IMPACT OF SOLAR POWERED MINI WATER SYSTEMS ON WASH SERVICE DELIVERY AMONG SCHOOLS IN PADER DISTRICT, UGANDA.

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Abstract

Introduction: In Pader district, the pupil-to-stance ratio was 76:1 in 2019, far higher than the national target of 40:1 and hand washing coverage was 21%. AMREF Health Africa end-line implemented a Solar for inclusive WASH services project between February 2021 and November 2023. Therefore, this study aimed to compare WASH service delivery indicators at the baseline and endline of implementing the Solar for Inclusive WASH services project. The findings of this study have implications on government policy and WASH interventions in institutions.

Methods: The study employed a cross-sectional design among 371 pupils in 6 target schools in Puranga and Tenam sub-counties, Pader district. The study used simple random sampling method when selecting participants in classes and systematic sampling was used in allocation of sample sizes for each school Quantitative data was collected using electronic structured questionnaires and analyzed using STATA version 14. Descriptive statistics were derived from the data collected. Research Approval was obtained from Mildmay Uganda Research Ethics Committee (MUREC) and Uganda National Council for Science and Technology (UNCST). Data collection for both the baseline and endline evaluation was conducted in the 6 similar target schools where project interventions were conducted.

Results: At the end-line, the round-trip distance from the classroom to the point of water collection was reduced to less than 200 meters and the turnaround time spent was reduced to less than 5 minutes for the majority of respondents. With the analysis of Paired sample T-test, the p-value (Sig.) for each of the two variables (turnaround time and distance travelled) of 0.000 is less than 0.05 that indicating that the implementation of the solar-powered mini water systems has significantly reduced the turnaround time spent and distance travelled by respondents in search of safe and drinking water while at school. There was a marked improvement in hand washing after defecation from 16.4% at baseline to 85.7% at end-line. Experiences of diarrhoea were reduced by 11.5% and none of the girls missed school due to menstruation at endline. The presence of water in school compound has reduced the practice of the pupils skipping classes during break off (break and lunch) due to search of water. The practice of children carrying water to school for use like drinking is no longer existent. The study reports that there has been a reduction in cases reported for girls undergoing menstruation missing class and resorting to stay at home.

Conclusion:

There was a significant improvement in access to water, hygiene and sanitation indicators in the schools following the implementation of the Solar for inclusive WASH services project.

Key words: Solar Powered mini water systems; WASH, water-related diseases, menstrual hygiene

Introduction

Safe water, effective sanitation and hygiene are critical to the health of every child. Worldwide, 546 million did not have safe, readily available water at school in 2021, 539 million children lacked a basic sanitation service and nearly 802 million children lacked a basic hygiene service at their school. Two thirds of primary schools in sub-Saharan Africa had no access to three essential services, drinking water, hygiene services and sanitation services. Large disparities existed between rural and urban schools, where far few rural/or primary met the criteria for basic WASH services (WHO/UNICEF, 2022).In rural Uganda, 46% of school children had limited or access to water services and majority of these were in primary schools (UNICEF, 2023). According to the National Population and Housing Census 2024, 70.8% of the population in Acholi sub region have access to safe drinking water Source. One of major hindrances to use of safe water by community members are the long distances to the water sources. 24.1 % of households have a drinking water source on premise. 13.9% households were found to move a distance between 1Km-5Kms to the water source (UBOS, 2024). Pader district is located in Acholi sub region in the Northern region of Uganda has been grappled with average safe water access of 62% for the past 5 years and this was still the case in 2019. 39% of the 231,700 people in this district still practice open defecation (Ministry of Water and Environment 2019). According to Water Atlas Pader district in January 2024, functionality of water points was at 77%, implying that even communities with water points do not still have access to safe and clean water (Ministry of Water and Environment, 2024). 22% of the villages do not have access to a safe water source, Hand washing coverage is reported at 71% (Water and Environment Sector Report, 2020). According to the Water, Sanitation and Hygiene in Schools: National Standards guidelines in Uganda, achieving national WASH standards in schools is very important to ensure children perform well, stay in school and keep a healthy life while at school. The limited access to safe drinking water and proper sanitation was equally experienced in schools with a pupil-to-stance ratio of 76:1. The Ministry of Education and Sports guidelines the pupil to stance ratio set standard for school institutions is 40:1. A UNICEF evaluation found that only 51% of schools in low income countries had access to adequate water sources, and 45% of schools had access to adequate sanitation (McMichael, 2019). Amuru district being one of the neighboring districts still struggling with low WASH coverage. According to Amuru district health report 2024, sanitation coverage among households is at 48% and hand washing coverage stands at 14%.

Access to basic water coverage among households still stands at 57%. (Amuru District Annual Report, 2023). Challenges associated with addressing menstrual hygiene management (MHM) among schools include lack of privacy, clean, inadequate facilities for changing and cleaning, lack of access to soap and water (Sommer & Sahin , 2013) (George M & et al, 2018)

33% of children do not have access to safe water and 60% of children live 30 minutes of walking distance from a water source (UNICEF, 2015). Inadequate WASH results in adverse health outcomes that reduce educational outcomes in children by contributing to absenteeism and impaired cognitive abilities. Girls and boys can be affected differently due to inadequate water, hygiene and sanitation leading to unequal learning opportunities (Jano, 2011). The quality of sanitation facilities in schools can also impact attendance rates of girls, especially once they have started to menstruate. Therefore, Amref Health Africa implemented Solar for Inclusive WASH services project in Puranga and Tenam sub-counties, Pader District to increase access to inclusive WASH services. The aim of this study was to compare WASH service delivery indicators at baseline and endline of the Solar for Inclusive WASH services project in six primary schools in Pader district.

Background

Amref Health Africa implemented a project titled Solar for Inclusive WASH services project in Puranga and Tenam sub-counties, Pader District to increase access to inclusive WASH services in six primary schools, for a period of 2 years and 8 months (February 2021– September 2023). The project installed water supply solar systems and permanent hand washing facilities, as shown in figure one. Additionally, it constructed water borne/water carried toilets and menstrual hygiene spaces (washrooms) to increase access to safely managed WASH services. To improve safe sanitation and hygiene practices, it implemented PHASE programs, promoted the formation of health clubs and provided SBCC materials in target schools. PHASE program are education sensitization sessions implemented by teachers along normal classes using approved PHASE manual by Ministry of Education and sport aimed at promotion personal hygiene and sanitation education among young school going children. SBCC materials are communication tools such as brochures, murals and posters used to promote positive behaviors and changes in knowledge, attitudes, and beliefs among school children.

Materials and Methods

Study design and setting

We conducted a cross-sectional study in six schools located the Puranga and Tenam sub-counties in Pader District from October to November 2023. Pader District is located in the Acholi Sub-region of North Uganda. It constitutes 18 sub counties and 650 Villages; with a high population of 231,700 people. And about 87 per cent of children of primary school-going age (6-12 years) were attending school in 2014 (Uganda Bureau of Statistics, 2017).

The baseline evaluation and endline evaluation were conducted during the period of June 2020 and April 2024 respectively.

Study population and eligibility

The target population for this study was school-going children aged 10 years and above. Pupils in 6 schools where the project was implemented were considered eligible for participation. We enrolled participants (students) that provided written informed assent and informed consent was obtained from the guardian/school head teachers. We excluded children who had joined the schools in less than one year and/or had not participated in project activities.

Sample size estimation

Sample size calculation was done using Yumane's method of sample size estimation as indicated in Appendix 1 (Taro, 1967). Using the project target population of pupils of 5100 and a level of significance of 5%, the estimated sample size was 371.

Sampling procedures and data collection

We used both simple random sampling and systematic sampling to select the number of pupils to be recruited per school that is not based on the total number of pupils in schools. Data collection for both the baseline and endline evaluation was conducted in the 6 similar target schools where project interventions were conducted A total of 62 were recruited from each of the following primary schools; Adongkena, Laminajiko Lamincwida Loborom and Ogonyo. 61 pupils were enrolled from Awere-Lakoga primary school. A sampling frame for each school was generated by obtaining class lists of eligible pupils. Unique numbers were assigned to all pupils from each class and then used a random number generator plus app to select pupils to be included in the study. Eligible participants underwent informed consent processing and then signed an assent form. Informed consent was obtained from the head teachers. Electronic questionnaires were administered upon the consent of both parties. Data was then checked for completeness daily.

Study measures and tools

A pre-tested electronic questionnaire was used to collect data from the participants. The questionnaire variables included socio-demographic information on age, sex, round trip distance from classrooms to the point of water collection, turn-around time spent fetching water in schools, Hand washing practices at critical times, the experience of water-related diseases 2 weeks before the study and absenteeism as a result of water related diseases.

Data analysis

Data were analyzed using Stata version 14.0 (Stata Corp LLC, College Station, Texas, USA). Categorical variables were summarized using frequencies and percentages, median and interquartile range. The chi-square test was used to analyze the indifferences between study population characteristics at baseline and end-line points.

Results

A total of 248 and 371 pupils participated in the study at baseline and end-line respectively. At both baseline and end-line, the majority of participants were aged between 13-14 years at 46.4% [115/248, 172/371] and more than half were female; 54% [134/248] and 53.4% [198/371] respectively. There were no differences between study populations at baseline and end-line for both age and sex (p-value<0.566 and p-value=0.187 respectively). For details see Table 1.

Table 1: Socio-demographic characteristics of 248 and 371 participants at baseline and endline respectively in 6 primary schools of the Puranga and Tenam sub-counties in Pader District.

Variable	Category	n[%] Baseline	n[%] Endline	*P*-value
Age				0.566
	10-12years	48[19.4]	82[22.1]	
	13-14years	**115[46.4]**	**172[46.4]**	
	15-16years	79[31.9]	102[27.5]	
	17years &above	6[2.3]	15[4.0]	
				0.071
Sex	Female	**134[54.0]**	**198[53.4]**	
	Male	114[46.0]	173[46.6]	

Total	**248[100]**	**371[100]**

WASH performance indicators at Baseline

46.4% [115/248] of participants reported a round trip distance of >1km from the classroom to the point of water collection and therefore 45.6% [113/248] spent 11-30 minutes fetching water during school time. The majority of respondents 77.4% [192/248] washed their hands before eating and only 16.1% [40/248] washed their hands after defecation. Thus 28.2% [70/248] experienced diarrhoea 2 weeks before the study and 14.1% [35/248] had missed school. In addition, 47.8% [64/198] of the girls had started menstruation. Of this, only 42.2% [27/64] reported not having missed school due to menstruation. For details see table 2.

Qualitative results.

According to the district education officer, lack of water affects menstruation hygiene management in schools, children have to carry their own drinking water, affects learning due reduced concentration in class. It causes time wasting due to congestion at water sources, as they compete with the communities. When water sources are far from the school, children are forced to escape to access these water sources that exposes them to various risks in the community such as accidents and gender-based violence.

Table 2: Baseline WASH performance indicators for 248 and 371 participants at baseline and endline respectively in 6 primary schools of the Puranga and Tenam sub-counties in Pader District.

WASH Performance Indicator	**Variable**	**Category**	**Median[IQR]/Ratio**	**n[%]**
Access to safe and basic water services	Round trip distance from classrooms to the point of water collection	Near [<200m]		0[0]
		Not Far [200-500m]		23[9.3]
		Far [501-1km]		110[44.3]
		Very far [>1km]		**115[46.4]**
	Turnaround time spent fetching water in schools	<5 minutes		11[4.4]
		5-10 minutes		45[18.2]
		11-30 minutes		**113[45.6]**
		31-60 minutes		79[31.8]
Access to safely managed sanitation services	Pupil stance ratio		76.1	
Appropriate Hygiene Practices	Hand washing practices at critical times	Before eating		**192[77.4]**
		After defecation		40[16.1]
		After playing		5[2.0]
		Other times		11[4.5]
	Experience of water-related diseases 2 weeks before the evaluation	Yes		**70[28.2]**
		No		178[71.8]
Water related diseases	Missed school last month due to diarrhoea	Yes		35[14.1]
		No		**213[85.9]**
	Number of days Missed		3[2,4]	
Menstrual hygiene	Number of days missed due to menstruation	1-3 days		**27[42.2]**
		4-6 days		25[39.1]

		>6 days		12[18.8]
	Total # of girls who get menstrual periods			**64[47.8]**

WASH performance indicators at the end-line

Of the 371 respondents, 99.5% made a round trip distance of less than 200 meters from classrooms to the point of water collection reducing the distance travelled by respondents by 800meters. 91.6% of respondents spent a turnaround time <5 minutes fetching water while in school. Hand washing practices at critical times were highest before eating at 90.5% followed by after defecation at 85.7%. The majority [83.3%] of respondents reported no experience of diarrhoea 2 weeks before the study. None of the 138 female respondents reported missing school due to menstruation. For details, see table 3.

With the Paired sample T-test of the WASH performance variables (Turn around time (time taken) and distance travelled) that may be affected by the implementation of the solar powered mini water systems. The p-value of two tailed Test Pr(|T| > |t|) is 0.000, which is less than 0.05 follows the hypothesis testing framework introduced by Fisher and extended to two-tailed tests by Neyman and Pearson. This rejects the null hypothesis accepts the alternative which indicates that the implementation of the solar powered mini water systems has significantly reduced the turnaround time spent and distance travelled by respondents in search of safe and drinking water while at school. For details see table 4 and table 5.

Table 3: Endline WASH performance indicators for 248 and 371 participants at baseline and endline respectively in 6 primary schools of the Puranga and Tenam sub-counties in Pader District.

WASH Performance Indicator	**Variable**	**Category**	**Median [IQR]/Ratio**	**n[%]**
Access to safe and basic water services	Round trip distance from classrooms to the point of water collection			
		Near[<200m]		369[99.5]
		Not Far[200-500m]		2[0.5]
	Turnaround time spent fetching water in schools			
		<5 minutes		340[91.6]
		5-10 minutes		27[7.3]
		11-30 minutes		4[1.08]
Access to safely managed sanitation services	Pupil stance ratio		64.1	
Appropriate Hygiene Practices	Hand washing practices at critical times			
		Before eating		**335[90.5]**
		After defecation		318[85.7]
		After playing		23[6.2]
		Other times		5[1.4]
	Experience of water-related diseases 2 weeks before the study	Yes		**62[16.7]**
		No		309[83.3]
Water related diseases	Missed school last month due to diarrhoea	Yes		57[15.4]
		No		**314[84.6]**
	Number of days missed due to diarrhoea symptoms		2[1,3]	
Menstrual hygiene	Number of days missed due to menstruation		0[0.0]	
	Total # of girls who get menstrual periods			**138[69.7]**

Table 4 Paired Sample T Test for Time Spent in Search for Water

Variable	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval] Lower	Upper
Baseline_time	248	3.052419	.0527299	.8303907	2.948562	3.156277
Endline_time	248	1.108871	.0214029	.3370537	1.066715	1.151026
Diff	248	1.943548	.0573126	.9025597	1.830665	2.056432

Mean(diff) = mean (baseline_time - endline_time) t = 33.9114

Ho: mean(diff) = 0 degrees of freedom = 247

Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0

Pr(T < t) = 1.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 0.0000

Table 5 Paired Sample T Test for Distance Travelled

Variable	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval] Lower	Upper
Baseline_distance	248	2.375	.0416231	.6554814	2.293019	2.456981
Endline_distance	248	1.008065	.0056909	.0896207	.9968556	1.019273
Diff	248	1.366935	.0423008	.6661536	1.283619	1.450252

Mean(diff) = mean (baseline_distance - endline_distance) t = 32.3147

Ho: mean(diff) = 0 degrees of freedom = 247

Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0

Pr(T < t) = 1.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 0.0000

Qualitative results.

The project has reduced the time children spend looking for clean water, coupled with aimless loitering, missing of classes after breaks and playing at the water source. The children always diverted to go swimming in the swamp and loitering along the roads and trading centres. This has however changed because the water is in the school compound. This agrees with a study by (McMichael, 2019) argues that an improvement in school WASH conditions is likely to reduce student absence especially for girls who are menstruating.

Those children that escaped from school to go and collect/ drink water especially in the afternoon barely came back to school. This project has helped us the teachers and administration to improve on time management and increased teachers to pupils contact time. *Not having access to water source on premises may force certain household members especially, to spend many hours a day fetching water instead of using this time to go to school* (Mabel G, 2019).

Discussion

This study compared the WASH performance indicators before and after the implementation of the solar powered mini water systems through the solar for inclusive WASH services project in six primary schools. Five WASH performance indicators were adopted for the schools where project implementation took place between February 2021 and November 2023 i.e. access to safe and basic water services, access to safely managed sanitation services, appropriate hygiene practices, water-related diseases and menstrual hygiene.

At the end-line, access to safe and basic water services among target schools has improved. This is well explained by 800 meters reduction in round trip distance travelled by pupils from the classroom to the point of water collection from greater than 1 kilometer to less than 200 meters.

This has consequently, reduced the turnaround time spent by pupils in search of water by 25 minutes from 30 minutes at baseline t to less than 5 minutes at endline as seen in figure 1 below.

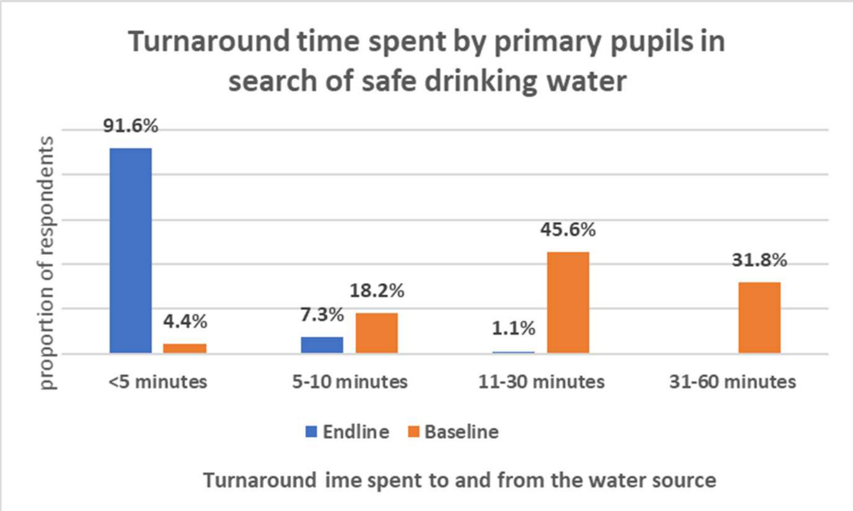

Figure 1. Time Spent in search of water

With the analysis of paired sample T-test, the p-value (Sig.) for each of the variable (turnaround time) of 0.0000 is less than 0.05 that indicates that the implementation of the solar powered mini water systems has significantly reduced the turnaround time spent in search of water from 11-30 minutes at baseline to less than 5 minutes at endline at school as seen in table 4.

The paired sample T-test analysis has a p-value of the variable (distance travelled) of 0.0000 is less than 0.05 indicating that the solar-powered mini water systems has significantly reduced the distance travelled by pupils from 1km at baseline to 200 meters at endline as shown in table 5 above. The findings are similar with a study done in Rakai which shows that if distance is reduced, it reduces the tiredness of children and increases their time to engage in alternative activities such as class work (Kamya, Asingwire, & and Waiswa, 2021). Access to safely managed sanitation services at endline is seen to have positive improvement as the overall pupil to stance ratio has reduced from 76:1 at baseline to 64:1 at endline. This can be explained due to the construction of the 6 stance latrines which have helped reduce congestion and waiting time of pupil when accessing sanitation at school.

Furthermore, more pupils washed their hands before eating at 90.4% and after defecation at 85.7%. This improvement of 69.6% from baseline could have been facilitated by the installed water supply solar systems and permanent hand washing facilities. These findings are similar to a study done in Indonesia where students in schools with functional handwashing stations were more likely to wash their hands (Karon et al., 2017).

As a result, experiences of diarrhoea were reduced by 11.5% at the end of the project, however there was no reduction in absenteeism due to diarrhoea. This could have been due to the fact that WASH practices go beyond schools to include homes and communities. This agrees with the study conducted in Kenya among school that wash intervention on school premises reduced acute respiratory illness among pupils but did not reduce diarrhea among pupils (Minal K Patel, 2012)

Lastly, whereas all 64 girls ever missed school due to menstruation at baseline, none of the respondents at the endline evaluation reported to have missed school due to menstruation. This can be explained by the project activities of providing menstrual hygiene spaces (washrooms) with water that provide privacy for girls for sanitary changing and cleaning during menstruation. The education on menstrual hygiene and making of reusable pads at the six primary schools has also improved the confidence of girls to engage senior women teachers during menstruation to provide emergency reusable sanitary pads during school time. This agrees with study findings in Malawi where girls were less likely to miss school due to menstruation, after the implementation of menstrual hygiene interventions in schools (Chidya et al., 2024).

Limitation of the study.

The study did not cater for other confounding variables such as teachers training skills across schools, parents' engagement in pupils' education, availability of food which could have an effect on WASH intervention outcomes.

Conclusion.

There was a significant reduction in distance travelled to a water source by 800km and turn-around time spent fetching water was less than 5 min after implementation of the solar power mini-water systems. Approximately, nine in every ten pupils washed their hands before eating and after defecation. Therefore, 1 in every 10 diarrheal experiences was prevented and absenteeism due to menstruation was averted to zero.

Recommendations.

There I need for further research to be done on the impact of the solar powered mini water systems on education outcomes.

There is need for line ministries like ministry of water and environment and ministry of education to work together and stop implementation of point water sources (boreholes) prone to breakdowns in schools that are shared with communities and adopt solar powered mini water systems that significantly improve access to wash services in schools.

Glossary

Sex – defined as binary sex categorization (male/female) that was designated at birth.

Menstrual hygiene spaces – defined as washrooms for females

Abbreviations

WASH – Water, Sanitation and Hygiene

PHASE – Personal Hygiene and Sanitation Education

SBCC – Social and Behavior Change Communication

WHO – World Health Organization

UNICEF – United Nations Children's Fund

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Declaration of interest statement

The authors declare that they have no competing interests or other interests that might be perceived to influence the results and/or their interpretation as reported in this paper.

Consent for publication

Not applicable

Availability of data and materials

This data is part of the ongoing WASH program in Amref Health Africa. Therefore, datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

Ethical considerations

The Research Ethics Committee of Mildmay Uganda (MUREC) and Uganda National Council for Science and Technology (UNCST) approved this study protocol and tools (SS2408ES). Additionally, the DHO of Pader district granted administrative permission to conduct the study. All participants provided written and signed informed consent. All data has been anonymized to maintain confidentiality. All methods were carried out following the relevant guidelines and regulations of the Declaration of Helsinki.

Declaration of generative AI and AI-assisted technologies in the writing process.

Not applicable

Appendices

Appendix 1: Math formulae for sample size estimation

n=N/1+N(e)^2

N - Target population, **e** - level of significance, **n** - estimated sample size

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