Center for European, Governance and Economic Development Research
cege

Discussion Papers

Number 364 – January 2019

MENSTRUATION HYGIENE MANAGEMENT AND WORK ATTENDANCE IN A DEVELOPING COUNTRY

Astrid Krenz and Holger Strulik

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

ISSN: 1439-2305

Menstruation Hygiene Management and Work Attendance in a Developing Country*

Astrid Krenz†

Holger Strulik‡

January 2019

Abstract. Women in developing countries face challenges in terms of managing their menstrual hygiene. Oftentimes they do not possess the right means nor materials nor have access to the right facilities. Using a newly released dataset for Burkina Faso and propensity score matching, we provide for the first time evidence of a strong causal impact of advanced menstrual hygiene management on work attendance. Access to advanced menstrual hygiene management materials (disposable sanitary pads) reduces work absenteeism of women by about 21 percentage points. When we stratify the sample by religious affiliation, we find the treatment effect to be insignificant for Christian women and strong and significant for Muslim women.

Keywords: Menstrual Hygiene Management, Work Attendance, Period Poverty, Propensity Score Matching, Gender Inequality.

JEL: D10, I12, I14, J16, O12.

* We would like to thank Stephan Klasen and Sebastian Vollmer for valuable comments. Astrid Krenz is thankful for support by an EU Marie Curie Cofund / Durham Junior Research Fellowship under EU grant agreement number 609412. The Stata Code that was programmed for the analyses is available upon request.

† Durham University Business School Mill Hill Lane Durham DH1 3LB, United Kingdom; email: astrid.m.krenz@durham.ac.uk.

‡ University of Göttingen, Department of Economics, Platz der Göttinger Sieben 3, 37073 Göttingen, Germany; email: holger.strulik@wiwi.uni-goettingen.de.

1. Introduction

Menstruation affects women's participation in daily life around the world. During their lifetime, women experience about 480 menstrual cycles, albeit with great variation at the individual level (NHS, 2018). The length of the menstrual period also varies but most periods last from 3 to 5 days (Women's Health, 2018). Aggregating averages, this means that women bleed about 2000 days or 5 years of the their life. Most of the menstrual periods are experienced in working age and we expect that the influence of menstruation on work participation depends on the quality of the used methods of menstrual hygiene management (MHM).

Menstrual management methods range from the medical suppression of menstruation to eating a balanced diet to the separation of menstruating women from particular places or activities. Here we focus on the most salient menstrual practice, the management of menstrual flow to prevent blood from soiling the clothes and, in particular, on the material used to absorb menstrual blood. In contrast to some related studies we consider all methods to absorb or catch menstrual blood, be they good or poor (or adequate or inadequate) as menstrual hygiene management methods. The WHO and UNICEF define *adequate* menstrual hygiene management as "women and adolescent girls using a clean menstrual management material to absorb or collect blood that can be changed in privacy as often as necessary for the duration of the menstruation period, using soap and water for washing the body as required, and having access to facilities to dispose of used menstrual management materials." (WHO 2012).

Women use a variety of materials to absorb or catch menstrual blood. Most women who can afford it use commercially manufactured products like disposable sanitary pads. In developing countries, however, many woman use inferior products like new or old cloth, cotton wool, toilet paper, underwear alone, sponge, mattress, leaves, ash, or nothing (Sumpter and Torondel, 2013; Loughnan et al., 2016; van Eijk et al., 2016). Most women in our sample from Burkina Faso use either "disposable sanitary pads" or "old cloth" to absorb menstrual blood. While both materials require a safe place to be changed, the reuse of old cloth poses further challenges of cleaning or storing the material. These tasks could be difficult or impossible to perform in work environments of subsistence agriculture or informal employment as, for example, street vendors without access to a private place to change and clean MHM materials during the workday. As menstruation remains a taboo and women are stigmatized by socio-cultural beliefs that regard menstruation as an impureness, women might not be able to clean their MHM materials

particularly in such a work setting that is open to the public (UNICEF 2013). Anticipating these difficulties, women may prefer to stay at home during their period.

The most obvious advantage of disposable sanitary pads is hygiene. If reused cloths are not washed and dried properly or washed with unclean water, they can cause vaginal infections and harmful diseases (Das et al., 2015; Torondel et al., 2018), which may prevent participation in the workforce due to bad health. Another important advantage of sanitary pads, in particular in environments where menstruating women are socially stigmatized, is that their use is less visible and that they are less subject to leakage. Menstruating women are thus less likely identified and subject to humiliation or exclusion from work. We expect the strength of this effect to vary with the women's religion and her religious environment. For example, Islamic faith regards menstruating women as impure and men are recommended to avoid women during menstruation (Whelan, 1975). Finally, sanitary pads are more convenient to wear and may better allow to perform motion-intensive and physically demanding work. In a sample of Ghanaian adolescent girls who were exposed to sanitary pads and cloth or toilet rolls as MHM materials, 98% stated that they were less fearful of soiling when using pads and 95% were less concerned about giving off a scent; 82% stated that pads were more comfortable, and 60% stated as an advantage that pads do not have to be washed (Scott et al., 2009).[1]

Although menstruation affects all women from menarche to menopause, studies on MHM practices and their impact on participation in daily life in developing countries focus on adolescent girls and the impact of MHM on school attendance. Studies of MHM on work attendance are a neglected issue (Sommer et al., 2016a and 2016b). With respect to school attendance several studies on African and South Asian countries find that girls miss school during their menstruation and that menstrual education and/or the provision of advanced MHM material reduces absence. However, most studies fail to control properly for confounders, suffer from measurement error and fail to establish a causal link (see Sumpter and Torondel, 2013, and Kuhlmann et al., 2017 for surveys). Of the rare studies using a quasi-randomized experimental design, Montgomery et al. (2012, 2016) and Hennegan et al. (2016) find a significant impact of sanitary pad provision on school attendance in Ghana and Uganda, respectively, while Oster and Thornton (2011) find no significant impact on menstrual cup provision in Nepal. One reason

[1]Work ability and attendance is also effected by menstrual pain. Aside from infections, we would, however, expect that pain arises independently from the used MHM material.

for this non-finding, they argue, is that (for the girls of their sample) menstruation has anyway a very small impact on school attendance. This contrasts with the African studies, which found that girls miss school for several days per month due to menstruation and its inadequate management.

A few studies discuss potential explanations for these ambiguous results. One is that girls were reported to help each other at school, when having their menstruation (UNICEF, 2013), or they were rather put under pressure to share a MHM material (Scott et al. 2009) which means that the impact of a policy intervention is hard to be evaluated without any bias, when treatment and control group participants mix up. Moreover, the menstrual cycle of a woman is a very sensitive subject, that can become very long when the body is subject to starvation or heavy and stressful work or sports e.g., moreover, the cycle is becoming shorter and more regular with age, whereas cycles tend to be longer and irregular for the first few years after menarche (UNICEF, 2013; Women's Health 2012). Young school girls may thus not miss many schooldays due to their very long or irregular cycles and results from experimental studies could be blurred by natural circumstances.

This paper shifts the focus from school to the workplace. There are several reasons why we expect that MHM has a stronger impact on attendance at work than at school. The work day is usually (much) longer than the school day, which increases the probability that MHM material needs to be changed or cleaned. Women working on the fields or on the street are less likely to find a toilet and access to clean water than school children. Working hard may stress the MHM material stronger than sitting still in a chair. Finally, working women are likely to be more exposed to other people and, in particular, to men who may avoid contact and/or humiliate women when they discover their menstruation.

There exists a small related literature on the effect of menstruation on work attendance in developed countries. Ichino and Moretti (2009) observe a 28-day cycle in absence from work for Italian female bank employees below age 45 and argue that this biologically-based difference in absence explains a significant part of the gender differential in earnings. Herrmann and Rockoff (2012) argue that the result is not robust and does not replicate for female teachers in New York. They report also differences in 28 days cycles of work absence for men of different ages, which casts doubt on the identification of menstruation-caused absence solely from the timing of days missed at work. Herrmann and Rockoff (2013) show for a representative sample of American

women that menstrual problems have a significant impact on health-related absence from work. These studies do not address the impact of inadequate MHM practices on work attendance. Intuitively, one might suspect that MHM problems are confined to developing countries. There exists, however, a public debate arguing that poverty-induced inadequate MHM is also an issue in developed countries (e.g. Abbott, 2018).

In this study we investigate the impact of MHM practices on work attendance for a nationally representative sample of women aged 15-49 from Burkina Faso. The data is collected from household and female datasets of the Performance Monitoring and Accountability 2020 (PMA2020) project of the Bill and Melinda Gates Institute for Population and Reproductive Health. PM2020 uses an innovative smartphone technology to gather data on family planning and water, sanitation and hygiene and other health areas in 11 developing countries in Africa and Asia (PMA2020, 2018). The distinctive feature of the dataset for Burkina Faso is that it provides (to the best of our knowledge, for the first time) individual data on absence from work due to menstrual problems, and rich information on MHM practices. One major problem of identification, the attribution of days missed at work to menstruation problems and MHM practices, is thus solved by design.

A remaining challenge of identification is that the adoption of good MHM practices is not exogenous. For example, we expect that richer and better educated women are more likely to be endowed with the knowledge and the financial means to access modern MHM methods. Indeed, we show that the women from our sample are more likely to use disposable sanitary pads (instead of old cloth) when they are from richer households and have secondary or higher education. In order to resolve the endogeneity problem, we use a propensity score matching method to obtain the causal effect of the used MHM method on work attendance.

To the best of our knowledge, this is the first study that rigorously estimates the causal impact of MHM on women's work absenteeism. Another advantage of our study is that we use large-scale survey data (compared to low-scale school interventions and experiments) that contains rich information on MHM practices, which has been checked for quality and is nationally representative. The rest of the paper is organized as follows. The next part describes the applied methodology and the used data set. Section 3 presents and discusses the results from the empirical analysis. The paper ends with a conclusion.

2. Methodology and Data

2.1. **Methodology.** We are interested in estimating the causal impact of advanced menstrual hygiene management on women's work absenteeism. As we cannot observe the same household or individual with and without use of advanced MHM, we face a methodological challenge. One solution is to conduct an experiment, a randomized controlled trial, to create the counterfactual from a random subset of the population. Given the absence of experimental data, and given the richness of information from the newly released dataset on Burkina Faso, we use observational data from PMA2020.

In order to resolve the endogeneity problem and to elicit the causal effect of MHM method on absence from work we use a matching strategy with the propensity score method. With this method, matched groups of treated and control are generated that have similar characteristics. Confounding factors that might impact how individuals are assigned to the treatment versus the control group and which would bias the estimate of the treatment effect, can thus be taken into account. Matching is done by a propensity score which is the estimated probability of receiving the treatment given the other characteristics that are observed. The difference in the average outcome between treated and untreated can be interpreted as the causal impact of the treatment variable under the assumption that selection into treatment is due to the observable covariates (Rosenbaum and Rubin 1983a).

The propensity score $p(X)$ is defined as the conditional probability of receiving the treatment given the observed characteristics (Rosenbaum and Rubin 1983 a): $p(X) = P(T = 1|X) = E(T|X)$ with X being a vector of the observed covariates and T being the treatment variable (1 or 0). The average effect of treatment on the treated (ATT) is estimated as follows:

$$\begin{aligned} ATT &= E(Y_{1i} - Y_{0i}|T_i = 1) = E[E(Y_{1i} - Y_{0i}|T_i = 1, p(X_i))] \\ &= E[E(Y_{1i}|T_i = 1, p(X_i)) - E(Y_{0i}|T_i = 0, p(X_i))|T_i = 1] \end{aligned} \tag{1}$$

where Y_{1i} and Y_{0i} are the outcome variables for the treated and for the control individual. The estimator provides the average impact of the treatment under the assumption of conditional independence and overlap between both groups (Rosenbaum and Rubin 1983a).[2]

[2]The conditional independence assumption means that the outcomes Y_0 and Y_1 are independent of treatment status, given a set X of observable covariates, formally $(Y_1, Y_0) \perp T|X$. After controlling for X, the assignment of units into treatment is said to follow a random pattern. The overlap condition means that for each value of X, there is a positive probability of being treated or untreated, $0 < P(T = 1|X) < 1$.

We use nearest-neighbor matching with replacement, which is the most commonly used matching method. With this method the match from the comparison group (j) for a treated individual is chosen that has the closest propensity score. An individual observation is left unmatched if it fails to have a propensity score that is within the so called caliper range (δ) from the non-treated individual's one. Formally, let T and C denote the set of treated and control individuals, N the number of treated individuals and Y_i^T and Y_j^C the outcomes of treated and control individuals. Then, $ATT = 1/N \sum_{i \in \delta(i)} (Y_i^T - Y_j^C)$ with $\delta(i) > |p(X_i) - p(X_j)| = \min(|p(X_i) - p(X_j)|)$.

2.2. **Data.** We use data from the Performance Monitoring and Accountability 2020 initiative (PMA2020). The PMA2020 is the first large scale provision of data on MHM through surveys.[3] The dataset contains representative data for 15 to 49 year old women including several items on MHM. With the release from August 2018, there is now data available for one country, Burkina Faso, that contains information on work absenteeism due to menstruation. The feature that women explicitly declare that work absenteeism was caused by menstrual problems solves an identification problem of related studies in developed countries, which tried to infer the cause of work absenteeism from the timing of work absence (Ichino and Moretti, 2009; Herrmann and Rockoff, 2012).

The data of Survey Round 5 was collected between November 2017 and January 2018. A two-stage cluster design with urban-rural strata was applied. The Institut National de la Statistique et de la Demographie of Burkina Faso draw a sample of 83 enumeration areas and from each area 35 households were randomly selected. Women between 15 - 49 years were contacted for interviews from these households. The final sample included 2811 households and 3556 females.

We use the subsample of women who stated that they worked outside their home during the last month. According to the World Development Indicators, in the year 2016, 59% of Burkina Faso's women aged 15-65 participated in the labor force; of those participating 47% worked in services, 33% in industry, and 20% in agriculture (World Bank, 2018). Our treatment group consists of working women who stated to have access to an advanced MHM method, namely the one-time use of pads. Working women who make use of an inferior MHM method, namely using an old cloth only, are defined as the control group. The information is taken from the answer to the question *During your last menstrual period, what did you use to collect or absorb*

[3]Hennegan et al. 2018 provide a study of females menstrual hygiene perception and available sanitation in the household, using PMA2020 data for Nigeria.

your menstrual blood? As shown in the Appendix Table A.1, these two methods are by far the most prevalent MHM practices in Burkina Faso. The group using only disposable pads contains 1137 women and the group only using old cloth contains 850 women, which together account for 80% of the women who provided answers on MHM materials used. The dependent variable 'work absenteeism' is measured by the answer to the question *Due to your last menstrual period, were there any work days in the last month that you did not attend?*. Only the observations for those women who worked outside of home (having a value = 1 for work participation, aside from homework) enter the regression. The variable 'work missed' is thus a dummy variable (0, 1) for the outside of home working population of women. This information is available for 818 women.

Women with access to advanced MHM (Disposable Pad) were matched to women with no access to advanced MHM (Old Cloth) using the propensity score that was generated from the following observed characteristics: the schooling degree of the woman (primary school or secondary education), the age of the woman, age squared, whether the women was married, wealth status of the household, whether the household had access to electricity, and a range of dummy variables for administrative regions.[4] The regression variables are supportive of both a high level of balance between the control and treatment group as well as of overlap of propensity scores across treated and untreated.

Table 1: MHM, schooling, and work

	Disposable Pad	Old Cloth
no school degree	21.3	76.1
primary school	21.7	15.2
secondary school	49.2	8.6
tertiary school	7.7	0.1
work participation	46.5	34.1
missed work	14.9	19.7
did not miss work	85.1	81.3

Notes: The Table shows the percentage shares of women who either use disposable sanitary pads or old cloth as MHM material with respect to their schooling degree and whether they missed work due to menstruation in the last month.

The most interesting aspects from the summary statistics are shown in Table 1 (Table A.2 in the Appendix shows the full summary statistics, moreover we do also report results from using composite survey weights as given within the PMA2020 dataset in Table A.3. We refer to these results later, in the last paragraph of the Results Section.). Of the women using Disposable

[4]In the PMA2020 wealth is a generated variable by the data providers. It reflects households' assets (livestock as well as electrical equipment, internet and car or motorcycle, etc.), building materials (condition and material of floor, roof and walls), water sources and sanitation facilities. We considered wealth of the middle class. Adding a control of low wealth produces a slightly stronger ATT but entails less good balance and overlap properties.

Pads, about 46% work (aside from housework) compared to 34% of the women using Old Cloth. Women using Disposable Pads are on average better educated and members of richer households; about 22% have primary school degree and 57% have secondary or higher education. Among the women who use only old cloth for their MHM, 76% have no school degree attained at all, about 15% have primary education and about 9% have a secondary school degree or higher. Of the Disposable Pad users, 82% are urban versus 23% among the Old Cloth users. Wealth is similarly unequally distributed. Of the Disposable Pad users, 15% are from the low or middle wealth tertile versus 77% of the Old Cloth users. The large differences in characteristics of users of modern versus traditional MHM methods and their potential influence on participation in the workforce call for a rebalancing strategy in order to make causal inferences.

3. Results

In a first step we estimated the propensity score for the sample using a probit model. The propensity score is the probability of receiving the treatment (Disposable Pads) conditional on the specified observable characteristics. The dependent variable is our treatment variable, that is a dummy of MHM use, with use of Disposable Pads (1) and use of Old Cloth (0). The results from this regression are shown in Table 2. In order to alleviate the interpretation of coefficients we also report the results from estimates of average marginal effects with the same regressors. Married women and women from the middle wealth tertile are less likely to use Disposable Pads. Women with primary and secondary education and women living in a household with electricity are more likely to use Disposable Pads and age exerts a weak non-linear influence on MHM use.

Figure A.1, in the Appendix, shows the estimated density function of the propensity score for the treated and untreated. The area that lies below both curves is the overlap. We see that there is sufficient overlap and common support at all levels of the propensity score and thus no need to discard any observations.

To assess the matching quality, we show results from balancing tests in Table 3. The bias in observables between treated and untreated women is reduced to a large degree. The t-values show that, especially for our main variables of interest which are the schooling and wealth of women, the similarity in observables (equality in means) of treated and control can not be rejected after matching.[5] Further test results of the quality of matching are reported in Table 4.

[5]Further tests across blocks of the propensity score revealed that the balancing property is satisfied for all control variables.

Table 2: Determinants of MHM Materials Usage (Disposable Pads vs. Old Cloth)

	Probit Model	Average Marginal Effects
Female characteristics		
primary schooling	0.6703***	0.1699***
	(0.1126)	(0.0303)
secondary schooling	1.3542***	0.3432***
	(0.166)	(0.049)
age	0.1642***	0.0416***
	(0.0391)	(0.0093)
age squared	-0.0027***	-0.0007***
	(0.0006)	(0.0001)
married	-0.3932**	-0.0997**
	(0.1819)	(0.0496)
Household characteristics		
middle wealth tertile	-0.8055***	-0.2042***
	(0.2154)	(0.0451)
electricity	0.5552***	0.1407***
	(0.2039)	(0.0531)
region Centre-Nord	-1.1976***	-0.3036***
	(0.2705)	(0.0559)
region Centre-Ouest	-0.2401	-0.0609
	(0.1724)	(0.0412)
region Centre-Sud	1.0722***	0.2718***
	(0.2342)	(0.0684)
region Plateau-Central	-0.521***	-0.1321***
	(0.1921)	(0.043)
region Nord	-0.5084**	-0.1289**
	(0.2504)	(0.0581)
region Sahel	-0.9086***	-0.2303***
	(0.2697)	(0.0593)
Obs.	817	
Log likelihood	-368.76	
Pseudo R^2	0.3053	

Notes: The Table shows the results from a probit model for estimating the impact of covariates on MHM usage (Disposable Sanitary Pad versus Old Cloth). The third column displays the average marginal effects from a probit model with the same regressors. Standard errors are clustered at regional level. *** denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, * denotes significance at the 10 percent level.

The pseudo-R^2 is substantially reduced in the matched sample (from 0.305 to 0.045), indicating that the observable characteristics are no longer predictive for determining the treatment group. Table 4 further shows that the mean and median bias for the overall matching process have been significantly reduced and Rubin's R is within the range of good matching quality.[6]

Table 5 shows the main result. The mean incidence of work absenteeism of women who had access to advanced MHM materials is 21 percent lower than for women in the control group of the sample. Access to advanced MHM materials significantly reduces work absenteeism due to menstruation. This constitutes an economically significant impact on aggregate labor supply

[6]Rubin's R gives the ratio between the treated and matched non-treated variance of the propensity score. R should lie between 0.5 and 2 for the samples to be considered sufficiently balanced.

Table 3: Balancing Tests

	Unmatched	Mean		%bias	%reduct	t-test	
Variable	Matched	Treated	Control		bias	t	$p > \|t\|$
age	U	29.496	32.561	-34.3		-4.75	0.000
	M	29.496	29.409	1.0	97.2	0.17	0.865
age squared	U	942.81	1146.5	-36.3		-5.05	0.000
	M	942.81	929.62	2.4	93.5	0.42	0.672
primary schooling	U	0.2803	0.163	28.6		3.80	0.000
	M	0.2803	0.318	-9.2	67.8	-1.34	0.179
secondary schooling	U	0.362	0.052	82.7		10.36	0.000
	M	0.362	0.345	4.5	94.5	0.58	0.563
married	U	0.494	0.754	-55.7		-7.45	0.000
	M	0.494	0.653	-34.1	38.8	-5.29	0.000
middle wealth tertile	U	0.0796	0.329	-64.9		-9.61	0.000
	M	0.0796	0.063	4.4	93.2	1.08	0.281
electricity	U	0.752	0.401	75.8		10.55	0.000
	M	0.752	0.795	-9.4	87.6	-1.69	0.091
region Centre-Nord	U	0.004	0.048	-28.2		-4.45	0.000
	M	0.004	0.011	-4.8	83.0	-1.42	0.156
region Centre-Ouest	U	0.068	0.100	-11.6		-1.63	0.105
	M	0.068	0.0625	2.0	82.3	0.37	0.709
region Centre-Sud	U	0.032	0.017	9.6		1.26	0.209
	M	0.032	0.009	14.6	-52.6	2.59	0.010
region Plateau-Central	U	0.021	0.069	-23.5		-3.48	0.001
	M	0.021	0.015	2.8	88.3	0.69	0.488
region Nord	U	0.027	0.09	-27.3		-4.05	0.000
	M	0.027	0.008	8.1	70.2	2.38	0.017
region Sahel	U	0.006	0.059	-30.4		-4.76	0.000
	M	0.006	0.021	-8.7	71.5	-2.16	0.031

Notes: The Table shows tests for balancing between the treatment and the control group across different control variables. The mean between treated and control group, the bias and bias reduction as well as results from a t-test for the difference in means is displayed.

Table 4: Bias Tests

	Pseudo R^2	Mean Bias	Median Bias	R
Unmatched	0.305	39.1	30.4	1.09
Matched	0.041	8.2	4.8	1.33

Notes: The Table shows tests for matching quality. The Pseudo R^2 as well as the mean bias, median bias and Rubin's R measure are displayed across the unmatched and matched observations.

as well as on individual wellbeing of the women and their families. The effect translates into up to 21 days of work missed per year due to inferior MHM materials.[7] As a robustness check, we also report results for alternative matching parameters. As shown in column 3 and 4 of Table 5, the results hardly change when the number of nearest neighbors is increased to 2 or the caliper is reduced to 0.06. We do further reports results from a Mahalanobis matching exercise.[8] The estimate is about of the same size and precision as the benchmark ATT estimate. For comparison, Table 5 shows also the regression results from a linear probability model, which estimates a much weaker negative effect of MHM use on missed work. Clearly, matching across the groups of women who are subject to advanced MHM and those who are subject to inferior MHM methods is important and reveals that the actual effect is much higher.

Table 5: Treatment Effect of Advanced MHM on Work Absenteeism

	ATT $n = 1$, $cal = 0.1$	ATT $n = 2$, $cal = 0.1$	ATT $n = 1$, $cal = 0.06$	Mahalanobis Matching	Linear Probability Model
Advanced MHM	-0.2121***	-0.2169**	-0.2121***	-0.2160***	-0.0679**
	(0.0516)	(0.1103)	(0.0516)	(0.0797)	(0.0283)
Obs.	817	817	817	817	818
R^2	0.305	0.305	0.305	0.305	0.369

Notes: The Table displays the treatment effect of advanced MHM practices on work absenteeism using different estimation methods. Standard errors are displayed in parentheses and have been adjusted for the ATT according to Abadie and Imbens (2016); n stands for the number of nearest neighbors used for the estimation; *cal* stands for the caliper used. Standard errors are clustered at regional level for the Linear Probability Model. For the Linear Probability Model covariates include primary and secondary schooling, age, age squared, married, middle wealth status and regional dummies. *** denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, * denotes significance at the 10 percent level.

In order to further explore potential heterogeneity in average treatment effects, we stratified the data according to groups of women with Christian or Muslim religion, low or high wealth status, and urban or rural residence. The results presented in Table 6 show that there is a strong significant impact of advanced MHM usage for the group of Muslim women while the effect is insignificant for Christian women. Socio-cultural beliefs of Islam are likely responsible for the result that Muslim women benefit more from effective MHM (by avoiding soiling or display of other side effects in the public). The treatment effect is further significant and larger in size than the baseline estimate for working women from the high wealth status group. The treatment

[7]For this calculation, we take a 365-day year of potential working days, 14 menstrual cycles per year and absence of 7 days due to a menstrual period: $((14 \cdot 7)/365) \cdot 0.2121 \cdot 365$.

[8]For Mahalanobis matching individuals are matched according to a distance metric, rather than (the closest) propensity score. Mahalanobis distance is equal to $D_{mn} = \sqrt{(X_m - X_n)' V^{-1} (X_m - X_n)}$ with X a vector of explanatory factors and V is the variance covariance matrix of X. A unit from the treatment group is then matched with a unit from the untreated that has the lowest Mahalanobis distance.

Table 6: Heterogenous Effects of Advanced MHM

Stratification by religion				
	Treatment	Control	Difference	T-Stat
Muslim	0.139	0.3966	-0.2576***	-2.63
Christian	0.145	0.0136	0.1312	0.96
Stratification by wealth				
	Treatment	Control	Difference	T-Stat
Low wealth tertile	0.235	0.1176	0.118	0.66
High wealth tertile	0.145	0.4242	-0.279***	-2.57
Stratification by urban-rural setting				
	Treatment	Control	Difference	T-Stat
Urban	0.143	0.319	-0.176**	-1.97
Rural	0.194	0.209	-0.015	-0.13

Notes: The table displays the heterogeneity of average treatment effects of the treated stratified by religion, wealth group, and urban versus rural residence.

effect is also significant for urban women but not for rural women. These results indicate that an effective MHM method is particularly important for women who likely work at higher positions in a modern work environment.

We further conducted tests to assess the robustness of the ATT estimate. While it is important whether the conditional independence assumption is fulfilled, it is, however, impossible to directly test for confoundedness by unobservable factors. Since Rosenbaum and Rubin (1983 b), the literature has suggested several ways to nevertheless assess the sensitivity of an ATT estimator to unobserved confounders. Here we follow the method of Nannicini (2007) and Ichino et al. (2008).[9] The method assumes that the conditional independence assumption is not satisfied given the observables but it would be satisfied if an additional simulated variable could be observed and it compares the estimates with and without matching on the simulated variable. The confounder is evaluated for how likely it is to occur and whether it is a problem if it was not included in the regression. In Table 7 the parameter d captures the outcome effect of a simulated variable in the absence of treatment and s the effect of the simulated variable on selection into treatment. Our baseline estimate is given in the case of unconfoundedness ($d = 0$ and $s = 0$). We simulated different effects upon outcome and selection into treatment by increasing d in 0.1 steps and we simulated the behavior of a potential confounder (Muslim religion), as suggested in Nannicini (2007).

The results in Table 7 show that in order to explain a meaningful deviation of the matching estimator from the baseline estimate caused by an unobserved confounding factor, this confounder

[9]Nannicini's method is applying commands from Becker and Ichino (2002) for the estimation of the ATT.

would have to have an enormous effect upon selection into treatment or on the untreated outcome. For really concerning confounding factors with large values of d and s (called 'killer confounders', see the case of $s = 0.6$ and $d = 0.5$) the confounder would have to increase the probability of selection into treatment by a factor greater than 19 and the probability that the outcome is greater than the mean by a factor greater than 18. The fact that the presence of such a confounder among the unobservables is very implausible further corroborates the robustness of our matching estimates. The results on Muslim religion show how the baseline estimate would be changed by the consideration of this previously unused confounder in the regression. The result that the point estimate hardly changes demonstrates that the confounder is not 'dangerous'; it has neither large effects on selection into treatment nor on the outcome. We can thus conclude that our baseline estimate is robust to unobserved confoundedness.

Table 7: Sensitivity for Unobserved Confounders

		ATT	Std. error	Outcome effect	Selection effect
Effect on untreated outcome	Effect on treatment assignment				
Simulated confounding factor					
$d = 0$	$s = 0$	-0.215	0.037	1.011	1.004
$d = 0.1$	$s = 0.28$	-0.176	0.077	1.673	3.893
$d = 0.2$	$s = 0.36$	-0.196	0.088	2.581	5.491
$d = 0.3$	$s = 0.44$	-0.230	0.091	4.267	7.642
$d = 0.4$	$s = 0.52$	-0.283	0.117	6.895	11.584
$d = 0.5$	$s = 0.60$	-0.411	0.110	18.767	19.403
Simulated confounding factor Muslim					
$d = -0.02$	$s = -0.04$	-0.203	0.043	0.980	0.851

Notes: The top part of the table displays the sensitivity analysis of the matching estimator for different settings of confounders based on the method from Nannicini (2007). The probability that a confounding factor is existent while an individual receives the treatment and has an outcome equal to one, and the probability that a confounding factor is existent while an individual receives the treatment and has an outcome equal to zero were each held at the level 0.8. The bottom part of the table shows the outcome for a simulation of a potential confounder by using Muslim religious affiliation. 100 bootstrap replications were run for the iterations.

The descriptive statistics from Table A.3 in the Appendix show that there are more women with lower education, lower wealth and higher incidence of living in rural areas in the overall population than in the survey sample. The literature has not yet developed a consensus view about how to address survey weighting for matching estimators. Here, we conduct an exercise following the suggestions by DuGoff et al. (2013). We estimate the average treatment effect of the treated running a regression on the matched sample using a composite measure of weights, dealing on the one hand with the two-way cluster-stratification of the survey sample, and on the other hand incorporating the weight of the estimate of the propensity score. For this purpose we

use the weights for matches between the treated and untreated that resulted from our baseline propensity score matching regression (the weight is 1 for observations from the treated group and for the control group it is the number of observations from the treated group that the observation is a match for) and adjust it for survey weights, that is we multiply it by the inverse of the weight for the enumeration area, the weight for the household, and the weight for the female respondent (as provided by PMA2020). With that measure, we obtain an ATT of -0.2608 (s.e. 0.0763) of MHM material usage for female work absenteeism. When we extend the weight by multiplying it with the propensity score, as suggested by DuGoff et al. (2013), the ATT becomes -0.3029 (s.e. 0.0721). These estimates differ insignificantly from the benchmark ATT in Table 5. As these estimates are close to our sample ATT, it makes us confident that the estimates from the survey sample allow for robust inferences at the population level.

4. Conclusion

Menstrual hygiene management constitutes a challenge for women especially in developing countries. Recent research has delivered ambiguous evidence about the causal impact of MHM practices for women's schooling outcomes, especially absenteeism from school. The non-significant impact that has been found by some experiments in single countries is in stark contrast to the voices raised by women and girls from developing countries, as well as several international institutions that point to a need of MHM materials and facilities for the poorest and most deprived. In this study we shifted the focus from school to the workplace and used a newly released dataset and propensity score matching in order to provide the first causal evidence of the impact of MHM on work attendance. Women in Burkina Faso who used advanced MHM practises (disposable sanitary pads) in contrast to old cloth reduced their probability to miss days working due to their menstrual period by about 21 percentage points. This constitutes an economically significant impact on aggregate labor supply as well as on individual wellbeing of the women and their families. These days of absence could imply a substantial loss of income for the household and an increased risk for the women's permanent employment. The results indicate a large problem of social exclusion of women due to menstruation and its inferior management.

In sample stratification we found that the MHM effect applies for Muslim women but not for Christian women. This indicates that the mechanism likely operates through social norms rather

than, for example, health or convenience effects. The use of disposable sanitary pads better prevents leakage and odor as well as the need to wash MHM material during the work day. It thus allows to better conceal menstruation and helps to avoid humiliation or outright exclusion from work in environments characterized by negative attitudes and social norms about menstruation. The feature that sanitary pads are preferred by better educated and richer women suggests that policies that improve MHM knowledge as well as policies that alleviate access through subsidies, direct development aid, and tariff reduction are likely to increase their prevalence. Better MHM practices will help women in developing countries to participate in daily life without shame and therewith contribute to their empowerment.

Our study is limited in that we only focus on one aspect of menstrual hygiene management, namely the use of absorbent materials for menstrual blood. We did not assess the impact of access to water, soap, facilities to change MHM materials and place of disposal of MHM materials. This is left out for further research, and we expect these issues to influence work absenteeism of women due to menstruation, aside from the impact of MHM materials. Our research would not have been possible without the PMA2020 data set of the Bill and Melinda Gated institute for Population and Reproductive Health, which provided for the first time rich data on MHM practices and their influence on women's work attendance due to menstruation.

References

Abadie, A., Imbens, G. W. (2016). Matching on the estimated propensity score, *Econometrica*, 84, 2, 781-807.

Abbott, G. (2018). Lets make period poverty history. The Observer, 25. August 2018 (`https://www.theguardian.com/society/2018/aug/25/lets-make-period-poverty-history-girls-miss-school-s`

Becker, S. and A. Ichino (2002). Estimation of average treatment effects based on propensity scores, *Stata Journal*, 2, 358-377.

Caliendo, M., Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, 22, 1, p. 31-72.

Das, P., Baker, K.K., Dutta, A., Swain, T., Sahoo, S., Das, B. S., Panda, B., Nayak, A., Bara, M., Bilung, B., Mishra, P.R., Panigrahi, P., Cairncross, S., Torondel, B. (2015). Menstrual hygiene practices, WASH access and the risk of urogenital infection in women from Odisha, India, *PLoS ONE*, 10, 6.

DuGoff, E. H., Schuler, M., Stuart, E. A. (2013). Generalizing Observational Study Results: Applying Propensity Score Matching to Complex Surveys, *Health Services Research*, 49, 1.

Hennegan, J., Zimmermann, L., Shannon, A.K., Exum, N.G., OlaOlorun, F., Omoluabi, E., Schwab, K.J. (2018). The Relationship between Household Sanitation and Women's Experience of Menstrual Hygiene: Findings from a Cross-Sectional Survey in Kaduna State, Nigeria, *International Journal of Environmental Research and Public Health*, 15, 905.

Hennegan, J., Dolan, C., Wu, M., Scott, L., Montgomery, P. (2016). Measuring the prevalence and impact of poor menstrual hygiene management: a quantitative survey of schoolgirls in rural Uganda, *BMJ Open*, 6, e012596.

Herrmann, M.A., and Rockoff, J.E. (2012). Does menstruation explain gender gaps in work absenteeism? *Journal of Human Resources* 47(2), 493-508.

Herrmann, M. A., and Rockoff, J. E. (2013). Do menstrual problems explain gender gaps in absenteeism and earnings? *Labour Economics* 24(C), 12-22.

Ichino, A., and Moretti, E. (2009). Biological gender differences, absenteeism, and the earnings gap. *American Economic Journal: Applied Economics* 1(1), 183-218.

Ichino, A., Mealli, F., Nannicini, T. (2008). From Temporary help jobs to permanent employment: What can we learn from matching estimators and their sensitivity?. *Journal of Applied Econometrics*, 23, 3, p. 305-327 .

Kuhlmann, A.S., Henry, K., and Wall, L.L. (2017). Menstrual Hygiene Management in Resource-Poor Countries, *Obstetrical and Gynecological Survey* 72(6), 356-376.

Montgomery, P., Ryus, C.R., Dolan, C.S., Dopson, S., and Scott, L. M. (2012). Sanitary pad interventions for girls' education in Ghana: a pilot study. *PloS one* 7(10), e48274.

Montgomery, P., Hennegan, J., Dolan, C., Wu, M., Steinfield, L., and Scott, L. (2016). Menstruation and the cycle of poverty: a cluster quasi-randomised control trial of sanitary pad and puberty education provision in Uganda. *Plos one* 11(12), e0166122.

Loughnan, L.C., Bain, R., Rop, R., Sommer, M., and Slaymaker, T. (2016). What can existing data on water and sanitation tell us about menstrual hygiene management?, *Waterlines* 35(3), 228-244.

Nannicini (2007). Simulation-based sensitivity analysis for matching estimators, *Stata Journal* 7(3), 334-350.

NHS (2018). *Periods and fertility in the menstrual cycle.* `https://www.nhs.uk/conditions/periods/fertility-in-the-menstrual-cycle/`

Oster, E., and Thornton, R. (2011). Menstruation, Sanitary Products and School Attendance: Evidence from a Randomized Evaluation. *American Economic Journal: Applied Economics* 3, 91-100.

PMA2020 (2018). Performance Monitoring and Accountability 2020. (`https://www.pma2020.org/`

Rosenbaum, P.R., Rubin, D.B. (1983 a). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70, 41-55.

Rosenbaum, P.R., Rubin, D.B. (1983 b). Assessing sensitivity to an unobserved binary covariate in an observational study with binary outcome. *Journal of the Royal Statistical Society, Series B* 45, 212-218.

Scott, L., Dopson, S., Montgomery, P., Dolan, C., and Ryus, C. (2009). Impact of providing sanitary pads to poor girls in Africa. Discussion Paper, University of Oxford.

Sommer, M., Chandraratna, S., Cavill, S., Mahon, T., and Phillips-Howard, P. (2016a). Managing menstruation in the workplace: an overlooked issue in low-and middle-income countries. *International Journal for Equity in Health* 15(1), 86.

Sommer, M., Caruso, B. A., Sahin, M., Calderon, T., Cavill, S., Mahon, T., Phillips-Howard, P.A. (2016b). A Time for Global Action: Addressing Girls' Menstrual Hygiene Management Needs in Schools. *Plos One* 13(2), e1001962.

Sumpter, C., Torondel, B. (2013). A systematic review of the health and social effects of menstrual hygiene management. *Plos One* 8(4), e62004.

Torondel, B., Sinha, S., Mohanty, J. R., Swain, T., Sahoo, P., Panda, B., Nayak, A., Bara, M., Bilung, B., Cumming, O., Panigrahi, P., Das, P. (2018). Association between unhygienic menstrual management practices and prevalence of lower reproductive tract infections: a hospital-based cross-sectional study in Odisha, India. *BMC Infectious Diseases* 18(1), 473.

UNICEF (2013). Menstrual Hygiene in Schools in 2 countries of Fracophone West Africa. Burkina Faso and Niger Case Studies in 2013.

Van Eijk, A.M., Sivakami, M., Thakkar, M.B., Bauman, A., Laserson, K. F., Coates, S., Phillips-Howard, P.A. (2016). Menstrual hygiene management among adolescent girls in India: a systematic review and meta-analysis. *BMJ Open*, 6(3), e010290.

Whelan, E. M. (1975). Attitudes toward menstruation. *Studies in Family Planning* 6(4), 106-108.

WHO (2012). Consultation on Draft Long List of Goal, Target and Indicator Options for Future Monitoring of Water, Sanitation and Hygiene. WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation. New York.

Women's Health (2018). *Menstruation and the menstrual cycle fact sheet.* U.S. Department of Health and Human Services, Office on Women's Health.

World Bank (2018). World Development Indicators. (`https://data.worldbank.org/indicator`)

Appendix

Table A.1: Detailed MHM usage and educational level in Burkina Faso

	Never	Primary	Secondary 1st cycle	Secondary 2nd cycle	Tertiary
Cotton wool	14	9	24	5	2
Cotton wool, diaper	1				
Cotton wool, undies	1				
Diaper	12	11	15	4	1
Diaper undies	1				
New cloth	42	8	10		
New cloth, diaper, undies	1				
New cloth, old cloth	13	3		1	
New cloth, undies	8				
Old cloth	646	129	71	2	1
Old cloth, cotton wool	1	1	2	1	
Old cloth, cotton wool, undies		1			
Old cloth, diaper	2				
Old cloth, other	6	1			
Old cloth, undies	45	6	1		
Pad multi	4	3	2	1	1
Pad once, pad multi					1
Pad multi, new cloth	1				
Pad once, pad multi, old cloth				1	
Pad, old cloth	3				
Pad once, other				1	
Pad once	242	247	387	172	88
Pad once, cotton wool			1		
Pad once, new cloth	5	5			
Pad once, diaper			1	1	
Pad once, new cloth, old cloth	1				
Pad once, tampons, toilet paper, undies			1		
Pad once, new cloth, undies	1		1		
Pad once, toilet paper			2		
Pad once, old cloth	20	17	12	1	
Pad once, old cloth, undies	1				
Pad once, old cloth, cotton wool			1		
Pad once, undies	3				
Pad once, tampons			3		3
Undies	108	16	15		
Pad once, undies			4		
Tampons			1		2
Observations ($Total = 2482$)	1182	457	554	190	99

Notes: The Table shows the number of women who used a certain type of MHM material. Women were given the chance to self-report which method they used and they were allowed to name several items. The results are displayed according to educational level.
Source: Data from PMA2020.

Table A.2: Summary Statistics

	Disposable Pad		Old Cloth	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
participation in work outside home	0.465	0.499	0.341	0.474
work missed	0.149	0.357	0.197	0.399
no school degree	0.213	0.410	0.761	0.427
primary school	0.217	0.413	0.152	0.359
secondary school	0.492	0.500	0.086	0.281
tertiary school	0.077	0.267	0.001	0.034
low wealth tertile	0.055	0.229	0.401	0.490
middle wealth tertile	0.099	0.299	0.369	0.483
high wealth tertile	0.845	0.362	0.229	0.421
electricity	0.736	0.441	0.360	0.480
married	0.387	0.487	0.745	0.436
age	25.7	8.5	30.6	10.0
age squared	732.2	495.0	1038.4	620.8
region Centre-Nord	0.017	0.128	0.101	0.302
region Centre-Ouest	0.095	0.293	0.089	0.286
region Centre-Sud	0.033	0.180	0.016	0.127
region Plateau-Central	0.029	0.168	0.040	0.196
region Nord	0.032	0.175	0.146	0.353
region Sahel	0.003	0.051	0.067	0.250
Muslim	0.560	0.497	0.661	0.474
Christian	0.424	0.494	0.231	0.421
urban	0.820	0.385	0.235	0.424
access to piped water	0.766	0.424	0.219	0.414

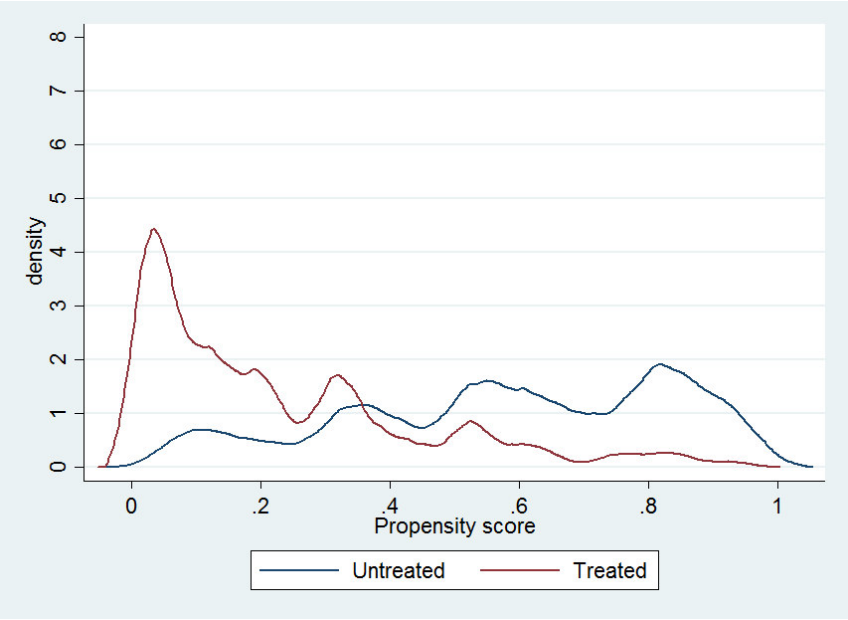
Notes: The Table shows descriptive statistics for women who either use disposable sanitary pads or old cloth as MHM material in regard to various variables.
Source: Authors' computations based on data from PMA2020.

Table A.3: Summary Statistics overall

	Survey Sample		Overall Population
Variable	Mean	Std. Dev.	Mean
work missed	0.1663	0.3725	0.1857
no school degree	0.4474	0.4973	0.5351
primary school	0.1894	0.3919	0.2719
secondary school	0.3184	0.466	0.1856
tertiary school	0.0448	0.207	0.0074
low wealth tertile	0.2033	0.4026	0.3014
middle wealth tertile	0.2149	0.4109	0.2785
high wealth tertile	0.5818	0.4934	0.4201
electricity	0.5750	0.4945	0.555
married	0.5400	0.4985	0.7160
age	27.8	9.5	30.1
Muslim	0.6029	0.4894	0.5877
Christian	0.3419	0.4745	0.2892
urban	0.5697	0.4952	0.0734
access to piped water	0.5317	0.4991	0.3395

Notes: The Table shows descriptive statistics for women for the PMA2020 survey sample as well as recalculated values for the population level using PMA2020 survey weights as a composite weight measure of enumeration area, household, female and propensity score.
Source: Authors' computations based on data from PMA2020.

Figure 1: Overlap



Notes: The Figure displays overlap in propensity score values between the treated and untreated group.
Source: Authors' depiction based on PMA2020 data.