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The causal impact of sanitary products on psychosocial well-being and school absenteeism: Evidence from Western Kenya

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Abstract

Can sanitary products improve schoolgirls' psychosocial well-being and school attendance? We evaluate a simple, disposable product (sanitary pads), and a complex, albeit, economically and environmentally sustainable product (menstrual cup), and compare with business as usual in a randomized pilot program across primary schools in Western Kenya. We estimate positive effects on physical and educational functioning, with stronger and more statistically precise effects early in the intervention period. Qualitative narratives are consistent with the estimated improvements in well-being. The improvements in psychosocial well-being tapered off in the sanitary pads arm, as the benefit stream of disposable products ceased. We found few statistically precise reductions in absenteeism in either treatment arm. The pilot program shows potential for psychosocial well-being improvements from menstrual hygiene interventions in schools.

Keywords: Sanitation, Education, School absenteeism, Adolescence, Psychosocial well-being, Randomized Controlled Feasibility Trial.
JEL: I15, I25, I31, J16, J13

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1 Introduction

There are over 330 million school age girls around the world, with almost 80 million in sub-Saharan Africa alone. Many girls miss out on education because of economic, social and physical barriers to attending school. The gender gap in education increases dramatically around puberty, and is the largest in sub-Saharan Africa (UNESCO, 2016). This raises questions about the role that menarche and the monthly management of menstrual periods play in determining girls' access to education, especially in low and middle income countries with limited access to sanitation in schools.

Nevertheless, it remains controversial whether menstruation leads to absenteeism from school or the workplace. On one hand, there is extensive qualitative and quantitative evidence which points to a correlation between menstruating days and absences from school in low and middle income countries (Alam et al., 2017; Grant et al., 2013; Mason et al., 2015; Tegegne and Sisay, 2014; Sivakami et al., 2019; van Eijk et al., 2016; Hennegan et al., 2019), supported by findings from high-income countries that work-absences vary with the menstrual cycle (Schoep et al., 2019; Ichino and Moretti, 2009). On the other hand, these findings may suffer from self-reporting bias (Grant et al., 2013), be sensitive to specification decisions or fail to replicate in other contexts (Herrmann and Rockoff, 2012), or even be economically insignificant (Oster and Thornton, 2011).

The effects of menstruation on schooling may, however, reach far beyond the absent/present dichotomy. Menstruating days may, in fact, correlate to lower work productivity (Schoep et al., 2019) and reduced concentration and participation in the classroom (Benshaul-Tolonen et al., 2020a; Chinyama et al., 2019; Mason et al., 2015; Sommer, 2010; Stoilova et al., 2022). Qualitative and quantitative studies show that some girls suffer while in school due to the fear of leaking menstrual blood and teasing (Mason et al., 2013; McMahon et al., 2011; Chinyama et al., 2019; Hennegan et al., 2019; Stoilova et al., 2022), leading to reduced attendance, participation and concentration (Benshaul-Tolonen et al., 2020a). Some of the mediating factors—poverty-related scarcity of sanitary products and pain medication, inadequate latrine infrastructure, and period-associated stigma—are acutely

relevant in low and middle-income countries (Schoep et al., 2019), highlighting an unmet need for safe menstrual health management felt by many young women in the world. This is also true in Kenya, the context for our study. Girls in Kenya often use cloth to manage their periods, which is associated with physical discomfort, infections and leaking (Mason et al., 2013; Crichton et al., 2013)[1].

Furthermore, through the potential pathways of absenteeism and psychosocial well-being, menstruation may impact long-term educational achievement and performance (Aucejo and Romano, 2016; Klein et al., 2022). It has been suggested that psychosocial pathways may partially account for the relationship between absenteeism and educational achievement (Aucejo and Romano, 2016; Klein et al., 2022; Morrissey et al., 2014). In particular, internalizing factors—for example anxiety, fear, social withdrawal, and concentration issues—are associated with increased risk of absenteeism (Rogers et al., 2024).

We conducted a three arm cluster randomized pilot trial in 30 primary schools in Western Kenya. We followed 644 girls in ages 14-16 over the course of an average of 10.9 months. The program reduced sexually transmitted infections and reproductive tract infections among treatment girls (Phillips-Howard et al., 2016). Attrition from the initial sample of 751 girls who met the inclusion criteria was balanced across treatment groups[2].

The three arm study design allows us to compare two potential menstrual hygiene interventions against business-as-usual: (1) the monthly provision of 16 single use sanitary pads, and (2) a reusable menstrual cup made from medical grade silicone. A recent meta-analysis using global evidence has shown menstrual cups to be a safe and sustainable option for menstrual hygiene management (van

[1]This is despite girls reporting to prefer disposable sanitary pads (Mason et al., 2013). The Kenyan Government has since our study scaled up a program aiming to provide free sanitary pads in schools. The baseline and endline focus groups did not reveal any evidence of students' having access to free sanitary pads from a government initiative (Mason et al., 2013).

[2]School dropout, and thus attrition from the sample, was pads=10.2%, cups=11.2%, control=8.0%, not statistically different. (Phillips-Howard et al., 2016). The spot check data was collected for all students, also those who dropped out. Therefore, the absenteeism rate can, to some extent, be considered reflective of drop-out rates too. However, the psychosocial well-being measures were only collected for students who were still enrolled in school and thus in the study; therefore, the results on psychosocial well-being are dependent on attrition being balanced across groups.

Eijk et al., 2019). Beyond the economic and environmental benefits of the cup, it can reduce the daily reliance on access to sanitation: A correctly inserted cup can be used safely for 12 hours without being emptied, meaning that a student may only need to manage it in the safety of the home. Nonetheless, study schools across all three treatment arms had adequate access to water, received soap, and access to a nurse, to ensure safe practices were available to all participating students.

We measure the policy impacts on school absenteeism, captured by researcher collected spot-check data[3], and self-reported psychosocial well-being measured by a validated pediatric quality of life index, PedsQL^{TM}, both not previously analyzed. We find that disposable sanitary pads improved self-reported physical well-being (5.6-5.8%, with and without SES controls). The menstrual cup improved physical and educational well-being in the first 9 months. Moreover, the menstrual cup led to a 10.1% improvement in emotional well-being among a vulnerable group; those with heavy periods. Overall, the effect sizes point to improvements in psychosocial well-being although we have somewhat limited statistical power. A coefficient plot over time shows some statistically significant improvements in psychosocial well-being across the two treatment arms, and across the well-being indexes. Moreover, the potential positive impacts of the trial are corroborated by narratives from focus groups held after 6 months of intervention, where girls confirmed physical, social and economic improvements from both treatment arms. In contrast, neither treatment arm reduced school absenteeism measured with statistical significance.

At the end of the study period, we observe a drop in psychosocial well-being effects in the sanitary pad group. This pattern corresponds with the end of the benefit stream of disposable products. The trade off between initial effects of an easy-to-adopt disposable product, and delayed, sustained effects of a complex, reusable technology is a key consideration for policy cost-effectiveness.

Further evidence of the impacts of providing menstrual products on girls' well-

[3]The initial study proposal included collection self-reported diaries of absenteeism and menstruation. Poor compliance among study subjects resulted in this data not being available for analysis (Phillips-Howard et al., 2016). In fact, the authors write: "Self-reported absence was rarely reported and not assessable" (Phillips-Howard et al., 2016). The research team additionally collected spot-checks on absenteeism on unannounced days, which we analyze for the first time in this study. Official school records were also collected but suffer from non random missing data.

being and education is direly needed. First, the question has not been sufficiently studied considering the size and diversity of the affected population. The best and only fully randomized study previously published on the topic focused on the menstrual cup (no sanitary pads) and followed 200 girls in Nepal, to understand the effects on absenteeism (Oster and Thornton, 2012). Second, disposable sanitary pads, one of the most commonly desired products (Mason et al., 2013; Benshaul-Tolonen et al., 2020a; Chinyama et al., 2019), have not previously been evaluated in a randomized school setting. By using a three-arm design, we can compare the baseline with the impacts of disposable sanitary pads and reusable menstrual cups. Lastly, we have limited understanding of how menstruation management impacts physical, emotional and social well-being of students, despite the importance of these for student performance, since this has not been evaluated in previous trials.

We contribute to a growing literature on how menstruation matters in schools. Notable studies include a pilot randomized trial in Nepal (Oster and Thornton, 2012), a quasi-experiment in India (Agarwal et al., 2022), a quasi-randomized study across 8 schools in Uganda (Montgomery et al., 2016), and recently ongoing projects in Kenya (Muthengi and Austrian, 2018) and Uganda (Kansiime et al., 2020). Our study is unique in that it allows for comparisons across technologies and measures impacts on psychosocial well-being. In addition, a recent intervention with adult women working in garment factories in Bangladesh showed that access to sanitary napkins and health information improved health outcomes and menstrual health management. However, the intervention did not change work attendance or earnings (Czura et al., 2024). Such findings—for adult women in the work force, and our findings for adolescent girls in primary schools—show the potential menstrual health management policies to have important effects on the health and quality of life of women and girls.

The remainder of the paper is organized as follows. We discuss the literature and previous evidence in Section 2, describe the program in Section 3, present main results and potential mechanisms in Section 4. Section 5 discusses the findings.

2 Background

Keeping students in the classroom is essential for academic success, regardless of the underlying reason for the absenteeism (Klein et al., 2022). It has been suggested that the effects of absenteeism are particularly detrimental for low-performing students (Aucejo and Romano, 2016), who may be at risk of dropping out. Several interventions have been focused, in particular, on girls' school enrollment and attendance. In low and middle income countries, tested policies include the provision of school uniforms (Evans et al., 2008), same gender teachers (Muralidharan and Sheth, 2016), providing school meals (Vermeersch and Kremer, 2005), and bicycles (Muralidharan and Prakash, 2017). In addition, a range of non-gender targeted interventions have also improved girls' school attendance (Evans and Yuan, 2022).

Sanitation interventions, in particular, aiming to improve schooling outcomes have gender-specific effects. A cluster randomized control trial that targeted latrines reduced absenteeism among girls but not among boys, and had no effect on test scores or enrollment (Freeman et al., 2012). Similarly, a latrine-building program in India improved enrollment rates of adolescent girls, but not boys, when single sex latrines were built (Adukia, 2017). Menstruation, as it increases the need for sanitation, running water and a safe space to wash and change, may be one of multiple factors making girls respond more strongly to latrine-improvements.

2.1 Menstrual hygiene management

A vast body of qualitative literature points toward the negative consequences in adolescent girls' lives of lacking suitable menstrual management practices (e.g. (Adinma and Adinma, 2009; El-Gilany et al., 2005; McMahon et al., 2011; Sommer, 2010)), synthesized in a recent meta-analysis (Hennegan et al., 2019). Reaching menarche constitutes a particularly sensitive time period, as girls may reach it without prior knowledge about puberty and menstruation (Sommer, 2010). In South Asia specifically, the timing of menarche correlates with school dropouts and early marriage (Field and Ambrus, 2008; Khanna, 2019).

In Kenya, results from focus group studies show that menstruation causes social stress among adolescent girls (Mason et al., 2013; McMahon et al., 2011), and it is linked to school absenteeism, reduced concentration while in school, and lowered self-esteem (Mason et al., 2015). Schoolgirls also report fear of leaking menstrual blood and of sexual harassment from male peers and teachers (McMahon et al., 2011). A recent quantitative study from Tanzania confirms these findings (Benshaul-Tolonen et al., 2020a).

The interaction of poverty with menstrual hygiene management (MHM), due to the expense of sanitary products, poses further problems. In some cases, the lack of affordability comes at a very high price: in Kenya, girls have reported to engage in transactional sex to earn money to pay for sanitary pads, or they receive sanitary pads as gifts from sexual partners (Mason et al., 2013; Phillips-Howard et al., 2015). Moreover, girls may feel embarrassed to disclose their preferred absorbent or suffer from self-reporting bias. In focus group surveys collected at baseline for this study, girls revealed that other female classmates use cloth and similar materials, but that they themselves use sanitary pads (Mason et al., 2013).

Links to absenteeism

High shares of girls in low and middle income countries report ever missing school during their periods: 41% in a study in Bangladesh (Alam et al., 2017), more than 50% in a study in Ethiopia (Tegegne and Sisay, 2014); 33% in a study in Tanzania (Benshaul-Tolonen et al., 2020a), and in India the numbers range from 6-11% (Sivakami et al., 2019) to 24% (van Eijk et al., 2016), depending on the study population and region (see (Benshaul-Tolonen et al., 2020b) for an overview). Recall bias and self-report bias may, however, obscure the true levels of absenteeism. Two studies illustrate the measurement issue. A study in Malawi found that menstruation-related absenteeism was only 4% of the total days of school missed when using face-to-face surveying. However, the same girls reported much higher levels of absenteeism when reporting in private to a computer (Grant et al., 2013). A baseline qualitative focus group study conducted in tandem with this RCT found that schoolgirls were willing to report that *other* students missed school during

their periods, but no student reported missing school during their period (Mason et al., 2013).

A few program evaluations have shed light on the role of sanitary products in determining levels of absenteeism. A pilot randomized control trial (n=199) conducted in Nepal provided a menstrual cup to girls in the treatment group (Oster and Thornton, 2011). While girls adopted the technology, partly due to network effects (Oster and Thornton, 2012), it had no effect on school absenteeism. Reported menstruation related absenteeism was, however, less than one day per school year, leaving a very small margin for improvement. The girls also reported that menstrual cramps were a more serious constraint to school attendance than lack of sanitary products (Oster and Thornton, 2011).

In addition, two studies used a non-randomized research design to answer the same question. In Ghana, a program provided sanitary pads and/or puberty education across four villages (each village had one treatment). The program surveyed 120 schoolgirls between the ages of 12-18. While the sanitary pad villages saw initial increases in school attendance, after five months of treatment the puberty education village caught up as well (Montgomery et al., 2012). In a scaled-up version of the program, implemented in Uganda, the four treatment arms were rolled out across 8 villages (two villages per treatment arm). In this instance, while school absenteeism increased over time across all villages, the effect was partially mitigated in the sanitary pad intervention villages (Montgomery et al., 2016).

Links to psychosocial functioning

It has been long hypothesized that poor sanitation and menstrual hygiene practices link to psychosocial well-being, through causing girls anxiety, fear, reduced concentration. These links largely stem from qualitative studies (Hennegan et al., 2019), and there has been limited rigorous quantitative evidence on the effect of MHM on psychosocial well-being (Hennegan and Montgomery, 2016). One cross sectional study explored schoolgirls in Uganda found a link between poor MHM and shame (Hennegan et al., 2016). In Tanzania, menstruation was positively associated with cramps and pain, as well as fear and stigma, with self-reported

effects on girls' absenteeism Stoilova et al. (2022). In India, it was found that poor sanitation is associated with higher levels of anxiety and lower well-being among women (Caruso et al., 2018). A non-randomized cluster trial in Ghana that provided sanitary pads and education measured self-reported pre-post levels of shame, lack of self-confidence, insecurity and lack of concentration in the classroom in the treatment groups only (Montgomery et al., 2012; Dolan et al., 2014). Improvements were seen in the treatment groups receiving sanitary pads (in contrast to the treatment group only receiving puberty education), although the existence of a secular trend in psychosocial well-being cannot be excluded (Dolan et al., 2014).

3 Methods

3.1 Program evaluation

We conducted a cluster randomized controlled feasibility study in Siaya County, Western Kenya to explore the effects of a menstrual hygiene intervention on absenteeism rates and psychosocial functioning. The field researcher team collected data between October, 2012 and November, 2013. An initial 751 students were enrolled and received treatment. In total, the study followed, 644 students, who did not drop out or migrate, until the end of the study over an average period of 10 months[4]. Due to capacity constraints the study had rolling enrollment, therefore, the program enrollment date varies across individuals and within schools.

The three treatment arms were (i) an insertable menstrual cup, (ii) 16 sanitary pads monthly, or (iii) control (usual practice). For ethical reasons, all participant received private soap, puberty education, and access a study nurse at the school. It is possible that the treatment resulted in differential utilization rates of the study nurse, if it changed demand for nurse access due to the treatment itself beyond what was specified in the treatment plan (which included regular visits to the nurse). We would not be able to disentangle such a nurse-demand effect from the treatment effect. Because of the three-arm randomized controlled study design,

[4]Further information regarding the enrollment of students into the program can be found in (Phillips-Howard et al., 2016).

we can compare the efficacy of sanitary pads and menstrual cups in improving outcomes, while taking cost and sustainability into account.

We collected several types of data, including quantitative surveys at baseline and throughout the study period, epidemiological testing, and researcher collected roll-call spot-check data for absenteeism on random, unannounced days for all students, as well as school-wide registers of attendance. The trial enrollment began on 15 August 2012 (enrollment) and finished on 27 August 2013. Endline finished on 21 November 2013. The study group also performed focus group research at baseline (Mason et al., 2013) and endline (Mason et al., 2015). Epidemiological outcomes were analyzed in Phillips-Howard et al. (2016). The menstrual cup and sanitary pad treatment arms led to lower prevalence of STIs and bacterial vaginosis risk after more than 9 months of treatment, and there was no differential attrition rate from the study (and from schools) across treatment arms. A subanalysis on the smaller sample that was followed for 12 months or longer, revealed diverging school drop-out rates (Phillips-Howard et al., 2016), indicating that a successful menstrual health program may have a long run impact on school enrollment. In contrast to (Phillips-Howard et al., 2016), this study focuses on school absenteeism (that is likelihood to miss school on a particular day) and psychosocial well-being.

Ethical approval was obtained from the Kenyan national committee and from Liverpool School of Tropical Medicine, the U.K.. The study was retrospectively registered in December 2014 (with registry number ISRCTN17486946) before beginning data analysis[5]. Head teachers provided verbal consent for the data collection and review. In addition, girls, who were not yet of legal age of consent, provided written assent before participating in the study, and a parent provided written informed consent in line with the IRB approval. The school administrations agreed to the researchers collecting roll-call data, but they were not informed about the dates during which the data would be collected.

[5]Registration of the pilot cluster randomized controlled study took place after participant enrollment had started, but before analysis.

3.2 School selection

The data were collected in Gem constituency, Siaya County, Western Kenya. 71 primary schools were identified in the region, and 9 schools were excluded because they did not have the targeted grades or did not consent to participate. A survey of the remaining 62 primary schools was undertaken, which indicated low levels of water available for hand-washing (60%) and soap (2%) (Alexander et al., 2014). Moreover, 84% of schools had gender-specific latrines, 77% of latrines lacked locks, and only 16% of the latrines were considered clean (Alexander et al., 2014). In total, 30 schools were identified that fulfilled the criteria specified for the study (a girls-only latrine, water for hand washing, pupil-to-latrine ratio $< 70 : 1$ (Phillips-Howard et al., 2016)) and were included in the study. Since 30 schools passed the inclusion criteria, those are the schools that were enrolled in the program. The selection of the 30 clusters was thus not determined by power calculation, but by the inclusion criteria.

The program did not intervene with the latrines during the study, but they were monitored. No improvements in latrine quality were found, although there was increased availability of soap (Alexander et al., 2018). The school selection criteria mean that the study population cannot be considered representative of youth of these ages in the region at large; in particular, girls enrolled in schools with less sanitary infrastructure may fare worse.

A community randomization ceremony was held to determine school level treatment allocation. This ceremony was attended by 30 head teachers and district education officers (DEO). Before the ceremony, three identical envelopes were sealed containing the treatment allocation. This was done by an administrator. During the ceremony, 30 head teachers (one per school) picked a colored ball each from an opaque bag. Subsequently, the DEO opened the sealed envelopes and revealed the assignment. The study was blinded to the laboratory staff and to the trial statistician, but the participants and school nurses were aware of the treatment allocation.

3.3 Eligibility and attrition

Power calculations indicated that 185 girls per treatment arm would provide statistical precision for the primary outcome of the trial, school dropout, an outcome reported in Phillips-Howard et al. (2016). To allow for attrition and statistical margin, 250 girls (25 per school) were aimed to be enrolled in each treatment arm (Phillips-Howard et al., 2016). Note that this study explores secondary outcomes, such as absenteeism and psychosocial well-being[6].

An initial 1005 girls were assessed for eligibility across the 30 treatment schools. Girls who declined participation (n=40), were not eligible because they were outside the age range (n=13), or had experienced less than 3 menses prior to surveying (n=170) were excluded (a flow diagram is available in Phillips-Howard et al. (2016). The selected age range (14-16 years) reflects the likely age at menarche, as girls in Western Kenya (Mumias and Asembo) reach menarche 1.5-2 years later than WHO reference populations, largely due to malnutrition: Average age at first period is 14.6 to 15.1 years, around the time of transition between primary school to secondary school Leenstra et al. (2005). Average age at menarche in four schools in Tanzania was similarly found to be 14.2 years with a standard deviation of 1.1 years (Stoilova et al., 2022).

With the treatment status randomly determined at the school level, 766 girls were subsequently enrolled into the study. A few girls left the school before the start of the intervention (4, 6, and 5 girls respectively per treatment arm), and the study proceeded with 751 participants. From 751, 96 girls were not followed up because they withdrew consent or migrated from the study schools, leaving 654 study participants. Since the data on psychosocial functioning was collected in schools, and not at home, these girls were no longer included. This sample size was further reduced by 11 girls who were found to be pregnant prior to the intervention, leaving 644 girls that were followed for the whole period and included in Phillips-Howard et al. (2016).

We work with two different samples, due to data availability. In the main

[6]For primary outcomes and information of the trial registration, please refer to Phillips-Howard et al. (2016)

analysis of school absences (which were collected for all students at these schools), we avoid introducing endogeneity to the sample by keeping students who withdrew, migrated, or became pregnant, as these outcomes are potentially relevant for our analysis. Therefore, we run the analysis on the full sample, yielding intent-to-treat estimates. This is possible since a student absent from school because of drop-out will be found absent during the researcher-collected spot-checks. The same approach is not possible when we estimate the effects on psychosocial well-being, since these were collected in school for students who remained in school. Importantly, drop-out rates did not vary by treatment arm indicating that attrition should not have introduced bias in our estimates.

3.4 Measuring adoption of the cup

The menstrual cup, while showing high rates of adoption according to a recent meta analysis (van Eijk et al., 2019), generally require repeated effort before successful use. In line with previous evidence (Oster and Thornton, 2012; van Eijk et al., 2019), the girls in the menstrual cup treatment group were initially slow to adopt the menstrual cup. To measure rates of adoption objectively, we introduced the validation method of visual inspections of the menstrual cup to confirm self-reported use (Phillips-Howard et al., 2016; van Eijk et al., 2018), as a menstrual cup will change color with persistent use. We monitored the use of the menstrual cup in the treatment arm (sample=207) over the study period, including problems inserting the cup, emptying it, or accidentally dropping it in the latrines, and self-reported adoption along with color-verified cup use (van Eijk et al., 2018)[7]. Girls verbally report using the cup earlier than the color-change is observed. Girls' self-reported use of the cup was 39% after one month, and 80% after 12 months (Mason et al., 2019). The self-reported measure and the color-verified measure of adoption converge around 10-12 months, and adoption is almost universal after 10 months. However, because of rolling enrollment, some girls were followed for less than 10 months, yielding an average adoption rate at just above 70% at endline

[7]The exact procedure of the color verification of the cups, whereby the study participants were asked to bring their clean menstrual cup to the study nurse, is described in more detail in van Eijk et al. (2018). The protocol received ethical clearance.

(van Eijk et al., 2018). This is comparable with evidence from a meta analysis where 73% of participants in menstrual cup studies wish to continue to use the cup after study completion (van Eijk et al., 2019). The intent-to-treat effects for the menstrual cup treatment arm show reduced incidence of sexually transmitted infections and bacterial vaginosis after 9 to 12 months (Phillips-Howard et al., 2016), in line with successful adoption rates (van Eijk et al., 2018). We did not consistently collect data on sanitary pad use, and there were no reports of girls in the sanitary pad treatment groups not using the pads, although some reported selling excess pads (see Section 4.3).

3.5 Measuring psychosocial well-being

To measure psychosocial well-being, we use the Pediatric Quality of Life Inventory (PedsQL^{TM}) 4.0 Generic Core Scales with 23 items, a licensed pediatric module to measure health-related quality of life (HRQoL). This measurement model provides a brief overview of a child or adolescent's multidimensional health-related quality of life as it contains scales for physical, emotional, social and educational functioning. We use the standard approach in calculating the scales, which is to take a weighted average of all responses, leading to a score between 0 and 100, where a higher value reflects a higher health-related quality of life. The supplementary information section contains a table that lists each individual question that was used to create the scales (see Table 1) as well as further information on PedsQL^{TM}.

The 4.0 Generic Core Scale has previously been utilized in various studies, including in prior menstruation related research and health studies in Kenya. In a quality of life study among adolescent girls in Australia, researchers concluded that menstruation related issues can have a significant impact on quality of life outcomes among teenagers (Azurah et al., 2013). The same HRQoL module revealed lower functioning among Estonian adolescent girls than boys especially on the physical health and emotional functioning domain, potentially due to the onset of menstruation (Viira and Koka, 2011). The PedsQL^{TM} score has been previously employed in health studies in our study region (Terer et al., 2013; Liu et al., 2016). Notably, (Liu et al., 2016) illustrate that the metric is responsive to changes in

Kenyan children as they find increased PedsQL scores among children following recovery from fever due to suspected malaria.

3.6 Measuring absences

The analysis of school absenteeism relies on roll-call data collected by the researchers, without the involvement of the school administration. The researchers showed up to school on previously unannounced days and took attendance in all classrooms. The timing of the spot-check was not noted and we cannot analyze patterns across the duration of a school day.

The planned data collection originally included self-reported absenteeism diaries, where a student would note daily if they had their period and if they attended school. However, the diary data was not consistently collected by the girls, and the extensive issue with missing data means no impact analysis was performed using this data[8]. Moreover, analysis of the school register data, which was collected on the same days as the spot-checks, showed large irregularities: Student absence is positively correlated with missing record (a student can be marked absent, present, or have no record) which would lead to biased coefficient estimates.

3.7 Econometric specifications

First, we analyze the effects of the program on self-reported well-being. The randomization of the treatment allows us to estimate a simple difference:

$$PsychIndex_{ism} = \beta_1 MenstrualCup_s + \beta_2 SanitaryPads_s + X_i'\gamma + \delta_m + \varepsilon_{ism} \quad (1)$$

Where the treatment coefficients are β_1 for *Menstrual Cup* and β_2 for *Sanitary Pads*, two indicator variables that take the value 1 if the student participated in

[8]However, self-reported absence data from girls' diaries showed a 6-fold greater rate of absence during menstruation (2%) compared with non-menstrual days (0.4%), but because of extensive missing data, we cannot tell if this is a true pattern (Phillips-Howard et al., 2016).

that treatment arm, and 0 otherwise. The variables have subscript s since they vary at the school-level. The specification controls for covariates (age and grade, and when specified SES), and calendar month fixed effects δ_m. Subscript i stands for the individual, at school s, surveyed in month m. Standard errors are clustered at the school level, which is the level of intervention. We follow the method outlined by Cameron et al. (2008) and bootstrap the standard errors to account for the small number of clusters. Since the indices are scaled from 0 to 100, coefficients are interpreted as point changes in the index, and the percent change is captured by the ratio of the coefficient over the mean value in the control group.

The psychosocial welfare index scores were only collected post treatment (with some exceptions), precluding us from running a difference-in-difference specification. In contrast, we have pre-intervention data on absenteeism. Therefore, we present the results for absenteeism as a simple difference as well as a double difference.

It is important to note that all students have an intervention date, even though only the treatment girls received their products on those dates. Girls in the control group only received the health information and soap on the intervention date. The first specification is the simple difference. This specification uses all observations from the spot-checks for each student after the intervention date to capture absenteeism over time. We use the following simple difference specification:

$$Absent_{ism} = \beta_1 MenstrualCup_s + \beta_2 SanitaryPads_s + X_i'\gamma + \delta_m + \varepsilon_{ism} \qquad (2)$$

Where the treatment coefficients are β_1 for *Menstrual Cup* and β_2 for *Sanitary Pads*, two indicator variables that take the value 1 if the student participated in that treatment arm, and 0 otherwise. We include a vector of controls (age and grade, and when specified SES), and δ_m is calendar month fixed effects. Subscript i stands for the individual, at school s, surveyed in month m. Using multiple observations per girl allow us to include month fixed effects. The calendar month fixed effects will take care of variation in absenteeism due to monthly changes such as holidays, changes in the academic year, and time-varying opportunity cost of

schooling. As previously, we use the wild cluster bootstrap method outlined by Cameron et al. (2008) and cluster standard errors at the school level. We estimate linear probability models.

The difference-in-difference regression specification compares absenteeism before and after treatment for the different intervention groups. A rational for this strategy is the pre-treatment differences observed in absenteeism across schools. Again, the coefficients β_1 for *Menstrual Cup* and β_2 for *Sanitary Pads* are two indicator variables take the value 1 if the student participated in that treatment arm, and 0 otherwise (determined at the school level). These variables capture level differences. We are now interested in the interaction effects between these treatment arms and the indicator variable for $After_{it}$, given by coefficients β_4 and β_5. $After_{it}$ captures the post-intervention data observations. In the difference-in-difference specification, we also include school fixed effects that soak up school-specific variations in sampling, such as the average SES-level across schools, and baseline level of absenteeism[9].

The main difference in difference specification is the following:

$$\begin{aligned} Absent_{ismt} = \beta_1 MenstrualCup_s + \beta_2 SanitaryPads_s + \beta_3 After_{it} \\ +\beta_4 MenstrualCup_s * After_{it} + \beta_5 SanitaryPads_s * After_{it} \\ +X_i'\gamma + \delta_m + \alpha_s + \varepsilon_{ismt} \end{aligned} \tag{3}$$

Where X_i is a vector of controls (age and grade, and when specified SES), and δ_m is calendar month fixed effects, and α_s is school fixed effects. Subscript i stands for the individual, at school s, surveyed in calendar month m, at time t.

[9]We exclude the school FE in a robustness test. As expected, it changes the coefficients β_1 and β_2, but not the coefficients β_4 and β_5 multiplying the variables of interest. Thus, the interpretation of the program effect is independent on the choice of including school FE.

3.8 Observable characteristics of the sample

Table 1 shows the main observable characteristics across the three different groups. Column 1 shows the mean value in the control group at baseline. Column 3 shows the coefficient the menstrual cup group, and column 4 for the sanitary pad group. Significance levels are represented by stars, using wild cluster bootstrapped standard errors following Cameron et al. (2008) to account for the limited number of clusters. Overall, there is balance across the three groups. The sanitary pad has higher levels of self-reported heavy periods and SES level, both marginally statistically significant at the 10% significance level. Stratifying on age and grade—which we will control for in all regressions—results in balance across groups for heavy periods, however, SES remains marginally statistically significant. For this reason, we will present results with control for SES in the robustness specifications. Further testing found no statistically significant differences between the menstrual cup and the sanitary pad treatment group at baseline.

Table 1: Baseline observable characteristics and balance across treatment groups

	(1)	(2)	(3)	(4)
Variable	**Mean (control)**	**Std. Dev.**	**Menstrual cup**	**Sanitary pad**
Age (year)	14.129	1.047	-0.163	-0.073
Grade	6.576	0.66	-0.056	-0.021
Has heavy periods	0.194	0.397	0.009	0.061*
Experiences cramps	0.635	0.483	-0.054	0.002
Length of period (days)	3.465	1.32	-0.113	-0.199
SES level	3.50	1.333	0.287	0.336*
Absent (pre-treatment)	0.005	0.009	0.03	0.064

Notes: *** p<0.01, ** p<0.05, * p<0.1 represent significance levels for statistical testing performed using wild cluster bootstrapped standard errors. Absent is calculated as the average rate of absenteeism from all pre-treatment spotchecks. There are no statistically significant differences between the menstrual cup group and the sanitary pad group.

3.9 Parallel trends

The spot-check were collected at multiple times during the study period. As a result, we are able to explore the trends in absenteeism over the treatment period. Enrollment in the program was rolling leading to the start date of the

intervention to differ across students. Fig 1 shows pre and post intervention levels in absenteeism, with the x-axis being a continuous measure of time in days, with day zero being the day of the treatment. A few results stand out: (i) absenteeism levels increasing with time in all treatment groups[10], (ii) there are pre-intervention differences in absenteeism, potentially due to school level differences in levels, (iii) the sanitary pad group has higher pre-intervention absenteeism, but is on a more flat trend after treatment.

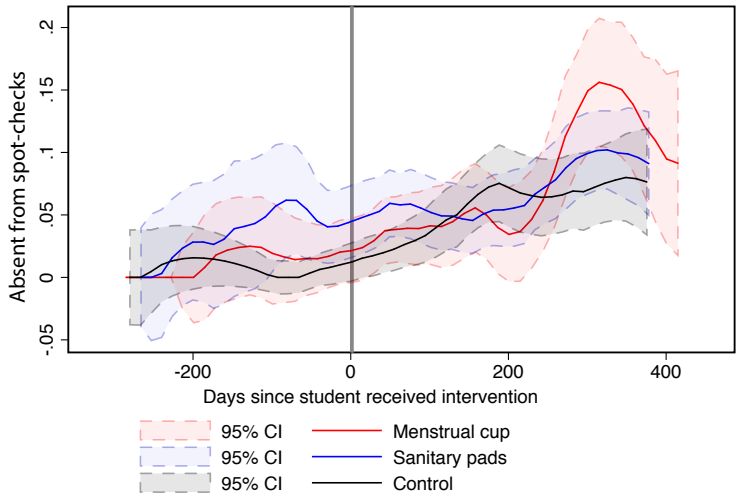

Figure 1: **Local polynomial smooth for timing of effects.** Notes: The figure plots local polynomial smooth with 95% confidence intervals. Day 0 represents the day the student received the intervention, with a calendar date that varies across individuals.

4 Results and Mechanisms

In this section, we will discuss the impact that the program had on psychosocial well-being and school absenteeism. We will also explore heterogeneity by severity of menstrual period symptoms reported at baseline as well as the timing of the effects.

[10]Which is natural, if absence behavior makes students lag behind in schoolwork and lead to further demotivation. Absences can lead to mid-term drop-out, which within our study is coded as absence.

Table 2: Main Results Psychosocial Functioning

Outcome index:	Physical functioning (0-100)	Emotional functioning (0-100)	Social functioning (0-100)	Educational functioning (0-100)
	(1)	(2)	(3)	(4)
Panel A: main specification				
Menstrual cup	2.276	2.848	2.072	3.601
	(1.677)	(2.087)	(2.377)	(2.176)
Sanitary pads	4.074**	1.410	1.349	2.039
	(1.833)	(2.258)	(1.780)	(1.663)
Observations	1,484	1,484	1,484	1,484
R-squared	0.081	0.059	0.075	0.070
Controls (age, grade)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Panel B: with SES controls				
Menstrual cup	2.835	2.679	3.545	3.664
	(1.700)	(1.989)	(2.157)	(2.259)
Sanitary pads	3.955*	0.597	1.372	1.449
	(1.998)	(2.371)	(2.143)	(2.033)
Observations	1,246	1,246	1,246	1,246
R-squared	0.092	0.071	0.092	0.084
Controls (age, grade, SES)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Panel C: with grade FE				
Menstrual cup	2.279	2.859	2.123	3.648*
	(1.620)	(2.082)	(2.290)	(2.126)
Sanitary pads	4.081**	1.416	1.343	2.027
	(1.821)	(2.262)	(1.746)	(1.658)
Observations	1,484	1,484	1,484	1,484
R-squared	0.082	0.060	0.077	0.071
Controls (age)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Grade FE	Yes	Yes	Yes	Yes
Panel D: < 9m				
Menstrual cup	3.667*	3.182	3.004	4.789**
	(2.131)	(2.241)	(2.739)	(2.279)
Sanitary pads	6.201***	2.527	2.753	3.385*
	(2.235)	(2.338)	(2.209)	(1.768)
Controls (age, grade)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Mean (control)	69.74	71.454	75.528	71.79

Notes: The outcome variable is the four psychosocial functioning indices ranging from 0-100, where 100 signifies full functioning. Panel B adds SES controls. Panel C adds grade FE. Panel D limits the sample to 9 months after the intervention. Wild bootstrapped clustered standard errors at the school level. *** p<0.01, ** p<0.05, * p<0.1.

4.1 Effects on psychosocial well-being

Previous qualitative evidence points to the lack of sufficient menstrual health management a source of worry in adolescent girls' lives, with impacts on wide range of well-being metrics. To capture the effect of the intervention on these important aspects of adolescent girls' lives, we collected data using the PedsQL™ module, throughout the treatment period. While the answers are self-reported by the girls, the module has been been extensively tested and validated in pediatric populations.

The menstrual cup and sanitary pad interventions increased girls' physical well-being by 3.2% (from the baseline mean value, statistically insignificant) and 5.8% (4.1 percentage points, statistically significant at the 10% significance level) respectively (Table 2, Panel A)[11]. The results are robust to the inclusion of SES controls (Panel B), the inclusion of grade fixed effects (Panel C), which also yields a marginally statistically significant effect of the menstrual cup on educational functioning.

4.1.1 Timing of the effects

The average student was enrolled in the program for 9 months, and our initial regressions included observations of psychosocial well-being at the end of the program. Panels D shows the results for the first 9 months after treatment, only. The results are stronger[12], and we detect statistically significant improvements on physical well-being and educational well-being in both treatment arms.

To further disentangle if the treatment effects are delayed and/or sustained, we use treatment month fixed effects instead of estimating the average effect. We hypothesize that treatment effects may be delayed treatment effects due to lack of

[11]The PedsQL™ functioning scales range from 0-100, with 100 being full functioning. We interpret the regression results in percentage changes from the mean. We, however, caveat that the data are based on underlying cardinal data rather than true ordinal measures.

[12]Appendix Table 2 shows how the result vary when we limit the sample to first 6, 7, 8, 9, 10 and 11 months of the program. Overall the results are comparable to those presented in Table 2, although they are somewhat stronger on average. In fact, we have several significant coefficients for physical and educational well-being for both treatment arms.

familiarity with the product and how to utilize it. Program effects may also taper off due to the end of the program and for mean reversion effects.

Fig 2 plots the regression coefficients by months of treatment. In the sanitary pad group, we discern three statistically significant effects already in the first two months, whereas in the menstrual cup group, the positive treatment effects are noted only from months 5-6. We hypothesize that these patterns stem from the delayed adoption of the menstrual cup, compared to the immediate adoption of sanitary pads.

Overall, the temporal decomposition indicates the existence of positive effects on all four psychosocial functioning indices in both treatment arms, although not all effects are measured with statistical significance.

The effects in the sanitary pad treatment arm taper off toward the last months. This is equivalent to the end of treatment period, from which point on they will no longer receive subsidized sanitary pads. In the menstrual cup group—a menstrual cup lasts up to 10 years—we see little such tapering off of effects, although the margins of error become larger as the sample sizes become smaller. These effects, tentatively, highlight important sustainability effects of the different sanitary products. As a robustness check, we exclude observations collected after the end of the program. Nevertheless, we still observe a tapering off of the treatment effects, especially for the sanitary pad group (see Appendix Figures 3 and 4). Interestingly, a review of focus group transcripts, indicate that some girls sold excess pads during the study period, which may have positively impacted their emotional and social functioning. At the end of the study, those girls will the access to sanitary pads for private use, as well as the income stream that excess may have generated. A longer discussion about the perceived financial benefits of the study can be found in Section 4.3.

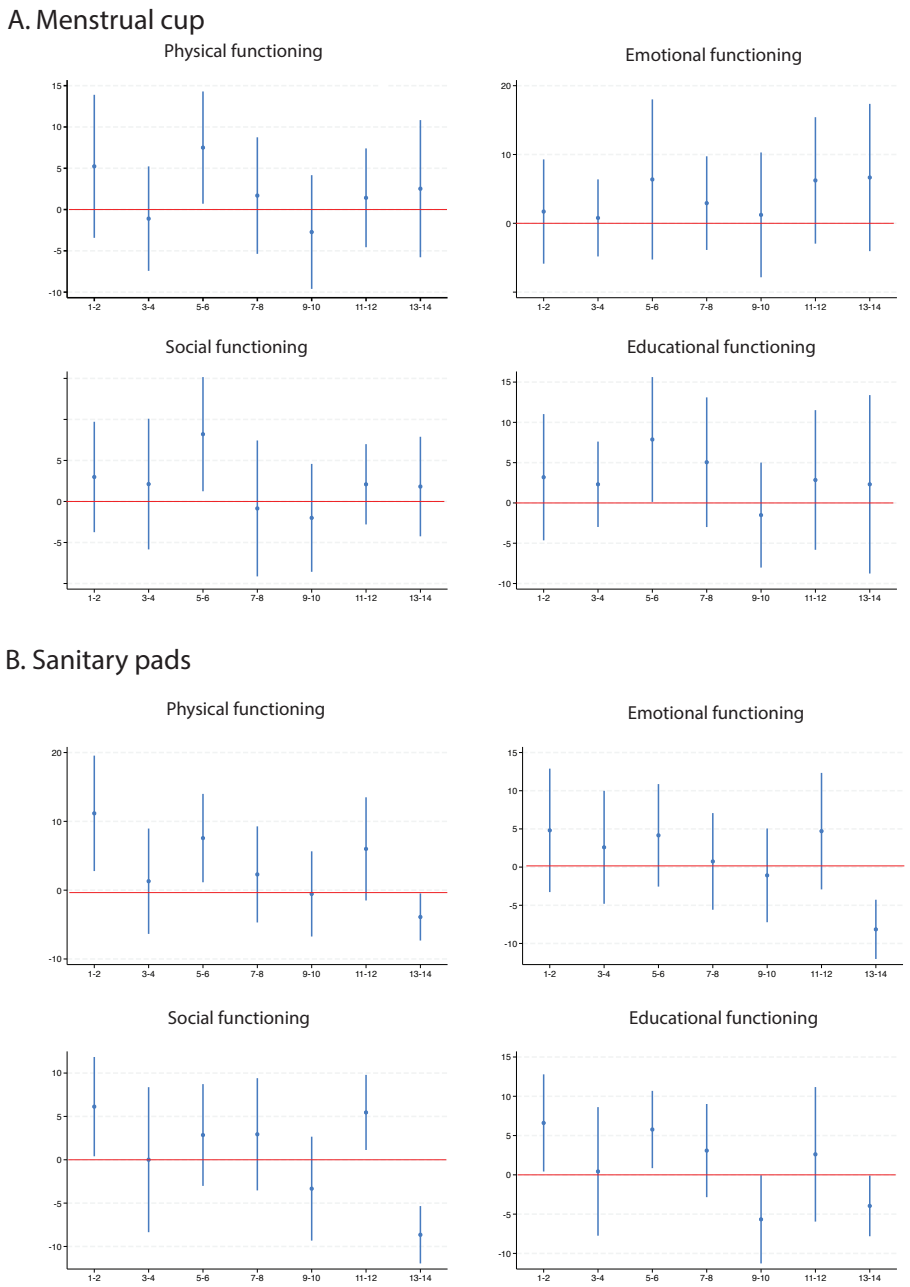

Figure 2: **Coefficient plot for menstrual cup and sanitary pad treatment on psychosocial functioning indices.** Notes: The figure plots the coefficients for the interaction term *months since intervention*menstrual cup* (Panel A), and *months since intervention*sanitary pads* in Panel B. Comparison is with the control group. Each student is surveyed multiple times. Controls included for age and grade, and month FE. Clustered standard errors. Includes individuals surveyed after the end of the intervention (end point varies, and is not indicated). Sample sizes are smaller in the last months.

Table 3: Sensitivity Analysis and Heterogeneity Analysis Physical Characteristics of Menstruation and Psychosocial Functioning

	(1) Physical functioning (0-100)	(2) Emotional functioning (0-100)	(3) Social functioning (0-100)	(4) Educational functioning (0-100)
Panel A: Heavy				
Menstrual cup	3.072	7.004*	5.448	6.249
	(2.243)	(3.922)	(3.548)	(3.801)
Sanitary pads	1.215	-0.291	0.587	1.053
	(3.296)	(3.413)	(4.034)	(2.897)
Observations	346	346	346	346
R-squared	0.070	0.086	0.074	0.075
Panel B: Heavy, <9m				
Menstrual cup	5.483	7.964*	6.552	7.985
	(3.355)	(4.617)	(4.190)	(4.794)
Sanitary pads	4.865	1.144	3.001	2.822
	(3.880)	(4.096)	(4.206)	(3.951)
Observations	281	281	281	281
R-squared	0.090	0.109	0.077	0.100
Panel C: Light/Medium				
Menstrual cup	1.913	1.335	0.978	2.508
	(2.109)	(2.211)	(2.789)	(2.224)
Sanitary pads	5.076**	2.042	1.702	2.293
	(1.863)	(2.471)	(1.836)	(1.951)
Observations	1,138	1,138	1,138	1,138
R-squared	0.096	0.063	0.087	0.083
Panel D: Light/Medium, <9m				
Menstrual cup	3.117	1.516	1.908	3.609
	(2.438)	(2.348)	(3.129)	(2.311)
Sanitary pads	6.927***	3.165	2.932	3.680*
	(2.184)	(2.321)	(2.211)	(1.868)
Observations	938	938	938	938
R-squared	0.102	0.076	0.087	0.097
Mean (control, heavy)	68.775	69.52	73.62	69.52
Mean (control, light/medium)	70.0	71.98	76.04	72.42
Controls (age, grade)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes

Notes: Regression results using self-reported psychosocial functioning as outcomes. The psychosocial functioning indices range from 0-100. All observations are collected after the beginning of treatment. Panel B and D show results for treatment months 0-9. Multiple observations per individual may be included. All regressions control for month fixed effects, and controls for grade and age. Wild cluster bootstrapped standard errors at the school level. *** p<0.01, ** p<0.05, * p<0.1.

4.1.2 Heterogeneity by severity of physical symptoms

We explore additional heterogeneity for girls who report having heavy periods. Among girls reporting heavy periods, the menstrual cup arm shows suggestive improvements in emotional functioning (Table 3, Panel A: 10.1%), consistent with qualitative evidence, but this heterogeneity was not pre-specified. This corroborates findings from earlier studies in South Africa and Uganda where young women noted that the menstrual cup reduces the need for changing on days with heavy bleeding days, resulting in less worrying (Hyttel et al., 2017; Beksinska et al., 2015).

Girls with light or medium periods report large improvements (7.3%) in physical well-being from the sanitary pad treatment (Panel C). Limiting the sample to the first 9 months, treatment effects are larger (Panel D), and the effect on educational functioning is also statistically significant. It is worth noting that while only a handful of the coefficients are statistically significant, all but one point toward improvements in psychosocial well-being[13]. The program power analysis was not calculated to allow for the heterogeneity tested in this table, nor was it pre-specified.

4.2 Effects on school absenteeism

The main results on absenteeism rely on researcher collected roll-call data. This data was collected on multiple previously unannounced days, to get an accurate estimate of student presence. Each student was observed multiple times before and after the intervention date (on average 4.1 times). Table 4 shows the main impacts of the program on absenteeism, including simple difference (columns 1 and 2), difference-in-difference (DiD)(columns 3-5), and a DiD strategy limiting to the first 9 months of treatment (columns 6-7).

[13]To better understand if a particular aspects of functioning drives the results, we include coefficient plots for all the components of the PedsQL^{TM} scores separately in the Appendix. We find that the vast majority of coefficients are positive and a handful are statistically significant (Appendix Figure 5). This confirms that the positive impacts observed earlier on the indices are not driven by particular questions or outliers. We encourage against interpretation of the individual components, in line with the PedsQL^{TM} manual, and labels are not provided.

In addition, we decompose the results by treatment months in Figure 3. Overall, the evidence does not point to clear, robust treatment effects on absenteeism. Point estimates are most negative around months 4–7; however, inference is limited by multiple comparisons (Figure 3). A previous study found that the adoption of the menstrual cup increased over time Phillips-Howard et al. (2016), which may correspond to the treatment effects visible around 6 months, although it would not explain the lack of treatment effect in the following months.

Table 4: Main Results on Absenteeism

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	SD	SD	DiD	DiD	DiD	DiD <9m	DiD <9m
After * Menstrual cup			0.016	0.017	0.018	-0.001	-0.001
			(0.022)	(0.023)	(0.021)	(0.014)	(0.014)
After * Sanitary pads			-0.021	-0.021	-0.016	-0.018	-0.017
			(0.030)	(0.030)	(0.031)	(0.027)	(0.027)
Menstrual cup	0.023*	0.022*	-0.142***	-0.145***	0.004	0.005	0.005
	(0.012)	(0.013)	(0.020)	(0.023)	(0.015)	(0.012)	(0.013)
Sanitary pads	0.016	0.016	-0.093***	-0.090***	0.031	0.031	0.031
	(0.020)	(0.020)	(0.024)	(0.025)	(0.020)	(0.019)	(0.019)
After			0.036***	0.034***	0.034***	0.034***	0.033***
			(0.012)	(0.012)	(0.011)	(0.011)	(0.011)
Observations	2,477	2,477	3,012	3,012	3,012	2,256	2,256
R-squared	0.016	0.016	0.042	0.043	0.020	0.019	0.019
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	No	No	Yes	Yes	No	Yes	Yes
SES level control	No	Yes	No	Yes	No	Yes	Yes

Notes: Regressions control for month FE, age and grade. Some specifications control for SES level and school FE. The outcome variable is the dichotomous variable "absent". Columns 1-2 use the simple difference specification. Columns 3-5 use the difference-in-difference specification. Columns 6-7 use the difference-in-difference specification and limit the sample to first 9 months of treatment, in line with previous limitations. Wild cluster bootstrapped standard errors at the school level. *** p<0.01, ** p<0.05, * p<0.1.

4.2.1 Heterogeneity by severity of physical symptoms

Evidence from Tanzania has shown that adolescents with more severe menstrual period symptoms, such as pain, cramps and heavy bleeding, are at higher risk of

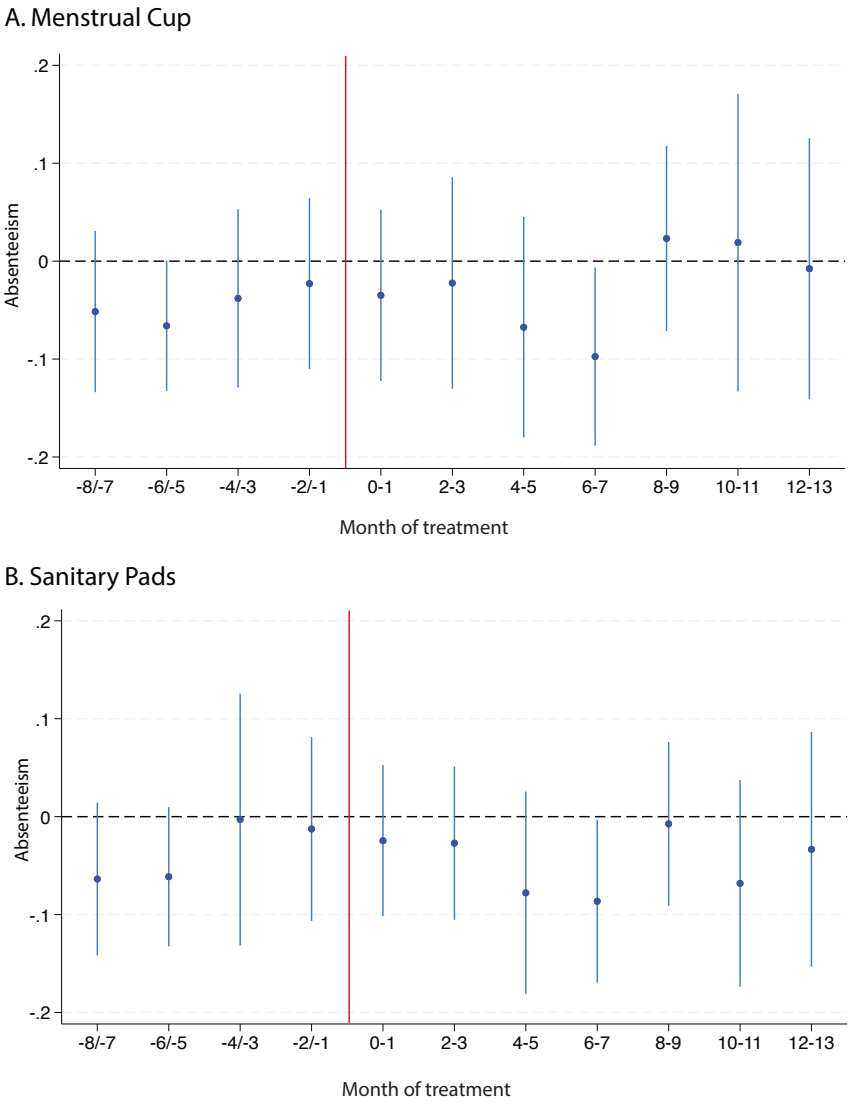

Figure 3: **Coefficient plot for menstrual cup and sanitary pad treatment on absenteeism.** Notes: The figure plots the coefficients for the interaction term *months since intervention*menstrual cup* (Panel A), and *months since intervention*sanitary pads* in Panel B. Comparison is with the control group. Each student is surveyed multiple times. Controls included for age and grade, and month FE. Clustered standard errors. Includes individuals surveyed after the end of the intervention (end point varies, and is not indicated). Sample sizes are smaller in the last months.

adverse impact on education (Stoilova et al., 2022). For this reason, we explore if the program had heterogeneous effects by self-reported characteristics of the menstrual periods. We use baseline information for 543 students regarding the duration and flow of their menstrual periods. In the sample, the average length of a menstrual cycle is 3.8 days (ranging from 1 to 8 days), 21.5% of girls report experiencing heavy bleeding (in contrast to light or medium), and 61% report cramps. A triple-difference specifications with principal component analysis using cramps, heavy bleeding, length of period interacted with the treatment variables, shows no additional treatment effects (Appendix table 3). However, when the sample is limited to 9 months after treatment, girls with higher PCA score in the sanitary pad group see a marginally statistically significant reduction in absenteeism.

4.3 Qualitative findings from focus groups

The study trial included qualitative analysis using focus group discussions held both before and after the intervention. Focus group discussions were carried out with girls, and separately, with their parents. Previous analyses of the focus groups have been published in Mason et al (2015), and this section builds on that work and reprints selected quotes. In addition, a partial review of the transcripts made by the lead author, resulted in a set of quotes that provide relevant comparisons to the main findings in the quantitative analysis. Such selective quotes are included below for illustration, but should be interpreted with caution since a full reanalysis of the transcripts was not performed[14].

Girls and parents in the treatment groups often reported perceived reductions in absenteeism. In addition, the girls reported that their physical well-being improved. Particularly, the menstrual cup appears to have improved the girls' ability to participate in physical education:

"So imagine you were running very fast and then the rag drops, but if you have [menstrual cup], you can run without even putting on the underwear." (from transcripts, reviewed May 2023).

[14]The brand name of the menstrual cup has been replaced with [menstrual cup] in all quotes.

One theme that emerged from the analysis was that the increase in physical well-being have spillovers for emotional well-being. One parent noted: "She is happy all the time and even when performing her chores, I do not see her fearful like I used to notice before when the month was coming to an end" (from Mason et al, 2015), and one girl in the sanitary pad group noted: "It [receiving sanitary pads] has helped us and being in a mixed school, you can just stand up bravely to answer a question in class because you know it won't leak on your cloth."

Another parent noted: "It [menstrual cup] can improve their performance because they will now concentrate more on their studies, not on how she will manage her periods because sometimes the teacher is busy teaching and she is just thinking about periods." (from Mason et al, 2015).

Preference of cup over pads

Another theme that emerged was the reported preference of the cup over sanitary pads in the cup treatment group. The girls reported a variety of reasons, including (i) less pressure to share it, in contrast to girls in the sanitary pads group felt pressure to share pads with family members and friends, (ii) that it resulted in less odor or itching, which could happen when a pad is worn longer, (iii) it's superiority during sports, and (iv) less leaking.

"It has helped me because before if I use [brand] sometimes I could find blood stain on my clothes and you know that is embarrassment, but since the [menstrual cup] was brought, if i insert it i just feel free and do not even have it in my mind that blood can leak." (from Mason et al, 2015).

A few more hesitant or negative narratives also emerged such as shock at first seeing the size of the cup, initial difficulty in properly inserting the cup, and claims that not all girls who say that use the cup indeed use it. These narratives are in line with the slow adoption rate observed in the cup treatment group. A limitation, noted in Mason (2015), is that only girls in the cup group had experience with both type of products.

Financial resources

The lack of financial resources to buy pads (the preferred product prior to the intervention) came up in several focus groups, hindering girls from attending school and pushing some girls to take boyfriends who can pay for pads.

"They miss school because sometimes they have started their periods but she has not bought pads. She knows that she has heavy flow and if she puts on rags, it will leak and so she is forced to stay at home until that day she will get money to buy pads, of which she is not even sure if she will get that money. And so her time in school is also wasted." (from transcripts, reviewed May 2023).

Girls mentioned that parents may not agree to buy pads when asked. Some girls ask boyfriends to buy pads, who in return may ask for sexual intercourse.

"He gives you money to buy pads and you have sex with him in return." (from transcripts, reviewed May 2023).

Receiving the menstrual cup appears to have relieved some of the economic pressure girls felt:

"[. . .] When we were not having the [menstrual cup], my mum was spending a lot of money buying pads, but since the [menstrual cup] came, my mum is spending the money wisely. Sometimes if the fees is needed or even exam fees she can give me. Sometimes she can also give me money to buy food at break time. So that is why I like [menstrual cup]". (from transcripts, reviewed May 2023)

"I can say that [menstrual cup] is good because you can use it for years and years, but with pads, once you have used it, that is it, you cannot use it again. But [menstrual cup] can be washed then reused in the following months, and that is why I feel that [menstrual cup] has helped us and we are thankful." (from transcripts, reviewed May 2023).

The sanitary treatment arm was also associated with positive financial outcome according to some of the girls, through saving on expenses, but also giving the opportunity to sell pads:

"I can sell because, if your friends comes to you to help her with pads, and

sometimes after giving her you will remain with nothing, maybe she had some little money which is not enough to buy pads. So she gives you the little money she has and then you give her pads." (from transcripts, reviewed June 2023)[15]. It should be noted that not all girls reported selling excess pads. Notably, these financial benefits from the sanitary pad group would disappear with the end of the study, in start contrast to the reusable, for up to 10 years, menstrual cup. This financial worry may partly explain why the initial positive effects of the sanitary pad group reverse (and potentially even turn negative), toward the end of the study period.

Synthesis of qualitative findings

Some girls participating in the focus groups perceived that their participation in the program had real implications on their well-being. It is important to note that while the quantitative causal inference in this paper does not find a treatment effect of the menstrual cup on absenteeism, both girls and parents noted that absenteeism behavior, alongside concentration and engagement in the classroom, improved with the menstrual cup group as well as in the sanitary pad group. We find it reassuring that the quantitative results on the physical well-being index, which are the strongest effects out of the PEDsQL^{TM} indicators, are corroborated through the narratives expressed by both girls and parents, and that these improvements are thought to have further implications for emotional and educational well-being, according to the girls themselves.

It is our recommendations that further studies ought to explore combinations of cash transfers and reusable sanitary products to mitigate the pressure on adolescent girls to enter into transactional sexual relationships, and that trials that explore the role of sanitation and menstrual health management assess holistically the impacts that access may have on adolescent girls' quality of life.

[15]We do not know to whom pads were sold. If sold to girls in nearby control schools, it could lead to an underestimation of the effects. Since the girls enrolled in the study only represented a fraction of girls in the enrolled schools, it seems likely that some products would be sold within the same school. Since this is a cluster randomized trial, that would have no impact on the estimation of the treatment effect.

5 Discussion

5.1 Limitations

We note some limitations to the randomized feasibility study. First, the three-arm cluster randomized study was rolled out across 30 intervention schools with 10 schools per treatment arm. 30 clusters may not yield enough statistical power to detect treatment effects, therefore the absence of estimated effects should not be considered conclusive. Better powered studies, both in terms of clusters and sample sizes, are necessary. The results presented in the manuscript may be understood as tentative.

Second, the randomization did not yield perfect balance in baseline characteristics across the treatment groups. We control for socioeconomic status in robustness specifications. This potential lack of balance may be due to the small number of schools included (30).

Third, the 30 schools are positively selected. The inclusion criteria—the existence of a girls-only latrine, water for hand washing, pupil-to-latrine ratio—reduced the number of available schools to sample from 62 to 30. However, the inclusion criteria were necessary to ensure that students' health were not jeopardized due to the study.

Fourth, the menstrual cup adoption rate increased slowly over time. Students were found to successfully use the cups after 9 to 12 months (Phillips-Howard et al., 2016; van Eijk et al., 2018), in line with results from Nepal (Oster and Thornton, 2012) and a meta-analysis (van Eijk et al., 2019). However, the average student was followed for only 9 months post-intervention. It is possible that the effects on school absenteeism lag behind adoption as students learn how to use the new technology effectively and update their expectations of the product's safety (Mason et al., 2019; van Eijk et al., 2019). One can conceive that a student may begin to use the menstrual cup at home, experiencing the improvements in psychosocial well-being, including physical mobility, before trusting that it will give full protection for the length of a school day. In addition, as period-related absenteeism is a fairly rare occurrence, the quality of data in terms of scope, accuracy and length must

be high to identify reductions in absenteeism stemming from the adoption of the menstrual cup.

Fifth, Sample sizes differ between the absenteeism data and the PedsQL^{TM} data due to data collection methods. The absenteeism data includes students who dropped out of school, while the PedsQL^{TM} data only follows girls that remained in the study. The absenteeism data was collected for all students enrolled in the 30 schools, not only the study sample.

5.2 Cost-effectiveness analysis

It has been considered that menstrual cups may provide an effective, economically and environmentally sustainable alternative to single-use sanitary pads. A recent meta analysis and review of global evidence by van Eijk et al. (2019) found that the menstrual cup is a safe menstrual hygiene option, among a diverse set of populations. Moreover, the study concluded that adoption of the cup increases over the course of several months, and estimated that 73% of participants wish to continue to use the menstrual cup after the study. In this study, adoption of the menstrual cup increases over time and reached similar levels of adoption.

The cost of a menstrual cup is vastly different from disposable sanitary pads. A menstrual cup costs about 8 USD and lasts for 10 years, with an annualized cost of 0.8 USD. This is in stark contrast with the average cost of regular brand sanitary pads at 24 USD annually.

The comparison of two different menstrual health technologies spurs discussions about the trade off between an easy-to-adopt disposable technology and a more complex, but environmentally and economically sustainable technology. Therefore, the menstrual cup may provide a promising public health intervention in low and middle income countries, with an annualized cost of only 0.8 USD per person, little need for recurring intervention beyond the initial training and provision, and less creation of biomedical waste than disposable sanitary pads. This finding is backed up by cost-effectiveness and cost-benefit analysis for the program that included health impacts (Babagoli et al., 2022), and a meta study indicating the suitability of the menstrual cup in low and middle-income countries (van Eijk

et al., 2019). A longer trial with larger sample sizes and more clusters could shed more light on the true cost-effectiveness of the sanitary products.

5.3 Conclusions

It has been argued that lack of access to menstrual products limits girls' school attendance, and reduces their psychosocial well-being. We test this hypothesis by evaluating a three-arm cluster randomized controlled feasibility study. We do not measure statistically stable reductions in absenteeism, in line with a previous study (Oster and Thornton, 2011). The failure to detect an effect could stem from (1) low levels of menstruation-related absenteeism, (2) limited statistical power because of the program design, (3) menstruation-related absenteeism being limited to the end of the school day which we were less able to capture, or (4) the slow adoption of the menstrual cup. It is not possible for us to determine if one of these, or the true lack of treatment effect leads us to not reject the null hypothesis. However, the girls and their parents reported changes in absenteeism and school participation due to the menstrual cup in focus groups.

Importantly, we show that access to menstrual products reach beyond absenteeism behavior. The menstrual cup and the sanitary pads may have increased girls' physical and educational well-being. We also note heterogeneity, where girls with heavy periods who received the menstrual cup reported improvements in emotional well-being, whereas those with light periods who received the sanitary pads improved in physical well-being. While not all of the coefficients that multiply the psychosocial indices are statistically significant, the results point to directional effects in aggregate, for heterogeneous sub-groups, and over time. These findings are also corroborated by quotes from focus groups.

Indicating the importance of considering program sustainability, the effects of the program are the strongest a few months into treatment. In contrast, the well-being taper off in the sanitary pad treatment arm toward the end of the study period. We interpret this as a potential reduction in girls' well-being at the end of the program due to loss of program benefits. We do not find the same effect in the menstrual cup group, which is expected as the menstrual cup lasts for up

to 10 years, and has been shown to remain a desirable sanitary technology after study completion (van Eijk et al., 2019).

Further research on the impacts of menstruation on education using a larger sample size is necessary to provide reliable estimates with plausible external validity across cultures and different populations. It will be necessary to conduct further studies to understand the potential that menstruation-related policies have for human capital development in low and middle income countries, not just in terms of school attendance, but overall psychological well-being.

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Supplementary Information

PedsQL^{TM} indicators for psychosocial well-being

Details on PedsQL^{TM} indicators for psychosocial well-being We use the Pediatric Quality of Life Inventory (PedsQL^{TM}) 4.0 Generic Core Scales with 23 items, a licensed pediatric module to measure health-related quality of life (HRQoL). The 23 item version of this measurement model provides a brief overview of a child or adolescent's multidimensional health-related quality of life as it contains scales for physical, emotional, social and educational functioning. Table 1 lists each individual question that was used to create the scales. We use the standard approach in calculating the scales, which is to take a weighted average of all responses. The response options and values assigned for each question are Never (0), Almost Never (25), Sometimes (50), Often (75), Almost Always (100), leading to a score between 0 and 100[16], where a higher value reflects a higher health-related quality of life. The composite averages are classified as low well-being (0-25), low moderate (26-50), moderate (51-75), and high (76-100).

The physical functioning score reflects aspects of the child's life, such as whether it is difficult to walk, run, do sports, do chores, and whether the child suffers from aches or low energy. The emotional functioning score reflects feelings of fear, sadness, anger, sleep issues and worries about the future. The social functioning score measures interpersonal well-being, including having friends, being teased and keeping up with other teenagers. Finally, the educational functioning metric includes questions on how the child is paying attention in class, forgetfulness, school work, and missing school. All questions directly reflect experiences in the last month before surveying, and are responsive to changes over time.

Previous Studies using PedsQL^{TM} The 4.0 Generic Core Scale has previously been utilized in a menstruation related quality of life study among 184 adolescent girls in Australia (Azurah et al., 2013). The authors found that patients

[16]For the PedsQL Generic Core Scales items are reversed scored to allow for easier interpretation

with dysmenorrhea (presence of menstrual cramps) had lower physical functioning, and patients with amenorrhea (absence of period after menarche, or not yet reached menarche by age 15) had lower psychosocial functioning. The study concluded that menstruation related issues can have a significant impact on quality of life outcomes among teenagers (Azurah et al., 2013). We hypothesize that because of differences in sanitation access between Kenyan and Australian adolescents, additional aspects related to menstruation may determine quality of life outcomes among menstruating teenagers in Kenya, for instance, access to sanitary products.

The same HRQoL module has been tested on Estonian adolescents, which revealed lower functioning among girls than boys especially on the physical health and emotional functioning domain. The authors suggested that onset of menstruation may be the reason (Viira and Koka, 2011), in line with Bisegger et al. (2005). Knox et al. (2015) argue that while menstrual issues are common among adolescents, they warrant further study due to the effects they may have on psychosocial functioning.

Researchers have previously employed the PedsQL^{TM} score in health studies in Kenya. For instance, Terer et al. (2013) found that high prevalence of schistosomiasis at the village level and lower socio-economic status are associated with lower scores of health related quality of life, especially in the psychosocial domains. A similar study focused on febrile children, ages 2-18 in Western Kenya, with suspected malaria and/The or dengue fever. After a one-month follow up, the authors found that the PedsQL^{TM} scores had increased among children with fever due to malaria or other causes, but less so among children with dengue (Liu et al., 2016), illustrating that the metric is responsive to changes in children in our study region.

Supplementary Figures and Tables

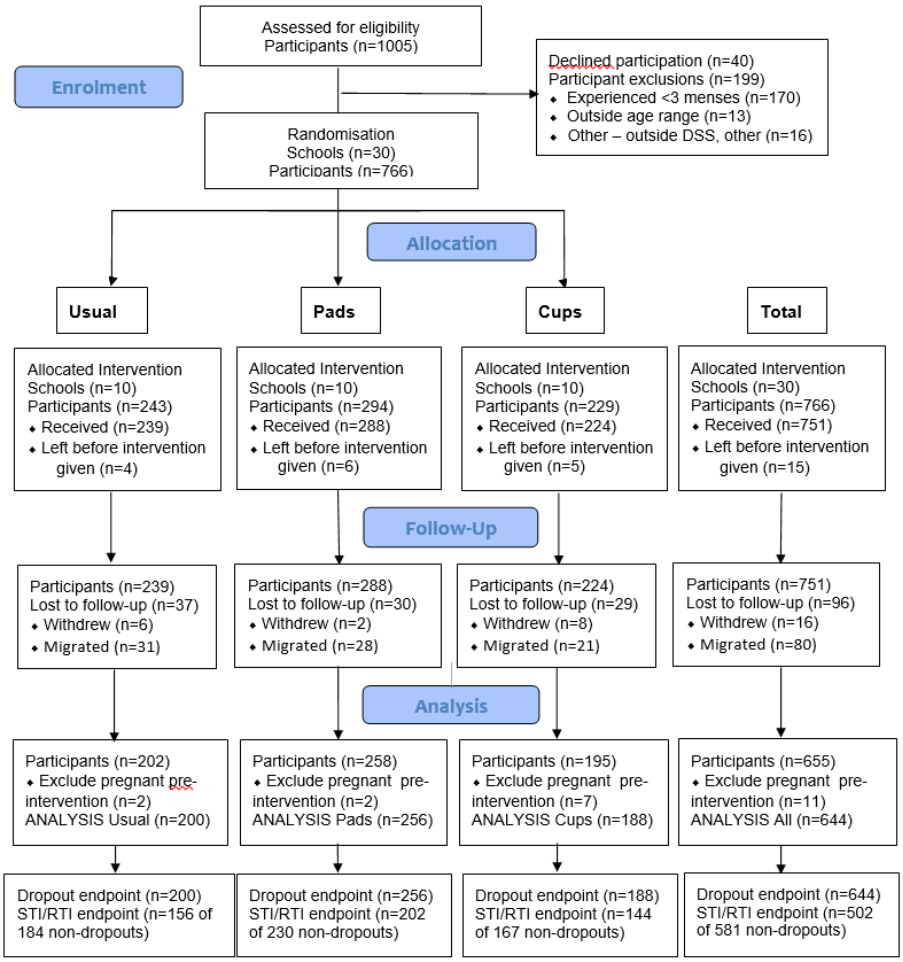

Figure 1: Study protocol. Reprint from Phillips-Howard et al. (2016)

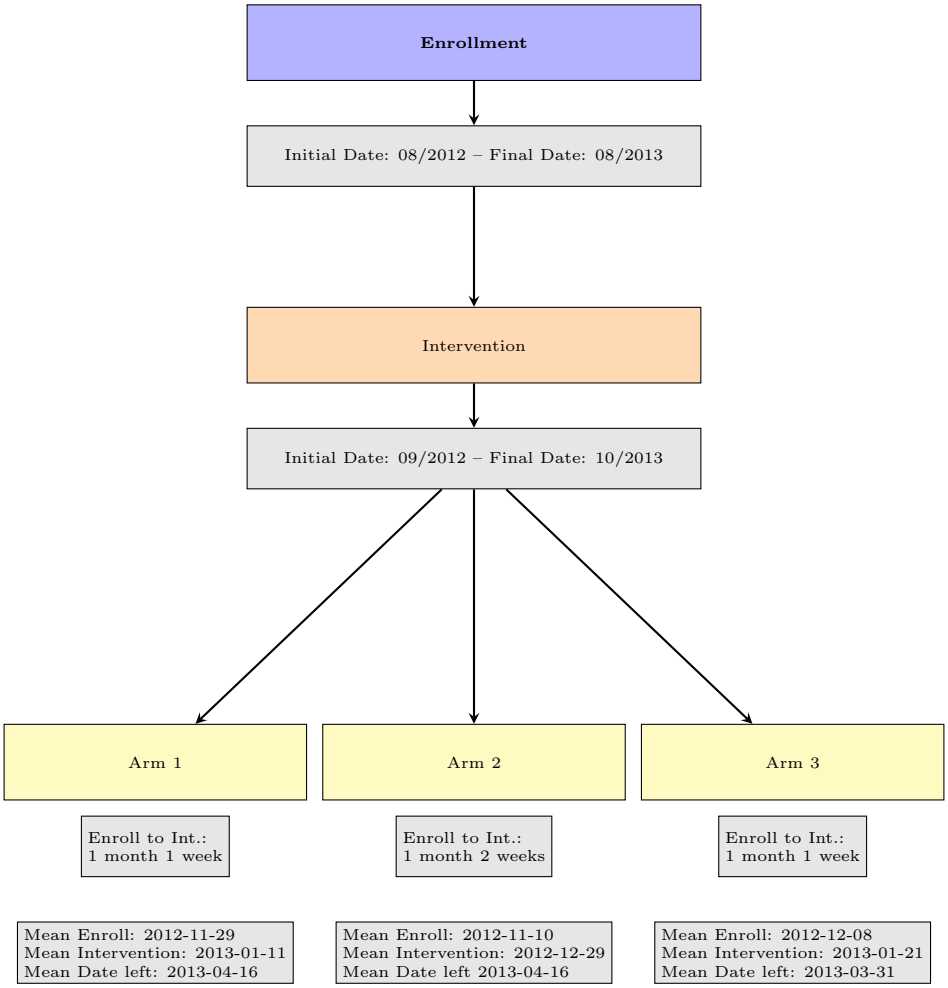

Figure 2: Time schedule for intervention

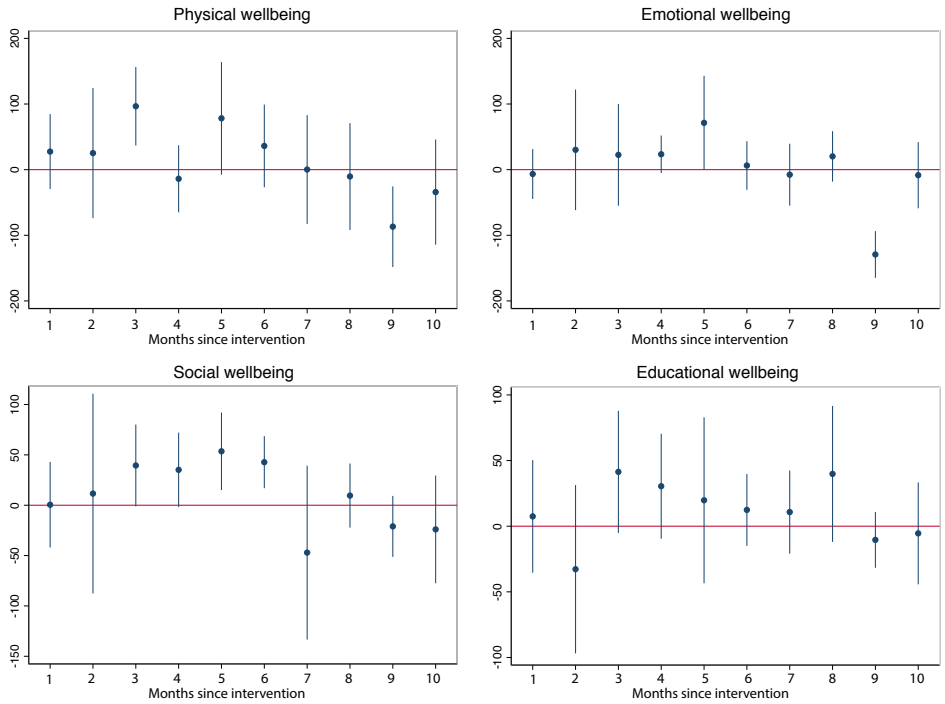

Figure 3: Coefficient plot for well-being measures menstrual cup arm. Notes: Plots the coefficients for the interaction term months since intervention*menstrual cup, and excludes all observations collected after the end of the intervention. Comparison is with the control group. Controls for duration in months, age and class.

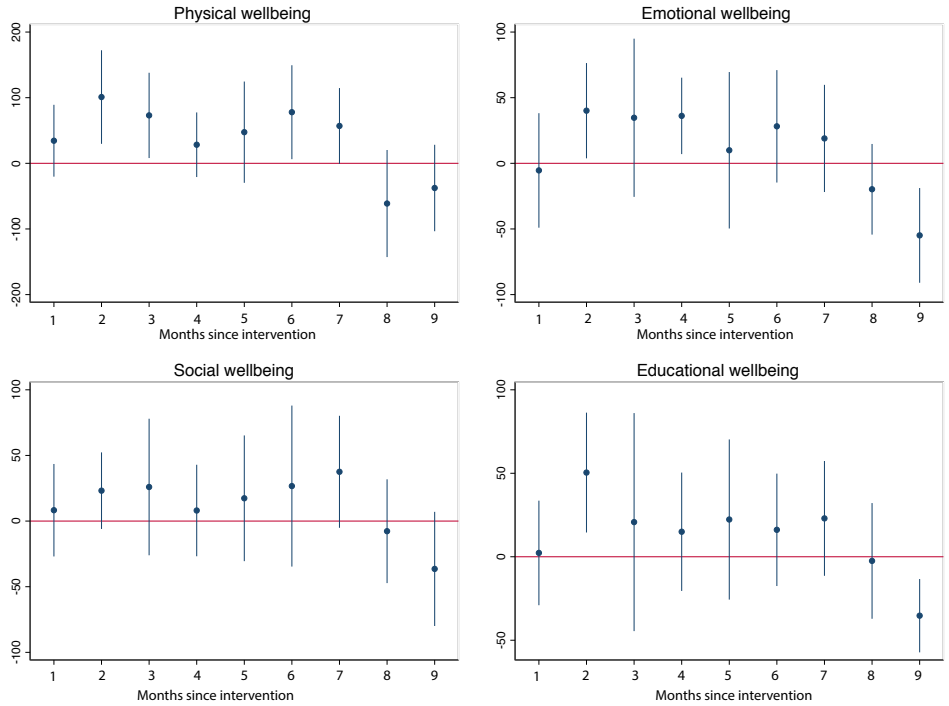

Figure 4: Coefficient plot for well-being measures sanitary pads arm. Notes: Plots the coefficients for the interaction term months since intervention*sanitary pad and excludes all observations collected after the end of the intervention. Comparison is with the control group. Controls for duration in months, age and class

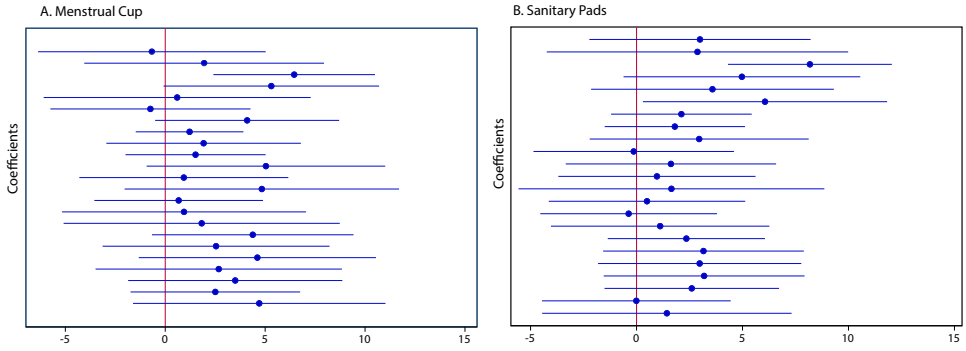

Figure 5: **Coefficient plot for single psychosocial functioning measures.** Notes: The figure plots the treatment coefficients for all the outcomes included in the index scores. Comparison is with the control group. Controls for duration of participation in the program (in months), age and class. Intentionally, the figure does not allow for exact interpretation of each variable in line with guidelines from PedsQL^{TM}.

Table 1: PedsQL^{TM} 23 items

Physical Functioning (8 items)
It is hard for me to walk more than one block
It is hard for me to run
It is hard for me to do sports activity or exercise
It is hard for me to lift something heavy
It is hard for me to take bath or shower by myself
It is hard for me to do chores around the house
I hurt or ache
I have low energy
Emotional Functioning (5 items)
I feel afraid or scared
I feel sad or blue
I feel angry
I have trouble sleeping
I worry about what will happen to me
Social Functioning (5 items)
I have trouble getting along with other teens
Other teens don't want to be my friend
Other teens tease me
I cannot do things that other teens my age can do
It is hard to keep up with my peers
Educational Functioning (5 items)
It is hard to pay attention in class
I forget things
I have trouble keeping up with my school work
I miss school because of not feeling well
I miss school to go to doctor or hospital

Notes: The students are asked: "In the box below, please tell us how much each sounds like you during the past One MONTH. There are no rights or wrongs answers. If you do not understand a question, please ask for help". Alternatives are: Never, Almost Never, Sometimes, Often, Almost Always. More information about PedsQL^{TM} 23 can be found at: https://www.pedsql.org/about_pedsql.html

Table 2: Robustness Results Psychosocial Functioning: Limiting the Treatment Period

Outcome index:	Physical functioning (0-100)	Emotional functioning (0-100)	Social functioning (0-100)	Educational functioning (0-100)
	(1)	(2)	(3)	(4)
Panel A: Months 0-6				
menstrual cup	3.943*	3.752	4.264	4.905**
	(2.189)	(2.716)	(2.778)	(2.113)
sanitary pads	7.312***	3.702	3.400	4.497**
	(2.336)	(2.838)	(2.301)	(1.901)
Panel B: Months 0-7				
menstrual cup	3.446*	3.222	2.847	4.699**
	(1.973)	(2.568)	(2.834)	(2.024)
sanitary pads	7.421***	3.706	3.392	4.661**
	(2.213)	(2.845)	(2.427)	(1.831)
Panel C: Months 0-8				
menstrual cup	3.930*	3.719	3.243	5.235**
	(2.217)	(2.351)	(2.876)	(2.396)
sanitary pads	5.852**	2.570	2.806	3.865*
	(2.340)	(2.553)	(2.274)	(1.890)
Panel D: Months 0-9				
menstrual cup	3.667*	3.182	3.004	4.789**
	(2.131)	(2.241)	(2.739)	(2.279)
sanitary pads	6.201***	2.527	2.753	3.385*
	(2.235)	(2.338)	(2.209)	(1.768)
Panel E: Months 0-10				
menstrual cup	3.081	2.963	2.645	4.159*
	(1.939)	(2.186)	(2.600)	(2.120)
sanitary pads	5.602***	2.516	2.476	3.079*
	(2.013)	(2.268)	(2.023)	(1.628)
Panel F: Months 0-11				
menstrual cup	3.062*	2.946	2.682	4.018*
	(1.694)	(2.095)	(2.258)	(2.023)
sanitary pads	5.539***	2.549	2.678	3.111*
	(1.943)	(2.225)	(1.849)	(1.682)
Controls (age, grade)	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Mean (control)	69.74	71.454	75.528	71.79

Notes: The outcome variable is the four psychosocial functioning indices ranging from 0-100, where 100 signifies full functioning. Panels vary the months included in the treatment period, to account for the rolling enrollment. Wild bootstrapped clustered standard errors at the school level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Heterogeneity Analysis Physical Characteristics of Menstruation and Absenteeism

	DiD	DiD, <9m
Menstrual cup	-0.133***	-0.100***
	(0.016)	(0.012)
Sanitary pads	-0.095***	-0.097***
	(0.022)	(0.024)
After	0.035***	0.038***
	(0.011)	(0.010)
Menstrual cup * After	0.013	-0.003
	(0.018)	(0.010)
Sanitary pad * After	-0.017	-0.018
	(0.030)	(0.026)
PCA	0.007	0.005
	(0.005)	(0.003)
PCA * After	-0.006	0.006
	(0.008)	(0.006)
PCA * Sanitary pad	0.004	0.008
	(0.012)	(0.011)
PCA * Menstrual cup	-0.004	-0.010
	(0.007)	(0.009)
PCA * Menstrual cup * After	-0.010	-0.011
	(0.012)	(0.016)
PCA * Sanitary pads * After	-0.014	-0.030*
	(0.015)	(0.017)
Observations	3,012	2,256
R-squared	0.044	0.045

Notes: The regression controls for month and school fixed effects, age and class. Wild cluster bootstrapped standard errors at the school level in parentheses. The PCA is a principal component analysis including self-reported characteristics of menstruation: cramps, heavy bleeding, and length of period in days. *** p<0.01, ** p<0.05, * p<0.1. This subgroup analysis was not pre-registered, warranting caution in interpretation.