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

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Abstract

Can sanitary products improve schoolgirls' school attendance and psychosocial well-being? We evaluate a simple, disposable product, and a complex, albeit, economically and environmentally sustainable product, and compare with business as usual in Kenyan primary schools. Disposable sanitary pads reduced school absenteeism by 7.9 percentage points while the menstrual cup had no discernible effect on absenteeism. Psychosocial well-being, measured by physical, emotional, educational and social pediatric quality of life indices, improved in both treatment groups 3 to 8 months after treatment. The benefits of the menstrual cup were especially strong for girls who self-reported heavy bleeding. The positive effects on psychosocial functioning are corroborated by narratives from focus groups. Improvements in psychosocial well-being tapered off as the benefit stream of disposable products ceased, but remained high in the group that had received a long-lasting product. 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 and scalability.

Keywords: Sanitation, Education, School absenteeism, Adolescence, Psychosocial well-being, Randomized Controlled Feasibility Trial.
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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 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), 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, 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].

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 sexual 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], and the collection self-reported diaries of absenteeism failed (Phillips-Howard et al., 2016)[3].

The three arm study design allows us to compare two potential menstrual hygiene interventions against business-as-usual: the monthly provision of 16 single use sanitary pads, and 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 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.

[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)

[3]An initial intent was to measure school absenteeism on menstruating and non-menstruating days using self-reported diaries. In fact, the authors write: "Self-reported absence was rarely reported and not assessable" (Phillips-Howard et al., 2016). While not reported in the initial trial, the research team additionally collected spot-check on absenteeism on unannounced days, alongside official school records of absenteeism. These two data sets, not previously analyzed, are used for the analysis in this paper.

We measure the policy impacts on school absenteeism, captured by researcher collected spot-check data, and self reported psychosocial well-being measured by a validated pediatric quality of life index, PedsQL^{TM}. We find that disposable sanitary pads reduced school absenteeism by 7.9 percentage points, and improved self-reported physical well-being (6.2%). The menstrual cup, which had slow adoption rate, had no discernible effect on absenteeism, but led to a 10.1% and 9% improvements in emotional and educational well-being among a vulnerable group. Overall, we see consistent improvements in psychosocial wellbeing in months 3-8 across treatment arms. The strength of the evidence is limited: psychosocial wellbeing was only repeatedly collected after treatment, and therefore we cannot control for initial level differences across the 30 clusters. However, we observe no significant differences in levels in the month of treatment, and diverge from the control group only appear in subsequent months. Moreover, these findings 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.

At the end of the study period, we observe mean reversal of the psychosocial well-being effects in the sanitary pad group. This pattern corresponds with the end of the benefit stream of disposable products. In contrast, we observe no such effect in the menstrual cup group; those students were welcome to keep using their menstrual cup. 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-being and education is direly needed. First, the question has not been sufficiently studied considering the size and diversity of the affected population, with the best case evidence limited to 200 girls in Nepal (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, and conduct cost-effectiveness analysis. Third, 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. Lastly, we provide evidence on the importance of using validated data on school absences: We replicate the main results on absenteeism using school register data—that suffers from non-random measurement error—which leads to a type II error and failure to reject the null hypothesis.

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.

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 qualitative evidence, cost-effectiveness, and the need for validated data on absenteeism. Finally, we conclude in Section 6.

2 Background

2.1 Pupil absenteeism

Several interventions have been found to increase girls' school enrollment and attendance in low and middle income countries, including 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), as well as a range of non-gender targeted interventions (Evans and Yuan, 2022).

Sanitation interventions aiming to improve schooling outcomes often 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.

2.2 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, unaffordability 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). Another study conducted in Kenya 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

There is limited evidence on the effect of MHM on psychosocial well-being (Hennegan and Montgomery, 2016), including cross sectional evidence on schoolgirls in Uganda (Hennegan et al., 2016). 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 participants received private soap, puberty education, and could access a study nurse at the school. Because of the three-arm randomized controlled study design, 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

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

school drop-put 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 wellbeing.

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.

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

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

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).

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).

766 girls were subsequently enrolled into the study, with the treatment status randomly determined at the school level. 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 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)[6]. 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 (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 Discussion).

3.5 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. In addition, the official school records of attendance were collected for all students on the same days, allowing for comparisons of data quality.

To illustrate that using non-verified school records can lead to measurement error, we show that the patterns of absences reported in the school register are non-random. Subsequently, we re-analyze the program effect on absenteeism using

[6]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.

the school record data instead of the researcher-collected roll-call data.

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[7].

3.6 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

[7]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).

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

3.7 Econometric specifications

The main regression specification compares absenteeism before and after treatment for the different intervention groups. The treatment coefficients are β_1 for *sanitarypad* and β_2 for *menstrual cup*, two indicator variables take the value 1 if the student participated in that treatment arm, and 0 otherwise. We are interested in the interaction effects between these treatment arms and the indicator variable for *post*.

$$\begin{aligned} Absent_{ismt} = \beta_0 + \beta_1 sanitarypad_i + \beta_2 menstrualcup_i + \beta_2 post_i \\ +\beta_3 post_t * sanitarypad_i + \beta_4 post_t * menstrualcup_i \\ +\lambda_i + \delta_m + \alpha_s + \varepsilon_{ismt} \end{aligned} \tag{1}$$

Where λ_i is a vector of controls (age and class, socioeconomic status when indicated, and period characteristics). The specification also controls for month fixed effects δ_m and school fixed effects α_s. This specification uses all spot-check collected, and as an alternative in the robustness section to account for the slow adoption rate. Because of the rolling enrollment of students into treatment, we have multiple but varying number of observations per student. For this reason, we include school fixed effects that soak up school-specific variations in sampling, SES and baseline level of absenteeism. We include month fixed effects because there are strong variation across months, due to holidays, changes in the academic year, and opportunity cost of schooling. We cluster the standard errors at the school level, which is the level of intervention.

The psychosocial welfare index scores were only collected post treatment (with some exceptions), which is why the specification shows a difference in levels across the groups:

$$PsychosocialIndex_{ism} = \beta_0 + \beta_1 sanitarypad_i + \beta_2 menstrualcup_i + \lambda_i + \delta_m + \alpha_s + \varepsilon_{ism} \quad (2)$$

Also controlling for covariates (λ_i), including socioeconomic status when indicated, month fixed effects δ_m and school fixed effects α_s. Because the psychosocial functioning indices run from 0-100, the interpretation of the coefficient is in percentage points, and the percentage change is captured by the coefficient/mean value in the control group. In the sensitivity analysis, we bootstrap the standard errors.

3.8 Observable characteristics of the sample

Table 1 shows the main observable characteristics across the three different groups. We should not interpret this table as a test of the success of the randomization. However, we note that the average age is 14.5 years, average class is grade 6, and 20% of girls have heavy periods, 60% experience cramps and the average period lasts 3.7-3.9 days. The socio-economic status (SES) is slightly higher in the two treatment groups compared to the control group, which could be due to the randomization being undertaken at the school level with 10 schools per arm. Therefore, some statistically significant differences are to be expected. Across all treatment arms, researcher-collected spot-check range from 4% to 7% of days, and there seems to be some differences in absenteeism at baseline.

The psychosocial functioning indices were collected post intervention. Therefore, we cannot test for balance at baseline (although we estimate zero coefficients in the first treatment month for all indices in both treatment arms). Physical functioning in the control group is 69.7, classified as moderate well-being, emotional functioning is 71.5 (moderate well-being), social functioning is 75.5 (high well-being), and educational functioning is 71.8 (moderate well-being). We find suggestive evidence of level differences post-intervention, where girls in the treatment schools are better off. To ensure that these differences are not due to differences in baseline socio-economic status, we will control for it in some specifications.

Table 1: Observable characteristics of the sample

Treatment arm:	Menstrual cup	p	$^{**}\alpha = 0.05$ $^{*}\alpha = 0.1$	Sanitary pads	p	$\alpha = 0.05$	Control
Baseline characteristics							
age (years)	14.56	0.76		14.51	0.08	*	14.58
grade	6.69	0.01	**	6.76	0.36		6.81
has heavy period	0.2	0.928		0.251	0.207		0.203
experiences cramps	0.619	0.716		0.636	0.425		0.602
length of period (days)	3.698	0.977		3.924	0.045	*	3.701
SES level	3.762	0.025	**	3.789	0.010	**	3.479
Attendance spot-checks							
absent (average)	0.06	0.05	*	0.07	0.00	**	0.04
absent pre-intervention	0.01	0.36		0.10	0.00	**	0.00
absent post-intervention	0.08	0.09	*	0.07	0.18		0.05
Psychosocial functioning indices (post-intervention)							
physical (0-100)	72.595	0.054	*	73.281	0.011	**	69.74
emotional (0-100)	74.142	0.067	*	72.986	0.264		71.454
social (0-100)	78.266	0.064	*	77.286	0.2097		75.528
educational (0-100)	74.372	0.075	*	73.808	0.135		71.79

Notes: p-values associated with two-sided T-tests are reported for mean values comparing the treatment arms with the control arm. Attendance spot-checks were researcher collected roll-calls for students on random and unannounced schooldays. The psychosocial functioning indices run from 0-100, where the composite averages are classified as low well-being (0-25), low moderate (26-50), moderate (51-75), and high (76-100). Psychosocial functioning indices were collected from the beginning of the treatment period.

Moreover, as girls were repeatedly surveyed post-intervention, we can explore the evolution of these index scores, allowing for level differences at the time of the intervention.

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, (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.

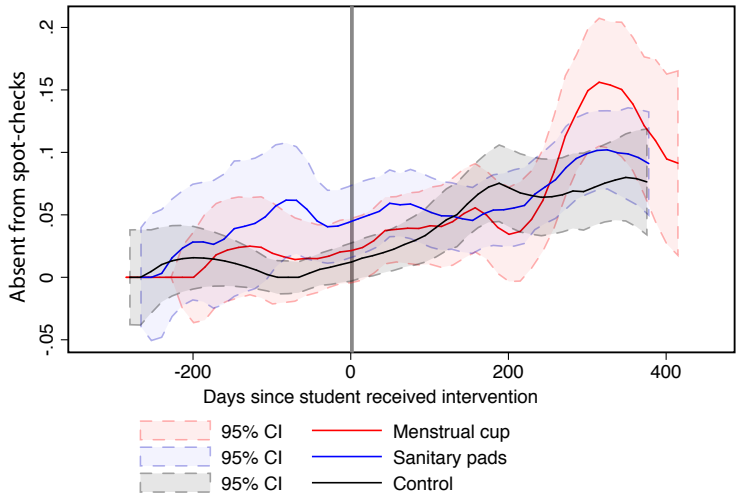

Figure 1: **Local polynomial smooth for timing of effects.** Notes: The figure plots local polynomial smooth with 95% confidence intervals. Day 0 represents the day the student received the intervention, with a calendar date that varies across individuals.

3.10 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.

Second, the randomization did not yield perfect balance in baseline characteristics across the treatment groups. Girls in schools that received the menstrual cup program were more likely to have had sex at baseline and were more likely pregnant prior to intervention compared to girls in other treatment arms, and we note some differences in socioeconomic status across the three groups. This can be due to the limited number of schools per treatment arm.

Third, 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.

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. We note a few discrepancy across the datasets, including variance in observable characteristics. We test the robustness to excluding any study individual for whom we observe discrepancies, which lead to loss of statistical significance or minor changes in magnitude in certain specification.

4 Results and Mechanisms

4.1 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 (average 4.1 times). Table 2 shows the main impacts of the program on absenteeism. The menstrual cup treatment arm did not reduce absenteeism, in line with the visual evidence examined in Fig 1. However, the sanitary pad treatment arm reduced absenteeism by 7.9 to 7.8 percentage points[8], where the latter estimate controls for socioeconomic status of the student and the length of a students' period in days, in addition to baseline control variables and fixed effects for month and school (Table 2, columns 1-3).

The adoption of the menstrual cup increased over time. To allow participants enough time to adopt the cup and change their absenteeism behavior, we limit the sample to include data from before the intervention and the last 50% of days from the post-intervention sample, meaning from day 209 of the study period. No significant treatment effect for the menstrual cup can be detected (Table 2 columns 4-6), although the sanitary pad treatment effect coefficient is slightly larger.

4.2 Effects on psychosocial well-being

The qualitative evidence points to menstrual health management a source of worry in adolescent girls' lives, with impacts on physical, emotional, social as well as

[8]Similar to the differences that can be calculated from Table 1, where absenteeism in the control group increased 5%, and reduced 3% in the sanitary pad group.

Table 2: Main Results on (A) Absenteeism and and Heterogeneity by Timing of Effects in Before-After Analysis, (B) Psychosocial Functioning

Panel A: Absenteeism						
Sample:				Before+50% after		
	(1)	(2)	(3)	(4)	(5)	(6)
menstrual cup	0.019	0.020	0.020	0.042	0.043	0.043
X after	(0.023)	(0.025)	(0.025)	(0.036)	(0.037)	(0.037)
pads	-0.079*	-0.078*	-0.078*	-0.090*	-0.089*	-0.089*
X after	(0.044)	(0.043)	(0.043)	(0.048)	(0.047)	(0.047)
menstrual cup	-0.187***	-0.191***	-0.062***	-0.176***	-0.181***	-0.014
	(0.020)	(0.023)	(0.019)	(0.029)	(0.033)	(0.031)
pads	-0.051	-0.046	0.041	-0.084***	-0.080***	-0.039
	(0.032)	(0.034)	(0.041)	(0.024)	(0.027)	(0.035)
after	0.027*	0.023	0.023	0.021	0.017	0.017
	(0.014)	(0.016)	(0.016)	(0.045)	(0.048)	(0.048)
length			-0.029***			-0.042***
of period			(0.004)			(0.006)
Observations	3,083	3,083	3,083	1,816	1,816	1,816
Controls	Yes	Yes	Yes	Yes	Yes	Yes
SES level control	-	Yes	Yes	-	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Psychosocial functioning				
Outcome index:	Physical functioning (0-100)	Emotional functioning (0-100)	Social functioning (0-100)	Educational functioning (0-100)
	(1)	(2)	(3)	(4)
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
Mean (control)	69.74	71.454	75.528	71.79
Controls	Yes	Yes	Yes	Yes
SES level control	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes

Notes: Regressions control for month and school FE, age and class. Outcome variable is the dichotomous variable "absent" in Panel A, and the four psychosocial functioning indices in Panel B ranging from 0-100, where 100 signifies full functioning. Clustered standard errors at the school level. *** p<0.01, ** p<0.05, * p<0.1.

educational wellbeing. 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 4% (from the baseline mean value, statistically insignificant) and 5.7% (statistically significant at the 10% significance level) respectively (Table 2, Panel B)[9].

4.3 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 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. Heavy bleeding is positively correlated with being absent from the first roll-call.[10].

Two triple-difference specifications, where heavy bleeding or a principal component (cramps, heavy bleeding, length of period) are interacted with the treatment variables, showed no heterogeneous treatment effects on absenteeism (Table 3). In contrast, girls in the menstrual cup group who self-reported heavy periods

[9]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. The results are robust to the exclusion of SES controls and bootstrapped standard errors (see Table 4 Panel C). However, correcting the initial results in Table 2, Panel B for family-wise error rate (FWER) because of the risk of Type I error using the Bonferroni correction, no results remain statistically significant.

[10]Appendix Table 2 shows the pairwise correlation coefficients between these variables and absenteeism in the first roll-call.

Table 3: Heterogeneity Analysis Physical Characteristics of Menstruation and Absenteeism

VARIABLES	(1) Absent	(2) Absent
menstrual cup	-0.056**	-0.052**
	(0.020)	(0.020)
sanitary pads	0.031	0.032
	(0.023)	(0.023)
endline	0.158***	0.151***
	(0.024)	(0.025)
endline* menstrual cup	0.026	0.011
	(0.045)	(0.037)
endline* sanitary pads	-0.066*	-0.058*
	(0.034)	(0.031)
heavy bleeding	0.005*	
	(0.002)	
heavy bleeding * endline	-0.018	
	(0.061)	
heavy bleeding * sanitary pad	0.008	
	(0.028)	
heavy bleeding * menstrual cup	-0.002	
	(0.011)	
heavy bleeding * endline * menstrual cup	-0.070	
	(0.082)	
heavy bleeding * endline * sanitary pads	0.022	
	(0.090)	
PCA		0.001
		(0.001)
PCA* endline		-0.030
		(0.026)
PCA * sanitary pads		-0.010
		(0.018)
PCA * menstrual cup		0.004
		(0.006)
PCA * endline* menstrual cup		-0.004
		(0.033)
PCA * endline * sanitary pads		0.025
		(0.039)
Observations	1,131	1,131
R-squared	0.077	0.079

Notes: All regressions control for month and school fixed effects, age and class. Clustered 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.

experienced larger improvements in emotional and educational wellbeing (Table 4, Panel A: 10.1% and 9%). 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 (Panel B). It is worth noting that while only a handful of the coefficients are statistically significant, all point toward improvements in psychosocial well-being.

Table 4: 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	Sample with heavy period			
menstrual cup	3.072	7.004**	5.448	6.249*
	(2.178)	(3.323)	(3.875)	(3.290)
sanitary pads	1.215	-0.291	0.587	1.053
	(3.511)	(3.767)	(3.995)	(2.933)
Observations	346	346	346	346
R-squared	0.070	0.086	0.074	0.075
Mean (control, heavy)	68.775	69.52	73.62	69.52
Panel B	Sample with light/medium period			
menstrual cup	1.913	1.335	0.978	2.508
	(2.469)	(2.595)	(3.111)	(2.645)
sanitary pads	5.076**	2.042	1.702	2.293
	(2.073)	(2.673)	(1.970)	(1.983)
Observations	1,138	1,138	1,138	1,138
R-squared	0.096	0.063	0.087	0.083
Mean (control, light/medium)	70.0	71.98	76.04	72.42
Panel C	Full sample: Bootstrapped standard errors			
menstrual cup	2.276	2.848	2.072	3.601
	(1.891)	(2.360)	(2.527)	(2.364)
sanitary pads	4.074**	1.410	1.349	2.039
	(2.066)	(2.458)	(1.981)	(1.862)
Observations	1,484	1,484	1,484	1,484
R-squared	0.081	0.059	0.075	0.070
Mean value (control group)	69.74	71.454	75.528	71.79
Controls	Yes	Yes	Yes	Yes
SES level control	No	No	No	No
Month FE	Yes	Yes	Yes	Yes
School 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. Multiple observations per individual may be included. Standard errors in Panel C are bootstrapped with 200 repetitions. All regressions control for month and school fixed effects, and controls for grade and age. *** p<0.01, ** p<0.05, * p<0.1.

4.4 Timing of the effects

The need and use of the sanitary products and ensuing improvements in wellbeing may be delayed, due to (1) lack of familiarity with the product and how to utilize it, and (2) delayed or irregular nature of the menstrual cycle among adolescents. In fact, more than 60% of female students in Tanzania reported irregular menstrual cycles. To allow for temporal variability, we decompose the effects on psychosocial functioning by months of treatment since the enrollment in the program. Fig 2 plots the regression coefficients by month of treatment. Due to lack of data pre-treatment, the first coefficient is month 1. The first month is never statistically significant, which is in line with pre-intervention balance. Overall, the temporal decomposition indicates the existence of positive effects on all four psychosocial functioning indices in both treatment arms. Several coefficients are statistically significant and positive between month 3 to month 8 since the beginning of treatment.

The effects in the sanitary pad treatment arm appear to 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. For the menstrual cup—which lasts up to 10 years—we see little such tapering off of effects, although the margins of error become larger (and the sample sizes 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 Figures 1 and 2). 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. A longer discussion about the perceived financial benefits of the study can be found in Section 5.1.

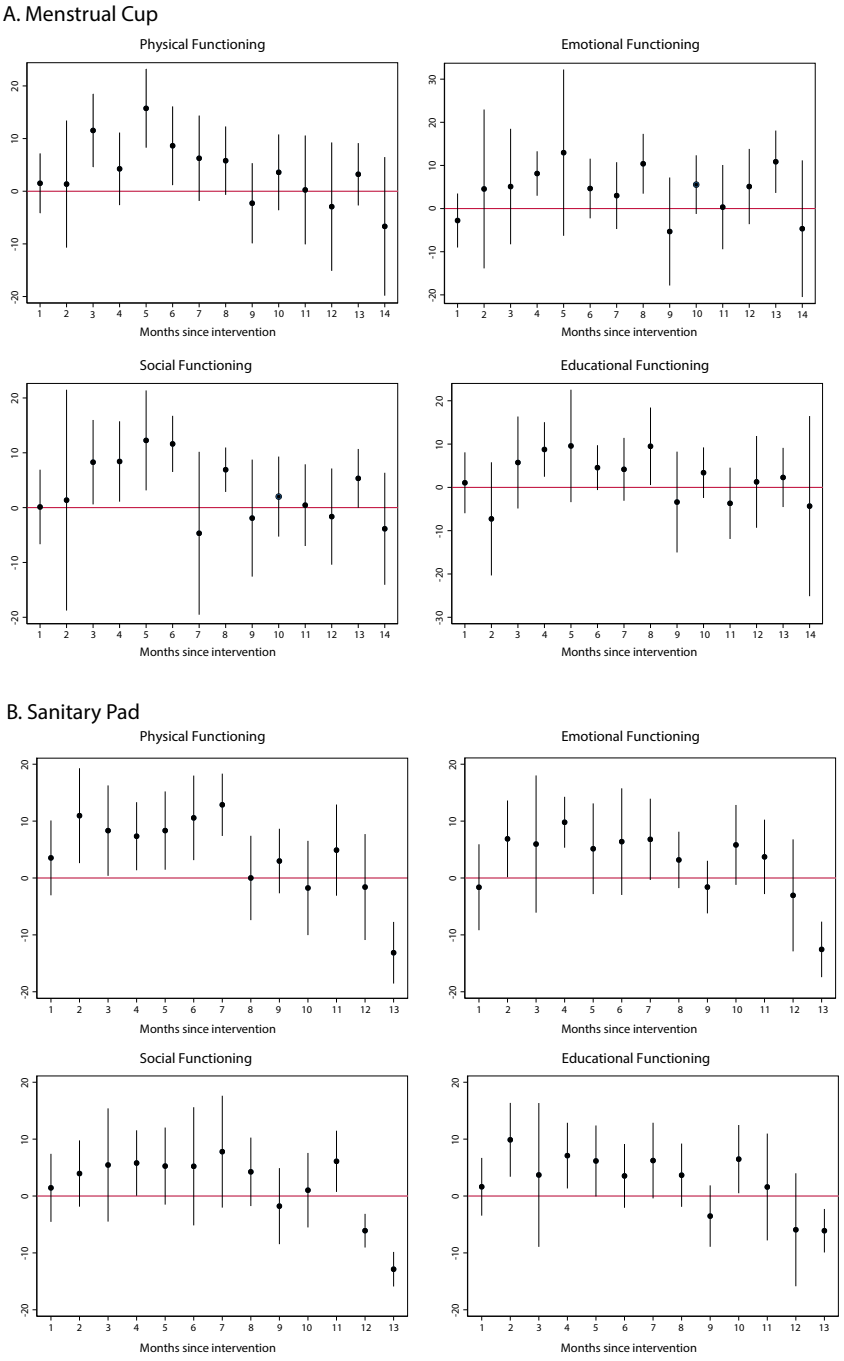

Figure 2: **Coefficient plot for menstrual cup and sanitary pad treatment on psychosocial functioning indices.** Notes: The figure plots the coefficients for the interaction term *months since intervention*menstrual cup* (Panel A), and *months since intervention*sanitary pads* in Panel B. Comparison is with the control group. Each student is sampled multiple times. Controls included for age and class. 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.

4.5 Drivers behind psychosocial functioning

The PedsQL^{TM} psychosocial functioning indices each contain a multitude of questions. 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. We find that the vast majority of coefficients are positive and a handful are statistically significant (Figure 3). This confirms that the positive impacts observed earlier on the indices are not driven by particular questions or outliers, and are representative of general positive trends in adolescents' well-being. We encourage against interpretation of the individual components and labels are not provided.

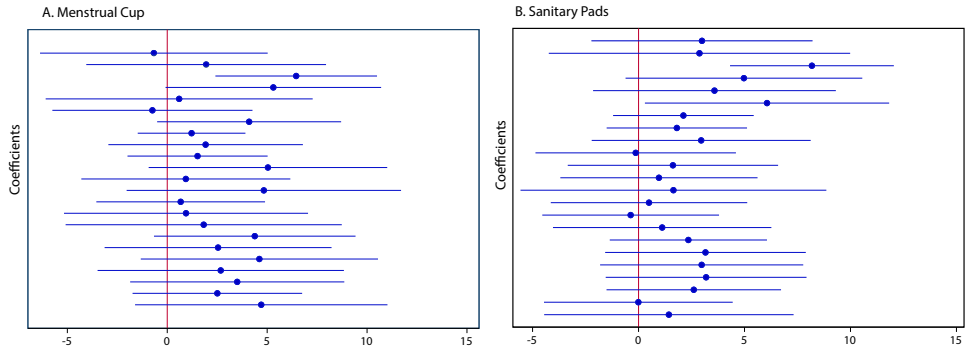

Figure 3: **Coefficient plot for single psychosocial functioning measures.** Notes: The figure plots the treatment coefficients for all the outcomes included in the index scores. Comparison is with the control group. Controls for duration of participation in the program (in months), age and class. Intentionally, the figure does not allow for exact interpretation of each variable in line with guidelines from PedsQL^{TM}.

5 Discussion

5.1 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.

We will discuss self-perceived impacts on (1) physical, (2) emotional, and (3) educational wellbeing, (4) the desirability of menstrual cups over sanitary pads, and lastly (5) financial resources.

Physical wellbeing

The focus groups discussions largely corroborate the main quantitative findings in this paper. Girls and parents reported reduced absenteeism in both treatment groups, in contrast to the control group. In addition, the girls report that their physical wellbeing improved. In particular, the menstrual cup appears to improve girls' ability to participate in physical education:

"I'm feeling good because when I put that Mooncup inside I can run, I can do anything." (from Mason et al, 2015).

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

Emotional and educational wellbeing

One theme that emerged from the analysis was that the increase in physical well-being have spillovers for emotional wellbeing. 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."

The improvements in physical wellbeing from the menstrual cup had additional effects on educational performance, both in the classroom and during physical education. 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).

Student-teacher relations may also have improved, especially in light of reduced corporal punishment:

"When he has just told you to go for game, for example athletics, people do press ups in the field. And then you will be told to pull or put your legs apart and when you will realize the kind of material that you are using and you are on your periods you will hesitate, then just stand until the teacher will decide to cane you because you are not doing what the others are doing." (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 Mooncup 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 firs 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).

"I wanted to say that they miss school because maybe sometimes they cannot get money to buy pads." (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).

The girls recognize the risks of engaging in unprotected sexual intercourse, summarized by one student: "Sometimes he can confuse you with money and then you develop friendship and maybe he is HIV positive, or he has gonorrhea, he can give you three things; pregnancy, gonorrhea or HIV and AIDS." (from transcripts, reviewed May 2023).

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

"Because they brought us mooncup, also you do not have to worry... I don't know... We waste a lot of money buying pads, and also the blood cannot leak, (movements of the chairs) and always [sanitary towel] sometimes you may be surprised blood leaks to your clothe then you get embarrassed." (from transcripts,

reviewed May 2023)

"[...] When we were not having the mooncup, my mum was spending a lot of money buying pads, but since the mooncup 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 mooncup". (from transcripts, reviewed May 2023)

"Some parents will just urge you, just use it my daughter I don't have money, will I be looking for money to buy maize [food] or to buy pads for you?!... So you will just use." (From Mason et al, 2015)

"I can say that mooncup 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 mooncup can be washed then reused in the following months, and that is why I feel that mooncup 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. By the time you will have your menses, you will tell your father to add you some little money then you add to the ones you had after selling the pads, and then you buy pads." (from transcripts, reviewed June 2023)[11]. 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

[11]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.

sanitary pad group reverse (and potentially even turn negative), toward the end of the study period.

Synthesis of qualitiative findings

Some girls participating in the focus groups perceived that their participation in the program had real implications on their wellbeing. 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 wellbeing 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 wellbeing, according to the girls themselves.

The study focused primarily on school outcomes and psychosocial wellbeing, alongside the epidemiological impacts reported in Philips-Howard et al (2016). The qualitative evidence, analyzed in Mason et al (2015) and here tentatively augmented with selected quotes from the transcripts, illustrate, furthermore, the economic implications of program participation. The lack of financial resources, generally, and specifically relating to purchasing sanitary napkins, was mentioned by various respondents across focus groups. The limited financial resources may push some girls to taking boyfriends who can help to buy sanitary napkins, putting them at risk of unwanted pregnancies, STIs and HIV.

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.

5.2 School absenteeism by gender

School absenteeism has important implications for student performance. The potential for a randomized trial focusing on menstrual health to reduce absenteeism is conditional on there being baseline menstruation-related absenteeism. To shed light on the gender patterns of absenteeism among primary students, we use an additional and original dataset containing the roll-call spot-checks for more than 6,000 female and male students across the 30 study schools.

All observations of study participants were removed from the initial analysis to avoid contamination from the intervention. 32,349 roll-call spot-check data points remain for 6,057 students. For now, we are not using the school register data. Because of study program eligibility rules, girls in the age range of 14-16 who had experienced three menstrual cycles will be underrepresented in the dataset of non-study participants. However, only 16.9% of girls initially contacted were excluded because they had not yet experienced 3 menses, indicating that girls ages 14-16 who were included in the study are in broad terms similar to those that were not.

To measure heterogeneity by age, we use a spline specification:

$$Absent_{ism} = \beta_0 + \sum_{a=10}^{18} \beta + \beta_{10} female_i + \beta_{11} grade_i + \delta_m + \alpha_s + \varepsilon_{ism} \quad (3)$$

for $a \in \{10, \ldots, 18\}$

where i indicates an individual observation, s school, m is month of the observation. The standard errors are clustered using robust standard errors. We include month (δ_m) and school fixed effects (α_s). The month fixed effects will soak up any variation that comes from the timing of the spot-check. This may be important if absenteeism differs across the months, for example due to the agricultural seasons. The school fixed effects absorb any observable or unobservable variation at the school level (including a more permissive norm toward absenteeism at some schools). In Kenya, there is ample variation in age within a given grade because some students start school later or retake grades, motivating the inclusion of a

grade fixed effect. Age 8-9 is used as the reference category[12].

Results are reported in Figure (Fig 4). Absenteeism among boys in each age category is not statistically different from the reference category of 8-9 years old. However, several age coefficients are statistically significant for girls. The interpretation is that absenteeism is more common among older girls, controlling for grade and fixed effects for school and survey month. The mean age of menarche in Western Kenya is 14.6-15.1 years of age (Leenstra et al., 2005), and this is around the ages where we see the largest increase in absenteeism.

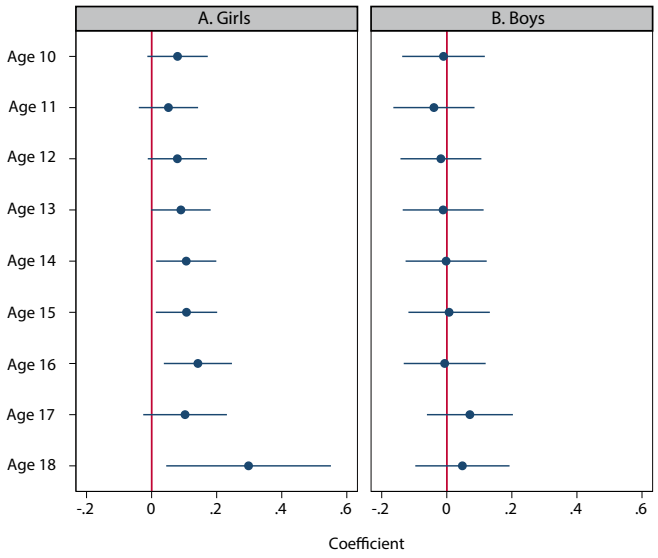

Figure 4: **Regression results on absenteeism for girls (A) and boys (B).** Notes: Reference category is age 8-9. Ages 19-21 are excluded because of small sample sizes. The regressions control for grade, school fixed effects and month fixed effect, and uses robust standard errors. Column 1 and 2 are two separate regressions.

5.3 Comparing spot-check data with school records

Thus far we have used roll-call spot-check data in the analysis. However, in addition to the research team collecting roll-call data, the official school registers

[12] All students older than 18 are excluded from the analysis in this subsection because of small sample sizes.

were collected on the same days for all students. To validate our results, we rerun our analysis of the program using roll-call data and the school records. Table 5 columns 1-2 uses the main difference-in-difference specifications, while columns 3-4 show the results using the same specification but measure absenteeism through school register data instead of roll-call data. Using the administrative school record data, we are at risk of concluding that the sanitary pad arm did not reduce absenteeism. Column 5 provides a chi-square test of equality of the coefficients in columns 1 and 3. The treatment effect for post * sanitary pad is biased when we use the school record data, although we cannot reject the hypothesis that the coefficients in columns 1 and 3 are equal.

Table 5: Treatment effects on absenteeism using spot-check or school records

Outcome:	Absent				
Data source:	Roll-call data		School record data		Chi-square (columns 1 and 3)
	(1)	(2)	(3)	(4)	(5)
post * menstrual cup	0.019	0.020	-0.014	-0.015	0.75 (p = 0.386)
	(0.023)	(0.025)	(0.034)	(0.033)	
post * sanitary pad	-0.079*	-0.078*	-0.017	-0.017	3.39 (p = 0.655)
	(0.044)	(0.043)	(0.029)	(0.029)	
Observations	3,083	3,083	2,229	2,229	
R-squared	0.056	0.058	0.071	0.071	
Controls	Yes	Yes	Yes	Yes	
SES control	No	Yes	No	Yes	
School fixed effects	Yes	Yes	Yes	Yes	

Notes: Clustered standard errors at the school level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The table compares roll-call data and school record data across two main specifications. Column 5 presents the equality of coefficients in column 1 and 3 for the main treatment variables.

To analyze the underlying differences in the two measures of absenteeism, the spot-check and the register data, we use Cohen's kappa coefficient. A kappa coefficient is used to measure the agreement be of two alternative measures for a categorical variable. The kappa coefficient shows the proportion of agreement between the two measures, correcting for chance. The scale varies from negative 1 to positive 1, where negative values indicate lower than chance agreement, and

positive values indicate higher than chance agreement. If the two variables are identical, the kappa coefficient will be 1 (Fleiss and Cohen, 1973).

We calculate two kappa coefficients. The first calculation codes missing absenteeism records from the school register data as "absent" (instead of missing data). The agreement between the variables is 74.33%, and the expected agreement is 65.36%. The kappa coefficient is κ=0.2588 (S.E.=0.005, Z= 52.08, p-value=0.000). The positive kappa illustrates that there is more agreement between the variables than determined by chance, and Landis and Koch (1977) classifies the strength of the agreement as fair (Fair = 0.21 - 0.40) although this classification has been criticized for being arbitrary.

An issue with the school records is missing observations, that is, the school record does not indicate if the student was absent or present for a particular day. When excluding all student-day observations (from both datasets) conditional upon the school record for that student-day is missing, the agreement between the two variables (spot-checks and school records) should thus increase. The new kappa coefficient is κ=0.3824 (SE=0.0065, Z=58.54, p-value=0.000) and the agreement is 91.03%, and the expected agreement 85.47%. The kappa coefficient is still classified as fair (Landis and Koch, 1977). This highlights that the spot-check data and the school register data have higher agreement on days where there is an entry in both dataset.

Measurement bias arises if the missing record (no entry) correlates with the absenteeism rate. In fact, there is a significant negative correlation between an absent record in the spot-check and an entry in the school record (OLS coefficient is -0.2389, SE=0.007, p-value=0.000, using school fixed effects and robust standard errors), meaning that absence sometimes show up as no record rather than absent. An intervention that changes a student's absenteeism pattern would thus also affect the likelihood of the student having an entry in the school record.

These results contrast with previous attempts to validate school records, such as a study in Malawi (Baird et al., 2011), where the authors found perfect agreement between the teacher's record of absence and spot-checks. These contrasting findings from Malawi and Kenya highlight the need to cross-validate school

records; if there is perfect agreement, school records are preferred because of their frequency, if inadequate agreement, spot-checks are needed despite the costs associated. We encourage future studies to use smart technology for monitoring of student attendance.

5.4 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 incremental cost-effectiveness ratio (ICER), defined as the difference in costs over the difference in effect: $ICER = (C_1 - C_0)/(E_1 - E_0)$. For absenteeism, $ICER_{ab,sp} = 24/7.9 = 3.04$, compared to a null effect in the menstrual cup group. For well-being, the significant results were limited to physical well-being, where the sanitary pad group saw a 31.643% effect with $ICER_{ph,sp} = 24/31.643 = 0.758$, and the menstrual cup saw a 22.682% effect (statistically insignificant) with $ICER_{ph,mc} = 0.8/22.682 = 0.0353$. The menstrual cup thus provides a much lower cost-effectiveness ratio (but statistically insignificant). We identified some additional statistically significant effects of both treatment arms for heterogeneous groups, not considered here.

Since all three arms, including the control group, received soap, puberty education, and close supervision from study nurses, the effects measured within this paper are in addition to the positive effects that soap, puberty education, and ac-

cess to school health care provides have on students' absenteeism and well-being.

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.

6 Conclusions

It has been argued that lack of access to menstrual products limits girls' school attendance. We test this hypothesis by evaluating a three-arm cluster randomized controlled feasibility study. We show that the monthly provision of sanitary pads reduced absenteeism by 7.8 percentage points, equivalent to a 50% reduction in absenteeism compared to the endline absenteeism rate in the control group. In line with a previous study (Oster and Thornton, 2011), the menstrual cup did not reduce the incidence of absenteeism. The failure to detect an effect could stem from the slow adoption of the menstrual cup, low levels of menstruation-related absenteeism, and limited statistical power because of the program design. 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.

Importantly, we show that access to menstrual products reach beyond absenteeism behavior. The menstrual cup and the sanitary pads increased girls' physical

well-being by 3.9% (not statistically significant) and 6.2% (statistically significant), respectively. Girls with heavy periods who received the menstrual cup reported improvements in emotional (10.1%) and educational functioning (9%), whereas those with light periods who received the sanitary pads improved 7.3% in physical functioning. While not all of the coefficients that multiply the psychosocial indices are statistically significant, the results point to clear 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, to harness the potential that menstruation-related policies have for human capital development in low- and middle-income countries and to close gender gaps in education not only in absences and enrollment, but performance, safety and 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, 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 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 Tables and Figures

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 feed 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
7 Items (5 items)
I feel happy
I feel good about myself
I feel good about my health
I get support from my family or friends
I think good things will happen to me
I think my health will be good in the future
In general, how is your health?

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. The last question "In general, how is your health?" has different alternatives: Bad, Fair, Good, Very Good, Excellent. More information about PedsQL^{TM} 23 can be found at: https://www.pedsql.org/about_pedsql.html

Table 2: Pairwise Correlations for Physical Characteristics of Menstruation and Absenteeism at the first Roll-Call

	(1)	(2)	(3)	(4)
Variable:	have cramps	heavy bleeding	length of period (days)	absent
have cramps	1.0000			
heavy bleeding	0.1642	1.0000		
length of period (days)	0.0475	0.0877	1.0000	
absent first roll-call	-0.0270	0.0103	-0.0389	1.0000

Notes: The table shows pairwise correlations between physical symptoms and absenteeism in the first roll-call conducted by the research team.

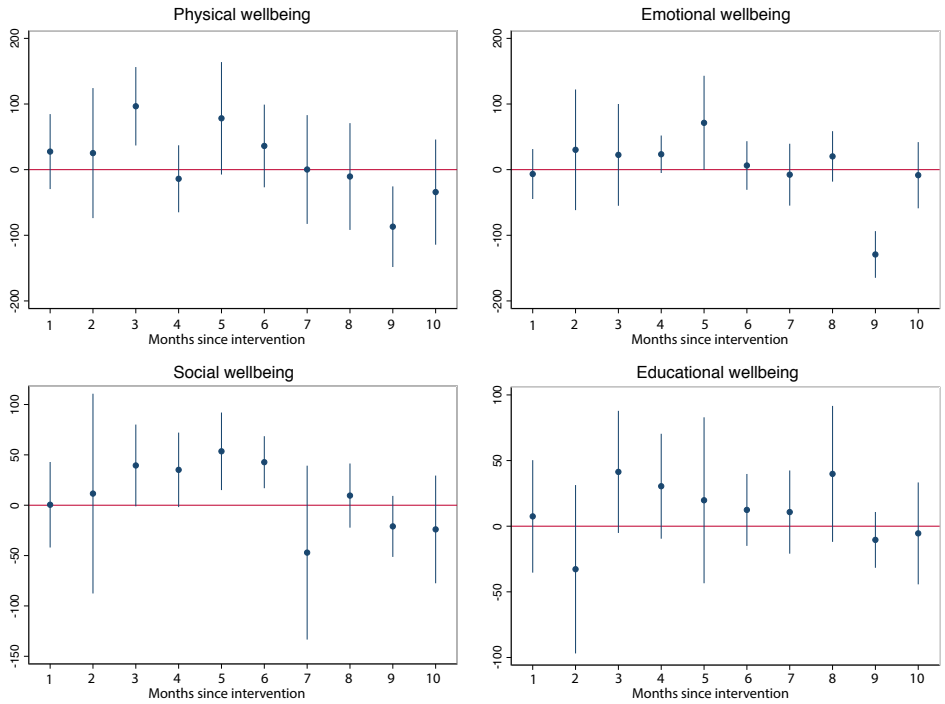

Figure 1: Coefficient plot for well-being measures menstrual cup arm. Notes: Plots the coefficients for the interaction term months since intervention*menstrual cup, and excludes all observations collected after the end of the intervention. Comparison is with the control group. Controls for duration in months, age and class.

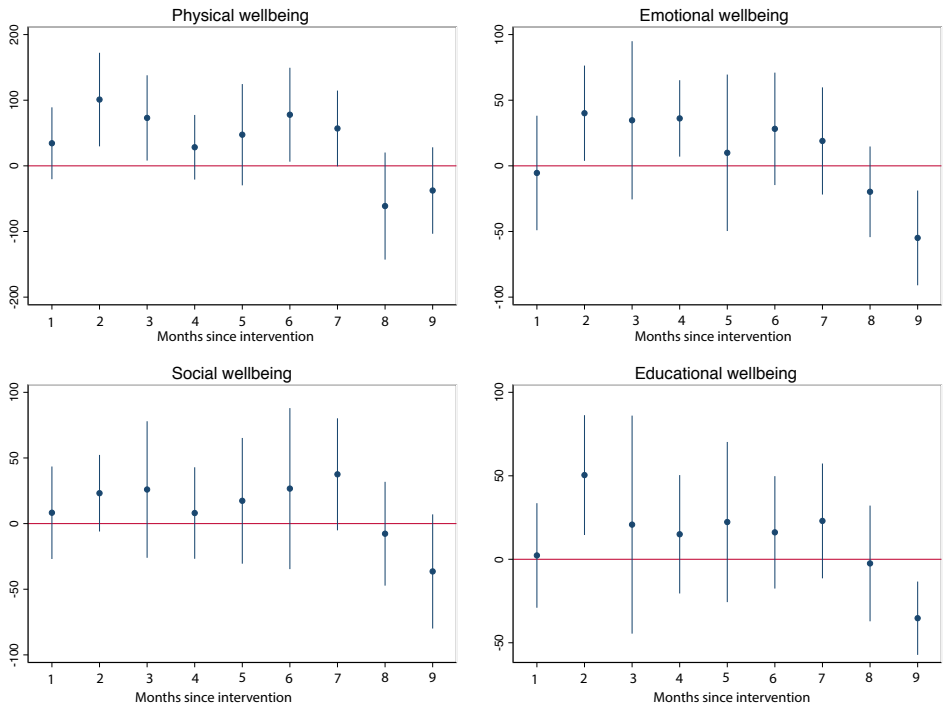

Figure 2: Coefficient plot for well-being measures sanitary pads arm. Notes: Plots the coefficients for the interaction term months since intervention*sanitary pad and excludes all observations collected after the end of the intervention. Comparison is with the control group. Controls for duration in months, age and class

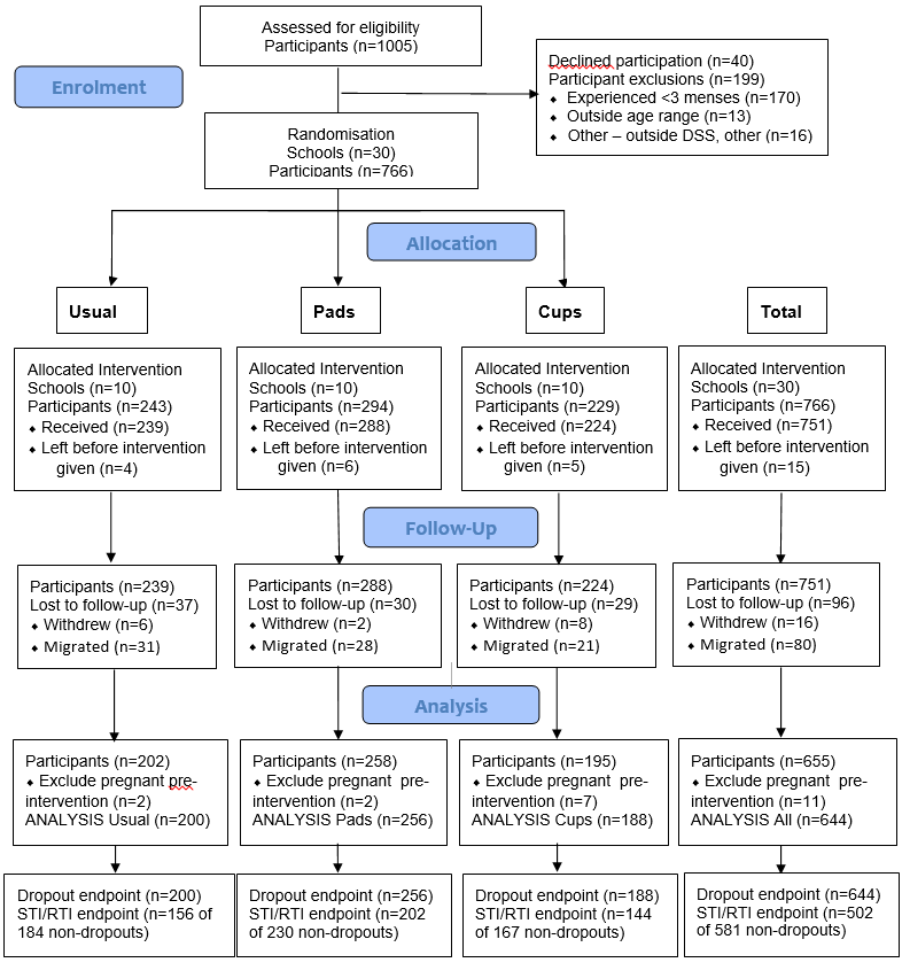

Figure 3: Trial study protocol. Reprint from Phillips-Howard et al. (2016)