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Water, Sanitation, And Primary School Attendance: A Multi-Level Assessment Of Determinants Of Household-Reported Absence In Kenya

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ABSTRACT

This cross-sectional analysis examined the influence of school and household water, sanitation, and hygiene (WASH) conditions on recent primary school absence in light of other individual, household, and school characteristics in western Kenya. School latrine cleanliness was the only school WASH factor associated with reduced odds of absence. The marginal effect of household characteristics, such as distance to water source, child involvement in water collection, and presence of a latrine, differed by gender. Demographic features were more important predictors of absence, suggesting that interventions to improve attendance must consider existing differentials attributable to gender, socio-economic status, and other household characteristics.

1. Introduction

The developmental impacts of improvements in water, sanitation, and hygiene (WASH) beyond health, such as the potential impact on educational attainment, are of increasing interest to policy makers, development agencies, and national governments (UNICEF, 2010). However, only a small number of studies have assessed the relationships between school- and household-level WASH conditions and educational outcome measures. Fetching drinking water for school can result in missed classes, especially when children make more than one trip to collect water per day (Hemson, 2007; Fisher, 2004). School sanitation and hygiene can be particularly important for child attendance, especially among female students during menstrual periods (Sommer, 2010; McMahon et al., 2011). A large-scale trial in China by Bowen et al. (2007) found a 42–48% decline in median episodes of absence comparing children in schools that received handwashing interventions to controls. A large trial in Cairo, Egypt, found that an intensive hand hygiene campaign significantly reduced influenza-related absence by 40% and diarrhea-related absence by 30% (Talaat et al., 2011). There was a 35% and 26% reduction in school absenteeism following two point-of-use water treatment and handwashing promotion interventions in primary schools in western Kenya, but neither of these studies utilized a control group (Blanton et al., 2010; O'Reilly et al., 2008). A recent large randomized control trial in western Kenya found that a hygiene promotion and water treatment intervention significantly reduced absenteeism by 58% among girls in selected geographic areas whereas the addition of a sanitation component to the intervention resulted in only marginally significant reductions in absence among girls. This trial had no significant impact on absence for boys (Freeman et al., 2011).

While these studies provide compelling information that school water and hygiene may have an influence on educational outcomes, there is a need to further understand the ways in which all components of WASH at both home and school influence school attendance. To further understand the reasons for the differences in absence by gender, intervention component, and geographic location in the Kenya trial, we explored baseline data in a cross-sectional analysis of the individual-, household-, and school-level factors that are associated with educational outcomes among primary-school aged children. This analysis is intended to provide insights on the influence of individual, household, and school factors on recent absence prior to environmental interventions that improve school-level facilities.

Understanding the link between WASH and educational attainment in a holistic manner has the potential to inform policies, strategies, and specific interventions within the broader health and development sectors. In Kenya, net primary enrollment (the percentage of children in the age group eligible for primary

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schooling who are currently enrolled in schools) is only 81% for boys and 82% for girls (UNESCO, 2011). Understanding educational participation based on enrollment numbers alone, however, does not reflect the true reality of educational participation. Many children enrolled in primary school miss classes for a variety of reasons, such as illness, caring for sick relatives, and household responsibilities, and employment (Ampiah and Adu-Yeboah, 2009). Literature on school absence and its impacts on children's educational, cognitive, and social development is focused primarily on upper income countries. Several studies have shown that absenteeism is associated with reduced academic performance (Lamdin, 1996; Moonie et al., 2008; Baxter et al., 2011) and is also associated with drop-out in resource poor-settings (Ampiah and Adu-Yeboah, 2009).

There are two potential pathways through which WASH conditions may influence school attendance. First, improved facilities at school are thought to provide a more appealing environment for learning where children can access services that might not be readily available at home, such as latrines or clean drinking water sources. In addition, children might be healthier and able to attend school more often if hygienic conditions reduce their exposure to diarrhea-causing pathogens. Likewise, poor WASH conditions in the home may result in illnesses or additional household responsibilities for WASH-related activities, such as fetching water, which could keep children from attending school. As national decision-makers and non-governmental organizations alike develop programs to improve educational attainment in low-income countries, it is important to understand the extent to which school WASH characteristics might influence children's attendance in light of individual demographic and household WASH characteristics.

1.1. Background

Individual-level, household-level, and school-level factors represent multiple levels of influence that can determine absence from school. The relationship between each of these three levels and primary school attendance are discussed below.

On the individual level, age and gender have been shown to influence school attendance and enrollment. Enrollment and current school attendance is typically higher among boys when compared to girls (Kazeem et al., 2010; Wells, 2009). In a 30-country study of primary school enrollment among children aged 8–11, there was a statistically significant association between increases in age and school enrollment among boys but not among girl children (Huisman and Smits, 2009). Studies in Kenya have identified an increase in the proportion of school-aged children attending school up to age 11 and a subsequent decline in enrollment following age 11 (Mugisha, 2006; Buchmann, 2000). Lewin (2009) found that age for enrollment, specifically older children enrolled in grade levels below their appropriate age, was significantly associated with decreased educational participation and continued enrollment in sub-Saharan Africa.

At the household level, educational attainment and school attendance are consistently associated with increases in household wealth (Kazeem et al., 2010; Chernichovsky, 1985; Filmer and Pritchett, 1999; Ainsworth et al., 2005). Other household-level factors associated with educational outcomes include parental educational attainment (Kazeem et al., 2010; Baschieri and Falkingham, 2009). Some studies have shown a gendered impact of these household-level factors. Glick and Sahn (2000) found increases in household wealth and parental education have a greater impact on girls' enrollment in primary school than on boys. Household composition, specifically the number of school-aged children in a household, has been shown to have a mixed effect on educational attainment. Some studies have identified higher rates of school enrollment and school attendance among larger families, while others have identified an increased likelihood of enrollment associated with larger family size and/or increases in the number of siblings (Wells, 2009; Huisman and Smits, 2009; Eloundou-Enyegue and Williams, 2006).

School characteristics associated with a decline in enrollment and school attendance include distance to primary school (Kazeem et al., 2010; Baschieri and Falkingham, 2009) and perceived quality of education (Baschieri and Falkingham, 2009). Huisman and Smits (2009) found that increases in the teacher to child ratio were significantly associated with an increased likelihood of primary school enrollment for both girl and boy children. While distance to primary school is often cited as an important determinant of school enrollment (Kazeem et al., 2010; Vuri, 2010), Filmer (2007) found that improving the availability of schools – specifically decreases in travel time to schools– yielded only marginal or non-significant improvement in enrollment. Factors within the school can impact learning and retention as well. Issues such as over-crowding, lack of educational materials, and lack of books may have a significant impact on educational outcomes, although there have been no formal assessments of this linkage, and international standards have thus far overlooked the quality of educational facilities (Watkins, 2000). Teacher absence has also been linked with reduced participation among pupils, and pupils in Ghana have been found to skip school later in the week when teachers are likely to be traveling or absent (Ampiah and Adu-Yeboah, 2009).

2. Data and methods

2.1. Data sources

Data for this cross-sectional analysis were taken from information collected at baseline for a large randomized trial of multiple school-based WASH interventions, Sustaining and Scaling School-Based Water, Sanitation, and Hygiene Plus Community Impacts (SWASH+). In 2007, the Kenyan Ministry of Education sent letters describing the study and soliciting information to all 1084 public primary schools in four districts of Nyanza Province and the Municipality of Kisumu. Nine hundred and four schools (83%) expressed interest in participating in the study by returning a self-administered questionnaire on school WASH conditions. Eligibility criteria were further refined to exclude schools that did not exceed the current Government of Kenya (GoK) pupil:latrine ratio (25:1 for girls, 30:1 for boys). One hundred and eighty-five schools deemed eligible for the study were randomly selected for inclusion. Further details on the design of the impact assessment are available in Freeman et al. (2011).

2.2. Sampling and data collection

Between February and March 2007, before any intervention began in the schools, Kenyan research staff administered structured questionnaires consisting of open-ended questions with pre-coded responses with head teachers of enrolled primary schools. Visits were unannounced. Respondents provided information on school water sources, storage, and water disinfection practices; school sanitation; and school handwashing facilities. Interviews were complemented by structured observations of school facilities, including sanitation quantity and quality, presence of handwashing facilities, school construction materials, and access to electricity. During sanitation observations, field staff rated specific conditions of each latrine bank on a four-point scale for the following categories: fly infestation, presence of fecal matter on the slab, odor, structural integrity of the walls, and quality of the latrine slab.

Between March and May 2007, Kenyan staff administered structured questionnaires with a systematic sample of 25–40 households in communities within the catchment area of each selected school. Households without a primary school-aged child were excluded. Heads of household at least 18 years old were the primary respondents, with a preference for females. Parent-reported school enrollment and absence in the two weeks prior to data collection were recorded for all children in the household between ages 5 and 18. Additional information was collected on household demographic characteristics; water sources; and WASH knowledge, attitudes, and practices. In addition, self-reported possession of a variety of household items was noted along with structured observations of construction materials of the home for use in the development of a household wealth index.

Household questionnaires were translated from English into the local language, Dholuo, and back-translated to English. Data were collected using personal digital assistants pre-programmed with a questionnaire. Oral informed consent was obtained from all respondents prior to data collection. The study protocol was approved by Emory University's Institutional Review Board, and the Kenyan Ministries of Education, Water, and Health provided permission to conduct the trial.

2.3. Study population

Surveys of 4519 households identified 10143 school-aged children living in the catchment area of the 185 primary schools, of which 9944 (98.0%) were currently enrolled in school. Primary outcome data – missing school at least once in the past two weeks – were not available for 118 children, who were thus removed from subsequent analyses. Of the remaining 9833 records, 1480 children (15.0%) were enrolled in schools other than the local primary school participating in the larger trial and were thus removed. Incomplete household- and school-level data resulted in the removal of an additional 379 records (4.5%), including: 10 schools (n = 304 child records) in which school latrine data were unavailable and 58 child records in which complete household-level data were not available. There was no significant association between records with missing data and recent household-reported absence. Final data were available from a total of 7966 children enrolled in primary school representing 3857 households and 175 primary schools. Information on the study population is presented in Table 1.

Table 1
Description of the study population.

	% Or mean (std. dev.)
Child characteristics	n = 7966
% Boys	52.0%
% Orphans	9.6%
Mean age (std. dev.)	
Males	10.7 (3.5)
Females	10.3 (3.3)
Characteristics of the household	n = 3815
Mother completed primary school	40.4%
Father completed primary school	36.0%
Female-headed household	32.6%
Mean children in hh (std. dev.)	3.2 (1.62)
Children involved in water collection	27.0%
Latrine observed at household	37.0%
Current water source >20 min	28.7%
Current water source protect	63.6%
Distance to local primary school >20 min	37.2%
School characteristics	n = 175
School has electricity	1.9%
School floors at least partially finished	56.7%
School provided handwashing water	7.4%
School children involved in water collection	38.9%
Mean pupils per latrine (std. dev.)	68.1 (42.1)
Mean pupils per teacher (std. dev.)	32.6 (10.0)
Mean pupils per room (std. dev.)	36.8 (13.3)

2.4. Statistical methods

Data were analyzed in STATA v11 (College Station, TX). Principal components analysis (PCA) was used to reduce categorical school latrine observations into a smaller number of continuous indices with a mean of zero and a standard deviation of one. For data collectors' latrine observations, one-way random effects ANOVA was used to calculate an estimate of inter-rater reliability referred to as ICC(1,k) by Shrout and Fleiss (1979). To measure socio-economic status (SES), a household wealth index was calculated through PCA of self-reported possessions and household construction materials (Filmer and Pritchett, 1998; Vyas and Kumaranayake, 2006). Because our analysis had a specific interest in the contribution of household water and sanitation to primary school absence, no water and sanitation indicators were included in the wealth asset index. Cut-off points were identified that corresponded to the lowest 40% of values, the middle 40%, and the highest 20% (Filmer and Pritchett, 1999), which also corresponded with natural groupings in our asset score. These groups were labeled as "poor", "middle", and "rich" for the sake of discussion. This approach to estimating household wealth results in a measure of relative deprivation rather than an absolute measure of poverty, and our socio-economic classifications represent only wealth classification *within* the study population. We imputed binary values based on community-specific median values for two variables for cases with missing data: time to school less than 20 min (n = 17) and time to current water source less than 20 min (n = 213). Other records with missing values were excluded from our analysis.

In surveyed households, absence in the previous two weeks was assessed for each child age 5–18 enrolled in a primary school. School-level data were appended to that child's household record. Multivariable logistic regression models with random intercepts at the school and household level were developed using the *xtmelogit* procedure. The dependent outcome variable was household-reported absence in the past two weeks (binary). Logistic regression results were translated into average marginal probabilities with the use of the *margins* command. Average marginal probabilities provide an estimate of the average change in the probability of the outcome (absence) associated with a one-unit change in the covariate of interest while all other independent variables are held constant at their existing values.

2.5. Model selection

Statistical analysis was completed in a number of stages. Given findings from previous studies, a first exploratory model (presented as Model 1) was constructed to determine whether effect modification existed between gender and household wealth. Results indicated that stratification by gender was necessary for all subsequent models. Our second, gender-stratified, model comprised of individual-, household-, and school-level variables identified a priori as possible predictors of school absence, not including household- or school-level WASH characteristics (Model 2). At the individual level, age was included in our analysis as both a linear and quadratic predictor. At the household level, our model included wealth, education of household heads (categorized into less than primary, completed primary, or respondent unavailable), and whether a female headed the household alone. Household size was reflected by including the total number of children less than 18 years old living in the household. Self-reported distance to the enrolled primary school was also included in the model,

dichotomized at 20 min. School-level variables included in our analysis were binary indicators of school electrification, whether the school had at least partially finished floors (an indication of better mobilization of community or governmental resources for school infrastructure improvement), the pupils per teach ratio for the school, and the number of pupils per classroom.

In our third model (Model 3), household- and school-level WASH indicators were added to Model 2. At the household level, WASH covariates included: reported use of a protected water source, reported distance to water source (dichotomized at 20 min), whether children were involved in household water collection, and the presence of a latrine observed on the compound. At the school level, WASH characteristics included reported use of a protected drinking water source at the school, whether the school reported involving children in drinking water collection, the pupils per latrine ratio, and the two components scores related to school latrine maintenance and structural quality derived from the principle components analysis.

For all models, continuous indicators were centered at their mean value, with the exception of age, which was centered at age 11. Variables related to pupil ratios (pupils per latrine, pupils per teacher, and pupils per classroom) were all adjusted so that a one-unit change in the variable corresponded to a 10-pupil change in the measurement.

2.6. Variance components

In order to assess the underlying propensity for recent absence both at the household and the school level, intra-class correlation (ICC) values were calculated using standard equations for converting variance of random intercepts in multi-level logistic regression modeling to ICC measures (Singer and Willett, 2003). The ICC values provide an estimate of the proportion of the total variance in the individual-level outcome of interest due to unmeasured – or unaccounted for – covariates at each higher level of the analysis. A gender-stratified model including only random effects at the household and school level was constructed (null model) and used to estimate variance in recent absence attributable to unaccounted for household- and school-level factors. ICC values were compared among the null model and Models 2 and 3 in order to assess changes in the unexplained variance of our individual-level outcome measure after accounting for various individual, household, and school-level covariates.

3. Results and discussion

3.1. Principal components analysis: latrine observations

Variability in the five school latrine observation variables was explained by two principal components. The first component had high loading values for smell, feces, and flies and accounted for 47.0% of the total variance in the observational data. The second factor had high loading values for slab (the material that forms the floor of the latrine) quality and superstructure (the structure surrounding the top of the latrine) quality and accounted for 33.5% of the total variance in observational data. Given loading values and high proportion of variance explained, these two factors were subsequently treated as indices of latrine maintenance quality and latrine structural quality, respectively.

The intra-cluster correlation assessment of inter-rater reliability of latrine characteristic scores demonstrated almost perfect agreement on similar measures of cleanliness and structural conditions of household latrines (0.94 and 0.96, respectively) as well as for school latrine cleanliness (0.97). For school latrine structural conditions, the assumed random error of observations exceeded the variability of rater-specific mean scores, resulting in a negative ICC calculation. However, due to the high degree of reliability for all other latrine observations and familiarity with the study population, it is assumed that the negative ICC(1,*k*) value for school latrine structure scores is due to a high degree of homogeneity in latrine conditions and not excessive heterogeneity in rater-specific means and that structural observation scores remain valid.

3.2. Recent absence by gender and socio-economic status

Parent-reported absence in the past two weeks was 18.5%. Results of Model 1 demonstrating probability of absence by gender and wealth group after accounting for clustering at the household and community levels are shown in Fig. 1. Absence among boy pupils was 17.0% compared to 20.1% among girls, with the calculated average marginal effect [ME] of gender – or change in the probability of absence when other covariates are held constant – of 2.6% (standard error [SE]: 0.70%). By wealth group, probability of absence rose from 15.3% among wealthiest children to 21.5% in children from the poorest household wealth group (ME: 3.9%, SE: 1.13%). When the combined effect of both household wealth and gender are considered, recent absence among boys ranged from 14.3 to 18.9% across wealth groups and 16.3–24.9% among girls. In effect, girls from the poorest wealth group in our sample showed a 71% increase in the probability of absence relative to boys in the richest wealth group and a 30% increase relative to boys in the poorest wealth group.

3.3. Individual-, household-, and school-level determinants of absence (Model 2)

Model 2 assessed changes in the probability of absence in the last two weeks associated with a number of individual-, household-, and school-level characteristics, stratified by gender (Fig. 2 and Table 2). For this model, the dependent mean probability of absence was 19.4% among girls and 16.6% among boys. Reported marginal effects – or changes in the probability of absence around the dependent population mean – are adjusted for other covariates included in the model, as well as adjusted for clustering at both the household and school levels.

At the individual level, we noted a differential effect of age on the probability of absence by gender (Fig. 2). Among girls, the probability of absence in the past two weeks was approximately 25% among the youngest girls in our sample, and probabilities declined steadily until age 11. After age 11, the probability of a girl missing school in the past two weeks increased notably with each

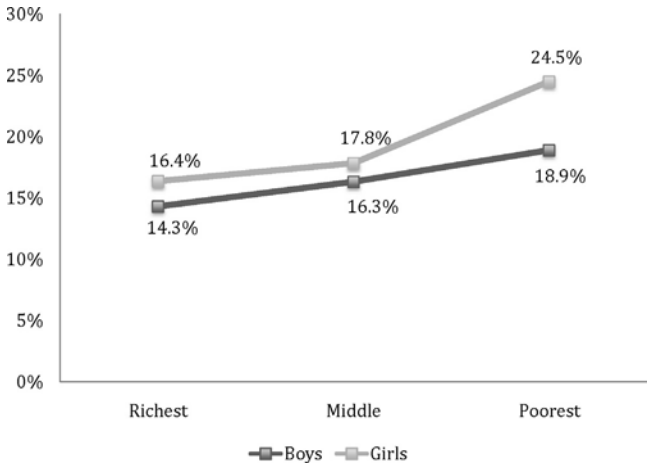

Fig. 1. Probability of absence in past two weeks by gender and household wealth group.

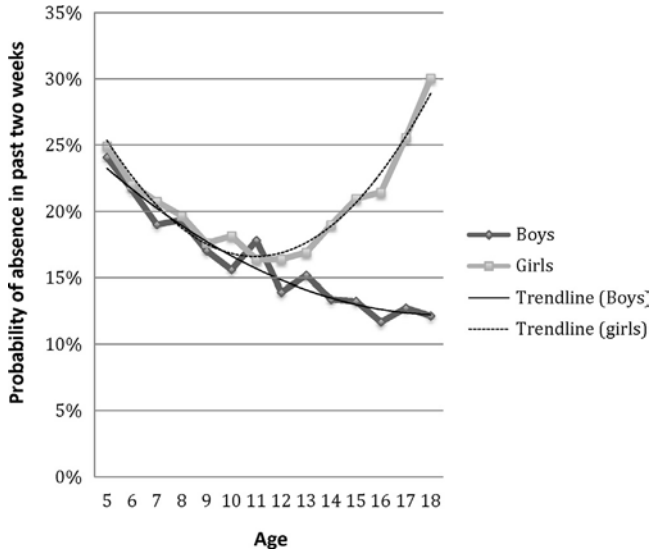

Fig. 2. Average marginal probability of absence by gender and age.

year increase in age, peaking at a 30% among the oldest girls in our sample. Among boys, the probability of absence steadily declined with age, from approximately 24% among the youngest boys in our sample to 12% among the oldest boys. The average marginal effect of each year increase in age for boys declined with each year increase in age.

The effect of household-level factors differed by gender as well (Table 2). For girls, living in a household that falls in the poorest wealth group remained a significant predictor of recent absence after adjustment for other household- and school-level factors, while the effect of wealth on absence among boys was no longer apparent. Living in a female-headed household was a highly significant predictor of absence, with 8.3% increase among girls and a 10.1% increase among boys in the average marginal probability of absence, which translates to 56% and 104% relative increase among girls and boys, respectively. Among girls, distance to the local primary school greater than 20 min was associated with a 2.6% increase in the average probability of absence compared to girls living closer (28.4% relative increase), while there was no statistically significant association among boys. School electrification, pupils per teacher ratio, pupils per classroom ratio were not significant predictors of absence while both boys and girls attending schools with at least partially finished floors was associated with a 3.7% reduction in the average marginal probability of absence for both boys and girls, although this reduction was only marginally significant among girls.

3.4. WASH determinants of absenteeism (Model 3)

Household- and school-specific WASH characteristics were added to Model 2 to provide specific information on the associations between WASH conditions at both the household and school level and recent absence after controlling for all other individual-, household-, and school-level characteristics (Table 3). Time to current household water source greater than 20 min was associated with a 2.6% and 3.3% increase in the average marginal probability of recent absence among girls and boys, respectively, although this was only marginally significant among girls. Children living in households with a latrine showed a decrease in absence (ME girls: -2.39, ME boys: -3.25), but the relationship was only statistically significant among boys. Living in a household in which children are involved in water collection was associated with a statistically significant 2.8% increase in the average marginal probability of missing school among girls (42% relative increase in the probability of absence), but this factor was not significant for boys.

At the school level, children involved in school water collection and use of a protected drinking water source at the school had no clear association with absence. Provision of handwashing water on the day of data collection, confirmed through observation, was associated with increased odds of recent absence between both genders, although these associations were not statistically significant. School sanitation

Table 2
Percent absent in past two weeks and average marginal effect of household- and school-level determinants on recent absence by gender (Model 2).

	Girls		Boys	
Percent absent in past two weeks	19.41		16.60	
	ME (%)	95% CI	ME (%)	95% CI
Household-level				
Household wealth				
Richest	Ref.		Ref.	
Middle	-0.30	(-3.26 to 2.66)	0.68	(-2.3 to 3.66)
Poorest	4.03**	(0.54 to 7.53)	-0.18	(-3.19 to 2.84)
Female head of household education				
Did not complete primary	Ref.		Ref.	
Completed primary	-2.05	(-4.77 to 0.68)	-1.83	(-4.18 to 0.53)
Unavailable or not present	-2.76	(-6.53 to 1.02)	-2.19	(-5.48 to 1.10)
Male head of household education				
Did not complete primary	Ref.		Ref.	
Completed primary	-0.88	(-5.45 to 3.70)	-4.03*	(-8.41 to 0.35)
Unavailable or not present	-4.24*	(-9.18 to 0.70)	-6.07**	(-11.02 to -1.12)
Female-headed household	8.31***	(4.46–12.15)	10.07***	(6.52 to 13.61)
Per child < 18 years old	0.22	(-0.47 to 0.91)	-0.21	(-0.81 to 0.39)
School-level				
School more than 20 min away	2.55**	(0.01 to 5.09)	0.37	(-1.78 to 2.52)
School has electricity	2.76	(-10.99 to 16.51)	5.21	(-6.27 to 16.68)
School floor at least partially finished	-3.71*	(-8.12 to 0.70)	-3.68**	(-7.42 to 0.06)
Pupils per teacher ratio (±10 pupils)	-1.04	(-4.06 to 1.98)	-1.10	(-3.65 to 1.45)
Pupils per classroom ratio (±10 pupils)	1.05	(-1.09 to 3.18)	0.40	(-1.39 to 2.20)

* p-Value < 0.1.
** p-Value < 0.05.
*** p-Value < 0.01.

Table 3
Association between household- and school-WASH characteristics (adjusted for determinants included in the Model 2) and recent absence, by gender (Model 3).

	Girls		Boys	
	ME (%)	95% CI	ME (%)	95% CI
Household WASH characteristics				
Current water source > 20 min	2.62*	(-0.49 to 5.73)	3.29**	(0.54 to 6.04)
Current water source protected	0.09	(-3.11 to 3.3)	0.32	(-2.44 to 3.07)
Children involved in hh water collection	2.81**	(0.15 to 5.47)	0.42	(-1.96 to 2.79)
Latrine observed at home/compound	-2.39	(-5.25 to 0.47)	-3.25**	(-5.85 to -0.64)
School WASH characteristics				
Children involved in school water collection	-0.38	(-6.29 to 5.53)	0.92	(-3.96 to 5.79)
Current school water source protected	-1.89	(-7.69 to 3.90)	-0.14	(-4.92 to 4.64)
Handwashing water available	5.78	(-2.29 to 13.85)	6.44*	(-0.34 to 13.22)
Pupils per latrine (±10 pupils)	0.29	(-0.24 to 0.82)	0.15	(-0.31 to 0.60)
School latrine maintenance quality index	-1.80*	(-3.90 to 0.30)	-2.23**	(-4.01 to -0.45)
School latrine construction quality index	0.34	(-1.77 to 2.45)	0.28	(-1.50 to 2.06)

* p-Value < 0.1.
** p-Value < 0.05.

quantity, as reflected in the pupils per latrine ratio, was not associated with absence. Indicators of school sanitation quality, however, had a clear association with recent absence among both girls and boys. For every one standard deviation increase in the school latrine maintenance quality index, representing increasingly cleaner latrines, there was a 1.7%, and 2.0% decrease in the marginal probability of missing school among girls and boys, respectively, although this was only marginally significant for girls. Conversely, changes in the school latrine structural quality index had no relationship with changes in the odds of recent absence.

Given the non-linear relationship between age and absence among girls and the higher rates of absence among older girls, we re-ran Model 3 among girls in our sample stratified above and below age 11 (results not shown). For both, demographic and household-level factors had a similar result, although the increase in the probability of absence among the poorest wealth group was not statistically significant among younger girls. The primary differences between the two models related to WASH characteristics at the school and household level. Among older girls, living in a household in which children are involved in water collection was associated with a 4.3% increase in the marginal probability of missing school in the past two weeks (p = 0.016) while the 2.6% increase among younger girls was not statistically significant (p = 0.115). The association between absence and quality of school latrines differed by age as well – among younger girls, one standard deviation increase in school latrine maintenance quality was associated with a 2.4% decrease in the marginal probability of absence (p = 0.040), while there were no meaningful or significant changes in absence associated with school latrine quality among older girls (ME: 0.3%, SE: 1.2%).

3.5. Variance components

ICC values for the null model and Models 2 and 3 are presented in Table 4. Unexplained variability in individual-level absence attributable to household-level factors not included in our models was consistently higher than unexplained variability due to missing school-level factors. Neither the inclusion of household- or school-level factors in Model 2 nor Model 3 resulted in substantial reductions in explained variance at the household-level. Our models, did however, do a better job of reducing variance in absence due to unmeasured factors at the school level. The inclusion of both school- and household-level WASH characteristics in Model 3 resulted in an 11% decrease in unexplained variance due to unmeasured school-level factors among girls and a 15.2% decrease among boys when compared to the null model.

4. Discussion

Controlling for household demographic and school factors, we found an increased probability of school absence in the previous two weeks among boys and girls in households having a distant water source and among girls in households in which children were involved in water collection. Having a household latrine was associated with a significant reduction in the marginal probability of absence among boys. The only school-level WASH factor associated with a significant reduced probability of recent absence was latrine cleanliness. Of particular note, sanitation *quantity* (i.e. pupils per latrine) was not associated with absence. The influence of various individual and household characteristics – notably age and household wealth – on absence was differential by gender, while school-level factors had a generally similar association with recent absence among boys and girls.

Table 4
Household- and school-level variances for null, base, and combined models, by gender.

Model	Household-level		School-level	
	Variance (ICC)	% Reduction[a]	Variance (ICC)	% Reduction[a]
Girls				
Null model	0.330	Ref.	0.204	Ref.
Model 2	0.317	4.1	0.200	1.9
Model 3	0.315	4.5	0.182	11.1
Boys				
Null model	0.287		0.199	
Model 2	0.264	8.2	0.183	8.1
Model 3	0.269	6.2	0.155	15.2

[a] % Reduction in variance from null model.

The increased probability of absence associated with children's involvement in household water collection and time to current water source is particularly noteworthy among girl children. Given that collection of drinking water is often a female's responsibility in sub-Saharan Africa (Mehretu and Mutambirwa, 1992; WHO/UNICEF, 2010), it may be the case that girl children are absent more due to a greater responsibility for household water collection. The association of absence with distance to a household's water source and presence of a latrine should be interpreted with caution, as access to a clean water source and household sanitation are two measures often included in indices of household wealth, and their association with recent absence may be a reflection of wealth rather than the factors themselves. However, both safe water and having a safe method of excreta disposal at home are associated with reduced diarrhea incidence (Cairncross et al., 2010); therefore, improved health may be a pathway to explain the association with better school attendance. Presence of a latrine may also be reflective of larger attitudes towards modernization and development (Jenkins and Curtis, 2005), and thus households with a latrine may place higher values of education.

Most school WASH interventions that have noted a change in attendance (Bowen et al., 2007; Talaat et al., 2011; Blanton et al., 2010; O'Reilly et al., 2008) focus on improvements in hygiene or water quality. While our analysis attempted to assess the importance of school water and hygiene facilities, no schools provided soap for handwashing and only three provided treated drinking water on the day of data collection, thus we were unable to assess the relationship between the provision of soap or water treatment in the school and absence. In addition, limited heterogeneity in school sanitation conditions may also have underestimated the contribution of latrine conditions to absence. Nonetheless, our findings suggest the *quality* of school sanitation may be more important than *quantity* in terms of improving school attendance. Although causal explanations cannot be drawn from the cross-sectional data used for this analysis, it is possible that students using dirty latrines increase their opportunity of exposure to diarrhea-causing pathogens, leading to absence due to illness (Greene et al., 2012). Additionally, studies have shown that students' usage of latrines is associated with their cleanliness (Mathew et al., 2009; Njuguna et al., 2009). Therefore, students may avoid school entirely rather than use dirty or uncomfortable latrines.

Findings from our analysis corroborate evidence from a variety of studies that have identified gender, age, and household wealth as significant predictors of educational outcomes (Wells, 2009; Mugisha, 2006; Buchmann, 2000; Chernichovsky, 1985; Filmer, 2007). While these studies have focused more on educational attainment and overall school enrollment, our data suggest that shorter-term measures – recent absence from primary school among enrolled children – follow similar patterns and are potentially subject to many of the same social and economic forces as general school enrollment and suggests that more a more holistic understanding of educational participation that assess not only enrollment but also regular attendance are needed (Lewin, 2009). The precipitous increase in probability of absence among girls after age 11 might have several explanations, including increasing involvement in household chores. The correspondence of increased absence with pubertal age should also be considered. Although onset of menarche is generally assumed to have an impact on educational outcomes (Abioye-Kuteyi, 2000; Ali and Rizvi, 2009; Scott et al., 2009; Sommer, 2009), studies which have documented this relationship have found conflicting results. A randomized trial in Nepal providing re-usable menstrual cups found that girls receiving the intervention were no more likely than their counterparts to attend school during their periods; however, the authors did not consider availability of water and sanitation in their trial (Oster and Thornton, 2010). A study in China found a significant decline in enrollment and time in school following the onset of menstruation among girls from households lacking access to sufficient water (Maimaiti and Siebert, 2009).

Among older girls, household-level WASH conditions were significantly associated with increased absence. As girls age, they may take on a greater burden of water collection and other chores in the household, decreasing time for schooling. Among younger girls, school latrine quality was significantly associated with recent absence while this was not the case for older girls. Because our analysis is cross-sectional, we are unable to determine causal pathways, but these findings do suggest that the relationship of school absence with poor WASH conditions differs by age and that household-level factors may play a larger role in shaping educational experiences among older girls while school-level factors might have a stronger influence on absence among younger girls.

There are a number of household-level factors with a known association with school enrollment – specifically birth order, parental occupation, and parental views on education (Kazeem et al., 2010; Huisman and Smits, 2009; Buchmann, 2000; Baschieri and Falkingham, 2009; Glick and Sahn, 2000) – that we were unable to account for in our analysis. This may explain the rather small reductions in unexplained variance attributable to unmeasured household-level factors after accounting for a number of school- and household-level characteristics.

The inclusion of the various school- and household-level covariates did result in substantial reductions in the unexplained variance due to school-level factors, despite the fact that few school-level characteristics were individually associated with changes in the probability of absence. There are two possible explanations for this. First, although few school-level WASH characteristics proved to be significantly associated with absence, the combined influence of these factors might account for a large portion of the variability in outcomes. Alternatively, since the variable representing the school also represents the community from which households were sampled, household-level WASH factors included in the model may exert an aggregate community-wide influence that is represented in part through the school ICC value.

5. Conclusions

5.1. Limitations

We note several important limitations in our current analysis. First, data are cross-sectional, and we are only able to assess correlations and not causal pathways. However, data from the randomized trial data will not necessarily allow for a detailed assessment of potential determinants at the individual, household, or school level; nor will they allow investigation into the ways in which school and household WASH contribute to educational outcomes in the absence of an intensive intervention. Findings from this analysis are to be viewed as hypothesis-generating rather than confirmatory. Similarly, our analysis was not weighted, making findings generalizable only to a hypothetical population similar to the children in our analysis. While weighting survey data has important implications for frequencies and mean values, it has been found to have little impact on measures of association at the population level. Our decision to not use weights in this analysis was mostly pragmatic.

Finally, the main outcome measure – absence in the past two weeks – relied on recall of the primary caretaker for school-aged children. These data may have resulted in bias in our estimates of recent absence. However, it was necessary to rely on household-provided information in order to explicitly link conditions in the

household with the specific child. There are few reasons to believe that recall bias in this study population would have been differentially influenced by household socio-economic status or WASH conditions. Additional analyses explicitly linking pupil and household-reported absence (data forthcoming) have shown an under-estimate of recent absence by household heads when compared to pupils.

5.2. Conclusions and implications

School absence has thus far been an under-explored topic in low- and middle-income countries. As primary school enrollment increases, more attention must be placed on the factors that determine actual *attendance* rather than enrollment alone. In middle- and high-income countries, attendance is associated with improved academic, cognitive, and social development, and there is no reason to assume that the same does not hold true for low-income settings.

Our multi-level framework was initially intended to explore the ways in which factors at the individual, household, and school levels simultaneously contributed to primary school absenteeism among a specific population of children in Kenya. This analysis may provide additional insight into the results of the subsequent randomized control trial of school WASH interventions, which found that the intervention did not have an overall impact on pupil-reported absence, although there were significant reductions in absence among girls attending schools that received a hygiene promotion and water treatment intervention in two of three geographic strata (Freeman et al., 2011). There are two important implications of this present analysis. First, interventions to reduce absence among primary school children must take into account existing differentials in attendance attributable to gender, socio-economic status, and other household characteristics. Our data suggest that household-level factors may, in fact, have a greater influence on absence than school-level factors. Similar to primary school enrollment, patterns of attendance follow a marked social gradient, with children from poorer households and girl children at a higher risk for missing school once enrolled than their counterparts. Interventions that target or explicitly address the needs of girls and the poorest are needed in order to ensure that universal access to education results in similar educational opportunities for all. Although a number of these household-level factors, such as wealth or living in a female-headed household, are beyond the scope of the vast majority of school-based interventions, school WASH interventions that do not address – or at least consider – the influence of household-level factors on primary school absence may not see optimal gains in educational outcomes. Building school latrines or improving hygiene practices at school may not result in improvements in educational outcomes if children, particularly older girls, still miss school due to collecting water at home.

Second, quality of school latrines was the most important school WASH factor associated with attendance whereas quantity of latrines was not as important. Like many development agencies and governments, the GoK maintains national standards of 25 girls per latrine and 30 boys per latrine (Republic of Kenya Ministry of Education, 2008) and has developed national programs and monitoring standards to achieve this aim in every school. Latrine quality is rarely emphasized in national policies of developing countries, although the GoK has recently begun to acknowledge the importance of latrine maintenance in its national school health strategy. While the randomized trial from which data for this analysis were taken found only marginally significant reductions in absence among girls in schools that received new latrines (Freeman et al., 2011), the associated intervention focused on increasing the number of latrines per school and did not include a focused latrine cleaning regimen. Efforts to improve school WASH, such as providing additional school latrines, may be more effective, as well as cost-effective, by ensuring that a minimum number of high-quality facilities are available for children, that adequate resources and services are available for maintaining and emptying school latrines, and that facility quality is monitored regularly rather than just providing more latrines. Policy interventions (such as the elimination of primary school fees) that have resulted in a large rise in the number of school-going children have not been accompanied by commensurate increases in school funding. As of 2003, Kenya's Free Primary Education Funds – government funds allocated to schools based on enrollment rates – provides only 10 Kenyan Shillings (0.11 USD) per child per year for electricity and water, and 127 Shillings (1.41 USD) per pupil for general maintenance and repairs of facilities, limiting the ability of over-burdened schools to improve and maintain already poor environmental conditions (Sawamura and Sifuna, 2008). Looking forward, it is important to understand the potential mechanisms through which quality of school sanitation and hygiene facilities impacts educational outcomes, and studies that prospectively monitor the links between infrastructure improvement and health and educational outcomes among primary school going children in Kenya and other resource poor settings are needed.

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