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Assessing The Impact Of A School-Based Latrine Cleaning And Handwashing Program On Pupil Absence In Nyanza Province, Kenya: A Cluster-Randomized Trial

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Abstract

Improving school water, sanitation and hygiene (WASH) conditions reduces pupil absence and illness. However, these benefits may depend on the conditions of the latrines and availability of consumables. We sought to determine whether a low-cost, policy-relevant, environmental-level latrine cleaning intervention could improve latrine cleanliness, increase its use and reduce absenteeism. methods In a three-arm, cluster-randomized trial we assessed absence via periodical roll-call among 17 564 pupils in 60 schools that had previously received WASH improvements as part of the SWASH+ project. Latrine conditions and use were also assessed using structured observation. Latrine cleanliness increased significantly during the post-intervention period among schools receiving the latrine cleaning package compared to controls, as did handwashing with soap. We found no difference in latrine use and absence across arms. The additive impact of cleaning may not have been strong enough to impact absence above and beyond reductions attributable to the original WASH infrastructure improvements and basic hygiene education the schools previously received. Improving latrine conditions is important for the dignity and well-being of pupils, and investments and strategies are necessary to ensure that school toilets are clean and pupil-friendly.

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Abstract

objectives Improving school water, sanitation and hygiene (WASH) conditions reduces pupil absence and illness. However, these benefits may depend on the conditions of the latrines and availability of consumables. We sought to determine whether a low-cost, policy-relevant, environmental-level latrine cleaning intervention could improve latrine cleanliness, increase its use and reduce absenteeism.

methods In a three-arm, cluster-randomized trial we assessed absence via periodical roll-call among 17 564 pupils in 60 schools that had previously received WASH improvements as part of the SWASH+ project. Latrine conditions and use were also assessed using structured observation. Latrine cleanliness increased significantly during the post-intervention period among schools receiving the latrine cleaning package compared to controls, as did handwashing with soap. We found no difference in latrine use and absence across arms.

conclusions The additive impact of cleaning may not have been strong enough to impact absence above and beyond reductions attributable to the original WASH infrastructure improvements and basic hygiene education the schools previously received. Improving latrine conditions is important for the dignity and well-being of pupils, and investments and strategies are necessary to ensure that school toilets are clean and pupil-friendly.

keywords school, sanitation, hygiene, latrine use, handwashing, absence

Introduction

Improved access to sanitation reduces helminth infection and diarrhoeal disease by providing a space for excreta disposal (Cairncross *et al.* 2010; Ziegelbauer *et al.* 2012). Sanitation facilities, however, may also increase exposure to pathogens if poorly maintained, used incorrectly, or if personal and hand hygiene materials are not available during and after use. High levels of microbial contamination have been found in sanitation facilities (Majra & Gur 2010; Sinclair & Gerba 2011; Pickering *et al.* 2012), and the spread of infectious diseases such as diarrhoea, dysentery and Hepatitis A has been linked to unsanitary toilets (Thomas & Tillett 1973; Koopman 1978; Rajaratnam *et al.* 1992).

Water-, sanitation- and hygiene (WASH)-related illnesses have been estimated to result in hundreds of millions of days of school absence(Hutton & Haller 2004), yet these projections are based on conditions in the home and do not account for the burden of disease resulting from inadequate access in the school setting. Data on school WASH access are scarce; however, UNICEF estimates that 49% of schools in low-income settings have inadequate access to water, 55% have inadequate access to sanitation (UNICEF 2012); no current estimates exist for the availability of soap or handwashing facilities.

Improving school WASH conditions is effective in reducing pupil absence and illness (Freeman *et al.* 2012, 2013 Freeman *et al.* 2014). School-based handwashing interventions have shown reductions in pupil absenteeism of 21–54% (Bowen *et al.* 2007; Talaat *et al.* 2011), and interventions that include both handwashing and water treatment have shown reductions in pupil absenteeism of 26–58% (O' Reilly *et al.* 2008; Blanton *et al.* 2010) and specifically for girls (Freeman *et al.* 2012).

The benefit of sanitation and hygiene improvements at school may depend on the consistent availability of soap and water for handwashing and on the conditions of the latrines, rather than on pupil to latrine ratios. In Kenya, baseline data from a cluster-randomized trial of school-based WASH interventions suggested that the quality of latrine facilities had a stronger correlation with recent absence (Dreibelbis *et al.* 2013), and the impact evaluation of the trial did not find evidence that construction of new latrines reduced absence compared to controls (Freeman *et al.* 2012). Pupils in schools that received new latrines had higher levels of faecal pathogens on their hands than those in schools that did not (Greene *et al.* 2012) and pupils reported latrine conditions – the presence of urine, faeces, mud, blood, flies and smell – to be a barrier to use (Caruso *et al.* In Press).

Informed by these findings, we employed a three-arm, cluster-randomized trial to determine whether the sustained provision of a latrine cleaning intervention could reduce pupil absence from rural primary schools in Western Kenya. We hypothesized that these low-cost, environmental-level interventions would improve latrine cleanliness, increase latrine use and reduce absenteeism.

Methods

Context

This study included schools previously enrolled in a cluster-randomized trial assessing the impact of a school-based hygiene promotion, water treatment, sanitation and water supply improvement program on pupil absence in Nyanza Province, Kenya (Freeman *et al.* 2012). This study took place in Nyando, Kisumu and Rachuonyo Districts in Nyanza Province, the western-most province of Kenya on the eastern shore of Lake Victoria. Rachuonyo District is considered geographically more rural than Nyando and Kisumu. Nyanza has 5.4 million inhabitants with 1.5 million (28%) attending primary school (KNBS 2010; KNBS 2011a,b).

Sample size

Data from the previous trial revealed that children in schools with better latrine conditions had a 2-week absence period prevalence of 0.126, compared to 0.147 in those with poorer latrine conditions. To detect a significant risk ratio of 0.86 in absence, the present study required 20 schools per intervention arm and 20 schools in the control arm, assuming a mean enrolment of 300 pupils per school ($k = 0.087$, alpha = 0.05, beta = 0.20) (Hayes & Bennett 1999).

School selection

Schools were eligible for inclusion in the study if they were as follows: enrolled in the SWASH+ study that did not receive an improved water source as part of the intervention ($n = 135$), had a dry season water source <1 km away, and had more than 25% of their school' s latrines identified as dirty (with excess smell, flies and/or presence of faeces in a 2009 program facilities assessment). Sixty-two schools met eligibility criteria. Two schools were omitted from participation because of participation in pilot testing of intervention components and flooding that disrupted school grounds, facilities and regular school activities. Stratified random assignment was used to allocate the remaining 60 schools to one of three intervention arms: Latrine Cleaning plus Handwashing (LC+HW), Handwashing (HW) and a control (C) (Figure 1).
A latrine cleaning intervention without the handwashing component was considered; however, latrine cleaning may increase the risk of pathogen exposure and it was deemed necessary to include a handwashing component to reduce that risk. Schools were stratified by both geographic strata (Rachuonyo or Nyando/Kisumu) and by the intervention previously received as part of SWASH+. Stratification was undertaken to ensure geography and previous intervention types were distributed across arms in similar proportion. Schools were then assigned using the random number generator in Microsoft Excel (Redmond, WA) prior to baseline data collection.

Interventions

The interventions selected for this trial focused on changing the school environment and were designed to be low cost, policy relevant and easily replicable at scale (Table 1). Inputs were informed by focus group discussions and interviews with pupils between July and October 2009 (Caruso *et al.* In Press) and were piloted in three schools (February–March 2010). Inputs for the two intervention arms – Latrine Cleaning plus Handwashing (LC+HW) and Handwashing (HW) – are described in Table 1.

Schools in the LC+HW arm received reusable hardware (buckets, brooms, hand brushes, plastic scoop), consumables (bleach, powdered soap), toilet tissue, handwashing

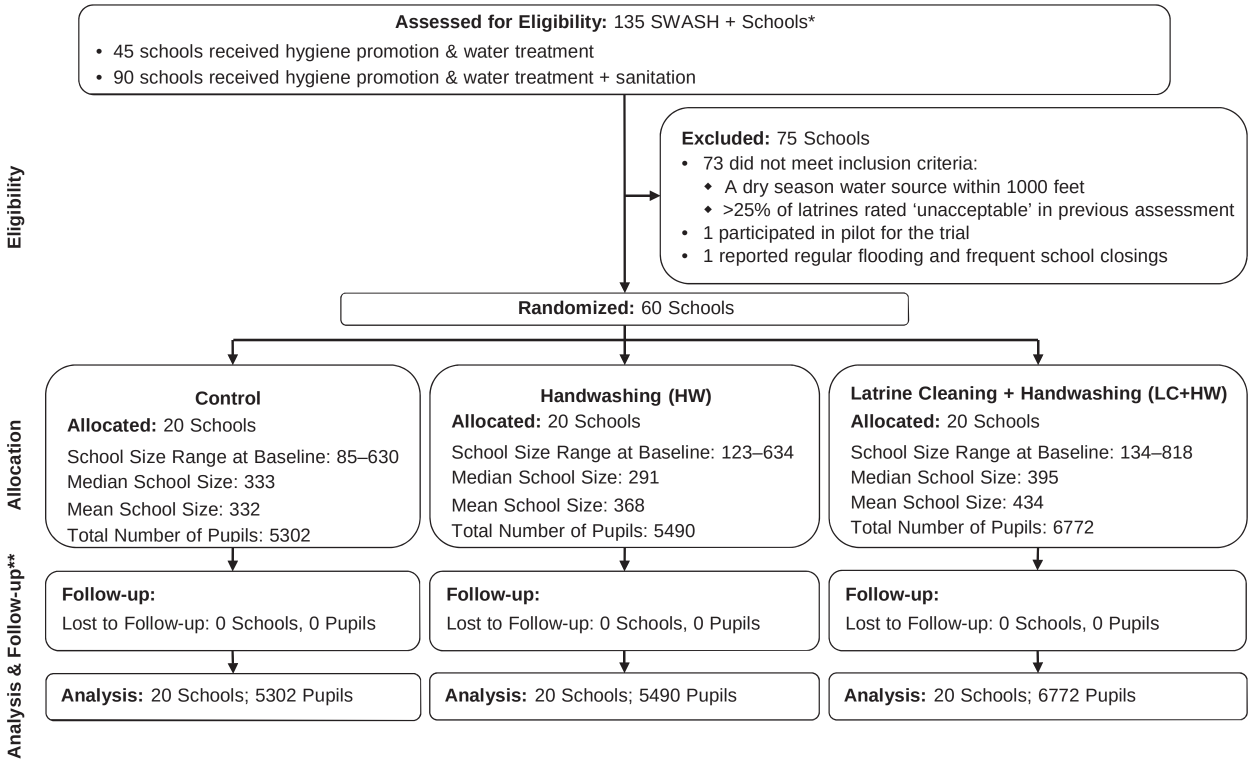

Figure 1 Flow chart indicating school and pupil eligibility, randomization, allocation, follow-up and analysis. *Schools received WASH interventions as part of the SWASH+ impact study (2007–2009). The hygiene promotion & water treatment intervention included handwashing containers with stands, chlorine solution for water treatment, and a 3-day training for teachers on hygiene promotion, behavior change strategies and water treatment. The sanitation intervention included newly constructed latrines. **Pupils may have transferred from the school throughout the course of follow-up. Tracking these pupils would have been difficult to verify. For consistency in data collection, a pupil's status of absent or present at school was taken without inquiry of where the pupil was if missing. We assumed, as a result of randomization, that transferring from the school would have been consistent throughout the intervention arms and our method of simply marking absent or present was sufficient.

materials, sheets for pupils to monitor latrines conditions daily and training for two teachers – the head teacher and health patron.

Toilet tissue was included as a type of preventative cleaning supply to dissuade smearing of faeces on walls, a behaviour pupils reported performing when they lack anal cleansing materials (McMahon *et al.* 2011a). Kenya's National School Health Guidelines indicate that schools should be providing appropriate anal cleansing materials such as toilet paper to pupils (MOPHS 2009) and pupils involved in focus group discussions from rural schools in the same province indicated that toilet paper was a preferred anal cleansing material (McMahon *et al.* 2011a). We piloted toilet tissue in three schools prior to the trial and in informal interviews, pupils responded positively to having it available for use (Caruso BA, Freeman MC, Rheingans R, data unpublished). Recognizing the potential risk of pathogen exposure to pupils engaged in latrine cleaning, materials were provided to make soapy water for handwashing, which including powdered soap and plastic bottles (Saboori *et al.* 2010).

Training sessions were conducted with one head teacher and one health patron from each school in the LC+HW arm. Health patrons were selected for inclusion because they are teachers who are specifically responsible for the school WASH environment (no additional pay provided for this responsibility). Head teachers were included because they supervise health patrons and are responsible for the pupils and the overall school environment.

All head teachers and health patrons were trained to instruct pupils to: (i) use the materials provided for latrine cleaning; (ii) monitor latrine conditions with a structured observation sheet; and (iii) make soapy water.

Table 1 Intervention components and input costs by study arm

Latrine cleaning + Handwashing (LC+HW)	Handwashing (HW)
Clean latrine package*	
Broom (1 broom; 150 KSH/1.75 USD)	
10 gallon buckets (2 buckets; 240 KSH/2.80 USD)	
Hand brush (1 brush; 40 KSH/0.50 USD)	
2.25 l bottle of Jik (bleech) (1 bottle; 240 KSH/2.80 USD)	
3.5 kg bag Omo powdered soap (1 bag; 620 KSH/7.30 USD)	
Plastic cup for scooping soap (1 cup; 10 KSH/0.12 USD)	
1/2 roll of toilet tissue per pupil (150 rolls; 2550 KSH/29.92 USD)	
Latrine conditions monitoring sheets	
Handwashing materials	Handwashing materials
500 ml plastic bottle (10 bottles; 160 KSH/1.90 USD)	500 ml plastic bottle (10 bottles; 160 KSH/1.90 USD)
3.5 kg bag Omo powdered soap (1 bag; 620 KSH/7.30 USD)	3.5 kg bag Omo powdered soap (1 bag; 620 KSH/7.30 USD)
Head teacher and health patron training	Head teacher and health patron training
Methods for making and using soapy water	Methods for making and using soapy water
Review of handwashing techniques and critical wash times	Review of handwashing techniques and critical wash times
Latrine cleaning and monitoring instruction	

	Per school		Per pupil	
	Kenya Shillings	US Dolars	Kenya Shillings	US Dolars
Average intervention input costs at implementation				
LC+HW	8530.00	110.59	28.43	0.37
HW	780.00	10.11	2.60	0.03
Average intervention input costs at midpoint†				
LC+HW	5089.25	65.98	16.96	0.22
HW	666.50	8.64	2.22	0.03
Total intervention costs for two terms				
LC+HW	13 619.25	176.57	45.40	0.59
HW	1446.50	18.75	4.82	0.05

*Schools received one latrine cleaning package for every four latrine doors. Even numbers of latrine packages were distributed per school for equity of supply availability among girls and boys. Four packages per school were distributed on average.
†After one term, supply levels were refreshed as needed. At a minimum, all schools received an additional 3.5 kg bag of Omo for handwashing and all LC+HW schools received four 3.5 kg bags of Omo and four bottles Jik for cleaning.

For latrine cleaning, methods for cleaning were demonstrated with all necessary supplies during the training. Teachers were provided with a step-by-step instruction sheet, which included a list of the materials needed; how to prepare, use and store cleaning materials; and a reminder to wash hands after cleaning. Instructions were informed by conversations with and observations of teachers and pupils in the pilot schools. For latrine monitoring, teachers were provided with a binder of monitoring sheets and were shown how to use them. Teachers were advised to have two pupils – one girl and one boy – observe latrines each day before lunch. Pupils would use a structured monitoring sheet to indicate which latrines had a bad, good or very good conditions, specifically, smell, flies, presence of faeces on walls and floor and urine. Pupils also recorded the amount of supplies available at the beginning and end of the week, which allowed the research team to see if more supplies were needed and how fast they were used. Teachers were also advised to come up with a system to equitably assign these responsibilities to students at their school. Finally, teachers were reminded of the critical times to wash hands and encouraged to remind the students in their schools. Inputs for the LC+HW arm cost 176.57 USD per school, approximately 0.59 USD per pupil.

The HW arm was included to determine whether handwashing inputs alone have an impact on absenteeism. Schools in the HW arm received powdered soap, plastic bottles and training, which cost 18.75 USD per school, approximately 0.06 USD per pupil.

Distribution of intervention supplies and training of head teachers and school health patrons on use of materials was led by CARE Kenya with support from the research team in June 2010 after baseline data collection. All schools in the intervention arms were provided additional supplies after the August school holiday as needed. Neither the schools nor the field enumerators were blinded to the intervention assignments.

Data collection

Trained enumerators from the Great Lakes University of Kisumu collected data in all schools at baseline (June 2010) and every 2 weeks from July to November 2010 (excluding August school break), for a total of five rounds of data collection post-implementation.

Latrine and handwashing conditions were observed at each round and recorded using Syware Visual CE v10 software (Cambridge, MA) on Dell Axim 951 (Round Rock, TX) personal digital assistants. Five latrine conditions were assessed and rated from 0 (absence) to 2 (strong presence): presence of faeces, urine, flies, smell and mud. At baseline, two enumerators independently collected conditions data at schools. Each enumerator followed standard data collection protocols, but start times were arranged such that conditions were observed without the presence of the other enumerator but close enough in time to ensure that the observed conditions had not changed between these two observations. Data from the two baseline observations were used to assess inter-rater reliability and internal consistency of conditions reporting. At the time of baseline data collection, enumerators were unaware of intervention allocation. For consistency and precision of subsequent data collection rounds, all latrine doors in each school were labelled at baseline using black permanent marker and were observed at the start of a school visit. Availability of handwashing water and soap/soapy water was assessed at the start of recess periods as teachers were advised to keep soapy water bottles in classrooms when not on recess to avoid theft and to assign a student to be in charge of bringing the bottles to the handwashing facility at the start and end of recess periods. Teachers were also advised to put bottles in an accessible and visible location for those accessing facilities during class time. Guidance to teachers was informed by feedback from teachers who were involved in the pilot phase.

Latrine use and handwashing behaviour were observed during the 30-min morning class recess. Structured observations were conducted with paper tools by trained enumerators who recorded if a girl or boy pupil entered a latrine block, what block it was, and whether or not the pupil washed their hands afterwards. Enumerators placed themselves in discrete locations where they each monitored a different set of latrines.

Pupil absence was assessed via roll-call. Enumerators created school-specific registries at baseline that included the names of all pupils enrolled at the school and their sex and age (if known). Roll was called at each unannounced visit, pupils announced if they were present, and they were marked absent or present.

Statistical methods

School enrolment and WASH data, including number of pupils per school, use of improved water source, distance to primary water source within <1 km, and sex-specific pupil to latrine ratios, were calculated and qualitatively compared at baseline to assess balance of intervention arms. All data were cleaned and analysed using SAS version 9.2 (Cary, NC).

Latrines were analysed at the individual door level to determine whether the intervention improved conditions. A latrine cleanliness score was calculated as the sum of five latrine conditions: presence of smell, faeces, urine, flies and mud. Baseline inter-rater reliability (ICC 1, $k = 0.88$) and internal consistency (ICC 3, $k = 0.79$) of the score were high (Portney & Watkins 2008). Post-implementation, each latrine cleanliness score was averaged across rounds and linear regression models accounting for clustering of data at the school-level were used to assess magnitude and significance of change.

To determine whether the intervention improved school latrine use, handwashing conditions and handwashing, school-level aggregated proportions of each set of indicators (averaged over each of the follow-ups) were compared between the intervention and control arms. Baseline levels were included in the model to enable a comparison of the change in each set of indicators from baseline to follow-up between the intervention and control arms. All models account for the stratified randomization (by geographic strata), baseline conditions and the clustering in the study design, using SAS survey procedures (e.g. PROC SURVEYREG).

To test our hypothesis that the latrine cleaning intervention would reduce absence, we employed multivariable linear regression models. Absence was determined for each pupil as the number of days absent from school over the total number of days observed post-implementation. The proportion of days of absence for each pupil was modelled against intervention status controlling for geographic strata and baseline school-level absence. A full model also included potential confounders: baseline school enrolment and community socioeconomic status (SES). Community SES was calculated using principal components analysis during the initial trial (Freeman *et al.* 2012). School-specific baseline absence is the proportion of students absent at baseline in each school specific to sex and grade. Accurate absenteeism data were not available at baseline for eight of the schools (2 HW, 6 C) because pupils were elsewhere for 'athletic days' on the date of visit. Subsequent rounds could not be used as a proxy for baseline as some schools had received interventions at that time. Regression imputation was used to estimate school-specific baseline absence by sex and grade for the schools missing data. Standard errors were adjusted to account for clustering at the school level (PROC SURVEYREG).

Results are presented for the entire school-population and are also stratified by sex and grade group. Sex stratification was determined *a priori* based on known differences in absence by sex. Grade groups were developed to reflect pupil schedules: Pupils in grades 1–3 only attend school in the morning; pupils in grades 4–7 attend school all day; and pupils in grade 8 have a rigorous examination schedule that determines secondary-school placement and is hypothesized to influence attendance.

Ethics

Ethics approval was granted by the Institutional Review Board at Emory University (Atlanta, GA) and the Ethical Review Committee at the Great Lakes University of Kisumu (Kisumu, Kenya). All schools in both the HW and Control arms received the same inputs as the LC+HW arm at the end of the study.

Results

Baseline pupil and school characteristics

A total of 17 564 pupils enrolled in 60 participating schools at baseline were tracked for absence. There were more pupils enrolled in the LC+HW schools (6772) than in the HW (5490) or control (5302) schools (Table 2). The proportion of pupils absent at baseline was lowest among control schools (9.8%) and highest among HW schools (12.9%). A greater proportion of LC+HW schools had an improved water source (85%) than in the other arms (65%). HW schools had a lower proportion of pupils per latrine (girls: 29.1, boys: 31.1), than those in the LC+HW (girls: 40.6, boys: 45.0) or control (girls: 42.4, boys, 34.2) arms.

Process outcomes

At each round, at least 79% of the LC+HW schools reported having the brooms, brushes and buckets provided as part of the intervention (data not shown). There was a slight drop in the availability of disinfectant products among LC+HW schools during the data collection round immediately after the August school holiday. At that time, only 55% of schools had bleach and 75% had powdered detergent; additional cleaning supplies were provided within 2 weeks. At all subsequent follow-up rounds, more than 80% of schools reported having these items. Half (50%) of LC+HW schools, 55% of HW schools and 25% of control schools had handwashing water available, and only 35% of LC+HW, 10% of HW schools and 0% of control schools had soap available at *all* follow-up observations (See: Saboori *et al.* 2013).

Impact on latrine cleanliness, use and handwashing

The mean latrine cleanliness score during the post-intervention period increased among the LC+HW schools only and was significantly higher (7.8, $P = 0.01$) than cleanliness scores for the control schools (6.9; Table 3). Other latrine conditions, such as drainage and proportion with a door, did not change between baseline and follow-up and were not statistically different between arms at follow-up. Latrine use was comparable at baseline between all arms. Aggregated use over follow-up rounds demonstrates an increase in latrine use across all arms. Use in LC+HW schools was not statistically higher than in the other arms.

Soap was available at handwashing stations more often during recess in LC+HW (73%, $P < 0.01$) and HW (55%, $P < 0.01$) schools during follow-up than in controls (5%). Water was observed in handwashing containers no more often in the LC+HW (84%, $P = 0.17$) and HW schools (78%, $P = 0.27$) than in control schools (68%), although a greater percentage of LC+HW and HW schools had water available than controls (Table 3).

A greater percentage of pupils in intervention schools practiced any kind of handwashing (LC+HW: 51.7%, $P = 0.02$; HW: 48.6%, $P = 0.03$; control: 33.3%) and handwashing with soap (LC+HW: 38.2%, $P < 0.01$; HW: 31.3%, $P < 0.01$; control: 2.9%) than those in control schools. An in-depth discussion of handwashing conditions and behaviours, with sex-disaggregated findings and assessment of hand contamination by study arm, has been reported elsewhere (Saboori *et al.* 2013).

Impact on absence

Mean absence over the follow-up rounds was greater for boys and girls in all grade groups across all intervention arms as compared to the single baseline measure with the

Table 2 Pupil characteristics and school WASH conditions at baseline for all trial arms

	Control		HW		LC+HW	
	n	%	*n*	%	*n*	%
Pupil enrollment	5302		5490		6772	
Grades 1–3	2127	40.1	2236	40.7	2680	39.6
Girls	1061	49.9	1094	48.9	1307	48.8
Grades 4–7	2693	50.8	2822	51.4	3465	51.2
Girls	1361	50.5	1403	49.7	1751	50.5
Grade 8	482	9.1	432	7.9	627	9.3
Girls	193	40.0	177	41.0	261	41.6
District						
Nyando/Kisumu	2551	48.1	2884	52.5	3836	56.6
Rachuonyo	2751	51.9	2606	47.5	2936	43.4
Pupil absence*	375	9.8	623	12.9	862	12.7
Grades 1–3	195	12.2	317	15.9	399	14.9
Boys	92	11.4	162	15.9	199	14.5
Girls	103	13.1	155	16.0	200	15.3
Grades 4–7	164	8.6	290	11.7	418	12.1
Boys	90	9.4	141	11.4	225	13.1
Girls	74	7.8	149	12.0	193	11.0
Grade 8	16	4.8	16	4.3	45	7.2
Boys	11	5.7	12	5.5	25	6.8
Girls	5	3.6	4	2.7	20	7.7
District						
Nyando/Kisumu	180	9.7	300	12.4	466	12.1
Rachuonyo	195	9.9	323	13.4	396	13.5
School facilities (n = 20)						
Water						
Current water source improved	13	65.0	13	65.0	17	85.0
Current water source >1 km away	2	20.0	1	5.0	1	5.0
Sanitation						
Mean girls per latrine (SD)	42.4 (34.4)		29.1 (16.5)		40.6 (27.4)	
Mean boys per latrine (SD)	34.2 (32.6)		31.1 (19.7)		45.0 (34.1)	

*Baseline data were collected at all schools, however events were being held at some control and HW schools which resulted in high rates of absenteeism that day. Therefore, baseline absenteeism was determined for only those schools that did not have an irregular event.

exception of girls in schools with the LC+HW intervention (Table 4). Except for boys in grades 1–3 of the control schools, this trend is consistent with baseline data demonstrating higher absence in grades 1–3 and declines through subsequent grade groups.

The adjusted absence rate among pupils in control schools was 12.6% during the intervention period, which was no different from that in HW schools (-0.3% difference, 95% confidence interval [CI]: -3.1;2.5) or LC+HW (+0.1% difference, 95% CI: -2.4;2.6). Neither intervention had a measureable impact on student absence when data were stratified by sex or grade group (See Table 5). Models with only design variables were not substantially different from the full models based on effect estimates and standard errors. All model parameters are shown in supplementary material.

Discussion

This is the first trial designed to assess the impact of a scalable, low-cost, school-level latrine cleaning supply intervention on pupil absence. All trial schools had previ-

Table 3 Baseline and follow-up for each intermediate outcome, reported by study arm

	Control		HW			LC+HW		
	Baseline	Follow-up*	Baseline	Follow-up*	*P*-value†	Baseline	Follow-up*	*P*-value†
Sanitation								
Latrine conditions	(n = 203 latrines)		(n = 240 latrines)			(n = 237 latrines)		
Cleanliness score	7.3 (0.4)	6.9 (0.3)	6.6 (0.3)	6.2 (0.3)	0.11	7.5 (0.3)	7.8 (0.2)	0.01
Drainage score	5.9 (0.0)	5.8 (0.1)	5.6 (0.2)	5.7 (0.1)	0.35	5.7 (0.1)	5.7 (0.0)	0.76
Proportion with door	0.7 (0.0)	0.7 (0.0)	0.7 (0.1)	0.7 (0.0)	0.13	0.7 (0.7)	0.8 (0.0)	0.47
School latrine use	(n = 20 schools)		(n = 20 schools)			(n = 20 schools)		
% of pupils that used a latrine	12.7% (1.3)	16.0% (1.7)	12.2% (1.3)	17.8% (1.5)	0.29	13.3% (1.7)	15.0% (1.4)	0.52
Handwashing								
School handwashing conditions								
Water in HW container	70.0% (10.7)	68.3% (7.2)	65.0% (11.2)	78.3% (6.4)	0.27	90.0% (7.0)	84.2% (4.7)	0.17
Soap available at HW containers	30.0% (10.8)	5.0% (2.3)	10.0% (6.7)	55.4% (5.5)	<0.01	30.0% (10.7)	72.5% (6.8)	<0.01
% of pupils that handwash after latrine use‡								
Washed with soap and water	3.6% (2.2)	2.9% (1.4)	1.3% (1.0)	31.3% (3.6)	<0.01	6.3% (4.6)	38.2 (5.55)	<0.01
Any type of handwashing	11.6% (3.3)	33.3% (4.0)	13.9% (5.2)	48.6% (3.9)	0.03	17.9% (5.4)	51.7% (5.3)	0.01

Data are mean (SD) or % (SE).
*Follow-up values are averaged over all of the follow-up rounds.
†*P*-value comparing intervention arm to control arm, accounting for baseline values, the stratified randomization, and the clustering in the study design.
‡Denominator is '% of pupils that used a latrine,' as shown above.

Table 4 Mean absence among primary school pupils by intervention type, grade group, and sex during follow-up (rounds 4–8) (N = 17 564)

	Control			HW			LC+HW		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Overall	5302	0.143	0.264	5490	0.143	0.249	6772	0.140	0.244
Grades 1–3									
Boys	1066	0.128	0.244	1142	0.155	0.258	1373	0.152	0.259
Girls	1061	0.152	0.280	1094	0.150	0.262	1307	0.146	0.259
Grades 4–7									
Boys	1332	0.168	0.282	1419	0.149	0.247	1714	0.149	0.241
Girls	1361	0.145	0.267	1403	0.135	0.240	1751	0.144	0.241
Grade 8									
Boys	289	0.087	0.188	255	0.081	0.178	366	0.063	0.170
Girls	193	0.075	0.204	177	0.127	0.266	261	0.068	0.176

Data are analyzed at the pupil level and only include pupils registered at the school at the time of baseline data collection.

ously received WASH interventions as part of the SWASH+ impact study, which found no significant difference in absenteeism among schools that just received water treatment and hygiene promotion and those that received new sanitation infrastructure (Freeman *et al.* 2012). This intervention was designed based on findings that latrine cleanliness was associated with reduced odds of absence (Dreibelbis *et al.* 2013), and pupils reported latrine conditions to be a barrier to use (Caruso *et al.* In Press). Handwashing materials and education were included to limit potential exposures among pupils who participated in cleaning given that the addition of new school latrines significantly increased risk of *E. coli* hand contamination among girls (Greene *et al.* 2012). We hypothesized that the intervention would improve latrine cleanliness, leading to increased use and reduced absenteeism among schools that had already received WASH infrastructure improvements and basic hygiene education.

Schools that received the LC+HW package had significantly cleaner latrines at follow-up rounds than those that did not receive the intervention; however, we did not find a significant increase in use or a reduction in absenteeism as hypothesized. There are a few possible explanations. First, improving latrine cleanliness may not have improved latrine conditions enough to encourage use. Certain structural components – such as floor, wall or door materials – make cleaning more difficult (Luby *et al.* 2010) and these components, while improved, may not have been clean enough. Integrity of latrine structures may also impair use. The LC+HW intervention did not aim to improve structural conditions, and these did not change as a result of our intervention. Future work should investigate how *both* cleanliness and structural conditions impact use of specific latrines, and if latrines with specific characteristics are used more frequently than others. Our simple, five-item measure proved reliable and would be easy to adapt to assess latrine cleanliness over time in other locations. A measure for assessing latrine structures should also be created and applied.

Second, the latrine cleaning intervention may not have been in place long enough to influence pupil behaviour and to change previously established habits. The intervention was designed to be scalable and focused on environmental-level improvements alone. It did not include a behaviour change component that specifically motivated pupils to use latrines and did not train pupils to use latrines correctly. Individual-level training on latrine use has been recommended (Le *et al.* 2012) and may have been effective, particularly for younger pupils given reports that young pupils are primarily responsible for making the latrines dirty (unpublished findings from piloting phase). In addition, increased emphasis on clean latrines could have intimidated pupils too much to use latrines if they feared being held responsible for making them dirty.

Finally, the additive impact of cleaning may not have been strong enough to impact absence above and beyond reductions attributable to the original WASH infrastructure improvements and basic hygiene education. While pupils should have access to facilities that are clean, other facility attributes may be more necessary to influence use and absence behaviour. For example, girls who are menstruating have indicated that they want access to water and a place to dispose of used sanitary materials inside

Table 5 Adjusted estimates of absence by intervention group, assessing all pupils collectively and stratifying by sex

Parameter	All pupils				Boys				Girls			
	Proportion absence	95% CI		*P*-value	Proportion absence	95% CI		*P*-value	Proportion absence	95% CI		*P*-value
All pupils												
Control	0.126	0.101	0.150		0.126	0.098	0.155		0.125	0.101	0.150	
HW *vs.* control	-0.003	-0.031	0.025	0.83	0.001	-0.031	0.028	0.93	-0.005	-0.033	0.023	0.73
HW+LC *vs.* control	0.001	-0.024	0.026	0.94	-0.001	-0.028	0.029	0.97	0.001	-0.024	0.027	0.91
Grades 1–3												
Control	0.140	0.105	0.175		0.131	0.085	0.178		0.150	0.111	0.189	
HW *vs.* control	0.014	-0.016	0.044	0.34	0.028	-0.004	0.060	0.09	0.001	-0.033	0.035	0.95
HW+LC *vs.* control	0.020	-0.012	0.051	0.22	0.033	-0.003	0.069	0.08	0.006	-0.029	0.042	0.72
Grades 4–7												
Control	0.140	0.106	0.173		0.151	0.109	0.194		0.129	0.095	0.163	
HW *vs.* control	-0.018	-0.047	0.011	0.22	-0.020	-0.054	0.014	0.24	-0.016	-0.045	0.012	0.25
HW+LC *vs.* control	-0.009	-0.037	0.019	0.53	-0.017	-0.048	0.014	0.28	-0.001	-0.030	0.029	0.96
Grade 8												
Control	0.067	0.036	0.098		0.079	0.044	0.113		0.050	0.011	0.088	
HW *vs.* control	0.020	-0.040	0.080	0.50	-0.007	-0.052	0.038	0.76	0.062	-0.030	0.153	0.18
HW+LC *vs.* control	-0.013	-0.046	0.019	0.41	-0.018	-0.050	0.014	0.26	-0.008	-0.059	0.044	0.77

latrines to manage menses effectively in the school setting (McMahon *et al.* 2011b; Crofts & Fisher 2012; Caruso *et al.* 2013; Haver *et al.* 2013; Long *et al.* 2013; Sommer *et al.* 2014). Regardless of cleanliness, girls may elect to not use latrines or not attend school if latrines are not equipped appropriately. Evaluation of latrines that suit the specific needs of girls is needed.

A significantly greater proportion of LC+HW and HW schools had soap available during recess periods and a significantly greater proportion of students from LC+HW and HW were observed washing their hands after latrine use compared to controls. While handwashing decreases the risk of diarrhoea and respiratory disease (Rabie & Curtis 2006; Cairncross *et al.* 2010; Burton *et al.* 2011), increased availability of supplies and handwashing behaviour in the intervention schools did not result in a decrease of absenteeism. Rates of handwashing may not have been high enough to reduce pathogen exposure in the school community and therefore impact health and absence. An assessment of *E. coli* contamination on pupil hands in a subset of the trial schools ($N = 24$) found that there was a non-significant reduction in contamination compared to controls (Saboori *et al.* 2013).

While consistent soap provision and moderate teacher training can influence pupil handwashing behaviour, a more intensive behaviour change intervention directly engaging and motivating students may be more effective at increasing the proportion of students washing hands after latrine use and in decreasing hand contamination. Intensive pupil behaviour change efforts will only be effective if water and soap – or equivalent culturally acceptable handwashing solutions – are available. Research has demonstrated that increased budgets for operational WASH costs positively impacted availability of needed supplies in schools, but did not ensure that students had access to those supplies once they were procured (Alexander *et al.* 2013). More intensive behaviour change may also need to occur among those teachers who are responsible for making water and soap available to pupils when they need it. This study did not directly observe or evaluate teacher behaviours or determine what factors motivated or hampered their ability to perform the behaviours they were hoped to perform. Because teachers play such a critical role in helping to sustain an enabling WASH environment, understanding teacher behaviours and creating teacher-specific behavioural programs may positively influence school WASH environments and student practices. In other words, behaviour change strategies should focus simultaneously on motivating students to use latrines and wash hands and on encouraging teachers and school management committees to do their part in sustaining the conditions needed to allow students to practice the behaviours they are taught.

This study had four primary limitations. First, randomization was expected to result in uniform school conditions across arms. However, more LC+HW schools had access to an improved water source and had handwashing water available at first visit compared to other arms. LC+HW schools also had higher latrine cleanliness scores at baseline, potentially limiting any marginal impact attributable to the intervention. A strength of the design is that randomization should lead to balance of confounders across intervention arms. Second, this intervention was initiated at the start of the second term and ran only through the end of the school year (end of term 3). The intervention may not have been in place long enough to influence and sustain latrine use behaviour change. Moreover, starting the intervention during the school year may have been a disadvantage. Habits may have already been formed and harder to change than if it had been initiated at the start of the school year prior to the establishment of habitual behaviours around latrine use. Third, because of study timing and other constraints, we were not able to carry out qualitative work at the close of the study to gain pupil insights about the interventions. We did pilot the interventions and make improvements to the intervention packages prior to the trial; however, a follow-up qualitative study may have helped to explain the results found and to provide suggestions for further improvement from the perspective of pupils. Finally, because this was a school-level intervention, blinding was impossible. This may have introduced courtesy bias in intervention schools that were aware of their involvement in the study. However, all school visits were unannounced and schools did not specifically know what conditions were being observed. Any courtesy bias was likely minimal. Despite strong inter-rater reliability of latrine condition observations at baseline, lack of blinding may have also introduced reporting bias on the part of our enumerator team. This bias may have exaggerated differences in conditions between intervention and control schools. However, noted differences are consistent with more objective observation measures (i.e. soap and water available for handwashing) the impact of this bias was likely minimal.

Conclusion

Provision of low-cost, locally available materials alongside a low-intensity teacher training led to increased latrine cleanliness in +HW schools and greater availability of handwashing materials and increased handwashing behaviour in LC+HW and HW schools over the course of the study period. However, we did not find evidence that our intervention increased use of latrines or pupil absence. Regardless, improving latrine conditions is important for the dignity and well-being of those pupils who are using the latrines, and investments and efforts should continue to make school sanitation environments clean and pupil-friendly. Soap provision influences handwashing behaviour, and efforts should be made to ensure supplies are consistently available. For both latrine use and handwashing behaviour, more intensive behaviour change strategies should be formulated and tested in the school setting to ensure that healthy habits can be established and maintained at school.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Adjusted estimates of absence by intervention group, assessing all pupils collectively and stratifying by sex with design variables and covariates.

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