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Abstract

Does access to sanitary products improve schoolgirls' well-being? We conduct the first cluster randomized controlled feasibility study to provide different sanitary technologies (sanitary pads or menstrual cup or usual practice) to 644 primary schoolgirls in western Kenya, across 30 schools with 10 schools per treatment arm. Inclusion restrictions were: ages 14-16 years, having experienced at least three menses, and no precluding disabilities. We find that disposable sanitary pads led to a 7.9 percentage point reduction in absenteeism. In addition, using a wider dataset from the 30 schools, we show that (1) boys have similar levels of absences to girls, (2) replication of the results using official school register data fails to detect the treatment effect, illustrating the need for high quality data on school absences. Narrow focus on absences limits our understanding of the effect that sanitary products have on schoolgirls' welfare: both sanitary pads and menstrual cups improved physical, emotional, social and educational well-being over time. Physical well-being improved in the sanitary pads group by 6.2%, and girls with heavy periods reported 10.1% improvements in emotional well-being from the menstrual cup. The results tapered off toward the end of the study in the sanitary pad group, but remained in the menstrual cup group—highlighting the trade off between strong initial effects of an easy to adopt disposable product compared with delayed and sustained effects of a complex, reusable technology at a significantly lower unit cost.

Keywords: Menstrual Health Management, Menstrual Cup, Sanitary Pads, Adolescence, Education, Absenteeism, Psychosocial well-being, PedsQL, Randomized Feasibility Trial.

Introduction

There are over 330 million school age girls around the world, with almost 80 million in sub-Saharan Africa alone. The gender gap in education is the largest in sub-Saharan Africa and it increases dramatically around puberty [1]. This raises questions about the role that menarche and the monthly management of menstrual periods play in determining girls' access to education.

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 strong correlation between menstruating days and absences from school in low- and middle-income countries [2–8], supported by findings from high-income countries that work-absences vary with the menstrual cycle [9,10]. On the other hand, these findings may suffer from self-reporting bias [3], be sensitive to specification or fail to replicate in other contexts [11], or even be economically insignificant [12].

The effects of menstruation on schooling may however reach far beyond the absent/present dichotomy. Menstruating days, in fact, correlate to lower work productivity [9,13], reduced concentration and participation in the classroom [4,14–16], and lowered psychosocial well-being due to stress and fear [4,16]. Therefore, absenteeism, while arguably important for school performance, is not the only relevant factor for educational success. Qualitative studies show that girls may suffer while in school due to the fear of leaking menstrual blood (because of lack of adequate protection) and the risk of being teased because of bad smell or leaks [8,15,17,18], which leads to reduced attendance, participation and concentration [14]. Girls in Kenya have reported shame and stigma surrounding menstruation, highlighting the psychological impacts of ‘menstrual poverty’ [19]. Some of the mediating factors—inadequate latrine infrastructure, poverty-related scarcity of sanitary products, and period-associated stigma—are more acutely relevant in low and middle-income countries [9], especially for vulnerable groups.

More research is warranted for four reasons. First, the question has not been sufficiently studied considering the size of the affected population. Second, disposable sanitary pads, one of the most commonly desired products [14,15,17], had not yet been evaluated in a randomized control study. Girls in Kenya—as well as in many other low and middle income countries—often use cloth, which is associated with physical discomfort, infections and leaking, despite preferring disposable sanitary pads [17]. Third, existing quantitative studies in low and middle-income countries that focus on menstruation often focus only on absences rather than other important factors that determine educational success, including physical, emotional and social well-being. Fourth, the majority of empirical quantitative (including non-causal) studies on the topic use self-reported recall absenteeism data or non-validated school records. This practice may lead to significant measurement error, but it is unclear if it leads to an overestimation or underestimation of menstruation-related absenteeism. We illustrate these four objectives by analyzing a cluster randomized control feasibility study conducted in Western Kenya that monitored school absences and psychosocial well-being. The three-arm randomized controlled design of the study allows us to compare outcomes across sanitary pad and menstrual cup users as well as to conduct a thorough cost-effectiveness analysis.

We contribute to a growing quantitative literature on how menstruation matters in an educational context. Similar studies include a small randomized trial in Nepal [20], a cluster quasi-randomized study across 8 schools in Uganda [21], and recently ongoing projects in Kenya [22] and Uganda [23]. We contribute to the literature by providing causal evidence on how access to different sanitary products can improve physical mobility as well as emotional and social well-being. The unique study design allows us compare to outcomes for two different sanitary technologies—menstrual cups and disposable sanitary pads—and thereby determine their relative efficiency. In addition, we replicate the results using school register data to demonstrate the importance of using validated data in program-based evaluations of absenteeism.

Background

Pupil absenteeism

Several interventions have been found to increase girls' school attendance and enrollment in low and middle income countries, including the provision of school uniforms [24], same gender teachers [25], providing school meals [26], and bicycles [27], as well as a range of non-gender targeted interventions [28].

One subset of interventions that can improve schooling attainment and school attendance includes health policies, such as *in utero* iodine treatment [29], deworming [30], combined deworming and iron supplementation [31], and hand-washing campaigns (through reductions in influenza, diarrhea, and conjunctivitis) [32]. In contrast to most health interventions, those that focus on access to sanitation 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 [33]. Similarly, a latrine-building program in India improved enrollment rates of adolescent girls, but not boys, when single sex latrines were built [34]. 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.

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. [16, 18, 35, 36]), synthesized in a recent meta-analysis [8].

Reaching menarche constitutes a particularly sensitive time period, as girls may reach it without prior knowledge about puberty and menstruation [16]. In South Asia specifically, the timing of menarche correlates with school dropouts and early marriage [37, 38].

In Kenya, results from focus group studies show that menstruation causes social stress among adolescent girls [17, 18], and it is linked to school absenteeism, reduced concentration while in school, and lowered self-esteem [4]. Schoolgirls also report fear of leaking menstrual blood and of sexual harassment from male peers and teachers [18]. A recent quantitative study from Tanzania confirms these findings [14].

The interaction of poverty with menstrual hygiene management, 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 [17, 39]. 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 [17].

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 [2], more than 50% in a study in Ethiopia [5]; 33% in a study in Tanzania [14], and in India the numbers range from 6-11% [6] to 24% [7], depending on the study population and region (see [40] 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 [3]. 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 [17].

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 [12]. While girls adopted the technology, partly due to network effects [20], 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 [12].

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 [41]. 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 [21].

Links to psychosocial functioning

There is limited evidence on the effect of MHM on psychosocial well-being [42], including cross sectional evidence on schoolgirls in Uganda [43]. In India, it was found that poor sanitation is associated with higher levels of anxiety and lower well-being among women [44]. 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 [41, 45]. 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 [45].

Methods

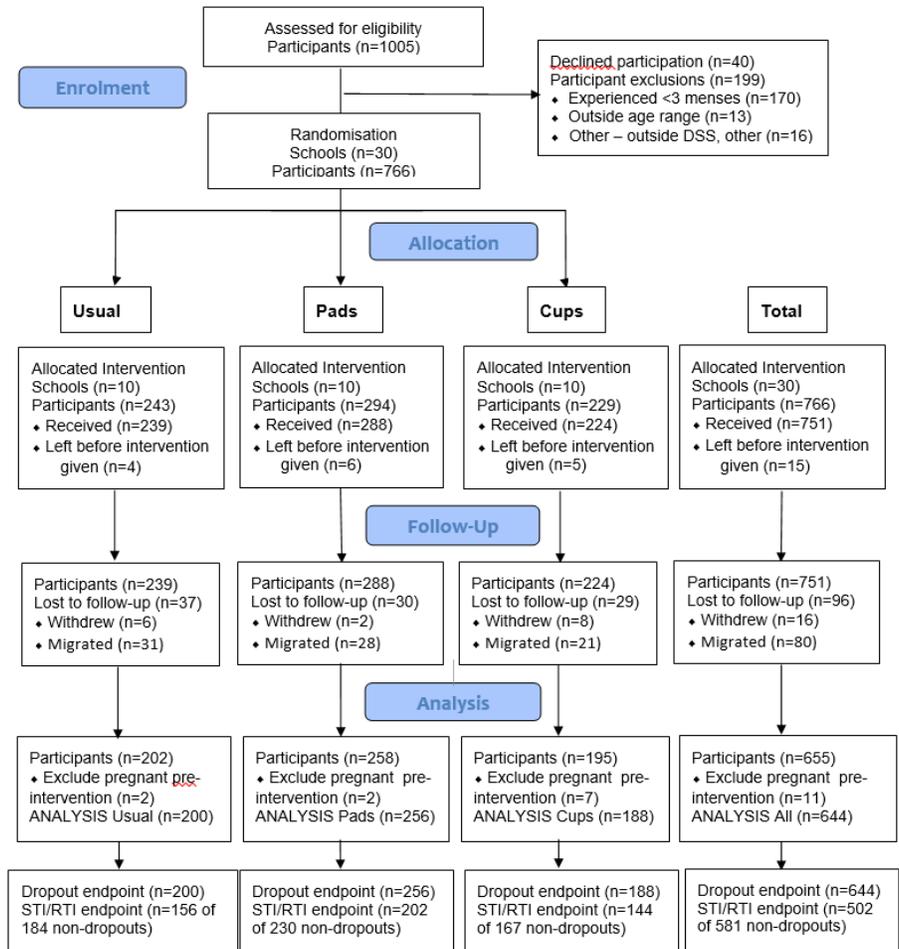
Program evaluation

We conducted a cluster randomized controlled feasibility study in Western Kenya (Fig 2) 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 (see flowchart in Fig 1). Due to capacity constraints the study had rolling enrollment, therefore, the program enrollment date varies across individuals and within schools.

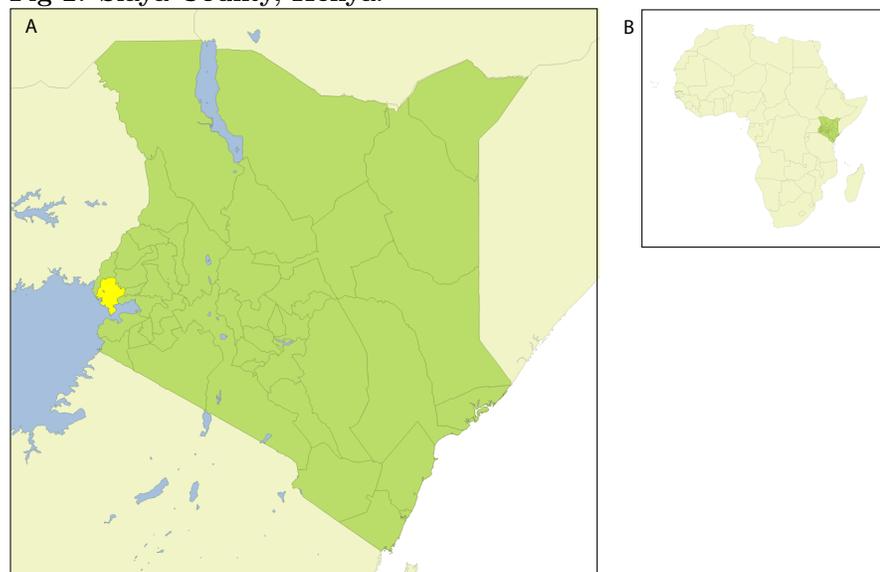
The three treatment arms were (i) an insertable menstrual cup, (ii) 16 sanitary pads monthly, or (iii) control (usual practice). For ethical reasons, all participants received private soap, puberty education, and could access a study nurse at the school. Because of the three-arm randomized controlled study design, we can compare the efficacy of sanitary pads and menstrual cups in improving outcomes, while taking cost and sustainability into account.

Fig 1. Flow Chart.



Notes: Flow chart of sample size. Reprint from [48]

Fig 2. Siaya County, Kenya.



Notes: Map of Kenya and Siaya County (A), and Africa (B)

We collected several types of data, including quantitative surveys at baseline, midline and endline, epidemiological testing, and roll-call data for all students. The study group also performed focus group research at baseline [17] and endline [4]. Epidemiological outcomes were analyzed in Phillips-Howard et al. (2016) [48]. 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), but there was no overall reduction in school drop-out rates [48]. However, school drop-out rates differed after interventions of 12 months or longer [48].

In line with previous findings, treatment girls were initially slow to adopt the menstrual cup (which is inserted into the vagina). [20]. Our study introduced the validation method of visual inspections of the menstrual cup to confirm self-reported use [48,49], as a menstrual cup will change color with persistent use. The validation indicated that girls over-reported use of the cup [49], but that adoption increased over time reaching above 70% at endline. Girls' self-reported use of the cup was 39% after one month, and 80% after 12 months [50]. 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 [48], in line with successful adoption rates [49].

Self-reported absence data from girls' diaries showed a 6-fold greater rate of absence during menstruation compared with non-menstrual days. However, the absenteeism rate reported in the calendars was minimal at 0.4% and 2% for non-menstruating and menstruating days, respectively [48]. This indicates that menstruation-related absenteeism is still fairly uncommon. However, the diary data could not be consistently collected, has not been cross-validated, and could suffer from self-reporting bias. As a result, our analysis of school absenteeism relies on roll-call data collected by the researchers. 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 the school record data instead of the researcher collected roll-call data.

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%) [51]. Moreover, 84% of schools had gender-specific latrines, 77% of latrines lacked locks, and only 16% of the latrines were considered clean [51]. 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 $< 70 : 1$ [48]) and were included in the study. 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 [52]. 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.

Using the pupil-latrine ratio, the trial statistician matched each of the 30 eligible schools in triplicate. Following this, an administrator not directly involved in the study placed the allocation assignments in three identical envelopes. Head-teachers and District Education Officers attended a community randomization ceremony. Head-teachers chose a colored ball from an opaque bag, with the color chosen determining the treatment status. After all of the balls had been chosen, a District Education Officer revealed treatment assignments by opening the three envelopes and revealing their color. Participants and study nurses were informed about the treatment allocation, but it was kept secret from the trial statistician and laboratory staff.

Ethics approval

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. Head teachers provided verbal consent for the data collection and review. In addition, girls provided written assent before participating in the study. The school administrations agreed to the researcher roll-call data collection method, but they were not informed about the dates during which the data would be collected.

Attrition

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 (see the flow chart in Fig 1). 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 [53]. Average age at first period is 14.6 to 15.1 years, around the time of transition between primary school to secondary school.

766 girls were subsequently randomized into the three treatment groups. 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. Note that girls who became pregnant during the study period were not excluded. 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) [48].

We work with two different samples, partly due to data availability. In the main analysis of school absences (which were collected for all students at these schools), we avoid having an endogenous sample by excluding 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. We complement the analysis without the students who migrated during the study or who were pregnant at baseline (sample=644), while for the psychosocial well-being outcomes, we work with the sample of 644 students who participated fully in the study period.

Measuring Adoption

We monitored the adoption 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 [49]. Girls verbally report using the cup earlier than the color-change is observed, although over the course of 10-12 months the two converge, and adoption is almost universal after 10 months. However, because of rolling enrollment, some girls were followed for less than 10 months [49].

PedsQL™ indicators for psychosocial well-being

We use the Pediatric Quality of Life Inventory (PedsQL™) 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. The supplementary information section contains a table that lists each individual question that was used to create the scales (S1 Table). 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.

The 4.0 Generic Core Scale has previously been utilized in a menstruation related quality of life study among 184 adolescent girls in Australia [54]. 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 [54]. 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 [55], in line with Bisegger et al. (2005) [56]. Knox et al. (2015) argues that while menstrual issues are common among adolescents, they warrant further study due to the effects they may have on psychosocial functioning [57].

Researchers have previously employed the PedsQLTM 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 [58]. A similar study focused on febrile children, ages 2-18 in Western Kenya, with suspected malaria and/or dengue fever. After a one-month follow up, the authors found that the PedsQL scores had increased among children with fever due to malaria or other causes, but less so among children with dengue [59], illustrating that the metric is responsive to changes in children in our study region.

Econometric specifications

The main regression specification compares outcomes 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*.

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

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 roll-calls collected, and as an alternative in the robustness section to account for the slow adoption rate. 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.

Balance at baseline

Table 1 shows balance at baseline surveying for the main observable characteristics. No statistically significant differences in age, class or period characteristics are observed for the three treatment groups. However, the socio-economic status (SES) is slightly higher

in the treatment groups compared to the control group. Only a few differences are observed in the roll-calls across the treatment groups, for term 0 roll-call 1, and for term 3 roll-call 1.

Table 1. Balancing table for the RCT

Treatment arm: Variable:	Menstrual cup	<i>p</i>	** $\alpha = 0.05$ * $\alpha = 0.1$	Pads	<i>p</i>	$\alpha = 0.05$	Control
<i>Observable characteristics</i>							
age	14.56	0.76		14.51	0.08	*	14.58
class	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
<i>roll-calls</i>							
absent (all roll-calls)	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
<i>Psychosocial functioning indices (post)</i>							
physical functioning index (post)	72.595	0.054	*	73.281	0.011	**	69.74
emotional functioning index (post)	74.142	0.067	*	72.986	0.264		71.454
social functioning index (post)	78.266	0.064	*	77.286	0.2097		75.528
educational functioning index (post)	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. 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).

The psychosocial functioning indices were only consistently collected post intervention. Therefore, we cannot test for balance at baseline. 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. Moreover, as some 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. However, we cannot prove that the evolution in these scores prior to treatment was equivalent across treatment arms.

Parallel trends

The roll-calls were collected at multiple times before and after treatment. As a result, we are able to explore the trends in absenteeism over the treatment period. Similarly, because enrollment in the program was rolling, the start date of the intervention differs across students, therefore, the x-axis for time centers around the date of the intervention (day 0). Fig 3 shows pre and post intervention levels in absenteeism, with the x-axis being a continuous measure of time in days. A few results stand out: (i) absenteeism levels are on an increasing trend in all treatment groups, (ii) there are pre-intervention differential levels in absenteeism, potentially due to school level differences in levels, (iii) the sanitary pad group has higher pre-intervention absenteeism, but exhibits a less sharp increase in absenteeism over the treatment period.

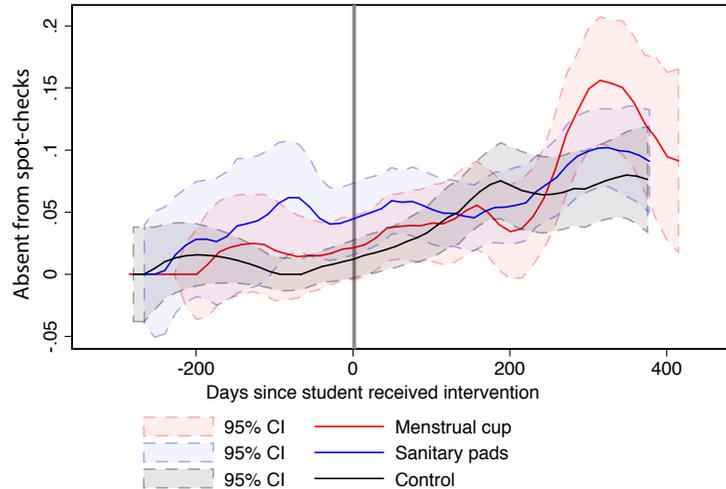


Fig 3. Local polynomial smooth for timing of effects. Notes: The figure plots local polynomial smooth with 95% confidence intervals. Day 0 represents the day the student received the intervention, with a calendar date that varies across individuals.

Results 342

Effects on school absenteeism 343

Table 2 shows the main results of the program regarding absenteeism. The menstrual cup treatment arm did not reduce absenteeism, in line with the visual evidence examined in Fig 3. However, the sanitary pad treatment arm reduced absenteeism by 7.9 to 7.8 percentage points, 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 month and school fixed effects (Table 2, columns 1-3). 344
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Temporal effects on absenteeism 350

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. 351
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Effects on psychosocial well-being 357

We collected well-being measures as part of the study, and changes in these well-being measures could shed light on the mechanisms driving the main results. The menstrual cup and sanitary pad interventions increased girls' physical well-being by 3.9% (statistically insignificant) and 5.4% (statistically significant at the 10% significance level) respectively (Table 2, Panel B). We explore sensitivity to alternative specifications, such as bootstrapped standard errors and heterogeneity in outcomes due to students' period-characteristics in S2 Table. Girls who report having heavy periods benefit emotionally from the menstrual cup (10.1%, Panel B), and girls with light or medium periods report large improvements (7.3%) in physical well-being from the sanitary pad 358
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Table 2. Main Results on Absenteeism and Heterogeneity by Timing of Effects in Before-After Analysis

Panel A: Absenteeism						
<i>Sample:</i>	(1)	(2)	(3)	Before+50% after		
				(4)	(5)	(6)
menstrual cup * after	0.019 (0.023)	0.020 (0.025)	0.020 (0.025)	0.042 (0.036)	0.043 (0.037)	0.043 (0.037)
pads * after	-0.079* (0.044)	-0.078* (0.043)	-0.078* (0.043)	-0.090* (0.048)	-0.089* (0.047)	-0.089* (0.047)
menstrual cup	-0.187*** (0.020)	-0.191*** (0.023)	-0.062*** (0.019)	-0.176*** (0.029)	-0.181*** (0.033)	-0.014 (0.031)
pads	-0.051 (0.032)	-0.046 (0.034)	0.041 (0.041)	-0.084*** (0.024)	-0.080*** (0.027)	-0.039 (0.035)
after	0.027* (0.014)	0.023 (0.016)	0.023 (0.016)	0.021 (0.045)	0.017 (0.048)	0.017 (0.048)
SES level		0.016 (0.014)	0.016 (0.014)		0.015 (0.023)	0.015 (0.023)
days of bleeding			-0.029*** (0.004)			-0.042*** (0.006)
Observations	3,083	3,083	3,083	1,816	1,816	1,816
R-squared	0.056	0.058	0.058	0.085	0.086	0.086
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
All roll-calls	Yes	Yes	Yes	No	No	No

Panel B: Psychosocial functioning				
<i>Outcome index:</i>	Physical	Emotional	Social	Educational
	functioning	functioning	functioning	functioning
	(0-100)	(0-100)	(0-100)	(0-100)
	(1)	(2)	(3)	(4)
menstrual cup	2.835 (1.700)	2.679 (1.989)	3.545 (2.157)	3.664 (2.259)
sanitary pads	3.955* (1.998)	0.597 (2.371)	1.372 (2.143)	1.449 (2.033)
Observations	1,246	1,246	1,246	1,246
R-squared	0.092	0.071	0.092	0.084
Mean value (control group)	69.74	71.454	75.528	71.79
Controls	Yes	Yes	Yes	Yes
SES level control	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes

Notes: All regressions control for month and school fixed effects, age and class. Clustered standard errors at the school level in parentheses. Outcome variable is the dichotomous variable "absent" in Panel A, and the four psychosocial functioning indices in Panel B. *** p<0.01, ** p<0.05, * p<0.1.

(Panel C). It is worth noting that while only a handful of the slope coefficients are statistically significant, all point toward improvements in psychosocial well-being.

These quantitative estimates are corroborated by reports from focus-groups collected after the intervention. Students who received sanitary pads or the menstrual cup reported that they were able to focus on their studies and what the teacher was saying, instead of worrying about leaking. Furthermore, parents observed that the girls using the program sanitary products were more free and confident [4].

Temporal effects on psychosocial well-being

Fig 4 shows regression coefficients by month since treatment for the menstrual cup and the sanitary pad groups occurs monthly. We did not collect The well-being indices at baseline, therefore, we cannot test for balance. However, the questions were collected multiple times after the intervention, so we estimate the treatment effects for each month since the beginning of the intervention. The first month is never statistically significant, which is in line with pre-intervention balance. We estimate statistically significant and positive treatment effects for several months after the beginning of the intervention. Overall, we find some positive and statistically significant treatment effects for both treatment arms across all four psychosocial indices.

However, the effects of the sanitary pad treatment arm seem to taper off toward the last month (month 13). For some girls, 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 no such tapering off of effects. These effects highlight potentially important sustainability effects of the different treatment arms. As a robustness check, tables that exclude observations collected after the end of the program (follow up) can be found in the supplementary information section. Nevertheless, in these exercises we still observe a tapering off of the treatment effects, especially for the sanitary pad group (see S1 Figure and S2 Figure). The students may respond in anticipation of losing their benefits at endline, such as the end of their access to free sanitary pads, soap and the school nurse. The latter two benefits were, however, universal for all study schools.

Effects on single PedsQL functioning measures

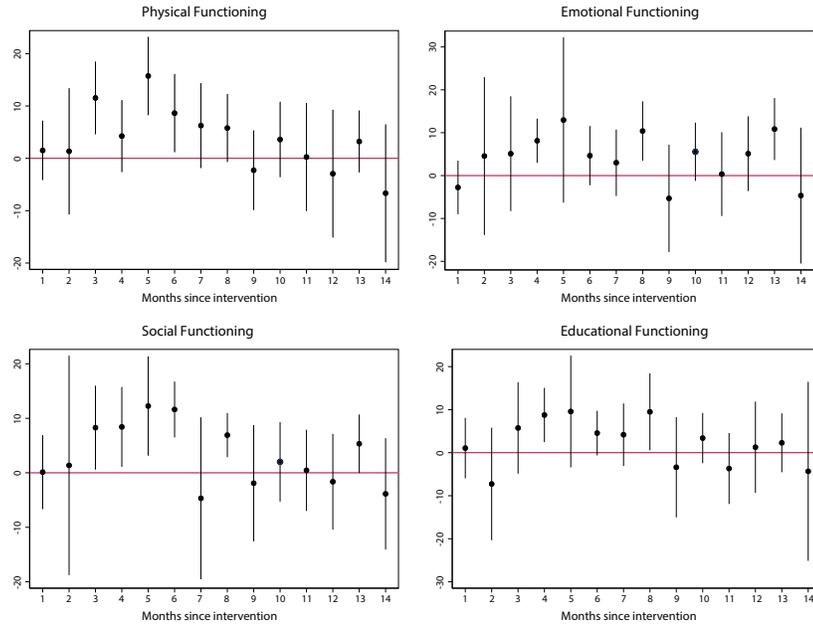
In addition, we include coefficient plots for all the components of the scores and find that a majority are positive and some are statistically significant (5). This confirms that the indices are not driven by outliers and are representative of general trends. We encourage against interpretation of the individual components and labels are not provided.

Robustness

Sensitivity to cluster exclusion

To test the robustness of results from school-specific shocks, we ran the main regression specification (controlling for school fixed effects, month fixed effects, and individual level controls) while dropping one school at a time. The results are robust as 26 out of 30 specifications yield statistically significant results at the 10% confidence level for the sanitary pad interaction term (see Fig 6). The exclusion exercise did not affect our interpretation of the menstrual cup treatment arm as our results remained statistically insignificant.

A. Menstrual Cup



B. Sanitary Pad

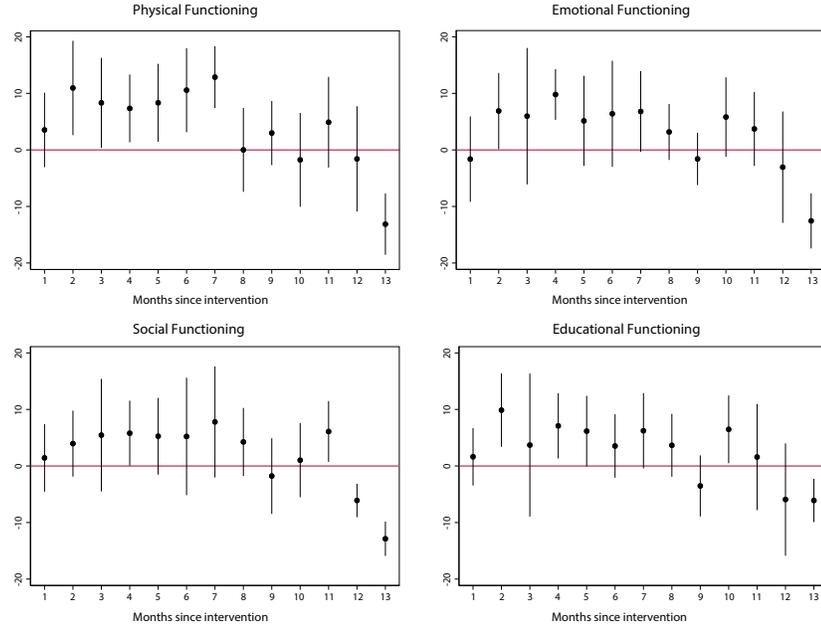


Fig 4. Coefficient plot for menstrual cup and sanitary pad treatment on psychosocial functioning indices. Notes: The figure plots the coefficients for the interaction term *months since intervention*menstrual cup* (Panel A), and *months since intervention*sanitary pads* in Panel B. Comparison is with the control group. Controls for duration in months, age and class. Clustered standard errors. Includes individuals surveyed after the end of the intervention.

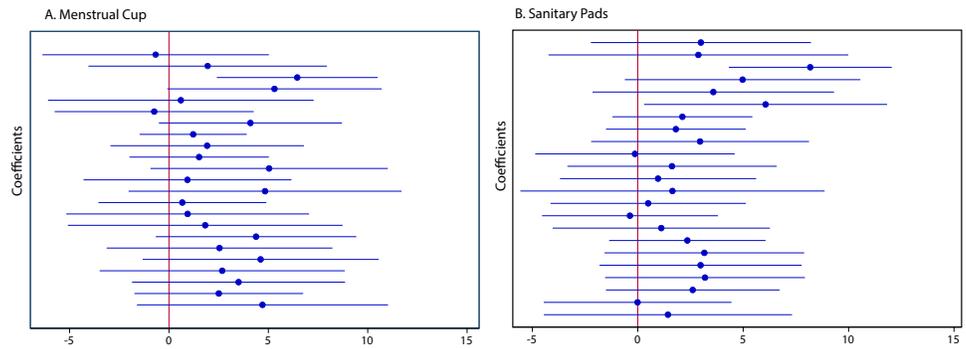


Fig 5. Coefficient plot for single psychosocial functioning measures. Notes: The figure plots the treatment coefficients for all the outcomes included in the index scores. Comparison is with the control group. Controls for duration of participation in the program (in months), age and class. The figure does not allow for exact interpretation of each variable.

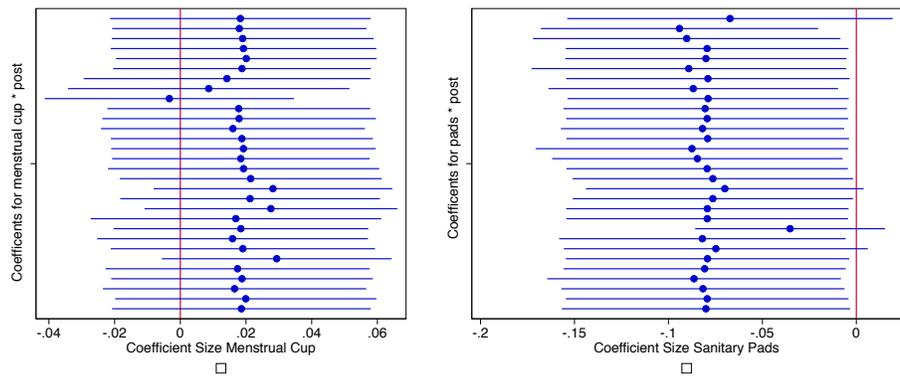


Fig 6. Coefficient plot of interaction effects (Treatment * Post) while dropping one school at a time. Notes: Coefficient plot of interaction effects *menstrual cup * post* and *pads * post* for the preferred specification while reducing the sample with one school at the time. 90% confidence intervals are plotted.

Measurement error stemming from school records

Thus far we have used roll-call data in the analysis. However, in addition to collecting roll-call data, the official school registers were collected on roll-call days for all students. To validate our results, we rerun our analysis of the program using roll-call data and the school records. Table 3 panel 1 uses the main difference-in-difference specification, while columns 3 and 4 show the results using the same specification but define absenteeism through school register data instead of roll-call data. Using the inadequate 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 3. Treatment effects on absenteeism using roll-calls or school records

<i>Outcome:</i>	Absent				Chi-square (columns 1 and 3)
	Roll-call data		School record data		
<i>Data source:</i>	(1)	(2)	(3)	(4)	(5)
post * menstrual cup	0.019 (0.023)	0.020 (0.025)	-0.014 (0.034)	-0.015 (0.033)	0.75 (p = 0.386)
post * sanitary pad	-0.079* (0.044)	-0.078* (0.043)	-0.017 (0.029)	-0.017 (0.029)	3.39 (p = 0.655)
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.

Mechanisms

Heterogeneity by severity of physical symptoms

For the students participating in the program, we have baseline information for 543 students regarding the duration and flow of their 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. Table 4 shows the pairwise correlation coefficients between these variables and absenteeism in the first roll-call. Experiencing period cramps somewhat correlates with heavy bleeding and longer periods. However, both cramps and length of period are negatively correlated with being absent from the first roll-call, although heavy bleeding is positively correlated with being absent from the first roll-call. A triple-difference specification, where heavy bleeding or a principal component (cramps, heavy bleeding, length of period) was interacted with the treatment variables, can be found in the supplementary information section (see S3 Table). We did not identify any heterogeneous treatment effects on absenteeism depending on the self-reported severity/length of the menstrual cycle.

Table 4. Pairwise correlations for physical symptoms and absenteeism

<i>Variable:</i>	(1)	(2)	(3)	(4)
	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.

Gender differences in absenteeism

Next, we test if adolescent schoolgirls are absent from school more compared to boys of similar ages to determine if it is plausible that girls miss several school days during their period. We use an original dataset that includes more than 6,000 female and male primary school students across the 30 study schools included in the program. The full data set consists of 71,140 observations, 6,836 of which are roll-call and register entries for students who participated in the randomized control study.

All observations of study participants were removed from the initial analysis to avoid contamination from the intervention. 32,349 roll-call data points remain for 6,057 students (see S4 Table). 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.

The average student in the sample was 12.9 years old, with the age ranging from 8 to 21 years, and 46% of students were girls. Absenteeism patterns are similar for girls (A) and boys (B) with girls missing 13.0% and boys missing 12.1% of roll-calls. The majority of students were absent less than 10% of the time and a smaller share were absent between 10% and 100% of the time (Fig 7).

To analyze these patterns, we use following specification:

$$Absent_{ism} = \beta_0 + \beta_1 female_i + \beta_2 age_i + \beta_3 grade_i + \delta_m + \alpha_s + \varepsilon_{ism} \quad (3)$$

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/or school fixed effects (α_s), to take care of heterogeneity in timing of absenteeism, and variability that come from school-specific factors in absenteeism. The month fixed effects will soak up any variation that comes from the timing of the roll-calls. This may be important if absenteeism differs across the months, for example due to the agricultural seasons. Moreover, the school fixed effects absorb any observable or unobservable variation at the school level (including a more permissive norm toward absenteeism at some schools). We include controls for both age and grade, despite them being correlated. In Kenya, there is ample variation in age within a given grade because some students start school later or retake grades. To measure heterogeneity by age, we use a spline specification:

$$Absent_{ism} = \beta_0 + \sum_{a=10}^{18} \beta_a + \beta_{10} female_i + \beta_{11} grade_i + \delta_m + \alpha_s + \varepsilon_{ism} \quad (4)$$

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

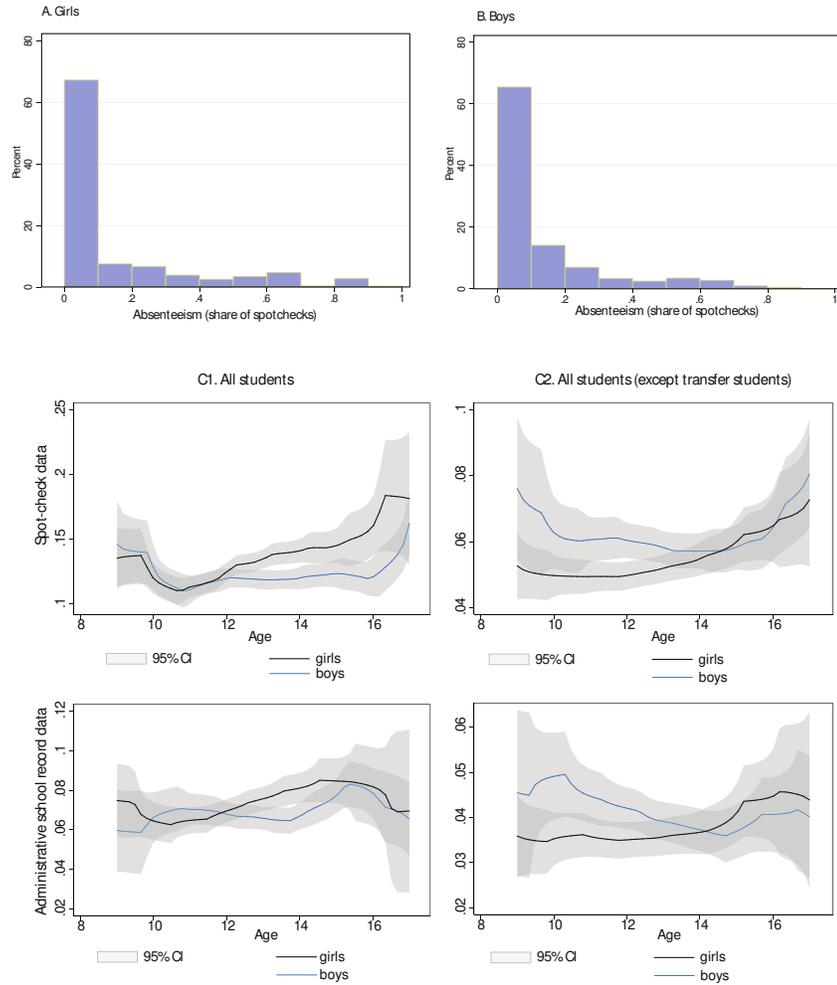


Fig 7. Absenteeism for girls (A) and boys (B) and across roll-call data and school register data (C-F) Notes: (A and B): The data is collapsed by student and student mean absenteeism is plotted on the X axis. (C-F): Local polynomial smooth with 95% confidence intervals. The data is collapsed by student age (9-17) on the X-axis and student mean absenteeism is plotted on the Y axis. Because of small sample sizes below 8 and above 17, these ages are excluded.

All students older than 18 are excluded from the analysis in this subsection because of small sample sizes. Each age category will have its own regression coefficient, allowing for a non-linear relationship with age (Fig 8), and age 8-9 is used as the reference category. Absenteeism among boys in each age category is not statistically different from the reference category of 8-9 years old. However, the age coefficients are statistically significant for girls, meaning that absenteeism is more common among older girls, controlling for grade and fixed effects for school and survey month. Results for two-year age bins are reported in the supplementary information section (see S6 Table).

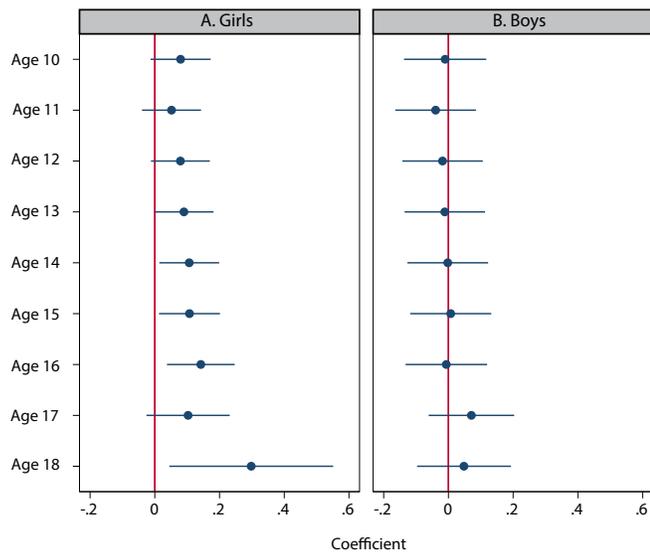


Fig 8. Regression results on absenteeism for girls (A) and boys (B). Notes: Reference category is age 8-9. Ages 19-21 are excluded because of small sample sizes. The regressions control for grade, school fixed effects and month fixed effect, and uses robust standard errors. Column 1 and 2 are two separate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

The mean age of menarche in Western Kenya is 14.6-15.1 years of age [53]. We shed particular focus on this group (see S5 Table), and find that for this age group, girls are 1.9-2.2 percentage points more likely to be absent on a roll-call day. The mean value of absence among boys and girls aged 13-16 is 12.8 percent, making the effect equivalent to 14.8% higher absenteeism among girls using the preferred specification (column 5).

Reasons for school absenteeism may vary across age and gender, as girls and boys face different expectations and demands from parents, peers, and teachers, and have different biological needs. Upon noticing that a student was absent, the researchers noted a reason for the absence. A limitation is that the reason is not directly reported by the absent student themselves, but by the teachers and peers. It is likely that certain reasons would be under-reported (such as menstruation, which is stigmatized) and others over-reported (such as sickness, if it becomes a "catch all" category). Table 5 ranks the reason for absenteeism for the 4,051 recorded absences in the roll-call data, and presents a p-value for the difference in means between boys and girls. Note this data excludes all present students. For 6.79% of the absent roll-calls, *unknown reason* was stated, which is different from no reason stated (*not available*, 0.04%). Girls are more likely absent because of school transfer, but are less likely absent because of being sick or having dropped out. There is no gender difference in having left school early on the day of the roll-call check.

Table 5. A) Reason for absenteeism for boys and girls B) Summary statistics roll-call datasets for boys and girls

Panel A: Reason for absenteeism						
<i>Sample:</i>	All students		Boys	Girls	p-value	$\alpha = 0.005$
	Frequency	Percent	Mean	Mean		
	(1)	(2)	(3)	(4)	(5)	(6)
Transferred to other school	2,390	59.00	0.542	0.642	0.000	*
Sick	883	21.80	0.236	0.199	0.0049	*
Dropped out	199	4.91	0.061	0.037	0.004	*
Fees	135	3.33	0.04	0.026	0.0155	*
Left school early	130	3.21	0.034	0.03	0.4308	
Passed away	17	0.42	0.007	0.001	0.0027	*
Changed class	12	0.30	0.002	0.004	0.4737	
Domestic duties	3	0.07	0	0.001	0.5178	
Suspended	2	0.05	0.001	0	0.1741	
Attending Funeral	1	0.00	0	0.001	0.2981	
Got married	1	0.02	0	0.001	0.2981	
Is pregnant	1	0.02	-	0.001	0.2981	
Unknown reason	275	6.79	0.076	0.059	0.0241	*
Not available	2	0.04	0	0.001	0.9551	
Total	4,051	100.00	2,106	1,945		
Panel B: Summary statistics						
	Mean	Std. Dev.	Min.	Max.	Obs.	Days missed in a month
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Girls</i>						
age	12.547	1.4	8	21	14924	-
grade	5.737	0.830	5	8	14924	-
absent	0.13	0.337	0	1	14924	2.73
absent (excluding transfers)	0.051	0.22	0	1	13675	1.071
reason for absent is sick	0.026	0.159	0	1	14923	0.546
<i>Boys</i>						
age	13.151	1.621	9	20	17425	-
grade	5.871	0.878	5	8	17425	-
absent	0.121	0.326	0	1	17425	2.541
absent (excluding transfers)	0.059	0.236	0	1	16284	1.239
reason for absent is sick	0.028	0.166	0	1	17425	0.588

Notes: Reason stated for absenteeism in the roll-call data. The reasons are not reported by the student. Panel A Column 5, presents the p-value to a two-sided t-test of the mean for boys (Panel A, column 3) and girls (Panel A, column 4). Panel B describes the summary statistics for the roll-call dataset for boys and girl.

Unfortunately, we cannot confirm to what extent "transfer" is capturing both transfers and drop-outs. Absenteeism for girls drops from 13% to 5.1% when outbound transfer students are excluded from the sample (Table 5, Panel B). For boys, the comparable values are 12.1% and 5.9%. We translate the average days absent into days per school month, counting a school month as 21 days. Total absenteeism including transfers is 13% for girls, equivalent to 2.73 school days in a month (the upper bound). Excluding transfer students, the absenteeism drops to just above 1 day per month. Girls are absent because of sickness in 2.6% of roll-calls equivalent to 0.55 days per month. Boys miss, on average, 0.59 school days per month because of sickness. Replicating the previous regression analysis and excluding transfer students flips the signs for the female dummy (S7 Table and S8 Table).

We note some limitations to this analysis; First, students who quit school prior to the study period are not included, meaning that the most vulnerable part of the population may have been excluded. Second, school eligibility criteria may, by design, have excluded the most vulnerable population who attend schools with the lowest latrine quality. Third, while the quality of the roll-call data is deemed high, the recorded reasons for absenteeism are based on school reporting as the student was not present to report directly to the researcher. Menstruation was never recorded as a reason for absence. Lastly, the time of the day the roll-call check was conducted was not recorded, making it potentially biased due to students leaving school early.

Discussion

Cost-effectiveness analysis

Menstrual cups may provide an effective, economically and environmentally sustainable alternative to single-use sanitary pads. A recent meta analysis and review study found that the menstrual cup is used internationally, and is safe [60]. Adoption of the menstrual cup (as monitored by changes in the coloration with persistent use), is not imminent but requires attempts over several menstrual cycles, in line with findings from van Eijk et al. (2019) [60] and Oster and Thornton (2012) [20].

A menstrual cup costs about 8 USD and lasts for 10 years, leading to 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 sanitary pads, unlike the menstrual cup, reduced school absenteeism, and both treatment arms improved psychosocial well-being.

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. 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 and puberty education has on absenteeism and well-being. A more detailed cost-benefit and cost-effectiveness analysis of the program, which includes the improvements in DALYs from the reduction in infection rates, can be found in Babagoli et al. (2020) [61].

The analysis highlights a trade-off between the simple and desirable but environmentally and economically unsustainable product of disposable sanitary pads,

and the more complex technology of menstrual cup that can provide protection for up to 130 menstrual cycles at a very small marginal cost. Given the promising findings from focus groups and the psychosocial well-being analysis, the menstrual cup may be a reasonable substitute for effective public health policy. However, future studies must determine the long term effects on enrollment and absenteeism of the menstrual cup.

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 only 10 schools per treatment arm. 30 clusters may yield enough statistical power to detect treatment effects. 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. Third, the menstrual cup adoption rate increased slowly over time. Students were found to successfully use the cups after 9 to 12 months [48, 49], in line with Oster and Thornton (2012) [20]. 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 [50, 60]. 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 data due to data collection methods. The absenteeism data includes students who had dropped out of school, while the PedsQL 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.

The absenteeism specifications include controls, school fixed effects, month fixed effects, and cluster standard errors at the school level which was the level of the randomization. Adding individual fixed effects and individual level clustering to the model specification leads to a reduction in statistical significance and coefficient magnitudes, but the direction of the relationships remain. For instance, we still see a negative treatment effect for the sanitary pad arm, but it is no longer significant.

Moreover, Kenya has in the recent years been at the forefront of supporting girls' MHM needs. In recent years, the Kenyan government has been providing free sanitary pads in public schools to help female students with menstrual needs. Early on in the government program, though, the provision was found to be inadequate [46], which is why we believe this policy did not interfere with our treatment protocol. Since 2017, Kenya has further stepped up their efforts to strengthen MHM programming in its educational system, including the development of a teacher handbook and standards for assessing how MHM friendly school sanitary infrastructure is [47], becoming a role model for MHM integration into the educational setting.

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 (taking into account the positive trend in absenteeism across all groups). In line with the results from Nepal by Oster and Thornton (2011) [12], we do not find that the menstrual cup treatment arm statistically reduced the incidence of absenteeism. While the failure to detect an effect could stem from the slow adoption of the menstrual cup and limited statistical power because of the program design, we test for delayed treatment effects across both treatment arms and find no evidence of a delayed effect on absenteeism in the menstrual cup treatment arm.

Importantly, we show that the effects of access to menstrual products reach beyond absenteeism. Both the menstrual cup and the sanitary pads increased girls' physical well-being by 3.9% (not significant) to 6.2% (statistically significant), respectively. In addition, girls with heavy periods who received the menstrual cup benefit emotionally (10.1%), whereas those with light periods who received the sanitary pads improved 7.3% on the physical score.

While not all of the coefficients that multiply the psychosocial indices are statistically significant, we show clear effects both in aggregate, for heterogeneous sub-groups and over time. Effects on well-being taper off in the sanitary pad treatment arm toward the end of the study period, indicating that girls' well-being is reduced at the end of the program when the girls lose the benefits of the program. 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.

The comparison of two different 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 provides 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.

Furthermore, we put these estimates into context by comparing with absenteeism data for boys enrolled in the same 30 schools. Absenteeism is not limited to adolescent girls. Girls are about 1 percentage point more likely to be absent than boys (13% of days missed, compared to 12.1% for boys). Boys are more likely to be reported absent because of sickness and have higher drop-out rates than girls, while girls are more likely to be reported as having transfer to another school. Non-transfer related absenteeism is fairly low, at around 1 school day per month for both girls and boys, of which roughly half a day is missed because of reported sickness. A back-of-the-envelope calculation indicates that girls and boys miss around 13 to 15 days of schooling per year, and that sickness accounts for about half of them. These numbers are still below the hypothesized level of menstruation-related absences often cited in the media, and highlight that boys also face challenges that similarly constrain attendance.

The analysis adds to a growing literature on the role of access to sanitary products for school absenteeism, such as Montgomery et al. (2016) [21] and Oster and Thornton (2011) [12]. Given the reported absenteeism levels among boys (12.1%) and girls (13%), in the absence of constraints specific to boys, a program aiming to reduce absenteeism among girls through menstrual health interventions needs to be well-powered to detect such effects. The results indicate that future researchers should further explore pupil absenteeism for both boys and girls, and that adolescent boys' absenteeism warrants

attention equal to that of girls.

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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Author contributions

Study design: PAP-H, KFL, LM, CO

Funding: PAP-H, KFL, ABT

Data collection in field: GZ, EN, CO, LM, DO, KA, KFL, PAP-H

Conceptualization: ABT, GZ, PAP-H

Formal analysis: ABT

Writing: ABT

Revisions: ABT, GZ, PAP-H, LM

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