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A Cluster-Randomized Trial Assessing The Impact Of School Water, Sanitation, And Hygiene Improvements On Pupil Enrollment And Gender Parity In Enrollment

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Abstract

We employed a cluster randomized trial design to measure the impact of a school based water, sanitation, and hygiene (WASH) improvement on pupil enrollment and on gender parity in enrollment, in primary schools in Nyanza Province, Kenya (2007-2009). Among schools with poor water access during the dry season, those that received a water supply, hygiene promotion and water treatment (HP&WT) and sanitation improvement, demonstrated increased enrollment (β=0.091 [0.009, 0.173] p=0.03), which translates to 26 additional pupils per school on average. The proportion of girls enrolled in school also increased by 4% (prevalence ratio (PR)=1.04 [1.00, 1.07] p=0.02). Among schools with better baseline water access during the dry season (schools that didn't receive a water source), we found no evidence of increased enrollment in schools that received a HP&WT intervention (β=0.016 [-0.039, 0.072] p=0.56) or the HP&WT and sanitation intervention (β=0.027 [-0.028, 0.082]p=0.34), and there was no evidence of improved gender parity (PR=0.99 [0.96, 1.02] p=0.59, PR=1.00 [0.97, 1.02] p=0.75, respectively). Our findings suggest that increased school enrollment and improved gender parity may be influenced by a comprehensive WASH program that includes an improved water source; schools with poor water access during the dry season may benefit most from these interventions.

Introduction

The world has made considerable gains in achieving universal primary education. However, by 2015 as many as 72 million primary school aged children will be out of school (UNESCO, 2011). In addition, in developing countries the gender parity index of gross enrollment ratio – the proportion of girls attending out of all eligible girls over the proportion of boys attending out of all eligible boys – is 0.91. There are many factors that influence pupil enrollment, including governmental policy, community, and individual factors, such as distance to school, poverty, number of siblings, teacher to pupil ratio, over-crowding and perceived quality of education (Baschieri & Falkingham, 2009; Filmer, 2007; Huisman & Smits, 2009; Kazeem, Jensen, & Stokes, 2010; Wells, 2009). Access to water, sanitation, and hygiene (WASH) at school is an understudied factor that may be a critical enabling factor for enrollment, attendance, and learning (UNICEF, 2010).

There is limited, but compelling evidence on the health and educational impact of school WASH improvements. Studies in China, Egypt, and Kenya have shown that a school hygiene promotion campaign can reduce absence and absence due to illness by between 20% and 58%, in some cases, specifically for girls (Bowen et al., 2007; Freeman et al., 2012; Nandrup-Bus, 2009; Talaat et al., 2011). Similar results have been found as part of a hygiene promotion and water treatment campaign (Blanton et al., 2010; O'Reilly et al., 2008). A multilevel comparison of school, household, and individual-level characteristics found that latrine conditions were the only school-level WASH factor significantly associated with pupil absence (Dreibelbis et al., 2012).

Although the percentage of children in Kenya attending school has increased 31% in the past 10 years to 81%, 1.1 million primary school-aged children remained out of schools – the world's 7th largest out-of-school population (UNESCO, 2011). Among primary schools in Kenya, the gender parity index of gross enrollment ratio is 0.98, which is on course with UNICEF goals. However, in Kenya there is a trend of decreasing gender parity with age, and the gender parity index of gross enrollment ratio is only .92 among secondary schools. In Kenya, schools are allocated resources based on population parameters, but selection of a specific primary school is left to the family, and it is thus feasible that the provision of new WASH infrastructure may draw children to a specific school from surrounding areas.

The objective of this study was to assess how a school-based hygiene promotion, water treatment, sanitation, and water source improvement program increased enrollment of primary school pupils in western Kenya. We also assessed how these interventions might improve gender parity in enrollment, especially among females in the upper primary school grades.

Methods

Background and study design

We conducted a cluster-randomized trial to assess the impact of several different school-based WASH interventions on health and educational attainment of school pupils (Freeman et al., 2012; Greene et al., 2012). The study took place in what were formally four districts of Nyanza Province, Kenya – Rachuonyo, Suba, Nyando, and Kisumu – between 2007 and 2009. Here we present data on the impact of school water supply improvements, hygiene promotion and water treatment (HP&WT), and latrine construction on school enrollment, with specific attention to gender parity in enrollment.

A rapid survey assessing school WASH conditions was sent to every public primary school (n=1,084) in the geographic area; 83% of the surveys were returned. For logistical purposes,

in collaboration with the Ministry of Education, the project stakeholders selected a sub-set of administrative divisions for inclusion in the research study. Schools with pupil to latrine ratios that exceeded the Government of Kenya standard of 25:1 for girls and 30:1 for boys were eligible for the study (Government of Kenya, 2008). Schools were then divided into two groups based on access to water supply during the dry season, where two separate randomized controlled trials took place. Schools with a water source within one KM were eligible for the "water available" group. Schools that did not have an improved source within one KM or any source within two KM were eligible for the "water scarce" group. An improved water source was defined using the definitions designated by the UNICEF/WHO Joint Monitoring Program (wssinfo.org). These distance cutoffs were determined in collaboration with implementing partners and the Kenyan Government.

Figure 1 shows the random sampling and allocation of schools. Of "water available" schools, 135 were randomly selected – stratified by geographic district – into three arms of 45 schools each: 1) HP&WT, 2) HP&WT and sanitation improvement, and 3) the "water available" control arm. The HP&WT intervention was based on an approach pioneered by the Centers for Disease Control and Prevention known as the safe water system, which includes water treatment at the point of use, safe storage of treated drinking water, and behavior change communication (Mintz, Reiff, & Tauxe, 1995). Hygiene promotion consisted of a three-day training of teachers on the importance of hand washing with soap, provision of water containers with taps, and instruction on hygiene education. Teachers were instructed on behavior change approaches for use at school, including child-to-child approaches for hygiene education; the project implementers did not directly target students. Soap was not provided by the intervention, but schools were encouraged to purchase it. Water treatment improvements included the provision of narrow-mouthed containers with taps for drinking water storage, and a one-year supply of WaterGuard – a 1.2% chlorine-based point-of-use water disinfectant promoted by Population Services International. Schools that received sanitation improvements received latrines to bring the school to the government standard of pupil to latrine ratio, up to a maximum of seven latrines. School teachers were given training on the maintenance of the facilities, but no maintenance materials or consumable products, such as toilet tissue, were supplied.

Among "water scarce" schools, 50 were randomly allocated to two arms: 1) HP&WT, sanitation, plus water supply improvement (WS) and 2) the "water scarce" control arm. Water supply improvements consisted of a drilled borehole (groundwater conditions permitting) with piped access to the school (n = 12) or, in locations where groundwater was inaccessible with a drilled well, a 60m^3 rainwater harvesting system (n = 13). In both study groups, control schools received the intervention at the end of the study period. All children attending the 185 study schools received yearly deworming with 400mg of Albendazole.

Schools were selected for inclusion in the study by researchers using a random number generator. Random allocation of schools to study arms was conducted by the research manager following the baseline data collection, and was stratified by district. The interventions were implemented by CARE and Water.org, and neither communities nor data collectors were blinded to the intervention status of the schools. Enrollment of pupils was completely enumerated, so no sampling was done at the pupil level.

Of the 185 schools in the study, baseline enrollment data were missing for two schools (1%), which disallowed us from using these two schools in the analyses. One school in the control arm of the water available group was missing data for the outcomes of interest in the 2008 measure, but not 2009, allowing us to include this school for only 2009.

Data collection

The outcomes of interest – total enrollment and the proportion of enrolled students who were girls – were collected from official school records at the start of the school year for the pre-intervention measure (2007) and for the two years of follow-up (2008, 2009). Data for school-level covariates were collected by structured interviews with head teachers and observations of the school WASH conditions pre-intervention in February to March of 2007, and for two years following the interventions between the months of September and October of 2008 and 2009. Data were collected by trained enumerators from the Great Lakes University of Kisumu.

Ethics statement

The Emory University Institutional Review Board (Atlanta, GA, USA) provided ethical approval for this project, and the Government of Kenya Ministries of Health, Water and Irrigation, and Education granted permission to conduct this trial. Head teachers of each school provided approval in *loco parentis*. Oral assent was obtained from all participants. There were no interim analyses or stopping guidelines.

Data analysis

All analyses were carried out in SAS version 9.2 (Cary, NC, USA). Both the total enrollment and the gender parity analyses used mixed multilevel regression models. The data were analyzed using an intention-to-treat analysis.

For the school enrollment analysis, we employed multivariable linear regression using SAS's MIXED procedure. The outcome variable, school enrollment, was a cluster-level (school-level) variable, which was log-transformed to meet regression assumptions of normality. To make inference to total enrollment—rather than log enrollment—we back transformed the expected mean log enrollment (at baseline covariate levels) for both the intervention and control groups via exponentiation.

The outcome for the gender parity analysis was the probability of being a girl (or the proportion of girls) enrolled in school, an individual-level variable. Prevalence ratios (PR), comparing the proportion of girls in the intervention arm to the proportion of girls in the control arm, were calculated directly using multivariable log-risk regression using SAS's GLIMMIX procedure. While the proportion of girls enrolled in school is not a traditional measure of gender parity, this outcome was chosen as it allowed for a robust statistical analysis of how parity in enrollment is affected by the interventions. Data were analyzed by grade cohort, meaning that children in grade one in 2007 were considered to be grade two in 2008 and grade three in 2009. As such, pupils in grade seven at baseline had only one follow-up time point and grade eight pupils were not included in the analysis. Including interaction terms between grade-cohort and the intervention allowed us to ascertain different levels of effectiveness of the intervention by grade cohort. The intracluster correlation coefficient (ICC) was calculated using one-way ANOVA.

Unadjusted models (including only design variables) and adjusted models (also including potential confounders) were considered for both the total enrollment analysis and the gender parity analysis. In each of our analyses, the intervention variable was included in the model along with several design variables: baseline outcome measures (either baseline enrollment or baseline proportion of girls), which accounted for potential differences at baseline; district, which accounted for the stratified randomization; and year, which was used to assess repeated measures over the two years of follow-up. The models accounted for intracluster correlation by including a random effect for school, and for correlation between repeated measures over time by specifying the working correlation matrix (Hayes, Moulton,

& Morgan, 2009). The adjusted total enrollment and gender parity models are shown below, and only vary from the unadjusted models in that the confounders are included in the models.

Total enrollment model:

$$Y_{ijk} = \beta_0 + \beta_1 \text{intervention} + \beta_2 \text{year} + \beta_3 \text{baseline} + \beta_4 \text{district1} + \beta_5 \text{district2} + \sum \beta_6 \text{confounders} + u_{0jk} + e_{ijk}$$

Y_{ijk} represents total school log enrollment, where there are observations at time i (2008 or 2009), in the jth school, within the kth district. Intervention, year, district, and each of our confounders (floor, electricity, and roof type) are represented by indicator variables. Baseline is the number of pupils enrolled at a given school in 2007, before the intervention. u_{0jk} represents a random intercept for the jth school within the kth district, and e_{ijk} represents the residual.

Gender parity model:

$$\ln[P(Y_{ijkl}|X)] = \beta_0 + \beta_1 \text{intervention} + \beta_2 \text{year} + \sum \beta_j \text{grade}_j + \beta_9 \text{baseline} + \beta_{10} \text{district1}$$
$$+ \beta_{11} \text{district2} + \sum \beta_6 \text{confounders} + \sum \beta_j \text{grade}_j * \text{intervention} + u_{0jkl}$$

Y_{ijkl} equals the proportion of girls enrolled, where there are observations at time i (2008 or 2009), in the jth grade, in the kth school, within the lth district. Grade_j represents an indicator variable for each grade and grade_j*intervention is the interaction term between each grade and the intervention. Baseline equals the proportion of girls enrolled in 2007. All other variables were as specified in the total enrollment model above.

A systematic model selection strategy was used to assess if there were significant interactions of any of the variables with the intervention, and if there were potential confounders (Kleinbaum & Klein, 2002). The three potential confounders that were chosen *a priori* were floor type (cement floors, earth floors, or both), electricity, or iron sheet roofs, all of which were considered to be potential measures of school-level wealth.

Results

Baseline conditions

School conditions at baseline are presented in Table 1. Few schools had electricity (0%-4%) and nearly all had iron sheet roofing (98%-100%). There was a slight imbalance at baseline in the floor variable, which was most pronounced in the water available group, where 33% of the HP&WT arm had earth floors, 45% of the HP&WT + Sanitation arm had earth floors, and 50% of the control arm had earth floors. Most other demographic variables, including access to water, pupil/latrine ratio, water available during school visit, and hand washing water were generally balanced between intervention arms.

In the water scarce group, the mean baseline enrollment for the HP&WT + Sanitation + WS arm was 332 pupils per school, and the control arm had 361 pupils per school (Table 2). However, in the water available group, the control arm was smaller (274 pupils per school) than the two intervention arms (355 and 344 pupils per school). At baseline, the mean proportion of girls was similar for all five study arms and ranged between 47% and 48% girls per school. The baseline proportion of girls decreased with increasing grade, and was

generally the highest among those in grade one (50%-51%) and the lowest among those in grade seven (38%-43%; data not shown).

Total enrollment

In the linear regression analyses for the water scarce group, log enrollment increased in the schools that received the HP&WT + Sanitation + WS intervention, compared to those in the control arm (adjusted: β=0.091 [0.009, 0.173] *p*=0.03; Table 3). When back transforming these results from log enrollment to total school enrollment, this translates to a 9% increase in mean (geometric) school enrollment in the schools that received the intervention compared to the control group, or a 26 pupil increase per school due to the intervention, and represents the average increase over both years of follow-up. An additional analysis found that of the schools in this HP&WT + Sanitation + WS arm, the adjusted estimate for the 12 schools that received the drilled borehole was β=0.116 ([0.017, 0.216] *p*=0.02) and the estimate for schools who received a harvesting system was β=0.060 ([-0.045, 0.167] *p*=0.25), both compared to the control arm. However, it should be noted that the outcome was not randomized by type of water system, so this additional analysis should be interpreted cautiously.

For the multivariable linear regression analysis of the water available group, we found no difference in log-enrollment for the adjusted model (HP&WT: β=0.016 [-0.039, 0.072] *p*=0.56; HP&WT + Sanitation: β=0.027 [-0.028, 0.082] *p*=0.34; Table 3). These differences, if significant, would translate to an overall increase of 6-8 pupils due to the interventions.

Gender parity in enrollment

In the water scarce group, the multivariable log risk regression analysis revealed a 4% average increase in the proportion of girls enrolled in intervention schools compared to control schools, over the two years of follow-up (adjusted model prevalence ratio (PR)= 1.04 [1.00, 1.07] *p*=0.02; Table 3). The ICC for the proportion of girls enrolled in the water scarce group at baseline was 0.03 [0.00, 0.11]. When grade was included as an interaction term with the intervention effect, to get grade-specific effects, data revealed that the grade cohort that benefits most from the intervention are girls who were in the sixth grade cohort (and would be 8th graders in 2009). In the sixth grade cohort, there was a 9% average increase in the proportion of girls enrolled in the intervention schools, compared to the control schools over the two years of follow-up (PR=1.09 [1.02, 1.18] *p*=0.02; Figure 2). In the seventh grade cohort, the proportion of girls enrolled in 2008 (seventh graders were only followed for one year) was 7% higher in the intervention schools than the control schools, but was not statistically significant (PR=1.07 [0.95, 1.19] *p*=0.26).

In the water scarce group, there was a gradual decrease in the effect of the intervention with increasing grade within lower primary school—grades one through four (Figure 2). For grade one there was a 6% increase in the proportion of girls in the intervention arm compared to the control arm (PR=1.06 [1.00, 1.12] *p*=0.05), a 5% increase for grade two (PR=1.05 [0.99, 1.11] *p*=0.09), a 2% for grade three (PR=1.02 [0.96, 1.08] *p*=0.47), and a 3% decrease for grade four (PR=0.97 [0.91, 1.03] *p*=0.32).

In the water available group, we found no effect of the intervention on gender parity in enrollment from either the arm that received WT&HP (PR=0.99 [0.96, 1.02] *p*=0.59) or the arm that received HP&WT and sanitation (PR=1.00 [0.97, 1.02] *p*=0.75; Table 3). We also found no effect on enrollment parity by grade for either of the intervention arms in this group (Figure 2). The ICC for the water available group was 0.03 [0.00, 0.08].

Discussion

The results of the various school based WASH improvements were mixed. We found evidence that schools classified as "water scarce" that received a comprehensive WASH intervention, including a water supply improvement, did show a substantial and significant increase in enrollment. We also found that increased school enrollment in that group coincided with improvements in gender parity in school enrollment, which was primarily driven by increases in the proportion of girls in grades one, six, and seven (the study design prevented an assessment at grade 8). Among those schools classified as "water available" that received the HP&WT intervention or the HP&WT and sanitation intervention, but no water supply improvement, we saw no significant improvement in enrollment or gender parity.

WASH improvements may provide an appealing environment to pupils and parents, through non-health mechanisms, such as through added amenities, convenience, privacy, and even added pride in one's school. One potential mechanism of effect is that that new water sources reduce the burden of water collection on children at school and/or home. This is supported by our gender parity analysis, which found improved enrollment specifically for girls, as it is known that the burden of water collection largely falls on women and girls in sub-Saharan Africa (UNICEF & WHO, 2012). In schools that received a drilled borehole, the community managed the water supply, and community members were permitted access. As such, the water supply component may have had effects beyond that of a strict school-based intervention. This mechanism would be dependent on improved water access, and may explain why we observed improvements only in those schools that received an improved water source.

Another potential mechanism for improvements in gender parity for enrollment is that a comprehensive WASH program that includes water source improvements may be particularly important to girls as they reach the age of menarche (McMahon et al., 2011; Pearson & McPhedran, 2008; Sommer, 2010). Our results in the water scarce schools were most pronounced during sixth and seventh grades, the grades when girls would likely be reaching menarche. The water supply could be important for effective personal hygiene, but shouldn't be considered independent from the other WASH components in the intervention, as water might also be necessary for the effective cleaning and use of latrines and latrines might allow for a private location where personal hygiene can take place.

Substantial facility improvements—WASH or otherwise—at a school, may influence parents to send their children, both boys and girls, to that school at a higher rate. It may be that in the context of this study, schools without a water supply at baseline benefitted more because the school improvements were more easily perceived by parents and students in a way that may have encouraged enrollment. A more notable improvement among schools with poorer baseline water availability might explain why we saw increases in the proportion of girls enrolled in the water scarce group, but not the water available group.

It is also possible that the improvements were through a health related mechanism. It has been well documented that poor WASH conditions may result in a variety of illnesses, such as diarrhea, helminth infection, and acute respiratory infection (Rabie & Curtis, 2006), which may lead to absenteeism (Bowen et al., 2007; Freeman et al., 2012), and could feasibly lead to eventual dropout. Although absenteeism and decreased enrollment are both measures that represent children not attending school, they are different outcomes in that the former is often temporary and the latter reflects a more permanent state of non-attendance and even actual drop-out. While possible that reduction in illness contributed to changes in

our outcomes, it seems unlikely, especially as we saw no differences in the water available schools that received either HP&WT, or HP&WT + Sanitation, but no water source.

A comparison of the effect of comprehensive WASH in the "water scarce" group that included a water supply improvement and the effect of interventions in the "water available" group that did not include a water supply should be approached with caution. The underlying sampling frame of these two groups was different and the "water scarce" schools had, by design, lower WASH access at baseline and were likely located in poorer communities. Our results suggest that an improved water source is integral to increased enrollment and improved gender parity, but we cannot know if these improvements were due to the water source by itself, or to the water source working in concert with the other WASH elements. Furthermore, while it seems that this intervention may be most important for water scarce schools, water available schools might have also benefitted from an improved water source. It is possible that we simply overestimated the quality and availability of the water supply in the water available schools. Table 1 shows several similarities in water availability at baseline, but it should be noted that these baseline measures compared water availability during the rainy season, and not water availability during the dry season which is what was used to differentiate between the "water scarce" and "water available" groups.

These data complement other findings from this trial, which suggest that the basic HP&WT package of interventions reduced absence among girls, but not boys (Freeman et al., 2012) and that there was no impact of the comprehensive HP&WT, sanitation, and water supply intervention on absence in water scarce schools (*Freeman, unpublished data*).

There were several limitations to the study. First, the intervention was not blinded, which has the potential to lead to reporting biases. However, both of the outcomes were collected from official school records and therefore were not likely to have been affected by any differential reporting bias. Second, we did not have the ability to track individual pupils, so we cannot know if increases in enrollment were due to increased retention, to increased enrollment from new enrollees, or if they were due to pupils transferring between schools. Given that over the surveillance period enrollment declined in the controls, and given the notable improvements in the gender parity in the upper grades, it is probable that the interventions may have reduced the drop-out relative to the controls rather than increased enrollment. Third, the results may have been affected by political upheaval in early 2008 following the presidential election, which led to migration in each of the districts, but especially in Nyando/Kisumu. However, when controlling for district, the results are similar, and the intervention did not have a differential effect based on the study area. Finally, the uptake and compliance of the WASH interventions was heterogeneous and the achievements in some schools was sub-optimal (Freeman et al., 2012). Low compliance in the intervention arms may bias results towards the null.

Conclusions

To our knowledge, this is the first study to use a randomized design to test the impact of school WASH improvements on enrollment and parity in enrollment. We found compelling evidence that a comprehensive WASH improvement program in schools with poor water access during the dry season schools led to increases in overall school enrollment, and as girls were impacted more than boys, the intervention improved enrollment parity. Additional research could elucidate the specific mechanism of enrollment by tracking pupils longitudinally and confirm the role of individual WASH characteristics in pupil retention. Qualitative research regarding the factors leading to school choice in resource-poor areas would also be of value.

Acknowledgments

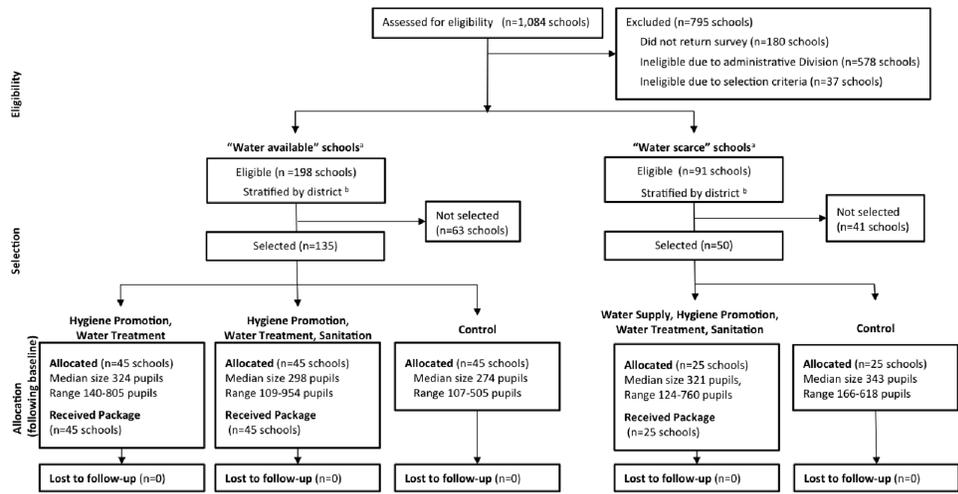## References

Baschieri A, Falkingham J. Staying in school: Assessing the role of access, availability, and economic opportunities - the case of Tajikistan. Population, Space and Place. 2009; 15(3):205–224.

Blanton E, Ombeki S, Oluoch G, Mwaki A, Wannemuehler K, Quick R. Evaluation of the role of school children in the promotion of point-of-use water treatment and handwashing in schools and households--Nyanza Province, Western Kenya, 2007. American Journal of Tropical Medicine and Hygiene. 2010; 82(4):664–671. [PubMed: 20348516]

Bowen A, Ma H, Ou J, Billhimer W, Long T, Mintz E, Hoekstra M, Luby SP. A cluster-randomized controlled trial evaluating the effect of a handwashing-promotion program in Chinese primary schools. Am J Trop Med Hyg. 2007; 76(6):1166–1173. [PubMed: 17556631]

Dreibelbis, R.; Greene, LE.; Freeman, MC.; Saboori, S.; Chase, RP.; Rheingans, R. Water, sanitation, and primary school attendance: A multi-level assessment of determinants of household-reported absence in Kenya. International Journal of Educational Development. 2012. In press: http://dx.doi.org/10.1016/j.bbr.2011.03.031

Filmer D. If you build it, will they come? School availability and school enrolment in 21 poor countries. Journal of Development Studies. 2007; 43(5):901–928.

Freeman M, Greene L, Dreibelbis R, Saboori S, Muga R, Brumback B, Rheingans R. Assessing the impact of a school-based water treatment, hygiene, and sanitation program on pupil absence in Nyanza Province, Kenya: A cluster-randomized trial. Tropical Medicine & International Health. 2012; 17(3):380–391. [PubMed: 22175695]

Government of Kenya. Sector plan for environment, water and sanitation: 2008-2012: Report of the government of Kenya. 2008

Greene LE, Freeman MC, Akoko D, Saboori S, Moe C, Rheingans R. Impact of a School-Based Hygiene Promotion and Sanitation Intervention on Pupil Hand Contamination in Western Kenya: A Cluster Randomized Trial. Am J Trop Med Hyg. 2012; 87(3):385–393. [PubMed: 22802437]

Hayes, R.; Moulton, LH.; Morgan, BTJ. Cluster randomized controlled trials. Chapman and Hall/CRC Press; New York: 2009.

Huisman J, Smits J. Effects of Household- and District-Level Factors on Primary School Enrollment in 30 Developing Countries. World Development. 2009; 37(1):179–193.

Kazeem A, Jensen L, Stokes CS. School attendance in nigeria: Understanding the impact and intersection of gender, Urban-Rural residence, and socioeconomic status. Comparative Education Review. 2010; 54(2):295–319.

Kleinbaum, DG.; Klein, M. Logistic Regression: A Self-Learning Text. 2nd. Springer-Verlag; New York: 2002.

McMahon SA, Winch PJ, Caruso BA, Obure AF, Ogutu EA, Ochari IA, Rheingans RD. 'The girl with her period is the one to hang her head' Reflections on menstrual management among schoolgirls in rural Kenya. BMC Int Health Hum Rights. 2011; 11(1):7. [PubMed: 21679414]

Mintz ED, Reiff FM, Tauxe R. Safe water treatment and storage in the home: a practical new strategy to prevent waterborne disease. Journal of the American Medical Association. 1995; 273:948–953. [PubMed: 7884954]

Nandrup-Bus I. Mandatory handwashing in elementary schools reduces absenteeism due to infectious illness among pupils: a pilot intervention study. Am J Infect Control. 2009; 37(10):820–826. [PubMed: 19850374]

O'Reilly CE, Freeman MC, Ravani M, Migele J, Mwaki A, Ayalo M, Ombeki S, Hoekstra RM, Quick R. The impact of a school-based safe water and hygiene programme on knowledge and practices

of students and their parents: Nyanza Province, western Kenya, 2006. Epidemiology & Infection. 2008; 136:80–91. [PubMed: 17306051]

Pearson J, McPhedran K. A literature review of the non-health impacts of sanitation. Waterline. 2008; 27(1):48–61.

Rabie T, Curtis V. Handwashing and risk of respiratory infections: a quantitative systematic review. Trop Med Int Health. 2006; 11(3):258–267. [PubMed: 16553905]

Sommer M. Where the education system and women's bodies collide: The social and health impact of girls' experiences of menstruation and schooling in Tanzania. [Research Support, Non-U.S. Gov't]. J Adolesc. 2010; 33(4):521–529. [PubMed: 19395018]

Talaat M, Afifi S, Dueger E, El-Ashry N, Marfin A, Kandeel A. Effects of hand hygiene campaigns on incidence of laboratory-confirmed influenza and absenteeism in schoolchildren, Cairo, Egypt. Emerg Infect Dis. 2011; 17(4):619–625. [PubMed: 21470450]

UNESCO. Education for All Global Monitoring Report: 2011. Paris, France: United Nations Educational, Scientific and Cultural Organization; 2011.

UNICEF. Raising Clean Hands: Advancing Learning, Health, and Participation through WASH in Schools. New York: UNICEF; 2010.

UNICEF & WHO. Progress on Drinking Water and Saniation, 2012 update. New York: Joint Monitoring Program; 2012.

Wells R. Gender and age-appropriate enrolment in Uganda. International Journal of Educational Research. 2009; 48(1):40–50.

Acronyms and abbreviation

WASH	water, sanitation, and hygiene
HP&WT	hygiene promotion and water treatment
WS	water supply improvement
PR	prevalence ratio
CI	confidence interval
p	(p-value)
ICC	intracluster correlation coefficient

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                                    │ Assessed for eligibility      │    │ Excluded (n=795 schools)                           │
                                    │ (n=1,084 schools)             │    │   Did not return survey (n=180 schools)            │
                                    └──────────────────────────────┘    │   Ineligible due to administrative Division         │
                                                                        │   (n=578 schools)                                   │
                                                                        │   Ineligible due to selection criteria (n=37 schools)│
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Eligibility

"Water available" schools[a]   "Water scarce" schools[a]

Eligible (n =198 schools)   Eligible (n=91 schools)
Stratified by district [b]   Not selected   Stratified by district [b]   Not selected
                                    (n=63 schools)   (n=41 schools)

Selection

Selected (n=135)   Selected (n=50)

Allocation (following baseline)

Hygiene Promotion,   Hygiene Promotion,   Water Supply, Hygiene Promotion,
Water Treatment   Water Treatment, Sanitation   Control   Water Treatment, Sanitation   Control

Allocated (n=45 schools)   **Allocated** (n=45 schools)   **Allocated** (n=45 schools)   **Allocated** (n=25 schools)   **Allocated** (n=25 schools)
Median size 324 pupils   Median size 298 pupils   Median size 274 pupils   Median size 321 pupils,   Median size 343 pupils
Range 140-805 pupils   Range 109-954 pupils   Range 107-505 pupils   Range 124-760 pupils   Range 166-618 pupils

Received Package   **Received Package**   **Received Package**
(n=45 schools)   (n=45 schools)   (n=25 schools)

Lost to follow-up (n=0)   **Lost to follow-up** (n=0)   **Lost to follow-up** (n=0)   **Lost to follow-up** (n=0)   **Lost to follow-up** (n=0)

[a] Schools having no water source within one km and no improved source within two km were classified as "water scarce"; All other schools were designated water "available."
[b] Selection was stratified across three geographic clusters spanning contiguous administrative divisions in four districts (Nyando/Kisumu Districts; Rachuonyo District; Suba District).

Figure 1.
Study flow diagram.
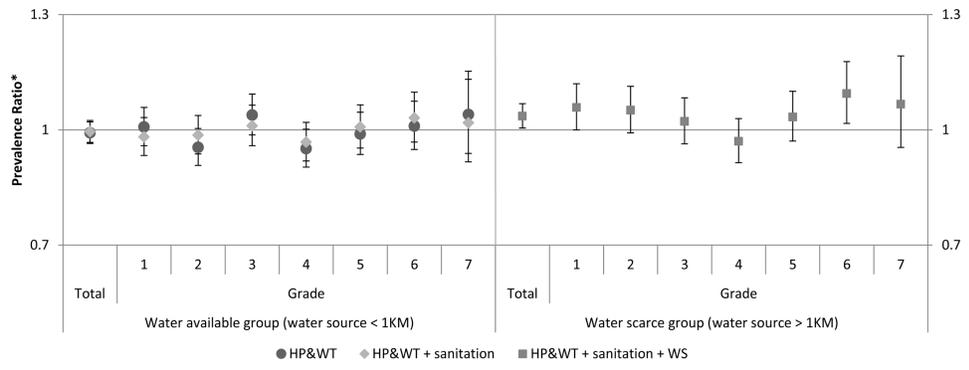
Figure 2.
Overall and grade-specific prevalence ratios for gender parity in enrollment.
*The prevalence ratio compares the proportion of girls in the intervention arm to the proportion of girls in the control arm, adjusting for intervention arm, year, district, floor type, and baseline enrollment levels

Table 1

Distributions of covariates at baseline, shown by water availability and intervention arm.

Covariates	Water available			Water scarce	
	HP&WT*	HP&WT + sanitation*	Control	HP&WT + sanitation + WS*	Control
Total	45	45	45	25	25
Concrete floor	13 (29%)	10 (23%)	5 (11%)	6 (24%)	8 (32%)
Earth floor	15 (33%)	20 (45%)	22 (50%)	14 (60%)	9 (36%)
Earth & concrete floor	17 (38%)	14 (32%)	17 (39%)	4 (16%)	8 (32%)
Electricity	2 (4%)	3 (5%)	0 (0%)	2 (4%)	0 (0%)
Iron Roof	45 (100%)	43 (98%)	43 (98%)	24 (100%)	25 (100%)
School's dry season water source is improved†	11 (24%)	13 (30%)	16 (36%)	4 (17%)	2 (8%)
Mean pupil/latrine ratio (SD)	61 (30)	77 (61)	61 (44)	66 (35)	70 (41)
Water available during school visit	24 (53%)	17 (39%)	23 (52%)	11 (46%)	14 (56%)
Hand washing water available during school visit	7 (16%)	1 (2%)	4 (9%)	4 (16%)	4(16%)

Data are means (SD) or number (%).

* HP&WT= hygiene promotion and water treatment, sanitation= latrine construction, WS= water supply improvements.

† Designation of "improved" source defined by the UNICEF/WHO Joint Monitoring Program (wssinfo.org)

Table 2

Mean (SE) school enrollment in 2007 (baseline), 2008, and 2009.

	Water available			Water Scarce	
Year	HP&WT*	HP&WT + sanitation*	Control	HP&WT + sanitation + WS*	Control
2007	355 (21)	344 (27)	274 (12)	332 (28)	361 (25)
2008	368 (21)	359 (26)	293 (13)	354 (31)	360 (25)
2009	353 (21)	338 (25)	269 (14)	342 (31)	329 (25)

*
HP&WT= hygiene promotion and water treatment, sanitation= latrine construction, WS= water supply improvements.

Table 3

Average effect of the interventions on log total enrollment and the proportion of girls enrolled for the water scarce and the water available groups.

Total enrollment		Unadjusted model*			Adjusted model†		
Group	Intervention	estimate†‡	95% CI	p	estimate†‡	95% CI	p
Water available	HP&WT§	0.019	-0.037, 0.075	0.50	0.016	-0.039, 0.072	0.57
	HP&WT + sanitation§	0.024	-0.031, 0.080	0.39	0.027	-0.028, 0.082	0.34
Water scarce	HP&WT + sanitation + WS§	0.086	0.006, 0.166	0.04	0.091	0.009, 0.173	0.03

Gender parity		Unadjusted model*			Adjusted model†		
Group	Intervention	PR**	95% CI	p	PR	95% CI	p
Water available	HP&WT§	1.00	0.97, 1.03	0.97	0.99	0.96, 1.02	0.59
	HP&WT + sanitation§	1.00	0.97, 1.03	0.96	1.00	0.97, 1.02	0.75
Water scarce	HP&WT + sanitation + WS§	1.03	1.00, 1.06	0.07	1.04	1.00, 1.07	0.02

* Unadjusted model includes intervention, year, district, and baseline enrollment levels.

† Adjusted model includes all design variables and floor type variable.

‡ The change in log enrollment due to the intervention.

§ HP&WT= hygiene promotion and water treatment, sanitation= latrine construction, WS= water supply improvements.

** The proportion of girls in the intervention arm, compared to the proportion of girls in the control arm.