Impact of Access to Piped Water on School Absenteeism: Evidence from Rural India

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Ashoka University, Fall 2021

December 17, 2021

1. Introduction

Universal primary education was featured as a key objective in the Millenium Development Goals (2000 - 2015) set out by the United Nations, and significant strides were made with primary enrollment in developing countries, reaching 91% in 2015 from 83% in 2000. In India, greater primary enrollment rates were achieved with the help of the Right to Education Act (2009) and the National Early Childhood Care and Education Policy (2013). Moreover, the District Information System for Education reported in 2012 that approximately 95% of India's rural population is within one kilometer of primary schools (Wadhwa, 2016). Additionally, the 2011 Annual Status of Education Report, which is responsible for tracking data related to rural education, found that the proportion of children in the 6-14 age group not currently enrolled in school was 3.3%, down from 6.6% in 2006 (ASER, 2012).

However, behind the veil of such promising statistics lies the status of children's learning outcomes in the country. India's performance in key indicators of educational outcomes remains abysmal (Gelda et al., 2013). For instance, the country ranked second to last in the 2009 Program for International Student Assessment which tracks student performance across countries in reading, mathematics and science. Moreover, only 48.2% of students in the fifth grade can read at the second grade level (ASER, 2012).

With more than one-fourth of India's population under the age of 14 (Worldbank), it is imperative that children's educational outcomes be ameliorated in order to improve the economic prospects of the country (Wadhwa, 2016). This begs the question of what channels can be leveraged to improve educational outcomes in a country as large as India. This paper aims to highlight one such channel: improving access to piped water.

We use OLS multivariate regression models to assess the impact of access to piped water on absenteeism in India using the IHDS I and IHDS II datasets. Our analysis was only limited to rural households who had children between the age group of 5 to 8 during the first survey round.

We employ a two part analysis where we initially perform linear regressions on variables exclusively reported in 2005 and 2012 respectively. In the process, we also estimate the differential impact of access to piped water on female school going children. Lastly, to limit endogeneity, we employ lagged measures as well as fixed effects to estimate the relationship. The estimates suggest a statistically insignificant negative relationship between access to piped water and absenteeism in India. A more pronounced, but statistically insignificant, effect of access to piped water is visible on girls' absenteeism as compared to that of boys. Similarly, a larger impact of access to piped water on muslim students' absenteeism as compared to students practicing other faiths is found. This relationship is statistically significant.

We evaluate different public policies, predominantly NRDWP, that have been directed in the recent past to increase rural supply of piped drinking water, challenges faced during studying the impact of such programmes and further scope to study or progress upon in the near future.

The paper is divided into 6 sections: Section 2 examines past literature on the subject, Sections 3, 4 and 5 describe the data, methodology and results, respectively. Section 6 concludes the paper.

2. Literature Review

Literature suggests that access to water can significantly improve the learning outcomes of primary school children. Vanaja (2018) assesses the impact of access to piped water on absenteeism in school. The author argues that providing in-house piped water connections can reduce the time spent in collecting water from external sources. This, she explains, is especially impactful for women and girls. She uses an instrumental variable estimation in a child fixed effects model to estimate the relationship and finds that there is a small but statistically significant negative effect of access to piped water on school absenteeism. Moreover, the effect is the same for both boys and girls (Vanaja, 2018).

Ilahi and Grimrad (2000) use a cross sectional data of 1991 to analyze the effect of access to piped water on time allocated to other activities by women in Pakistan. They find that the

distance to the water source has a significant negative impact on the time spent in water collection by women (Ilahi & Grimrad, 2000) .

Nauges and Strand (2011) estimate the impact of fetching water on girls' school attendance in Ghana using a panel dataset (Demographic and Health Surveys). Their results indicate a statistically significant negative relation between girls' school attendance and water collection. More precisely, if the water collection time is reduced by half, the girls' attendance increases by seven percentage points on average. Moreover, they find a stronger impact of fetching water in rural regions (Nauges & Strand, 2011).

Komarulzaman, de Jong and Smots (2019) argue that the task of fetching water is, most often, entrusted to women and children. This, in turn, increases the probability of them catching water-borne diseases, which, in effect, reduces children's study time. As a result, children's school attendance may go down due to joint effects of diarrhoea and time spent on collecting water. They use a fixed effects estimation on a panel dataset for 265 districts in Indonesia over the period 1994-2014 and find that districts where more households have access to private water facilities have a higher school enrolment rate and lower school absenteeism (Komarulzaman et al., 2019).

Hunter et al. (2015) undertook a quasi-experimental study to assess the impact of provision of safe drinking water on school absenteeism in Cambodia. They conducted this study on eight schools, four of which were provided free of charge water containers. They used a negative binomial model in generalized estimating equations to analyse the weekly absenteeism rates and found that there was a strong negative relationship between water provision and absenteeism (Hunter et al., 2015).

Choudhari & Desai (2021) estimate the impact of access to piped water and LPG on children's educational outcomes using a multi-level random-intercept model. Their findings point towards the fact that children in households that do not spend time collecting firewood and water have

substantially higher educational outcomes compared to those who have to engage in such non-paid activities. Additionally, they find that this effect is greater in households where women are entrusted with the tasks of fetching water and firewood (Choudhari & Desai, 2021).

3. Data and Summary Statistics

We use panel data from IHDS round I (2005) and round II (2012) to identify whether access to piped water impacts students' learning outcomes at the primary level. IHDS is a "nationally representative, multi-topic panel survey of 41,554 households in 1503 villages and 971 urban neighborhoods across India" (IHDS).

The list of variables used have been tabulated in Table I. Our dependent variable is absenteeism as provided in the dataset. It stands for the number of days in a year a student was absent. The key predictor is a household's access to piped water. It is a dummy variable that denotes whether a household has access to piped water. $female_i$ is also a dummy variable indicating if the child is female or not. We also use an interaction term that estimates the differential impact of access to piped water on a girl child's absenteeism, relative to that of a boy. Apart from this, we include a number of control variables. Confidence in school is a dummy variable that equals 1 if the household has confidence in the institution of school and 0 if otherwise. Private school is a dummy equalling 1 if the school is a private institution and 0 otherwise. We also create a dummy variable for access to midday meal schemes which equals 1 if the child's school provides midday meals and 0 if not. Lastly, we use school fees and distance from school as controls since they have a direct bearing on the ability of the parents to send their children to school.

Highest adult educ denotes the highest access to education for any member in the household and religion is a categorical variable with 1 representing Hindus, 2 muslims, 3 christians and 4 other religions. We do not use categorisation for caste as data has been hidden by the IHDS.

As the table suggests, the mean absenteeism in 2005 is 3.23 which increases to approximately 5 in 2012. Around 15% of the people had piped drinking water in 2005 which increased to 20% in

2012. Six percent of the students were enrolled in private schools and 82% of the observations belong to Hindu religion.

Importantly, the mean distance to school increased from 1.9 kms to 3.12 kms between 2005 to 2012. This increase could be attributed to different factors not within the scope of this paper but something to be kept in mind while analysing the results.

4. Methodology

As stated earlier, we limit our sample to only rural households that had children between the ages of 5 to 8 in the first round of survey. Decisions such as the choice of school, the area and piped drinking water are much more heterogeneous in urban households given the vast expanse of preferences a metropolitan area brings in while decision making of the households. Distance to the institute becomes completely insignificant as urban households have much more options to consider and their decision of whether or not to send their children to schools would very weakly depend on distance to school. Furthermore, with expansive transportation facilities,, there would be time saving effects. Therefore, to have a thorough analysis of the impact of piped drinking water, we only restrict it to rural households.

Moreover, only households that had children between the ages of 5-8 are chosen from the First round because any new children born between the two survey rounds would enable biased results. IHDS highlights through one of the variables if the household has a child less than 15 years old and we use this variable to further select our sample.

We conduct a two part analysis, where we first attempt to understand the correlations between time savings through piped drinking water on school absenteeism in both 2005 and 2012 using a multivariate correlational study. Thereafter, after validating our findings with the initial hypothesis, we try to reduce endogeneity in our model using lagged variables and state fixed effects while also exclusively studying the differential impact of piped drinking water on key variables.

Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) absentee2005	1.000							
(2) piped2005	-0.059	1.000						
(3) private	-0.108	0.137	1.000					
(4) female	0.098	-0.035	-0.082	1.000				
(5) school_conf2005	-0.098	-0.034	0.072	-0.031	1.000			
(6) enjoys_scho~2005	0.051	0.049	0.019	0.108	0.110	1.000		
(7) fees2005	-0.106	0.181	0.126	-0.133	-0.020	-0.090	1.000	
(8) midday2005	-0.037	-0.082	-0.108	0.096	0.059	0.220	-0.346	1.000

The above matrix of correlations is used to set ground for our first part of analysis. We use Equation 1 and Equation 2 as part of our estimation strategy in the first half:

$$absent_{i2005} = \beta_0 + \beta_1 piped_{ih2005} + \beta_2 private_{i2005} + \beta_3 female_i + \beta_4 distance\ from\ school + \beta_5 school\_conf_{i2005} + \beta_6 fees_{i2005} + \beta_7 female_i X\ piped_{i2005} + \beta_8 midday_{i2005} + \epsilon_{i2005} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$absent_{i2012} = \beta_0 + \beta_1 piped_{ih2012} + \beta_2 private_{i2012} + \beta_3 female_i + \beta_4 distance\ from\ school_i + \beta_5 school\_conf_{i2012} + \beta_6 fees_{i2012} + \beta_7 female_i X\ piped_{i2012} + \beta_8 midday_{i2012} + \epsilon_{i2012} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

We set up a multivariate OLS model in (1) and (2) to estimate the effect of piped drinking water in a household on school absenteeism for a school going child. As our subscripts in both the equations suggest, equation (1) estimates the effects in 2005, whereas equation (2) in 2012 based on the findings of IHDS 1 and IHDS II respectively.

Piped drinking water is a proxy for time saving effects that could be substituting through two different channels: Either the children who were earlier burdened with the responsibility of collecting water from long distances can now use that time for going to school and in other school related activities, or mothers and other members of the household could instead use that time to focus on other household chores or in activities that enable children learning outcomes. These activities could be preparing children breakfast, taking them to school, supervising learning outside the classroom and so on.

We decided to exclude any controls in the first part of our analysis as the primary objective was to look at the strong correlation effect among key variables and school absenteeism. Our hypothesis was that β_1, β_2, β_5 and β_8 should be negative. Piped drinking water will have time savings effects translating into lower absenteeism. Similarly, as the literature has suggested that private institutions have better accountability mechanisms than public schools(Mbiti), it would also result in lower absenteeism among children. Higher confidence in school institutions would imply resources and time spent by households in promoting regular attendance among children thus reducing absenteeism. As fetching water is considered one of the household chores usually burdened on the women in the household, we also believed that there would be a differential impact of piped drinking water on female children.

After validating our hypothesis in the first part(Ref to Section 4), we set up a fixed effects multivariate OLS model with lagged variables and other controls to reduce endogeneity and to control for reverse causality.

Whether or not the Government might be able to link a village to piped water supply depends on a multitude of factors such as available resources of water, budget allocations, feasibility and so on. Evenmore, piped drinking water more often than not is a paid subscription based service and the decision of whether to select itself to the service is made on a household level than a village or district level. Getting access to piped water thus becomes a two level selection: A village level selection followed by a self selection by the household.(Vanaja, p. 5) This selection causes endogeneity in our model as the reasons that lead to a household to have piped water might be correlated with their kids having higher absenteeism. It can be very much possible that only richer households can afford piped drinking water in the first place and their children only attend private schools which have lower absenteeism rates. Our first analysis also could suffer from reverse endogeneity as lower absenteeism rates might imply a household prioritises their children's education very highly and thus invests in systems that have time saving effects including but not limited to piped drinking water.

Therefore, we use Equation 3 for our second part of estimation

$$absent_{i2012} = \beta_0 + \beta_1 piped_{i2005} + \beta_2 female_i X\ piped_{i2005} + \delta_k + \beta_3 HH\ consumption\ levels_{i2005}$$

$$+ \beta_4 distance\ from\ school_i + \beta_5 privateX\ piped_{i2005} + \beta_6 muslimX\ piped_{i2005} + \beta_{ij} X_{ij} + \epsilon_i$$

……(III)

where $absent_{i2012}$ refers to the number of days a school going child was absent in 2012, $piped_{i2005}$refers to if the household had supply to piped drinking water in 2005, $female_i X\ piped_{i2005}$ is an interaction term measuring the differential impact of piped water in 2005 on female students in 2012. $HH\ consumption\ levels_{i2005}$ serve as a proxy for income effects on absenteeism. We avoided the use of income variables directly as it might not reflect the true preference choices of the household in terms of spending. $privateX\ piped_{i2005}$ shows the differential impact of piped drinking water on a student going to a private school and $muslimX\ piped_{i2005}$ shows the differential impact on muslim students. Our reason to choose an

interaction between a muslim child and piped drinking water was to see if piped water leveraged any discrimination faced by certain communities in access to public resources such as pond or well water.(Certain communities might not be allowed to collect water and thus having piped water gives them time saving effects)

δ_k denotes the state level fixed effects we added to account for heterogeneity among different states in India as each state not only faces different challenges in water equity but also allocates a separate budget for water related schemes and policies. Finally X_{ij} refer to the covariates added to control for omitted variable bias as much as possible within our study.

Our next section collates and discusses the results of our analysis in detail.

5. Results

Table II and III show our findings from our first part of analysis done using Eqn (I) and Eqn(II). For 2005, we found that our estimate for piped water is positive and statistically insignificant (Table II). However, the differential impact of being female and having access to piped water is negative. This means that access to piped water in the household has a larger impact (in the hypothesised direction) on a female child's rate of absenteeism as compared to males. For 2012, we found that our estimate for piped water is negative and statistically significant at the 95% confidence level. Moreover, the differential impact of access to water on absenteeism for female students is also negative. However, in this case, the coefficient is statistically insignificant. However, the direction of the relationship is in line with our expectations.

We believe that this effect of access to piped water on absenteeism could be explained through 2 channels: First, in many households, the female children are given the duty to fetch water and this causes them to lose out on attending school. With access to piped water, these kids can save precious time and use it to attend school. Second, there is a possibility that having access to piped water allows the parents of these children to focus on other household chores such as

childcare, thereby freeing up the time of the female child who could have been entrusted with the chores in the event that the parents had to fetch water from long distances.

However, regression estimates from Table II and Table III suffer from endogeneity. First, there is a possibility that those children whose absenteeism rates are less belong to well-educated and well-off families. This would mean that such kids would have a higher probability of having access to piped water in their homes, thereby causing the problem of reverse causality. Second, our current model has not accounted for any factors that vary by state but remain constant over time. This could include state-level policies on water supply and education.

To tackle these issues, we regress absenteeism rates from 2012 on the access to piped water in 2005. This would allow us to establish a unidirectional relationship between access to piped water and absenteeism. Additionally, we use a state fixed effects model to account for all those factors that vary by states. Table IV presents the output.

Column (1) presents the aggregated effect of access to piped water in 2005 on absenteeism of students in 2012 without the controls. We find that the coefficient for *piped2005* is negative but insignificant. Column (3) presents the disaggregated effect of access to piped water in 2005 on absenteeism of male children and female children in 2012. This column includes the controls as well as the state fixed effects. Here, we find that access to piped water for boys has a negative impact on absenteeism. Similarly, the differential impact of access to piped water on absenteeism for girls is also negative. Even though these estimates are not statistically significant, they are in the hypothesised direction.

Another interesting finding is that the differential impact of access to piped water on a muslim child's absenteeism is negative and statistically significant at the 95% confidence level. One interpretation of this finding is that Muslim households in our sample are generally less well-off as compared to households practicing other religions in that they have to work especially hard to fetch water. It could also be possible that muslim households being a minority in many districts can be discriminated against accessing water resources in the village and thus may have to travel

long distances to fetch water. Therefore, access to piped water supply at home has had a more significant impact on their absenteeism rates than the others.

Furthermore, Table IV suggests that being in a private school will have a statistically significant negative impact on absenteeism. This is in line with our expectations as private schools, in general, provide better infrastructure and are less prone to have a hostile environment for children belonging to the underprivileged sections. At the same time, students in private schools are more likely to already belong to well-off families, thus lowering their chances of absenteeism.

Lastly, the impact of distance to school on absenteeism has a negative and statistically significant relationship with absenteeism. This is a surprising finding as one would expect to see that an increase in the distance to school increases the cost of commuting in terms of time and effort for parents and students, thus increasing absenteeism. One possible explanation for this relationship could be that the schools provide students who live far away from school a cost-effective means of transport. However, this does not explain why a reduction in the distance to school would increase absenteeism for students.

6. **Conclusion**

This paper studied the impact of piped drinking water on children' school outcomes, mainly absenteeism. We looked at IHDS panel data for rural households from rounds I and II and used the OLS estimation method on a state-fixed effects model to estimate the relationship of interest. The paper found that access to piped drinking water did have a negative impact on absenteeism, albeit a statistically insignificant one. Additionally, the differential impact of access to piped water on girls' absenteeism was found to be negative but statistically insignificant. Lastly, the differential impact of access to piped water on muslim students' absenteeism was found to be negative and statistically significant at the 95% confidence level.

However, as we suggested at different stages in our paper, our analysis suffers from endogeneity as we do not employ any particular strategy to make causal claims. Furthermore, our analysis might still suffer from omitted variable bias as many control variables that measure school infrastructure quality, such as access to electricity and toilets, number of classrooms etc, could not be added due to lack of data. Moreover, as we specified, piped drinking water being a subscribed service could potentially create a selection bias of only selecting households that could pay for piped water in the first place. Lastly, our key predictor results are statistically insignificant. So, even though our results align with findings of Vanaja (2018), more evidence is required to make any policy level decision.

With the launch of the National Rural Development Water Programme (NRDWP) in 2008-09, we can see a gradual shift to piped water across the country. This policy could act as a natural experiment for a DiD regression analysis in further research. For this paper, however, we had to limit our analysis as only 17 households in our sample were found to be in the post-treatment group, i.e have piped water and also children enrolled in schools in 2011 compared to 2005. Future studies, with more data available could look at the potential impact of this programme and its implication on children's health and learning outcomes.

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Appendix

Table I

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
absentee2005	93701	3.232	8.934	0	150
absentee2012	93701	5.02	10.125	0	148
EH9 5.1 Piped indoor water	19432	.15	.357	0	1
EQ9 5.1a,b indoor piped drinking water	19393	.2	.4	0	1
private	93701	.063	.243	0	1
EH4 2.4 School distance (Km)	15788	1.921	3.286	1	68
EQ4 2.5 School distance (Km)	24421	3.117	6.159	1	99
school conf2005	93701	.139	.346	0	1
11.6 Highest adult educ [max=15]	93692	7.432	4.797	0	15
EH4 2.12 Mid-day meal (recoded)	15458	.537	.499	0	1
EQ4 2.14 Mid-day meal	22814	.561	.496	0	1
private	93701	.063	.243	0	1

enjoys school2012	93701	.05	.218	0	1
enjoys school2005	93701	.051	.219	0	1
religion cat	.	.	.	.	.
Hindu	93701	.822	.382	0	1
Muslim	93701	.119	.324	0	1
Christian	93701	.021	.144	0	1
Other	93701	.038	.19	0	1
HH Annual income Rs2012	93701	89849.546	141738.45	-209026.78	4145807

Table II

Linear regression

absentee2005	Coef.	St.Err.	t-value	p-val	[95% Conf	Interval]	Sig
piped2005	**.934**	**1.97**	**0.47**	**.636**	**-2.939**	**4.806**	
private	**-3.081**	**1.776**	**-1.73**	**.084**	**-6.573**	**.41**	*
female	**3.056**	**1.392**	**2.19**	**.029**	**.319**	**5.793**	**
female_piped2005	**-5.209**	**3.147**	**-1.66**	**.099**	**-11.396**	**.978**	*
school_conf2005	**-2.44**	**1.297**	**-1.88**	**.061**	**-4.989**	**.109**	*
fees2005	**-.001**	**0**	**-2.29**	**.023**	**-.002**	**0**	**
midday2005	**-2.327**	**1.331**	**-1.75**	**.081**	**-4.944**	**.289**	*
Constant	**9.92**	**1.419**	**6.99**	**0**	**7.13**	**12.709**	***

Mean dependent var	**7.170**	**SD dependent var**	**12.557**
R-squared	**0.049**	**Number of obs**	**412**
F-test	**3.002**	**Prob > F**	**0.004**

Akaike crit. (AIC)	**3248.277**	**Bayesian crit. (BIC)**	**3280.445**

****** p<.01, ** p<.05, * p<.1***

Table III

Linear regression

absentee2012	Coef.	St.Err.	t-value	p-val	[95% Conf	Interval]	Sig
piped2012	-4.586	2.2	-2.08	.038	-8.909	-.263	**
private	-1.2	2.182	-0.55	.582	-5.488	3.087	
female	.325	1.658	0.20	.845	-2.934	3.583	
female_piped2012	-.446	3.449	-0.13	.897	-7.225	6.332	
o	0	.	.	.	.	.	
fees2012	0	0	-0.75	.455	-.001	0	
midday2012	6.269	1.728	3.63	0	2.873	9.665	***
Constant	9.408	1.752	5.37	0	5.966	12.851	***

Mean dependent var	**11.268**	**SD dependent var**	**16.119**

R-squared	**0.077**	**Number of obs**	**471**
F-test	**6.472**	**Prob > F**	**0.000**
Akaike crit. (AIC)	**3930.567**	**Bayesian crit. (BIC)**	**3959.651**

****** p<.01, ** p<.05, * p<.1***

Table IV

	(1)	(2)	(3)	(4)
	absentee2012	absentee2012	absentee2012	absentee2012
piped2005	-2.845	-1.683	-.705	-.705
	(1.748)	(2.314)	(2.287)	(3.078)
private	-4.249***	-3.548*	-4.229**	-4.229**
	(1.625)	(1.85)	(1.855)	(1.929)
dist_sc_2012	-.256***	-.256**	-.249**	-.249***
	(.099)	(.102)	(.097)	(.072)
female	.815	1.113	1.029	1.029
	(1.353)	(1.499)	(1.428)	(1.771)
female_piped		-.778	-.186	-.186
		(3.55)	(3.34)	(2.459)
piped_private		-.527	-1.182	-1.182
		(3.223)	(3.087)	(3.023)
piped_muslim		-9.708*	-9.878*	-9.878**
		(5.787)	(5.706)	(3.756)
1bn.religion_cat				

2.religion_cat		**4.053***	**.389**	**.389**
		(2.233)	**(2.367)**	**(2.658)**
3.religion_cat		**-3.273**	**-3.355**	**-3.355**
		(7.745)	**(7.641)**	**(3.315)**
4.religion_cat		**-2.103**	**2.142**	**2.142**
		(3.067)	**(3.11)**	**(4.815)**
school_conf2005		**2.294**	**3.062****	**3.062**
		(1.456)	**(1.477)**	**(2.449)**
HHEDUC		**-.418****	**-.228**	**-.228**
		(.166)	**(.163)**	**(.336)**
XCOTOTAL		**0****	**0****	**0**
		(0)	**(0)**	**(0)**
_cons	**12.313*****	**11.582*****	**9.713*****	**9.713*****
	(1.112)	**(1.82)**	**(1.847)**	**(2.081)**
Observations	**530**	**530**	**530**	**530**
R-squared	**.037**	**.064**	**.22**	**.22**
controls	**No**	**Yes**	**Yes**	**Yes**

state fixed effects	**No**	**No**	**yes**	**yes**
cluster	**No**	**No**	**No**	**yes**

Standard errors are in parentheses

****** p<.01, ** p<.05, * p<.1***