The Effects of The Water Project on School Attendance in Rwanda

A Thesis Presented in Partial Fulfillment of the Honors Bachelor's Degree

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Abstract

According to the 2014-15 Demographic and Health Survey (DHS), 27% of households in Rwanda use water sources that are considered unhealthy. The Water Project is a non-profit organization that aims to provide clean water facilities to communities across Africa. Literature supports the claim that contaminates found in unclean water can cause poor cognitive development in children, which can effect educational attainment. This research paper examines the effects of The Water Project on school attendance in Rwanda. Employing the 2010 and 2014-2015 DHS data set encompassing more than 100,000 individuals in Rwanda, a differences-in-differences model is used to answer this question. The purpose of this model is to calculate the effect of a treatment on an outcome. This is done by comparing the average change over time for the treatment group, compared to the average change over time for the control group. The final results show there is no difference in school attendance in Rwanda between the treated and non-treated group.

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April 2018
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1 Introduction

In Rwanda, school attendance is a large indicator of a community's access to education. The net attendance ratio (NAR) is the total number of age specific individuals attending school. According to data from the 2010 Demographic and Health Survey (DHS), the NAR for primary levels in Rwanda was 87%. This means that almost 9 out of 10 children aged 7-12 attend primary school in Rwanda. However, at the secondary level of education, the NAR drops drastically. In most cases, children between the ages of 13-18 are at the secondary level of education. In Rwanda, the NAR for this age group is 15%. There are also large education disparities between gender, urban/rural locations, province, and wealth.

I found such low levels of school attendance rates to be daunting, especially since education is vital to alleviating poverty. The motivation behind this paper is to determine what could be a potential cause for such low levels of school attendance. The 2010 DHS revealed that 25% of households do not have access to safe and clean drinking water. Fortunately, there are numerous non-profit organizations and NGO's working to provide safer water to communities in Africa. One of those is The Water Project, a non-profit organization, which has implemented hundreds of clean water interventions across Africa. In Rwanda alone they have installed more than 85 clean water wells to various communities. We would expect that access to clean water affects school attendance by allowing children to spend more time in school instead of spending time collecting dirty all day, or being sick from a waterborne illness. Therefore, my goal is to examine if there is a relationship between school attendance and access to clean drinking water. Formally, I want to examine the effects of The Water Project on school attendance rates in Rwanda.

I will answer this question by using data from the Rwanda Demographic and Health Surveys (DHS.) I will also use data from The Water Project to collect information on where each water intervention is located in Rwanda. To answer the question presented in this paper, I will use a differences-in-differences statistical model. With this, I will be able to capture the differential effects of a treatment on a treatment group versus a control group.

The said treatment will be access to clean water provided by The Water Project.

Examining the effects of The Water Project on school attendance is important because if we could narrow down one way to help increase school attendance rates we could use this information to help alleviate poverty for those in developing countries. Most previous literature has only examined the effects of contaminated water on the overall health of individuals. Zhang and Xu (2016) looked at the educational benefits of a water treatment program that was implemented in rural China in the 1980s. Their research primarily focused on the long-term benefits of treated water. However, I am contributing to the current literature by examining the short-term effects of a different water intervention program, located in a different country.

The sample is restricted to youth currently enrolled in school who are between the ages of 11-16. Rwanda consists of thirty districts, nine of which are districts that The Water Project implemented clean water interventions. Between May, 2011 and December, 2013 seventy-seven water projects were installed. Therefore, 2010 is the pre-treatment period and 2014 is the post-treatment period. The final results indicate that their is no difference in school attendance between the treated and non-treated locations from 2010 to 2014. As shown in Table 2. The results also show that there is no difference in an improved water source between the treated and non-treated location from 2010 to 2014. As seen in Table 3. This could explain why there is no change in school attendance rates. It is expected that those who benefited from the The Water Project were not captured in the DHS survey.

2 Literature Review

This paper estimates the effects of The Water Project on school attendance in Rwanda. The World Health Organization reported Rwanda to have a population of 11.6 million people as of 2015 ("Rwanda," 2017). Rwanda is one of the smallest countries in Africa, but with such a large population it has one of the highest population densities in the world (Gasana et al., 2002). However, According to the World Health Organization, there were over 75,000 deaths in Rwanda in the year 2013. Over one-third of the deaths in developing countries are caused by the consumption of contaminated water (Gasana et al., 2002). While there have been several studies conducted that look at how the consumption of contaminated water in developing countries can effect the health of youth, little research has been conducted that looks at how contaminated water can effect the educational attainment of youth. Poor water quality increases health issues in children, which results in absenteeism in the classroom, poor mental focus, and poor energy levels (Zhang et at., 2016).

Contaminated water is an outlet for various diseases. The prime targets of these diseases are children under the age of 5 (Gasana et al., 2002). There are four main transmission routes of water-related diseases: waterborne, water-washed, water-based, water-related insect vector. The most commonly seen type of transmissions in developing countries is waterborne and water-washed (Zwane et al., 2007). Waterborne is defined as transmission of water-related disease via ingestion of pathogens in drinking water resulting in diarrheal diseases, enteric fevers, and Hepatitis A (Zwane et al., 2007). Water-washed related diseases are contracted via incidental ingestion of pathogens in the course of other activities. Such activities include not having a sufficient amount of water for bathing and proper hygiene. Examples of water-washed related diseases are Diarrheal disease, Trachoma and Scabies (Zwane et al., 2007). In the first two years of life, children suffer an average of six to eight episodes of diarrheal disease each year (Gasana et al., 2002). Each episode of diarrhea usually lasts 3 to 7 days but in some severe cases the attack may last up to 10-14 days (Gasana et al., 2002).

So what causes such frequent diarrhea episodes? An inadequate water supply, poor sanitation, overcrowding, and malnutrition are the main factors in the spread of diarrheal disease in developing countries (Gasana et al., 2002). The main reasons for inadequate water supply in most developing countries is due to excessive utilization of water by domestic, agriculture, and industrial sectors (Sharma, R. K., et al. 2017). In Rwanda, eighty percent of the population is engaged in agriculture, and inadequate water supply is a large concern for households in rural areas of Rwanda (Rosa et al., 2014). Fortunately, a National Water Policy was implemented in 2004 with the aim to increase the rate of access to drinking water to 100 percent by 2020 in Rwanda ("Water and Sanitation Profile," 2017).

There have been several research articles released that examine the various methods of providing clean water and evaluate which methods are the most effective. A lot of emphasis has been placed on communal infrastructures as most research shows that community access to clean water significantly reduces child mortality risks ("Poverty and the Environment," 2007). Another reason there is a heavy emphasis on community infrastructures is because there is an obvious externality: cleanliness by one person protects the entire community (Bennett, 2012).

Building wells is commonly seen by most non-profit organizations as a means of providing safer water. However, research shows that based on a study conducted in West Africa, 79% of wells showed moderate to heavy fecal contamination (Bordalo et al., 2007). If wells are shallow (5-11m) and do no have protected wellheads, then they are especially vulnerable to contamination via infiltration of soil from rainfall (Bordalo et al., 2007). Upkeep of wells once implemented is also a large concern. A study from Kenya found that nearly 50% of wells dug in the 1980s were neglected and had fallen to disrepair by 2000 (Zwane et al., 2007).

Another means of providing safe drinking water is via the implementation of point-of-use water treatment systems. With this technique there has been a 20-30 percent reduction in diarrheal disease in households (Zwane et al., 2007). However, one concern with this approach to clean water is whether or not households are willing to adopt a system that may alter the taste of water and stall the speed at which water is available for consumption (Zwane et al., 2007). In short, there does not seem to be a perfect answer as to which method of providing water is the most effective. Some organizations, such as The Water Project, claim they use whichever method seems to be the most appropriate for each household/community.

While it is a known fact that water pollution is responsible for malnutrition, it is also responsible for poor cognitive development in children (Sharma et al., 2017). Of the nine water contaminates found in unclean water, Fluoride, Arsenic, and Iron are the most common (Sharma et al., 2017). High levels of fluoride can cause bone damage, anemia, lack of mobility, and skin diseases. Exposure to high levels of Arsenic can cause vomiting, diarrhea, abdominal pain and in extreme cases skin, lung, urinary and kidney cancer. An overconsumption of Iron can cause digestive disorders and damage blood tissues (Sharma et al., 2017). A study conducted in Bangladesh found a negative relationship between exposure to Arsenic via contaminated water and children's test scores (Asadullah et al., 2011). Another study looking at rural youth in China found that access to treated water increases the completed years of education by 1.1 years (Zhang et al., 2016).

There has also been research conducted to show that consumption of contaminated water not only has the ability to affect children, but it also has the ability to affect a fetus (Currie et al., 2013). Based on a study in New Jersey, exposure to contaminated water while pregnant is associated with an increase in low birth weight by 14.55% (Currie et al., 2013). As a group, low birth weight children have higher rates of subnormal growth, illnesses, and neuro-developmental problems (Hack et al., 1995). Follow-up studies on low birth weight children found that the consequences of low birth weight were still evident in their adolescence years (Hack et al., 1995).

Education is crucial for breaking the cycle of poverty. Therefore, providing safe, drinkable water to every individual is essential to increasing student's performance and attendance rates in school. The returns to education in Rwanda are especially significant. An additional year of primary schooling yields a return of 19.4%, an additional year of secondary school yields a return of 29.0%, and higher education yields a private return of 33.3% (Lassibille et al., 2005). Without access to clean water, the probability of school attendance rate decreases for children. Without proper education, individuals are unable to break their current cycle of poverty and continue residing and raising their children in unsafe and unhealthy living conditions.

3 Data and Methodology

For the data, I rely primarily on the Rwanda Demographic and Health Surveys (DHS) from the years 2010 and 2014-2015. The data is repeated cross-sectional. I will use the household questionnaire, which covers thirty districts in Rwanda. For the purpose of this paper I am examining both rural and urban households in all thirty districts. I also use data from The Water Project to gather information on clean water interventions that have been implemented in Rwanda. Of the thirty districts in Rwanda, The Water Project implemented clean water interventions in nine of them. Between May, 2011 and December, 2013 seventy-seven water projects were installed. Therefore, 2010 is the pre-treatment period and 2014 is the post-treatment period.

The Water Project is a non-profit organization with the goal of providing clean water to sub-Saharan communities in Africa. This organization was chosen due to the extensive collection and monitoring of their water projects. The Water Project invests in local teams to solve the problem of finding safe water. This organization believes in investing locally to help local leaders unlock their potential. The Water Project states that lack of access to clean water limits education and leads to a cycle of poverty. They also claim that lack of clean water largely affects females in sub-Saharan Africa, as it could take them several hours to collect clean water. Therefore, this organization aims to provide water projects within 1/2 mile of a village. All water projects are monitored to confirm they are functioning properly to ensure the impacts last. The Water Project implements various water project types according to the needs and resources of each community. However, in Rwanda, only borehole wells with hand pumps were installed. I am only using data for the water projects that are currently still properly working.

For the sample I am focusing on individuals, both male and female, between the ages of 11-16 who are currently enrolled in school. The typical age for primary school in Rwanda is ages 7-12. Therefore, the age span was chosen to capture the four year gap between the data collected in 2010 and the data collected in 2014. There are 110,252 observations for the household sample. For individuals between the ages of 11-16 who are in school the sample size is 16,083 observations.

To gauge the effects of The Water Project on school attendance I am using a differences-in-differences model:

$$Y_{ist} = \alpha + \beta_1 Post_t * District_s + \beta_2 X_{ist} + \beta_3 Post_t + \gamma_s + \epsilon_{ist} \tag{1}$$

Here the subscript i indicates the household, s the district, and t the time in years. Y_{ist} is the school attendance rate for ages 11-16. $Post_t$ is a dummy variable that represents the post-treatment year, 2014. $District_s$ represents the location in which a clean water intervention was administered. The control variables, household size, number of adults in household, highest grade completed, mother in household, father in household, wealth index, and type of residence, are represented by X_{ist}. A dummy variable, γ_s, was created to capture the districts in Rwanda. ϵ_{ist} is the error term.

District fixed effects were used to exploit within-district variations over time. When using fixed effects, we must make one identifying assumption: unobservable factors that might simultaneously affect the left-hand side and right-hand side of the regression are time-invariant. By including fixed effects, we are controlling for the average differences across districts in any observable or unobservable predictors. By controlling for all time-invariant differences, fixed effects models greatly reduce the chances of omitted variable bias.

The purpose of this model is to calculate the effect of a treatment on an outcome. This is done by comparing the average change over time for the treatment group, compared to the average change over time for the control group. With this model we are specifically interested in the coefficient on the interaction term between $Post_t$ and $District_s$. This coefficient, β_1, is known as the differences-in-differences estimator. It reveals the changes in school attendance by youth, aged 11-16, after The Water Project went into effect, relative to those districts where a water project was not installed over the same time period.

The difference-in-difference model is used because repeat observations on a unit, also know as panel data, is not necessary. Instead, it is sufficient to use repeated cross-section sampling from the same aggregate units. However, to estimate any casual effects, one major assumption must hold: the parallel trend assumption. This assumption states that in the absence of the intervention, the difference between the treatment and control group is constant.

4 Analysis

4.1 Descriptive Statistics

There are large education disparities in Rwanda between gender, age, urban/rural locations, and wealth. For both primary and secondary school, females have a slightly higher attendance rate than males. However, 22% of females have no education, while only 15.5% of males have no education. Females between the ages of 15-19 complete the most years of education, while males between the ages of 20-24 complete the most years of education. For both males and females, those who live in urban locations, on average, complete two more years of education than those who live in rural locations. For both males and females, those in the lowest wealth quintile complete an average of one year of education, while those in the highest quintile complete an average of 4 years of education.

25% of households have an unimproved (or not safe) water source. 28% of rural households have an unimproved water source, while only 7% of urban locations have an unimproved water source. A shocking 53% of households recorded that it takes more than thirty minutes to collect clean drinking water, while only 5% of households have clean water on the premises.

Table 1 displays some of the characteristics for the following group under analysis: individuals between the ages 11-16 in Rwanda. It splits the sample by status before and after the water intervention was implemented. This allows us to compare the sample before and after the intervention. As seen in Table 1, there are differences across the treated and non-treated areas. However, when looking at the results for both the 2010 and 2014 years, we see that the differences between the treated and non-treated areas are relatively small.

The 2010 treated districts have, on average, larger family sizes and more mothers and fathers present in the household. The 2010 non-treated districts have, on average, poorer households, more adults, a higher highest grade of education completed, and more households in urban locations. However, only number of adults, highest grade completed, father in household, and urban location are statistically significant.

The 2014 treated areas have, on average, more mothers and fathers present in household. The 2014 non-treated areas have, on average, poorer households, larger family sizes, more adults in household, higher highest grade of education completed, and more urban households. However, only family size, number of adults, highest grade completed, and urban location are statistically significant. This can be seen in Table 1.

4.2 Main Results

Table 2 provides the differences-in-differences estimation for school attendance. From the table we see that the non-treated areas had higher school attendance than the treated areas. The DD estimator is -0.02, indicating that the treated districts have a lower school attendance rate by 2 percentage points. This estimator is not statistically significant. While negative, this parameter is very close to zero. Therefore, we can conclude that The Water Project has no effect on school attendance rates for individuals between 11-16 in Rwanda.

Table 3 provides another differences-in-differences estimation, except for an improved water source. An improved water source is any water source safer than no protected water. Households in the non-treated areas had more improved water sources than the households in treated areas. Again, the DD estimator is very close to zero, indicating that The Water Project has no effect on improving water sources in Rwanda.

Table 4 lists the regression results of the effects of The Water Project on school attendance in Rwanda. The sample is limited to individuals aged 11-16 years old. The control variables include dummy variables for the wealth index, family size, number of adults, highest grade completed, mother in household, father in household, and urban location. When controlling for all control variables, we see that the treated districts have a lower school attendance rates by 1.7 percentage points. However, the parameter of interest is not statistically significant.

The fact that The Water Project does not have an effect on improving water sources could be an explanation for why The Water Project does not have an effect on school attendance. We can not conclude that The Water Project is ineffective in improving school attendance. However, we can assume that there might be some limitations to who the DHS survey reached. It is possible that those individuals who benefited from The Water Project were not captured in the DHS survey.

5 Limitation to the Data

5.1 Parallel Trends Assumption

The main assumption behind the differences-in-differences model is the parallel trends assumption. This assumption states that in the absence of an intervention, the difference between the treatment and control group is constant. I was unable to confirm that this assumption holds with my sample. The DHS survey is collected every five years (i.e. 2005, 2010, 2014-15). However, in 2006, the number of districts in Rwanda was reduced from 106 to thirty and the number of provinces was reduced from twelve to five. In 2005, the DHS survey did not gather data on households from all 106 districts. Instead, data was collected according to the 12 provinces, which do not match up with the 5 provinces from the later years. It was not feasible to accurately match up the districts/provinces over the years. Therefore, I am unable to determine if there are any trends that persisted prior to the pre-treatment year.

5.2 Wealth Index

The wealth index is broken down into five quintiles; poorest, poorer, middle, richer, and richest. The DHS created this variable on the basis of household goods data. Households were asked questions regarding ownership of durable goods (radio, television, car, ect.) and housing characteristics (access to electricity, number of rooms, type of toilet facility, ect.). Each good was assigned a score and these scores were added up to obtain a total for each household. However, this variable fails to accurately explain the wealth of a household. This is due to the fact that, by the nature of the quintile breakdown, a group of households will always fall into the *poorest* group. However, there is no way to gauge how poor said household is.

6 Conclusion

This research paper examines the effects of The Water Project on school attendance in Rwanda. The results show that The Water Project has no effect on school attendance rates in Rwanda between the treated and non-treated areas. The results also show that there is no difference in an improved water source between the treated and non-treated areas from 2010 to 2014. Regardless of the results, this does not necessarily mean The Water Project has no effect on school attendance. However, we can conclude that there were some limitations with the DHS survey. Individuals who were impacted by The Water Project may not have captured in the survey.

Without clean water, the chances of breaking out of poverty are very slim. With access to water, households can efficiently maintain agriculture production. Children can attend school instead of spending hours collecting dirty water, or being sick from waterborne illnesses. Parents find more time to care for their families, expand farming to sustainable levels, and even run small businesses. While the results from this research paper show that The Water Project has no effect on school attendance, The Water Project is still benefiting each community in which they have installed water projects.

Table 1: Descriptive Statistics Pre- and Post-Treatment for Individuals Between Ages 11-16

	2010					**2014**				
	Treated Area		**Non-Treated Area**			**Treated Area**		**Non-Treated Area**		
Descriptive Statistic	**Mean**	**S.D.**	**Mean**	**S.D.**	**T. Stat**	**Mean**	**S.D.**	**Mean**	**S.D.**	**T. Stat**
Poor Household	0.377	0.485	0.388	0.487	0.935	0.364	0.481	0.368	0.482	0.304
Family Size	6.205	2.108	6.164	2.198	-0.790	5.903	1.903	6.106	2.088	4.251
Number of Adults	2.165	1.032	2.212	1.177	1.805	2.058	0.948	2.230	1.104	7.065
Highest Grade Completed	3.387	1.698	3.641	1.770	6.085	3.691	1.911	4.040	1.963	7.417
Mother in Household	0.923	0.267	0.915	0.278	-1.169	0.959	0.199	0.952	0.214	-1.385
Father in Household	0.792	0.406	0.771	0.420	-2.081	0.863	0.344	0.863	0.344	0.006
Urban	0.042	0.2	0.171	0.376	19.968	0.122	0.328	0.237	0.425	13.083
Observations	16,610		38,985			15,897		38,778		

Table 2: Differences-in-Differences

Sample: Youth Aged 11-16 Currently Attending School in Rwanda							
	Treated Area			**Non-Treated Area**			
	2010	**2014**	**DT**	**2010**	**2014**	**DC**	**DD (DT-DC)**
School Attendance	0.886	0.841	-0.05**	0.891	0.860	-0.031***	-0.02
	(0.318)	(0.365)	[0.009]	(0.312)	(0.347)	[0.006]	[0.012]

Notes: Standard deviations are in parentheses. Standard errors are in brackets. *p<0.1, **p<0.5, ***p<0.01

Table 3: Differences-in-Differences

Sample: Households with an Improved Water Source in Rwanda							
	Treated Area			**Non-Treated Area**			
	2010	**2014**	**DT**	**2010**	**2014**	**DC**	**DD (DT-DC)**
Improved Water Source	0.654	0.648	-0.006**	0.773	0.763	0.01***	-0.016
	(0.476)	(0.478)	[0.005]	(0.419)	(0.425)	[0.003]	[0.006]

Notes: Improved water source is any water source better than no protected water. Standard deviations are in parentheses. Standard errors are in brackets. *p<0.1, **p<0.5, ***p<0.01

Table 4: Regression Results for Youth Between Ages 11-16

Key Regressors	**School Attendance**
Post_Treat	-0.017
	(0.011)
Post	-0.037***
	(0.006)
Observations	15,767
R-Squared	0.030

Notes: Standard errors in parentheses. *p<0.1, **p<0.5, ***p<0.01. Other covariates include: wealth index, family size, number of adults, highest grade completed, mother in household, father in household, and urban. All specifications include district fixed effects.

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