4th-Grade Exam)



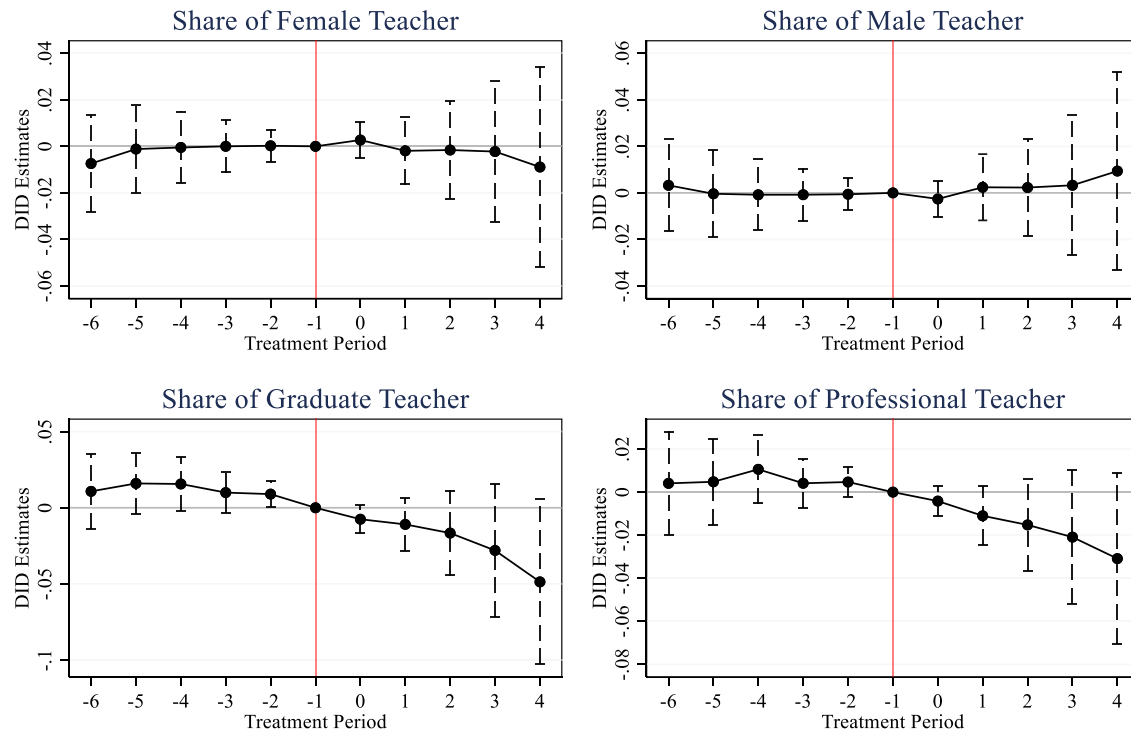
Notes: The figure shows coefficient estimates from the regression of girl's lower primary school-leaving examination outcomes on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed. Year -1 is the omitted reference period while year 0 is the first year in which the vending machine was installed in the school. School-leaving examination outcomes include: (1) Number of students who appear at the school-leaving exam, (2) Number of students who pass the school-leaving exam, and (3) Number of students who pass the school-leaving exam with distinction. The outcome variables in the top row are log examination outcomes plus one, while the outcome variables in the bottom row are ratios of the examination outcomes to the number of students in the exam grade. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Appendix A20. Heterogeneity by Village-level Amenities

	(1) Public Bus Services	(2) National Highways	(3) Community Health Centers	(4) Primary Health (Sub) Centers	(5) Family Welfare Centers	(6) Maternity & Child Welfare Centers	(7) Rural Production Markets	(8) Private Courier Services
AfterT × [Indicator=1]	-0.246*	-0.293**	-0.190	-0.231	-0.246	-0.207	-0.238	-0.333
	(0.138)	(0.134)	(0.324)	(0.153)	(0.176)	(0.151)	(0.188)	(0.218)
AfterT × [Indicator=0]	0.472	-0.192	-0.219	-0.107	-0.167	-0.222	-0.187	-0.058
	(0.568)	(0.165)	(0.141)	(0.259)	(0.207)	(0.271)	(0.189)	(0.127)
p-value (Indicator=1 – Indicator=0)	0.217	0.623	0.933	0.677	0.769	0.959	0.846	0.268
R ²	0.664	0.664	0.664	0.664	0.664	0.664	0.664	0.664
School fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
School-specific linear time trends	Y	Y	Y	Y	Y	Y	Y	Y
Block × year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
No. of observations	11,514	11,514	11,514	11,514	11,514	11,514	11,514	11,514

Notes: The table reports coefficient estimates of the effect of sanitary pad vending machine on the dropout rate of girls using a balanced panel. The outcome variable is dropout rates of female students in the 7th-grade. The estimates are estimated using Equation (1) with some modifications, where the post-treatment dummy is interacted with a binary indicators indicating the presence of public bus services (Column 1), national highways (Column 2), community health centers (Column 3), primary health centers (Column 4), family welfare centers (Column 5), maternity and child welfare centers (Column 6), rural production markets (Column 7) and private courier services (Column 8). The p-values are derived from the statistical significance test on the differences in estimated coefficients between the two types of villages. Standard errors are clustered at the school level. The significance of each coefficient is indicated by: *** 1 per cent significance ** 5 per cent significance; * 10 per cent significance.

Appendix 21. Dynamic Treatment Effects on the Share of Teacher by Gender and Qualification



Notes: The figure shows coefficient estimates from the regression of the share of female teacher (top left panel), the share of male teacher (top right panel), the share of teacher who has at least a bachelor degree (bottom left panel), and the share of teacher who has professional teaching qualification (bottom right panel) on a set of time period dummies that indicate the number of years before and after the sanitary pad vending machine was installed, using a balanced panel. The sample used in these estimations include schools that provide 7th-grade courses. The specification is the same as Equation (1), except that the AfterT dummy indicator is replaced with a set of relative time dummies that indicate the number of years before and after the installation of sanitary pad vending machine in the school. Year -1 is the omitted reference period while year 0 is the first year in which the sanitary pad vending machine was installed in the school under the She Pad scheme. Ninety-five percent confidence intervals are displayed around each point estimate. Standard errors are clustered at the school level.

Appendix B: Data Construction and Merging Details

Appendix B1. District Information System for Education (DISE)

We obtain enrollment data, school infrastructure details, and school-leaving examination outcomes of registered primary and secondary schools in Kerala from the District Information System for Education (DISE). Both the enrollment data and infrastructure data span from 2013 to 2019.

The enrollment data contains the number of female and male students enrolled and retained in c^{th} -grade in school s in each academic year. In India, the primary education begins at the age of 6. In Kerala, the primary education is imparted from 1st-grade to 4th-grade (age 6 to 10); upper primary education is imparted from 5th-grade to 7th-grade (age 10 to 13); lower secondary education is imparted from 8th grade to 10th-grade (age 13 to 16); and upper secondary education is imparted from 11th-grade to 12th-grade (age 16 to 18). Schools are further categorized into several categories: lower primary only (1st-Grade – 4th-Grade); lower primary and upper primary (1st-Grade – 7th-Grade); lower primary to upper secondary (1st-Grade – 12th-Grade); upper primary only (5th-Grade – 7th-Grade); upper primary to higher secondary (5th-Grade – 12th-Grade); primary to lower secondary (1st-Grade – 10th-Grade); upper primary and lower secondary (5th-Grade – 10th-Grade); lower secondary only (8th-Grade – 10th-Grade); lower secondary and upper Secondary (8th-Grade – 12th-Grade); and upper secondary only (11th-Grade – 12th-Grade).

The annual data on school infrastructure and facilities includes the presence of electricity, library, playground, ramps, computer lab, regular medical check-ups, roads that make school accessible, school management committee, and school development plan; the type of boundary wall, water source, and school management; the status of school building; the number of classrooms, sanitation facilities, and books in the library; and the number of female teachers, the number of male teachers, and the number of teachers with professional teaching qualification or graduate degree.

School-leaving examination outcomes for the 4th-grade and 7th-grade students reported in the years from 2013 to 2016 are also available in the DISE. Information collected includes the number of students who participated, who passed, and who earned high scores on the exam. We note that the examination outcomes from the DISE are lagged by one year. For instance, upper primary school-leaving examination outcomes reported in 2016 are outcomes of examinations taken by 7th-grade students in the year 2015. In view of the low coverage of examination data both over time and cross-sectionally, coupled with the staggered nature of the treatment intervention, treatment effects on examination outcomes may be estimated with large imprecision.

The DISE data are based on annual reporting by school headmasters. Each year, school headmasters respond to a nationally-standardized survey-questionnaire. The consistency, accuracy and completeness of the responses are examined by cluster officials, before submitting it to district officials and state officials for further rounds of examinations. In the final step, each state is responsible for hiring external agents to conduct post-enumeration audits and site-visits to ensure data accuracy (Kaushal, 2010).

We identify unique schools based on the unique identifier provided in the DISE data. We perform the following data cleaning steps to remove inconsistencies in data. First, we remove schools that have multiple entries of inconsistent data for any academic year. We then remove schools that have zero or missing enrollment across all academic years from 2013 to 2019. Indian schools are grouped into three types: all-boys school, all-girls school, and mixed-gender school. We remove schools that have enrollment information inconsistent with school's gender type from the estimation sample. Lastly, we remove schools that only appear in the dataset after 2013.

Appendix B2. Merging DISE data to SHE Pad Scheme Data

We merge the school-year level DISE data to a proprietary dataset that contains treatment information of the SHE Pad Scheme based on the name of school and the name of district. As

the names of the school in the two datasets are not standardized, we employ fuzzy matching using the *matchit* program in Stata. We split both datasets into subsamples based on district names, and performed fuzzy matching of school names within each district subsample. For each district subsample, the output of the matching algorithm assigns one or more SHE Pad schools to the DISE schools based on similarity scores. For schools that have nonunique matches and similarity score not equal to one, we perform data mapping by hand based on the output file from the fuzzy matching. After the first round of matching, we collect unmatched schools in the DISE data and unmatched schools in the SHE Pad Scheme, and repeat the fuzzy matching and hand matching procedure on the unmatched set of data. This fuzzy matching and manual cleaning procedure is repeated three times after most of the schools in the treatment data are matched. Out of the 858 treated schools in the SHE Pad Scheme dataset, we are able to match 765 (89 percent) schools to the DISE data.

Appendix B3. Merging DISE data to Population Census of India 2011

2011 Census data is a village-level data that contains a wide range of village-level amenities information such as the number of population and household by caste, the number of community and primary health center, the presence of public transportation by type and the presence of road by type.

We merge the DISE data to the 2011 Census data based on the village name, block name and PIN (Postal Index Number) code. As the names of the villages and blocks are not standardized across the datasets, we perform several rounds of fuzzy matching and manual cleaning. We first match the two datasets based on the block name using fuzzy matching *matchit*. For blocks that do not have a perfect match (similarity score equals 1), we manually clean matched outputs from the *matchit* algorithm. Next, we repeat the fuzzy matching and hand matching procedure based on the village name on the original datasets. After the first and second steps, we have two lists of matched names – matched block names, and matched village names. We merge these lists to both the DISE data and the 2011 Census data, and then merge

DISE data to 2011 Census data based on matched village name and matched block name. For the unmatched villages, we perform a second round of matching using fuzzy match of village names and exact match of PIN code. We successfully merge 60 percent of the schools in the baseline sample, including 445 treated schools and 10,212 control schools.

Appendix C: Comparability between Treated and Control Schools

Selection occurs when the treatment intervention is not random, leading to potential bias in the estimated treatment effects.

At the school-level, there are significant differences between treated schools and control schools in various baseline school characteristics, as shown in Appendix A3. In particular, treated schools are about 40 percent larger than control schools. Concerning this is an argument against the reliability of our causal estimates—that is, our point estimates could be biased upwards if schools that have larger number of menstruating female students are specifically selected into the treatment program. We reckon that this selection channel is unlikely to affect our estimates. Firstly, an existing study by Phillips-Howard et al. (2016) that examines the effect of a random distribution of sanitary pads to menstruating students does not find significant treatment effects on school attrition; this suggests that there is limited correlation between targeting menstruating students and treatment effects of sanitary pads on dropouts. Secondly, it is empirically unclear that targeting schools with a larger number of menstruating girls leads to a larger reduction in girls' dropout. This is supported by our empirical results that show no significant treatment effects on dropouts of higher-grade students from the 8th-grade to the 10th-grade.

Also, aside from the lack of access to sanitary pads, marginal girls may still dropout of schools due to several reasons, including accessibility (Adukia, Asher and Novosad, 2020), safety (Adukia, 2017), child marriage (Field and Ambrus, 2008) and household labor (Montmarquette, Viennot-Briot and Dagenais, 2007). Thus, treating schools that have a larger

girls' population with free sanitary pads does not mechanically generate upward bias in the estimation of treatment effects on dropouts. Lastly, our findings of significant reduction in dropouts of girls in the 7th-grade are unlikely to be due to such selection, as the treatment program are not specifically targeted at girls in the 7th-grade. We show in Appendix A1 Panel D that schools treated with SHE Pad Scheme are found to vary substantially in the grades that they offered.

Our main identifying assumption is violated when schools with distinct characteristics would have followed a different path even in the absence of sanitary pad vending machine installation. In our main empirical specification, we include block-year fixed effects to control for regional time-variant characteristics, alleviating concern that more developed blocks simultaneously drove schools into the SHE Pad Scheme and provided schools with additional educational resources. We additionally include a year-interacted vector of baseline school characteristics, school fixed effects and school-specific linear time trends to account for differences in school-level characteristics. Our identifying assumption then becomes that female students in treated schools would otherwise have changed similarly, on average, to female students in control schools with similar baseline characteristics and trends located within their same block.

Our estimated treatment impacts are also robust to a wide range of control group redefinitions, as reported in Table 3. From Columns 1 through 6, the estimated treatment effects remain consistent in terms of both direction and magnitude. We also use various matching methods based on school-level characteristics (Appendix A5 Columns 1 – 6) and on baseline outcome variable using synthetic control method (Appendix A5 Column 7). For samples obtained from propensity score matching methods, we calculate mean differences in baseline school characteristics between control schools and treated schools (Appendix A6). Control samples obtained from the nearest neighbor matching and coarsened exact matching, in particular, resemble treated schools very closely in terms of baseline school characteristics,

reaffirming that the estimated treatment effect is not due to confounding by school-level characteristics.

At the regional level, sanitary pad vending machines may be more likely to be installed in schools located in high-growth regions where students enrollment are expected to grow. The inclusion of school-specific linear time trends in our baseline specification helps alleviate concern of differential growth rates across treated and control schools. Additionally, in Panel B of Appendix 1, we show that treated schools are widely dispersed across the state of Kerala, with more than 80% of villages having only one school that has been treated since 2015. In Appendix A7, we regress treatment indicator on baseline village-level characteristics obtained from Census 2011 and we do not find statistically significant selection of treatment based on village-level attributes.

Appendix D: Choice of Main Outcome Variable

Appendix D1. Measure of Dropout Rate

Our main outcome variable is students dropout, which is the fraction of students who discontinue schooling in the subsequent year, and is calculated as $Enrollment_{c,s,t} - Enrollment_{c+1,s,t+1} / Enrollment_{c,s,t}$.

We use the cohort-based students dropout, rather than students enrollment, as the main outcome variable for two primary reasons. First, the use of dropout rate as the outcome variable arises from and aligns directly with anecdotal discussions that connect girls' menstruation event to their school participation outcomes and hence decisions to continue schooling. As menstruation occurs six years after an average girl starts schooling, the measure of cohort-based dropout rates enables us to capture school-going decisions of marginal students who are affected by menstruation. Second, the total size of enrollment in school varies by cohort and is generally fixed at a specific level due to constraints of resources. As a result, estimating changes in the enrollment before and after treatment can result in noisy estimates. As a further

robustness test, we re-estimate the baseline specification using log enrollment (plus one) as the outcome variable. Following the way we construct the cohort-based dropout rates, the treatment effect on students enrollment in the c^{th} -grade corresponds to the effect on students dropout in $c - 1^{\text{th}}$ -grade. The dynamic effects on log enrollment, as depicted in Appendix A8, follow closely with our baseline results.

There are potential concerns of measurement issues for the measure of cohort-based dropout rates. First, grade retention may occur, which could either deflate or inflate the dropout rates.¹ We calculate the retention rate in each grade as the ratio of the repeater's enrollment in c^{th} -grade in the current year to the total enrollment in c^{th} -grade in the previous year. From 1st-grade through 10th-grade, the retention rates are negligible: the average retention rates across academic years range from 0.0009 to 0.0071. We perform robustness check by replacing the outcome variable with an adjusted measure of dropout that takes into account of repeater's enrollment:

$$\text{Enrollment}_{c,s,t} - (\text{Enrollment}_{c+1,s,t+1} - \text{Repeater}_{c+1,s,t+1} + \text{Repeater}_{c,s,t+1}) / \text{Enrollment}_{c,s,t}.$$

Second, total enrollment at $t + 1$ may include new admissions in addition to previously enrolled students at t , which could mask potential dropouts in that cohort. New admissions can be generalized into three categories, including (1) student transfers due to random events such as change in financial circumstances, (2) standard transitions across educational sections including transitions from lower primary to upper primary, from upper primary to lower secondary, and from lower secondary to upper secondary, and (3) student transfers or transitions due to the treatment program. The first and second categories are unlikely to affect the treated and control schools differently, our concern then lies in distinguishing student dropouts from new admissions of the third type. This is empirically challenging as attendance

¹ Two scenarios may occur: (1) students in c^{th} -grade in year t who have to repeat the grade are not captured in $\text{Enrollment}_{(c+1),s,(t+1)}$, (2) students who fail $c+1^{\text{th}}$ -grade in year t and have to repeat the grade are included in $\text{Enrollment}_{(c+1),s,(t+1)}$.

data and student-level enrollment information are unavailable in the DISE. We deal with this issue by limiting the sample to villages with only one school that encompasses the 8th-grade. This sample restriction follows from the idea that in India, children go to school within their villages. With only one school that provides 8th-grade education in the village, all students who have completed 7th-grade and wish to further studies will enter the only school that offers 8th-grade courses in the village. Assuming that children do not travel across villages to attend schools, this exercise allows us to tease out non-random admissions that are driven by school's treatment status.

Appendix D2. Students Dropout and Quantile Treatment Effects.

Treatment effects can vary across treatment units; as such, the average treatment effect will not provide sufficient information about the effect of treatment on other points in the outcome distribution that may also be of research interest. This is crucial considering the way our dropout variable was constructed. Question arises as to whether our estimated treatment impacts are driven by treated schools that have few dropouts but large student transitions—the estimated reduction in dropout rates after treatment intervention could be solely driven by an increased number of students who selectively transferred to treated schools from non-treated schools. While we address this issue by restricting the sample to villages with only one school that provides 8th-grade courses, we further estimate quantile treatment effects to characterize the heterogeneity of treatment effects along the dropout distribution. In particular, statistically significant treatment effects at the low quantile of distribution, if any, may suggest potential contamination of treatment effect estimates by non-random student transitions.

In addition, estimating quantile treatment effects is useful to understand the distributional impacts of and mechanisms behind treatment intervention. Schools that experience large students dropout may receive larger impact from the installation of sanitary pad vending machine as these schools are likely to have a larger population of students who are

economically disadvantaged and are able to avoid dropout if provided with free sanitary pads. On the contrary, these schools may receive smaller impact from the treatment program, as economically disadvantaged students would still quit schools regardless of the free provision of sanitary pads due to other financial implications or social-cultural factors.

We estimate Quantile Treatment Effects on Treated (QTET) of the installation of sanitary pad vending machine on students dropout using:

$$(1) \quad QTET(\tau) = F_{Y_1|D=1}^{-1}(\tau) - F_{Y_0|D=1}^{-1}(\tau) .$$

$F_{Y_1|D=1}^{-1}(\tau)$ is the distribution of treated potential outcomes for the treated schools at τ -th quantile, and $F_{Y_0|D=1}^{-1}(\tau)$ is the distribution of untreated potential outcomes for the treated schools at τ -th quantile. To identify the distribution of untreated potential outcomes for the treated, we rely on the conditional independence assumption which indicates that the selection into treatment is random after conditioning on covariates. Following the propensity score re-weighting approach proposed by Firpo (2007), the vector of covariates, X , includes all measures of baseline school-level characteristics included in our baseline DID estimations and block-year fixed effects. Under the conditional independence assumption, $F_{Y_j|X}(y_j) = F_{Y_j|X,D=j}(y_j)$, and equation (1) can be rewritten as:

$$(2) \quad QTET(\tau) = F_{Y_1|X,D=1}^{-1}(\tau) - F_{Y_0|X,D=0}^{-1}(\tau) .$$

The QTET can thus be defined as the difference between the distribution of the observed outcomes for treated schools and the distribution of the observed outcomes for untreated schools, at some quantile τ . We focus on girls-only and mixed-gender schools, and restrict the sample to year 2015 or later for untreated schools and post-treatment years for treated schools.

Appendix A9 presents the estimated quantile treatment effects of sanitary pad vending machine installation on the dropout rate of girls in the 7th-grade. For schools at the lower distribution of dropout rates, treatment effects are estimated with large imprecision and are statistically insignificant, providing an additional piece of evidence suggesting that our

estimated treatment impacts are less likely to be driven by non-random student transitions. Across the quantiles of the distribution, the estimated reduction in dropouts hover around 11 percentage points, and becomes strongly statistically significant from the 75th percentile onwards before increases considerably to 23.4 percentage point at the 95th percentile of the dropout distribution.

For schools that are at the highest range of dropout quantile, the larger treatment effect can be explained by the larger fraction of marginal students enrolled in these schools. These results bring to light the extent of school segregation in the country, where schools and thereby quality of education are segregated by income and socio-economic status. As suggested in the existing literature, school segregation has consequential impact on inequality in socioeconomic attainment outcomes (Card and Krueger, 1992; Card and Rothstein, 2007; Billings, Deming and Rockoff, 2014). These results provide useful insights: the effects of free distribution of sanitary pads on dropout rates of female students are largest for schools at the highest dropout quantiles, highlighting the important role of free sanitary pad provision in providing female students an equal opportunity toward academic success and thereby narrowing educational and economic inequality.

Appendix E: Discussion on the Estimated Treatment Impacts

If the lack of access to sanitary products leads to school absenteeism and dropout among female students, as indicated by many qualitative and policy reports, then students who are either unable to access to or afford sanitary products may exhibit large gains from the treatment program. Specifically, free distribution of sanitary pads under the SHE Pad Scheme would most impact marginal female students who have just experienced their first period and do not have resources to manage menstruation in public places. These students are mostly in the 7th-grade, based on the minimum age of 6 years old for admission to 1st-grade in India and the

mean menarche age of 13 years old for girls in Kerala. This is reflected in our estimation results that show significant treatment impacts only among female students in the 7th-grade.

The scatterplot in Appendix A1, panel C also presents an interesting observation: not every female student in school collects free sanitary pads under the SHE Pad Scheme. Assuming that 80% of girls from the 7th-grade to the 12th-grade have experienced menarche, the average fraction of menstruating girls who collect free sanitary pads from vending machines in school stands at 27.08 percent in our sample. This fraction is consistent with the poverty rate of 30.2 percent in Kerala (India National Family Health Survey 2015-2016), suggesting that the SHE Pad Scheme is effective in promoting the usage of hygienic menstrual protection, especially among girls from economically deprived group.

The statistically significant treatment impact found on only girls in the 7th-grade reflects two important implications. First, not only that the 7th-grade is the grade in which an average Kerala girl experiences first menstruation, it is also the final grade of the upper primary education section in which students make schooling decision on whether to continue the secondary education section. According to data from UNESCO Institute for Statistics 2021, India has one of the world's lowest rates of transition from lower education level-to-higher education level: the out-of-school rate for girls of lower secondary school age stands at 13 percent, which is six-fold higher than the average rate of 2 percent for OECD member countries. Considering that the RTE act only provides free and compulsory education for children until the completion of upper primary school, the estimated treatment impact on female students in the 7th-grade highlights the important role of free access to sanitary pads in nudging marginal girls towards higher educational attainment.

Second, our estimated treatment impacts capture the treatment effects on marginal students whose outcomes are affected by inadequate management of menstruation. The insignificant treatment impact on girls in higher grades suggests that marginal students may still dropout from school regardless of free access to sanitary pads due to other reasons such as financial

constraints, help in domestic chores and cultural issues. A further discussion on this can be found in Appendix C. Nonetheless, our estimated treatment impacts on outcomes of girls in higher grades may be underestimated, as marginal students who have gone through few years of menstruating would have already dropped out from school, and hence from our estimation sample, before their schools were treated under the SHE Pad Scheme.

The treatment effect can be attributed to both menstruating girls and marginal girls who have future needs for sanitary pads in anticipation of menarche. As menarche age varies across individuals, many marginal students who have not experienced menarche in the 7th-grade, particularly those who are initially discouraged from continuing schooling due to affordability, would also continue to enroll in the 8th-grade in anticipation of their future needs of sanitary pads.

Underestimation may also occur due to the differential timing of first menstruation within the age range of 11 to 16 across girls. Marginal students who experienced early menarche at age below 12 years old (students in the 6th-grade and below) or late menarche at age above 14 years old (students in the 8th-grade and above) would benefit from the treatment program and choose to continue schooling in response to the free distribution of sanitary pads. However, as these students belong to the minority treated units in their cohort, treatment impacts on these students would be undetected due to low statistical power.

An alternative argument to the reduced dropout of 7th-grade female students after treatment is that lower-grade students who previously dropped out from schools few years before treatment rejoined schools after treatment, which may cause an upward bias to our estimated effect. We argue that this does not threaten our causal estimates because female students, if they were to return to schools after few years of absence, would rejoin schools at the grade at which they have previously left. For instance, a student who completed 3rd-grade but left school two years before treatment would still need to attend 4th-grade upon return. However, we do not see any significant treatment effects on girls in grades other than the 7th-grade (Table 1).

Appendix F: Additional Robustness and Falsification Tests

Appendix F1. Standard Error Clustering

In the baseline estimation, as the treatment intervention occurs at the school level, we cluster standard errors at the school level to allow for student outcomes to be correlated within the same school. However, village-wide shocks could result in correlated outcomes of students within the same village. In Column 1 of Appendix A16, we estimate standard errors by clustering at the more conservative village level and find that the estimated treatment estimate remains highly statistically significant.

Appendix F2. Contamination of Treatment Intervention

Some schools in the control sample are not installed with sanitary pad vending machines but receive free sanitary pads regularly from the local government; some schools in the treated sample are installed with vending machines but do not have any students utilizing the machine on the record. Such contamination of treatment intervention confounds our treatment effects, resulting in a downward bias in the treatment effect estimate. In Appendix A16, we re-estimate treatment effects after removing control schools that received free sanitary pads (Column 2), treated schools with no students utilizing the vending machine (Column 3), and both (Column 4) from the sample. Treatment effect estimates are statistically significant and are found to be larger than the baseline estimate.

Appendix F3. Additional Falsification Tests

In Appendix A17, we test whether the treatment effect on student dropouts in treated schools is confounded by treated schools having more educational resources and fundings from the local government. As shown in Columns 1 through 6, we do not find statistically significant change in the amount of funds and grants received and spent by treated schools post-treatment. School outcomes may also be positively correlated with the extent of government monitoring. We use the log number of visits by cluster resource coordinators (CRC) and the log number of visits by block-level officers as the outcome variables to estimate treatment effects on the

extent of monitoring by the government officials. As presented in Columns 7 and 8, there is no treatment effect on the number of visits by government officials.

Appendix F4. Additional Placebo Test.

In Appendix A14 Panel A, we randomly select a placebo treatment year for each treated school to validate our DID estimates. Here, we randomly select 494 placebo treated schools from the control sample, and assign a random treatment year from 2013 to 2020 to these schools. We estimate the baseline equation as if the placebo year were the treatment year in which sanitary pad vending machine was installed. This two-step randomization and estimation process is repeated 1000 times. In Appendix A14 Panel B, we plot the distribution of the estimated coefficient on *AfterT*, which is the placebo effect of sanitary pad vending machine on the dropout rates of female students in the 7th-grade. Similar to the kernel distribution presented in Panel A, the placebo estimates are centered around zero.

Appendix G. Peer Effects

Positive effects of free sanitary pads on examination outcomes may spill over to male students in treated schools as they may be motivated by female students' positive learning behaviors induced by the treatment program (Calvó-Armengol, Patacchini, and Zenou, 2009; Epple and Romano, 1998; Evans, Oates and Schwab, 1992; Zimmerman, 2003). Appendix A18 plots the estimated coefficients from the regression of the outcomes of boys' upper primary school-leaving examination on the treatment period indicators. We show that the performance of male students in the upper primary school-leaving examination significantly improves after the treatment. The post-treatment improvement in boys' examination outcomes mirrors the improvements of girls' examination outcomes as presented in Figure 2, confirming the positive peer influence brought by the SHE Pad Scheme.

Appendix H. Additional Heterogeneity Analyses

In Appendix A20, we use village-level amenity information from the Population Census of India 2011 to proxy for the level of accessibility in the village. If treatment affects student dropouts mainly through accessibility, students in villages with high accessibility should exhibit a muted response to the treatment. We find that schools located in villages that have high accessibility, as characterized by the presence of public buses, national highways, primary health and welfare centers, rural production markets and private courier services, have larger point estimates of treatment effects, corroborating our results in Section 3.4 that the affordability mechanism is the main mechanism through which the free distribution of sanitary pads affects the dropout decisions of girls in the 7th-grade.

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